THE DISTRIBUTION OF *Gonocephalus* SPECIES (REPTILIA, IGUANIA, AGAMIDAE) ON SUMATRA, INDONESIA

Yunfika Rahmi[1]*, Mistar Kamsi[2], Jimmy A. McGuire[3], David P. Bickford[4] and Djoko T. Iskandar[1]

[1] School of Life Sciences and Technology, Institut Teknologi Bandung, 10, Jalan Ganesa, Bandung 40132, Indonesia.
[2] Sumatran Orang Utan Conservation Program, 51/74, Jl. KH. Wahid Hasyim, Babura, Medan 20154 Indonesia.
[3] Museum of Vertebrate Zoology, University of California at Berkeley, CA 94720, USA
[4] Raffles Museum for Biodiversity Research, National University of Singapore.

*Corresponding author: yunfika.rahmi@gmail.com; iskandar@sith.itb.ac.id

Abstract

We studied an agamid lizard genus, *Gonocephalus* (Kaup, 1825), characterized by having an angled head at the supraciliary region bordered with the eyes. It is distributed in the Sundaland and Southeast Asia, known from South Indochina in the North and the larger Sunda Island in the South, extending to the Philipines in the East. In this study, it is found that *G. grandis* specimens from Borneo have different color pattern compared to those from Sumatra. To confirm these findings, a thorough examination of all specimens of genus *Gonocephalus* had been performed at Laboratory Biosystematics, SITH ITB. The examination was carried out by measuring morphological data and meristic characters. The data were analyzed using Discriminant Analysis (DA) to determine the composition of the genus *Gonocephalus* group and Mann-Whitney test to compare species in the genus *Gonocephalus*. The results of discriminant analysis showed three axes which have eigenvalues greater than two. Axes 1 and 2 showed the best compotition group of each species in genus *Gonocephalus*. The results showed that composition of *Gonocephalus* is clustered based on crest characters. *Gonocephalus kuhlii*, *G. doriae*, *G. chamaeleontinus*, *G. borneensis* and *G. liogaster* have the nuchal crest is directly linked with the dorsal crest. In the other hand, *G. grandis, G. klossi,* and *G. megalepis*, all three have a gap between dorsal and nuchal crest. The results also showed that *G. borneensis* and *G. doriae* from Sumatra and Borneo specimens are grouped together in the same cluster. The Mann-Whitney test results showed that populations of *G. borneensis* and *G. doriae* from Sumatra are identical to those from Borneo. This study confirmed that *G. doriae* and *G. borneensis* are present on Sumatra for the first time, hence expand the distribution of the two species. The results also showed new distributional record of several species within the genus.

Keywords: *Gonocephalus*, Sumatra, Borneo, Java, new locality record

Introduction

Agamid lizards of the genus *Gonocephalus* Kaup, 1825, are known as angular or square head lizards based on the presence of curved eyebrow and bony ridge between the eyes and nostrils (Manthey and Schuster, 1996). The first ever described species of this genus is *Iguana chameleontinus* (Laurenti, 1768). *Gonocephalus* has characteristics which differs from other agamid genera, such as the absence of a spine in the neck area such as *Acanthosaura* and *Calotes*, hornlike structure as in *Aphaniotis*, *Harpesaurus*, *Hylagama*, and *Thaumatorhynchus*, spreadable skin membrane with extremely elongated rib as in *Draco*, prehensile tail as reported for *Cophotis*. However *Gonocephalus* has a shoulder fold similar to *Bronchocela*, *Dendragama*, *Lophocalotes*, *Phoxophrys*, and *Pseudocalotes*, and also has a visible tympanum described also for *Broncocela*, *Dendragama*, *Lophocalotes*, and *Phoxophrys* (Manthey and Denzer, 1991). At present, the genus *Gonocephalus* (sensu stricto), comprised of 17 species and is restricted to Southeast Asia (Uetz and Hallerman, 2012). *Gonocephalus* (*sensu lato*) is distributed from Indochina to Philipines and Indo-Australian

Archipelago (Boulenger, 1885; Bourret, 1943; Wermuth, 1967 in Ananjeva and Dujsebayaseva, 1996).

In Indonesia alone, *Gonocephalus* can be found on Sumatra, Borneo and Java. Up to present, there are seven species of *Gonocephalus* on Sumatra, six species on Borneo and two species on Java (de Rooij, 1915). As already known, the herpetological fauna of Sumatra is still poorly known and recent herpetological collections have been infrequent (Inger & Iskandar, 2005; Teynié *et al*., 2010). Relative to other Sunda islands, the herpetofauna of Sumatra has been understudied (Iskandar and Erdelen, 2006) and accurate distribution patterns of *Gonocephalus* in Sumatra remains unknown.

