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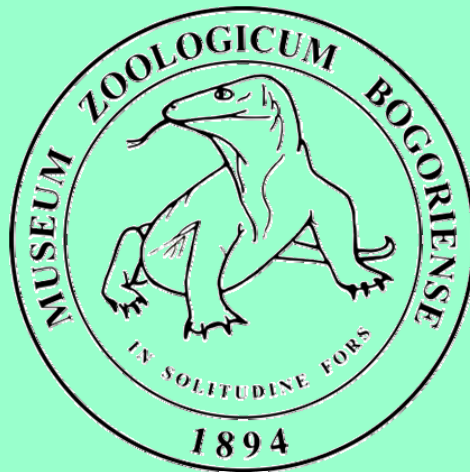


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email: treubia@gmail.com

NEW SPECIES OF *LEOPOLDAMYS* (MAMMALS, RODENTIA: MURIDAE) FROM KALIMANTAN AND JAWA

Ibnu Maryanto & M.H. Sinaga

Division of Zoology, Research Center for Biology, Indonesian Institute of Sciences,
Jl. Raya Jakarta-Bogor Km. 46, Cibinong - Bogor, 16911, Indonesia
Email: ibnu_mar@yahoo.com; ibnu.maryanto@lipi.go.id

Abstract

During May-June 2008 survey an individual *Leopoldamys* was caught with bicolored tail sharply demarcated between the upper and lower part from Haju Maruwai area in Kalimantan. Following this two more specimens from the MZB collection were found with individual bicolor tails from Bukit Baka National Park West Kalimantan and Cibodas Botanical Garden Gede Pangrango, West Jawa. Comparative study on the external characters and skull measurements with *L. sabanus*, *L. edwardsi* and *L. siporanus* from Kalimantan, Jawa and Sumatra and adjacent islands (using invariable, multivariate and discriminant analysis), revealed significant differences between the new *Leopoldamys* sp and established *L. sabanus*, *L. edwardsi* and *L. neilli* from Jawa, Kalimantan, Sumatra and adjacent islands. On the basis of these characteristic differences we described it as *Leopoldamys diwangkarai* sp nov and its exposition is discussed.

Key words: *Leopoldamys*, Kalimantan & Jawa

INTRODUCTION

Ellerman (1947-1948) relocated *Mus sabanus* Thomas, 1887 as *Leopoldamys* based on an adult male (BM 95.10.4.27) collected by John Whitehead in mount Kinabalu Sabah, Borneo. The *sabanus* group of the genus *Leopoldamys* comprises three known species distributed in South East Asia Sunda Shelf and Mentawai Island; *Leopoldamys sabanus* in Indochina and Thailand to Malaysia, Sumatra, Jawa, and Kalimantan and

adjacent islands, *L. edwardsi* in East Himalayan foothills to South China, North Thailand and North Vietnam; isolated mountane in populations in Malaya (above 750 m) and Sumatra; *L. neilli* in Saraburi Province, Thailand, and *L. siporanus* in Mentawai Islands (Ellerman 1947-1948, 1949, 1961, Marshall 1977, Musser 1981). On the mainland of Sumatra, Jawa and Kalimantan, four subspecies were described *L. sabanus sabanus* (Thomas, O, 1887) (Kalimantan), *L. s. mayapahit* (Robinson & Kloss 1919) (Jawa), *L. s. tapanulius* (Lyon 1916) (Tapanuli, Sumatra), *L.s. ululans* (Robinson & Kloss 1916) (Daras, Kerinci, Sumatra).

The coloration of the tail among vertebrate animals especially among the murid group is one of the diagnostic characters between murid species. Musser (1981) emphasized that strict adherence to this diagnosis effectively precludes a number of *Leopoldamys* species. The tail of *L. edwardsi* is normally uniform dark brown. In *L. sabanus* the tail is distinctly patterned black and white, with the black extending continuously, or sometimes in patches along the upper surface except for the distal third, which is white all round. That of *L. neilli*, the tail is dark basically and along the top for about two-thirds of its length, without vivid contrast from the white. The tail of *L. siporanus* is dark uniformly with 60 % white distally.

