

## New Records of the Polynesian Rat *Rattus exulans* (Mammalia: Rodentia) from Taiwan and the Ryukyus

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**Masaharu Motokawa, Kau-Hung Lu, Masashi Harada and Liang-Kong Lin (2001)** New records of the Polynesian rat *Rattus exulans* (Mammalia: Rodentia) from Taiwan and the Ryukyus. *Zoological Studies* 40(4): 299-304. The Polynesian rat *Rattus exulans* (Mammalia: Rodentia: Muridae) is newly recorded from Taiwan and the Ryukyus on the basis of 3 specimens from the lowland area of Kuanghua, Hualien County, eastern Taiwan, and 2 from Miyakojima Island, the southern Ryukyus. This rat may have been introduced by ships sailing to Taiwan and the Ryukyus from other islands where the species occurs. The morphological identification of *R. exulans* from young *R. rattus* is established on the basis of cranial measurements. In *R. exulans*, two measurements (breadth across the 1st upper molar and coronal width of the 1st upper molar) are smaller than corresponding values in *R. rattus*. The alveolar length of the maxillary toothrow is smaller in *R. exulans* from Taiwan and the Ryukyus than in available conspecific samples from Southeast Asia and other Pacific islands. Thus, this character may be useful in detecting the origin of the northernmost populations of *R. exulans* represented by the present specimens. The karyotype obtained from one of the Taiwanese specimens does not differ from that previously reported for *R. exulans*. <http://www.sinica.edu.tw/zool/zoolstud/40.4/299.pdf>

**Key words:** *Rattus exulans*, *Rattus rattus*, Taiwan, Miyakojima Island, New record.

The Polynesian rat, *Rattus exulans*, is a small rat species assigned to the subgenus *Rattus* (e.g., Musser and Carleton 1993). This species is widely distributed across Southeast Asia, from eastern Bangladesh through Myanmar (Burma), Thailand, Laos, Cambodia, Vietnam, the Malay Peninsula, Sumatra, Java, Borneo, the Philippines, Sulawesi, some islands of the Lesser Sunda Archipelago, and the Moluccas. It is also found in New Guinea, New Zealand, and on a majority of tropical and subtropical Pacific islands (Corbet and Hill 1992, Musser and Carleton 1993). *Rattus exulans* occurs in habitats created and maintained by humans, such as houses, granaries, cultivated lands, scrub areas, and forest edges (Musser and Newcomb 1983, Corbet and Hill 1992). Thus, the species is regarded as a commensal, extending its distribution by accompanying

human activities (Roberts 1991). While the original range of this species is uncertain, it is assumed to have been from Southeast Asia north of the Isthmus of Kra (Musser and Newcomb 1983). Many of the current local populations, such as those in the Malay Peninsula, Java, the Philippines, Sulawesi, and the Oceanian region, are thought to have originated through accidental artificial transportation (Musser and Newcomb 1983, Roberts 1991).

*Rattus exulans* is the smallest of the 56 species of the genus *Rattus* occurring worldwide (Corbet and Hill 1992, Musser and Carleton 1993), as is most prominently expressed by its small hind foot length (about 23 mm) and skull length (about 29-32 mm). For example, all of the other 35 Oriental *Rattus* species have hindfoot lengths  $\geq 25$ , and skull lengths  $\geq 31$  mm (Corbet and Hill 1992). The species is also

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known for its short maxillary tooththrow, with the 1st upper molar less than 1/2 of the entire tooththrow length (Marshall 1977, Corbet and Hill 1992).

Recently, we collected 3 individuals of *R. exulans* from Hualien Co. in Taiwan. We also found 2 specimens from Miyakojima I. of the southern Ryukyus in the collection of the National Science Museum, Tokyo. These are the 1st records of this species from the whole of Taiwan and the Ryukyus, respectively. In this paper, we describe morphological characteristics of those 5 specimens, and compare them with young *R. rattus*, which much resembles *R. exulans*. We also report a male karyotype of *R. exulans* from Taiwan.