On that basis, we analyzed *Gonocephalus* specimens from Java, Sumatra, and Borneo in the Biosystematics Laboratory, School of Life Science and Technology, ITB. We studied further specimens collected from Sumatra, which are morphologically similar to *Gonocephalus borneensis*, and *G. doriae* from Borneo, as *G. borneensis* and *G. doriae* are previously known as endemic species from Borneo. In the analysis, we compared specimens to a broader range of samples of *Gonocephalus* from Java, Sumatra, and Borneo to reveal the exact distribution of each species in those regions.

All *Gonocephalus* specimens used in this study is stored in the Laboratory of Biosystematic, School of Life Sciences and Technologi, ITB or Museum Zoology, School Life Sciences and Technology ITB. A total of 88 specimens were used in this study. Of these, 72 specimens were collected from Sumatra, 14 specimens were from Borneo, and two specimens from Java.

Materials and Methods / Experimental

Measurements on morphological characters were taken using calipers accuracy to nearest 0.05 mm, except for tail length which was measured with a measuring tape. Meristic characters were examined using naked eyes accept for juvenile specimens or specimens who have small scales were examined using binocular microscope. Measurement method for morphological and meristic characters are slightly modified from those described by Ota and Hikida (2000), Hallerman (2000), Hallerman and McGuire (2001), and Siler *et al.* (2010). Abbreviations used are as follows : SVL = Snout-Vent Length, TL = tail length, HL = Head Length, HW = Head Width, HD = Head Deep, SL = Supralabial, IL = Infralabial, M = Number of scales row around midbody, HLL = Hind Limb Length : consist of Humerus (Hu), Radius-Ulna (RaUl), and Hand (with claw), FL = Foot Length (with claw), FLL = Forelimb Length : contain of Femur (Fe), Tibia-Fibula (TF), and Foot (with claw), FIL-FVL = Finger I-V Length (without claw), TIL-TVL = Toe I-V Length (without claw), SHL = Snout-Hindlimb Length, AGL = Axila-Groin Length, D.Orbit = Diameter of horizontal orbit, D.Tympanum = Diameter of Tympanum, TW = Tail Width, TD = Tail Depth, MBW = Midbody Width, MBD = Midbody Depth, END = Eye-Nostril Distance, ESL = Eye-Snout Length, FIS-FVS = Finger I-V subdigital, TIS-TVS = Toe I-V subdigital, number of canthus rostralis scales, number of mid ventral scales consist of mental to cloaca and chest to cloaca, number of mid dorsal scales, number of rows tail keeled scales, ventral scales, number of nuchal, dorsal, nuchal-dorsal crest, crest gap, number of tubercle in dorsal or in throat, ratio of TL and SVL, HW and HL, HLL and SVL, HLL and FL, HD and HL, HD and HW, AGL and SVL, SFL and HL, TW and TL, TD and TL FL and SVL, Foot and SVL, Toe and SVL, MBW and MBD, D.orbit and D.tympanum, Hu and RaUl, Fe and TF, End and Snl.

The results of morphological and meristic measurements were statistically analyzed by Discriminant Analysis (DA) using SPSS 17.0 software and Canoco for Windows 4.5. Discriminant Analysis is a method to tests significant differences in characteristic between communities delimited by classification (Ludwig and Reynold, 1988). This analysis is used for several purposes, for example to classify cases into several groups using a discriminant prediction equation, test the theory by observing whether cases were classified as predicted or not, investigate differences among the groups, and determine the most parsimonious way to distinguish among groups. Both morphology and meristic data were standardized using z-score method because each uses different measurement unit (Rachmansah, 2009). The variables were analyzed with Canoco program in order to find out which have significant contribution to classification, based on the variable of each eigenvalue. Subsequently, the data will be analyzed using discriminant analysis.

 ISSN 2088-9127

Afterward, a graphical overview of discriminant analysis, each group of sample are plotted in two discriminant functions, the horizontal and vertical axes as the first two functions. This graph showed the similarity of specimens within group (Zahuranec, 2000).

Univariate statistic analysis using Mann-Whitney test method was also carried out to compare one species to another.

Results and Discussion

The statistical analysis of all (88) specimens was performed using DA on 49 parameters. The results showed that among 49 parameters, only nine variables and three discriminant functions have eigenvalues that were greater than two. For this study we used only the first and second axes, the first discriminant function has 81.5 % of the discriminating ability to separate groups and the second accounts for 10.6 %, as they covered more than 92.1% of the whole data (100%) which means the rest of the discriminant functions were only complementary to the data distribution pattern in the analysis. These first and second discriminant function were used as axes in distribution pattern

Table 1. showed each of discriminant function has variables, which are important for genus *Gonocephalus* clustering. From each function, the highest value is considered to have greater discriminating power, was shown in bold. From those seven discriminant function, the first and second discriminant function had eigenvalue greater than two than the others.

