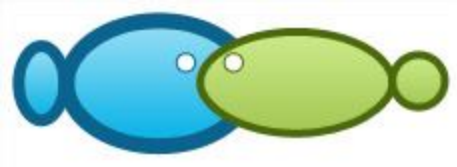

Variation in morphometric characteristics of Nike fish (amphidromous goby larva) in Leato waters, Gorontalo Bay, Indonesia

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Abstract. Nike is a local term used to refer to the schooling of amphidromous goby larvae that have a limited appearance in their habitat. Fishing this aquatic biota in large quantities without reliable scientific information may lead to a critical depletion in its population, and threaten the sustainability in nature. In this study, the species of aquatic animals making up the school were ascertained via genetic and morphological studies. Nike speciation through genetic studies has recently begun and is still being developed. A morphometric study was conducted to estimate the species and stadia composing the larva school. The aim of this study is to provide data on morphometric variations of Nike fish found in Leato waters, Gorontalo Bay, Indonesia. A total of 16 sites were sampled along the coastal area from March to May 2018. Overall, total length (1.687-2.425 cm TL), standard length (1.340-2.439 cm SL), head length (0.018-0.117 cm HL), body depth (0.017-0.202 cm BD), and body width (0.014-0.130 cm BW) of the larvae schools in three occurrence periods were found to be different. Furthermore size variations during the day of occurrence each month were also found to be significantly different ($p < 0.05$). Therefore, the morphometric method is potentially capable of identifying the species and the stadia of Nike.
Key Words: amphidromous larva, goby, Nike, Tomini, morphometric, morphology.

Introduction. Initially, Nike schools were thought to be endemic single species populations inhabiting Gorontalo waters. Pasisingi & Abdullah (2018) revealed that the fish is an amphidromous goby schooling consisting of several species. Amphidromous fish migration between sea and freshwater is associated with reproduction purposes. The characteristic elements in amphidromous are reproduction in freshwater, passage to sea by newly hatched larvae, a period of feeding and growing at sea usually a few months long, return to the freshwater of well-grown juveniles, and a further period of feeding and growing in fresh water, followed by reproduction there (McDowall (2007). Amphidromous fishes are found predominantly on the tropical and subtropical islands of the globe. There are few amphidromous species on continents (McDowall 2010). Interaction between migration and selection influencing the evolution of species with marine-dispersing larvae is challenging since the processes that govern population connectivity has not been well quantified (Moody et al 2019).

Both molecular and morphometric variation methods are needed for more accurate identification and the purpose of extensive information on fish larval diversity in nature. Fish larvae are mostly ecologically and morphologically different in comparison with their adult counterparts, along with their development processes (Rezagholinejad et al 2016). Morphometric fish variation can be significant for discriminating phenotypic stocks as groups with similar life-history traits (Mounir et al 2019). Identifying the fish larvae stage is a great challenge due to its small size and incomplete body completeness. Nevertheless, morphometric characters were made and developing as a practical guide

for identifying fish species both in adult stadia (Peterson & Lietz 2017; Santos et al 2019) and larvae (Azmir et al 2017; Mazaheri Kouhanestani et al 2020).

Several previous Nike studies have been carried out in Gorontalo waters, located in the coastal waters of Tomini Bay, Indonesia. They assessed handling and processing (Kasim et al 2017; Andhini et al 2020; Husain et al 2019), the population and distribution (Olii et al 2017; Sutrisno et al 2018; Pasisingi et al 2020a), the habitat pollution (Salam et al 2016) and economic analysis of capture (Wolok et al 2019). So far, Nike fish speciation in Gorontalo waters using a molecular approach continues to be developed (Usman 2016; Olii et al 2019; Sahami et al 2019; Pasisingi et al 2020b). Nevertheless, no studies were concerned about identifying the characteristics of the fish using morphometric and meristic approaches. The combination of genetic and morphometric information much reinforces information about the speciation of Nike fish. In other waters, goby morphometric approach continues to be carried out and developed (Keith et al 2016, 2017, 2019; Lejeune et al 2016) to record data of the fish spreading worldwide. A very limited identification key to the location of the water (Victor et al 2010; Mwaluma et al 2014; Rodriguez et al 2017) in order to provide morphometric variations of Nike in nature, increased the urgency of this study. The complications in larval and juvenile identification cause the scarcity of the majority of gobies data (Tran et al 2018). The present study, combining with meristic information and other identified vital variables, might be a basic method intended to facilitate the key identification of Nike as well as other goby fish larvae from Gorontalo waters. This research aims to provide data on morphometric variations of Nike fish found in Leato waters, Gorontalo Bay, Indonesia.

