Morphometric variations of twospot catfish (*Mystus nigriceps*) from Kampar Kanan, Kampar Kiri, and Tebo Batang Alai rivers, Indonesia

[1,2]Syafrialdi Syafrialdi, [2]Dahelmi Dahelmi, [2]Dewi I. Roesma, [3]Hafrijal Syandri

[1] Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Muara Bungo University, Jambi, Indonesia; [2] Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University, West Sumatra, Indonesia; [3] Department of Aquaculture, Faculty of Fisheries and Marine Science, Bung Hatta University, West Sumatra, Indonesia. Corresponding author: D. Dahelmi, dahelmi@gmail.com

Abstract. Twospot catfish, *Mystus nigriceps*, known locally as 'ingir-ingir' fish, is a popular consumption fish with high economic value. The exploitation of *M. nigriceps* continuously increases over time, which causes the declining of its wild population. Human interference is needed to maintain its existence, e.g. through domestication. Hence, more studies are essential for the conservation of this species, including on morphological aspects. This study aimed to assess the morphometric variations of *M. nigriceps* populations from Kampar Kanan (KKA), Kampar Kiri (KKI) and Tebo Batang Alai (TBA) rivers. 33 morphometric characters were measured using the Truss method on 150 individuals *M. nigriceps* evenly collected from the three rivers. Kruskal-Walls analysis revealed that 15 characters were significantly different. Further tests using Mann-Whitney showed that the most significant differences (18 characters) were found between the KKA and TBA populations, while the least significant differences (7 characters) were observed between the KKI and TBA populations. The cluster analysis with phenogram indicated that the differences in the morphometric characters among populations were in accordance with their geographical distance. The morphometric characters of the KKA population were more varied than those in KKI and TBA rivers.
Key Words: characters measurements, domestication, fish body, fish habitats, structure stocks.

Introduction. *Mystus nigriceps* (Valenciennes, 1840) is a catfish species taxonomically included in the Bagridae family. It lives in slow-flowing streams with muddy substrate (Ng 2002), in between submerged twigs or sunken log within the swamp as well as in calm puddles such as oxbow lake (Simanjuntak et al 2006). Previous studies reported that *M. nigriceps* is distributed in Sumatra, Java and Borneo (Ng 2002; Kotellat et al 2013). It has economic value, either as fresh and processed fish for consumption or as ornamental fish (Sanjayasari & Pramono 2009; Haniffa 2009).

The increasing demand has led to its overexploitation from even juveniles and spawning individuals, threatening the natural populations of *M. nigriceps* (Lim & Ng 2008). On the other hand, the production of Bagridae family, including wild-caught *M. nigriceps*, has been reported to decrease (Directorate General of Capture Fisheries 2010). The IUCN Red List unfortunately lists *M. nigriceps* as 'not evaluated species', hence urging for more planned management efforts to conserve this species (Ng 2019).

Morphometric studies play an important role in the efforts to optimize the management of the stock potential as fishery resource, being also related to various other perspectives, including evolution, ecology and fish behavior (Usman et al 2014; Syandri et al 2014; Ndiwa et al 2016). Various studies have been previously carried out using morphometric characters, such as the determination of the morphological relationships between species, fish stock identification and structure assessment, fish distribution description and evolving morphometric characters detection (Azrita & Syandri 2014; Chaklader et al 2015; Siddik et al 2016). Moreover, there were also researches about the interactive effects between environment (habitat types) and selection, based on body size and shape in species' offspring (Cadrin 2000; Roesma & Santoso 2011).

Studies on the morphometric characters of *M. nigriceps* are still far from sufficient. The appropriate information regarding species morphometric characters provide support in strategizing fishery resource management (Aryani et al 2017; Allaya et al 2017). Therefore, this study aimed to assess the morphometric variations of *M. nigriceps* from Kampar Kanan, Kampar Kiri, and Tebo Batang Alai rivers in Sumatra, in support to the conservation management.

Material and Method

Study sites. A total of 150 *M. nigriceps* individuals were evenly sampled from two rivers in Riau Province, Kampar Kanan (KKA) and Kampar Kiri (KKI), and one in Jambi Province, the Tebo Batang Alai (TBA) River (Figure 1). Sampling efforts were assisted by local fishermen, involving the use of gill nets and longline fishing, in compliance with the method described in Prchalova et al (2009). Samples were labeled in accordance with the sampling location and fixed in 10% formalin solution for 10 to 15 days. Fish samples were then washed with running water before being transferred into 70% alcohol solution for permanent storing preservative. Species identification was confirmed with the help of relevant guides (Kottelat et al 1993; Ng 2002).