From the total of seven discriminant functions, the best group composition structure of each species in the genus *Gonocephalus* was obtained when using discriminant function one and two as axes in the scatter plot. The combine-group scatter plot showed that the first discriminant function is plotted on the horizontal axis and second on the vertical axis. According to the vertical line, *G. klossi, G. megalepis*, and *G. grandis* were located on the left side of this vertical line, while *G. borneensis, G. liogaster, G. doriae, G. kuhlii*, and *G. chamaeleontinus* are placed on the right side. The first discriminant function distinguished *G. borneensis, G. liogaster, G. doriae, G. kuhlii*, from *G. chamaeleontinus* from *G. klossi*, *G. megalepis*, and *G. grandis*. Generally, the group composition of genus *Gonocephalus* could be derived from crest (continued or separated crest) and used to separate between the group of *G. klossi, G. megalepis*, and *G. grandis*; and *G. borneensis, G. liogaster, G. doriae, G. kuhlii*, and *G. chamaeleontinus* (see figure 1).

Table 1. The first nine extracted Variables loading and seven functions obtained through discriminant analysis based on 49 morphological and meristic variables of *Gonocephalus* species.

		Functions						
		1	2	3	4	5	6	7
Variables	Nuchal-dorsal crest	**0.878***	0.125	-0.118	-0.041	-0.213	-0.058	-0.091
	Nuchal	-0.417	**0.430***	0.010	-0.041	-0.164	0.092	-0.406
	tubercles at jaw	0.188	0.296	**0.814***	0.341	-0.167	-0.047	0.075
	IL	0.039	-0.106	-0.199	**0.534***	0.010	0.172	-0.019
	HLL/FL	0.071	0.307	-0.261	0.215	**0.603***	-0.071	0.337
	TIL	-0.025	-0.090	0.198	-0.216	0.377*	-0.374	-0.048
	Head tubercles	-0.067	-0.259	0.291	-0.280	0.198	**0.591***	0.184
	HLL/SVL	0.010	0.448	0.149	-0.162	0.488	**0.537***	-0.132
	mental until cloaca	-0.114	0.361	-0.065	-0.327	-0.342	.094	**0.441***

Notes: Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.
*Largest absolute correlation between each variable and any discriminant function

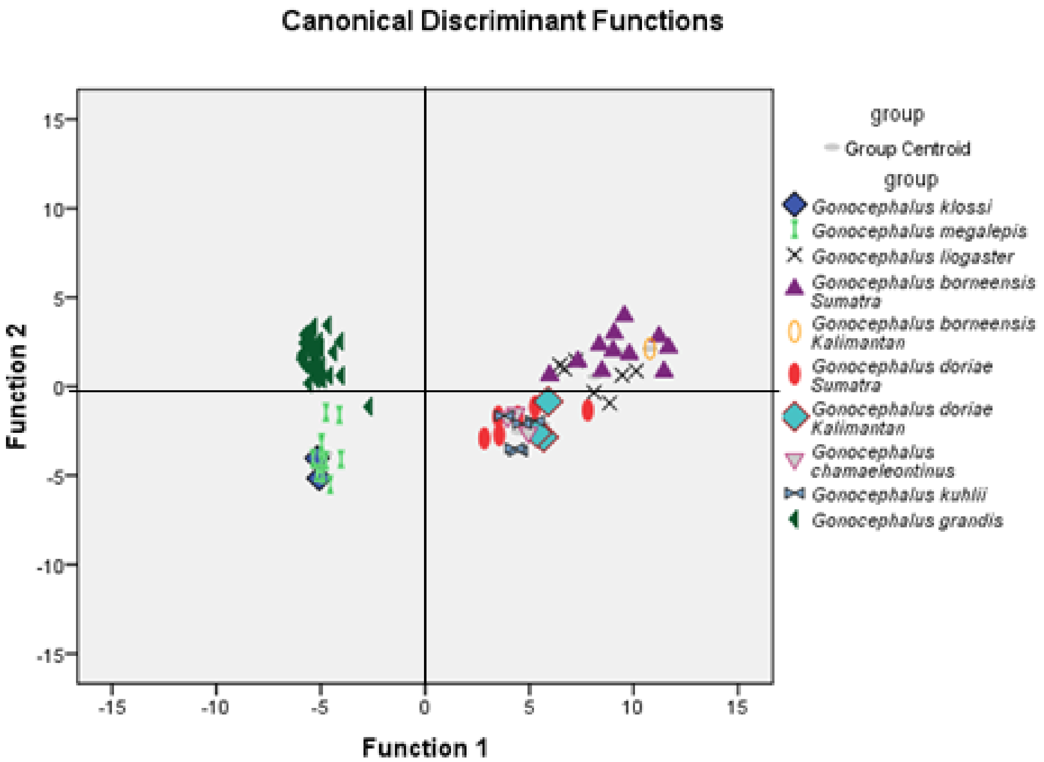

Figure 1. Scattered plot diagram using first and second functions as axes showing the group composition in the genus *Gonocephalus* based on morphometrical ratio and meristical values.

