ISSN : 0082 - 6340

TREUBIA

A JOURNAL ON ZOOLOGY
OF THE INDO-AUSTRALIAN ARCHIPELAGO

Vol . 37, pp 1-92

December, 2010

Published by

RESEARCH CENTER FOR BIOLOGY
INDONESIAN INSTITUTE OF SCIENCES
BOGOR, INDONESIA

ISSN 0082-6340
Accreditated: A
No. 259/AU1/P2MBI/05/2010

TREUBIA

A JOURNAL ON ZOOLOGY OF THE INDO-AUSTRALIAN ARCHIPELAGO
Vol. 37, pp. 1 – 92, December 2010

Subscription and Exchange

RESEARCH CENTRE FOR BIOLOGY
Jl. Raya Jakarta-Bogor Km 46 Cibinong-Bogor 16911 - Indonesia
email: treubia@gmail.com

Editor's note

It is great that Treubia volume 37 can be published in year 2010. Recently, it was difficult to get appropriate papers since animal taxonomy has not been an attractive subject in the field of biology. There was a lack of submitted manuscripts in 2009 that made Treubia could not be published in year 2009.

This volume of TREUBIA contains five papers of vertebrates and invertebrates. Three papers (nematode, rats and land snail) were from the results of field works in eastern part of Indonesia i.e. West Papua which was rarely explored.

Also, this year Indonesian zoologist' community lost the pioneer and expert in parasite taxonomy, Dr. Sampurno Kadarsan. His name has been used to name new species of leeches, tick, rat, lizard and frog by his successors to acknowledge his impact and contribution. He served as an editor of Treubia from 1992 to 1997 and was a proof reader for some years until his permanent retarded eye sight. So, his death was a great lost for all of us especially for the Museum Zoologicum Bogoriense.

Finally, I would like to thank all of the co-editors, referees, computing assistant, secretary and administrative assistant for their collaborative work. I acknowledge financial support from the Director of Research Centre for Biology LIPI to publish this precious journal.

Cibinong, 15 December 2010

Dewi M. Prawiradilaga
Chief Editor

Treubia 2010, 37: 49 - 82

Received : 8 October 2010
Accepted : 22 November 2010

TAXONOMIC STATUS OF SPINY RATS (*MAXOMYS* JENTINK, RODENTIA) FROM INDONESIA AND MALAYSIA BASED ON MORPHOLOGICAL STUDY

Anang Setiawan Achmadi

Museum Zoologicum Bogoriense, Research Center for Biology, Indonesian Institute of Sciences. Jl.Raya Jakarta-Bogor Km. 46, Cibinong 16911, Indonesia
Corresponding email addresses:
gudelly@gmail.com

ABSTRACT

The morphological study was focused on the analysis of morphometric variations of the spiny rats (*Maxomys* Jentink) across their Indonesian and Malaysian ranges in order to clarify the taxonomic status of this genus. The genus was widespread throughout South Asia, and many taxa (species and subspecies) have been described. Univariate and multivariate analyses (Principal Component Analyses and Discriminant Function Analyses) were carried out based on 24 craniometric characters in 187 skulls. Results indicated that *Maxomys* consist of 13 species: *M. whiteheadi, M. surifer, M. rajah, M. ochraceiventer, M. baeodon, M. alticola, M. musschenbroekii, M. hellwaldii, M. wattsi, M. pagensis, M. bartelsii, M. inas* and one distinct population of *M. whiteheadi* from 16 known species of *Maxomys* in Malaysia and Indonesian archipelago. The multiple regression analyses showed no sexual dimorphism in relation to the characters used; however all characters were geographically significant in some species.

Key words: geographical variation, *Maxomys*, morphology, statistical analyses, taxonomy.

INTRODUCTION

Recent reappraisal of the mammalian fauna of the Indo-Malayan region has pointed to a dramatically different view of the biogeographic boundaries of the Indo-Malayan and Australian regions from the traditional ones based on Wallace's and Weber's lines (Kitchener *et al.* 1990. Kitchener & Maryanto 1995). The Indo-Malayan region presents a unique opportunity to study either intra or inter specific morphological variations in relation to geographical barriers. Comprehensive and accurate re-evaluation of morphological characters in certain cases resulted in the discovery of new species. Such re-evalution has been conducted in Indonesia for bats, rodents and primates (Kitchener & Maryanto 1993, Maryanto *et. al.* 1997, Merker & Groves 2006).

Spiny rats, well known as *Maxomys*, are common rats which can be found in lowland and mountain forests up to 3000 m a.s.l., from primary forests, secondary forests, plantations and disturbed areas adjacent to forests (Payne *et al.* 1985, Corbet & Hill 1992, Francis 2008). The 16 known species of *Maxomys* have widespread distributions starting from the mainland of Southeast Asia, throughout much of the Indochinese region, Malaya Peninsular to Borneo, Sulawesi, and Palawan, as well as on several smaller islands of the Sunda Shelf (Ruedas & Kirsch 1997, Corbet & Hill 1992, Musser & Carleton 2005).

A number of previous studies have been conducted in order to reveal the taxonomic status of *Maxomys*. However, many scientists have suggested that detailed and accurate re-evalution are still needed before the systematics of this genus is stable. Ruedas & Kirsch (1997) noted that *Maxomys* is a species-rich genus embracing a wide range of morphological, geographic, ecological, and altitudinal variations, and that most species still require rigorous definition.

Musser & Newcomb (1983), Corbet & Hill (1992), Watts & Baverstock (1994), Musser & Carleton (2005) all showed that *Maxomys* was not closely related to *Rattus* as earlier authors (e.g. Ellerman, 1941) had placed it. Musser *et al.* (1979), Corbet & Hill (1992), Musser & Carleton (2005) made detailed definitions of the Sundaic species of *Maxomys,* and offered a working hypothesis about the taxonomy and geographical distribution of *Maxomys.* The genus is divided into 16 species: *M. alticola*, *M. bartelsii, M. baeodon*, *M. dollmani*, *M. hellwaldii*, *M. hylomyoides*, *M. inas*, *M. inflatus, M. moi*, *M. musschenbroekii*, *M. ochraceiventer, M. pagensis, M. panglima, M. rajah, M. surifer* and *M. wattsi.* There was no systematic revision of this genus since then. This re-evaluation of the morphological characters of *Maxomys* was conducted with the main goal to reveal the morphological and geographical variations within this genus. The hypothesis tested here is whether there is significant variation in characters within *Maxomys* species from Indonesia and Malaysia

MATERIALS AND METHODS

A total of 187 skulls from adult specimens consisting of *M. whiteheadi, M. rajah, M. ochraceiventer, M. surifer, M. baeodon, M. pagensis, M. bartelsii, M. inas, M. musschenbroekii, M. hellwaldii, M. wattsi,* and *M. alticola* were studied (Appendix 1). All specimens studied were deposited at Museum Zoologicum Bogoriense (MZB) Indonesia, Museum Zoological UNIMAS (MZU) Malaysia and Raffles Museum, Singapore. Specimens were judged as adult based on fusion of basisphenoid or basioccipital sutures. Twenty four measurements of craniometric characters were made using digital calipers (Mitutoyo^{TM}) to 0.01 mm. The dimensions and limits are illustrated in Figure 1 and defined in Maryanto (2003). The characters were: GSL (greatest skull length), POW (post orbital width), ZB (zygomatic width), BoZP (breadth of zygomatic plate), IOB (interorbital breadth), NL (nasal length), NW (nasal width), BB (breadth of braincase), BH (braincase height), DL (length of diasthema), PL (palatal length), UMR (upper molar tooth row), IFL (length of incisive foramina), IFB (breadth of incisive foramina), M^1W (upper molar 1 width), M^2W (upper molar 2 width), M^3W (upper molar 3 width), M^1M^1 (distance of right-left upper molar 1), M^2M^2 (distance of right-left upper molar 2), M^3M^3 (distance of right-left upper molar 3), BL (bulla length), MSW

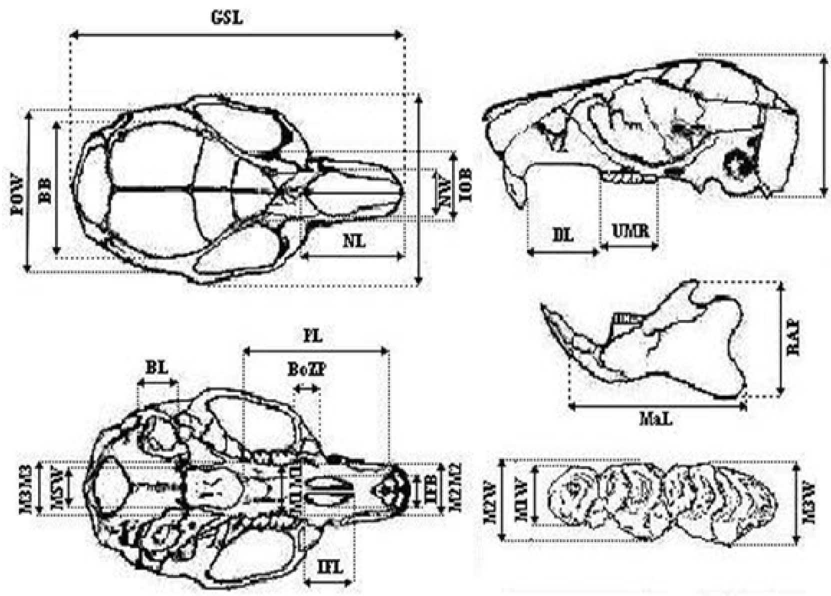

Figure 1. Views of cranium and molars of *Maxomys*, showing limits of cranial and dental measurements. See text for abbreviations and additional information

(mesopterygoid fossa width), RAP (ramus angular process), MaL (length of mandible).