A recent survey to Central Kalimantan at Haju area May-June 2008 one *Leopoldamys* was collected. The long bicolored tail (dark above and white below) is sharply demarcated between the upper and lower parts. We examined 48 *L. sabanus* from MZB museum and found two specimens with identical bicolored tail as in the recent specimens collected at Haju in May-June 2008. The two additional specimens were from Bukit Baka National Park, West Kalimantan and Cibodas Botanical Garden Gede Pangrango Mountain, West Jawa.

A comparative study of *Leopoldamys* sp with the museum collection of *L. sabanus* and *L. siporanus*, revealed there are morphological character differences (tail coloration, tail length, hind foot length and also skull measurements) (Figure 1, Table 1). On the basis of these differences, we decided to describe the *Leopoldamys* sp as *Leopoldamys diwangkarai* sp. nov. as an additional species for the *Leopoldamys* group in Indonesia, the results of which is appended herewith.

MATERIALS AND METHODS

Twenty three measurements of skull, dentary, and external characters were recorded following by Musser (1981). The following detailed measurements (all made in mm) were: Skull: greatest skull length (GSL), breadth of braincase (BBC), breadth of palate of upper molar 1 (BBPM1), breadth of incisive foramina (BIF), breadth of mesopterygoid fossa (BMF), breadth of rostrum (BR), breadth of zygomatic plate (BZP), crown length of upper molar 1-3 (CLM1-3), height of braincase (HBC), interorbital breadth (IB), length of bullae (LB), length of bony palate (LBP), length of diastema (LD), length of incisive foramina (LIF), length of rostrum (LR), post palatal length (PPL), zygomatic breadth (ZB), breadth of upper molar 1 (BM1), breadth of upper molar 2 (BM2), breadth of upper molar 3 (BM3), length of hindfoot (LHF), tail length (LT), total head and body length (HBL). The specimens of small *Leopoldamys* from Haju and Bukit Baka (Kalimantan) and Cibodas Jawa are different from *Leopoldamys siporanus*, *L. sabanus* and *L. edwardsi*, and appear more closely related to *L. sabanus*.

Skull and external measurements were compared for all species, but discriminant function analyses (DFA) were carried out for skull characters only. The stepwise canonical variate analyses were run for skull, dental and dentary using all characters and a reduced set of these characters. This reduced set of characters was selected based on minimization of Wilks Lambda. All pelage color descriptions and terminology followed by Kornerup & Wanscher (1978).

RESULTS

Taxonomy

Leopoldamys diwangkarai sp.nov (Figure 1; Table 1)

Holotype

MZB 30976, adult female; skin and skull stored in dry cabinet and carcass fixed in 7 % formalin and preserved in alcohol 70%, collected by Ibnu Maryanto and Achmad Saim, dated 28 May 2008.

Type locality

Primary forest, Pemantang, Haju, Murung Raya, Central Kalimantan (00° 19' 22.1" S; 114° 49' 58" E).

Etymology

We used named after the old language of Indonesia Sanskrit words of which are rarer or extinct in Indonesian language now; the meaning of the name is sun.

Paratype

MZB 26723, adult female, skin stored in dry cabinet, collected by MH. Sinaga at Cibodas West Jawa (1400 m Asl) (7° 00' S; 106 57 E), date: 14 December 2004

MZB 15852, adult male; skin stored in dry cabinet, collected by MH. Sinaga, Wartika Rosa Farida at Bukit baka. West Kalimantan Camp 3. date 6 Juni 1994

Diagnosis

Leopoldamys are large bodied murid characteristics in the following combination: very long tail, short and sleek pelage, 2+2 pair mammae, a long and narrow cranium, short and oblong incisive foramina, palatal bridge ending before or at back of maxillary tooth-row, slitlike sphenopalatine vacuities, pterygoid fossa not perforated by large foramina, very small bullae, pressed tightly against the squamosal bones of; zygomatic arch set high on sides of braincase, mandible with small coronoid processes and shallow emargination between condyloid and angular processes, large and strong incisors with bright orange enamel layers, uppers strongly opisthodont, upper molars large and simple in occlusal patterns (Musser 1981; Corbet & Hill 1992). *Leopoldamys* has characteristic long tail, the total tail length approximately 125-180% of the body (Corbet & Hill 1992, Payne *et al.* 1985, Yasuma 1994, Maryanto *et al.* 1999).

