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# Morphometric variations of halfbeak fish (*Zenarchopterus buffonis*) from estuary of West Sumatra, Indonesia

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**Abstract**. Study on morphometric variations of halfbeak fish (*Zenarchopterus buffonis* Valenciennes, 1847) from estuary of West Sumatra has been conducted from December 2013 to April 2014. The fish samples were collected from four locations i.e. Batang Tarusan (Pesisir Selatan), Batang Antokan (Agam), Batang Basampan (Padang Pariaman), and Sungai Pisang (Padang). A total of 22 characters of morphometric and 8 characters of meristic were measured and calculated in this study. The data were subjected to the Kruskal Wallis analysis and continued with Mann Whitney test, Principal Component Analysis, and Unweighted Pair Group Method Average Arithmetic. The result showed that 18 characters have high variation. Those characters were Total length (TL), Pre-dorsal Length (PDL), Pre-pelvic Length (PPvL), Length before Anal fin (LBAF), Head depth (HD), Body Depth (BD), Depth of caudal peduncle (DCP), Upper jaw length (UPL), Lower jaw length (LJL), Eye diameter (ED), Length of dorsal fin base (LDFB), Pre-anal Length (PAL), Pre-pelvic Length (PPvL), Length of pectoral fins (LPF), and Length of tail fin (LTF), the number of circular scales on the caudal peduncle (CSCP), the number of branched dorsal fin rays (D), and the number of branched pectoral fin rays (P). Therefore, it was high variation in morphology among halfbeak population in West Sumatra waters. However, there was close morphology appearance between Batang Antokan and Batang Basampan, while Batang Batusan was discrete distantly among other populations.

**Key Words**: morphology, meristic, estuary, PCA, Kruskal-Wallis.

**Introduction**. *Zernachopterus buffonis* or commonly known as halfbeak is a fish species which has characteristics back turquoise, silvery-white belly, dark blue stripe on the side of the body, lower jaw longer than the upper jaw (Kottelat et al 1993). *Z. buffonis* is ovoviviparous, and one of the anal soft rays is expanded in width as secondary sexual character of the male (Meguro 1972). It is a carnivorous estuarine fish based on preliminary investigation on the pharyngeal musculoskeletal (Stiassny & Jensen 1987; Tibbetts & Carseldine 2003). *Z. buffonis* has a potency as an ornamental fish due to its attractive colors and morphology. Several studies on the *Z. buffonis* have been reported by several researchers, for example, mating behavior of *Z. buffonis* and Z. *gilli* (Kottelat & Lim 1999), habitat preferences (Ikejima et al 2003) and genetic variation (Lewallen et al 2011). However, study on the morphological variation of *Z. buffonis* especially from western Sumatra waters was not conducted until now.

Information on morphological differences is crucial to contribute a better management plan and conservation strategies (Muchlisin et al 2014). According to Matthews (1998), the morphological variation of a fish species is influenced by at least three factors: phylogenetic heredity that may constrain morphological diversification within the group; adaptation of the body and fins to the hydrodynamic conditions in their habitat; and adaptation of head, jaw, and propulsive musculature for obtaining food. Quantitative morphology of fishes can be studied through morphometric and meristic techniques. These are two main numerical techniques used in the process of scientific description of fishes (Loy et al 2000; Barriga-Sosa et al 2004; Pinheiro et al 2005). These techniques have been often used to identify or differentiate between genera and species (Palma & Andrade 2002; Barriga-Sosa et al 2004), strains and crossbreeds and population or groups within species (Cabral et al 2003; Pinheiro et al 2005).

The morphometrics methods have been successfully discriminated numerous fish stocks throughout the world, for example Muchlisin (2013) used the morphological characters to discriminate among rasbora group in Lake Laut Tawar, Indonesia. Gunawickrama (2007) found a high morphological heterogeneity of interspecific on *Etroplus suratensis* at six locations in western part of Sri Lanka. This method has also successfully differentiated stock of the Atlantic horse mackerel - *Trachurus trachurus* (Murta et al 2008). Hence, the objective of the present study was to examine the morphological variations of *Z. buffonis* collected from different areas within West Sumatra waters.

