GEOGRAPHICAL DISTRIBUTION AND MORPHOMETRY OF *HEIMYSCUS FUMOSUS* (BROSSET *ET AL.*, 1965)

Violaine NICOLAS[1], Wim WENDELEN[2], Walter VERHEYEN[3] & Marc COLYN[1]

RÉSUMÉ

Plus de 35 ans après sa description, le Muridé africain *Heimyscus fumosus* reste mal connu et peu de spécimens sont déposés dans les musées. Depuis 1992 nous avons collecté 239 spécimens dans dix localités d'Afrique centrale, nous permettant de confirmer sa distribution géographique. Cette espèce est présente dans les forêts de plaine situées entre les rivières Sanaga et Oubangui-Congo. De plus, l'étude d'une population du sud-ouest du Gabon nous a permis d'analyser les variations morphologiques intra-populationnelles chez cette espèce. Nos résultats mettent en évidence une augmentation avec l'âge de la plupart des mesures externes et crâniennes; en revanche, le dimorphisme sexuel est faible.

SUMMARY

More than 35 years after its original description, our knowledge of the De Balsac's mouse (*Heimyscus fumosus*) remains poor, and few specimens are deposited in museums. We collected 239 specimens of this species in ten central African localities. We therefore had the opportunity to confirm its geographical distribution, which covers lowland forests between the Sanaga and the Oubangui-Congo rivers. Moreover, based upon specimens collected from a single locality, we analysed intra-populational morphological variations of the De Balsac's mouse. We showed that most external and cranial measurements increased with age; while sexual dimorphism was low.

INTRODUCTION

De Balsac's Mouse (*Hylomyscus fumosus*) was described in 1965 from Gabon by Brosset *et al.* While the validity of the species is not questionable, its affiliation

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to the genus *Hylomyscus* gives rise to controversy. Misonne (1969) suggested the creation of a new genus *Heimyscus* based on its cranial characteristics. He was followed by Meester & Setzer (1971), and Musser & Carleton (1993). Although Duplantier (1982), emphasized that the external morphology of *H. fumosus* differs significantly from that of other *Hylomyscus*, he kept it within the genus *Hylomyscus*. In this paper, we use the nomenclature proposed by Musser & Carleton (1993).

In the original description, the external and cranial morphology of *H. fumosus* was carefully described. However, no information on cranial measurements were given and few specimens were deposited in museums.

Our knowledge of *H. fumosus* remains poor. It is mentioned from five localities in Gabon (Brosset *et al.*, 1965), Central African Republic (Petter & Genest, 1970), Cameroon (Robbins *et al.*, 1980), Republic of Congo (Granjon, 1991), and Equatorial Guinea (Lasso, 1995), and one paper deals with its ecology (Duplantier, 1982).

In the context of several international projects on the tropical forest biodiversity, we carried out surveys on small mammals communities in four central African countries. During these field works we collected 239 *H. fumosus* from ten localities. In this paper, we precise the distribution of this species and its habitat preferences, and, for the first time, analyse morphological variations of one population from Gabon.

STUDY AREAS AND METHODS

From 1992 to 2001, we captured *H. fumosus* in ten localities (Table I) located in Cameroon, Central African Republic (C.A.R.), Republic of Congo and Gabon. They were trapped with Sherman and snap traps arranged in lines or grids, and with pitfall lines with drift fences (see details in Colyn *et al.*, 1996). In order to define the geographical distribution of *H. fumosus*, we combined data from our surveys, museums collections (Table I) and bibliographical data.

At most localities, several types of habitat were surveyed (primary forest, secondary forest, fallow land, savannahs). Details on habitat characteristics are given in Nicolas & Barrière (2001) for Monts Doudou, in Barrière & Nicolas (2000) for Batouri, and in Colyn et al. (1996) for other localities. Habitat preferences and spatial variations in trapping success (number of specimens caught per 100 trap-nights) were evaluated by Chi-square tests.

