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Results of the Archbold Expeditions. No. 92 Taxonomic Notes on *Rattus dollmani* and *Rattus hellwaldi* (Rodentia, Muridae) of Celebes

By Guy G. Musser[1]

More than 60 named kinds of *Rattus* (as the genus is defined by Ellerman, 1941) are recorded from Celebes (Laurie and Hill, 1954). I have studied representatives of many of those forms, and have examined enough material to conclude that the number apparently does not reflect the actual diversity, either of good species or of well-differentiated intraspecific populations, of *Rattus* on Celebes. Despite the many named forms that are currently recorded in the literature, and the level of knowledge that such a plethora of names implies, no reliable information exists that will provide complete answers to any of these questions: How many species of *Rattus* actually occur on Celebes? What are the biological and distributional characteristics of populations comprising those species? How many forms are native to Celebes and how many were introduced by man? What are the zoogeographic relationships between the species of *Rattus* on Celebes and those in the Philippines and the Indo-Malayan region on one hand, and the kinds of *Rattus* in areas to the east and south of Celebes, particularly New Guinea and Australia, on the other?

There is enough material from Celebes in institutional collections (primarily in the Archbold Collection of the American Museum of

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Natural History, the United States National Museum of the Smithsonian Institution, and the British Museum [Natural History]) from which data can be obtained that will answer certain aspects of the questions listed above. Particular sampled populations of *Rattus* can be described as regards their morphology, geographic distribution, and ecology. The taxonomic status of these samples can also be clarified to some degree.

The *hellwaldi*-group of *Rattus* is such an example. I have studied specimens of rodents of the *hellwaldi* type in the American Museum of Natural History. The lot is heterogeneous and consists of samples that represent three populations; two are distinctive morphological segments of *hellwaldi,* the other series represents a population that is apparently reproductively isolated from *hellwaldi.* Subsequently, through the courtesy of Dr. Charles O. Handley, Jr., I examined the large collection of *R. hellwaldi* in the United States National Museum, Smithsonian Institution. That lot is one of the largest available for study in any institution and represents the best geographic coverage of northern and middle Celebes. In studying this material my intention was not to analyze critically individual and geographic variation in *hellwaldi,* but to see if any of the morphological characteristics seen in samples in the American Museum of Natural History that are from southern Celebes fit the material from northern and middle Celebes.

The results of my studies, along with data recorded in the literature, indicate that two species of rodents of the *hellwaldi* type occur on Celebes. The present report documents the morphological and distributional relations between those species and their relationship to a small sample of *hellwaldi* from southwestern Celebes.

COMPARISONS BETWEEN *RATTUS HELLWALDI* AND *RATTUS DOLLMANI*

Rattus hellwaldi is a large-bodied, long-tailed rodent endemic to Celebes. It was described and named in 1879 by F. A. Jentink on the basis of two specimens that were collected at Menado, northeastern Celebes and given to the Leiden Museum by S. C. I. W. van Musschenbroek. Since the time of Jentink's description, more specimens of *hellwaldi* have been obtained, not only from numerous localities in northern Celebes, but from middle and southern Celebes as well. Parts of those series have provided the basis for new taxa. These new records and descriptions were recorded in four important papers. Miller and Hollister (1921), on the basis of a collection made by H. C. Raven, described and named two subspecies of *R. hellwaldi.* One of these,

localis, was represented by specimens from Laboea Sore and Parigi, localities in the southern part of the northern peninsula, just above middle Celebes. The other subspecies, *cereus,* was based on examples of *hellwaldi* from Tolitoli, northwestern Celebes. In the same report, Miller and Hollister mentioned specimens from extreme northeastern Celebes and examples from the interior of middle Celebes that they regarded as being inseparable from typical *R. hellwaldi.* Tate (1936) listed specimens he had identified as *hellwaldi* that were obtained from southeastern and southwestern Celebes by G. Heinrich. Sody (1941) documented additional specimens of *hellwaldi* from northern Celebes and described and named a subspecies, *griseogenys,* based on specimens from southeastern Celebes. Finally, Ellerman (1941) discussed a collection made by W. J. C. Frost on Celebes during 1938, recorded examples of *hellwaldi* from northern Celebes, and described and named *dollmani,* on the basis of a specimen from middle Celebes, as a subspecies of *hellwaldi.*

In January 1932, Gerd Heinrich worked in southeastern Celebes on the coastal and inland lowlands and on the slopes of Mengkoka Gebirge, whose highest point exceeds 2500 meters. His collections were made in three areas: Wawo, on the coastal plain of the Gulf Van Bone, at an elevation of 50 meters and west of Mengkoka Gebirge; Goenoeng Masembo, at an elevation of 550 meters, on the southeastern slopes of Mengkoka Gebirge; and Goenoeng Tanke Salokko, a camp northwest of Goenoeng Masembo at 1500 meters elevation on the eastern slopes of Mengkoka Gebirge.

Heinrich obtained rodents of the *hellwaldi* type at all three places and Tate (1936, p. 574) recorded these specimens as *R. hellwaldi.* Sody (1941, p. 305), however, examined two of the nine specimens from Goenoeng Masembo (those two were in the Buitenzorg Zoological Museum), thought they differed in color of pelage from examples of typical *hellwaldi* that he had at hand from northern Celebes, and proposed the subspecies, *griseogenys,* for the material from Goenoeng Masembo, a name that is also applicable to the material from Wawo.