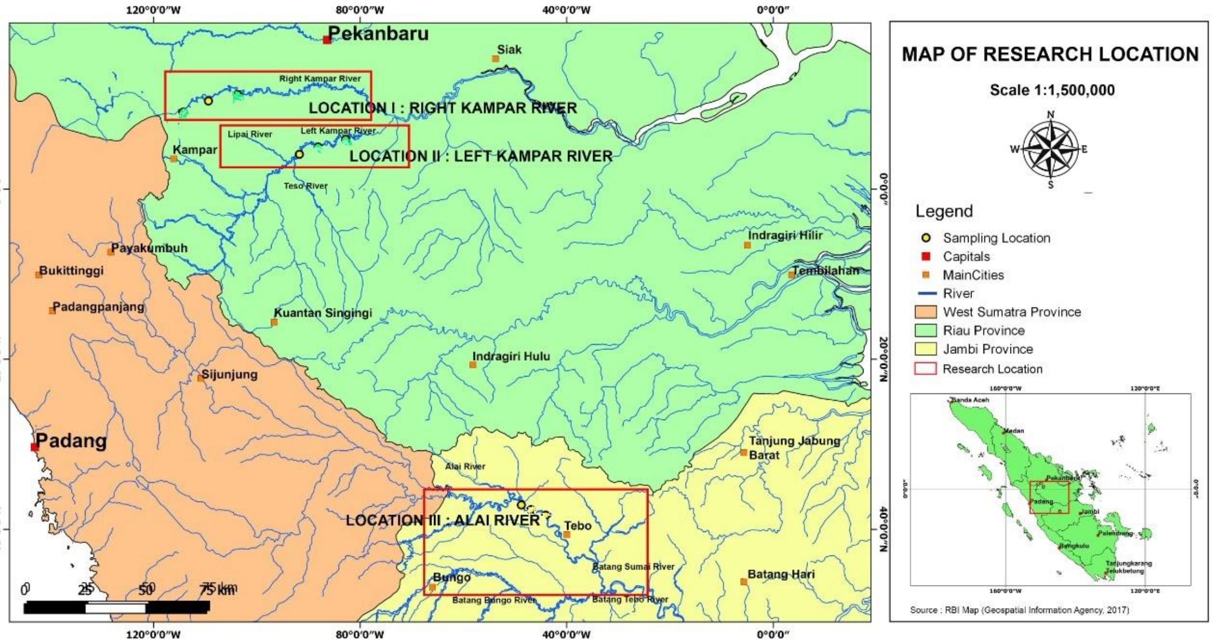

Figure 1. The location of Renggis reef and the coral nursery at Tekek, Tioman Island, Malaysia.

Morphometric characters. The measurements concerned 33 morphometric characters of *M. nigriceps*, referring to Strauss & Bookstein (1982) and Kotellat et al (1993) (Figure 2). Measurement used digital calipers with 0.01 mm precision. This mensural work had taken place in the Genetics and Bio-molecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, West Sumatra.