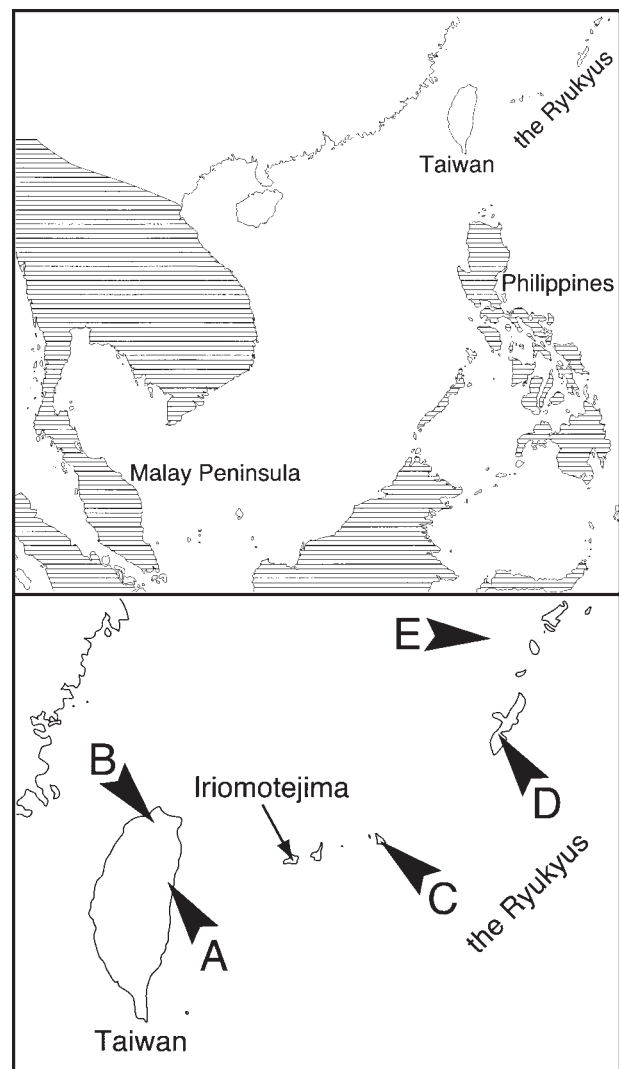
## MATERIALS AND METHODS

The 3 Taiwanese specimens (National Museum of Natural Science, Taichung [NMNS] 4520, 4521, 4524), all males, were collected in June 1999 from Kuanghua in Chian Village of Hualien Co., eastern Taiwan (23°50'N, 121°30'E, ca. 10 m in elevation; Fig. 1). All these specimens were captured by live traps from a fallow sweet potato field less than 5 km from Hualien Port, one of the biggest cargo harbors in Taiwan. They were kept alive in the laboratory by KHL until Mar. 2000 when they were prepared as museum specimens. The 2 specimens from the Ryukyus (National Science Museum, Tokyo [NSMT] M3334, M3335), both females, were labeled as being collected at "Miyako-kou" (Miyako Port) of Miyakojima I., the southern Ryukyus (ca. 24°50'N, 125°20'E, 159.00 km<sup>2</sup> in area, 114.6 m in elevation; Mezaki 1980) (Fig. 1). The collecting dates of these specimens are uncertain, but they were donated to the museum on 13 and 14 June 1955.

Besides these Taiwanese and Ryukyu specimens, three male *R. exulans* from the Malay Peninsula (NSMT M7771, M7772, M7773) and 5 young *R. rattus* with unerupted 3rd molars in both the upper and lower tooththrows were examined for comparisons. Of the latter, one specimen was collected from Yangmingshan National Park, northern Taiwan (Zoological Collection of Kyoto Univ. [KUZ] M3358 [female]), three from Ioutorishima I., central Ryukyus (KUZ M1562 [female], M1563 [male], and M1564 [male]), and 1 from Naha City on Okinawajima I., central Ryukyus (KUZ M744 [male]).