Leopoldamys diwangkarai sp. nov. distinguished from *L. sabanus*, *L. siporanus*, *L. edwardsi*, and *L. neilli*, by combination of the relatively small body size (189-190 gram), head and body (197-225 mm), long tail (293-317 mm or 140-152% of head and body length), bicolor tail sharply separated between upper and lower, dark in the upper part and white in the lower.

It differs from *Leopoldamys sabanus*, *L. edwardsi* and *L. siporanus* by some smaller measurements of the skull and teeth, and longer in maxillary tooth row. Lacrimal bones small and smaller than other *Leopoldamys* spp, infraorbital fissure relatively not bigger, occipital tends to rather decline, The skull shape of *Leopoldamys diwangkarai* sp. nov. distinguished to *L. sabanus* by interparietal posteriorly which is not flatter or rather smoothly arch, the interparietal bone of the new one wider than *L. sabanus* and consequently the suture of parietal ridge of *Leopoldamys diwangkarai* sp. nov. is down below. Further, the parietal bone of *Leopoldamys diwangkarai* sp. nov from

Jawa more is inflated and than others the new from Kalimantan. The palatum of *Leopoldamys spp.* more wider than the new one.

The zygomatic plate of *Leopoldamys diwangkarai* sp.nov. is rather small, anterior margin tends to oblique and not curved like in *Leopoldamys sabanus* but more similar to *L. siporanus*; if the zygomatic plate of *Leopoldamys diwangkarai* sp.nov is projected to incisive foramina, the basal anterior margin of zygomatic plate shows relative extension to the anterior or half of the incisive foramina like in *L. siporanus*, while only 1/3 on *L. sabanus* and *L. edwardsi*.

Description

The pelage color of *Leopoldamys diwangkarai* sp. nov, the upper part demarcated sharply from the under part. Head and body are brownish and rather reddish with dark grey under fur (specimens from Kalimantan) and much duller (Jawa specimen), relatively longer and softer hair than *Leopoldamys sabanus*, and the venter part is white to cream. The front and hind feet have dark stripe down to the dorsal surfaces, but dorsal strip with hind paw more blackish than in *L. sabanus*, *L. edwardsi* which rather are dark grey.

Measurements (in mm) of the holotype MZB 30976 and paratype MZB 15852, 26723 were smaller than other *L. sabanus*, *L. siporanus* and *L. edwardsi* (Corbet and Hill 1992; Maryanto *et al.* 1999) (Table 1). The measurements of *Leopoldamys diwangkarai* sp.nov are as follows: Greatest skull length (GSL) (49.52-52.4), breadth of braincase (BBC) (17.8-18.82), breadth of palate of upper molar 1 (BBPM1) (3.66-5.3), breadth of incisive foramina (BIF) (3.11-3.68), breadth of upper molar 1 (BM1) (2.63-2.91), breadth of upper molar 2 (BM2) (2.58-3.01), breadth of upper molar 3 (BM3) (2.1-2.31), breadth of mesopterygoid fossa (BMF) (3.09-3.78), breadth of rostrum (BR) (7.14-9.69), breadth of zygomatic plate (BZP) (4.54-4.91), crown length of upper molar 1-3 (CLM1-3) (8.54-9.28), height of braincase (HBC) (12.47-13.03), interorbital breadth (IB) (7.57-8.24), length of bullae (LB) (5.03-5.59), length of bony palate (LBP) (10.64-11.44), length of diastema (LD) (12.6-13.5), length of incisive foramina (LIF) (7.17-7.66), length of rostrum (LR) (16.45-16.7), post palatal length (PPL) (15.81-17.5), Zygomatic breadth (ZB) (23.13-24.78), ear length, 21; head and body length, 197.8; hind foot length, 42.73; tail length, 300.19. All measurements (in mm) are lower than *L. sabanus*, *L. siporanus* and *L. edwardsi* (Table 1) (Musser 1981, Maryanto *et al.* 1999).