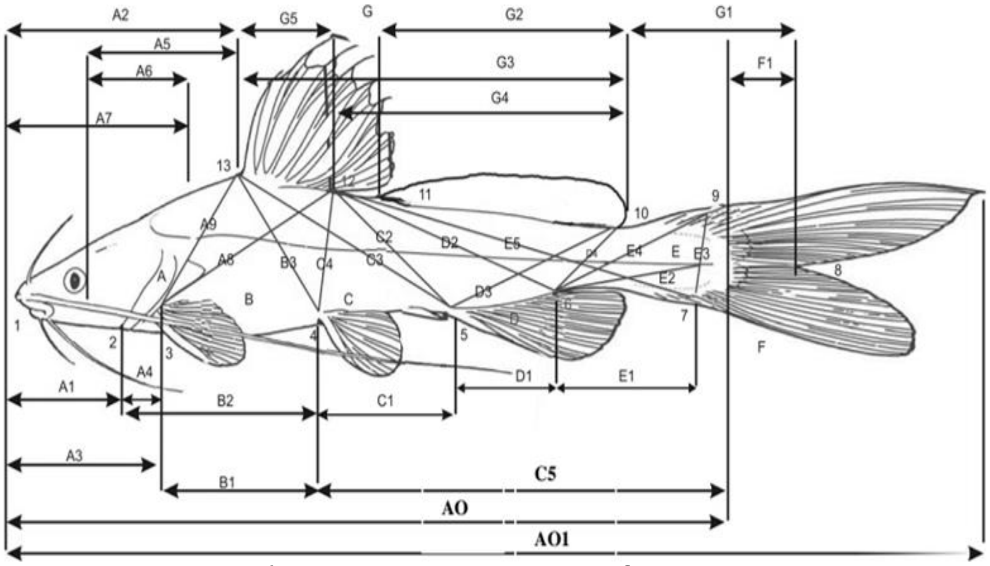

Figure 2. Morphometric measurements of *Mystus nigriceps.*

The measurement parameters are as follow: A01 is total length, A0 is standard length, A1 is snout length-lower part operculum, A2 is pre dorsal length, A3 is snout distance-upper part operculum, A4 operculum distance lower-upper part, A5 is post orbital-pre dorsal distance, A6 is post orbital–head bump distance, A7 is snout–head bump distance, A8 is pectoral-post dorsal fin distance, B1 is operculum upper part-pre pelvic fin distance, B2 is operculum lower part-pre pelvic fin distance, B3 is pre pelvic-pre dorsal fin distance, C1 is pre pelvic-pre anal fin distance, C2 is pre anal–post dorsal fin distance, C3 is pre dorsal-pre anal fin distance, C4 is pre ventral-post dorsal fin distance, C5 is pre ventral-caudal fin base distance, D1 is anal-fin base length, D2 is post anal-post dorsal fin distance. D3 is pre anal-post adipose fin distance, D4 is post anal-post adipose fin distance, E1 is post anal-caudal fin base distance, E2 is post anal-caudal fin base distance, E3 is depth of caudal peduncle, E4 is post anal-caudal fin base distance, E5 is post dorsal-caudal fin distance, F1 is caudal fin length, G1 is post adipose-caudal fin distance, G2 is adipose length, G3 is pre dorsal-post adipose fin distance, G4 is post dorsal-post adipose fin distance, G5 is dorsal fin distance.

Statistical analysis. In anticipating size differences among sample populations, all measurements were classified according to fish standard length (Roesma & Santoso 2011; Syandri et al 2014), before being transformed by using Log10. The Kruskal-Wallis test was then performed to identify the morphometric characters differences from all sampling populations (Roesma & Santoso 2011). The Mann-Whitney analysis followed the Kruskal-Wallis test, for a refined analysis of the differences (Roesma & Santoso 2011). These two tests were applied using the SPSS program version 16.0. Unweighted Pair Group Arithmetic Average (UPGMA) was used to examine the relationships of all characters among populations. Cluster analysis produced a phenogram based on character similarities, applied with the NTSYS PC program Ver.2.02i. Taxonomic distance between each population was inferred from their Euclidean distance (Rohlf 2001).

Results and Discussion. Measurement of morphometric characters on all samples of *M. nigriceps* revealed that 15 (45.45%) out of 33 characters significantly differed among populations (Table 1). Those characters could be grouped as follows: four (12.12%) head characters (SNL-LPO, SNL-UPO, POB-HBD, Sn-HBD), ten (30.30%) body characters (SL, OLP-PrPD, PrP-prDD, PreP-PradPrA-PDD, PrV-PDD, PA-PDD, APL, PRD-PApD, DD) and one (3.03%) tail character (DCP). Further, the Mann Whitney test hinted the highest morphometric differences between the KKA and TBA populations, covering 18 characters (54.54%). They were grouped into five (15.15%) head characters (SNL-LPO, Snl-UPO, PSO-PrDD, PsO-HBD, Sn-HBD), eleven (33.33%) body characters (TL, OLP- PrPD, PrP-PrDD, PrP-Prad, PrA-PsDD, PRD-Prad, PrV-PsDD, PsA-PsDD, APL, PRD-PsApD, DD) and two (6.06%) tail characters (DCP, PsA- CD).

Table 1

Statistical differences among morphometric characters of *Mystus nigriceps* populations using Kruskal-Wallis test

