Morphological variation of *Ahaetulla prasina* (Boie, 1827) (Squamata: Colubridae) in Indonesia, with an expanded description of the species

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Abstract. Since Leviton (1967) argued that genus *Ahaetulla* needed to extensively review, we started to examine the most common *Ahaetulla* species in Indonesia, *A. prasina*. This study aims to explain the morphological variation and analyses pattern of *A. prasina* population from Sumatra, Java, Kalimantan and Sulawesi mainland. This study was carried out by manually counting and measuring the characteristics of 64 *A. prasina* specimens belongs to Museum Zoologicum Bogoriense (MZB) collections on 2016. All morphological characters have analysed using PCA, homogeneity test and one way anova test. The results shown there have variation in meristic characters as the adaptation pattern due to environmental condition and sexual dimorphism. In contrast, the morphometric characters shown that there no significant and slightly variation within population in these mainlands. Kalimantan population has larger head size than others and assumed as an adaptation towards its prey. This evidence proved that *A. prasina* is a snake species which successfully adapt in various environment types.

Keywords: Adaptation, *Ahaetulla prasina*, characters, morphological variation

1. Introduction

The “*ahaetulla*” name firstly used on “*Coluber ahaetulla*” which described by Linnaeus, 1758 [1] from five collected specimen materials and represented colubrid species from “Asia America”. Lönnberg [2] and Andersson [3] have explained that four materials from South America interpreted as *Thalerophis richardi* (now *Leptophis ahaetulla*) and one material from Asia interpreted as *Ahaetulla ahaetulla* (synonym of *Dendrelaphis pictus*). *C. ahaetulla* was mentioned several times before 10th Ed. of the *Systema Naturae* and on the 10th edition of the *Systema Naturae*, Linnaeus only gave a single count of the one of his *T. richardi* specimen. This develop to us to establish the definite designation of a type specimen of *C. ahaetulla* (synonym of *L. ahaetulla*) to the South American species [4, 5].

Thus, Genus *Ahaetulla* firstly described by H.F. Link [6] with two species members, *A. fasciata* (now *Dendrelaphis pictus*) and *A. mycterizans* which considered as the genus type designated by Meise & Hennig [7]. Currently, generic name of *Ahaetulla* refers to Asian colubrid snakes which consist of eight species members, namely *A. dispar* ( Günther, 1864), *A. fasciolata* (Fischer, 1885), *A. fronticincta*
(Günther, 1858), *A. mycterizans* (Linnaeus, 1758), *A. nasuta* (Bonnaterre, 1790), *A. perroteti* (Duméril & Bibron, 1854), *A. prasina* (Boie, 1827) dan *A. pulverulenta* (Duméril & Bibron, 1854) [4, 8].

Leviton [9] explained the genus *Ahaetulla* needed to extensively review and examination. The high variability of several principal taxonomic characters, notably anal plate, forth upper labial and ventral shields count makes the recognition of the species difficult. The study of morphological variation of *Ahaetulla* species member is still inadequate, especially in Indonesia. We started to examine the most common *Ahaetulla* species in Indonesia, *A. prasina*. Therefore, this study aims to explain the morphological variation and analyses pattern of *A. prasina* population from Sumatra, Java, Kalimantan and Sulawesi mainland.

2. Materials and method

2.1. Study site and materials

This study was conducted at Museum Zoologicum Bogoriense (MZB) Biological Research Center LIPI, Cibinong on January–June 2016. We studied 64 (♂ = 15, ♀ = 49) *A. prasina* specimens MZB collections (see in appendix A) and collected from Sumatra (15; ♂ = 2, ♀ = 13), Java (18; ♂ = 3, ♀ = 15), Kalimantan (13; ♂ = 1, ♀ = 12) and Sulawesi (18; ♂ = 9, ♀ = 9) mainland. The distribution of the specimens has shown in figure 1.

2.2. Character measurements

Following van Rooijen and Vogel [10], we recorded several characters (see in table 1) pertaining to body ratio, shape and color description and scalation. We modified the measurements by adding some characters to count.

We used Vernier Calliper; Fujifilm Finepix HS25 EXR Digital Camera; AmScope Stereo Microscope, Straight Pin and ImageJ v. 1.50g software to measured and counted all the characters. Vent was determined following Dowling [11] method and Subc was counted on one side, the terminal scute was exclude. Descriptive and meristic results will be presented on species description and comparison on population in each mainland. Morphometric measurement was analyzed using Principal Component Analysis (PCA), Homogeneity Test and One-Way Anova methods in SPSS v.16 software.

