

Supplementary Material

Sperm morphology of the Rattini – are the interspecific differences due to variation in intensity of intermale sperm competition?

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Table S1. Source of material used in the study with museum numbers of specimens applicable

Divisions: Dac=Dacnomys, Max=Maxomys, Ech=Echiothrix, R=Rattus

Museums: FMNH=Field Museum of Natural History, Chicago; NMV=Museums Victoria, Melbourne; SAM=South Australian Museum, Adelaide; EBU=Evolutionary Biology Unit, SAM; ANWC=Australian National Wildlife Collection, Canberra

Species name	Division	Number of Specimens	Location of source of specimens	Specimen numbers	Phylogeny
<i>Leopoldamys sabanus</i>	Dac	3	Ulu Gombak & Ulu Lepah, Malaysia	RS1 [*] , RS2 [*] , RS [*]	Yes
<i>Leopoldamys edwardsi</i>	Dac	4	Frasers Hill, Malaysia; Savannakhet Pr., Laos	RE1 [*] , ANWC M32369, ANWC M32379, ANWC M32378	Yes
<i>Chiromyscus chiropus</i>	Dac	1	Savannakhet Pr., Laos	ANWC M32295	No
<i>Niviventer culturatus</i>	Dac	1	Houhoansang, Taiwan	SAM13285	Yes
<i>Niviventer fulvescens</i>	Dac	1	Nakai plateau, Khammouane Pr., Laos	ANWC M33395	Yes
<i>Niviventer cremoriventer</i>	Dac	1	Cibodas, Mt. Gede, West Java	SAM15174	Yes
<i>Niviventer lepturus</i>	Dac	2	Cibodas, West Java	ANWC M27097; ANWC M27100	Yes
<i>Saxatilomys paulinae</i>	Dac	1	Nakai plateau, Khammouane Pr., Laos	ANWC M32530	Yes
<i>Maxomys bartellsii</i>	Max	2	Cibodas, Mt Gede, West Java	SAM15175, SAM15176	Yes
<i>Maxomys panglima</i>	Max	1	Mt. Balabag, Palawan Island, Philippines (ex Field Museum of Natural History, Chicago) (FMNH)	FMNH63224	Yes
<i>Maxomys moi</i>	Max	1	Nakai plateau, Laos	ANWC M33243	No
<i>Maxomys whiteheadi</i>	Max	1	Ulu Gombak, Malaysia	RW1 [*]	Yes
<i>Maxomys musschenbroekii</i>	Max	2	Mt Gandang Dewata, Mamasa	NMV C37003, NMV C37007	Yes
<i>Crunomys melanius</i>	Max	2	FMNH	FMNH154862, FMNH167889	Yes

<i>Berylmys bowersi</i>	R	2	Fraser's Hill & Ulu Lepah, Malaysia	Rbo2 ^x , Rbo3 ^x	Yes
<i>Sundamys muelleri</i>	R	1	Ulu Lepah, Malaysia	RM2 ^x	Yes
<i>Bunomys fratrorum</i>	R	2	Dumoga-Bone NP, Sulawesi. 0°34 ¹ N 123°54 ¹ E	SAM12619, SAM12623	Yes
<i>Bunomys chrysocomus</i>	R	2	Dumoga-Bone NP, Sulawesi. 0°34 ¹ N 123°54 ¹ E	SAM12621, SAM12617	Yes
<i>Bunomys andrewsi</i>	R	3	Mt. Gandang Dewata	NMV C36985, NMV C36982, NMV C36987	Yes
<i>Bunomys penitus</i>	R	1	Mt. Gandang Dewata 0°34 ¹ N 123°54 ¹ E	NMV C36983	Yes
<i>Paruromys dominator</i>	R	5	Dumoga-Bone NP, Sulawesi. 0°34 ¹ N 123°54 ¹ E; Kotamobagu; Gunung Muajat	SAM12632, SAM15164, SAM12622, CHSW39, CHSW105	Yes
<i>Rattus argentiventer</i>	R	2	Phetchburi, Amphoesthep, Thailand	SAM14923, SAM14924	Yes
<i>Rattus sakeratensis</i> (= <i>R. losea</i>)	R	1	central Thailand	R11	Yes
<i>Rattus tiomanicus</i>	R	3	Fraser's Hill, Malaysia	Rt1 ^x , Rt2 ^x , Rt3 ^x , Rt4 ^x	No
<i>Rattus exulans</i>	R	5	Institute for Medical Research, Kuala Lumpur, Malaysia	Re1, Re2, Re3, Re4, Re5	Yes
<i>Rattus rattus</i>	R	8	Phetchburi, Amphoesthep, Thailand & Adelaide, South Australia	na	Yes
<i>Rattus hoffmanni</i>	R	1	Dumago – Bone NP, Sulawesi	SAM12625	Yes
<i>Limnomys bryophilus</i>	R	2	Burkidnan Prov., Mindanao Island, Philippines	FMNH148044; FMNH148049	Yes
<i>Limnomys sibuanus</i>	R	1	Burkidnan Prov., Mindanao Island	FMNH147949	Yes
<i>Bandicota bengalensis</i>	R	5	Penang, Malaysia	Bb13 ^{xx} , Bb14 ^{xx} , Bb15 ^{xx} , Bb16 ^{xx} , Bb17 ^{xx}	Yes