Material and Method

Study area. Monthly sampling was conducted in the coastal of Leato, Gorontalo, Indonesia. A total of 16 sites were sampled along the coastal area (Figure 1). Samples were taken from March to May 2018 with consideration of the fish appearance in waters for choosing the sampling sites as the fish does not perform periodically at a specific time and point.

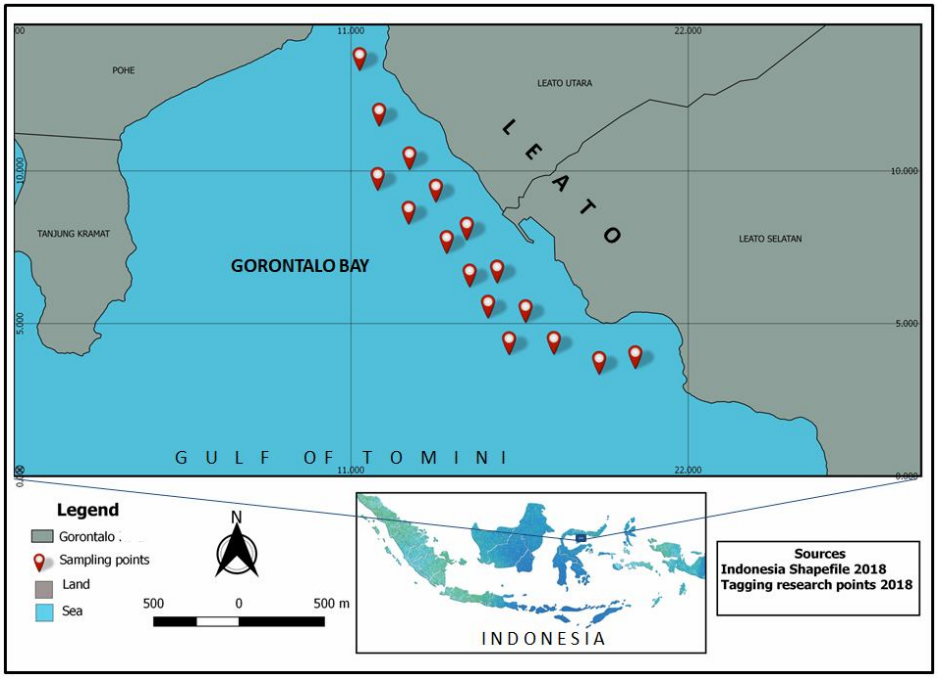

Figure 1. Sampling sites of Nike fish larvae in the Leato waters, Gorontalo Bay, Indonesia.

Sampling technique. The depth of the sampling locations ranged from 1 m to 5 m. Fish larvae were collected using a fishnet with a mesh size of 0.5 inches. The larvae samples were immediately fixed in the icebox and transferred to the laboratory for morphometric measurement purposes. The larva sample parameters were measured using Vernier

Caliper with an accuracy of 0.001 cm. Total length (TL) is the distance from the tip of the snout to the tip of the longest ray of caudal fin; standard length (SL) is the distance from the tip of the snout to the end of the hypural plate; head length (HL) is the distance from the tip of the snout to the posterior point of opercular membrane; body depth (BD) is the maximum distance from ventral to dorsal; body width (BW) is the greatest width of the body (Figure 2).