Character	*Population*			
	KKA n=50	*KKI n=50*	*TBA n=50*	*Kruskal-Wallis test*
AO (SL)	102.15±7.59 89.18-118.24	108.93±10.67 87.82-142.27	105.90±14.72 84.68-140.38	X²=8.905 p=0.012*
A1 (SnL-LPO)	0.10±0.02 0.06 0.15	0.10±0.02 0.05-0.14	0.11±0.02 0.07-0.16	X²=8.129 p=0.017*
A3 (SnD-UPO)	0.21±0.01 0.18-0.24	0.21±0.02 0.12-0.23	0.22±0.01 0.18-0.24	X²=7.060 p=0.029*
A6 (PsO-HBD)	0.12±0.03 0.08-0.28	0.12±0.02 0.09-0.21	0.10±0.01 0.08-0.13	X²=37.340 p=0.000*
A7 (Sn-HBD	0.24±0.03 0.21-0.37	0.25±0.02 0.21-0.29	0.22±0.02 0.17-0.25	X²=39.751 p=0.000*
B2 (OLP-PrPD	0.36±0.06 0.24-0.73	0.34±0.03 0.23-0.39	0.34±0.03 0.24-0.39	X²=8.711 p=0.013*
B3 (PrP-PrDD)	0.23±0.01 0.21-0.26	0.24±0.02 0.20-0.28	0.25±0.02 0.23-0.29	X²=24.911 p=0.000*
C1 (PrP-PrAD)	0.26±0.02 0.21-0.30	0.26±0.02 0.24-0.33	0.25±0.02 0.22-0.33	X²=11.206 p=0.004*
C2 (PrA-PsDD)	0.31±0.02 0.26-0.36	0.32±0.02 0.29-0.44	0.32±0.03 0.28-0.47	X²=11.047 p=0.004*
C4 (PrV-PsDD)	0.19±0.02 0.15-0.23	0.20±0.02 0.16-0.23	0.21±0.03 0.16-0.31	X²=20.358 p=0.000*
D2 (PsA-PsDD)	0.36±0.02 0.32-0.41	0.36±0.02 0.32-0.42	0.36±0.04 0.17-0.41	X²=8.162 p=0.017*
E3 (DCP)	0.09±0.01 0.07-0.11	0.09±0.01 0.08-0.11	0.10±0.02 0.08-0.24	X²=27.562 p=0.000*
G2 (ApL)	0.46±0.02 0.40-0.53	0.46±0.02 0.41-0.53	0.47±0.02 0.40-0.53	X²=7.673 p=0.022*
G3 (PrD-PsApD)	0.62±0.02 0.58-0.68	0.63±0.03 0.56-0.73	0.63±0.03 0.55-0.70	X²=11.532 p=0.003*
G5 (DD)	0.11±0.02 0.07-0.17	0.12±0.02 0.08-0.08	0.12±0.02 0.08-0.16	X²=8.699 p=0.013*

* significance value under P <0.05.

The differences of morphometric characters between KKA and KKI populations comprising ten characters (30.30%), were divided into one (3.03%) head character (PsO-HBD), eight (24.24%) body characters (SL AO, P-PsDD, OLP-PrPD, PrP-PrDD, PrV-PsDD ,PrV-CFBD, PRD-PsApD, DD) and one (3.03%) tail character (DCP). The KKI and TBA populations were the least different, encompassing seven characters (21.21%), detailed as follows: three (9.09%) head characters (SNL-LPO, PSO-HBD, Sn-HBD), three (9.09%) body characters (PrP-PrDD, PrP-Prad, PrV-PsDD) and one (3.03%) tail character (DCP) (Table 2).

Table 2

Statistical similarity between *Mystus nigriceps* using the Mann-Whitney test

Population	*KKA river*	*KKI rver*	*TBA river*
KKA River	-		
KKI River	10 (30.3%)	-	
TBA River	18 (54.54%)	7 (21.21%)	-

The number of significantly different morphometric characters indicated an existing morphometric variation in the overall *M. nigriceps* populations. Morphometric variations on fish possibly emerge as a response to differences in habitat, such as the size of their living aquatic environment (Syandri et al 2014). Arzita et al (2013) previous study has also observed typical morphometric characters of *Channa lucius* in responding to environmental natural or artificial changes. In general, morphometric variations found in most organisms appear as a response to fluctuating environmental factors.

Four characters showed consistent differences among 33 characters used to compare *M. nigriceps* populations in KKA, KKI and TBA sites. These four characters were PsO-HBD, PrP-PrDD, PrV-PsDD, and DCP. They were then used as typical differentiators among *M. nigriceps* populations.

The UPGMA analysis resulted in grouping the tested populations in a way that supportively correspond with the results from the Mann Whitney analysis. The KKA and KKI populations were lumped together, while TBA population was in a separate group (Figure 3). This positioning was in accordance to the geographical distance of each population.