Two way statistical analyses were used, univariate and multivariate analyses, as described in Maryanto & Sinaga (1998) and Maryanto (2003). Principal Component Analyses (PCA) and Discriminant Function Analyses (DFA) were initially run for all characters for all species as separated groups. Then DFA were run for a subset of five or more characters, based on criteria of minimised Wilk's lambda to select the best discriminating variables. The results obtained with a reduced character set were very similar to those based on all characters (Kitchener *et al.* 1993).

RESULTS AND DISCUSSION

Univariate Statistics

Mean, standard deviation, minimum and maximum values and samples size were represented in Table 1. These suggest that *M. hellwaldii* is the largest in size for all skull characters and *M. whiteheadi* (Small size or S) is the smallest species for most characters except for ZP, UMR, IFL, M1W, M^2W, M^3W and BL larger than *M. baeodon* and NW, HB, D, and MSW slightly larger than *M. inas.* The means of *M. whiteheadi* Large size (L) are slightly smaller than *M. ochraceiventer* and clearly larger than *M. whiteheadi* Small size (S) and *M. baeodon.*

Table 1. Univariate analysis : mean, number of individuals, standard deviation, maximum and minimum values of skull and dentary characters.

Species	GSL	BB	ZB	ZP	IOB	NL	NW	POW	HB	D	PL	UMR
Maxomys whiteheadi (S)												
N	90	90	90	90	90	90	90	90	90	90	90	90
Mean	32.40	13.69	14.75	2.87	5.62	10.86	3.71	13.44	9.26	8.10	12.38	5.36
S D	1.32	0.49	0.53	0.22	0.29	0.62	0.25	0.47	0.36	0.46	0.52	0.26
Minimum	29.08	12.45	13.31	2.40	4.94	9.12	3.09	11.99	8.39	7.27	11.51	4.84
Maximum	35.13	14.54	15.92	3.52	6.25	12.36	4.17	14.27	9.97	9.35	13.78	6.14
Maxomys whiteheadi (L)												
N	21	21	21	21	21	21	21	21	21	21	21	21
Mean	36.38	14.67	16.35	3.22	6.21	12.29	3.98	14.44	9.93	9.36	14.34	5.89
S. D	1.39	0.52	0.64	0.29	0.48	0.66	0.26	0.44	0.46	0.65	0.72	0.31
Minimum	34.19	13.22	15.31	2.79	5.35	11.20	3.37	13.39	9.04	8.17	13.11	5.23
Maximum	39.71	15.43	18.21	3.72	6.99	13.83	4.38	15.15	11.07	10.93	16.02	6.44
Maxomys musschenbroekii												
N	11	11	11	11	11	11	11	11	11	11	11	11
Mean	37.15	14.98	17.17	3.46	6.24	12.80	3.89	14.71	10.34	9.33	14.46	6.31
S. D	1.27	0.35	0.53	0.25	0.19	0.69	0.33	0.14	0.26	0.33	0.55	0.19
Minimum	35.17	14.5	16.15	3.17	5.89	11.86	3.33	14.47	9.95	8.85	13.87	5.86
Maximum	39.66	15.57	18.02	4.06	6.52	14.20	4.34	14.91	10.75	9.85	15.82	6.61

Table 1. continued

Species	GSL	BB	ZB	ZP	IOB	NL	NW	POW	HB	D	PL	UMR
Maxomys ochraceiventer												
N	3	3	3	3	3	3	3	3	3	3	3	3
Mean	37.69	15.74	16.59	3.01	6.60	12.60	4.33	14.61	10.63	9.26	14.57	6.12
S. D	0.58	0.21	0.27	0.13	0.39	0.29	0.04	0.22	0.38	0.07	0.21	0.15
Minimum	37.26	15.54	16.29	2.86	6.23	12.34	4.30	14.40	10.37	9.19	14.45	5.94
Maximum	38.35	15.96	16.81	3.10	7.01	12.91	4.37	14.83	11.06	9.33	14.81	6.22
Maxomys baeodon												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	34.09	14.31	15.05	2.38	6.50	12.38	4.05	13.92	10.23	9.24	12.86	4.56
S. D	0.75	0.41	0.45	0.34	0.24	0.83	0.21	0.62	0.50	0.26	0.81	0.22
Minimum	33.10	13.92	14.49	1.95	6.15	11.35	3.87	13.12	9.73	8.92	11.23	4.25
Maximum	35.20	15.04	15.66	2.77	6.83	13.26	4.41	14.80	11.10	9.53	13.36	4.86
Maxomys wattsi												
N	4	4	4	4	4	4	4	4	4	4	4	4
Mean	41.70	16.03	18.73	3.17	7.42	16.95	4.70	15.80	11.52	10.74	16.77	6.63
S. D	1.39	0.67	0.34	0.25	0.12	0.79	0.20	0.33	0.21	0.47	0.57	0.20
Minimum	40.43	15.13	18.25	2.81	7.29	16.27	4.52	15.47	11.24	10.21	15.95	6.38
Maximum	43.56	16.70	18.98	3.39	7.54	17.85	4.98	16.25	11.75	11.36	17.25	6.80

Table 1. continued

Species	**IFL**	**IFB**	**M1W**	**M^2W**	**M^3W**	**M^1M^1**	**M^2M^2**	**M^3M^3**	**BL**	**MSW**	**RAP**	**DL**
Maxomys whiteheadi (S)												
N	90	90	90	90	90	90	90	90	90	90	90	90
Mean	4.58	2.40	1.55	1.46	1.14	2.95	3.35	3.81	4.51	2.49	7.85	15.66
S. D	0.30	0.18	0.09	0.09	0.09	0.22	0.26	0.27	0.24	0.17	0.44	1.19
Minimum	3.95	2.07	1.34	1.24	0.83	2.27	2.76	3.12	4.00	2.03	6.73	5.94
Maximum	5.30	2.85	1.79	1.68	1.36	3.49	4.01	4.48	5.40	3.09	9.11	17.50
Maxomys whiteheadi (L)												
N	21	21	21	21	21	21	21	21	21	21	21	21
Mean	5.18	2.80	1.64	1.56	1.18	3.53	3.85	4.30	4.76	2.78	8.97	17.41
S. D	0.42	0.27	0.10	0.09	0.09	0.32	0.23	0.23	0.46	0.30	0.44	0.91
Minimum	4.52	2.20	1.45	1.40	1.04	3.05	3.50	4.03	3.77	2.16	8.40	16.24
Maximum	5.94	3.16	1.81	1.73	1.34	4.18	4.52	5.04	5.49	3.21	10.46	19.80
Maxomys musschenbroekii												
N	11	11	11	11	11	11	11	11	11	11	11	11
Mean	5.37	2.59	1.88	1.79	1.25	3.25	3.77	4.41	5.25	2.97	9.63	19.13
S. D	0.26	0.19	0.08	0.05	0.06	0.12	0.14	0.18	0.20	0.20	0.33	0.90
Minimum	5.08	2.32	1.75	1.72	1.15	3.09	3.51	4.11	5.04	2.63	9.19	18.31
Maximum	5.89	2.86	2.02	1.91	1.35	3.47	3.94	4.72	5.76	3.36	10.16	21.55
Maxomys ochraceiventer												
N	3	3	3	3	3	3	3	3	3	3	3	3
Mean	4.60	2.78	1.87	1.76	1.43	3.47	3.85	4.27	4.79	2.86	9.10	17.93
S. D	0.22	0.29	0.04	0.10	0.17	0.29	0.16	0.17	0.15	0.03	0.14	0.32
Minimum	4.43	2.49	1.83	1.65	1.24	3.18	3.70	4.10	4.62	2.83	8.97	17.57
Maximum	4.84	3.06	1.90	1.82	1.57	3.76	4.01	4.43	4.88	2.89	9.25	18.16