Figure 1. The distribution map of *A. prasina* used specimens.
Table 1. List of characters used in this study and their abbreviations.

| Abbreviation | Description                                      | van Rooijen & Vogel [10] | This study (2016) |
|--------------|--------------------------------------------------|--------------------------|------------------|
| Ros          | number and description of rostral                | -                        | √                |
| PreF         | number, description and length of prefrontal     | -                        | √                |
| Int          | number, description and length of internasal     | -                        | √                |
| Fron         | number, description and length of frontal        | -                        | √                |
| Par          | number, description and length of parietal       | -                        | √                |
| Nas          | number of nasal                                  | -                        | √                |
| PreOc        | number of pre-ocular                             | -                        | √                |
| PostOc       | number of post ocular                            | √                        | √                |
| SupraOc      | number of supra ocular                           | -                        | √                |
| Lor          | number of loreal                                 | √                        | √                |
| SL           | number of supra labial                           | √                        | √                |
| IL           | number of infra labial                           | √                        | √                |
| Temp         | number of temporal                               | √                        | √                |
| Eye          | description of eye color and shape               | -                        | √                |
| Dor          | number of dorsal row                             | √                        | √                |
| Vent         | number of ventral shield                         | √                        | √                |
| Subc         | number of sub caudal                             | √                        | √                |
| Sex          | sex                                              | √                        | √                |
| ParEd        | number of the scales bordering the posterior edge of the parietals | √                        | -                |
| Men          | number and description of mental                 | -                        | √                |
| Chin         | number and description of chinshield             | -                        | √                |
| Gul          | number and description of gular                  | -                        | √                |
| Dorso        | description of dorsolateral                      | -                        | √                |
| ScaT         | description of scales type                       | -                        | √                |
| ES           | eye – snout length                               | √                        | √                |
| NS           | nostril – snout length                           | -                        | √                |
| HL           | head length                                      | √                        | √                |
| HW           | head width                                       | -                        | -                |
| IO           | length between the eyes (inter orbital)          | -                        | √                |
| SVL          | snout – the end of ventral length                | √                        | √                |
| TL           | tail length                                      | √                        | √                |
| ToL          | snout – the tip of tail length                   | -                        | √                |
| ED           | eye diameter                                     | √                        | √                |
| SW           | snout width                                      | √                        | -                |

3. Results and discussion

3.1. Character description of A. prasina
Elongated head with narrow snout; rostral 1, horseshoe shaped; 2 triangular internasal; 2 elongated rectangular prefrontal; frontal 1, wide anterior and narrowed posterior; 2 elongated triangular parietal; nasal 1; loreal 1-4; preocular 1, wide and partially folded up; 1 triangular supraocular; yellowish and
oval eyes with horizontal pupil; postocular 2, superior > inferior; temporal 1+2, 2+2, 2+3, rarely 3+3; supralabial 8-10, 1st touched nasal, 2nd-3rd touched loreal and preocular; 4th-6th touched eyes and 7th is the largest supralabial; infralabial 8-11, 1st scale touched each other, 1st-4th or 1st-5th touched anterior chinshield; mental 1, triangular, untouched anterior chinshield; anterior chinshield 2; posterior chinshield 2; gular scales 2-4. Midbody dorsal scale rows 15-15-13, rarely 15-15-11; ventral (\(\delta\)) = 198-223, (\(\Omega\)) = 197-227; anal divided, rarely undivided; subcaudal (\(\delta'\)) = 161-192, (\(\Omega\)) = 156-190; dorsolateral shown along each side of body; smooth scales; coloration green and has variation brownish, yellow and blueish green; when in defensive position shown black and white pattern. Max. SVL 1293 mm; in average \(\delta = 796.14 \pm 76.74;\) \(\Omega = 842.90 \pm 205.42.\)