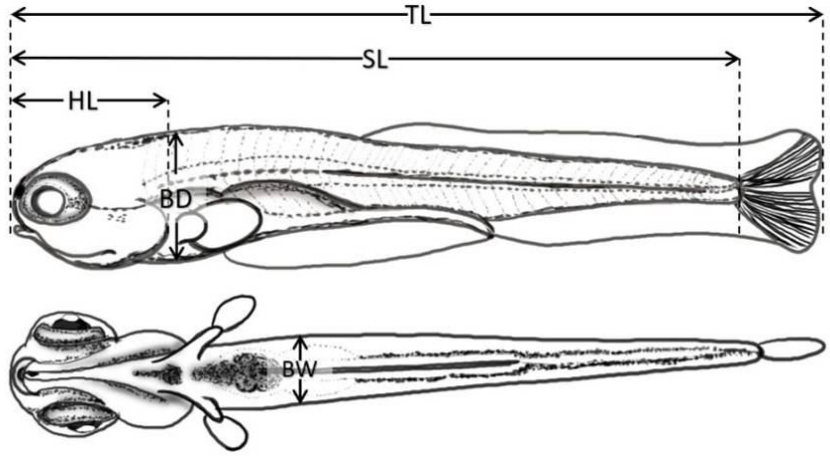

Figure 2. Morphometric characters measured on the larva body.

Statistical analysis. With IBM SPSS Statistics V22.0, statistical analysis was performed using the Kruskal-Wallis H and Mann-Whitney U tests to check significant differences of each morphometric measurements among the sampling day from three different sampling periods. Data also were analyzed using MINITAB 14.0 tool to show the similarity level of each morphometric character among different sampling times.

Results. The amphidromous goby larvae that appear in the waters of Gorontalo still holds many mysteries. The limited period of occurrence and the various abundance of Nike in each period is a unique phenomenon that needs to be studied more profoundly. Local fishermen informed that Nike is generally present every month. However, in the past few years, Nike occasionally does not appear in certain months. At a glance, the morphometric among individual compilers of schools Nike is slightly different (Figure 3). Nonetheless, this study shows that the morphometric characters of the fish larvae vary greatly both based on the area and time of appearances.

Figure 3. Nike fish collected from the Leato waters, Gorontalo Bay, Indonesia in 2018.

Morphometric variation. Characteristics of larvae fish morphometric from three different sampling periods were summarized in Table 1, 2. 3. The size variations during the day of occurrence each month were found to be significantly different ($p < 0.05$). In March, the most extended average size of TL, SL, HL, BD, and BW was found on the appearance of the first day. In April, the longest average TL, SL, BD, and BW were

established on the appearance of the third day, while the longest average HL was found on the presence of the first day. In May, the lengthiest TL was found on the appearance of the seventh day. The longest SL and HL means were found on the first-day appearance, while the longest BD and BW average was shown on the third day of the existence.

In March, the average size of fish TL that appeared on the first and third days was not significantly different. Similar to the average size of the third and fourth days of BW size, there is no difference significantly. Whereas, other morphometric features were significantly different among the present days in waters. In April, the average size of the first and third days of HL and BD of the first and third days as well as the second and third days showed no significant difference. May is the longest period occurrence with nine days.

Overall, at a 75% similarity level, morphometric variables among the three different months were dissimilar (Figure 4). Fully, TL and SL characters in March and April show more similar, while HL, BH, and BW in April and May have a high level of similarity.

Discussion. Lack of scientific data on the development and life cycle of amphidromous goby is the main obstacle in tracing the species that make up the school of Nike larvae. This research has not been able to show at what stage Nike was found. However, the results showed that there were morphometric variations in the schools, which further strengthened the study results that Nike was a multi-species larva group. The variation of the larva development size was apparent. It might be possible that the Nike schooling stages in March, April, and May have different larval phases among individuals composing the groups. The morphometric characters that differ from each other among three months indicate that the larva schooling in a particular month is a separate and distinct population from those found in other months.

Morphometric is an aspect that needs to be mastered to determine fish species. In evolutionary ecology, predicting specification is a primary goal (Yamasaki et al 2020). The completeness of body organs is a significant feature of the phases of individual species. Before becoming a juvenile, the larvae fish go through pre flexion, flexion, and post flexion phases (Bera et al 2019; Coelho et al 2019; Kim et al 2020). The embryo incubation time is species-specific and usually lasts from 4 to 10 days, depending on environmental factors such as water temperature. Newly hatched gobies are 1 to 3.5 mm in length, depending on species (Von Linden et al 2020). Different species of gobioids showed a variable mean duration of larvae as well (Heim-Ballew et al 2020). Skeletal development and total length larva were not observed just immediately after hatching. According to Yun et al (2020), the increase in total length and bone development of a species from the Gobiidae family was only observed on the third day after hatching.