Table 1. continued

Species	IFL	IFB	M1W	M^2W	M^3W	M^1M^1	M^2M^2	M^3M^3	BL	MSW	RAP	DL
Maxomys baeodon												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	4.44	2.67	1.53	1.45	1.04	3.99	4.00	4.23	3.66	2.64	7.91	16.83
S. D	0.24	0.19	0.03	0.09	0.10	0.39	0.36	0.36	0.41	0.22	0.45	0.87
Minimum	4.07	2.42	1.49	1.27	0.94	3.52	3.48	3.70	3.22	2.40	7.31	15.69
Maximum	4.74	2.87	1.58	1.52	1.23	4.53	4.43	4.61	4.18	3.00	8.65	18.25
Maxomys wattsi												
N	4	4	4	4	4	4	4	4	4	4	4	4
Mean	5.91	3.42	2.10	1.98	1.46	3.50	4.03	4.42	5.34	3.06	9.55	21.36
S. D	0.46	0.08	0.02	0.04	0.13	0.19	0.32	0.19	0.19	0.09	0.45	0.84
Minimum	5.36	3.36	2.07	1.94	1.32	3.22	3.63	4.23	5.12	2.95	9.11	20.32
Maximum	6.36	3.53	2.12	2.03	1.57	3.64	4.34	4.66	5.57	3.15	9.96	22.25

Table 1. continued

Species	GSL	BB	ZB	ZP	IOB	NL	NW	POW	HB	D	PL	UMR
Maxomys surifer												
N	13	13	13	13	13	13	13	13	13	13	13	13
Mean	38.74	16.00	16.62	3.22	6.03	13.80	3.96	15.44	10.57	10.57	15.73	6.03
S. D	0.95	0.26	0.36	0.27	0.35	0.10	0.23	0.24	0.31	0.31	0.34	0.15
Minimum	37.45	15.42	15.94	2.81	5.48	13.55	3.66	15.01	10.11	9.92	15.11	5.79
Maximum	39.89	16.45	17.14	3.71	6.58	13.96	4.38	15.82	11.33	11.00	16.16	6.29
Maxomys rajah												
N	12	12	12	12	12	12	12	12	12	12	12	12
Mean	41.44	17.01	18.82	3.65	6.65	15.60	4.60	16.37	11.61	11.38	17.45	6.78
S. D	1.82	0.58	0.81	0.33	0.27	0.89	0.25	0.49	0.27	0.37	0.35	0.26
Minimum	39.09	16.48	17.59	3.23	6.09	13.96	4.31	15.32	11.24	10.71	16.74	6.39
Maximum	44.68	18.14	20.06	4.16	6.99	16.85	5.04	17.04	11.98	12.04	17.85	7.17
Maxomys pagensis												
N	3	3	3	3	3	3	3	3	3	3	3	3
Mean	47.02	17.53	19.89	3.81	7.33	18.09	5.44	16.78	12.10	12.60	18.35	6.69
S. D	0.58	0.59	1.34	0.20	0.08	0.65	0.43	0.41	0.20	0.43	0.19	0.13
Minimum	46.47	16.97	19.01	3.58	7.24	17.34	4.96	16.49	11.91	12.28	18.18	6.54
Maximum	47.63	18.15	21.43	3.96	7.40	18.54	5.77	17.24	12.31	13.08	18.56	6.77
Maxomys hellwaldi												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	47.71	18.55	20.82	4.22	7.44	18.63	5.48	18.01	12.51	11.87	17.47	6.91
S. D	1.00	0.42	0.48	0.24	0.26	0.75	0.28	0.44	0.16	0.33	0.59	0.14
Minimum	46.01	17.99	20.29	3.95	7.20	17.46	5.09	17.39	12.27	11.46	16.56	6.74
Maximum	48.92	19.12	21.43	4.64	7.86	19.56	5.82	18.62	12.69	12.29	18.09	7.07

Table 1. continued

Species	GSL	BB	ZB	ZP	IOB	NL	NW	POW	HB	D	PL	UMR
Maxomys bartelsii												
N	11	11	11	11	11	11	11	11	11	11	11	11
Mean	38.46	14.72	16.39	3.27	6.45	13.92	3.93	14.57	10.35	10.47	14.90	5.31
S. D	0.80	0.36	0.38	0.23	0.15	0.40	0.21	0.36	0.35	0.27	0.39	0.13
Minimum	37.49	14.12	15.69	3.01	6.19	13.30	3.60	13.97	9.89	9.86	14.30	5.10
Maximum	39.95	15.25	16.81	3.65	6.76	14.69	4.19	15.09	11.19	10.79	15.41	5.51
Maxomys alticola												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	37.76	16.01	16.66	2.62	7.37	14.70	4.24	15.37	11.57	9.95	14.95	5.38
S. D	0.54	0.23	0.61	0.22	0.33	0.60	0.20	0.39	0.40	0.56	0.69	0.09
Minimum	37.08	15.62	15.70	2.35	7.09	13.83	3.87	14.84	10.81	9.12	14.13	5.29
Maximum	38.52	16.31	17.47	2.98	7.85	15.32	4.42	15.94	11.90	10.61	16.21	5.51
Maxomys inas												
N	1	1	1	1	1	1	1	1	1	1	1	1
	33.74	14.16	14.87	3.15	5.76	11.82	3.41	13.69	9.17	7.74	12.83	5.46

Table 1. continued

Species	IFL	IFB	M^1W	M^2W	M^3W	M^1M^1	M^2M^2	M^3M^3	BL	MSW	RAP	DL
Maxomys surifer												
N	13	13	13	13	13	13	13	13	13	13	13	13
Mean	5.41	2.92	1.83	1.71	1.44	3.60	3.61	3.78	4.78	2.53	8.67	19.46
S. D	0.25	0.21	0.08	0.09	0.06	0.15	0.14	0.21	0.13	0.15	0.30	0.37
Minimum	5.08	2.56	1.69	1.56	1.36	3.31	3.34	3.29	4.43	2.34	8.17	18.81
Maximum	5.87	3.28	1.95	1.85	1.57	3.85	3.79	4.04	4.95	2.93	9.42	19.97
Maxomys rajah												
N	12	12	12	12	12	12	12	12	12	12	12	12
Mean	5.80	3.04	2.08	2.00	1.58	4.08	4.25	4.58	4.61	2.85	10.58	21.18
S. D	0.28	0.20	0.08	0.09	0.10	0.20	0.24	0.25	0.31	0.13	0.56	1.14
Minimum	5.50	2.81	1.96	1.87	1.43	3.79	3.88	4.07	4.09	2.56	9.81	19.54
Maximum	6.52	3.44	2.22	2.17	1.73	4.46	4.62	4.88	5.06	3.11	11.58	22.67
Maxomys pagensis												
N	3	3	3	3	3	3	3	3	3	3	3	3
Mean	6.74	3.31	2.24	2.02	1.57	4.19	4.47	5.03	5.17	3.02	10.92	23.61
S. D	0.55	0.19	0.05	0.03	0.10	0.25	0.11	0.15	0.57	0.33	0.43	0.74
Minimum	6.27	3.19	2.19	1.99	1.48	3.90	4.34	4.89	4.52	2.82	10.59	22.95
Maximum	7.35	3.52	2.29	2.04	1.68	4.35	4.55	5.18	5.51	3.40	11.41	24.41
Maxomys hellwaldi												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	7.05	3.37	2.07	1.87	1.33	4.18	4.55	5.17	7.28	3.41	11.35	23.86
S. D	0.38	0.12	0.09	0.11	0.12	0.29	0.29	0.31	1.29	0.11	0.35	0.80
Minimum	6.38	3.18	1.95	1.74	1.19	3.90	4.20	4.85	6.21	3.29	10.69	23.12
Maximum	7.57	3.52	2.20	2.06	1.52	4.63	4.99	5.73	9.38	3.57	11.7	24.87

Table 1. continued

Species	IFL	IFB	M^1W	M^2W	M^3W	M^1M^1	M^2M^2	M^3M^3	BL	MSW	RAP	DL
Maxomys bartelsii												
N	11	11	11	11	11	11	11	11	11	11	11	11
Mean	6.17	2.62	1.63	1.51	1.09	3.58	3.78	4.14	5.13	2.40	7.96	19.02
S. D	0.26	0.14	0.07	0.05	0.04	0.26	0.20	0.16	0.20	0.15	0.24	0.34
Minimum	5.76	2.39	1.51	1.42	1.03	3.31	3.56	3.91	4.66	2.17	7.58	18.61
Maximum	6.62	2.82	1.74	1.58	1.18	4.27	4.25	4.54	5.32	2.70	8.23	19.56
Maxomys alticola												
N	6	6	6	6	6	6	6	6	6	6	6	6
Mean	5.63	2.73	1.76	1.69	1.24	4.04	4.01	4.19	4.47	2.97	9.07	18.46
S. D	0.29	0.12	0.09	0.04	0.06	0.19	0.25	0.14	0.26	0.08	0.40	0.52
Minimum	5.20	2.60	1.68	1.65	1.16	3.69	3.60	4.04	4.22	2.83	8.64	17.88
Maximum	5.97	2.93	1.88	1.77	1.32	4.21	4.28	4.40	4.82	3.06	9.79	19.35
Maxomys inas												
N	1	1	1	1	1	1	1	1	1	1	1	1
	4.77	2.27	1.55	1.46	1.03	3.09	3.35	3.93	4.89	2.30	8.35	16.45

Multiple Regression

Multiple regression analysis was employed to determine the influence of sex in variation. All of the characters examined were not significantly (P<0.05) influenced by sex (Table 2). Consequently, multivariate analyses were combined for males and females.