## Materials and Method

***Sampling sites***. Fish samples were collected from December 2013 to April 2014 at four locations representing every region of the western part of West Sumatra, namely Batang Tarusan, Koto Salido, Pesisir Selatan District (01°20'09"S, 100°34'11"E), Sungai Pisang, Teluk Kabung, Padang city (01°06'38"S, 100°23'02"E), Batang Basampan, Teluk Busuk, Pariaman District (00°43'22"S, 100°12'42"E) and Batang Antokan, Tanjung Mutiara, Agam District (00°23'20"S, 99°55'24"E) (Figure 1).

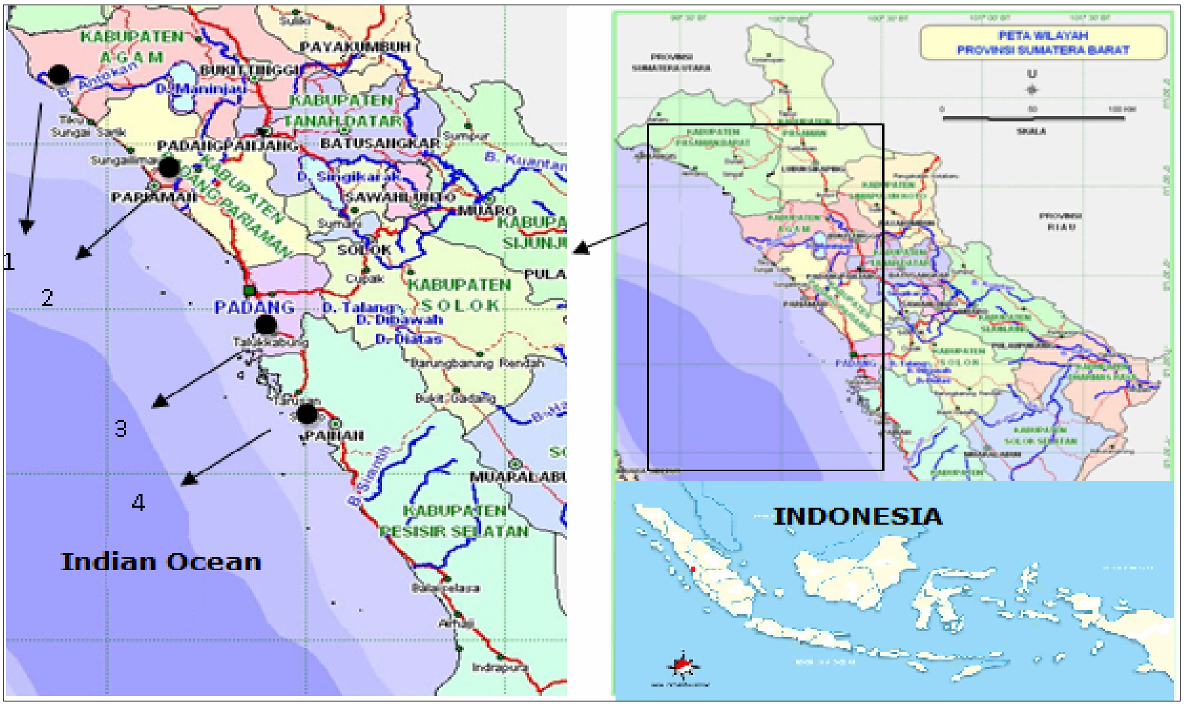

Figure 1. Map of sampling sites *Zenarchopterus buffonis* in West Sumatra (1. Batang Antokan, 2. Batang Basampan, 3. Sungai Pisang, 4. Batang Tarusan).

***Sampling procedures***. The fish samples were collected using casting nets, then labeled and photographed prior to preserve into 10% formalin solution and transported to Laboratory of Genetics and Cell Biology, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Andalas, Padang. The fish samples were identified using Nelson (1994), Saanin (1968) and Kottelat et al (1993). A total of 22 characters of morphometric (Table 1) and 8 characters of meristic (Table 2) were measured and calculated in this study. The measurements were done on leftside of fish sample (Figure 2). The water quality parameters were also recorded *in situ.*

Table 1

The morphometric characters of *Z. buffonis* measured in the study

| *Characters* | *Code* | *Characters* | *Code* |
|---|---|---|---|
| Total length | TL | Length of caudal peduncle | LCP |
| Standard length | SL | Upper jaw length | UJL |
| Head length | HL | Lower jaw length | LJL |
| Pre-dorsal length | PDL | Body width | BW |
| Pre-pelvic length | PPvL | Eye diameter | ED |
| Pre-anal length | PAL | Distance of two eyes | DTE |
| Head width | HW | Length of dorsal fin base | LDFB |
| Head depth | HD | Length of pectoral fins | LPF |
| Head length behind eye | HLBE | Length of tail fin | LTF |
| Body depth | BD | Length of pelvic fin base | LPvFB |
| Depth of caudal peduncle | DCP | Length of anal fin base | LAFB |