Almost every morphometric feature is significantly different among the occurrence days. Speciation through the morphometric approach requires an extra precision as environmental factors may determine the life and development of the larvae. The same species may exhibit different morphometric performance if they inhabit different water conditions as a form of adaptation for survival. Dodson et al (2019) revealed evidence of stage-specific temperature-related mortality. Temperature played a significant role in influencing the abundance of larvae through its interaction with the abundance of the preceding developmental stage and provided. Season and condition of water currents are also environmental parameters related to the abundance and distribution of fish larvae in coastal areas (Sagala et al 2020). Light presence in traps significantly increased the capture and retention of larvae compared to unlit traps (de Vlaming & Bestgen 2020).

Research on all aspects of Nike life needs to continue. Domestication efforts are a long-term solution that can be considered as the larva is consumed and exploited periodically. Species data is required to explore the fish life in nature to maintain the availability in nature. A further detailed study on systematic ecology and biology of the goby schools from other geographical locations in Indonesia waters is also needed. It can help Nike speciation and to gather more information for sustainable Nike fish management purpose.

Table 1

The average size of the morphometric character of Nike fish population in March 2018

Char.	*Day 1 (n = 200)*		*Day 2 (n = 200)*		*Day 3 (n = 400)*		*Day 4 (n = 200)*	
(cm)	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*
TL	2.222 ± 0.368^{a}	1.040-3.050	1.687 ± 0.289^{b}	1.200-2.900	2.169 ± 0.274^{a}	1.400-3.320	1.896 ± 0.296^{c}	1.000-3.000
SL	1.879 ± 0.419^{a}	0.135-5.365	1.402 ± 0.248^{b}	1.010-2.500	1.768 ± 0.269^{bc}	1.010-2.800	1.574 ± 0.248^{d}	1.010-2.950
HL	0.117 ± 0.124^{a}	0.010-0.610	0.027 ± 0.027^{b}	0.005-0.210	0.116 ± 0.226^{bc}	0.005-1.320	0.039 ± 0.063^{d}	0.005-0.610
BD	0.202 ± 0.110^{a}	0.010-0.480	0.023 ± 0.018^{b}	0.005-0.130	0.097 ± 0.214^{bc}	0.010-1.220	0.042 ± 0.058^{d}	0.005-0.350
BW	0.130 ± 0.067^{a}	0.010-0.350	0.019 ± 0.015^{b}	0.005-0.090	0.029 ± 0.025^{bc}	0.001-0.340	0.031 ± 0.035^{bc}	0.005-0.300

Char. = morphometric characteristics; n = sample size. The values with different superscript letters are significantly different ($p < 0.05$).

Table 2

The average size of the morphometric character of Nike fish population in April 2018

Char. (cm)	*Day 1 (n = 150)*		*Day 2 (n = 300)*		*Day 3 (n = 150)*	
	Mean±SD	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*
TL	2.493 ± 0.240^{a}	2.010-3.100	2.711 ± 0.223^{b}	2.100-3.500	2.821 ± 0.203^{bc}	1.900-3.300
SL	2.115 ± 0.220^{a}	1.720-2.800	2.346 ± 0.206^{b}	1.800-2.900	2.439 ± 0.163^{bc}	1.700-2.800
HL	0.047 ± 0.030^{a}	0.010-0.150	0.033 ± 0.009^{bc}	0.010-0.050	0.039 ± 0.035^{a}	0.010-0.450
BD	0.034 ± 0.018^{a}	0.010-0.140	0.033 ± 0.007^{bc}	0.004-0.050	0.034 ± 0.007^{ac}	0.010-0.050
BW	0.024 ± 0.010^{a}	0.010-0.080	0.025 ± 0.060^{b}	0.010-0.040	0.031 ± 0.006^{bc}	0.010-0.050

Char. = morphometric characteristics; n = sample size. The values with different superscript letters are significantly different ($p < 0.05$).