Table 2. Multiple regression on sex, locality and interactions among these factors in *Maxomys* for skull and dentary characters. F values are presented for main effects with significance levels are *) 0.05>p>0.01; **) 0.01>p>0.001; and ***) P>0.001

Dependent Variable	Sex	Locality	Interaction
GSL	1.297	12.062***	0.260
BB	0.099	9.372***	0.414
ZB	0.504	12.616***	0.365
ZP	1.711	8.983***	0.971
IOB	1.540	16.442***	0.430
NL	0.433	13.686***	0.302
NW	0.964	11.050***	0.107
POW	0.770	0.858***	0.592
HB	0.679	11.679***	0.586
D	0.523	8.980***	0.158
PL	0.955	7.474***	0.183
UMR	1.878	11.147***	1.141
IFL	0.547	15.472***	0.320
IFB	2.291	4.879***	0.634
M1W	1.398	12.826***	0.449
M2W	0.827	9.988***	0.541
M3W	0.224	4.171***	0.873
M1M1	0.157	6.658***	0.502
M2M2	0.336	6.775***	0.814
M3M3	1.150	11.148***	0.697
BL	0.036	14.501***	0.613
MSW	0.027	13.255***	0.899
RAP	0.725	10.766***	0.266
DL	0.362	12.986***	0.497

Multivariate Analyses

Morphological Variation Within Genus Maxomys

PCA analysis of morphology *Maxomys* indicates significant variation between or within *M. whiteheadi* (L), *M. whiteheadi* (S), *M. rajah, M. surifer, M. baeodon, M. ochraceiventer, M. alticola, M. musschenbroekii, M. hellwaldii, M. wattsi, M. pagensis, M. bartelsii* and *M. inas.* Five principal components (PCs) extracted from 24 measurements accounted for 90,0 % of the total variation (Table 3). The DFA is based on 24 characters, and repeated using a reduced set of five characters in order to avoid over fitting the data (Kitchener & Maryanto 1995). The five characters were selected by minimising Wilk's lambda on the first canonical variate. The DFA plot is based on five characters similar to the complete characters set (Maryanto 2003). The five characters in the DFA are GSL, BB, ZB, NL, PL (Table 4).

Table 3. Total variation accounted for 24 measurements on five principal components (PCs)

	Initial Eigenvalues			**Extraction Sums of Squared Loadings**		
	Total	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**
1	17.71	73.80	73.80	17.71	73.80	73.80
2	1.44	6.01	79.81	1.44	6.01	79.81
3	1.08	4.52	84.32	1.08	4.52	84.32
4	0.82	3.41	87.73	0.82	3.41	87.73
5	0.54	2.27	90.00	0.54	2.27	90.00

Extraction Method: Principal Component Analysis.

Table 4. Standardised and unstandardised (in the brackets) canonical variate function coefficients derived from analysis of five characters

	Function				
	1	**2**	**3**	**4**	**5**
GSL	0.017(0.013)	0.830(0.653)	-0.603(-0.474)	1.100(0.866)	-0.794(-0.625)
BB	0.461(0.984)	-0.108(-0.230)	-0.496(-1.059)	0.423(0.904)	0.762(1.626)
ZB	0.005(0.010)	0.091(0.164)	1.436(2.581)	-0.176(-0.316)	0.253(0.454)
NL	0.477(0.754)	0.433(0.686)	-0.196(-0.311)	-0.963(-1.524)	0.149(0.236)
PL	0.476(0.886)	-1.212(-2.254)	-0.048(-0.090)	-0.290(-0.539)	-0.236(-0.439)
(Constant)	(-36.865)	(0.182)	(-3.679)	(-12.610)	(-5.679)

This analysis extracted five significant functions, which accounted for 100% of total variations. Discriminant Functions (DF) 1, 2, 3, 4, and 5 accounted for 88.49 % (P<0.001; df : 60), 4.92 % (P<0.001; df : 44), 3.23 % (P<0.001; df : 30), 1.88 % (P<0.001; df : 18) and 1.49 % (P<0.001; df : 8) of the variation between populations respectively (Table 5) with 87.7 % of the originally grouped cases correctly classified and 12.3% misclassified. Furthermore, the number of functions at group centroids between skull, dental and dentary characters from each species are distinct.

Table 5. Total explained variation for 24 measurements on five Discriminant functions (DFs)

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	21.38(a)	88.49	88.49	0.98
2	1.19(a)	4.92	93.41	0.74
3	0.78(a)	3.23	96.63	0.66
4	0.45(a)	1.88	98.51	0.56
5	0.36(a)	1.49	100.00	0.51

a. First 5 canonical discriminant functions were used in the analysis.

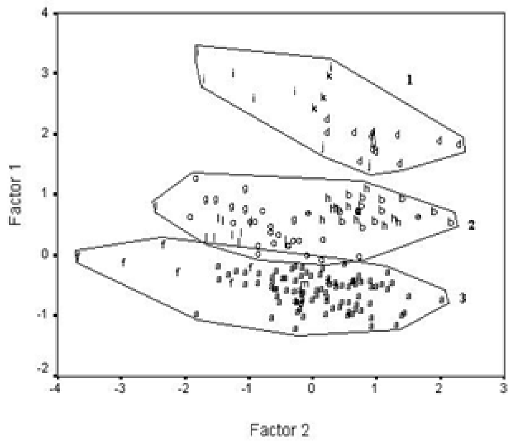

Figure 2. Plot of scores on factor axes 2 and 1 from principal component analysis (PCA) of 24 skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

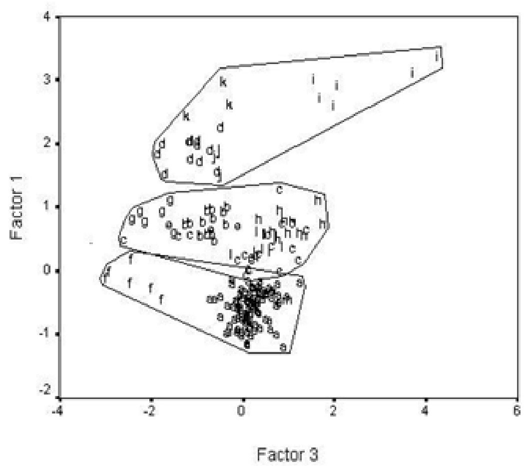

Figure 3. Plot of scores on factor axes 3 and 1 from principal component analysis (PCA) of 24 skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

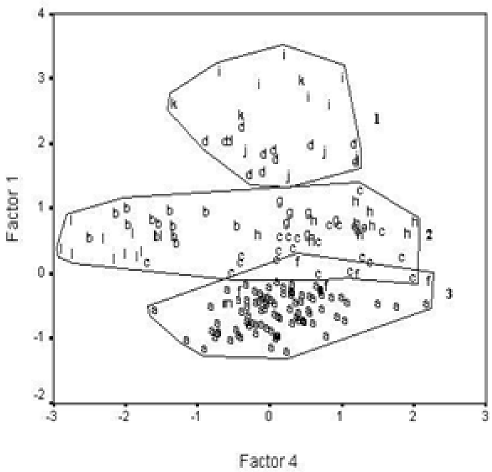

Figure 4. Plot of scores on factor axes 4 and 1 from principal component analysis (PCA) of 24 skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

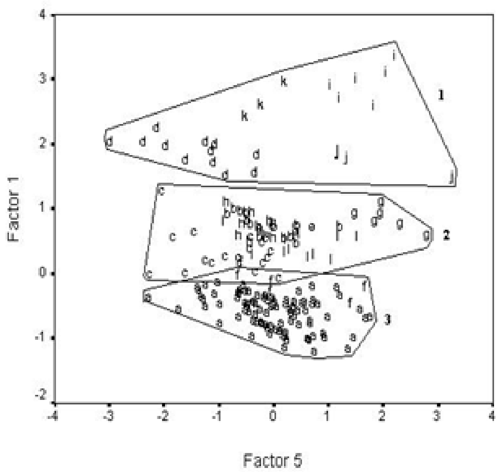

Figure 5. Plot of scores on factor axes 5 and 1 from principal component analysis (PCA) of 24 skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

