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MORPHOLOGICAL VARIATIONS OF THE GENUS *Huia* Yang, 1991 IN REGION OF JAVA, KALIMANTAN AND SUMATRA

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Abstract. *Huia is a frog belonging to the family Ranidae which has a wide distribution in the world, including in Indonesia. Huia in Indonesia consists of 4 species spread from Sumatra, Java and Kalimantan, namely Huia masonii, Huia cavitympanum, Huia modligianii, and Huia sumatrana. Huia was originally incorporated into the genus Amolops and divided into 3 different sub-genus. The method used was quantitative descriptive as the data obtained in the form of descriptions of the morphometric and meristic characters PAST 3 analyzed software of wet specimens from the Museum Zoologicum Bogoriense. The aims were to determine the morphological variations in Huia characters due to the interesting distribution patterns of species, that were scattered on each island. The results obtained show that there were morphological variations but have not shown significant grouping with the dominant character of each population of the entire genus Huia in Indonesia.*

Keywords: *Huia cavitympanum, Huia masonii, Huia modligianii, Huia sumatrana, morphology, PCA.*

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INTRODUCTION

Indonesia has a high diversity of Amphibians from the Anura Order. There are many species of Anura in the world, 11% of which are in Indonesia. The Anura Order consists of frogs and toads (Kusrini & Ross, 2006). Anura can be recognized easily by the squatting body shape which has four legs (Mistar, 2008). The hind limbs are usually long for jumping, such as toads, the hind limbs are usually relatively short and slender, serving for hopping around for food. The eyes are unusually large, with either horizontal or vertical pupils (Iskandar, 1998). Ecologically Anura is one of the components of the ecosystem which have a very important role. Anura acts as primary consumer predators such as insects or other invertebrates Anura has special characteristics depending on the type and group (Oliver et al., 2015).

Huia was incorporated into the genus *Amolops*. Then an update was carried out by dividing into 3 different sub-genus *Amolops* Cope in mainland Southeast Asia, which are *Amolops*, *Huia*, and *Meristogenys*

(Yang, 1991). The species is found in Java, Sumatra, Kalimantan, Thailand, South China, and *Meristogenys jerboa* endemic Kalimantan (Iskandar, 1998). The cascade frogs of the *Amolops* inhabit rocky, fast-running streams in the rivers. Distributing from South Asia to China and Southeast Asia (Jiang et al., 2016). The family of Ranidae is widespread in the Sundaland and split into several species which adapt to suitable habitats. Ranidae occupies a niche habitat (Gan et al., 2015). A genus of small to medium-sized slender frogs with very long legs and vocal pouches at the sides of the mouth (in males). These frogs have a peculiar kind of tadpole, adapted to live in torrents. They were previously considered as belonging to the genus *Amolops*. *Huia* a subgenus of *Amolops Cope*, but most authors now use *Huia* (Inger, 1999). The distinctive character of the *Amolops* group is the character of the tadpoles which has a suction mouth type (gastromyzophorus) and has lymph nodes (Arifin et al., 2018).

Huia is part of the Anura Order and Ranidae Family, which has the local name of Torrent Frog. Ranidae is a frog that has a wide distribution in the world, including in Indonesia. *Huia* in Indonesia consists of 4 species spread from Sumatra, Java and Kalimantan. (Yang, 1991) said that *Huia masonii* which is synonymous with *Huia javana* comes from Java, *Huia cavitympanum* comes from Kalimantan, while *Huia sumatrana* and *Huia modligianii* come from Sumatra. *Amolops* is a large group of Ranidae Family where distribution reaches the mountain valleys of Southeast Asia (Matsui, 2006).