Intra-populational variability of external and cranial measurements of *H. fumosus* was studied on 207 specimens trapped in Monts Doudou (Gabon). Five standard external measures were taken on freshly killed mice: weight (W), head+body length (HB), tail length (TL), hindfoot length with nail (HF), ear length (EL). Specimens were preserved in 10 % formalin and skulls were later on removed and cleaned at the lab. Twenty three craniometrical and dental dimensions were measured on every skull (Tab. II). All specimens were age-classified using the following stages of tooth eruption and tooth-wear patterns of the maxillary toothrows: age-class 0: M^3 not yet fully erupted; age-class 1: all cheekteeth fresh but fully erupted, the exposed dentine of the three cusps of the first row of M^1 are not yet fused; age-class 2: wear is light, dentine-bridge between the cusps of the first row of M^1 becomes progressively wider as the cusps wear down; age-class 3: wear is obvious, the bottom of the grove between row 2 and 3 is reached and the grove is

TABLE I

Number of specimens of Heimyscus fumosus *collected by our team in ten Central African localities, and number of specimens deposited in museum and reviewed for our analysis of the geographical distribution of this species. Localities of collect, name of the collector, year of capture, and museum where the specimens are deposited are precised. The following acronyms identify the museum: CMNH: Carnegie Museum of Natural History, MHNP: Museum d'Histoire Naturelle de Paris, MRAC: Musée Royal de l'Afrique Centrale de Tervuren, SBP: Station Biologique de Paimpont*

Country	Locality	Co-ordinates	Collector	Year of collect	Museum	Nb of skulls examined
Specimens collected by our team:						
Cameroon	Bodjouo	03.21N-13.02E		1995	SBP	2
C.A.R.	Grima	04.02N-17.05E		1996	SBP	2
	Bambio	03.57N-16.58E		1994	SBP	1
	Batouri	03.54N-17.02E		1994 1999	SBP	6
	Salo	03.11N-16.06E		1994	SBP	2
Rep. Congo	Mbomo	00.24N-14.44E		1995 to 1997	SBP	8
Gabon	La Makandé	00.41S-11.55E		1995	SBP	7
	Gongué	00.47S-11.55E		1992	SBP	3
	Monts Doudou	02.09S-10.30E		2000 to 2001	SBP	207
	Malounga	03.09S-10.45E		1998	SBP	1
Specimens in museums:						
Cameroon	Efulen (1)	02.47N-10.32E	Good	1944	CMNH	1
	Eseka (2)	03.38N-10.47E	Robbins	1974	CMNH	1
	Yaoundé (3)	03.52N-11.31E	Mouchet	1956	MHNP	1
C.A.R.	Kongana (10)	02.47N-16.25E	Ray	1993	MRAC	6
	Boukoko (11)	03.54N-17.55E	Pujol	1962	MHNP	1
Congo	Kouboutchi (13)	04.19S-11.47E	Granjon	1990	MHNP	2
Gabon	Makokou (14)	00.34N-12.52E	Dubost	1962 to 1964	MHNP	18

TABLE II

Recapitulation and short description of the measurements as used in this study. For a full description we refer to Verheyen et al. *(1996)*

Numbers	Acronyms	Morphometrical characters
M1	GRLS	greatest length of skull
M2	PRCO	condylobasal length
M3	HEBA	henselion-basion
M4	HEPA	henselion-palation
M5	PAFL	length of palatal foramen
M6	DIA1	length of diastema
M7	DIA2	distance between alveolus M^1 and cutting edge of upper incisor
M8	INTE	smallest interorbital breadth
M9	ZYGO	zygomatic breadth
M10	PALA	smallest palatal breadth
M11	UPTE	length of upper cheekteeth
M12	UPDA	breath of upper dental arch
M13	M^1BR	greatest breadth of first upper molar
M14	ZYPL	smallest breadth of zygomatic plate
M15	BNAS	greatest breath of nasals
M16	LNAS	greatest length of nasals
M17	LOTE	length of mandibular teeth
M18	BULL	length of auditory bulla
M19	BRCA	greatest breadth of braincase
M20	DINC	depth of upper incisor
M21	ROHE	mediosagittal projection of rostrum height
M22	ROBR	greatest rostrum breadth
M23	PCPA	distance between coronoid and angular processes