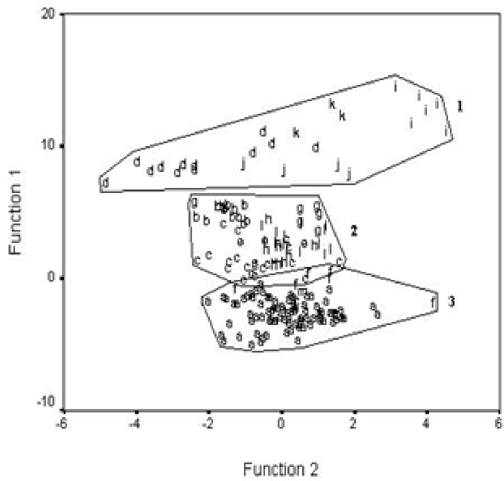

Figure 6. Plot of scores on function axes 2 and 1 from discriminant function of five dominant variables skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

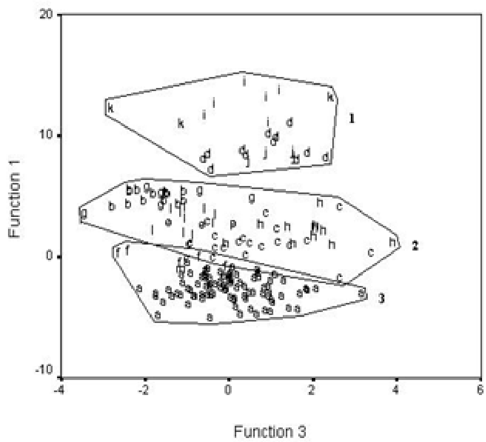

Figure 7. Plot of scores on function axes 3 and 1 from discriminant function of five dominant variables skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

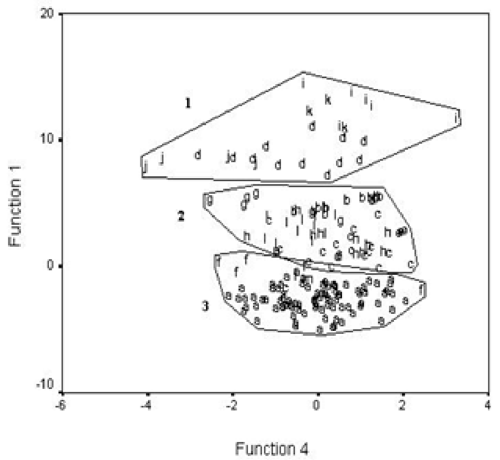

Figure 8. Plot of scores on function axes 4 and 1 from discriminant function of five dominant variables skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

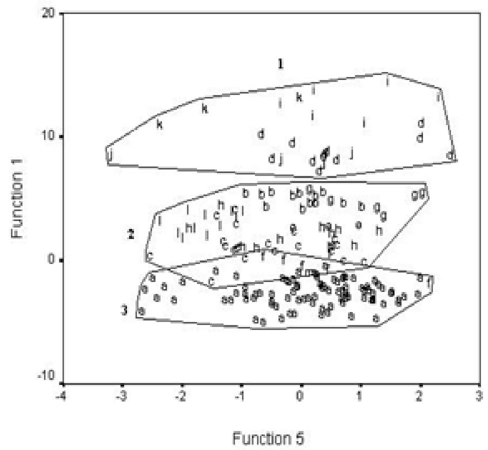

Figure 9. Plot of scores on function axes 5 and 1 from discriminant function of five dominant variables skull measurements of *Maxomys.* Groups classification: a, *M. whiteheadi* (S); b, *M. surifer;* c, *M. whiteheadi* (L); d, *M. rajah;* e, *M. ochraceiventer;* f, *M. baeodon;* g, *M. alticola;* h, *M. musschenbroekii;* i, *M. hellwaldii;* j, *M. wattsi;* k, *M. pagensis;* l, *M. bartelsii;* m, *M. inas;* (1), large body size; (2), medium body size; and (3), small body size

The configurations of PCA and DFA plots suggest that spiny rats in Indonesia and Malaysia comprise thirteen major morphological distinctness (figures 2; 3; 4; 5; 6; 7; 8; 9). These are: *M. rajah, M. surifer, M. baeodon, M. alticola, M. ochraceiventer, M. whiteheadi* (S)*, M. musschenbroekii, M. hellwaldii, M. wattsi, M. pagensis, M. bartelsii, M. inas* and the two distinct populations of *M. whiteheadi* (L). Plots of PCA and DFA show that the genus *Maxomys* is divided into three major groups based on body size: group 1 has large body size and contains four species: *M. rajah, M. pagensis, M. wattsi,* and *M. hellwaldii.* Group 2 contains medium body sized species: *M. surifer, M. alticola, M. bartelsii, M. musschenbroekii, M. ochraceiventer* and *M. whiteheadi* (L). Group 3 has small body size and comprises *M. whiteheadi* (S), *M. baeodon* and *M. inas.*

Maxomys whiteheadi (L) has distinct morphological characters from the other *Maxomys* shown by good separation from other species and large variation in 24 of the skull, dental and dentary characters measured. This species seems similar in morphological features to *M. whiteheadi* (S) and *M. ochraceiventer,* supported by overlapping measurements in certain individuals of skull characters. Characters examined of this species are strictly distinct from *M. ochraceiventer* collected from entire Borneo island.

Geographical variation within Maxomys whiteheadi Small and Large based on morphological characters

DFA analysis of geographical variation within *M. whiteheadi* (S) indicates significant variation from three different regions: Sumatra, southern region of Borneo, and northern region of Borneo. Two discriminant functions extracted accounted for a 100% of the total variation (Table 6). The DFA was done on all 24 characters and repeated using a reduced set of seven characters in order to avoid over fitting the data (Kitchener & Maryanto 1995). The seven characters were selected by minimising Wilk's lambda on the first canonical variate. The DFA plot is based on seven characters similar to the complete characters set (Maryanto 2003). The seven characters in the DFA are BB, IOB, NL, NW, M^1M^1, M^3M^3, and RAP (Table 7). This analysis extracted two significant functions, which accounted for 100% of total variations. Discriminant Functions (DF) 1 and 2 accounted for 94.04% ($P<0.001$; df : 14) and 5.96% ($P<0.05$; df : 6) of the variation between populations respectively (Table 6) with 88.2% originally grouped cases correctly classified and 12.9% misclassified; 82.9% of cross-validated grouped cases were correctly classified. Furthermore, a number of functions at group centroids between skull, dental and dentary characters from each species are also distinct.

Table 6. Total explained variation for 24 measurements on two Discriminant functions (DFs)

Function	Eigenvalue	% of variance	Cumulative %	Canonical Correlation
1	3.35 (a)	94.04	94.04	0.88
2	0.21(a)	5.96	100.00	0.42

Table 7. Standardised and unstandardised (in the brackets) canonical variate function coefficients derived from analysis of seven characters

	Function	
	1	2
BB	1.034(2.558)	0.059(0.145)
IOB	-0.691(-2.522)	-0.462(-1.684)
NL	0.820(1.413)	0.119(0.205)
NW	0.334(1.663)	0.143(0.714)
M1M1	-0.390(-2.044)	0.551(2.890)
M3M3	-0.509(-2.000)	0.580(2.282)
RAP	0.009(0.019)	-0.944(-2.089)
(Constant)	(-28.725)	(1.922)

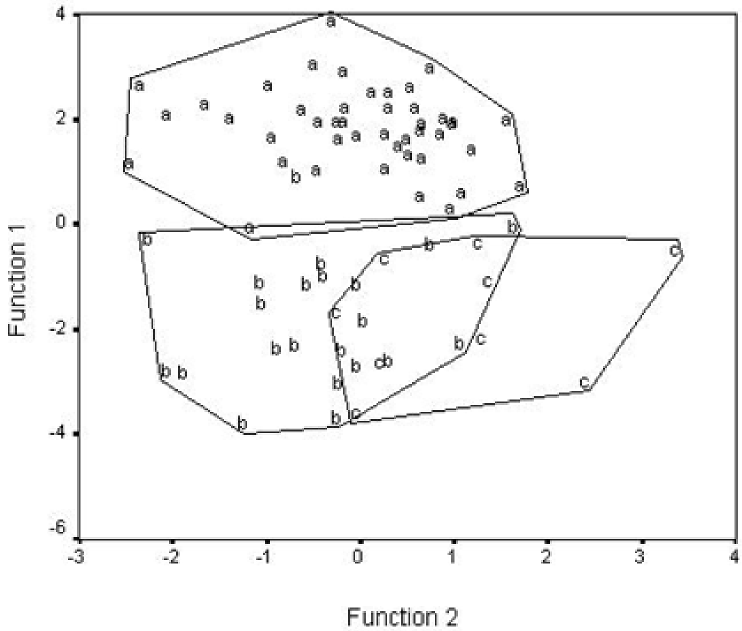

Figure 10. Plot of scores on function axes 2 and 1 from discriminant function of seven dominant variables skull measurements from *M. whiteheadi* (S). Group classifications: a, Southern Borneo; b, Sumatra; and c, Northern Borneo

The configuration of DFA plots suggests that *M. whiteheadi* (S) is divided into three major geographical populations (Figure 10). The first group comprises populations from (1) Kutai, East Kalimantan and DAS Sebangau, Central Kalimantan; (2) Kayan Mentarang; North-eastern part of Kalimantan; and (3) Mount Palung, Ketapang, West Kalimantan. The second group comprises populations from Sarawak (Northern Borneo; Kubah National Park and UNIMAS peatswamp forest), and the third group comprises populations from the northern part (Deli and South Tapanuli) and the southeastern part (Kalianda, Lampung) of Sumatra. The populations from Sumatra are slightly similar in skull features and some characters overlap for some individuals from Northern or Southern Borneo. However, the populations from Northern Borneo are clearly distinct from Southern Borneo populations. This distinction possibly reflects geographical barriers such as mountains, highlands or large rivers in Borneo.