Figure 1. also showed *G. borneensis* and *G. doriae* from Sumatra and Borneo were clustered in the same group. These results showed that *G. borneensis* and *G. doriae* from Sumatra are identical to those from Borneo based on morphometric and meristic data.

The univariate statistics such as Mann-Whitney test was used to compare morphological and meristic data of two different species or populations in this study. After Mann – Whitney test that was performed between the species on the right cluster in Figure 1. the outcome showed significant differences between *G. liogaster* and *G. borneensis*; also among the species *G. doriae*, *G. chamaeleontinus*, and *G. kuhlii*. The results of Mann-Whitney test referred to the degree of similarity and dissimilarity between species. Table2. shows some characters, which contribute to similarity based on 49 informative characters from Canoco and nine characters from DA. Table 2. showed the higest similarity between two species in the genus *Gonocephalus* was scored 47, between *G. klossi* - *G. chamaeleontinus* and *G. klossi* - *G. kuhlii*. Based on morphological description, both of them has different characters which distinguish with each others however measurements of morphological and meristic character s showed that both of them have overlapping values. However, *G. klossi* - *G. chamaeleontinus* and *G. klossi* - *G. kuhlii* have close relationships because the typical diagnostic features of species and scales-based both of nuchal and dorsal crest are not similar (Manthey and Denzer, 1991). This is relationship concern to *chamaeleontinus*-group and *megalepis*-group, as in the relationship between *G. megalepis* – *G. chamaeleontinus, G. klossi* - *G. chamaeleontinus*, and *G. klossi* – *kuhlii* (see figure 2.). The relationship between *G. klossi* - *G. grandis*, *G. megalepis* – *G. liogaster*, *G. liogaster* – *G. chamaeleontinus*, *G. borneensis* – *G. doriae*, *G. borneensis* – *G. chamaeleontinus* are not in accordance with the conclusion of Manthey and Denzer (1991). They concluded that *G. grandis* has a close relationship with *G. semperi* and *bellii*-group with *robinsoni*-group. It is conceived that this work used a number of different set of characters compared to the work of Manthey and Denzer to differentiate *Gonocephalus* and the high intraspecific variations are not powerful to differentiate species within the genus (see table 2.).

ISSN 2088-9127

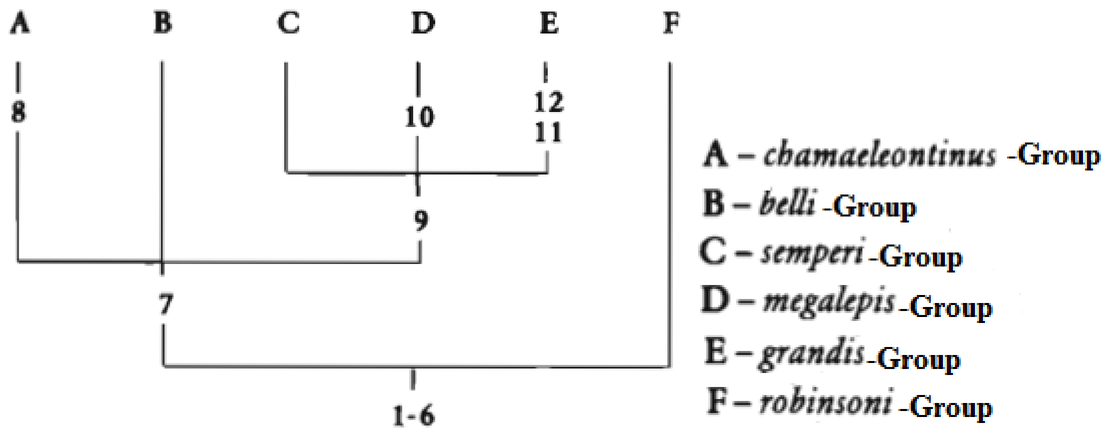

Figure 4.3 Relationship among group of *Gonocephalus* (based on Manthey and Denzer, 1991)

Table 2. Similarity and dissimilarity of group of genus *Gonocephalus* (according to Manthey and Denzer, 1991)

Characters	Group of genus *Gonocephalus*					
	A	B	C	D	E	F
1-6 Typical diagnostic features of species seen	X	X	X	X	X	X
7 Basic scale nuchal is not same with dorsal crest	X	X	X	X	X	
8 Eyebrow arch high, clear angular	X					
9 Separated from the dorsal of the nuchal crest			X	X	X	
10 Tail flattened laterally extremely				X		
11 Female without dorsal crest					X	
12 Separate neck crest of overlapping scales or skin-like overlap					X	

The species from genus of *Gonocephalus* almost has same characters or only few characters which differs each other especially the species which have close relationship with other species in genus of *Gonocephalus* as in *G. borneensis* - *G. liogaster*, *G. doriae* - *G. chamaeleontinus*, and *G. klossi* - *G. megalepis*. This is one of reasons of why identification of species in the genus *Gonocephalus* is sometimes difficult. The characters used to differentiate between one species and another, however, might not be applicable to differentiate this same species with the remaining members of the same genus (Ramadhan, 2011).