Table 2

Meristic characters of *Z. buffonis* measured in the study

| *Characters* | *Code* |
|---|---|
| The number of scales before dorsal fin | SBDF |
| The number of scales along the lateral line | SLL |
| The number of scales above lateral line | SALL |
| The number of circular scales on the caudal peduncle | CSCP |
| The number of branched dorsal fin rays | D |
| The number of branched pelvic fin rays | Pe |
| The number of branched pectoral finrays | P |
| The number of branched anal fin rays | A |

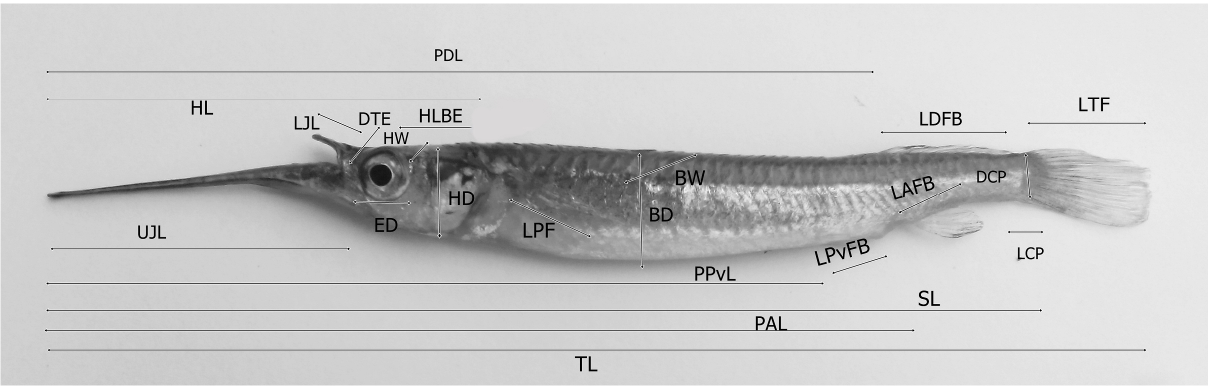


Figure 2. Measurement of character of fish morphology.

***Data analysis***. The data collected were analyzed by Kruskal Wallis test and continued with Mann Whitney U test using SPSS ver. 19. We also analyzed the data with the Principle Component Analysis (PCA) using MVSP 3.1 and Unweighted Pair Group Method with Arithmetic Mean (UPGMA) cluster analysis using NTSYSpc Ver. 2.0.2i software.

**Results and Discussion**. The study revealed that the habitat of *Z. buffonis* is freshwater to brackishwater where salinity ranged from 0 to 0.3 ppt, and water temperature ranged from 27 to 32$^{o}$C. The fish could tolerate the dissolved oxygen from 3.54 to 7.09 ppm and the substrate was mostly muddy. Water velocity recorded was different among locations (Table 3). A total of 135 *Z. buffonis* were collected during the study. The Kruskall-Wallis test on the morphometric and meristic characters showed that 18 characters were significantly different; they were 15 morphometric characters and 3 meristic characters

(Table 4). This indicated that *Z. buffonis* in West Sumatra waters has higher variation in morphology.

Morphological variations of fishes within species are probably affected by environmental condition. This result corresponds to Nuryanto (2001) that the environment condition is one of the important factors that influencing variation in the morphology of the nilem fish (*Osteochilus* sp.); these factors include river flows and the availability of food. In addition, Naesje et al (2004) and Poulet et al (2004) stated that the phenotypic variation can occur due to ecological conditions, such as geographic isolation and environmental factors. Based on the Mann Whitney test on percentage of characters variation showed that higher variation was found between Batang Basampan and Sungai Pisang populations (Table 5). This variation was probably due to the differences in water velocity, depth and turbidity among two locations. The morphological data showed that several characters of fish sample from Batang Tarusan were higher compared to other locations. The significant differences of characters among populations were found at TL, PDL, PPvL, PAL, LJL, LDFB, LPF, LTF (Table 4). This indicated that the most differences occurred in the fins organ. The fins are playing important role on fish movement; we speculate that the fishes living in the higher water velocity location modified their morphology especially in size of fins. Their fins were bigger than the fins of fish found in the lower velocity location.