The DFA plots for *M. whiteheadi* (L) show that there is geographical variation among the populations. Within this populations, there is significant variation between Borneo mainland (represented by specimens from Melak, Kalimantan, Sarawak, and Sabah) and those from both Sumatra and Peninsular Malaysia (Figure 11-13).

Four discriminant functions were extracted which accounted for 100% of the total variation (Table 8). Discriminant Functions (DF) 1, 2, 3 and 4 accounted for 92.05% ($P<0.001$; df : 32), 6.04% ($P<0.001$; df : 21), 1.44% ($P<0.01$; df : 12), and 0.47% ($P>0.05$; df : 5) of the variation between populations respectively with 100% of the originally grouped cases correctly

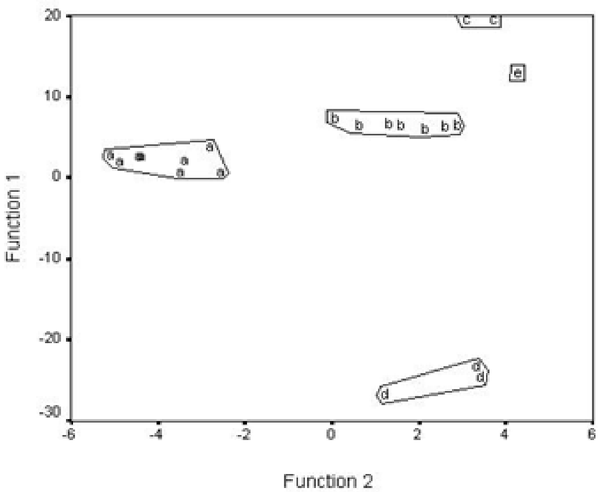

Figure 11. Plot of scores on function axes 2 and 1 from discriminant function of eight dominant variables skull measurements from *M. whiteheadi* (L). Group classifications: a, Southern Borneo; b, Sumatra Island; c, Malaya Peninsular; d, Northwestern Borneo; and e, Northeastern Borneo

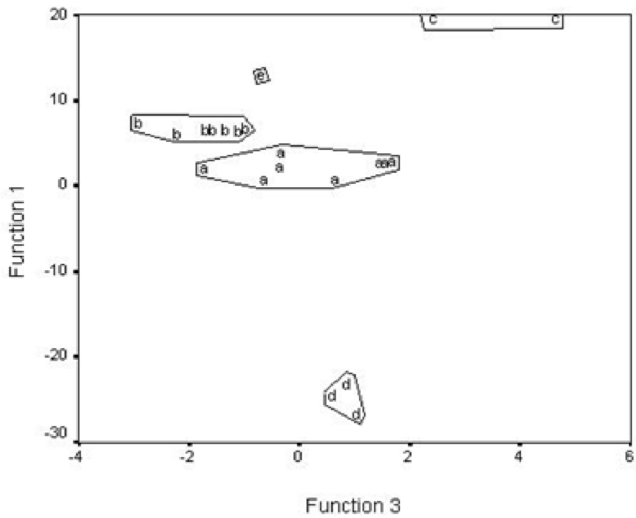

Figure 12. Plot of scores on function axes 3 and 1 from discriminant function of eight dominant variables skull measurements from *M. whiteheadi* (L). Group classifications: a, Southern Borneo; b, Sumatra Island; c, Malaya Peninsular; d, Northwestern Borneo; and e, Northeastern Borneo

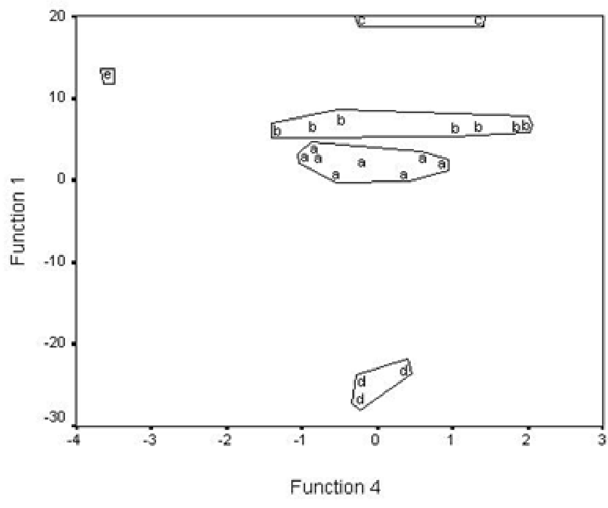

Figure 13. Plot of scores on function axes 4 and 1 from discriminant function of eight dominant variables skull measurements from *M. whiteheadi* (L). Group classifications: a, Southern Borneo; b, Sumatra Island; c, Malaya Peninsular; d, Northwestern Borneo; and e, Northeastern Borneo

Table 8. Total explained variation for 24 measurements on four Discriminant functions (DFs)

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	191.54(a)	92.05	92.05	1.00
2	12.57(a)	6.04	98.09	0.96
3	3.01(a)	1.44	99.53	0.87
4	0.97(a)	0.47	100.00	0.70

a first 4 canonical discriminant functions were used in the analysis.

Table 9. Standardised and unstandardised (in the brackets) canonical variate function coefficients derived from analysis of eight characters

	Function			
	1	**2**	**3**	**4**
BB	0.109(0.243)	-1.681(-3.747)	0.816(1.819)	0.638(1.421)
ZP	3.814(22.640)	0.006(0.034)	0.818(4.858)	-0.351(-2.083)
IOB	0.068(0.271)	1.913(7.664)	0.273(1.095)	0.296(1.186)
D	-4.702(-8.325)	-1.367(-2.420)	0.505(0.895)	-0.342(-0.606)
UMR	2.969(13.792)	-0.467(-2.171)	0.054(0.251)	0.477(2.216)
IFL	3.728(10.776)	1.514(4.377)	-1.129(-3.263)	0.398(1.151)
MSW	2.477(8.892)	1.514(-0.404)	0.308(1.106)	-1.045(-3.750)
RAP	-2.401(-5.631)	-0.112(2.112)	-1.336(-3.134)	0.086(0.201)
(Constant)	(-111.376)	(2.196)	(-17.022)	(-26.249)

classified and 90.5% cross-validated grouped cases correctly classified. The eight characters were selected by minimizing Wilk's lambda on the first canonical variate in order to avoid over fitting data. The eight characters in the DFA are BB, ZP, IOB, D, UMR, IFL, MSW, and RAP (Table 9).

The configuration of DFA plots suggest that *M. whiteheadi* (L) is divided into five major geographical populations (Figures 11, 12, 13); these are (1) populations from Melak, Kutai, East Kalimantan, Central Kalimantan

(Southern Borneo); (2) populations from Sumatra; (3) a Sarawak group (Northwestern Borneo); (4) a Malay peninsular group; and (5) a Sabah group (Northeastern Borneo). Each of the groups showed good separation between them. Populations from Sumatra seem similar and closely related to the Southern Borneo populations. The Sarawak and Malay peninsula groups are clearly different from the other populations and stand as a single group. These different populations are most likely a reflection of geographical barriers such as mountains, highlands, large rivers and seas in this region which have isolated the populations.

Based on this study, we summarized that *Maxomys* can now be divided into 16 species with *M. whiteheadi* (L) as a distinct new species yet to be described. Based on the features of skins, skulls and body size configuration *M. whiteheadi* (L) seems more similar to *M. whiteheadi* (S) than to *M. ochraceiventer* or *M. baeodon*; both of which is sympatric. Furthermore, skull, dental and dentary characters of *M. musschenbroekii* and *M. wattsi* from Sulawesi show similar features to *Maxomys* populations from Kalimantan, in particular populations of *M. alticola, M. ochraceiventer, M. surifer* and *M. whiteheadi* (L) an observation supported by overlapping measurements in some cases. *Maxomys wattsi appears* to be closely related to *M. rajah* which is supported by overlaps in measurements. Musser *et al.* (1979) observed that *M. musschenbroekii* was a small rat, more like *M. alticola, M. inas*, and *M. ochraceiventer* in body size. It was also more similar to those species, and to *M. hylomyoides* and *M. whiteheadi* in features of skin, skull, and teeth than to either *M. hellwaldii* or *M. dollmani*. Ellerman (1941) indicated that *M. musschenbroekii* and *M. whiteheadi* (S) were conspecific but there is no evidence, at least from the study of skins and skulls, to support that view.