Table 3. also showed overlapping data of nine variables from result of DA. These results show that nine variables did not contribute an important role in showing a close relationship with each other. The more parameters were used to determine a relation of one species with the other species, the higher precision of that relationship.

The results of univariate statistics and morphological observation also showed that there is no difference between *G. doriae* from Sumatra and Borneo. The same results applied to *G. borneensis* as well. Based on the previous statements, *G. borneensis* and *G. doriae* were also found in Sumatra (aside Borneo).

It is well known that the Sundaland are united and separated several times in the geological history. However, the Islands Western of Sumatra is separated in a much older period. This fact indicate that a species also occur in the Mentawai might be even older than the Sunda Islands. Several islands such as Pagai, Siberut and Sipora are once linked. Nias and Mentawai were linked to Sumatra following the Pini-Tanah Masa islands. In the other hand Simeulue has Banyak Islands a landbridge. Only Enggano was never virtually in contact with Sumatra. Judging from the wide distribution of *G. chameleontinus* in the whole Sundaland and in the Mentawai, this species is expected to occur when Sundaland is still a single landmass (Hall, 1998). *Gonocephalus liogaster* might occur together with *G. chameleontinus* as they occur in the Mentawai. This distribution might date back to the Miocene (Hall, 1998). In the other hand, *G. doriae* and *G. borneensis*, their occurrence in the Sundaland should dated back at least to the last glaciation where Java is already separated, but landbridge existed between Sumatra and Borneo (Hall, 1998). However, the differences in dorsal coloration pattern of *G. grandis* might indicate that it has a wider genetic variation and might indicate older stock in the Sundaland compared to the two other species.

Gonocephalus kuhlii occurs on Java and Sumatra, is supposed to follow the Strait Makassar watershed. In the other hand, *G. bellii* is recorded from Peninsular Malaysia and Borneo. It probably migrates following the same path as for *Ansonia* and *Leptolalax* as these two amphibian genera are specious in both land masses, but very badly represented or absent on Sumatra (Iskandar and Mumpuni, 2004; Iskandar and Colijn, 2000; Grismer, 2006; Inger, 1999). Their distribution is probably linked to the East Mekong watershed.

Gonocephalus beyschlagi and *G. megalepis* are found in several widespread areas in Sumatra. Other species such as *G. klossi* and *G. lacunosus*, each evolved independently on Sumatra, but only occurs in a very restricted range, are probably younger compared to *G. beyschlagi* and *G. megalepis*. *Gonocephalus myobergi* evolve on Borneo and *G. robinsonii* on the Malayan Peninsula might evolve independently as for example *G. klossi* or *G. lacunosus*, but can also be as old as *G. beyschlagi* (Manthey, 2010).

Local extinction might play an important role in *Gonocephalus* speciation. It is well known that Sumatra has the highest number of species and in particular many of them have a very restricted distribution. We expect that volcanic eruption of the 33 volcanoes in Sumatra might account for local barrier. Most Sumatran volcanoes erupted incessantly during the Miocene, Pleistocene up to present. First, a high number of individuals might be wiped out from a given locality and producing bottle necking. That means a reduction of genetic variability and the unexpected appearance of a rare variation. In the other hand, a vast area will be burned out and serve as land barrier to prevent a given population to roam from one place to another. Volcanoes do not exist in Borneo and Peninsular Malaysia is the most plausible explanation that only few species inhabited that island and only one species is considered as endemic (Uetz and Hallermann, 2012). This information shows that *G. borneensis* and *G. doriae* could be found at Sumatra Island.

Gonocephalus borneensis

Referred specimens: Ten juvenile females, one juvenile male (JAM 09856), and two adult females specimens. The specimens are Sumatra (JAM 09856, JAM 09860, JAM 09864, JAM 00853, JAM 09862 from Kabupaten Deli Serdang; 0140, 0489, 505, 506, 550 from Aceh; Borneo (1024 from Hulu Kapuas, Kalimantan Barat).

Variations: juveniles of *Gonocephalus borneensis* from Sumatra has a longer body compared to specimens from Borneo, but those from Borneo have a longer tail; largest, widest, and deepest head (supraciliary border higher); the ratio of diameter of orbit and tympanum is longer; and a slighty longer snout.

Gonocephalus chamaeleontinus

Referred specimens: A juvenile female, one adult male, and one adult female. Specimens are JAM 09202 from Kabupaten Bengkulu, Sumatra; JAM 10641 from Desa Bulasat, Kecamatan Pagai Selatan, Kabupaten Kepulauan Mentawai, Propinsi Sumatra Barat; and TGS 0004 from Tanggamus, Sumatra.