3.2. **Meristic analysis**

Some meristic characters have shown intraspecies variation from number and scale pattern between examined individuals (table 2). These characters have wide range variation between individuals, loreal 1 – 4 (\(\delta = 2.5 \pm 0.7;\) \(\Omega = 2.6 \pm 0.6), supralabial 8 – 10 (\(\delta = 8.9 \pm 0.3;\) \(\Omega = 9.0 \pm 0.3), infralabial 8 – 11 (\(\delta = 8.7 \pm 0.6;\) \(\Omega = 8.8 \pm 0.8), gular 2 – 4 (\(\delta = 2.5 \pm 0.5;\) \(\Omega = 2.8 \pm 0.5), temporal pattern 1+2, 2+2, 2+3, rarely 3+3, dorsal rows 15-15-13, rarely 15-15-11. These meristic variations strongly correlated with individual adaptation towards on their environment. Individuals with many number of scales commonly live in humid environment and vice versa. The adaptation has conducted as a strategy to avoid dehydration from the body [12].

The differences between ventral and subcaudal count on male and female individuals have known as sexual dimorphism. On male individuals, ventral 198 – 223 (211.2 ± 7.2; n = 15) and subcaudal 161 – 192 (181.6 ± 9.1; n = 14) scales have counted. On female individuals, ventral 197 – 227 (213.1 ± 6.9; n = 49) and subcaudal 156 – 190 (171.8 ± 8.5; n = 45) scales have counted. The ventral and subcaudal scales count have strong correlation with the number of ribs and vertebra and will be affected to body size. This phenomenon termed as pleomerism [13]. From the results (see in the average) revealed, female individuals have larger ventral scales than male individuals, otherwise the subcaudals fewer than males. The results proved female individual has larger body than males, but male individual has longer tail than females. Female individual need larger body to produce and keep the eggs in the ovarium and male individual need longer tail to keep the hemipenis [13-16].

3.3. **Morphometric analysis**

In contrast with meristic results, morphometric results have shown through PCA analysis (figure 3) that have no significant morphological variation within \(A. prasina\) populations in Sumatra, Java, Kalimantan and Sulawesi. This results also supported by homogeneity test (table 3) that concluded have no significant morphometric variances within population in these four islands (sig. > 0.05).

![Figure 2. Ahaetulla prasina (Boie, 1827)](image-url)
Table 2. Meristic characters count on 64 specimens of *A. prasina*.

| Characters          | Java    | Kalimantan | Sumatra | Sulawesi |
|---------------------|---------|------------|---------|----------|
| Individuals (n)     | n = 3   | n = 15     | n = 12  | n = 2    |
| Rostral             | 1       | 1          | 1       | 1        |
| Internasal          | 2       | 2          | 2       | 2        |
| Prefrontal          | 2       | 2          | 2       | 2        |
| Frontal             | 1       | 1          | 1       | 1        |
| Supraocular         | 1       | 1          | 1       | 1        |
| Nasal               | 1       | 1          | 1       | 1        |
| Loreal              | 1-3     | 1-3        | 3       | 1-3      |
| Preocular           | 1       | 1          | 1       | 1        |
| Postocular          | 2       | 2          | 2       | 2        |
| Supralabial         | 9       | 8-9        | 9       | 9-10     |
| Infralabial         | 8-9     | 8-10       | R(9); L(8) | 8-10     |
| Temporal            | 1+2; 2+2 | 1+2; 2+2; 2+3 | 1+2; 2+2; 2+3 | 1+2; 2+2; 2+3 |
| Mental              | 1       | 1          | 1       | 1        |
| Chinshield          | 2 anterior; 2 posterior | 2 anterior; 2 posterior | 2 anterior; 2 posterior | 2 anterior; 2 posterior |
| Gular               | 2-3     | 2-4        | 2       | 2-3      |
| Midbody Scales      | 15-15-13; 15-15-11 | 15-15-13 | 15-15-13 | 15-15-13; 15-15-11 |
| Ventral             | 209     | 200-217    | 199     | 210-227  |
| Subcaudal           | 181-191 | 156-176    | 161     | 165-186  |

Visualization from three-dimensional scatter plot of PCA indicate that the population from Sumatra, Java, Kalimantan and Sulawesi are still overlapping to each other. However, in PC 1 VS PC 3 and PC 2 VS PC 3 scatter plot visualization shown Kalimantan populations slightly clumped than others. The difference among Kalimantan population than others have shown in IO, ED, NS, ES and PreF characters. In Kalimantan population, IO, ED, NS and ES bigger than other populations, otherwise PreF smaller than other populations. Nonetheless, One-Way Anova results (table 4) indicates there have significant average differences within populations in IO, ES, NS, ED, SVL, TL, ToL, Int and PreF characters (Sig. < 0.05). This results also explained that *A. prasina* populations in Sumatra, Java, Kalimantan and Sulawesi have small differences in certain characters even though not span too far.
Figure 3. Visualization of Principal Component Analysis (PCA) results; (a) 3D scatter plot, (b) PC 1 VS PC 2, (c) PC 1 VS PC 3, (d) PC 2 VS PC 3.