The biogeographic boundaries of the species of *Maxomys* in the Southeast Asia region, do not follow the Wallace's Line and show no separation into eastern and western species groups. This is supported by strong evidence about similarity in morphological features from skull characters between eastern and western *Maxomys* species and consistently confirms the observations suggested by Ellerman (1941) and Musser *et al.* (1979).

ACKNOWLEDGEMENT

We are most grateful to Prof. Dr. Ibnu Maryanto for supervision, assistantship and support the fieldwork in East Kalimantan, Borneo Island. Special thanks to Prof. Dr. Mohd. Tajuddin Abdullah, the leader of two grants from the Ministry of Higher Education-FRGS grant number 06(08)6602007 and UNIMAS Eco-Zoonosis Grant (ZRC/03/2007(03) and for supervision on writing this paper. I would like to thank UNIMAS for granting the Zamalah (Scholarship) UNIMAS 2008/10 and Gary Paoli as fieldwork leader in East Kalimantan; BHP Billiton for supporting fieldwork in East Kalimantan. Museum Zoologicum Bogoriense (MZB) and Universiti Malaysia Sarawak (UNIMAS) for providing samples, support and facilities. All MZB and UNIMAS technicians and laboratory assistants for assisting in fieldwork and laboratory.

REFERENCES

Corbet, G.B. & J.E. Hill, 1992. *The Mammals of the Indomalayan Region: A Systematic Review.* Oxford University Press, Oxford, 488 pp.

Ellerman, J.R, 1941. *The Families and the Genera of Living Rodents. Vol. II. Family Muridae.* British Museum (Natural History), London, 690 pp.

Francis, C.M. 2008. *A Field Guide to the Mammals of South-East Asia: Thailand, Peninsular Malaysia, Singapore, Myanmar, Laos, Vietnam and Cambodia*. New Holland Publishers, London, 392 pp.

Kitchener, D.J. & I. Maryanto, 1995. A new species of *Melomys* (Rodentia; Muridae) from Yamdena Island, Tanimbar group, Eastern Indonesia. *Records of the Western Australian Museum* **17**: 43-50.

Kitchener, D.J., L.H. Schmitt, S. Hisheh, R.A. How, N.K. Cooper & Maharadatunkamsi, 1993. Morphological and genetic variation in the bearded tombs bats (*Taphozous*: Emballonuridae) of Nusa Tenggara, Indonesia. *Mammalia* **57**(1): 63-83.

Kitchener, D.J, Boeadi, L. Charlton & Maharadatunkamsi, 1990. Mammals of Lombok island, Nusa Tenggara, Indonesia: systematics and natural history. *Supplement Records of the Western Australian Museum* **33**: 1-129.

Kitchener, D.J & I. Maryanto, 1993. Taxonomic reappraisal of *Hipposideros larvatus* species complex (Chiroptera; Hipposideridae) in Greater and Lesser Sunda islands, Indonesia. *Records of the Western Australian Museum* **16**:119-174.

Maryanto, I. 2003. Taxonomic status of the ricefield rat *Rattus argentiventer* (Robinson and Kloss, 1916) (Rodentia) from Thailand, Malaysia and Indonesia based on morphological variation. *Records of the Western Australi*a *Museum* **22**: 47-65.

Maryanto, I & M.H. Sinaga, 1998. Variasi morfologi *Maxomys surifer* asal Sumatra, Kalimantan dan Jawa. *Berita Biologi* **5**: 183-191.

Maryanto, I., I. Mansjoer, D. Sajuthi & Y. Suprijatna, 1997. Morphological variation of the silver leaf monkeys *Trachypithecus auratus* (E. Geoffroy, 1812) and *Trachypithecus cristatus* (Raffles, 1821) from Thailand Malaysia and Indonesia. *Treubia* **31**:113-131.

Merker, S & C.P. Groves, 2006. *Tarsius lariang*: a new primate species from Western Central Sulawesi. *International Journal of Primatology* **27**(2): 465-471.

Musser, G.G., 1991. Sulawesi Rodents: Descriptions of New Species of *Bunomys* and *Maxomys* (Muridae, Murinae). *American Museum Novitates* 3001. American Museum of Natural History, New York, 41 pp.

Musser, G.G. & C. Newcomb, 1983. Malaysian murids and the giant rat of Sumatra. *Bulletin of the American Museum of Natural History* **174**: 327-598.

Musser, G.G. & M.D. Carleton, 2005. Family Muridae, Rodentia. In: D.E. Wilson & D.M. Reeder (eds.). *Mammals Species of the World: A Taxonomic and Geographic Reference*. 3rd edition. Smithsonian Institution Press, Washington D.C., pp 1365-1370.

Musser, G.G, J.T. Marshall Jr & Boeadi, 1979. Definition and contents of the Sundaic genus *Maxomys* (Rodentia, Muridae). *Journal of Mammalogy* **60**: 592-606.

Musset, G.G, A.L. Smith, M.F. Robinson & D.P. Lunde, 2005. Description of a new genus and species of rodent (Murinae, Muridae, Rodentia) from the Khammouan Limestone National Biodiversity Conservation Area in Lao PDR. *American Museum Novitates,* American Museum of Natural History, 31 pp.

Payne, J., C.M. Francis & K. Philipps. 1985. *A Field Guide to the Mammals of Borneo*. Sabah Society and World Wildlife Fund, Kota Kinabalu, 332 pp.

Ruedas, L. A & J.A.W. Kirsch, 1997. Systematics of *Maxomys* Sody, 1936 (Rodentia: Muridae: Murinae): DNA/DNA hybridization studies of some Borneo-Javan species and allied Sundaic and Australo-Papuan genera. *Biological Journal of the Linnean Society* **61**: 385-408.

Watts, C.H.S & P.R. Baverstock, 1994. Evolution in some South-east Asian murinae (Rodentia) assessed by microcomplement fixation of albumin and their relationship to Australian murines. *Australian Journal of Zoology* **42**: 1-12.

Appendix 1. List of samples used in analysis

Maxomys whiteheadi (Small body size)

MZB 29090 Female, MZB 29092 Female, MZB 29073 Male, MZB 29093 Male, MZB 29094 Male, MZB 29098 Male, MZB 29099 Male, MZB 29100 Male, MZB 29102 Male, MZB 29103 Female, MZB 29104 Female, MZB 23645 Female, MZB 23642 Female, MZB 23641 Male, MZB 29059 Female, MZB 29061 NR, MZB 29064 Female, MZB 29071 Female, MZB 29081 Female, MZB 23607 Female, MZB 23601 Male, MZB 23651 Male, MZB 23647 Male, MZB 23638 Male, MZB 15384 Male, MZB 26247 Male, MZB 22220 Female, MZB 22212 NR, MZB 22215 Female, MZB 26251 Male, MZB 22217 Female, MZB 22222 Male, MZB 26253 Male, MZB 26234 Male, MZB 26246 Male, MZB 22210 Male, MZB 11647 Female, MZB 13338 Female, MZB 18347 Male, MZB 18370 Male, MZB 18371 Male, MZB 24986 Female, MZB 5661 Male, MZB 15383 Male, MZB 15569 Female, MZB 15571 Female, MZB 20560 Male, MZB 20569 Female, MZB 20580 Female, MZB 20567 Male, MZB 20582 Male, MZB 20559 Male, MZB 20,574 Female, MZB 20,571 Male, MZB 20,562 Female, MZB 20,568 Male, MZB 24944 Female, MZB 24957 Female, MZB 2071 Female, MZB 24931 Female, MZB 15385 Female, MZU TK152846 Female, MZU 819 Male, MZU TK156129 NR, MZU 1844 Male, MZU TK152353 NR, MZU 326 Male, MZU 1052 Female, MZU TK152362 NR, MZB NA014 NR, MZB 5679 Male, MZB 5673 Male, MZB 5663 Male, MZB 24893 Male, MZB 24963 Male, MZB 24898 Male, MZB 13031 Female, MZB 15382 Male, MZB 23648 Male, MZB 29065 Female, MZB 29067 Female, MZB 29069 Female, MZB 22233 Female, MZB 29074 Male, MZB 29078 Male, MZB 29082 Female, MZB 29083 Female, MZB 29084 Male, MZU TK152862 NR, MZB 29076 Female.