The 10 specimens from Wawo (A.M.N.H. Nos. 101025–101034) and the seven examples from Goenoeng Masembo (A.M.N.H. Nos. 101037–101043) are indeed representatives of *R. hellwaldi.* The configuration and size of the skulls closely resemble the holotype of *hellwaldi,* as judged from photographs and measurements of the skull of that specimen that are on file in the American Museum of Natural History. The photographs and the measurements were obtained by George H. H. Tate when he visited the Leiden Museum in 1937.

In features of skin and skull the specimens from Wawo and Goenoeng Masembo also resemble the large series of typical *hellwaldi* in the United States National Museum of the Smithsonian Institution, that were obtained from northeastern and middle Celebes. Samples from northeastern, middle, and southeastern Celebes overlap broadly in dimensions of skins and skulls, are practically indistinguishable in cranial configuration, and differ only slightly in color of pelage; when there are enough specimens with which to adequately analyze individual and geographic variation in *hellwaldi* from areas throughout Celebes, I suspect that Sody's name, *griseogenys,* will prove to be untenable.

The 10 specimens that Heinrich obtained from Goenoeng Tanke Salokko (A.M.N.H. Nos. 101087–101089, 101091, 101092, 101094, 101098–101100, and 101102), the highest of the three localities, are not examples of *R. hellwaldi.* In size (table 1) and in characteristics of skin and skull they answer Ellerman's (1941, p. 218) description of *dollmani,* known previously only by the holotype collected at Rantekaroa, in Quarles Gebirge of middle Celebes. The identity of the material from Goenoeng Tanke Salokko as *dollmani* was confirmed for me by Karl F. Koopman during his visit to the British Museum [Natural History], in September, 1968. Through the courtesy of Mr. J. E. Hill, Dr. Koopman kindly compared one of the specimens from Goenoeng Tanke Salokko (A.M.N.H. No. 101087) with the holotype of *dollmani.* According to his observations, both A.M.N.H. No. 101087 and the holotype of *dollmani* are alike in color of upper parts and underparts, external dimensions, size and general configuration of the skull, size and shape of the zygomatic plates, and length of the maxillary tooth row.

Ellerman considered *dollmani* to be a subspecies of *R. hellwaldi.* But the ranges of variation in size of most dimensions that were measured, proportions, color of pelage, and cranial configuration in the series of *dollmani* from Goenoeng Tanke Salokko fall outside the observed ranges of variation in these features in the sample of *hellwaldi* from Wawo and Goenoeng Masembo, and in all the material of *hellwaldi* (including those examples of *R. h. localis* and *R. h. cereus*) that I have seen from north and middle Celebes in the United States National Museum, Smithsonian Institution. The magnitude of the morphological differences observed between *hellwaldi* and *dollmani* indicates that each is apparently a distinct species. Contrasting features between *hellwaldi* (as indicated by samples from Wawo and Goenoeng Masembo) and *dollmani* (the series from Goenoeng Tanke Salokko) are discussed below.

Upper Parts: The upper parts of *R. hellwaldi* are clothed by short (8–9 mm. in length along the back) and thin pelage; there is little

underfur. The sides of the body are bright, orange-brown (proximally, the hairs are pale gray for about three-fourths of their length, and distally, orange-brown). This coloration also extends over the upper parts of the forearms out to the wrists, the dorsal surfaces of the thighs and legs to the ankles (a pale, brown band, 10–15 mm. wide, encircles each leg just before the ankle), onto the neck and sides of the head, and underneath the eye. The cheeks are whitish gray. The top of the head and the entire back is much darker, a brownish orange suffused with black. This darkened effect is due largely to the presence of two kinds of hair. One type is long and bristle-like; in each the basal half is gray and the distal half is brownish black. These hairs are numerous along the top of the head and back, but occur less frequently along the sides. The other type consists of soft overhairs that are dark gray at the base and brownish orange at the tip.

The pelage covering the upper parts of *R. dollmani* is longer (10–12 mm. in length along the back), much thicker, and softer than the pelage of *R. hellwaldi; dollmani* lacks the hard bristle-like hairs that are common in the other species. The pelage of *dollmani* is also much darker. The sides of the body, neck, head, and upper parts of the thighs and hind legs are a dark, brownish orange. The hairs of these areas are dark gray for most of their length and tipped with brownish orange. The top of the head and the back is darker, a dark brown suffused with grayish black tones. The pelage of the entire upper parts has a burnished appearance, a luster that contrasts sharply with the rather flat tone seen in the pelage of *hellwaldi.*

UNDERPARTS: The underparts of *R. hellwaldi* are white. The short (4–5 mm. in length) hairs clothing the undersurfaces of the body are white for their entire length. In a few specimens the thorax and neck are suffused with pale gray because the white hairs have gray bases in these regions.

In most specimens of *R. dollmani* the underparts are gray and lightly frosted with white. The hairs (they are slightly longer, 7–8 mm., and denser than in *hellwaldi*) are gray for most of their length and tipped with white. In three specimens the midventral area near the inguinal region is white, and another individual has white patches scattered over the thorax and along the midline of the stomach.

FEET: The dorsal surfaces of both the front and hind feet of *R. hellwaldi* are pale yellow and are sparsely haired; their undersurfaces are darker. The bottom of each hind foot is naked from the tips of the toes to the calcaneum.

In *R. dollmani* the upper parts of the front and hind feet are clothed

with fine, short, whitish gray hairs, hence these surfaces are whitish or silver gray. The bottom of each hind foot is naked from the tips of the toes to about three-fourths of the way back; the remaining surface, to the calcaneum, is sparsely covered with short hairs.