This finding was supported by PCA analysis that there was a low degree of overlapping between Tarusan population and other populations, while the high degree of overlapping was recorded between Batang Antokan and Batang Basampan (Figure 3). Similar to the PCA analysis results, the UPGMA analysis showed that Batang Tarusan had the highest variation in morphology, while the lowest variation occurred between Batang Antokan and Batang Basampan (Figure 4).

Morphological variations among populations were also possibly occurred caused by limitation of movement or migration due to geographic isolation (Jerry & Cairns 1998). However, morphological variations of estuarine fishes are not only affected by geographical isolation, but differences in microhabitat condition also play an important factor for fishes in estuary region (Roby et al 1991; Suneetha & Naevdal 2001).

Overall test, the Kruskal-Wallis test, Mann Whitney U test, PCA and UPGMA analyses, showed that *Z. buffonis* from several populations within West Sumatra have morphological variations among populations. A similar result was reported in *Etroplus suratensis* from six locations in western Sri Lanka (Gunawickrama 2007), who speculated that these variations occur not because of the distance and geographical position, but rather due to habitat conditions and partial isolation.

Brown & Gibson (1983) stated that each species has a specific geographic distribution; it was controlled by the physical condition of the environment. Therefore the distribution and morphology variation that appears as a response to the physical environment variation where the species lives. Moreover, variations in morphological characters can be caused by genetic factors (Allen 1991; Nelson 1994). In addition, Allee & Schmidt (1951) and Fryer (1996) stated that geographic isolation is one of the causes of the onset of speciation. This process can be observed from the changes and differences in morphology within a population (Schluter & McPhaill 1992).

Table 3
The habitat conditions of *Z. buffonis* according to sampling location in West Sumatra, Indonesia

| *Location* | *Batang Tarusan (Koto Salido)* | *Batang Antokan (Tanjung Mutiara)* | *Pisang River (Teluk Kabung)* | *Batang Basampan (Teluk Busuk)* |
|---|---|---|---|---|
| Water temperature ($^0$C) | 27.0 | 28.5 | 29.0 | 32.0 |
| Turbidity (%) | 24.07 | 18.5 | 100 | 25.09 |
| River width (m) | 16.3 | 18.5 | 20 | 16.80 |
| Depth (m) | 6.23 | 2.7 | 0.675 | 1.75 |
| Flow velocity of water (m $s^{-1}$) | 0.169 | 0.012 | 0.130 | 0.082 |
| Substrate of river | muddy & rocky | muddy | rocky | muddy & sandy |
| pH | 7.05 | 7.35 | 7.19 | 7.00 |
| Dissolved $O_2$ (ppm) | 7.09 | 7.09 | 3.54 | 3.87 |
| Salinity (ppt) | 0.2 | 0 | 0.2 | 0.3 |

Table 4
The Kruskal Wallis test on morphometric and meristic characters of *Z. buffonis* according to sampling locations in estuary of West Sumatra. The values were mean±SD, (min – max size)