interrupted on the lingual side of the molar; age-class 4: wear is extensive, the dentine of row 2 and 3 make contact with each other; age-class 5: wear is severe, M^1 is heavily eroded and all rows are communicating. Sexual dimorphism and growth were statistically evaluated by Student t-test on the basis of both external and cranial measurements.

RESULTS

GEOGRAPHICAL DISTRIBUTION AND HABITAT PREFERENCE (Fig. 1)

H. fumosus, described from Makokou (Gabon, Brosset *et al.*, 1965), is also mentioned from Eseka (Cameroon, Robbins *et al.*, 1980), La Maboké (C.A.R., Petter & Genest, 1970), Monte Alen (Equatorial Guinea, Lasso, 1995) and Kouboutchi (Republic of Congo, Granjon, 1991); specimens from Yaoundé and Efulen (Cameroon), and from Kongana and Boukoko (C.A.R.) are also deposited in different museums. We collected this species in ten additional localities: Bodjouo (Cameroon), Grima, Bambio, Batouri and Salo (C.A.R.), Mbomo (Republic of Congo), La Makandé, Gongué, Monts Doudou and Malounga (Gabon).

Further to the West, in Nigeria (Gambari forest, Happold, 1977; Gotel Mountains and Mambilla Plateau, Hutterer *et al.,* 1992), Ghana (Jeffrey, 1977), Ivory Coast (Adam, 1977; Dosso, 1983; Collinet *et al.*, 1984), Liberia (Mont Nimba, Verschuren, 1986) and Guinea (Mont Nimba, Gautun, 1986) *H. fumosus* was never captured. The same applies to the North for the C.A.R (Bamingui-Brendja, Colyn, unpub. data), and to the East for the Democratic Republic of Congo (Kikwit, Leirs *et al.*, 1999; Ituri forest, Gubista, 1999; Masako, Dudu, 1991; Kisangani left and right bank of the Congo river, Colyn unpub. data). More eastward, this species was