Gonocephalus doriae

Referred specimens: Two juvenile females, two adult males, and six adult females. Specimens are from Sumatra (JAM 11110, JAM 11111 from Desa Haloban, Pulau Tuanku, Kecamatan Pulau Banyak, Kabupaten Aceh Singkil, Propinsi Nangroe Aceh Darussalam; JAM 10684 from Desa Bulasat, Kecamatan Pagai Selatan, Kabupaten Kepulauan Mentawai, Propinsi Sumatra Barat; 507, 508, 640 from Aceh; and an unnumbered specimen). Borneo (819 from Ketapang, Kalimantan; 1260, 1229 from Katingan, Kalimantan Tengah).

Variation: Adults from Sumatra have a shorter body and longer tail; a larger, wider, and deeper head (supraciliary border higher); the ratio of diameter of orbit and tympanum is smaller; and a slighty longer snout compared to those from Borneo.

ISSN 2088-9127

Table 3. Similarity between speciies based on 49 (below diagonal) and nine (above diagonal) variables of *Gonocephalus* based on Mann-Whitney test.

	G. klossi	*G. megalepis*	*G. liogaster*	*G. borneensis*	*G. doriae*	*G. chamaeleontinus*	*G. kuhlii*	*G. grandis*
G. klossi		**8/9**	**4/9**	**3/9**	**3/9**	**9/9**	**4/9**	**4/9**
G. megalepis	44/49		**3/9**	**2/9**	**4/9**	**5/9**	**5/9**	**3/9**
G. liogaster	31/49	40/49		**8/9**	**4/9**	**7/9**	**4/9**	**5/9**
G. borneensis	25/49	16/49	46/49		**5/9**	**6/9**	**2/9**	**3/9**
G. doriae	30/49	20/49	37/49	41/49		**9/9**	**5/9**	**2/9**
G. chamaeleontinus	47/49	39/49	40/49	38/49	46/49		**8/9**	**5/9**
G. kuhlii	47/49	30/49	32/49	31/49	39/49	40/49		**3/9**
G. grandis	39/49	25/49	32/49	25/49	22/49	5/49	25/49	

Similarities (9 parameters) (above diagonal)

Similarites (49 parameters) (below diagonal)

Notes: The orange highlighted squares indicated two pairs of species with highest degree of similarities based on the statistic test, but different in the observed morphological characters. While the green highlighted ones referred to the pair of species where the test results according to morphological characters.

Gonocephalus grandis

Referred specimens: Twenty juvenile females, eight adult males, and six adult females. The specimens are Sumatra (grandis 1-4, 6800 from West Sumatra; 498, 639, 593 from Aceh,; JAM 09236 from Kotamadya Padang,; JAM 09769 from Deli Serdang,; JAM 10263, JAM 10121, JAM 10120 from Desa Madula, Kecamatan Gunung Sitoli, Kabupaten Nias,; JAM 11178 from Desa Haloban, Pulau Tuanku, Kecamatan Pulau Banyak, Kabupaten Aceh Singkil, Propinsi Nangroe Aceh Darussalam; JAM 09584, JAM 09582, and JAM unnumber from Cagar Alam Rimbo Panti, Kabupaten Pasaman, Propinsi Sumatra Barat; JAM 09770 from Kabupaten Deli, Sumatra; JAM 10213 from Desa Lili'uso, Kecamatan Lolofutimoi, Kabupaten Nias, Propinsi Sumatra Utara); Borneo (1001 from Kapuas Hulu, Kalimantan; RMBR 00869, RMBR 00839, RMBR 00721, Baobao 15, D 410, G. 38, Baobao 23, 15638, Bal 0124, CAMP 35.7 from Kalimantan; KR 0438 and KR 0435 from Karimata, Kalimantan; 1201 from Murung Raya, Kalimantan; and 939 from South Kalimantan).

Variations: Male and female of *Gonocephalus grandis* differ in nuchal and dorsal crest and pattern of dorsal scales. Females of *Gonocephalus grandis* have a black stripe from dorsal to eyes. The variation both of *Gonocephalus grandis* from Sumatra and Borneo especially for those of females is *Gonocephalus grandis* from Sumatra has a black pattern rounded on the dorsal and black stripe from nuchal and below the nuchal up to the eyes.

Gonocephalus klossi

Referred specimens: Two adult males are identified as a *Gonocephalus klossi*. The specimens are RMBR 00341 and RMBR 00318 from Bengkulu, Sumatra.

Gonocephalus kuhlii

Referred specimens: Three juvenile females and two adult females. Specimens are from Sumatra (JAM 10550, JAM 110711, and JAM 10682 from Desa Bulasat, Kecamatan Pagai Selatan, Kabupaten Kepulauan Mentawai, Propinsi Sumatra Barat); and Java (kuhlii1 and kuhlii2 from Cibodas, West Java).

Variations: *Gonocephalus kuhlii* from West Java has nuchal crest overlap at the base, broad, rounded ventrals often in the chest, underside of the thigh with smooth scales and *G. kuhlii* from East Java has nuchal crest scales overlap only slightly or small space separated, narrow at the base, slightly keeled or ventrals scales, underside of thighs keeled scales with strongly curved up (Manthey and Denzer, 1993).