TAILS: The tail of *R. hellwaldi* is long, evenly tapered, and covered with short hairs. It is grayish brown above, but the ventral surface and distal third is unpigmented. There are 10–13 scale rows per centimeter (counted near the basal third of the tail).

The tail of *R. dollmani* is similar in shape to that of *hellwaldi,* but is covered with longer hairs and is more finely scaled (14–16 scale rows per centimeter).

MAMMAE: The 12 female specimens of *R. hellwaldi* from Wawo and Goenoeng Masembo have four pairs of mammae: one pectoral pair, one postaxillary pair, one abdominal pair, and one inguinal pair.

In contrast, the four female specimens of *R. dollmani* from Goenoeng Tanke Salokko have three pairs of mammae, one postaxillary pair, one abdominal pair, and one inguinal pair.

CRANIA: Although the basic configuration is similar in the two species, the skull of *hellwaldi* is much larger, more strongly built, and angular compared with the smaller, more delicately built and rounded skull of *dollmani* (figs. 1 and 2). Besides size, the contrast in ridging of the braincase between the two forms is also diagnostic. In *hellwaldi,* the top of the braincase is bounded by strong, wide, and prominent ridges that run from the interorbital region, where they form wide supraorbital shelves, backward along the lateral edges of the frontal and parietal bones to the occiput. The top of the braincase of *dollmani* is also bounded by ridges similar in position to those seen in *hellwaldi,* but they are much weaker and narrower. The supraorbital shelves are thin and narrow, and the ridges bounding the posterior half of the parietal bones are barely evident; each is represented only by slight elevations that margin the rear portion of the braincase.

The size and shape of the zygomatic plates is another prominent feature that distinguish the two species. Specimens of *hellwaldi* have wide zygomatic plates. Each plate has a conspicuous and wide anterior spine. Thus, in dorsal view, the zygomatic notch is conspicuous and deep. In contrast, the zygomatic plates of *dollmani* are much narrower and they lack anterior spines. Viewed in lateral profile, the anterior edge of each zygomatic plate extends downward directly from the anterior margin of the dorsal zygomatic root, rather than curving outward from it and then down as in *hellwaldi.* In dorsal view the zygomatic notch is either very shallow or not evident. Other qualitative

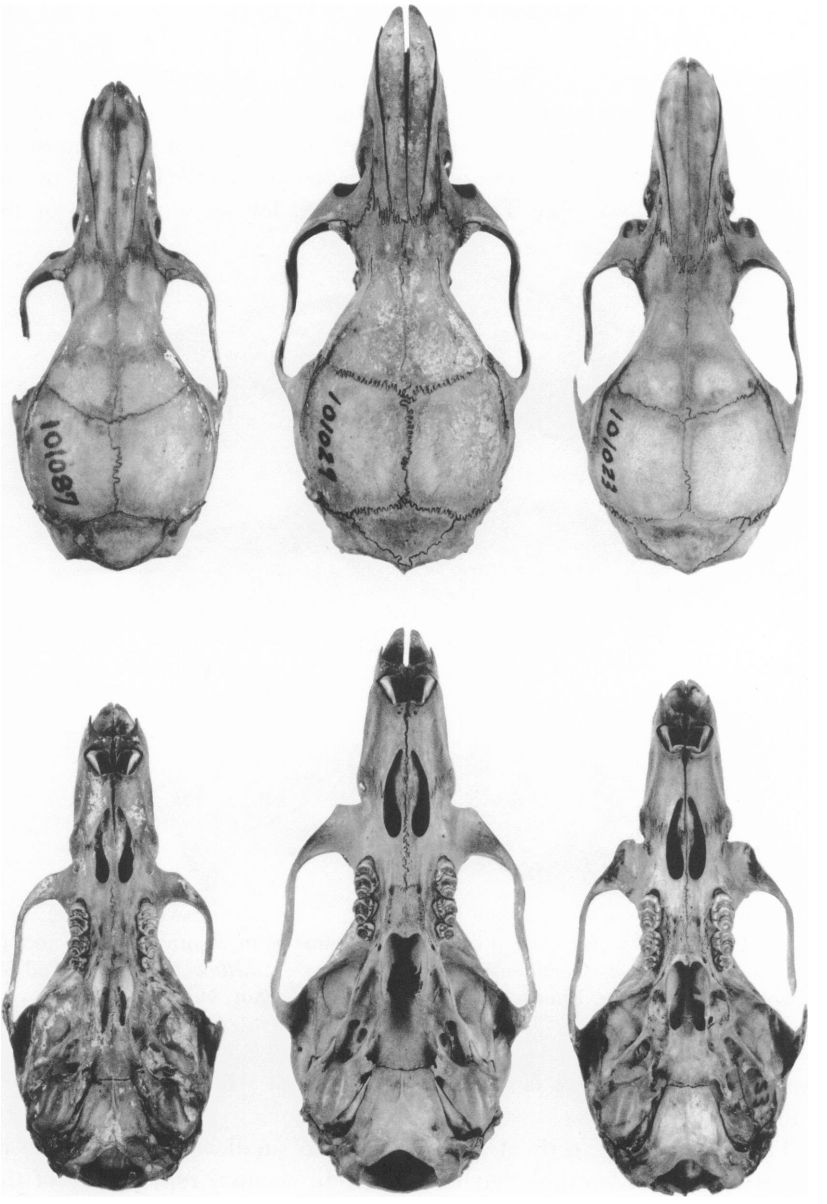

FIG. 1. Dorsal (top) and ventral (bottom) views of crania. From left to right: *Rattus dollmani* (A.M.N.H. No. 101087, adult female), Goenoeng Tanke Salokko; *R. hellwaldi* (A.M.N.H. No. 101029, adult female), Wawo; and *R. hellwaldi* (A.M.N.H. No. 101023, adult female), Lombasang. Photographs by Robert E. Logan. ×1.5.

differences between crania of the two species can be seen in figures 1 and 2. Proportional similarities and differences are discussed below.