<i>Bandicota indica</i>	R	6	Amphoe, Banglen, Pr Nakornpathom, & Supraburi, Thailand	B31 **, B32 **, B35 **, B36 **, B39 **, B40 **	Yes
<i>Bandicota savilei</i>	R	3	Ban Yaikara; Sri Thep, Phetchburi, Thailand	SAM14920; SAM14922; SAM14926	Yes
<i>Nesokia indica</i>	R	2	Kazan Kislagh, Central Iran; Rangpur, NW Bangladesh	FMNH97499; ANWC M31698	No
<i>Rattus colletti</i>	R	4	Evolutionary Biology Unit, SAM ***	Rc100, Rc101, Rc360, Rc102	Yes
<i>Rattus fuscipes</i>	R	8	Upper Sturt, South Australia	Rf1, Rf100, Rf102 et al	Yes
<i>Rattus leucopus</i>	R	3	Evolutionary Biology Unit, SAM ***	R11, JM974, JM2388	Yes
<i>Rattus lutreolus</i>	R	3	Grampians, Victoria	Rlut1, Rlut3, Rlut12	Yes
<i>Rattus steini</i>	R	3	Southern Highlands, Papua New Guinea	RsA63, RsE64, RsE65	Yes
<i>Rattus tunneyi</i>	R	2	Evolutionary Biology Unit, SAM ***	Rt120, Rt130	Yes
<i>Rattus villosissimus</i>	R	4	Evolutionary Biology Unit, SAM ***	Rv100, Rv101, Rv102, Rv104	Yes
<i>Eropeplus canus</i>	R	4	Lore Lindu & Mt. Gandangdewata, SW Sulawesi	NMV C37048; NMV C37050, NMV C36990, NMV C36991	Yes
<i>Sommeromys macrorhinos</i>	Ech	1	Mt. Gandang Dewata	NMV C37074	Yes
<i>Tateomys macrocercus</i>	Ech	2	Mt. Gandang Dewata	NMV C37081, NMV C37026	Yes
<i>Paucidentomys vermidax</i>	Ech	1	Mt. Gandang Dewata	NMV C23914	Yes
<i>Gracilimus radix</i>	Ech	3	Mt. Gandang Dewata	NMV C37053; NMV C37055; NMV C36996	Yes
<i>Waiomys mamasae</i>	Ech	1	Mt. Gandang Dewata	NMV C37027	Yes

* For information of location of the specimens see Breed and Yong (1986); ** for information of location of where these specimens were obtained see Breed (1998); ***Bred at EBU. na=not applicable.

Reference

Breed, W. G., and Yong, H.-S. (1986). Sperm morphology of murid rodents from Malaysia and its possible phylogenetic significance. *Am. Mus. Novit.* **2856**, 1–12.

Table S2. Specimens used in phylogenetic analyses and GenBank accession numbers for each locus