The process of forming the distribution pattern of species is interesting to study, it is inseparable from geological formation and the rate of speciation which has gone through a long and complex process. Based on taxonomy, it raises a new problem related to the changes in a fairly high level of similarity in the morphology of the adult Ranidae. The initial genus of the Ranidae was named *Rana*, due to changes in morphology and geographic location which has many similarities with Ranidae. Therefore, there is a need for data references from morphological variations using morphometry for each character. Furthermore, publications on morphological variations in Indonesia are still rare. This research is expected to obtain credible morphological data, that can explain the differences in the characters.

MATERIALS AND METHODS

The research was conducted on July 2 - August 16 2018 at the Herpetology Laboratory, Museum Zoologicum Bogoriense, Puslit. LIPI Cibinong Bogor. Wet specimens, 70% alcohol, calipers, rulers, tweezers, trays, pins, cameras, and stationery were used in this study. The research used quantitative descriptive because the data obtained were in the form of descriptions of morphometric and meristic characters which were then analyzed using PAST 3 software. The data was processed into PCA (Principal Component Analysis) to obtain morphometric characters in the form of gender, foot's web and 27 morphometric character parameters of body parts (Table 1).

Table 1. Morphometric characters

Morphometric Character	Description
Snout Vent Length (SVL)	Length from tip of snout to the cloaca
Head Length (HL)	From the posterior of the jaws to the tip of the snout
Head Width (HW)	At the widest point ; the angle at the jaws
Snout Length (SL)	Distance from the tip of the snout to the anterior corner of the eye
Snout Narial Distance (SN)	The width of the nose
Eye Diameter (ED)	Horizontally from the anterior to posterior corner of the eye
Eye Narial Distance (EN)	The length of the distance between the nostrils and the outer point of the eye
Inter Narial Distance (IND)	Shortest distance between the inner margins of the nostrils
Inter Orbital Distance (IOD)	The shortest distance between the anterior corners of the orbits
Upper Eyelid Width (UEW)	The greatest width of the upper eyelid margins
Vertical Tympanum Diameter (TDV)	The vertical diameter of the tympanum
Horizontal Tympanum Diameter (TDH)	The horizontal diameter of the tympanum
Eye Tympanum Distance (ET)	The length of the distance between the tympanum and the outer point of the eye
Lower Arm Length (LAL)	Distance from the elbow to the tip of Finger IV
Hand Length (HAL)	Hand length, measured from the palm of the fingertip
Femur Length (FE)	Femur length, measured from the cloaca to the base of the femur
Tibia Length (TL)	Tibia length, measured from the cloaca to the base of the tibia
Foot Length (FL)	From the base of the inner metatarsal tubercle to the tip of Toe IV
Inner Metatarsal Tubercle (IMTL)	The greatest length of the inner metatarsal tubercle
Finger 1 Length (F1L)	First finger length
Finger 2 Length (F2L)	Second finger length
Finger 3 Disc Width (F3DW)	The disc width of the third toe
Toe 4 Disc Width (T4DW)	The greatest horizontal distance between the edges of Toe IV disk
Forelimb Length (FLL)	The length of the hand, measured from the tip of the longest finger to the base of the hand
Length Finger 3 Disk From The Base of The Pad to its Tip (FPL)	Finger length of third disks from the base of the pad to end
Length of Toe Disk 4 (TFL)	Measure at the widest point on Finger IV
Hindlimb Length (HLL)	Measured from vent to tip of Toe IV

RESULTS AND DISCUSSION

The calculated meristic characters showed inconsistency in the pattern of the web disk on the feet between *Huia* species (Table 2.).