| *Character code* | *Sampling locations* | | | | *Kruskal Wallis value* |
|---|---|---|---|---|---|
| | *Batang Tarusan (N = 32)* | *Batang Antokan (N = 36)* | *Batang Basampan (N = 33)* | *Sungai Pisang (N = 34)* | |
| | | | *Morphometry* | | |
| TL | 157.59±10.92 (137–180) | 138.19±9.14 (114–153) | 144.64±8.69 (123–163) | 138.91±12.54 (115–165) | $X^2$ = 19.706 P = 0.000* |
| PDL | 54.69±6.59 (42.62–65.70) | 43.71±4.22 (30.17–50.48) | 46.64±4.12 (39.1–54.45) | 45.30±4.05 (37.58±54.55) | $X^2$ = 19.366 P = 0.000* |
| PPvL | 41.01±4.72 (30.37–48.39) | 34.79±3.46 (27.33–43.45) | 36.30±3.53 (27.43–43.83) | 36.59±3.95 (28.45–45.48) | $X^2$ = 16.204 P = 0.001* |
| PAL | 51.75±5.05 (41.76–63.84) | 43.61±4.37 (33.26–53.28) | 46.39±4.27 (35.59–55.52) | 46.29±4.92 (35.94–56.75) | $X^2$ = 16.822 P = 0.000* |
| HD | 11.92±1.47 (9.45–16.88) | 10.31±0.84 (7.93–11.88) | 10.92±1.45 (9.2–16.61) | 10.62±1.02 (8.41–12.89) | $X^2$ = 11.311 P = 0.010* |
| BD | 13.64±2.20 (9.16–20.35) | 11.53±1.43 (7.74–14.7) | 12.94±1.38 (9.34–15.31) | 12.04±1.33 (9.67–14.47) | $X^2$ = 14.986 P = 0.001* |
| DCP | 6.56±0.61 (5.35–8.12) | 5.65±0.43 (4.35–6.43) | 5.97±0.52 (5.13–7.45) | 5.93±0.49 (4.73–7.19) | $X^2$ = 15.290 P = 0.001* |
| UJL | 6.55±0.64 (5.38–8.03) | 5.52±0.50 (4.24–6.69) | 5.55±0.30 (4.86–6.01) | 5.56±0.66 (4.25–7.66) | $X^2$ = 12.903 P = 0.004* |
| LJL | 44.89±4.74 (31.97–55.26) | 39.55±3.32 (29.11–43.88) | 42.84±2.60 (35.09–46.76) | 40.87±3.69 (34.93–50.17) | $X^2$ = 9.043 P = 0.0287* |
| ED | 6.24±0.54 (5.16–7.79) | 5.71±0.42 (4.57–6.96) | 5.83±0.44 (4.72–6.82) | 5.90±0.47 (4.99–6.91) | $X^2$ = 24.699 P = 0.000* |
| LDFB | 19.13±2.11 (15.12–23.06) | 16.59±1.74 (11.64–20.96) | 18.18±2.51 (14.13–28) | 16.42±1.78 (13.16–20.75) | $X^2$ = 8.509 P = 0.036* |
| LAFB | 7.77±0.98 (5.51–10.03) | 6.46±0.71 (5.13–8.31) | 6.76±0.73 (5.24–8.02) | 7.20±1.28 (5.34–12.07) | $X^2$ = 13.039 P = 0.004* |
| LPvFB | 1.68±0.39 (1.05–2.95) | 1.58±0.20 (1.05–1.89) | 1.70±0.17 (1.27–1.95) | 1.63±0.24 (1.14–2.32) | $X^2$ = 14.032 P = 0.002* |
| LPF | 17.66±2.57 (11.56–24.34) | 15.43±2.12 (10.63–20.84) | 16.24±2.07 (12.37–20) | 16.21±2.18 (10.2–22.33) | $X^2$ = 10.616 P = 0.013* |
| LTF | 18.77±2.56 (13.32–25.64) | 16.57±1.75 (11.35–19.59) | 17.07±1.99 (11.88–20.93) | 17.16±2.69 (9–23.21) | $X^2$ = 8.359 P = 0.039* |
| | | | *Meristic* | | |
| CSCP | 5.18±0.39 (5-6) | 5±0 (5–5) | 5±0 (5–5) | 4.76±0.49 (4–6) | $X^2$ = 25.071 P = 0.000* |
| D | 6.65±0.65 (5–8) | 7±0 (7–7) | 6.72±0.45 (6–7) | 6.82±0.52 (6–8) | $X^2$ = 10.059 P = 0.010* |
| P | 7.68±0.53 (6–8) | 8±0 (8–8) | 7.93±0.24 (7–8) | 7.67±0.53 (7–9) | $X^2$ = 17.865 P = 0.000* |

Note: significant p ≤ 0.05; N - number of samples; * - significant test results.

Table 5

Percentage variation of character between locations Z. *buffonis* in estuary of West Sumatra based on The Mann Whitney U test. The values in parentheses are the number of different characters (BT - Batang Tarusan, BA - Batang Antokan, BB - Batang Basampan, SP - Sungai Pisang)