Morphometric characters among *M. nigriceps* populations showed a significant difference ($P<0.05$). It indicates that the existing morphometric differentiation among the fish population was induced by environmental factors. The observed morphometric differences were indications of the continuous response to different aquatic environments. The difference between the habitat types of *Mystacoleucus padangensis* fish was reported as a mediator of the morphological adaptations in this fish species (Nofrita et al 2015). Previous research also concluded that selective pressure and ecological properties contributed to the divergence of *Osteochilus hasseltii* (Roesma & Santoso 2011). Hence, it is plausible to hypothesize that ecological factors have significantly impacted morphometric variations of *M. nigriceps*. The current and depth of water are closely related aspects to swimming behavior of fishes. It was previously observed that current velocity, water quality and aquatic ecology contribute to morphometric variations in fish (Nofrita et al 2015; Aryani et al 2017). This is also detected in the current study, where the morphometric characters of *M. nigriceps* experiences a great extent of variation.

Morphometric differences among *M. nigriceps* populations pointed out that they live in variable water depths and have an evolving mobility adaptation, either for avoiding predators or capturing prey. This fact is in line with some previous studies (Blake et al 2005; Rouleau et al 2010; Vieira et al 2016). Morphometric variations in fish may be influenced by environmental factors and ecological selection (Roesma & Santoso 2011). It may happen at early life stages as fish life is highly dependent on many environmental factors, such as temperature, pH, dissolved oxygen TDS, ammonia and alkalinity (Turan et al 2004; Vieira et al 2016; Aryani et al 2017). Thus, fish adaptation to typical ecological factors in each local environment may become the main influencing factor for this morphogenetic process.

The characters PsO-HBD, PrP-PrDD, PrV-PsDD, and DCP are possibly the main differentiators between *M. nigriceps* populations. A research on *Osteochilus vittatus* (Cyprinidae) indicated four main distinguishing characters, namely dorsal fin tip-caudal fin tip (C5), upper mouth tip-dorsal fin base (A4), gill cover base- dorsal fin tip (B4) and mandible-base of dorsal fin (A5) (Syandri et al 2014). Meanwhile, on *Rasbora maninjau* (Cyprinidae), there were found major differentiating characters in eye diameter, caudal peduncle, and fins (Aprilian et al 2016). The main differentiating characters among populations are knowingly affected by water body area and geographical distances between populations (Thirumaraiselvi et al 2013; Syandri et al 2014). The differences in morphological characteristics between anterior and posterior body parts also reflected the adaptive response to environmental factors, especially to water current (Nofrita et al 2015; Kaoueche et al 2017). This morphometric response, however, depends on fish species as different phenotypic responses may arise from the same selective pressure (Franssen et al 2013). The continuous adaptation of the species populations living in different streams, lakes, and reservoirs possibly led to morphometric variations in that fish species (Roesma & Santoso 2011; Syandri et al 2014).

Ecological conditions in the three study sites are variable due to anthropogenic activities such as plantations, livestock farming and fishing along the riparian of KKA, KKI and TBA. These anthropogenic influences impact the ecological conditions of water bodies due to the concentration of pollutants and effluents discharged into it. This condition was also suspected to have triggered morphometric differentiation among *M. nigriceps* populations. Agricultural wastes, either directly or indirectly discharged into the water bodies can induce morphometric change in fish populations by altering ecological factors (Roesma & Santoso 2011). Moreover, populations with numerous individual members will be affected by intra- and inter-species competition for feeding resources. The feeding competition is expected to impact certain morphological characters on the fish body. Morphometric differentiation can be caused by growth patterns and fish conditions (Johansson et al 2006; Dinh et al 2016). Specifically, during the development stage of gonad and ontogeny, any change in food composition may strongly impact the fish body shape. During the ontogeny period, the phenotypic of an individual begins developing. At this stage, factors such as food availability, water depth, fertilizer and pesticides residues from agricultural activity can influence morphological divergence of fish (Krabbenhoft et al 2009; Franssen et al 2013; Allaya et al 2017).

Aside the differences on body parts, *M. nigriceps* specimens from different populations presented differences between the head parts. Morphological variations in fish head may be related to the feeding behavior (Delariva & Agostinho 2001). The differences in exploiting ecological resources, water depth and variability of food sources participate to the shaping of the head parts (Kaoueche et al 2017). The difference in these ecological resources correlates with the characteristics of aquatic ecosystems such as chemical-physical factors, natural substrates, and size of prey.

The phenogram was constructed using morphometric characters equations (Figure 3) indicated that the grouping of *M. nigriceps* populations corresponds to its geographical distance from each sampling location.