Five external measurements taken by the collector were used: body weight (BW), head and body length (HB: obtained by subtracting tail length from total length), tail length (T), length of hind foot exclusive of claw (HF), and ear length (E). The ratio of T

to HB in percentage (TR) was calculated for each specimen. The following 16 cranial measurements were taken to the nearest 0.01 mm using digital calipers (Mitsutoyo Co.) after Carleton and Straeten (1997): occipitonasal length (ONL), greatest zygomatic breadth (ZB), breadth of the braincase (BBC), breadth across the occipital condyles (BOC), least interorbital breadth (LIF), length of nasals (LN), breadth of the rostrum (BR), postpalatal length (PPL), length of the bony palate (LBP), length of the upper diastema (LD), length of the incisive foramen (LIF), breadth across the 1st upper molars (BM1s),



**Fig. 1.** Map showing the distribution (upper, shaded area) of the Polynesian rat *Rattus exulans* in Southeast Asia (Corbet and Hill 1992) and the sampling localities of *R. exulans* and *R. rattus* described in this study (lower). A: Kuanghua, Chian Village, Hualien County; B: Yangmingshan National Park, Taipei City; C: Miyakojima Island; D: Okinawajima Island; E: Ioutorishima Island.

breadth of the zygomatic plate (BZP), length of the auditory bulla (LAB), alveolar length of the maxillary tooththrow (ALM), and coronal width of the 1st upper molar (WM1). Also, condylobasal length, measured from the occipital condyles to the anterior edge of the incisor (CBL), and height of the braincase (HBC) were taken for each specimen. The karyotype was prepared from one of the Taiwanese *R. exulans* (NMNS 4524) following Motokawa et al. (1997).

## RESULTS

The external and cranial measurements are summarized in table 1. One *Rattus exulans* from Hualien Co., Taiwan (NMNS 4524), exhibited much wear on its teeth and thus was considered an old adult. The remaining 2 from Taiwan and both specimens from the Ryukyus (NMNS 4520, 4521, NSMT M3334, M3335) were considered younger adults, showing moderate wear on the teeth. All these adults of *R. exulans* from Taiwan and the Ryukyus were small in size (BW 43.0-55.1 g, HB 115.0-140.0 mm, and HF 22.0-23.0 mm). The tails were uni-

formly dark, slender, and not longer than the head and body length (TR 76.4%-100.0%).

Skulls of *R. exulans* from Taiwan (Fig. 2) and the Ryukyus were small (ONL 27.93-32.33 mm). The rostrum was short, wide, and moderately high. The interorbital and zygomatic regions were narrow. The zygomatic plate was also narrow, and the braincase was oval. The profile gradually curved downward from the midpoint of the braincase to the anterior edge of the rostrum. The diastema was short. The incisive foramen was also short and wide, with its posterior border not exceeding the anterior edge of the 1st upper molar. The palatal bridge was short, and the mesopterygoid fossa was wide. The auditory bulla was oval and long, with its greatest length being larger than the alveolar length of the maxillary tooththrow. The maxillary tooththrow was short (ALM 4.28-4.95 mm), slender, and narrow with a small WM1 (1.38-1.46 mm); the length of the 1st upper molar was less than 1/2 of the maxillary tooththrow length. The distance between the right and left maxillary tooththrows was small (BM1s 5.60-6.30 mm). The external tubercle in front of the main loph of the 2nd upper molar (b in the definition of Tate [1935])

**Table 1.** External and cranial measurements of the Polynesian rat *Rattus exulans* from Taiwan, the Ryukyus, and Malay Peninsula, and *R. rattus* from Taiwan and the Ryukyus