Viewed from above the cranium is long and narrow, nasal relatively longer and

the posterior ends of nasal extend behind premaxilla or frontal suture and closer to *L. sabanus* than *L. edwardsi*, interorbital area wide but not broader as in *L. sabanus*, *L. siporanus* and *L. edwardsi*; zygomatic and malar processes tend to be narrower than *L. sabanus* and *L. edwardsi*, Zygomatic breadth of *Leopoldamys diwangkarai* is 23.13-24.78 mm, male of *L. sabanus* from Kalimantan ($25,80 \pm 1,14$) and female ($22,98 \pm 0,91$ mm), and male specimens from Jawa ($22,98 \pm 0,91$ mm) and female ($24,90 \pm 1,29$ mm) (Table 1). Viewed from side the premaxillary tends to be relatively tighter than *L. sabanus* and *L. edwardsi*; medial of post-tympanic hook at the upper end of post-glenoid foramen for vein from the transverse sinus rather tight. Viewed from below, bulla relatively larger in proportional than *L. sabanus* and *L. edwardsi* or *L. siporanus*; external pterygoid processes of Jawan specimens not as well developed as in Kalimantan, the incisive foramina from Jawa shorter with a narrower rostrum than Kalimantan

On Molar row, the specimens of *Leopoldamys diwangkarai* sp.nov are longer in proportion than other *Leopoldamys* spp; further, the molar of a specimen from Jawa is broader than Kalimantan. In comparison to Musser (1981) cusplets of *Leopoldamys diwangkarai* sp.nov analyzed indicate affinity to other *Leopoldamys* spp, for example the enamel pattern of upper molar cups t3 of M2 and M3 known in *Leopoldamys diwangkarai* sp.nov (100%, n=3), usually lacking on upper molar cups t3 of M3. The anterior cusplet of lower molar in M1 is lacking *Leopoldamys diwangkarai* sp.nov (100%, n=3). The anterolabial cusp on lower M2 and M3 is lacking in *Leopoldamys diwangkarai* sp nov.