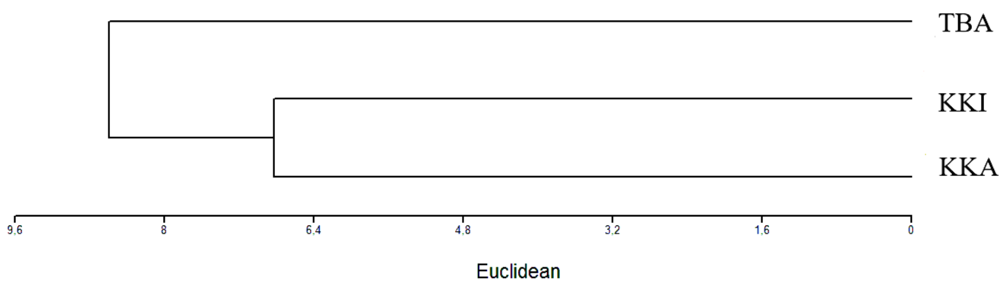

Figure 3. Phenogram of morphometric characters among *Mystus nigriceps* populations.

The similarity in morphometric characters indicates the resemblance in behavior, adaptation and migration patterns across the aquatic environment (Pearce et al 2011; Damjanovic et al 2015). Waters bodies within close geographical proximity tend to have relatively similar ecological conditions. This situation may lead to the population's flexibility in migrating between the water bodies (Wibowo et al 2008). The morphometric dissimilarities of freshwater shrimp *Macrobrachium vollenhoveni* were also thought to be related to the geographical distance among sampling sites (Konana et al 2010). In the current study, the variability of the morphometric characters of *M. nigriceps* was higher in the KKA population than in the KKI and TBA populations. Therefore, among the three populations, the KKA population was recommended as a germ-plasm pool for conservation and domestication of *M. nigriceps* in the future.

Conclusions. The morphometric determinations indicated that 15 characters were significantly different between the studied *M. nigriceps* populations. The highest morphometric differences were observed between Kampar Kanan (KKA) and Tebo Batang Alai (TBA) populations, covering 18 morphological characters. The smallest set of morphometric differences were found between Kampar Kiri (KKI) and TBA populations, concerning seven characters. The observed morphometric differences in *M. nigriceps* populations were correlated with their geographical distance. The KKA population can be recommended as germ-plasm candidate for conservation and domestication of *M. nigriceps*, as it has a higher variability of morphometric characters than KKI and TBA populations.

Acknowledgements. The authors are grateful for the financial assistance provided by the Ministry of Research and Technology, Directorate of Higher Education, through the Domestic Postgraduate Education Scholarship (BPPDN) scheme. The authors would also like to express their gratitude for the moral and material support received from the Muara Bungo University and from the Genetics and Bio-molecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, West Sumatra, Indonesia.

References

Allaya H., Faleh A. B., Rebaya M., Zrelli S., Hattour A., Quignard J. P., Trabelsi M., 2017 Morphological differences between two populations of the little tunny, *Euthynnus alletteratus* (Rafinesque, 1810) in Tunisian waters (Central Mediterranean Sea). Pakistan Journal of Zoology 49(5):1621-1629.

Aprilian E., Roesma D. I., Tjong D. H., 2016 Morphological variation of Bada fish (*Rasbora maninjau*, Lumbantobing) in Maninjau Lake, West Sumatra. Journal of Entomology and Zoology Studies 4(2):541-544.

Aryani N., Hasibuan S., Mardiah A., Syandri H., 2017 Morphometric characteristics of Asian catfish, *Hemibagrus wyckii* (Bleeker, 1858) (Bagridae), from the Riau Province of Indonesia. Pakistan Journal of Biological Sciences 20(8):382-389.

Azrita, Syandri H., Dahelmi, Syaifullah, Nugroho E., 2013 [Morphological characterization of snakehead fish (*Channa lucius*) in the waters of Singkarak Lake, West Sumatra, Tanjung Jabung Timur Floods, Jambi and Kampar Riau floods]. Jurnal Natur Indonesia 15(1):1-8. [In Indonesian].

Azrita, Syandri H., 2014 Morphological character among five strains of giant gourami, *Oshpronemus gouramy* Lacepede, 1801 (Actinopterygii: Perciformes: Osphronemidae) using a truss morphometric system. International Journal of Fisheries and Aquatic Studies 2(6):344-350.

Blake R. W., Law T. C., Chan K. H. S., Li J. F. Z., 2005 Comparison of the prolonged swimming performances of closely related, morphologically distinct three-spined sticklebacks *Gasterosteus* spp. Journal of Fish Biology 67(3):834–848.