Taxon	Voucher	Voucher Institution	GenBank accession numbers				
			cytb	IRBP	GHR	RAG1	BRCA1
<i>Bandicota bengalensis</i>	T065	na	AM408336	AM408331	AM910945	na	na
<i>Bandicota indica</i>	ABTC 64912	South Australian Museum	SJS	HM217713	na	na	na
<i>Bandicota savilei</i>	R1191	na	HM217385	HM217665	na	na	na
<i>Berylmys bowersi</i>	MVZ 186482/T-861	Museum of Vertebrate Zoology	AM408337	AM407896	DQ019056	DQ023457	KC953160
<i>Bunomys andrewsi</i>	NMV Z20459	Museums Victoria	NEW	NEW	NEW	na	na
<i>Bunomys chrysocomus</i>	NMV Z26378	Museums Victoria	NEW	NEW	NEW	NEW	NEW
<i>Bunomys fratrorum</i>	NMV Z54174	Museums Victoria	NEW	NEW	NEW	NEW	na
<i>Bunomys penitus</i>	FMNH213103	Field Museum of Natural History	NEW	NEW	NEW	na	na
<i>Crnomys melanius</i>	FMNH 147105	Field Museum of Natural History	DQ191477	DQ191506	GQ405379	na	na
<i>Eropeplus canus</i>	NMV Z21733	Museums Victoria	NEW	NEW	NEW	NEW	NEW
<i>Gracilimus radix</i>	MZB 37399	Museum Zoologicum Bogoriense	KU375188	KU375186	KU375187	KU375185	KU375189
<i>Leopoldamys edwardsi</i>	MVZ 186501	Museum of Vertebrate Zoology	KJ607279	HM217687	na	KJ607312	na
<i>Leopoldamys sabanus</i>	CMNH 102138	Carnegie Museum of Natural History	KJ607280	KJ607302	DQ019063	KC953513	KC953186

<i>Limnomys bryophilus</i>	FMNH 147970	Field Museum of Natural History	DQ191479	DQ191508	GQ405380	na	na
<i>Limnomys sibuanus</i>	FMNH 147947	Field Museum of Natural History	DQ191480	DQ191509	GQ405381	na	na
<i>Maxomys bartelsii</i>	ABTC 48063	South Australian Museum	EU349762	EU349857	DQ019066	DQ023460	EU349666
<i>Maxomys muschenbroekii</i>	MZB 34728	Museum Zoologicum Bogoriense	KJ607281	KJ607304	KJ607293	KJ607316	KJ607267
<i>Maxomys panglima</i>	KUMNH 165356	University of Kansas Museum of Natural History	KC878129	KC878226	KC878187	KJ607317	KJ607268
<i>Maxomys whiteheadi</i>	ROM 113074	Royal Ontario Museum	KJ607282	KJ607305	KJ607294	na	na
<i>Niviventer cremoriventer</i>	FMNH 35796	Field Museum of Natural History	KJ607284	KC953417	DQ019067	KC953541	KC953198
<i>Niviventer culturatus</i>	MVZ 180686	Museum of Vertebrate Zoology	GU479941	KC953418	DQ019068	DQ023458	KC953199
<i>Niviventer fulvescens</i>	WAM M38541	Western Australian Museum	NEW	NEW	NEW	NEW	na
<i>Niviventer lepturus</i>	NMV Z25195	Museums Victoria	na	NEW	NEW	NEW	NEW
<i>Paruromys dominator</i>	NMV C37024	Museums Victoria	KJ607285	KJ607307	KJ607296	KJ607320	KJ607271
<i>Paucidentomys vermidax</i>	FMNH 213102	Field Museum of Natural History	KJ607286	KJ607308	KJ607297	KJ607321	KJ607272
<i>Rattus argentiventer</i>	MSB 93171	Museum of Southwest Biology	SJS	HM217602	na	SJS	na
<i>Rattus colletti</i>	ABTC51642	South Australian Museum	na	HQ334598	na	na	KCR
<i>Rattus exulans</i>	NK 80010	na	NK 80010	KC953446	DQ019074	DQ023455	na
<i>Rattus fuscipes</i>	QM 18999	Queensland Museum	EF186435	HQ334610	na	na	na

<i>Rattus hoffmanni</i>	MVZ 225813	Museum of Vertebrate Zoology	KC878168	KC878238	KC878200	NEW	NEW
<i>Rattus leucopus</i>	ABTC42806	South Australian Museum	na	HQ334582	na	HQ334652	HQ334396
<i>Rattus losea</i>	ABTC 118627	South Australian Museum	HM031715	na	na	na	na
<i>Rattus lutreolus</i>	D39	Southern Cross University	na	HQ334611	na	HQ334676	HQ334422
<i>Rattus rattus</i>	T820/T660/CACG A65	Centre for Animal Conservation Genetics	na	HM217606	AM910976	HQ334643	na
<i>Rattus steini</i>	ABTC47100	South Australian Museum	na	HQ334588	na	HQ334657	HQ334401
<i>Rattus tunneyi</i>	RAT132	Southern Cross University	na	HQ334627	na	HQ334690	HQ334434
<i>Rattus villosissimus</i>	ABTC 00549	South Australian Museum	EU349729	HQ334576	EU349826	EU349915	EU349673
<i>Saxatilomys paulinae</i>	ABTC 116266	South Australian Museum	KU375155	KU375173	na	KU375181	KU375145
<i>Sommeromys macrorhinos</i>	MZB 34758	Museum Zoologicum Bogoriense	KU375156	KU375174	KU375164	KU375182	KU375146
<i>Sundamys muelleri</i>	MVZ 192334	Museum of Vertebrate Zoology	EU349787	AY326111	DQ019077	DQ023456	EU349668
<i>Tateomys macrocercus</i>	MZB 34788	Museum Zoologicum Bogoriense	KU375157	KU375175	KU375165	na	KU375147
<i>Waiomys mamasae</i>	MZB 37000 / NMV C37027	Museum Zoologicum Bogoriense	KJ607287	KJ607309	KJ607298	KJ607322	KJ607273