The results of the graph (Figure 2.) show that in general, the sample analysis re-

sults overlap with other locality, although the results of each quadrant form groups with similar characters. All of these characters are equally dominant and affect the entire scatter plot around the center of the axis. However, each region is grouped in its respective regions. There are many Java regions in Java. The characters in the West Java region fill the four quadrants. The characters that lead to the West Java and Central Java regional quadrant I i.e ED, ET, SL, HL, SVL, FL, and IND as these characters are strong in these quadrants. In the East Java region, the characters that lead to quadrant II i.e FE, TDH, TL, TDV, HW, F2L, and IMTL. Quadrant III, the characters that strengthen the region i.e FLL, F1L, TFL, T4DW, SN, and LAL. It can be seen in quadrant IV, the characters that strengthen namely UEW, HAL, IOD, F3DW, and EN. Quadrants III and IV are occupied by the West Java region. This is because the regional character of West Java spreads to each of the other regions in Java Island. There may many specimens in the Zoological Bogoriense Museum from West Java, so that fewer specimens found Central Java and East Java. Comparisons between specimens from various regions in Java Island conclude that West Java regions have the reinforcing character of these specimens. *Huia masonii* is a frog endemic of Java Island. Based on the results of observations on the morphology of *Huia masonii*, it has the characteristics of a pointed snout, large disc of toes or disk, dark brown with a smooth skin texture, the length of the first finger is the same as the length of the second finger which has black spots on the back, has obvious dorsolateral folds, with a small tympanum, the crossbars on the thighs have 4-6 lines and have a membrane that is not full of the web disk (I-0-0II0-0III0-1IV1-1 / 2V) (Figure 1).

Huia cavitympanum scatters plot graphs cannot be analyzed using PCA because of limited specimen collections. *Huia cavitympanum* is a frog endemic of Borneo, this type of *Huia* is one of the frogs that has the easiest morphological character to distinguish from other species (Yang, 1991). *Huia cavitympanum* has the most different morphological characteristics, namely contrasting body color, sunken tympanum, long large head, smooth skin texture, the length of the first finger is the same or longer than the second finger, dorsal dark brown, cross bars on the thigh is 3-4 stripes, has a disc of the toes and has a distinct dorsolateral crease with fully web disk (I-0-0II0-0III0-0IV0-0V) (Figure 1). This species is similar to *Meristogenys jerboa*, which has the same distribution on the island of Borneo. (Figure 5) The characteristics are slender and medium -sized, with male SVL 31-53 mm, and female 60-82 mm, head width less than long size, the snout is slight, nostrils closer to the tip of snout than eyes, large and translucent tympanum view. The vomerine teeth are grouped at the back edge with the vomerine protrusions fused backward between the choanae. The fingers have slender, the first finger is slightly longer than the second, the disks of all the fingers are extended into the small disk circummarginally. Subarticular tubercles are oval and bulging, supernumerary tubercles are seen on at least two outer fingers, three separate palmar tubercles behind, three-toed disks that are equal to or slightly larger than the fingers, toes completely on the web disk. The subarticular tubercle exists with the metatarsal outer tubercle. Rough scaly skin on the back, dorsolateral folds usually appear dark brown just below. Males have a gular sac or vocal sac (Yang, 1991).

Table 2. Meristic characters

Spesimen	Spesies	Web disk	Sex
Amph. 12356	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 2400	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 246	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 28116	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 19764	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 8189	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 16699	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 22371	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 1624	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph.19755	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 23971	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 11840	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 6986	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 14356	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 8154	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 5181	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 4610	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 7309	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 10746	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 16400	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 15928	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 28355	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 15833	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Female
Amph. 27105	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 19753	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 16681	*Huia masonii*	I-0-0II0-0III0-1IV1-1/2V	Male
Amph. 3863	*Huia cavitympanum*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 6760	*Huia cavitympanum*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 26223	*Huia cavitympanum*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 2985	*Huia cavitympanum*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 2981	*Huia cavitympanum*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 27090	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27091	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27060	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27061	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27062	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27069	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27070	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27071	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27072	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 27082	*Huia modligiani*	I-0-0II0-0III0-1/2IV0-0V	Male
Amph. 33791	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male

Amph. 15593	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 14858	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 3461	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 70187	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 12560	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 27725	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 58055	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 6494	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 10343	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 13193	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 10364	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Female
Amph. 18626	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 36824	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Male
Amph. 428	*Huia sumatrana*	I-0-0II0-0III0-0IV0-0V	Female