TEETH: In shape, proportions, number of roots, and topography of crowns, the maxillary teeth of *R. dollmani* are small versions of the teeth of *R. hellwaldi* (see Tate, 1936, p. 569, for an illustration of the

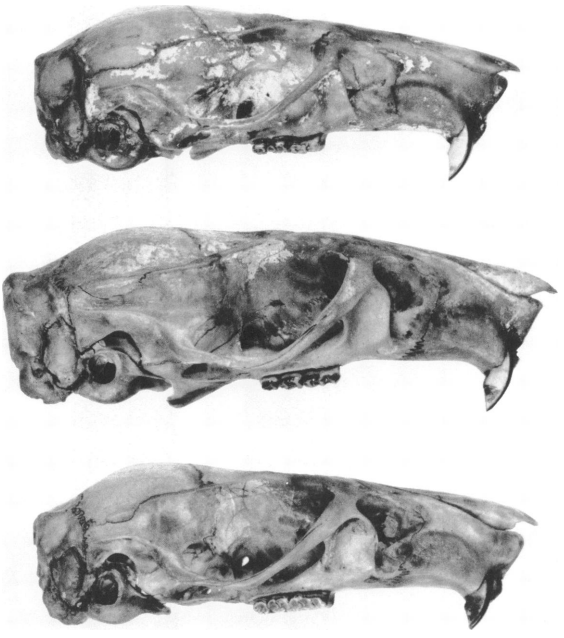

FIG. 2. Lateral views of crania of the specimens in figure 1. From top to bottom: *R. dollmani,* Goenoeng Tanke Salokko; *R. hellwaldi,* Wawo; and *R. hellwaldi,* Lombasang. Photographs by Robert E. Logan. ×1.5.

teeth of *hellwaldi*); size is the only feature that will consistently distinguish the two species.

The mandibular teeth of *dollmani* are also small versions of those in *hellwaldi* in most features, but they differ in occlusal topography of the third molar. In *dollmani,* the anterior lamina of the third molar is shaped like a flattened ellipsoid in dorsal view, whereas the same structure in *hellwaldi* is dumbbell-shaped.

ABSOLUTE SIZE AND PROPORTIONS: Specimens of *R. dollmani* are significantly smaller (at the .05 level of statistical significance) than those of *R. hellwaldi* in length of head and body, hind foot, and ear; greatest

TABLE 1

MEASUREMENTS (IN MILLIMETERS) FROM SAMPLES (OF ADULTS) OF *Rattus hellwaldi* AND *R. dollmani*

(The mean and standard deviation, plus and minus two times the standard error of the mean, extremes [in parentheses], coefficient of variation, and size of sample are listed, in that order, for each dimension.)[a]

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Length of head and body[c]					
Males		158.7 ± 7.5	212.5 ± 2.1	195.0 ± 7.1	
		150.1–167.3	209.5–215.5	185.0–205.0	
		(150–163)	(211–214)	(190–200)	
		4.7	1.0	3.6	
		3	2	2	
Females	175	164.8 ± 6.9	196.7±10.7	196.2 ± 9.6	170
		157.9–177.7	188.6–204.8	187.6–204.8	
		(160–175)	(180–215)	(185–210)	
		4.2	5.4	4.9	
		4	7	5	
Length of Tail					
Males		204.3±14.5	224	205.5 ± 7.8	
		187.5–221.1	—	194.5–216.5	
		(195–221)	—	(200–211)	
		7.1	—	3.8	
		3	1	2	
Females	210	210.0 ± 5.3	215.6 ± 7.3	210.8 ± 5.5	182
		203.9–216.1	210.0–221.1	205.8–215.8	
		(206–216)	(205–226)	(206–220)	
		2.5	3.4	2.6	
		3	7	5	

TABLE 1—(*Continued*)