| *Character* | *BT vs BA* | *BT vs BB* | *BT vs SP* | *BA vs BB* | *BA vs SP* | *BB vs SP* |
|---|---|---|---|---|---|---|
| | | | *Morphometry* | | | |
| TL | U = 307 | U = 304 | U = 307 | U = 548 | U = 529.5 | U = 428.5 |
| | P=0.000* | P=0.003* | P=0.000* | P=0.580 | P=0.332 | P=0.096 |
| SL | U = 75.5 | U = 170.5 | U = 75.5 | U = 321.5 | U = 609 | U = 332.5 |
| | P=7.470 | P=2.676 | P=7.470 | P=0.001* | P=0.971 | P=0.004* |
| HL | U = 539 | U = 343 | U = 539 | U = 429 | U = 553,5 | U = 453 |
| | P=0.065 | P=0.015* | P=0.649 | P=0.047* | P=0.491 | P=0.175 |
| PDL | U = 275 | U = 284 | U = 275 | U = 517 | U = 400 | U = 435 |
| | P=0.000* | P=0.001* | P=0.000* | P=0.354 | P=0.012* | P=0.114 |
| PPvL | U = 401 | U = 361 | U = 401 | U = 560 | U = 336 | U = 292 |
| | P=0.031* | P=0.028* | P=0.031 | P=0.682 | P=0.001* | P=0.000* |
| PAL | U = 400 | U = 404 | U = 400 | U = 525 | U = 301 | U=321 |
| | P=0.030* | P=0.103 | P=0.030* | P=0.407 | P=0.000* | P=0.002* |
| HW | U = 475 | U = 499 | U = 475 | U = 533 | U = 413 | U = 355 |
| | P=0.214 | P=0.703 | P=0.214 | P=0.463 | P=0.019* | P=0.009* |
| HD | U = 266 | U = 492 | U = 266 | U = 169 | U = 539 | U = 131 |
| | P=0.000* | P=0.636 | P=0.000* | P=3.302 | P=0.390 | P=6.939 |
| HLBE | U = 502 | U = 403 | U = 502 | U = 395 | U = 497 | U = 493 |
| | P=0.363 | P=0.100 | P=0.363 | P=0.016* | P=0.176 | P=0.393 |
| BD | U = 478 | U = 350 | U = 478 | U = 311 | U = 386 | U = 428 |
| | P=0.228 | P=0.019* | P=0.228 | P=0.000* | P=0.007* | P=0.095 |
| DCP | U = 552 | U = 504,5 | U = 552 | U = 558,5 | U = 326 | U = 329 |
| | P=0.768 | P=0.757 | P=0.768 | P=0.669 | P=0.000* | P=0.003* |
| LCP | U = 495 | U = 408 | U = 495 | U = 589.5 | U = 595 | U = 522.5 |
| | P=0.319 | P=0.115 | P=0.319 | P=0.956 | P=0.841 | P=0.629 |
| UJL | U = 478 | U = 272 | U = 478 | U = 398 | U = 575 | U = 353 |
| | P=0.228 | P=0.000* | P=0.228 | P=0.018* | P=0.663 | P=0.009* |
| LJL | U = 509.5 | U = 319 | U = 509.5 | U = 440 | U = 499.5 | U = 510 |
| | P=0.413 | P=0.006* | P=0.413 | P=0.064 | P=0.186 | P=0.522 |
| BW | U = 386 | U = 421 | U = 386 | U = 271 | U = 571.5 | U = 196 |
| | P=0.019* | P=0.160 | P=0.019* | P=0.000* | P=0.634 | P=4.704 |
| ED | U = 316 | U = 419 | U = 316 | U = 400.5 | U = 449 | U = 282.5 |