Table S3. Raw data of body mass, testes mass, relative testis mass (RTM) and sperm morphological parameters of rodents in the Tribe Rattini (mean \pm s.d.)

Species name	Trib e	Division	Average Body and testes mass				Sperm Morphology (mean \pm SD)			
			Sample Size	Body Mass (g)	Testes Mass (mg)	RTM (%)	Head Area (μm^2)	Apical Hook Length (μm)	Apical Hook Angle ($^\circ$)	Tail Length (μm)*
<i>Chiromyscus chiropus</i>	R	Dac	1	xx	2538	-	14 \pm 2.4	5.1 \pm 1.0	239 \pm 14	173 \pm 4
<i>Leopoldamys edwardsi</i> †	R	Dac	4	343	7327	2.14%	22 \pm 3.8	8 \pm 1.2	246 \pm 16	168 \pm 6
<i>Leopoldamys sabanus</i> †	R	Dac	3	384	9528	2.48%	18 \pm 1.7	8 \pm 0.8	266 \pm 14	175 \pm 5
<i>Niviventer cremoriventer</i> †	R	Dac	1	75	1222	1.63%	19 \pm 1.0	6.0 \pm 0.5	325 \pm 9	123 \pm 3
<i>Niviventer culturatus</i> †	R	Dac	1	103	1876	1.82%	25 \pm 3	10 \pm 0.6	283 \pm 17	171 \pm 2
<i>Niviventer fulvescens</i>	R	Dac	1	xx	547	-	23 \pm 1.6	9.0 \pm 0.6	332 \pm 12	129 \pm 2
<i>Niviventer lepturus</i>	R	Dac	2	xx	522	-	18 \pm 1.2	6 \pm 0.4	308 \pm 9	115 \pm 10
<i>Saxatilomys paulinae</i>	R	Dac	1	xx	1982	-	28 \pm 3	12 \pm 0.6	294 \pm 9	158 \pm 3
<i>Crunomys melanius</i>	R	Max	2	xx	255	-	43 \pm 5.7	5 \pm 0.9	283 \pm 21	105 \pm 4
<i>Maxomys bartellsii</i> †	R	Max	2	87	4417	5.06%	26 \pm 2.7	7.0 \pm 0.8	304 \pm 13	148 \pm 2
<i>Maxomys musschenbroekii</i> †	R	Max	2	104	2721	2.63%	26 \pm 2.0	7 \pm 0.8	287 \pm 17	151 \pm 2
<i>Maxomys panglima</i>	R	Max	1	xx	xx	-	15 \pm 1.5	7 \pm 0.5	216 \pm 5	383 \pm 16
<i>Maxomys moi</i> †~	R	Max	1	181	3660	2.02%	26 \pm 2.5	3.0 \pm 0.3	294 \pm 17	100 \pm 1
<i>Maxomys whiteheadi</i> †	R	Max	1	64	952	1.49%	39 \pm 3.8	6 \pm 1.2	271 \pm 30	123 \pm 2
<i>Bandicota bengalensis</i> †	R	R	5	334	1956	0.59%	23 \pm 1.5	5 \pm 0.3	274 \pm 13	135 \pm 3