Maxomys whiteheadi (Large body size)

MZB 29058 Female, MZB 29062 Female, MZB 29066 Female, MZB 29068 Female, MZB 29070 Female, MZB 29077 Male, MZB 29080 Male, MZB 18482 NR, MZB 29086 Female, MZB 28961 Male, MZB 28962 Female, MZB 28960 Female, MZB 28963 Male, MZB 28967 Male, MZB 28968 Male, MZU TK153703 Male, MZU TK153717 Male, MZU TK152349 NR, MZU TK152861 NR, MZU 471 Male, MZU 1618 Female.

Maxomys wattsi

MZB 12159 Male, MZB 12160 Male, MZB 12161 Male, MZB 12163 NR

Maxomys surifer

MZB 4961 Male, MZB 4962 Female, MZB 4969 Female, MZB 4971 Female, MZB 4974 Male, MZB 4976 NR, MZB 4977 Female, MZB 4978 Male, MZB 4979 Male, MZB 4983 Female, MZB 4984 Male, MZB 4985 Male, MZB 4987 Female.

Maxomys rajah

MZU TK152850 Male, MZU TK152852 Male, MZB 14756 Female, MZB 14774 NR, MZB 14779 Male, MZB 14752 Male, MZB 22496 Male, MZB 22621 Female, MZB 23661 Male, MZB 23662 Male, MZB 23663 Female, MZB 27436 Not recorded.

Maxomys pagensis

MZB 22355 Female, MZB 2885 Female, MZB 17565 Male.

Maxomys ochraceiventer

MZB 23606 Male, MZB 23971 Male, MZB 23970 Female.

Maxomys musschenbroekii

MZB 26935 Female, MZB 26942 Female, MZB 26943 Male, MZB 26945 Male, MZB 26946 Male, MZB 26950 Female, MZB 26951 Male, MZB 26953 Male, MZB 26955 Male, MZB 26956 Male, MZB 26960 Female.

Maxomys hellwaldii

MZB 26964 Male, MZB 26971 Female, MZB 26982 Male, MZB 26988 Male, MZB 26991 Male, MZB 27163 Female.

Maxomys bartelsii

MZB 2188 Male, MZB 9537 Male, MZB10135 Male, MZB 10872 Male, MZB 10875 Female, MZB 10876 Female, MZB 10877 Male, MZB 12430 Female, MZB 12462 NR, MZB 12919 Male, MZB 22525 Male.

Maxomys baeodon

MZU TK152835 Male, Raffles Museum 3312 Male, Raffles Museum 3533 Male, Raffles Museum 3543 Female, Raffles Museum 3571 Female, Raffles Museum 3224 Female.

Maxomys alticola

Raffles Museum 4213 Male, Raffles Museum 4203 Male, Raffles Museum 4214 Male, Raffles Museum 4013 Male, Raffles Museum 4223 Female, Raffles Museum 4215 Male.

Maxomys inas

MZB 13432 Female.

OBITUARY

Dr. Sampurno Kadarsan

Late Dr. Sampurno Kadarsan passed away in Bandung on 17 September 2010 at the age of 81 years old. He was survived by his wife and four married daughters. He was born in Surabaya on 11 August 1929. However, he lived in Bogor for much of his time.

Education

He entered Diploma in biology in 1955 under the Ministry of Agriculture. Then, he joined the University of California, Berkeley – USA and achieved BSc. degree in Entomology & Parasitology in 1959. Upon returning to Indonesia, he undertook further study at Bandung Institute of Technology (ITB) and achieved his first degree in biology in 1964. Then, he got an opportunity to enter the University of Maryland, College Park, USA for postgraduate study and achieved his PhD degree in 1971.

Working Career

He started working in the division of Marine Fishery (*Djawatan Perikanan Laut*) in Jakarta. Then, he moved to the division of Nature Research (*Djawatan Penyelidikan Alam*) in Bogor as an assistant in biology. In 1960 he became the director of Museum Zoologicum Bogoriense, under the Centre for Nature Research Institute (*Lembaga Pusat Penyelidikan Alam*). In 1977 he became a senior professor at the Fakulti Perubatan, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia. He became a senior scientist at the National Biological Institute-Indonesian Institute of Sciences (LIPI) in 1981. In 1986 he was the Director of the Research & Development Centre for Biology and Head of the Indonesian Botanic Gardens, LIPI. He achieved Principle Scientist in 1990. Since 1993 he obtained professorship in parasitology at the Faculty of Veteriner – Bogor Agriculture University. He was the editor of journal of Treubia from 1992 to 1997, and remained as a proof reader until 2007.

INSTRUCTIONS FOR AUTHORS

1. General. - Manuscripts to be published in TREUBIA must be written in English, typed in Times New Roman font 12 and submitted in triplicate to the editors of TREUBIA, Division of Zoology, Research Center for Biology, Widyasatwaloka, Jl. Raya Jakarta-Bogor Km. 46, Bogor 16911, Indonesia. They should not be offered for prior or simultaneous publication elsewhere. Concise writing and omission of unessential material are recommended. After acceptance, a soft copy of the manuscript files should be sent to the editors of TREUBIA. Further correspondence can be conducted through email address: treubia@ gmail.com
2. Text. - The text must be typed, double spaced throughout. Captions of tables, figures, and plates should be inserted where you want them to be inserted, or listed at the end of the manuscript. All numbers under 10 and any number forming the first word of a sentence must be spelled out. Year should be completely written. Scientific names should all be italicized. It is recommended to use metric measurements in abbreviation (*e.g*. kg, cm, ml).
3. Citation. - References are to be cited in the text by the author's surname and year of publication, *e.g*. (Calder 1996, Carpenter 2005, Somadikarta 1986). For two authors, both names should be cited: *e.g*. (Ackery & Vane-Wright 1984). For three or more authors, only the first author is given followed by *et al*., *e.g*. (Foster *et al*. 2002).
4. Abstract. - Except for short communications, articles should be accompanied by an abstract not to exceed 250 words which clearly states the essence of the paper. Key words should be mentioned following the abstract.
5. Acknowledgements, if any, should be placed preceding the list of references
6. References. - List of references should be in alphabetical order by the first or sole author's surname. Journal references should include author's surname and initials, year of publication, title of the paper, full title of the journal (typed in *italic*), volume number (typed in **bold**) and inclusive page numbers. Book references should include author's surname and initials, year of publication, title of the book (typed in italic) or/and title of the chapter and editor (if part of a book), publisher, city of publication, and page numbers.

   For example:

   LaSalle, J. & M.E. Schauff, 1994. Systematics of the tribe Euderomphalini (Hymenoptera: Eulophidae): parasitoids of whiteflies (Homoptera: Aleyrodidae). *Systematic Entomology* **19**: 235-258.

   MacKinnon, J. & K. Phillips, 1993. *Field Guide to the Birds of Borneo, Sumatra, Java and Bali*. Oxford University Press, Oxford, 491 pp.

   Stork, N.E., 1994. Inventories of biodiversity: more than a question of numbers. *In*: Forey,P.L., C.J. Humphries & R.I. Vane-Wright (eds.), *Systematics and Conservation Evaluation*. Clarendon Press (for the Systematics Association), Oxford, pp. 81-100.

   Maddison, D.R., 1995. Hemiptera. True bugs, cicadas, leafhoppers, aphids, etc.. Version 01 January 1995 (temporary). *http://tolweb.org/Hemiptera /8239/1995.01.01*. *In*: The Tree of Life Web Project, *http://tolweb.org/* (accessed on 27 November 2007).

7. Proofs and reprints. - Final proofs are given to the first or sole author for correction and approval. Twenty five reprints are supplied free of charge. Joint authors will have to divide these copies among them at their discretion. Additional reprints can be furnished at cost, the order should be placed before the final printing.

CONTENT

VOL. 37, DECEMBER 2010

NO	CONTENT	PAGES
1.	**Dwi Astuti and Sri Sulandari.** The DNA Sequence Performance of COI Gene in White Cockatoos (*Cacatua*, Psittaciformes)……….………………………………………..	1
2.	**Endang Purwaningsih.** New Species of Strongylid Nematode, *Labiostrongylus biakensis* (Nematoda: Strongyloidea) from *Macropus agilis* (Gould, 1842) from Biak, Papua ….....………..	15
3.	**Ibnu Maryanto, M. H. Sinaga, A. S. Achmadi and Maharadatunkamsi.** Morphometric Variation of *Rattus Praetor* (Thomas, 1888) Complex from Papua, with the Description of New Species of *Rattus* from Gag Island……………….................	25
4.	**Anang Setiawan Achmadi.** Taxonomic status of the spiny rats (genus *Maxomys* Jentink, 1910) from Indonesia and Malaysia based on morphological study……………………………………	49
5.	**Nur Rohmatin Isnaningsih and Ristiyanti M. Marwoto.** Redescription of land snail *Leptopoma* (*Leucoptychia*) *lamellatum* Sykes, 1903 from Raja Ampat, West Papua (Mollusca, Gastropoda, Cyclophoridae) …..	83