| | P=0.001* | P=0.152 | P=0.001* | P=0.020* | P=0.055 | P=0.000* |
| DTE | U = 84 | U = 216 | U = 84 | U = 321 | U = 449 | U = 229 |
| | P=1.492 | P=0.000* | P=1.492 | P=0.001* | P=0.055 | P=0.000* |
| LDFB | U = 565 | U = 394 | U = 565 | U = 471 | U = 498 | U = 338 |
| | P=0.892 | P=0.078 | P=0.892 | P=0.139 | P=0.180 | P=0.005* |
| LPF | U = 446 | U = 422 | U = 446 | U = 570.5 | U = 348 | U = 319.5 |
| | P=0.110 | P=0.164 | P=0.110 | P=0.777 | P=0.001* | P=0.002* |
| LTF | U = 355 | U = 292 | U = 355 | U = 532 | U = 553 | U = 547 |
| | P=0.006* | P=0.001* | P=0.006* | P=0.456 | P=0.488 | P=0.860 |
| LPvFB | U = 506 | U = 493 | U = 506 | U = 591 | U = 386 | U = 380 |
| | P=0.389 | P=0.646 | P=0.389 | P=0.971 | P=0.007* | P=0.023* |
| LAFB | U = 432 | U = 495 | U = 432 | U = 534 | U = 475 | U = 397 |
| | P=0.076 | P=0.665 | P=0.076 | P=0.471 | P=0.107 | P=0.039* |
| | | | *Meristic* | | | |
| SBDF | U = 526.5 | U = 484 | U = 526.5 | U = 484 | U = 29.5 | U = 38.5 |
| | P=0.445 | P=0.494 | P=0.445 | P=0.083 | P=2.830 | P= 5.539 |
| SLL | U = 517.5 | U = 462 | U = 517.5 | U = 577.5 | U = 74.5 | U = 66 |
| | P=0.172 | P=0.084 | P=0.172 | P=0.338 | P=4.528 | P=1.115 |
| SALL | U = 576 | U = 528 | U=576 | U = 594 | U = 576 | U = 528 |
| | P=1 | P= 1 | P=1 | P=1 | P=0.142 | P=0.160 |
| CSCP | U = 468 | U = 429 | U = 468 | U = 594 | U = 468 | U = 429 |
| | P=0.006* | P=0.009* | P=0.006* | P=1 | P=0.005* | P=0.007* |
| D | U = 414 | U = 510 | U = 414 | U = 432 | U = 504 | U = 516 |
| | P=0.001* | P=0.769 | P=0.001* | P=0.000* | P=0.036* | P=0.472 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pe | U = 513 P=0.359 | U = 244,5 P=7.708 | U = 513 P=0.359 | U = 216 P=1.445 | U = 519 P=0.208 | U = 295.5 P=0.000* |
| P | U = 414 P=0.000* | U = 410.5 P=0.017* | U = 414 P=0.000* | U = 558 P=0.136 | U = 414 P=0.000* | U = 412.5 P=0.010* |
| A | U = 418.5 P=0.031* | U = 210 P=5.712 | U = 418.5 P=0.031* | U = 184.5 P=2.519 | U = 366 P=0.002* | U = 482 P=0.255 |
| Percentage variation of character | 40% (12 character different) | 36.7% (11 character different) | 36.7% (11 character different) | 30.0% (9 character different) | 40.0% (12 character different) | 50.0% (15 character different) |