		R. dollmani			*R. hellwaldi*	
		Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Length of hind foot[d]						
	Males		37.3±0.6	46.5±0.7	46.0±1.4	
			36.7–38.0	45.5–47.5	44.0–48.0	
			(37–38)	(46–47)	(45–47)	
			1.6	1.5	3.0	
			3	2	2	
	Females	38	37.5±0.6	44.1±1.7	45.4±1.1	40
			36.9–38.1	42.9–45.4	44.4–46.4	
			(37–38)	(42–47)	(44–47)	
			1.6	3.9	2.4	
			4	7	5	
Length of ear						
	Males		21.7±0.6	25.0±1.4	24.5±0.7	
			21.0–22.3	23.0–27.0	23.5–25.5	
			(21–22)	(24–26)	(24–25)	
			2.8	5.6	2.9	
			3	2	2	
	Females	25	21.3±0.5	24.6±0.8	24.4±1.3	26
			20.8–21.8	24.0–25.2	23.2–25.6	
			(21–22)	(23–25)	(23–26)	
			2.3	3.3	5.3	
			4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Greatest length of skull					
Males		41.33±0.92	49.60±1.27	47.75±0.07	
		40.27–42.39	47.80–51.40	47.65–47.85	
		(40.8 - 42.4)	(48.7 - 50.5)	(47.7 - 47.8)	
		2.23	2.56	0.14	
		3	2	2	
Females	41.2	42.53±1.05	48.01±1.34	47.52±1.36	45.0
		41.48–43.57	47.00–49.03	46.30–48.74	
		(41.3 - 43.7)	(46.3 - 50.2)	(46.5 - 49.9)	
		2.47	2.79	2.86	
		4	7	5	
Breadth of braincase					
Males		16.67±0.32	18.25±0.21	18.30±0.00	
		16.29–17.05	17.95–18.55	—	
		(16.3 - 16.8)	(18.1 - 18.4)	—	
		1.92	1.15	—	
		3	2	2	
Females	16.2	16.58±0.30	17.90±0.41	17.96±0.44	16.9
		16.28–16.87	17.57–18.23	17.57–18.35	
		(16.3 - 17.0)	(17.3 - 18.5)	(17.4 - 18.6)	
		1.81	2.29	2.44	
		4	6	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Height of braincase					
Males		12.15±0.49	13.35±0.35	13.05±0.07	
		11.45–12.85	12.85–13.85	12.95–13.15	
		(11.8 - 12.5)	(13.1 - 13.6)	(13.0 - 13.1)	
		4.03	2.62	0.53	
		2	2	2	
Females	—	11.87±0.12	13.15±0.33	13.35±0.13	12.7
		11.73–12.00	12.88–13.42	13.22–13.48	
		(11.8 - 12.0)	(12.9 - 13.8)	(13.2 - 13.5)	
		1.01	2.50	0.90	
		3	6	4	
Length of nasals					
Males		14.97±0.31	20.15±0.21	18.40±0.00	
		14.61–15.33	19.85–20.45	—	
		(14.7 - 15.3)	(20.0 - 20.3)	—	
		2.07	1.04	—	
		3	2	2	
Females	—	15.83±0.47	19.00±0.58	18.80±0.78	19.1
		15.35–16.30	18.56–19.44	18.10–19.50	
		(15.4 - 16.5)	(17.9 - 19.6)	(17.8 - 19.9)	
		2.97	3.05	4.14	
		4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Length of rostrum[c]					
Males		14.23±0.35	17.30±0.42	16.05±0.21	
		13.83–14.63	16.70–17.90	15.75–16.35	
		(13.9 – 14.6)	(17.0 – 17.6)	(15.9 – 16.2)	
		2.46	2.42	1.30	
		3	2	2	
Females	—	15.03±0.49	16.66±0.59	16.38±0.78	15.8
		14.05–16.00	16.21–17.10	15.68–17.08	
		(14.3 – 15.3)	(15.9 – 17.4)	(15.7 – 17.6)	
		3.26	3.54	4.76	
		4	7	5	
Breadth of rostrum					
Males		7.17±0.55	8.65±0.07	7.95±0.21	
		6.53 – 7.81	8.55 – 8.75	7.65 – 8.25	
		(6.8 – 7.8)	(8.6 – 8.7)	(7.8 – 8.1)	
		7.67	0.80	2.64	
		3	2	2	
Females	—	7.58±0.50	8.14±0.24	8.04±0.44	7.7
		7.07 – 8.07	7.96 – 8.32	7.65 – 8.43	
		(6.9 – 8.1)	(7.7 – 8.4)	(7.7 – 8.8)	
		6.59	2.94	5.47	
		4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Zygomatic breadth					
Males		18.97±0.85	21.60±0.00	21.0	
		17.99–19.95	—	—	
		(18.0 - 19.6)	—	—	
		4.48	—	—	
		3	2	1	
Females	*ca.* 19	19.7	21.53±0.46	20.98±0.75	20.2
		—	21.16–21.91	20.31–21.65	
		—	(21.0 - 22.4)	(20.2 - 22.0)	
		—	2.13	3.57	
		1	6	5	
Interorbital breadth					
Males		6.67±0.21	7.65±0.21	7.30±0.28	
		6.43 - 6.91	7.35 - 7.95	6.90 - 7.40	
		(6.5 - 6.9)	(7.5 - 7.8)	(7.1 - 7.5)	
		3.14	2.74	3.83	
		3	2	2	
Females	7.0	7.20±0.41	7.19±0.23	7.42±0.38	7.2
		6.79 - 7.61	7.02 - 7.36	7.08 - 7.76	
		(6.8 - 7.6)	(6.9 - 7.6)	(7.1 - 8.0)	
		5.69	3.19	5.12	
		4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Palatal length					
Males		15.30±0.50	18.90±0.28	17.90±0.42	
		14.72–15.88	18.5 – 19.3	17.30–18.50	
		(14.8 – 15.8)	(18.7 – 19.1)	(17.6 – 18.2)	
		3.26	1.48	2.34	
		3	2	2	
Females		15.95±0.33	18.56±0.59	18.40±0.92	17.5
		15.62–16.28	18.12–19.01	17.58–19.22	
		(15.5 – 16.3)	(17.8 – 19.4)	(17.7 – 20.0)	
		2.06	3.17	5.00	
		4	7	5	
Length of diastema					
Males		9.67±0.40	12.45±0.07	11.50±0.28	
		9.21–10.13	12.35–12.55	11.10–11.90	
		(9.3 – 10.1)	(12.4 – 12.5)	(11.3 – 11.7)	
		4.13	0.56	2.43	
		3	2	2	
Females	10.0	10.68±0.90	11.90±0.59	11.72±0.73	11.5
		9.78–11.57	11.46–12.34	11.07–12.37	
		(9.7 – 11.8)	(11.3 – 12.6)	(11.2 – 13.0)	
		8.42	4.95	6.22	
		4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Length of incisive foramina					
Males		6.13±0.15	7.10±0.28	7.10±0.42	
		5.95 - 6.31	6.70 - 7.50	6.50 - 7.70	
		(6.0 - 6.3)	(6.9 - 7.3)	(6.8 - 7.4)	
		2.44	3.94	5.91	
		3	2	2	
Females	—	6.30±0.08	6.97±0.23	7.10±0.24	6.9
		6.22 - 6.38	6.80 - 7.14	6.88 - 7.32	
		(6.2 - 6.4)	(6.7 - 7.3)	(6.8 - 7.4)	
		1.26	3.29	3.38	
		4	7	5	
Breadth of incisive foramina					
Males		3.40±0.17	3.90±0.14	3.75±0.21	
		3.20 - 3.60	3.70 - 4.10	3.45 - 4.04	
		(3.3 - 3.6)	(3.8 - 4.0)	(3.6 - 3.9)	
		5.00	3.58	5.60	
		3	2	2	
Females	—	3.62±0.22	3.80±0.06	3.78±0.16	3.2
		3.40 - 3.85	3.75 - 3.85	3.63 - 3.93	
		(3.4 - 3.9)	(3.7 - 3.9)	(3.6 - 4.0)	
		6.07	1.57	4.23	
		4	6	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Length of palatal bridge[f]					
Males		6.37±0.31	8.20±0.00	7.65±0.07	
		6.01 - 6.73	—	7.55 - 7.75	
		(6.1 - 6.7)	—	(7.6 - 7.7)	
		4.86	—	0.91	
		3	2	2	
Females	—	6.75±0.13	8.10±0.34	7.92±0.47	6.8
		6.62 - 6.88	7.84 - 8.36	7.50 - 8.34	
		(6.6 - 6.9)	(7.6 - 8.7)	(7.5 - 8.7)	
		1.92	4.19	5.93	
		4	7	5	
Alveolar length of M^{1-3}					
Males		6.17±0.06	6.85±0.07	6.70±0.14	
		6.11 - 6.23	6.75 - 6.95	6.50 - 6.90	
		(6.1 - 6.2)	(6.8 - 6.9)	(6.6 - 6.8)	
		0.97	1.02	2.08	
		3	2	2	
Females	6.2	6.13±0.15	6.79±0.15	7.04±0.15	6.8
		5.98 - 6.27	6.68 - 6.90	6.90 - 7.18	
		(6.0 - 6.3)	(6.5 - 6.9)	(6.9 - 7.2)	
		2.44	2.20	2.13	
		4	7	5	