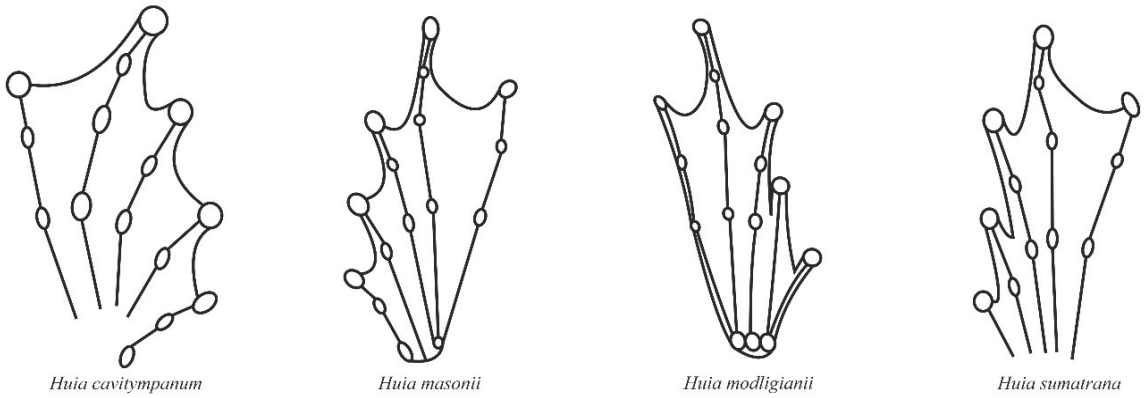

Figure 1. Web disk of *Huia*.

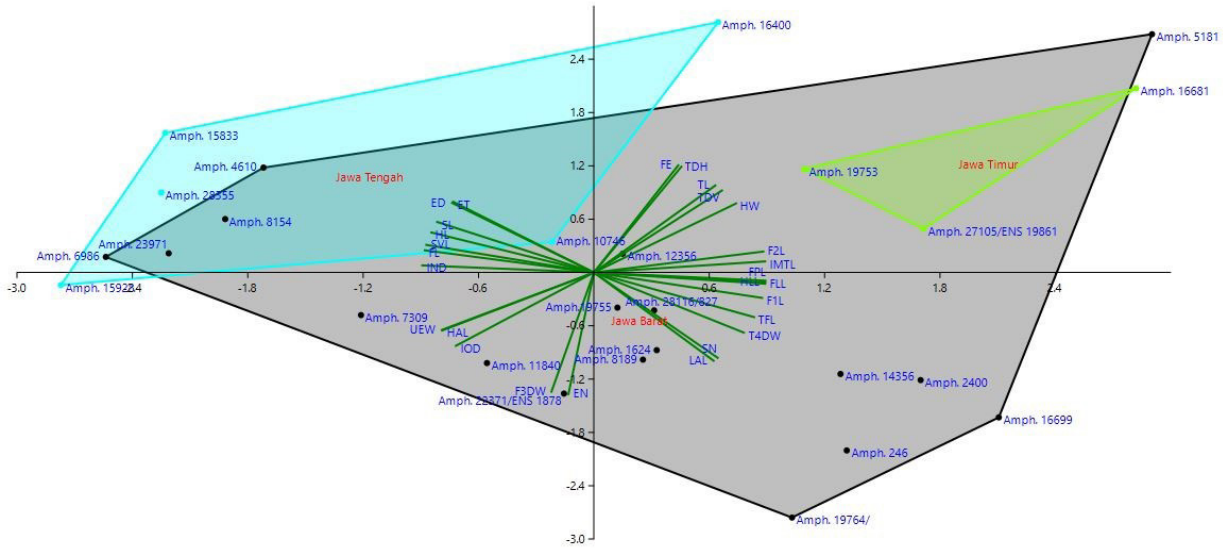

Figure 2. Scatter plot PCA of *Huia masonii*. Black: West Java; Blue: Central Java; Green: East Java