Table 3

The average size of the morphometric character of Nike fish population in May 2018

Char. (cm)	*Day 1 (n = 99)*		*Day 2 (n = 220)*		*Day 3 (n=200)*		*Day 4 (n=300)*		*Day 5 (n = 300)*		*Day 6 (n = 300)*		*Day 7 (n = 300)*		*Day 8 (n = 137)*		*Day 9 (n = 20)*	
	Mean±SD	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*	*Mean±SD*	*Range*
TL	1.944 ± 0.472^{a}	1.200-3.320	2.311 ± 0.325^{b}	1.300-3.000	2.239 ± 0.166^{bc}	2.100-3.290	2.308 ± 0.360^{d}	1.300-3.600	2.197 ± 0.416^{d}	1.300-3.600	2.215 ± 0.424^{d}	1.300-3.900	2.425 ± 0.324^{de}	1.300-3.100	2.208 ± 0.336^{d}	1.600-3.200	1.925 ± 0.446^{f}	1.400-3.600
SL	1.625 ± 0.396^{a}	0.010-2.800	2.436 ± 0.407^{b}	1.200-3.300	2.239 ± 0.166^{bc}	2.000-3.000	2.001 ± 0.315^{d}	1.100-3.300	1.887 ± 0.394^{de}	1.100-3.300	1.853 ± 0.425^{de}	0.100-3.400	2.102 ± 0.297^{df}	1.100-2.900	1.890 ± 0.304^{de}	1.340-2.800	1.708 ± 0.431^{g}	1.200-3.300
HL	0.027 ± 0.022^{a}	0.005-0.110	0.036 ± 0.008^{a}	0.010-0.060	0.034 ± 0.009^{ab}	0.002-0.060	0.031 ± 0.013^{c}	0.002-0.190	0.023 ± 0.011^{d}	0.005-0.060	0.023 ± 0.010^{de}	0.010-0.070	0.031 ± 0.009^{c}	0.011-0.050	0.112 ± 0.092^{e}	0.010-0.370	0.018 ± 0.006^{a}	0.010-0.030
BD	0.027 ± 0.019^{a}	0.005-0.110	0.033 ± 0.007^{a}	0.010-0.050	0.033 ± 0.007^{a}	0.020-0.050	0.031 ± 0.007^{b}	0.004-0.050	0.021 ± 0.009^{bc}	0.005-0.060	0.022 ± 0.010^{bc}	0.010-0.050	0.031 ± 0.008^{b}	0.004-0.055	0.162 ± 0.102^{d}	0.010-0.340	0.017 ± 0.007^{bc}	0.010-0.030
BW	0.023 ± 0.017^{a}	0.005-0.090	0.029 ± 0.007^{a}	0.010-0,050	0.027 ± 0.007^{c}	0.010-0.051	0.026 ± 0.007^{c}	0.010-0.040	0.025 ± 0.014^{b}	0.005-0.090	0.020 ± 0.009^{bc}	0.010-0.050	0.027 ± 0.008^{d}	0.010-0.060	0.075 ± 0.046^{de}	0.010-0.195	0.014 ± 0.005^{bc}	0.010-0.020

Char. = morphometric characteristics; n = sample size. The values with different superscript letters are significantly different ($p < 0.05$).