Character	<i>R. exulans</i>						<i>R. rattus</i>		
	Taiwan and the Ryukyus			Malay Peninsula			Taiwan and the Ryukyus		
	Mean	(range)	n	Mean	(range)	n	Mean	(range)	n
BW	43.2	( 43.0 - 55.1 )	3	—			24.6	(21.0 - 29.4 )	4
HB	124.6	(115.0 - 140.0 )	5	104.3	(100.0 - 111.0 )	3	92.0	(84.0 - 97.0 )	4
T	117.0	(107.0 - 115.0 )	4	116.3	(110.0 - 124.0 )	3	101.2	(89.0 - 107.0 )	4
TR	95.3	( 76.4 - 100.0 )	4	111.5	(110.0 - 112.8 )	3	110.8	(93.7 - 127.4 )	4
HF	22.8	( 22.0 - 23.0 )	5	23.0	( 22.0 - 24.0 )	3	24.5	(23.9 - 25.6 )	5
E	15.5	( 15.0 - 17.5 )	5	14.7	( 14.0 - 16.0 )	3	15.7	(14.2 - 17.0 )	5
ONL	30.49	( 27.93 - 32.33)	5	29.74	( 28.35 - 31.43)	3	28.21	(27.93 - 28.75)	4
CBL	28.77	( 26.51 - 29.60)	4	27.15	( 25.68 - 28.80)	3	26.09	(25.97 - 26.24)	5
ZB	14.56	( 13.05 - 15.10)	5	13.99	( 13.39 - 14.59)	2	14.41	(14.04 - 14.69)	4
BBC	13.12	( 11.83 - 14.04)	5	12.68	( 12.24 - 13.36)	3	13.32	(12.91 - 13.64)	5
BOC	6.81	( 6.07 - 6.90)	4	6.82	( 6.59 - 7.16)	3	7.26	( 7.04 - 7.53)	5
IOB	4.79	( 4.53 - 4.92)	5	4.51	( 4.29 - 4.79)	3	4.94	( 4.83 - 5.05)	5
LN	11.60	( 10.41 - 13.18)	5	10.01	( 9.27 - 10.51)	3	9.68	( 8.91 - 10.11)	4
BR	5.27	( 4.64 - 5.80)	5	5.13	( 4.49 - 6.03)	3	4.78	( 4.58 - 4.83)	5
PPL	10.50	( 9.22 - 11.05)	5	10.14	( 9.98 - 10.30)	2	9.02	( 8.98 - 9.75)	4
LBP	5.90	( 5.58 - 6.34)	5	6.33	( 6.09 - 6.56)	2	5.94	( 5.28 - 6.65)	4
LD	8.26	( 7.54 - 9.10)	5	7.78	( 7.10 - 8.46)	3	6.76	( 6.39 - 7.11)	5
LIF	5.52	( 4.84 - 6.07)	5	5.14	( 4.92 - 5.55)	3	4.75	( 4.42 - 5.06)	5
BM1s	6.00	( 5.60 - 6.30)	5	6.03	( 5.82 - 6.24)	3	6.70	( 6.53 - 6.80)	5
BZP	3.26	( 2.98 - 3.41)	5	3.04	( 2.66 - 3.49)	3	2.75	( 2.60 - 3.14)	5
LAB	5.60	( 5.12 - 6.03)	5	5.69	( 5.59 - 5.87)	3	5.62	( 5.17 - 5.90)	5
ALM	4.70	( 4.28 - 4.95)	5	5.16	( 5.04 - 5.39)	3	5.33	( 5.09 - 5.67)	5
WM1	1.43	( 1.38 - 1.46)	5	1.51	( 1.46 - 1.57)	3	1.96	( 1.82 - 2.06)	5
HEI	9.20	( 8.35 - 10.02)	5	8.67	( 8.29 - 9.12)	3	9.15	( 9.00 - 9.44)	5

See text for abbreviations of measurements.

was weakly developed in 1 specimen (NMNS 4520), whereas it was not found in the remaining 4.

The karyotype of a male *R. exulans* from Hualien Co., Taiwan, is shown in figure 3. It consists of 7 meta- or submetacentric, two subtelocentric, and 11 acrocentric pairs in autosomes, and acrocentric X and Y sex chromosomes. The total diploid number (2n) and the fundamental number of autosomes (NF) were 42 and 58, respectively. This karyotype does not differ from that previously reported for *R. exulans* from Southeast Asia and the Oceanian region (Yosida 1973).