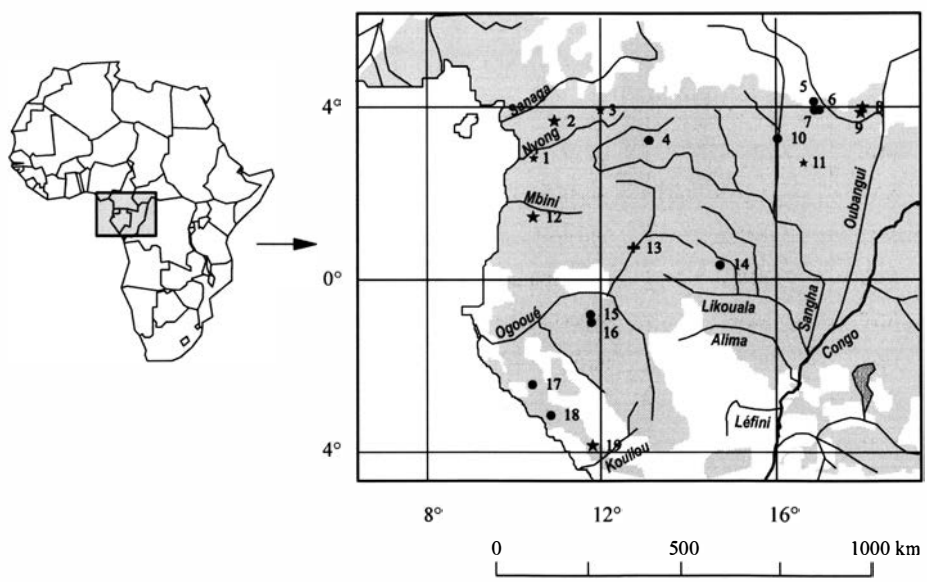

Figure 1. — Geographical distribution of *Heimyscus fumosus*. The symbol + refers to the type locality, ✶ refers to specimen deposit in a museum, and ●refers to our own data. The numbers refer to the following localities: (1) Efulen, (2) Eseka, (3) Yaoundé, (4) Bodjouo, (5) Grima, (6) Bambio, (7) Batouri, (8) La Maboké, (9) Boukoko, (10) Salo, (11) Kongana, (12) Monte Alen, (13) Makokou, (14) Mbomo, (15) La Makandé, (16) Gongué, (17) Monts Doudou, (18) Malounga, (19) Kouboutchi.

never found in Uganda (Mayanja, Delany, 1971; Kibale, Struhsaker, 1997) and Malawi (Zomba Plateau, Nyika Plateau and Mulanje Mountain, Happold & Happold, 1989).

All these data confirm that *H. fumosus* is only present in lowland forests, between the Sanaga River (West) and the Oubangui-Congo River (East).

In Monts Doudou, all specimens were captured in primary forest, and at the nine other localities, 28 out of 32 specimens were collected in primary forest. The four others were collected in fallow land (two in Gongué and one in Bodjouo) or in secondary forest (one in Batouri). *H. fumosus* seems to prefer primary forest, rather than secondary forest or open areas. Moreover, it would prefer *terra firme* forest rather than riparian or swamp forest, as indicated by captures realized in Monts Doudou forest: trapping success of 0.17, 0.07 and 0.07 in *terra firme*, riparian and swamp forests respectively ($\chi^2 = 6.822$, df = 2, $P < 0.05$). Finally, this species seems to be mainly terrestrial since no capture occurred on lianas or branches.

For a given habitat (*terra firme* forest), the abundance of *H. fumosus* varied depending on sites. For example, its trapping success was of 0.17, 0.02 and 0.02 in Monts Doudou, Mbomo and Batouri respectively ($\chi^2 = 61.400$, df = 2, $P < 0.001$) and its relative abundance among the murid community was of 9, 4.3 and 1.1 % respectively at the same localities.

INTRA-POPULATIONAL MORPHOLOGICAL VARIATIONS

The dorsal pelage is dark-grey, a little reddish for old individuals; the ventral colour, from the cheeks to the beginning of the tail, is whitish. The belly hairs are grey basally and white in the terminal half. The coloration of the belly passes gradually into that of the back. The dorsal sides of the fore and hindfeet are white, and the morphology of the hindfoot agrees with the description given by Brosset *et al.* (1965). The ear, black-grey, is well developed (mean length 16.6 mm). The tail is slightly longer than the head and body length. The mean length of the tail for adult specimens is 95 mm (70 mm – 115 mm); the head and body length are 90 mm (68 mm – 104 mm). The mean hindfoot length for adult specimens is 20.2 mm (16.3 mm – 22.1 mm). Females have 3 pairs of nipples (1 pectoral and 2 inguinal).

Figure 2 illustrates the variation present in cusp and ridge patterns of the right maxillary teeth of four representative specimens among the 207 specimens examined. Cusp and ridge patterns are rather stable from one individual to another. In 40 % of the specimens (e.g. GA1984 and GA2982), the t_3 cusp of M^1 shows a beginning of splitting in two. The two most variable characters are the length and breadth of the molars.

Sexual dimorphism was tested for each age-class separately, and for all age-classes combined. Whatever the age-class, mice of both sexes do not differ significantly for most of the considered variables. When all age-classes are pooled together in analysis, males have a larger interorbital breadth (M8) and rostrum breadth (M22) than females (Table III).