<i>Bandicota indica</i> †	R	R	6	529	2439	0.46%	9±2.6	0	0	58±11
<i>Bandicota savilei</i> †	R	R	3	274	1263	0.46%	9±1.0	0	0	66±5
<i>Berylmys bowersi</i> †	R	R	2	495	18186	3.67%	27±3.7	11±0.6	285±19	172±8
<i>Bunomys andrewsi</i>	R	R	3	149	2744	1.82%	19±2	7±0.9	268±13	146±3
<i>Bunomys chrysocomus</i> †	R	R	2	118	3523	3.00%	25±3.4	8±1.0	296±13	162±4
<i>Bunomys fratrorum</i> †	R	R	2	130	362	0.28%	16±2.0	4±0.4	241±13	118±5
<i>Bunomys penitus</i> †	R	R	1	173	2150	1.24%	28±1.9	8±0.7	288±8	166±2
<i>Limnomys bryophilus</i>	R	R	2	xx	412	-	20±2.1	9±0.7	280±11	156±5
<i>Limnomys sibuanus</i>	R	R	1	xx	320	-	17±0.9	7±0.4	278±5	147±4
<i>Nesokia indica</i>	R	R	2	178	510	0.29%	12±1.0	0	0	76±4
<i>Paruromys dominator</i> †	R	R	5	385	1979	0.51%	37±2.5	7.0±1.0	274±18	122±3
<i>Rattus argentiventer</i> †	R	R	2	267	3926	1.47%	22±2	9±0.6	291±3	172±2
<i>Rattus colletti</i> †	R	R	4	139	2047	1.48%	25±2.6	7.0±1.0	308±26	154±4
<i>Rattus everetti</i> †	R	R	1	250	2206	0.88%	21±1.8	7±0.6	273±16	153±2
<i>Rattus exulans</i> †	R	R	5	56	1539	2.76%	33±2.3	10±0.8	296±9	172±1
<i>Rattus fuscipes</i> †	R	R	8	117	4591	3.94%	21±1.7	8±1.0	303±6	147±3
<i>Rattus hoffmanni</i> †	R	R	1	160	1615	1.01%	32±3.5	8±0.7	286±9	149±2
<i>Rattus leucopus</i> †	R	R	3	122	3639	2.99%	24±4.2	8±0.6	290±18	146±2
<i>Rattus losea</i> †	R	R	1	110	2174	1.98%	19±0.9	9±0.6	289±7	162±2
<i>Rattus lutreolus</i> †	R	R	3	116	4285	3.69%	33±2.5	10±1.0	302±14	155±1

<i>Rattus rattus</i> †	R	R	8	129	3378	2.61%	27±2.4	9.0±0.8	284±14	156±1
<i>Rattus steini</i> †	R	R	3	81	1187	1.47%	22±1.9	9±1.1	282±16	137±11
<i>Rattus tiomanicus</i>	R	R	4	90	3473	3.86%	-	-	-	-
<i>Rattus tunneyi</i> †	R	R	2	177	4640	2.63%	34±1.5	10±0.7	289±13	150±1
<i>Rattus villosissimus</i> †	R	R	4	199	2143	1.08%	25±2.0	8±0.7	313±13	150±2
<i>Sundamys muelleri</i> †	R	R	1	400	7440	1.86%	28±2.2	9±0.8	285±16	150±2
<i>Gracilimus radix</i> †	R	Ech	3	45	576	1.29%	25±2.7	5±0.8	284±14	114±2
<i>Paucidentomys vermidax</i> †	R	Ech	1	108	3270	3.03%	19±1.3	9.4±0.4	324±8	132±2
<i>Sommeromys macrorhinos</i> †	R	Ech	1	27	271	1.00%	18±1.9	7.4±0.3	298±11	161±1
<i>Tateomys macrocercus</i> †	R	Ech	2	42	826	1.97%	15±2.1	5.3±0.5	303±12	125±3
<i>Waiomys mamasae</i> †	R	Ech	1	64	1284	2.01%	25±2.0	5.5±0.6	301±9	106±7
<i>Eropeplus canus</i> †	R	R	4	300	969	0.32%	18±3.0	1.7±0.3	-	115±2

* = sperm tail length is taken from the connecting piece to the tip of the end piece in all cases

† = species included in phylogenetic analysis

~ = analysed on the phylogeny as *Maxomys surifer*

^{xx} no weight recorded

Note: In *Eropeplus canus* the spermatozoa in 3/4 individuals had sperm with short apical hook; in the other no hook was present.

Tribes

(from LeCompte *et al.* 2008, *BMC Evol. Biol.* **8**, 199)

R=Rattini

Divisions

(from Musser & Carleton, 2005, in Wilson DE & Reeder DM Mammal Species of the World)

Dac= Dacnomys

Max=Maxomys

Ech=Echiothrix

R=Rattus

Fig. S1. Phylogeny where known of species used in the study.