Cadrin S. X., 2000 Advances in morphometric identification of fishery stocks. Reviews in Fish Biology and Fisheries 10:91–112.

Chaklader M. R., Siddik M. A. B., Nahar A., 2015 Taxonomic diversity of paradise threadfin *Polynemus paradiseus* (Linnaeus, 1758) inhabiting southern coastal rivers in Bangladesh. Sains Malays 44:1241-1248.

Damjanovic K., Glauser G., Bshary R., Ros A. F. H., 2015 Intra- and interspecific social challenges modulate the levels of an androgen precursor in a seasonally territorial tropical Damselfish. Hormones and Behavior 71(1):75–82.

Delariva R. L., Agostinho A. A., 2001 Relationship between morphology and diets of six *Neotropical loricariids*. Journal of Fish Biology 58:832-847.

Dinh Q. M., Qin J. Q., Dittmann S., Tran D. C., 2016 Morphometric variation of *Parapocryptes serperaster* (Gobiidae) in dry and wet seasons in the Mekong Delta, Vietnam. Ichthyological Research 63:267–274.

Franssen N. R., Harris J., Clark S. R., Schaefer J. F., Stewart L. K., 2013 Shared and unique morphological responses of stream fishes to anthropogenic habitat alteration. Proceedings of the Royal Society B 280:20122715.

Haniffa M. A., 2009 Native catfish culture-a technology package for fish farmers. Aquaculture Asia Magazine 14(3):22-24.

Johansson F., Radman P., Andersson J., 2006 The relationship between ontogeny, morphology, and diet in the Chinese hook snout carp (*Opsariichthys bidens*). Ichthyological Research 53:63–69.

Kaoueche M., Sfar L. B., Hammami I., Hassine O. K. B., 2017 Morphometric variations in white seabream *Diplodus sargus* (Linneaus, 1758) populations along the Tunisian coast. Oceanologia 59:129-138.
Konana K. M., Adepo-Goureneb A. B., Ouattaraa A., Nyingyc W. D., Gourenea G., 2010 Morphometric variation among male populations of freshwater shrimp *Macrobrachium vollenhovenii* Herklots, 1851 from Côte d'Ivoire Rivers. Fisheries Research 103:1–8.
Kottelat M., Whitten A. J., Kartikasari S. N., Wirjoatmodjo S., 1993 Freshwater fishes of Western Indonesia and Sulawesi. Periplus Editions, 221 p.
Krabbenhoft T. J., Collyer M. L., Quattro J. M., 2009 Differing evolutionary patterns underlie convergence on elongate morphology in endemic fishes of Lake Waccamaw North Carolina. Biological Journal of the Linnean Society 98:636–645.
Lim K. K. P., Ng H. H., 2008 *Pseudomytus heokhuii*, a new species of bagrid catfish from Sumatra (Teleostei: Bagridae). Zootaxa 1686:37–47.
Ndiwa T. C., Nyingi D. W., Claude J., Agnese J. F., 2016 Morphological variations of wild populations of Nile tilapia (*Oreochromis niloticus)* living in extreme environmental conditions in the Kenyan Rift-Valley. Environmental Biology of Fishes 99:473–485.
Ng H. H., 2002 The identity of *Mystus nigriceps* (Valenciennes In Cuvier & Valenciennes, 1840), with the description of a new Bagrid catfish (Teleostei: Siluriformes) from Southeast Asia. The Raffles Bulletin of Zoology 50(1):161-168.
Ng H. H., 2019 *Mystus nigriceps*. The IUCN Red List of Threatened Species 2019, e.T89823163A89823197.
Nofrita, Dahelmi, Syandri H., Tjong J. H., 2015 Morphological differentiation between Bilih fish (Cyprinidae: *Mystacoleucus padangensis*, Blekeer) in Singkarak Lake and Anai River, West Sumatra, Indonesia. Journal of Entomology and Zoology Studies 3(5):171-175.
Pearce A., Slawinskic D., Feng M., Hutchins B., Fearns P., 2011 Modelling the potential transport of tropical fish larvae in the Leeuwin current. Continental Shelf Research 31(19):2018–2040.
Prchalova M., Kubecka J., Riha M., Mrkvicka T., Vasek M., Juza T., Kratochvil M., Peterka J., Drastik V., Krizek J., 2009 Size selectivity of standardized multimesh gillnets in sampling coarse European species. Fisheries Research 96:51–57.
Roesma D. I., Santoso P., 2011 Morphological divergences among three sympatric populations of Silver Sharkminnow (Cyprinidae: *Osteochilus hasseltii* C.V.) in West Sumatra. Biodiversitas 12(3):141-145.
Rohlf F. J., 2001 NTSYS numerical taxonomy and multivariate analysis system version 2.0.2. Appllied Biostatistic, New York, USA, 43 p.
Rouleau S., Glemet H., Magnan P., 2010 Effects of morphology on swimming performance in wild and laboratory crosses of brook trout ecotypes. Functional Ecology 24(2):310–321.
Sanjayasari D., Pramono T. B., 2009 Domestication strategy of Senggaringan Fish (*Mystus nigriceps*) to combat protein deficiency as food security. The 1sst International Seminar on Animal Industry, pp. 336-340.
Siddik M. A. B., Hanif M. A., Chaklader M. R., Nahar A., Fotedar R., 2016 A multivariate morphometric investigation to delineate stock structure of gangetic whiting, *Sillaginopsis panijus* (Teleostei: Sillaginidae). Springer Plus 5(520):1-13.
Simanjuntak C. P. H., Raharjo M. F., Sukimin S., 2006 [Ichthyofauna in floodplain of Kampar Kiri River]. Iktiologi Indonesia 6(2):99-109. [In Indonesian].
Strauss R. E., Bookstein F. L., 1982 The truss: Body form reconstruction in morphometric. Systematic Zoology 31(2):113-135.
Syandri H., Azrita, Junaidi, 2014 Morphological characterization of Asang fish (*Osteochilus vittatus*, Cyprinidae) in Singkarak Lake, Antokan River and Koto Panjang Reservoir West Sumatra Province, Indonesia. Journal of Fisheries and Aquaculture 5(1):158-162.
Thirumaraiselvi R., Thangaraj M., Ramanadevi V., 2013 Morphometric and genetic variation in three populations of Indian Salmon (*Polydactylus plebeius*). Notulae Scientia Biologicae 5(3):275-281.