The influence of growth on cranial and external measures was analysed for each sex separately, and for both sexes combined. Whatever the sex, most measurements increase significantly with age. Only five measurements out of 28 did not vary significantly: hindfoot length (HF), upper cheekteeth length (M11), upper molar breath (M13), mandibular cheekteeth length (M17) and auditory bulla length (M18; Table IV). The increase with age, of skull length (M1), zygomatic breadth

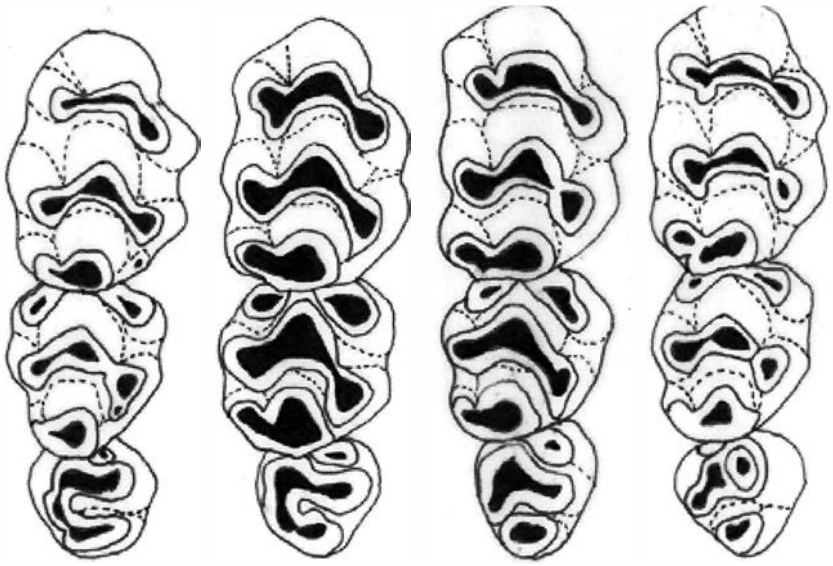

Figure 2. — Comparative drawings of the right maxillary teeth of *Heimyscus fumosus*. Left to right: GA3440, GA1984, GA1437 and GA2982.

(M9), nasals breadth (M15), length of nasals (M16), braincase breadth (M19) and rostrum breadth (M22) are visualized in Figure 3.

DISCUSSION

H. fumosus is present in a large area of lowland forests, between the Sanaga River and the Oubangui-Congo River. Its low trap success could explain its rarity in museum collections.

It seems to prefer primary forest, and particularly *terra firme* forest. However, it can also be present occasionally in adjacent habitats. Thus, it was collected in manioc fields, at the immediate vicinity of a marshland, and in riparian and secondary forest by Brosset *et al.* (1965) and by Lasso (1995). The preference of *H. fumosus* for *terra firme* forest could be related to the fact that this species digs burrows (Duplantier, 1982), has a poor swimming ability (V.N. pers. obs.), and is terrestrial (Brosset *et al.*, 1965; Duplantier, 1982; our data).

Misonne (1969) suggested the creation of the genus *Heimyscus* for this species, owing to its cranial morphology. However, no thorough comparative effort was made to justify his proposition, and a comparative revision of *Hylomyscus* and *Heimyscus* is still needed. According to Verheyen & Bracke (1966), in order to make a systematic revision of a given Murid-species, one must make first a thorough morphological study of one "interbreeding population". Our study on the intra-popula-