Huia sumatrana is a frog endemic of Sumatra Island which has entered a vulnerable status. Based on the results of morphological observations on the *Huia sumatrana* specimen, it is almost similar to *Huia masonii* which is endemic of Java and *Huia modligianii* from Sumatra. Its characteristic has tympanum which is larger than other types of *Huia*. *Huia sumatrana* has a slightly pointed snout, dorsolateral folds with a light brown body color smooth skin texture, spots on the back, has a wide disc, cross bars on the thighs are 3-4 lines, the length of the first finger is equal to the length of the second finger and the web or the membrane is not full web disk (I-0-0II0-0III0-1IV1-1 / 2V) (Figure 1).

Based on the *Huia sumatrana* chart (Figure 3), in general, each region is grouped in its respective regions. The characters in the West Sumatra region fill the four quadrants. The characters that lead to the regional quadrant I of Lampung, Jambi, Sumatra Selatan and West Sumatra are TL, HL, FL, LAL, FT, FLL, HW, SL, TDV, and TDH because these characters are strong in these quadrants. In quadrant II, the characters from North Sumatra are dominated by the same characters in the West Sumatra region which include IMTL, F1L, IND, UEW, FPL, ED, and SN. However, the Aceh region has quite a similar character to the West Sumatra and North Sumatra regions. This is because the Aceh region is dominated by *Huia modligianii* rather than *Huia sumatrana* according to the description of the original description of the *Huia modligianii* (Doria et al., 1999). EN, F3DW, T4DW, and TFL characters in quadrant III of West Sumatra and Lampung still dominates the similarity character and the North Sumatra region is not so far from the two dominating regions. Quadrant IV of the reinforcing characters namely FE, HLL, HAL, and SVL with the West Sumatra, Lampung region and the similar of characters from the Bengkulu region. Of the four quadrants, Sumatra West and Lampung are predominantly regional. So that comparisons between specimens from various regions on the island of Sumatra conclude that many of the regions of West Sumatra have the reinforcing character of these specimens. Based on the overall data that has been presented, there is no sign of a prominent variation in the characters between the islands.

Huia modligianii is a type of frog that represents Sumatra, apart from *Huia sumatrana*, which is endemic of Sumatra Island. However, *Huia modligianii* is commonly found in Aceh with the conservation status category vulnerable to extinction. *Huia modligianii* specimen have a characteristic dark brown body color with a skin texture that is quite rough and smooth on the ventral side, pointed snout , dorsolateral folds with small tympanum, cross bars on the thighs have 6 lines, the length of the first finger is the same as the second finger the unfilled membrane having the webbing formula (I-0-0II0-0III0-1 / 2IV0-0V) (Figure 1).

Huia characters from Sumatra are similar to the genus *Sumaterana*. The genus *Huia* has similarities with another genus in the Ranidae Family because of the dorsolateral fold. However, *Huia modligianii* has similar characteristics to *Sumaterana crassiovis*. The characters are male SVL = 27.94–48.87 mm ; female = 40.98–83.99 mm (Figure 5). The dorsum is moderately smooth and granulated, with or without scattered tubercles, the supratympanic fold (the fold of skin over the tympanum, starting at the back of the eye). Dorsolateral fold was present, tibial length 58.08–79.67% SVL. Outer metatarsal tubercles are absent but inner metatarsal tubercles are present. The first finger is relatively shorter or less long than the II finger. Has a vocal sac and nuptial

path in males (Arifin et al., 2018).

The PCA scatters plot graph of all species in each region shows that the most dominant morphometric character in all quadrants is *Huia masonii* among other *Huia* specimens (Figure 4a & 4b). The characters in *Huia sumatrana* overlap with *Huia modligianii*. This overlap can occur because the characters of *Huia sumatrana* and *Huia modligianii* have strong similarities according to the previous explanation. In addition, the characteristics of *Huia cavitympanum* which are in a different quadrant from several *Huia* species are due to the characteristics of *Huia cavitympanum* that quite different, apart from body size.