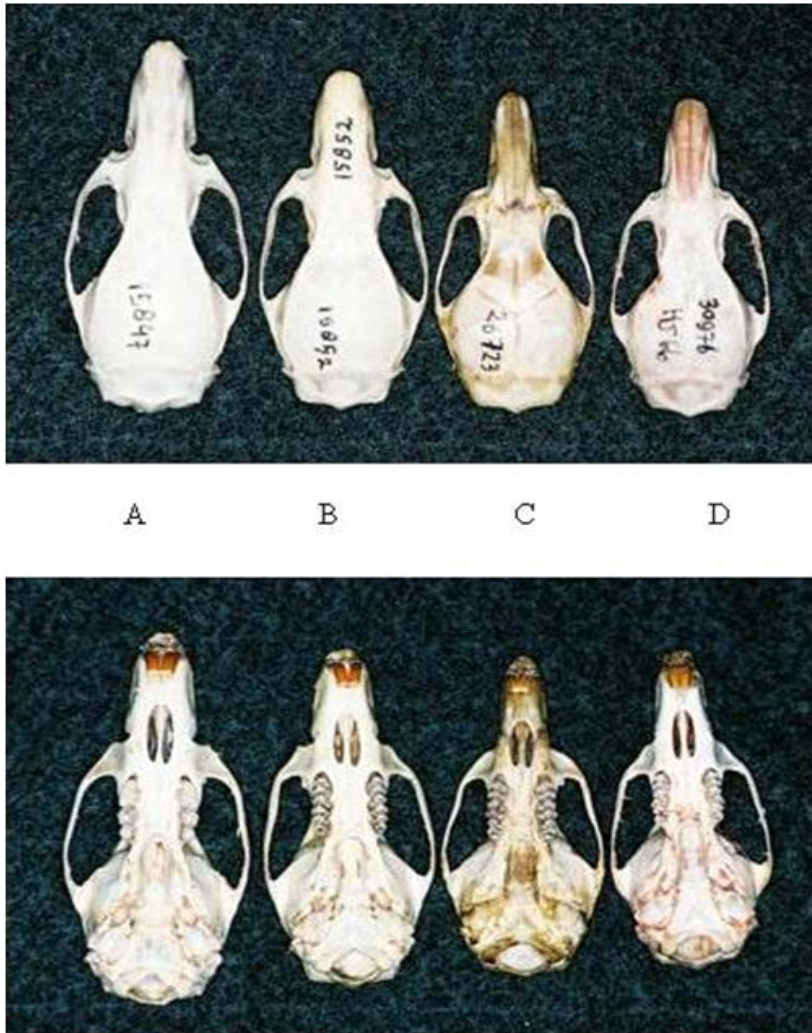


Figure 1a. View of skull of *L. sabanus* (A), *L. diwangkarai* sp nov from Bukit baka West Kalimantan (B), Cibodas West Jawa (C) and Pemantang Central Kalimantan (D)



Figure 1b. View of skin of *L. diwangkarai* sp nov from Bukit baka West Kalimantan (A), Pemantang Central Kalimantan (B) and Cibodas West Jawa (C)

Table. 1 Measurements characters of *Leopoldamys* spp (in mm)

Characters	<i>L. siporanus</i> (n=9)					<i>L. sabanus</i> (n=48)					<i>L. diwangkarati</i> sp. nov (n=3)					<i>L. edwardsi</i> (n=1)	
	MIN	MAX	MEAN	Std		MIN	MAX	MEAN	STD		MIN	MAX	MEAN	STD	MEAN	STD	
LHB	178.00	287.00	256.33	35.65		185.00	270.00	227.42	17.28		197.00	225.00	209.00	14.42			
LT\$	220.00	335.00	285.22	32.61		284.00	545.00	350.24	42.96		293.00	317.00	303.33	12.34			
LHF	45.00	52.50	50.17	2.21		42.00	51.00	47.29	2.25		42.73	49.00	45.58	3.17			
LE\$	24.00	28.00	26.38	1.60		21.00	30.00	25.74	1.94		20.00	27.00	23.85	3.55			
GLS	49.98	59.30	54.60	3.21		49.00	58.00	54.46	2.36		49.52	52.40	50.58	1.58	59.81	26.60	
ZB	22.68	28.43	25.54	1.84		22.90	27.88	25.17	1.26		23.13	24.78	23.71	0.93	9.62	0.38	
IB	8.82	10.11	9.29	0.46		7.84	9.36	8.56	0.42		7.57	8.29	7.87	0.32	20.57	1.28	
LR	16.30	19.75	17.52	1.27		14.74	19.65	17.68	1.21		16.45	17.09	16.75	0.32	8.40	1.28	
BR	8.30	10.24	9.49	0.63		8.18	10.93	9.31	0.62		7.14	9.69	8.40	0.19	5.13	0.19	
BZP	4.79	6.37	5.47	0.52		4.62	6.45	5.53	0.47		4.54	4.91	4.75	0.62	21.49	0.29	
BBC	19.25	21.03	20.44	0.55		18.66	220.35	24.92	32.56		17.80	18.93	18.52	0.50	15.01	0.85	
HBC	12.66	14.51	13.41	0.71		12.67	15.17	13.74	0.54		12.47	13.03	12.70	0.29	14.93	0.50	
LD	13.77	16.07	14.70	0.95		12.43	16.14	14.42	0.90		12.60	13.50	12.93	0.85	21.28	0.25	
PPL	16.95	22.46	19.75	1.69		17.03	21.84	19.23	1.20		15.81	17.50	16.70	0.30	4.59	0.30	
LIF	6.93	8.80	7.62	0.57		6.75	8.96	7.90	0.52		7.17	7.66	7.40	0.25	9.33	0.30	
BIF	3.40	4.02	3.68	0.19		2.74	4.05	3.40	0.28		3.11	3.70	3.38	0.43	12.38	0.95	
LBP	11.10	13.16	12.11	0.68		10.00	13.71	11.73	0.71		10.64	11.44	11.13	0.36	4.90	0.29	
BBPM1	4.10	5.17	4.47	0.42		3.72	6.58	4.97	0.69		3.66	5.55	4.55	0.29	5.88	0.37	
BMF	3.81	5.18	4.31	0.43		3.43	4.56	4.00	0.28		3.09	3.78	3.37	0.36	4.90	0.29	
LB	5.05	5.44	5.21	0.15		4.88	5.74	5.31	0.22		5.03	5.59	5.35	0.29	5.88	0.37	
CLMI_3	9.87	10.83	10.27	0.28		9.07	10.51	9.77	0.35		8.54	9.28	8.93	0.17	3.22	0.17	
BM1	2.85	3.19	3.02	0.12		2.56	3.00	2.82	0.10		2.63	2.94	2.83	0.22	2.99	0.11	
BM2	2.73	3.08	2.95	0.11		2.30	2.94	2.71	0.12		2.58	3.01	2.82	0.22	2.99	0.11	
BM3	2.11	2.40	2.22	0.09		1.57	2.84	2.09	0.18		2.10	2.31	2.19	0.11	2.39	0.11	