Table 3. Test of homogeneity of variances.

| Characters         | Levene Statistic | df1 | df2 | Sig. |
|--------------------|------------------|-----|-----|------|
| Head Length        | 2.483            | 3   | 59  | 0.07 |
| Inter Orbital      | 1.065            | 3   | 59  | 0.37 |
| Eye – Snout        | 1.111            | 3   | 59  | 0.35 |
| Nostril – Snout    | 1.542            | 3   | 59  | 0.21 |
| Eye Diameter       | 0.633            | 3   | 59  | 0.60 |
| Snout Vent Length  | 0.876            | 3   | 59  | 0.46 |
| Tail Length        | 0.984            | 3   | 59  | 0.41 |
| Total Length       | 0.680            | 3   | 59  | 0.57 |
| Internasal         | 0.184            | 3   | 59  | 0.91 |
| Prefrontal         | 1.135            | 3   | 59  | 0.34 |
| Frontal            | 0.709            | 3   | 59  | 0.55 |
| Supra Ocular       | 1.287            | 3   | 59  | 0.29 |
| Parietal           | 0.555            | 3   | 59  | 0.65 |
### Table 4. One-Way Anova on morphometric characters within population in Sumatra, Java, Kalimantan and Sulawesi.

| Characters       | Sum of Squares | df | Mean Square | F       | Sig.     |
|------------------|----------------|----|-------------|---------|----------|
| Head Length      |                |     |             |         |          |
| Between Groups   | 0.864          | 3  | 0.288       | 2.369   | 0.080    |
| Within Groups    | 7.170          | 59 | 0.122       | 10.020  | 0.000    |
| Total            | 8.034          | 62 |             |         |          |
| Inter Orbital    |                |     |             |         |          |
| Between Groups   | 220.870        | 3  | 73.623      |         |          |
| Within Groups    | 433.500        | 59 | 7.347       |         |          |
| Total            | 654.370        | 62 |             |         |          |
| Eye - Snout      |                |     |             |         |          |
| Between Groups   | 78.446         | 3  | 26.149      |         |          |
| Within Groups    | 96.467         | 59 | 1.635       |         |          |
| Total            | 174.913        | 62 |             |         |          |
| Nostril - Snout  |                |     |             |         |          |
| Between Groups   | 45.886         | 3  | 15.295      |         |          |
| Within Groups    | 29.787         | 59 | 0.505       | 30.296  | 0.000    |
| Total            | 75.673         | 62 |             |         |          |
| Eye Diameter     |                |     |             |         |          |
| Within Groups    | 113.757        | 59 | 1.928       | 17.123  | 0.000    |
| Total            | 212.799        | 62 |             |         |          |
| Snout Vent Length|                |     |             |         |          |
| Between Groups   | 76.278         | 3  | 25.426      |         |          |
| Within Groups    | 140.857        | 59 | 2.387       | 10.650  | 0.000    |
| Total            | 217.134        | 62 |             |         |          |
| Tail Length      |                |     |             |         |          |
| Between Groups   | 77.598         | 3  | 25.866      |         |          |
| Within Groups    | 142.103        | 59 | 2.409       | 10.739  | 0.000    |
| Total            | 219.701        | 62 |             |         |          |
| Total Length     |                |     |             |         |          |
| Between Groups   | 382.270        | 3  | 127.423     |         |          |
| Within Groups    | 1924.983       | 59 | 32.627      | 3.905   | 0.013    |
| Total            | 2307.253       | 62 |             |         |          |
| Internasal       |                |     |             |         |          |
| Between Groups   | 491.716        | 3  | 163.905     |         |          |
| Within Groups    | 1380.743       | 59 | 23.402      | 7.004   | 0.000    |
| Total            | 1872.458       | 62 |             |         |          |
| Prefrontal       |                |     |             |         |          |
| Between Groups   | 123.274        | 3  | 41.091      |         |          |
| Within Groups    | 4241.570       | 59 | 71.891      | 0.572   | 0.636    |