Gonocephalus liogaster

Referred specimens: Three juvenile females and four adult males. The specimens are

Sumatra (*G. liogaster* and 198 from Sipetang, Tapanuli Utara); Borneo (RMBR 00788 from West Kalimantan; 1065 from Kapuas, West Kalimantan; KR 0206 from Karimata, 882 from Ketapang, West Kalimantan; and 1215 from Murung Raya, Central Kalimantan).

Gonocephalus megalepis

Referred specimens: A juvenile female (JAM 00860), five adults males, and five adult females. The specimens are JAM 00860 from Deli Serdang,Sumatra; 0265, 0266, 0268, and 313 from Solok, Sumatra; 0476 and unnumbered from Sumatra; RMBR 00340, RMBR 00362, RMBR 00339, RMBR 0267 from Bengkulu, Sumatra.

Key to *Gonocephalus* species occuring in the Sunda Island.

1.	a.	Supracilliary border strongly raised………………………………………	(2)
	b.	Supracilliary border normally raised……………………………………..	(3)
2.	a.	Dorsal crest spine much lower than nuchal, isosceles triangle shape of nuchal crest ventral scales keeled; and short snout………………..............	*G. kuhlii*
	b.	Dorsal crest spine much lower than nuchal, lanceolate shape of nuchal crest; ventral scales smooth; and short snout………………………………………	*G. chamaeleontinus*
	c.	Dorsal crest spine almost high as the nuchal, sickle shape of nuchal crest; ventral scales smooth; and sligthly longer snout………………………………	*G. doriae*
3.	a.	Separate crest (there is gap scales which separated both of nuchal and dorsal crest)……………………………………………………………………….	(4)
	b.	Continuous crest (nuchal and dorsal crest are not separated from each other)……………………………………………………………………….	(8)
4.	a.	Nuchal crest above the base scale rows at the beginning very low….............	(5)
	b.	Nuchal crest above the base scale rows at the beginning high……………….	(6)
5.	a.	Base of dorsal crest spine has variable scales sizes………………..............	*G. lacunosus*
	b.	Base of dorsal crest spine composed of more or less uniform scales………...	*G. megalepis*
6.	a.	Dorsal scales uniform, no tuberculate scale at edge of jaw………..............	(7)
	b.	Dorsal scales unequal and enlarge scales distributed, small tuberculate scales present at edge of jaw………………………...	*G. klossi*
7.	a.	Dorsal scales uniform in size and small, no enlarged dorsolateral…………..	*G. grandis*
	b.	Dorsal scales uniform and large (almost equal with ventral scales), body with enlarged, geometrical dorsolateral scales forming an oblique rows……………………………………………………………………………	*G. mjoebergi*
8.	a.	Ventral covered with smooth scales………………………………..............	(9)
	b.	Ventral covered with keeled scales……………………………….............	(10)
9.	a.	Ventral scales smooth, head scales large, equal, keeled; tubercles at the throat absent………………………………………………………………..	*G. liogaster*
	b.	Ventral scales smooth, head scales large, unequal, keeled; many tubercles present at the throat…………………………………………………………	*G. beyschlagi*
10.	a.	Ventral strongly keeled, a black blotch on gular sac, tubercles at the throat absent, and dorsal scales with many enlarge scales, irregular distributed…………………………………………………………………..	*G. bellii*
	b.	Ventral scales keeled, no coloration on gular sac, throat with many tubercles and dorsal scales with a few enlarge scales, regular distributed……………………………………………………………………	*G. borneensis*

Conclusion

From the usage of DA, crest can be used to separate species within the genus *Gonocephalus*. In *Gonocephalus kuhlii*, *G. doriae*, *G. chamaeleontinus*, *G.borneensis* and *G. liogaster* the nuchal crest is directly linked with the dorsal crest, *G. grandis, G. klossi,* and *G. megalepis* has a gap between dorsal and nuchal crest. Also, confirmed the finding that *G. borneensis* and *G. doriae* are found on Borneo and Sumatra.

Acknowledgment

Gilang Ramadhan and Ramadhani Eka Putra, Ph.D for taught and give me advice in statistical analysis; Angga Rachmansah and Samantha Vivia for your help in English writing corrections, discussion, and review about this manuscript; Andri Irawan, Adisty S.M, Leonard R. Aditya, Umilaela for taught me about herpetology and shared a lot of experience with you; Ahliana Afifati Sani and Arni Rahmawati F.S for being my besties; and all of my friends for support and a lot of happiness with you. Thank you very much.

References

[1] Ananjeva, N.B. and Matveyeva-Dujsebayeva, T.N. 1996. *Some evidences of **Gonocephalus** species complex divergence base on skin sense organ morphology*. Russ J Herpetol, 3: 82–88.