Based on the overall data that has been analyzed, it shows that there are morphological variations that have not shown a significant grouping with the dominant character of each population of the entire genus *Huia*. Tolerance ranges in evolutionary and geological processes can also affect distribution even though the tolerance ranges are quite small. However, the formation of morphological variations in *Huia* is possible a diagnostic character on the PCA scatter plot results. The characters of the PCA results still highlight the characters in each regional specimen. Habitat specifications from *Huia* and landscapes in Java, Kalimantan, and Sumatra are not sufficiently supportive for the formation of new, more adaptive characters. So that *Huia* is a species that can adapt and its evolution can maintain the rate of speciation.

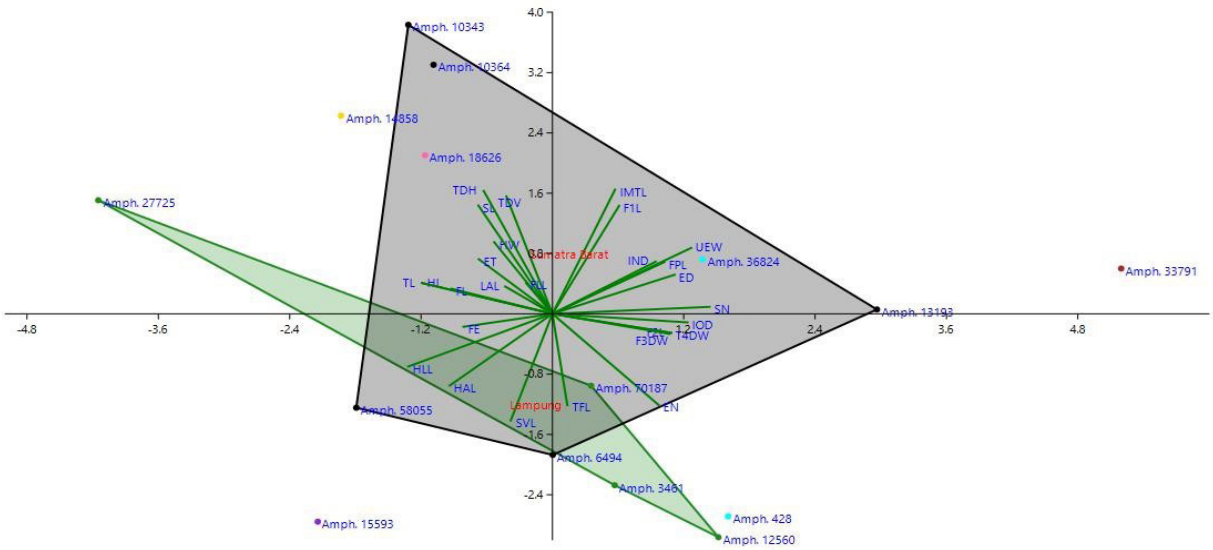

Figure 3. Scatter plot PCA of *Huia sumatrana*. Black: West Sumatra; Green: Lampung; Brown: Aceh; Purple: Bengkulu; Pink: South Sumatra; Aqua: North Sumatra; Yellow: Jambi)