TABLE III

Comparison between males and females of Heimyscus fumosus *for 5 external measurements and 23 cranial measurements. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. To provide general trends results for all age-classes combined are given. Body weights are in grams and other measurements are in millimetres*

	females							males				
	n	mean	min	max	SD	t-value		n	mean	min	max	SD
W	83	17.19	7.00	27.00	3.97	-0.25		102	17.33	7.80	23.00	3.62
BL	90	86.82	62.00	102.00	8.95	-0.39		112	87.28	64.00	104.00	7.68
TL	88	91.11	37.00	115.00	11.16	-1.62		109	93.40	70.00	111.00	8.73
HF	90	19.87	17.00	22.00	0.92	-0.18		112	19.91	9.40	22.10	1.46
EL	80	16.37	12.00	25.00	1.59	-0.37		106	16.45	13.30	19.20	1.22
M1	67	25.42	22.65	27.70	0.98	0.39		88	25.36	22.30	27.05	1.08
M2	71	23.35	20.05	25.45	1.05	-0.17		99	23.38	19.90	25.20	1.10
M3	72	19.99	16.95	22.15	0.98	-0.13		99	20.01	16.65	21.65	1.02
M4	77	11.15	9.75	12.25	0.53	0.23		102	11.13	9.70	12.05	0.53
M5	77	3.95	3.15	4.55	0.27	0.52		102	3.92	3.10	4.75	0.30
M6	77	7.16	5.80	8.20	0.44	0.01		102	7.16	5.90	7.95	0.43
M7	77	7.84	6.40	8.85	0.49	-0.17		102	7.86	6.40	8.85	0.49
M8	77	4.56	3.95	5.00	0.19	-2.62	**	101	4.64	4.20	5.10	0.21
M9	73	11.68	10.50	12.95	0.44	0.41		101	11.66	10.45	12.75	0.44
M10	77	2.73	2.35	3.35	0.18	0.22		102	2.73	2.20	3.10	0.17
M11	77	3.61	3.20	3.80	0.13	-0.78		102	3.63	3.30	4.05	0.15
M12	77	5.07	4.70	5.70	0.20	-0.24		102	5.08	4.60	5.50	0.19
M13	77	1.18	1.05	1.25	0.04	0.95		102	1.18	1.10	1.35	0.05
M14	77	2.21	1.75	2.55	0.16	0.82		102	2.20	1.75	2.55	0.15
M15	77	2.49	1.90	3.10	0.19	-1.00		102	2.52	2.15	2.85	0.16
M16	72	9.89	7.70	11.20	0.66	0.16		95	9.88	7.85	11.25	0.69
M17	77	3.42	3.15	3.70	0.13	-0.03		102	3.42	3.20	3.70	0.12
M18	75	4.07	3.75	4.50	0.18	1.19		100	4.04	3.55	4.60	0.18
M19	75	10.54	9.80	11.30	0.32	0.15		102	10.54	9.55	11.20	0.30
M20	77	1.14	0.85	1.35	0.09	-1.52		102	1.16	0.90	1.40	0.10
M21	77	5.19	4.50	5.85	0.27	-1.02		101	5.24	4.50	5.80	0.29
M22	77	4.37	3.70	5.15	0.30	-2.09	*	102	4.47	3.80	5.10	0.26
M23	76	6.51	5.30	7.60	0.43	-0.05		102	6.52	5.45	7.50	0.43

TABLE IV

Comparison between Heimyscus fumosus *of age-classes 1 and 2 for 5 external measurements and 23 cranial measurements. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Body weights are in grams and other measurements are in millimetres*