TABLE 1—(*Continued*)

	R. dollmani			*R. hellwaldi*	
	Quarles Gebirge[b]	G. Tanke Salokko	Wawo	G. Masembo	Lombasang (A.M.N.H. No. 101023)
Width of zygomatic plate					
Males		2.77±0.12	3.85±0.07	3.95±0.21	
		2.65 - 2.89	3.75 - 3.95	3.65 - 4.25	
		(2.7 - 2.9)	(3.8 - 3.9)	(3.8 - 4.1)	
		4.33	1.81	5.31	
		3	2	2	
Females	—	2.80±0.18	3.91±0.23	3.82±0.24	4.3
		2.62 - 2.98	3.74 - 4.09	3.61 - 4.03	
		(2.6 - 3.0)	(3.7 - 4.4)	(3.6 - 4.2)	
		6.42	5.88	6.28	
		4	7	5	

[a] Cranial measurements were obtained with either dial calipers or with Anderson's (1968) craniometer. I am grateful to Miss Margareta Becker for taking most of those cranial measurements and for computing the statistics. (Dr. Sydney Anderson has graciously allowed me uninterrupted use of his measuring device.)

[b] Measurements are from Ellerman, 1941, p. 218.

[c] Most external measurements are those of the collector and were taken from labels on the study skins.

[d] Measured on the dry study skin, and includes the claw.

[e] Measured from the tip of the nasals to the posterior margin of the zygomatic notch and parallel to the long axis of the skull.

[f] Measured from the posterior margins of the incisive foramina to the anterior edge of the mesopterygoid fossa.

length of skull; breadth and height of braincase; length of nasals, palate, incisive foramina, palatal bridge, and maxillary tooth row; zygomatic breadth; and width of zygomatic plates (table 1; fig. 3). Length of tail and diastema, and breadth of rostrum, interorbital region, and incisive foramina do not differ significantly between the two species.

Proportional relationships between the samples of *dollmani* and the two series of *hellwaldi* are graphically illustrated in the form of a ratio diagram in figure 3. Although Simpson (1941) has described the method for constructing such diagrams, figure 3 requires a brief explanation. For each external and cranial measurement, the absolute value of the mean and the absolute values of plus and minus two standard errors of the mean were converted to logarithms. The sample of *hellwaldi* from Wawo was chosen as the standard. For each dimension the logarithm of the mean of the standard was subtracted from the logarithm of the mean, and from the logarithms of plus and minus two standard errors of the mean, of each of the two other samples. Measurements larger than the standard are represented on the diagram by positive values, those smaller than the standard are represented by negative values. For each sample three lines were constructed by connecting the points representing values of that sample. The middle line connects the means of each measurement in a sample and the two outer lines connect points that are plus (the right side of the mean) and minus (the left side) two standard errors of each mean. Samples with the same proportions as the standard will be represented by means on a line parallel to that of the standard, regardless of absolute size. And, if values for the samples being compared with the standard are similar in absolute size they will be close together on the diagram. Also, if proportions between any of the measured dimensions are similar, the relative positions of their points to each other on the horizontal scale will be similar.