Note: significant p ≤ 0.05; * - significant test results.

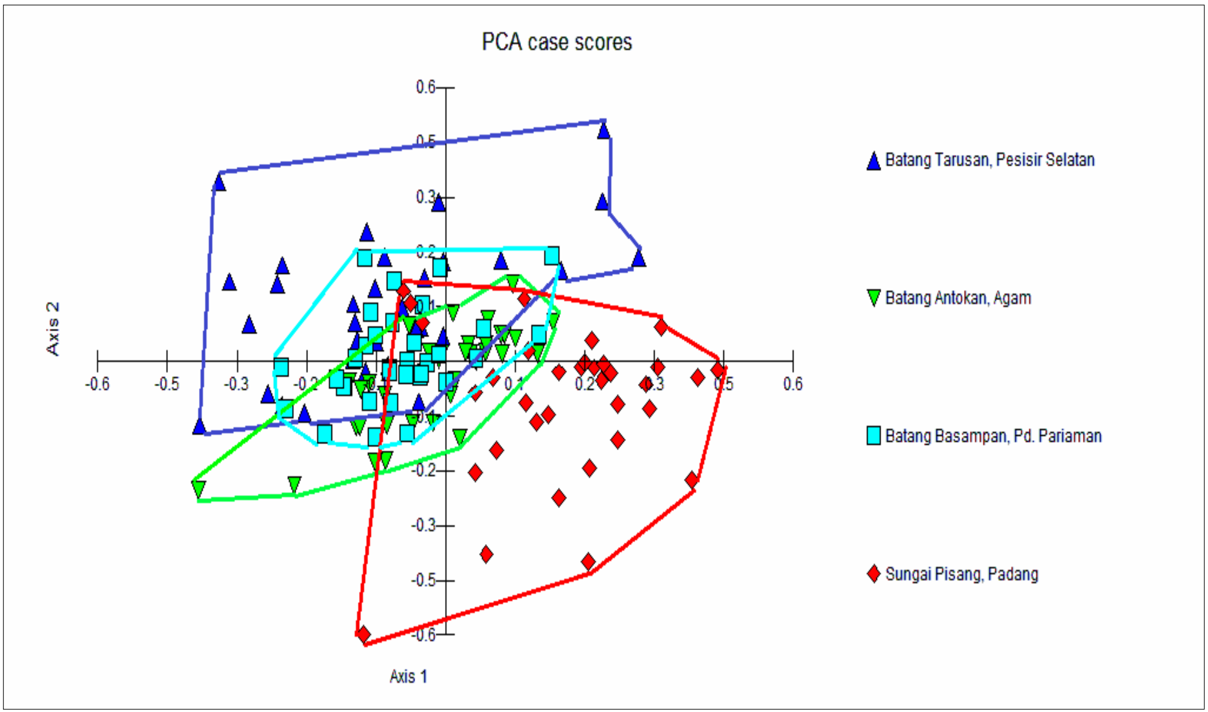


Figure 3. Plot of Principal Component Analysis (PCA) of *Z. buffonis* from several locations of West Sumatra based on morphological data.

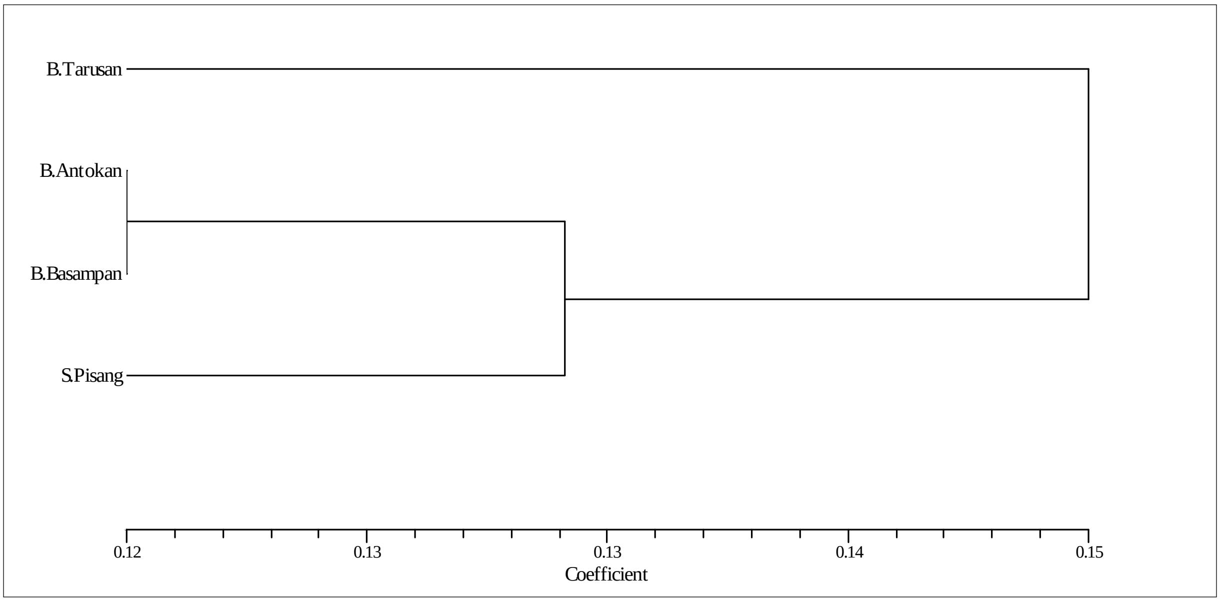


Figure 4. *Z. buffonis* dendogram from several locations in West Sumatra.

**Conclusions**. It was concluded that the existence of morphological variation among populations of Z. *buffonis* of estuary of West Sumatra occurred. They were Total length (TL), Pre-dorsal Length (PDL), Pre-pelvic Length (PPvL), Length before Anal fin (LBAF), Head depth (HD), Body Depth (BD), Depth of caudal peduncle (DCP), Upper jaw length (UPL), Lower jaw length (LJL), Eye diameter (ED), Length of dorsal fin base (LDFB), Pre-anal Length (PAL), Pre-pelvic Length (PPvL), Length of pectoral fins (LPF), and Length of tail fin (LTF), The number of circular scales on the caudal peduncle (CSCP), The number of branched dorsal fin rays (D), and The number of branched pectoral fin rays (P). We found a close morphology appearance between Batang Antokan and Batang Basampan, while Batang Batusan was discrete distantly among other populations.

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