## DISCUSSION

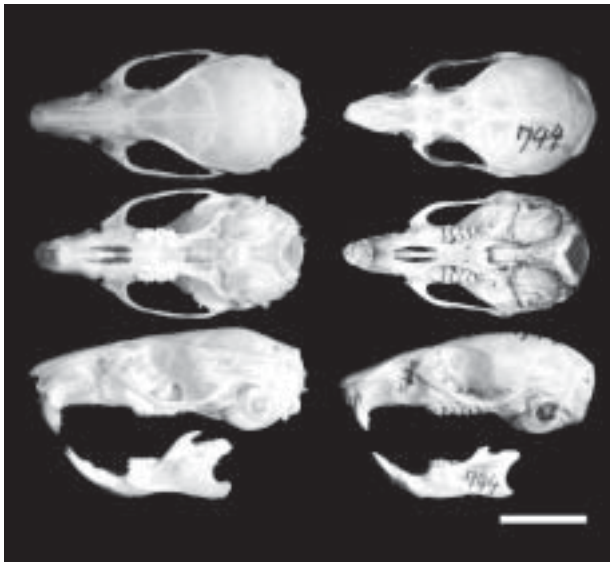
The specimens from Taiwan and the Ryukyus show character states diagnostic of *Rattus exulans*: small body, short hind foot, small cranium, 1st upper molar less than 1/2 the length of the maxillary tooththrow, long auditory bulla, and oval braincase (Tokuda 1941, Corbet and Hill 1992). The present discovery extends the distribution of this primarily tropical species substantially northward (Fig. 1). The specimens from Hualien Co., Taiwan, and from Miyakojima I. in the Ryukyus may have been introduced from some island in Southeast Asia by ship

cargo or other transportation media, because *R. exulans* is regarded as a commensal species (Musser and Newcomb 1983, Roberts 1991). It is probable that *R. exulans* has established breeding colonies in Hualien Co., Taiwan, because a pregnant female of *R. exulans* was also found in this area (Lu unpubl. data).

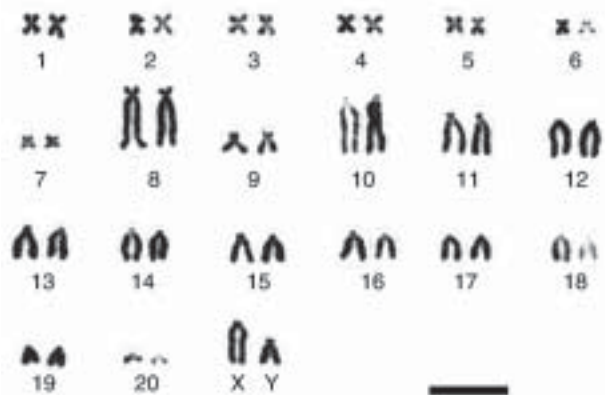
In 1964, Uchida identified 2 rat specimens from Iriomotejima I., the southern Ryukyus (Fig. 1), as *R. exulans* or its close relative. We were unable to examine these specimens, but judging from their measurements and photographs given by Uchida (1964), they probably actually belong to *R. rattus*. For example, the hind feet of those specimens were distinctly longer (29 and 30 mm; Uchida 1964) than those of *R. exulans* (22.0-24.0 mm; this study). Likewise, their maxillary tooththrows were longer (7.4 mm in both vs. 4.28-5.39 mm for *R. exulans* in this study), and their 1st upper molars were obviously greater than 1/2 the length of the maxillary tooththrows (see Figs. 4-10, and 4-11 of Uchida [1964]).

*Rattus exulans* is morphologically quite similar to young *R. rattus*. Nevertheless, an identification key has not yet been established to distinguish them. We examined 5 young specimens of *R. rattus* with unerupted 3rd molars in both the upper and lower tooththrows, and most of their measurements overlapped with those of *R. exulans* examined here (Table 1). Even so, these 2 species could be distinguished by 2 measurements for the maxillary tooththrows (BM1s and WM1): their values were larger in young *R. rattus* than in adult *R. exulans* (Table 1). Direct side-by-side comparisons indicated that the maxillary tooththrow is smaller and less robust in *R. exulans* than in *R. rattus* (Fig. 2).

There is a possible geographic variation in ALM



**Fig. 2.** Crania of adult male *Rattus exulans* from Kuanghua, Chian Village, Hualien County, eastern Taiwan (NMNS 4521), and *R. rattus* from Naha City, Okinawajima Island (KUZ M744: right). Dorsal, ventral, and left lateral views of the maxillae and left external view of the mandibles are shown from top to bottom. The latter is a young individual with unerupted 3rd molars in both the upper and lower tooththrows.