Absolute values of the mean, and plus and minus two times the standard error of the mean, for each dimension in each sample, and size of each sample are listed in table 1. All the points in the ratio diagram were derived from females except the values for the zygomatic breadth of *R. dollmani* which are from males. I simplified the diagram in figure 3 by omitting the breadth of rostrum for each sample. That dimension is extremely variable and the three samples do not differ significantly in breadth of rostrum, either in absolute size or proportionally. The logarithmic transformation of the data and the subtractions were done on an Olivetti Underwood Programma 101 electronic desk computer. I am indebted to Dr. Sydney Anderson for writing the

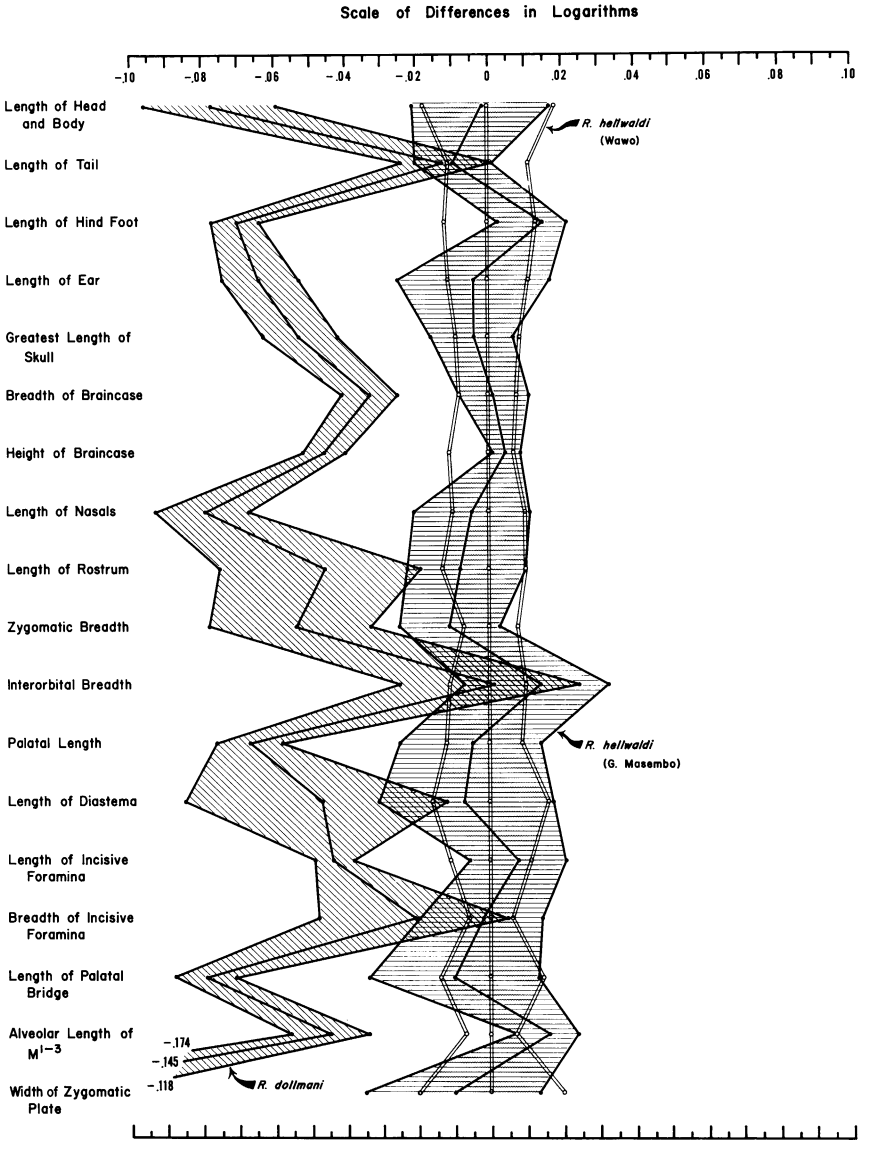

FIG. 3. Ratio Diagram. Eighteen dimensions are compared in three samples of *Rattus: R. dollmani* from Goenoeng Tanke Salokko (diagonal lines), and *R. hellwaldi* from Goenoeng Masembo (horizontal lines) and Wawo (gray background). For explanation see text and table 1.

necessary program.

The points that represent the series of *Rattus hellwaldi* from Goenoeng Masembo cluster around and close to the standard. The shape and position of the lines formed by connecting those points are clearly similar to the sample from Wawo and not significantly different from it. The configurations of the two sets of lines that represent the two samples of *hellwaldi* are unlike the configuration formed by the three lines representing the series of *dollmani.* Some of the conspicuous differences in external and cranial proportions between the two species that are seen in figure 3 are the following. With respect to the standard, *dollmani* has a much longer tail relative to its length of head and body than does either sample of *hellwaldi,* although absolute length of tail in the two species is similar; shorter nasals relative to its greatest length of skull; a relatively, although not actually wider, interorbital breadth (in comparison with cranial breadth); longer incisive foramina relative to both its palatal length and length of palatal bridge; a shorter palatal bridge relative to its length of maxillary tooth row; and narrower zygomatic plates relative to all other external and cranial dimensions. Other similarities and differences in proportions of the dimensions that were measured in samples of *dollmani* and *hellwaldi* are evident in the ratio diagram.