| Total            | 4364.844       | 62 |             |         |          |
| Frontal          |                |     |             |         |          |
| Between Groups   | 61.985         | 3  | 20.662      |         |          |
| Within Groups    | 2675.457       | 59 | 45.347      | 0.456   | 0.714    |
| Total            | 2737.442       | 62 |             |         |          |
| Supra Ocular     |                |     |             |         |          |
| Between Groups   | 91.945         | 3  | 30.648      |         |          |
| Within Groups    | 4077.941       | 59 | 69.118      | 0.443   | 0.723    |
| Total            | 4169.885       | 62 |             |         |          |
3.4. Discussion
According to Hora [17], Ahaetulla species have been spreading from the central origin (Indochina and Malaya region) to Sundaland and Wallacea in a relatively short period, approximately 50 kya on Pleistocene age. During Pleistocene age, many faunas from Asia continent could migrate to South East Asia (SEA) caused by orogenetic movements affecting many parts of SEA and lowering of the sea level. As a result, many regions of SEA emerged to become dry land and acting as the land bridges [18]. Glacial Maxima cycles also playing an important role to lowering of the sea level and the last happened approximately 18 kya [19, 20]. Faunal migration from Sundaland to Wallacea occurred through land bridge between Sundaland and Sulawesi in the southern of Makassar Strait. Kalimantan and Sulawesi already separated by over 2000 m depth Makassar Strait since 25 mya [21, 22]. The slight morphological variation within population in Sumatra, Java, Kalimantan and Sulawesi may be caused by short distribution period and similar environment condition among the central origin region to Sundaland and Wallacea region [23]. A. prasina has large range of environment tolerances, consequently it needed less effort adaptation to survive in new habitat. Therefore, A. prasina able to maintain the gene flow and reduce speciation process because reproductive isolation and natural selection have not occurred [24] [25]. The differences of head characters within Kalimantan population than others probably caused by prey size. We supposed prey size in Kalimantan bigger than others, consequently A. prasina need to adapt the condition by enlarged the head size to swallow the prey [26]. The evidences proved that there are slightly morphological variation of A. prasina populations within in Sumatra, Java, Kalimantan and Sulawesi. The variations can be analyzed through meristic characters such as the pattern and number of scales and morphometric characters such as head and body ratio sizes. All the variations probably caused by the adaptation process to the environment and its prey.

4. Conclusion
Morphological variation of A. prasina towards to meristic characters are loreal, supralabial, infralabial, gular, temporal and reduction pattern of midbody scales. The variation of ventral and subcaudal scales have been influenced by sexual dimorphism. The clustering patterns towards to morphometric characters from four populations in Sumatera, Java, Kalimantan and Sulawesi have showed no significant and overlapping clusters. However, Kalimantan population has slightly grouped by larger head size than the populations in other islands.

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Appendix A.

_Ahaetulla prasina_ specimens examined

**(Java):** MZB 516; MZB 1011; MZB 1347; MZB 1461; MZB 2794; MZB 2871; MZB 3092; MZB 3796; MZB 3901; MZB 3902; MZB 3903; MZB 3904; MZB 3906; MZB 4113; MZB 5177; MZB 5274; MZB 5415; MZB 5822; 

**(Kalimantan):** MZB 518; MZB 1335; MZB 1344; MZB 1592; MZB 1858; MZB 2012; MZB 2437; MZB 2592; MZB 2881; MZB 3028; MZB 3257; MZB 5810; MZB 5917; 

**(Sumatra):** MZB 510; MZB 1635; MZB 2117; MZB 2906; MZB 3585; MZB 3619; MZB 3705; MZB 5203; MZB 5204; MZB 5338; MZB 5339; MZB 5341; MZB 5835; MZB 5836; 

**(Sulawesi):** MZB 2013; MZB 2638; MZB 3049; MZB 3391; MZB 3392; MZB 3395; MZB 3396; MZB 3398; MZB 3428; MZB 3657; MZB 3660; MZB 3663; MZB 3664; MZB 3665; MZB 4032; MZB 4553; MZB 5168; MZB 5193.