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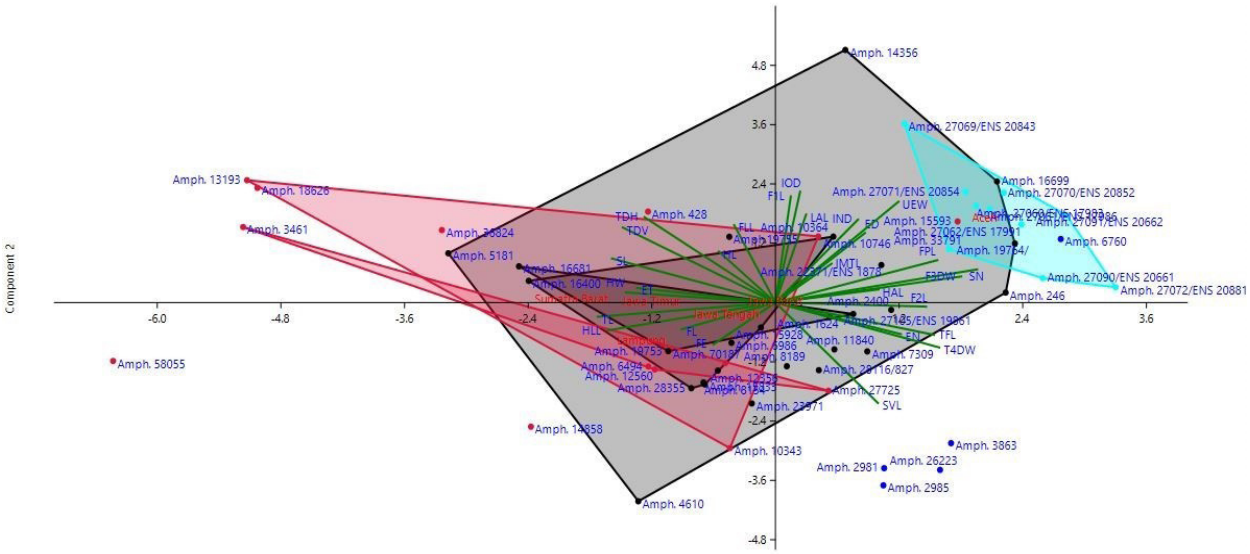

Figure 4a. Scatter plot PCA of *Huia.* Black: *Huia masonii* Java; Aqua: *Huia cavitympanum* Kalimantan; Red: *Huia sumatrana* Sumatra; Brown: *Huia modligianii* Aceh

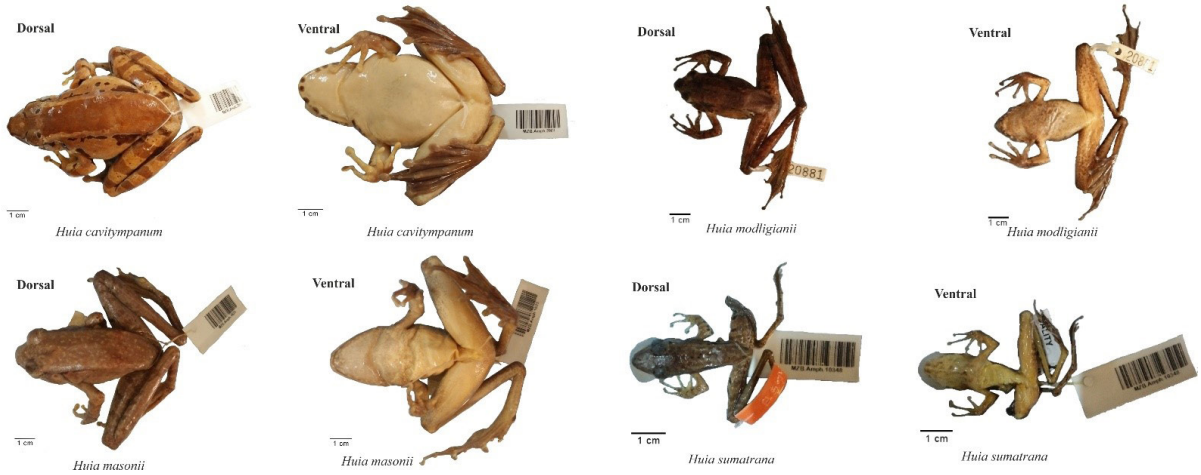

Figure 4b. Specimens of *Huia*

Figure 5. *Sumaterana crassiovis* and *Meristogenys jerboa* specimens

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