Turan C., Ergüden D., Turan F., Gürlek M., 2004 Genetic and morphologic structure of *Liza abu* (Heckel, 1843) populations from the Rivers Orontes, Euphrates and Tigris. Turkish Journal of Veterinary and Animal Sciences 28:729-734.
Usman B. I., Amin S. M. N., Arshad A., Kamarudin M. S., 2014 Morphometric relations in the grey eel catfish in the coastal waters of Port Dickson, Peninsular Malaysia. Journal of Environmental Biology 37:573-578.
Vieira A. R., Rodrigues A. S. B., Sequeira V., Neves A., Paiva R. B., Paulo O. S., Gordo L. S., 2016 Genetic and morphological variation of the Forkbeard, *Phycis phycis* (Pisces, Phycidae): Evidence of panmixia and recent population expansion along its distribution area. Plos One 11(12):1-19.
Wibowo A., Sunarno M. T. D., Makmur S., Subagja, 2008 [Identification of the structure of Belida fish stocks (*Chitala* spp) and their implications for natural population management]. Jurnal Penelitian Perikanan Indonesia 14(1):31–44. [In Indonesian].
*** Directorate General of Capture Fisheries, 2010 [Maritime and fisheries statistical data]. Ministry of Maritime Affairs and Fisheries, Indonesia, 282 p. [In Indonesian].

Received: 25 April 2020. Accepted: 04 August 2020. Published online: 12 August 2020.
Authors:
Syafrialdi Syafrialdi, Andalas University, Faculty of Mathematics and Natural Sciences, Department of Biology, 25163 Padang, West Sumatera, Indonesia, e-mail: syafrialdi_umb@ymail.com
Dahelmi Dahelmi, Andalas University, Department of Biology, Faculty of Mathematics and Natural Sciences, 25163 Padang, West Sumatra, Indonesia, e-mail: dahelmi@gmail.com
Dewi Imelda Roesma, Andalas University, Faculty of Mathematics and Natural Sciences, Department of Biology, 25163 Padang, West Sumatra, Indonesia, e-mail: dewiroesma@sci.unand.ac.id.
Hafrijal Syandri, Bung Hatta University, Faculty of Fisheries, 25133 Padang, West Sumatera, Indonesia, e-mail: syandri1960@yahoo.com

How to cite this article:
Syafrialdi S., Dahelmi D., Roesma D. I., Syandri H., 2020 Morphometric variations of twospot catfish (*Mystus nigriceps*) from Kampar Kanan, Kampar Kiri, and Tebo Batang Alai rivers, Indonesia. AACL Bioflux 13(4):2107-2115.