In summary, apparently two species of rodents of the *hellwaldi* type occur on Celebes. Specimens of *R. dollmani* are known only from Rantekaroa, at an elevation of 1800 meters, in middle Celebes, and from Goenoeng Tanke Salokko, 1500 meters in elevation, in southeastern Celebes. Although its habits and specific habitat are unknown, *dollmani* is apparently a rodent of the highlands and it likely occurs in forests. Heinrich (1932), in a sketchy account of his work and travels in southeastern Celebes, indicated that his camp on Goenoeng Tanke Salokko was in cool, wet, virgin forest. (I am indebted to Mrs. Vera Chimene for translating this section of Heinrich's book for me.)

Specimens of *R. hellwaldi* have been obtained from many areas in Celebes. In addition to the examples from southeastern Celebes that are in the American Museum of Natural History, I examined the following material from northern and middle Celebes, which is in the United States National Museum, Smithsonian Institution: Tolitoli, 12 specimens (including the holotype of *R. h. cereus*); Koeala Prang, three specimens; Paleleh River, three specimens; Molinggopoto, two specimens; Teteamoet, 43 specimens; Temboan, 25 specimens; Laboea Sore, 13 specimens (including the holotype of *R. h. localis*); Parigi, one specimen; Koelawa, one specimen; Gimpoe, two specimens; and

Pinedapa, 56 specimens. All of these examples, the material from Wawo and Goenoeng Masembo, the specimens recorded by Sody (1941, p. 305) from Amoerang and Lola Tetawiran, and those mentioned by Ellerman (1941, p. 219) from Tonsea, are from lowlands, either coastal plains, river bottomlands, or foothills. No information regarding either the habits or specific environment of *R. hellwaldi* is available to me.

A SPECIMEN OF *RATTUS HELLWALDI* FROM SOUTHWESTERN CELEBES

The geographic distribution of *R. hellwaldi* also includes southwestern Celebes. Its occurrence there is based on an adult female (A.M.N.H. No. 101023) obtained by Gerd Heinrich from Lombasang, on the northwestern slope of Goenoeng Lampobatang (Piek Van Bonthain), 1100 meters in elevation. The specimen is of special interest because it indicates the presence of *hellwaldi* in the highlands of southwestern Celebes, and because it may represent a distinct population of that species; it differs significantly in coloration, size, and in proportions from the material that I have compared it with in both the American Museum of Natural History and the United States National Museum, Smithsonian Institution.

Compared with examples of *R. hellwaldi* from Wawo and Goenoeng Masembo, the specimen from Lombasang has darker upper parts that are a burnished, yellowish brown, instead of bright, orange brown; the cheeks are pale yellow instead of whitish gray; and the head and body, tail, and hind feet are shorter (their measurements fall outside of the ranges of variation seen in the two other series, table 1), but the ears are longer relative to length of head and body.

Cranial measurements of the specimen from Lombasang also fall outside the ranges of variation observed in the two samples from southeastern Celebes. Although similar to specimens in those series in configuration of skull (figs. 1 and 2), it differs from them as follows: the skull is shorter; the braincase is lower and narrower; the nasals are longer relative to greatest length of the skull; the palatal length is shorter; the incisive foramina are actually narrower, and narrower relative to their lengths; the palatal bridge is actually shorter, and shorter relative to length of maxillary tooth row; and each zygomatic plate is wider relative to any of the other measured dimensions.

In features of skin and skull, the specimen from Lombasang differs from examples of *R. hellwaldi* from northern and middle Celebes in most of the same features, and to the same degree, as it differs from

the samples from southeastern Celebes. The Lombasang individual stands well apart in morphology of skin and skull from any of the other sampled populations of *hellwaldi.* For example, the magnitude of difference between it and representatives of typical *hellwaldi* is much greater than the degree of morphological contrast seen between any sample of the currently recognized, weakly differentiated subspecies from northern (*localis* and *cereus*) and southeastern (*griseogenys*) Celebes and typical *hellwaldi.*

I do not intend here to propose a name for the population of *hellwaldi* that is represented by the specimen from Lombasang; that would be premature. More specimens must be obtained and studied, not only from southwestern Celebes, but from areas farther north in the southern half of middle Celebes, before the geographic and ecologic distributions of *hellwaldi* can be fully documented, and before the parameters of the population from southwestern Celebes can be described. I only want to point out that if the features seen in the specimen from Lombasang prove to be characteristic of the population in the highlands of southwestern Celebes, then that population is a morphologically well-differentiated segment of *hellwaldi.* That species would then be another of the several kinds of *Rattus* that occur throughout Celebes, but that are represented in the highlands of southwestern Celebes by a distinctive population. Other named forms of *Rattus,* such as *bontanus* (a member of the *xanthurus*-group of *Rattus*), *coelestis* (related to *R. nigellus*), *heinrichi* (a derivative of *R. penitus*), *mollicomulus* (a distinct segment of *R. hoffmanni*), and *ursinus* (a well-differentiated form of *R. dominator*) represent distinctive (at either the subspecific or specific levels of differentiation) populations of *Rattus,* populations that are apparently endemic to the highland mass of southwestern Celebes.

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