Distribution

Bukit Baka National Park, West Kalimantan Province, Pemantang, Murung Raya Central Kalimantan province and Cibodas Gede Pangrango National Park West Jawa

DISCUSSION

The recent discovery of *Leopoldamys diwangkarai* sp. nov. has increased to four species of *Leopoldamys* on the islands and mainland of Indonesia. Two of these species *L. sabanus* including the new *L. diwangkarai* in Jawa and Kalimantan and three species *L. sabanus*, *L. edwardsi* and *L. tapanulius* in Sumatra.

By statistical analysis in order to avoid over fitting the data, a problem inherent in analyzing large sets of characters in DFA, the data sets for skull characters were reduced to subsets of four characters. These skull characters: crown length of upper molar 1-3 (CLM1-3), breadth of upper molar 2 (BM2), height of braincase (HBC), interorbital breadth (IB) were selected to minimize the value of Wilks' lambda (Table 2). These skull characters provided similar clusters for all of *L. sabanus*, *L. siporanus* and *L. edwardsi* in discriminant function space (as the full set of characters did too). All four skull characters are important in the discriminant function and their coefficient values loaded heavily (> 0.5) on Function 1. Function 1 explained 82.7% (df=8, wilks lambda=0.184, $\chi^2=77.054$, $P=0.001$), and Function 2 explained 17.3% (df=8, wilks lambda=0.653, $\chi^2=19.423$, $P=0.001$). A total 98% of individual were classified to their correct group, the characters that separated between *Leopoldamys diwangkarai* sp. nov. and others which have loadings more than 0.5 in Function 2 are crown length of upper molar 1-3 (CLM1-3) and breadth of upper molar 2 (BM2); and follow in function 1 which separated between *L. sabanus* or *Leopoldamys diwangkarai* sp. nov. and *L. siporanus* based on loading factors of more than 0.5 are height of braincase (HBC) and interorbital breadth (IB).

Regarding the multivariate analysis, the Discriminant Function Analysis or DFA was carried out to contribute to distinguishing the morphology of four species of *Leopoldamys* from Indonesia. Univariate statistics also support the distinction between *Leopoldamys diwangkarai* sp. nov and others, based on characters of BBC and BMF, Clm1-3 and IB or CLM1-3 and GSL (Figure 2) and indicate *Leopoldamys diwangkarai* sp.nov is relatively smaller than *L. sabanus*, *L. siporanus* and *L. edwardsi*. Ecologically

Leopoldamys diwangkarai sp. nov. overlaps with *Leopoldamys sabanus*. *Leopoldamys sabanus* is known to be distributed in primary forest. *Leopoldamys diwangkarai* sp.nov is more restricted to niche habitat of in primary at 400 m asl in Kalimantan and in the montane forest at 1100 m asl as in Cibodas West Jawa and Bukit Baka National Park.