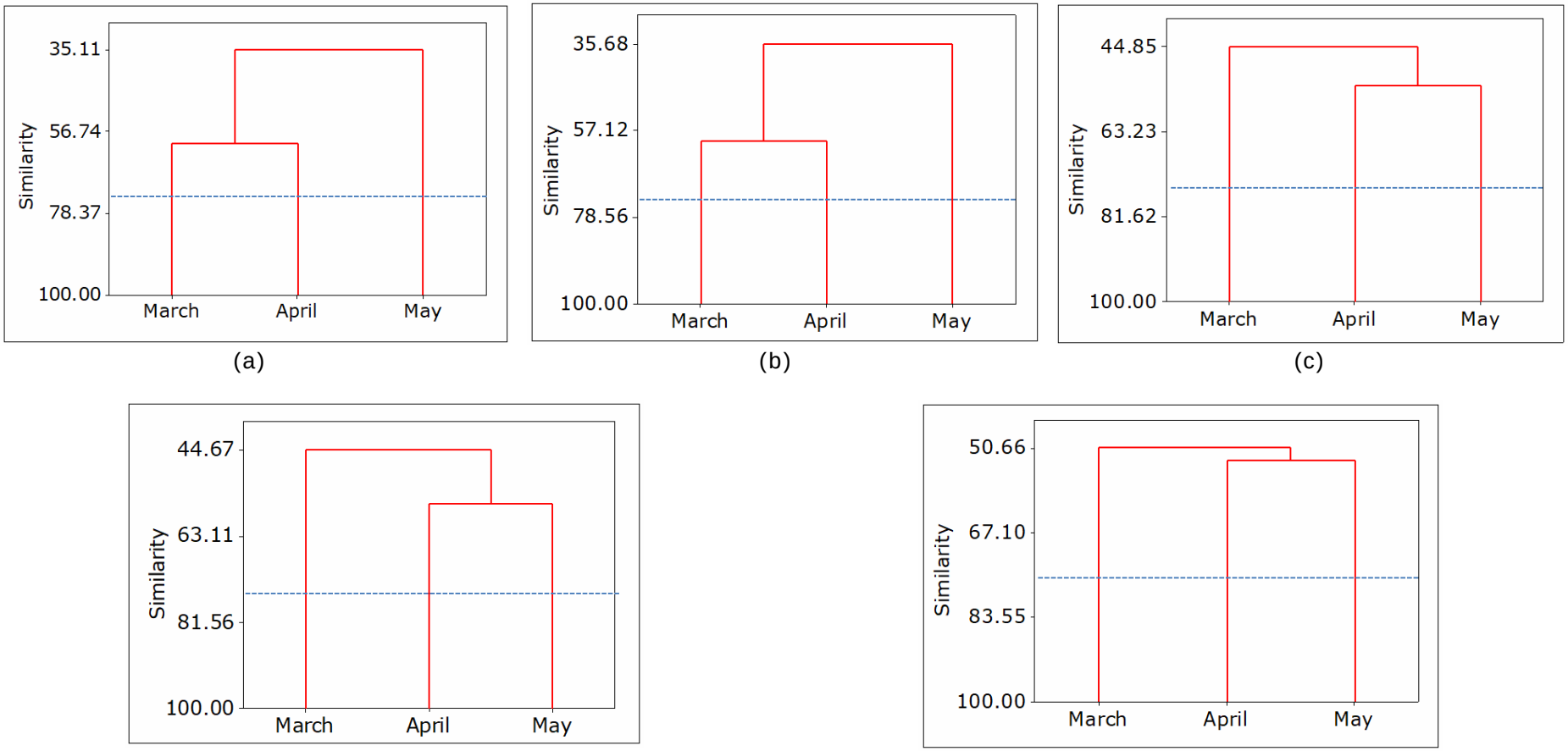

Figure 4. Dendrogram cluster based on similarity level (%) of the morphometric features: (a) TL, (b) SL, (c) HL, (d) BD, (e) BW in March, April, and May 2018 (----- = 75% similarity level).

Conclusions. All the morphometric characters, total length (1.687-2.425 cm TL), standard length (1.340-2.439 cm SL), head length (0.018-0.117 mm HL), body depth (0.017-0.202 cm BD), and body width (0.014-0.130 cm BW), of Nike larvae schools in Leato waters among three occurrence periods, were significantly different. Therefore, the geometric morphometric method is potentially expanded in the future for identifying the species and the stadia of Nike fish.

Acknowledgements. We express our gratitude to Siti Anindita Farhani for providing a morphometric larva sketch (Figure 2). We also thank Thomas Tammu, Ismet Panu, Dewi Hasiru, Nurul Hasanah for their assistance during the sampling.

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Received: 15 August 2020. Accepted: 22 November 2020. Published online: 06 January 2021.
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How to cite this article:
Pasisingi N., Katili V. R. A., Mardin H., Ibrahim P. S., 2021 Variation in morphometric characteristics of Nike fish (amphidromous goby larva) in Leato waters, Gorontalo Bay, Indonesia. AACL Bioflux 14(1):28-36.