	age-class 1							age-class 2				
	n	mean	min	max	SD	t-value		n	mean	min	max	SD
W	76	15.91	7.80	25.00	3.62	-5.37	***	75	18.57	13.30	23.00	2.31
HB	83	84.36	64.00	98.00	7.32	-5.75	***	80	90.33	70.00	104.00	5.80
TL	80	89.93	70.00	108.00	8.46	-4.16	***	80	95.74	37.00	111.00	9.19
HF	82	19.71	9.40	22.10	1.58	-1.80		81	20.07	17.60	22.10	0.89
EL	77	16.19	13.30	18.70	1.13	-3.12	*	78	16.82	14.20	25.00	1.40
M1	66	25.02	22.30	27.05	1.03	-4.19	***	73	25.66	22.60	26.85	0.78
M2	71	22.91	20.05	24.95	1.04	-5.20	***	82	23.67	20.75	25.00	0.74
M3	72	19.58	17.25	21.55	0.94	-5.24	***	82	20.28	17.55	21.60	0.70
M4	77	10.92	9.70	11.80	0.54	-5.02	***	85	11.30	10.20	12.00	0.40
M5	77	3.85	3.10	4.55	0.29	-3.95	***	85	4.02	3.40	4.75	0.25
M6	77	6.96	5.90	7.65	0.40	-5.93	***	85	7.29	6.30	7.95	0.31
M7	77	7.62	6.50	8.40	0.45	-6.33	***	85	8.01	7.00	8.75	0.33
M8	77	4.57	3.95	5.10	0.22	-1.91		84	4.63	4.30	5.00	0.17
M9	75	11.51	10.50	12.30	0.45	-3.52	***	84	11.73	10.45	12.60	0.34
M10	77	2.66	2.20	3.10	0.16	-4.52	***	85	2.76	2.50	3.05	0.13
M11	77	3.62	3.35	4.00	0.14	0.20		85	3.61	3.20	4.05	0.15
M12	77	4.99	4.60	5.30	0.16	-4.78	***	85	5.11	4.75	5.50	0.16
M13	77	1.18	1.10	1.25	0.04	-0.55		85	1.18	1.05	1.35	0.05
M14	77	2.18	1.75	2.45	0.15	-1.91		85	2.22	1.80	2.55	0.14
M15	77	2.45	1.90	2.85	0.18	-4.17	***	85	2.56	2.25	2.90	0.15
M16	73	9.63	7.70	10.95	0.71	-4.65	***	79	10.09	8.20	11.25	0.51
M17	77	3.43	3.20	3.70	0.11	0.86		85	3.41	3.15	3.70	0.13
M18	75	4.05	3.55	4.60	0.19	0.12		83	4.05	3.75	4.50	0.17
M19	76	10.47	9.55	11.30	0.33	-2.27	*	84	10.58	9.90	11.20	0.26
M20	77	1.11	0.85	1.30	0.09	-5.60	***	85	1.18	0.90	1.35	0.07
M21	77	5.11	4.50	5.75	0.28	-4.77	***	84	5.30	4.50	5.85	0.23
M22	77	4.31	3.70	4.95	0.27	-5.15	***	85	4.51	3.90	5.00	0.21
M23	77	6.34	5.40	7.05	0.42	-5.19	***	84	6.64	5.55	7.50	0.31

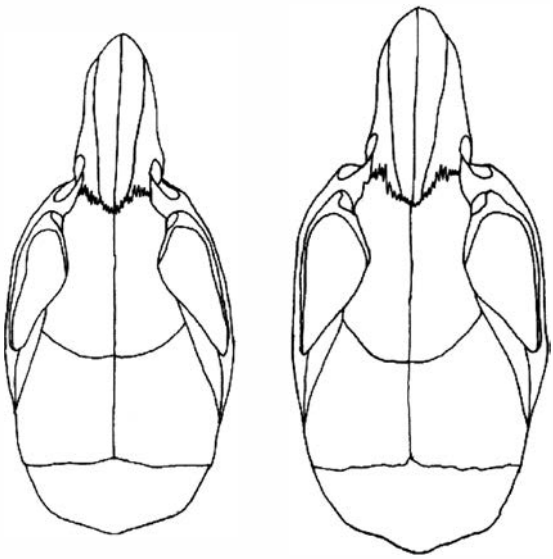

Figure 3. — Drawings of the dorsal view of two *Heimyscus fumosus*, illustrating the variability in skull morphology relative to age. Left to right: GA3119 (age-class 1) and GA2542 (age-class 4).

tional morphological variations of *H. fumosus* in Monts Doudou could provide a baseline for an incoming systematic revision of the genus *Heimyscus*.

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