Table 2. Standardized and un-standardized (in bracket) Canonical Discriminant Function Coefficients

Characters	Function	
	1	2
CLM1-3	0.468 (1.373)	0.694 (2.037)
BM2	0.661 (5.216)	-0.573 (-4.520)
IB	0.908 (2.117)	-0.014 (-0.033)
HBC	-0.902 (-1.589)	0.440 (0.775)
(Constant)	-24.534	-17.768

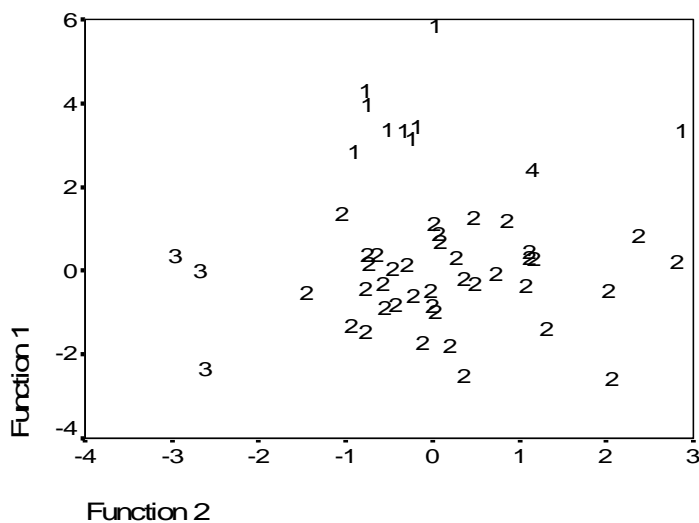


Figure 2. The dendrogarm discriminant function analysis of *Leopoldamys* spp from Indonesia (1=*L. siporanus*, 2= *L. sabanus* and 3= *L. diwangkarai* sp nov, 4=*L. edwardsi*)

As compared by Musser (1981), the cusp of molars indicate that *Leopoldamys diwangkarai* sp.nov tend to follow with other *Leopoldamys* spp. Skull measurement of *L. diwangkarai* from Jawa is broader than those from Kalimantan (Payne *et al.* 1985, Maryanto & Sinaga 1998), rostrum narrow and shorter, incisor more shorter, sutura between frontal and parietal “V” shaped than curved on Kalimantan specimen, parietal bone domed (inflated) and wider. Occipital foramen of Jawa specimen bigger. Shorter and broadened incisive foramina, molar wider and longer maxillary tooth row than Kalimantan specimen. The specimens from Jawa also indicated that the coloration is much duller than Kalimantan. The parietal bone also shown inflated and possibly that the Jawan population is a different subspecies.

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Apendix 1.

List of specimens examined of Museum Zoologicum

Leopoldamys diwangkarai sp.nov (all paratypes)

Kalimantan	Male	MZB 15852
Jawa	Female	MZB 26723
<i>L. siporanus</i>		
Siberut	Male	MZB 14807
Pagai	Male	MZB 5191, 5192, 5194, 5196, 5197
	Female	MZB 5193
Sipora	Male	MZB 2882
	Female	MZB 2881
<i>L. sabanus</i>		
Sumatra	Male	MZB 11826, 13206, 13208, 13844, 15376, 15377, 15437, 15438, 18274, 18275
	Female	MZB 5199, 5200, 13000, 13207, 15090, 16137, 16603
Kalimantan	Male	MZB 12703, 14758, 14759, 14760, 14761, 14762, 17998, 17999, 18002, 18003, 18044, 18045,
	Female	MZB 12720, 14757, 14763, 14764, 15847, 18000,
Java and Nusa Kambangan	Male	MZB 10912, 11103
	Female	MZB 669, 670, 5201, 5202, 5203, 11310, 12057, 14026, 14780
Siantan, Anamba	Male	MZB 5204, 5205
<i>L. edwarsi</i>	Male	MZB 14641

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