[2] de Rooij, N. 1915. *The Reptiles of Indo-Australian Archipelago. Lacertilia, Chelonia, Emydosauria.* Leiden: E.J. Brill, Ltd.

[3] Hall, R. 1998. *The plate tectonics of Cenozoic SE Asia and the distribution of land and sea*. *Biogeography and geological evolution of SE Asia* (eds R. Hall and J.D. Holloway). Leiden : Backhuys Publishers.

[4] Hallerman, J. 2000. *A new species of **Calotes** from the Mollucas (Indonesia), with notes on the biogeography of the genus (Sauria: Agamidae).* Bonn zool Beitr, 49: 155-163.

[5] Hallerman, J. and McGuire, J.A. 2001. *A new species of **Pseudocalotes** (Squamata: Agamidae) from Bukit Larut, West Malaysia*. Herpetologica, 57(3):255-265.

[6] Grismer, L.L., 2006. *A new species of **Ansonia** Stoliczka 1870 (Anura: bufonidae) from a lowland rainforest in southern peninsular Malaysia*. Herpetologica, 62: 471–480.

[7] Inger, R.F. 1999. *Distribution of amphibians in Southern Asia and adjacent islands. Patterns of distribution of amphibians: a global perspective* (ed. W.E. Duellman). Baltimore : The Johns Hopkins University Press.

[8] Inger, R.F. and Iskandar, D.T. 2005. *A collection of amphibians from West Sumatra, with a description of a new species of **Megophrys**, Amphibia: Anura*. Raffles Bull Zool, 53: 133-14.

[9] Iskandar, D.T and Colijn, E. 2000. Checklist of Southeast Asian and New Guniean Herpetofauna. I. Amphibians. Treubia, 31(3) : 1-133.

[10] Iskandar, D.T. & Mumpuni. 2004. *A new toad of the genus **Ansonia** Amphibia*, *Anura*, *Bufonidae from Sumatra*, *Indonesia*. Hamadryad, 28(1-2):59 – 65

[11] Iskandar, D.T. and Erdelen, W.R. 2006.*Conservation of amphibians and reptiles in Indonesia: issues and problems*. Amph Rept Cons, 4: 60-87.

[12] Ludwig, J.A. and Reynold, J.F. 1988. *Statistical Ecology: A Primer on Methodes and Computing*. Canada: John Wiley & Sons Inc.

[13] Manthey, U. and Denzer, W. 1991. *Die echten Winkelkopfagamen der gattung **Gonocephalus** Kaup (Sauria: Agamidae) II. Allgemeine angaben zur biologie und terraristik.* Sauria, 13(2): 19-22.

[14] Manthey, U and Denzer, W. 1993. *Die echten Winkelkopfagamen der gattung **Gonocephalus** Kaup (Sauria: Agamidae) IV. **chamaeleontinus**-Gruppe.* Sauria, 15(2): 23-28.

[15] Manthey, U. and Schuster, N. 1996. *Agamid Lizard*. United Stated: T.F.H. Publication, Inc.

[16] Manthey, U. 2010. *Agamid Lizard*. Germany: Chimaira Buchhandelsgesellschaft mbH.

[17] Moody, S. 1980. *Phylogenetic and historical biogeographic relationships of the genera in the family Agamidae* (Reptilia, Lacertilia): Unpubl Ph. D. Diss. Univ. Michigan. Ann Arbor: 373.

[18] Ota, H.; Matsui, M.; Hikida, H.; and Mori, A. 1992. *Extreme karyotypic divergence between species of the genus **Gonocephalus** (Reptilia: Squamata: Agamidae) from Borneo and Australia*. Herpetologica, 48: 120–124.

[19] Rachmansah, A. 2009. *Definition of the **Cyrtodactylus agamensis** group and description of its species composition*. Biology, Degree Thesis, Institut Teknologi Bandung.

[20] Ramadhan, G. 2011. *Species of the Genus **Boiga** from The Lesser Sunda Island Compared to Other Indonesian Species*. Biology, Degree Thesis, Institut Teknologi Bandung.

[21] Siler, D.C.; Diesmos, A.C.; and Brown, R.M. 2010. *New loam-swimming skink, genus **Brachymeles** (Reptilia: Squamata: Scincidae) from Luzon and Catanduanes Island*. J Herpetol, 44 (1): 49-60.

[22] Teynié, A.; David, P.; and Ohler, A. 2010. *Note on a collection of amphibians and*

*reptiles from Western Sumatra, Indonesia,with a description of a new species of the genus **Bufo***. Zootaxa, 2416: 1-43.
[23] Uetz, P and Hallerman, J. 2012. ***Gonocephalus***. Available online: http://reptile-database.reptarium.cz (accessed on 14th May 2012).
[24] Zahuranec, B.D. 2000. *Zoogeography and systematics of the laternfishes of the genus **Nannobrachium** (Myctophidae: Lampanyctini)*. Smiths Contrib Zool, 69: 607.

ISSN 2088-9127