**Fig. 3.** Conventional karyotype of male *Rattus exulans* from Kuanghua, Chian Village, Hualien County, Taiwan (NMNS 4524). The bar represents 10  $\mu$ m.

within *R. exulans*, because ALMs in the Taiwanese and Ryukyu specimens (4.28-4.90 mm) are smaller than those in the Malayan specimens (5.04-5.39 mm, Table 1). Corresponding values for specimens from the Pacific Islands and the Philippines, reported by previous authors (Tokuda 1933, Tate 1935, Rickart et al. 1993, Heaney et al. 1999) are also larger than those for the specimens from Taiwan and the Ryukyus (> 4.9 mm). In addition, the tail ratio in rats from Taiwan and the Ryukyus seems to be smaller (76.4%-100.0%) than that in other conspecific populations (Table 1, Corbet and Hill 1992). The Taiwanese and Ryukyu populations thus may be differentiated morphologically from the other populations, possibly representing an undescribed taxon. Therefore, detailed examinations of geographic variation in these characters using specimens from the entire distribution range of the species would be expected to be very effective in detecting the origin and history of the Taiwanese and Ryukyu populations, and to revise the systematics of *R. exulans*.

*Rattus exulans* occurs in broad habitats more or less influenced by human activities (e.g., houses, granaries, cultivated lands, scrub areas, and forest edges; Musser and Newcomb 1983, Corbet and Hill 1992). On the other hand, *R. rattus* is generally thought to occur only in the vicinity of and inside human houses (Aoki and Tanaka 1941, Kaneko 1994). Four of the 5 specimens of *R. rattus* used in this study, however, were collected from habitats far from human houses: one from a grassland in Yangmingshan National Park, northern Taiwan, at an elevation of 800 m (KUZ M3358), and 3 from a grassland of Ioutorishima I., the central Ryukyus, which has had no human residents since 1959 (Motokawa 1998). In addition, two specimens of *R. rattus*, formerly misidentified as *R. exulans* by Uchida (1964: see above), were collected from a she-oak forest of Iriomotejima I., the southern Ryukyus. *Rattus rattus* has also been recorded from other uninhabited islets in the Ryukyus, such as Nakanokamishima I., the southern Ryukyus (Kohno et al. 1995) and Yokoatejima I., the northern Ryukyus (Ikehara et al. 1994). Therefore, it is obvious that *R. rattus* actually occurs not only in human houses but also in forests and grasslands, at least in Taiwan and the Ryukyus, and this suggests its syntopic occurrences with *R. exulans* in these regions.

The mammal faunas of Taiwan and the Ryukyus are characterized by high levels of endemism (Lin and Lin 1983, Motokawa 2000). The exotic *R. exulans* may have been affecting native mammals in Taiwan and the Ryukyus. It is strongly recommended that intensive surveys be made of the distri-

bution of *R. exulans* in Taiwan and the Ryukyus, to estimate the effect of *R. exulans* on the native small mammals there. These surveys will be useful to protect the biodiversity of mammals on these islands.

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## 臺灣及琉球兩地玻里尼西亞鼠(*Rattus exulans*)之新記錄

本川雅治<sup>1</sup> 盧高宏<sup>2</sup> 原田正史<sup>3</sup> 林良恭<sup>4</sup>

本研究為玻里尼西亞鼠(*Rattus exulans*)於臺灣與琉球之新記錄。有三個標本採自臺灣東部花蓮縣吉安鄉光華村，另外兩個標本則來自屬於琉球列島南部的宮古島地區。此種老鼠可能是從南亞地域的島嶼隨著船侵入臺灣與琉球。以頭骨測距為基礎可區別玻里尼西亞鼠與年幼的家鼠(*R. rattus*)：玻里尼西亞鼠有二個測值遠小於家鼠，即第一上臼齒的左右寬度與第一上臼齒齒冠的寬度。來自臺灣與琉球的玻里尼西亞鼠標本的下顎齒列齒槽長皆小於南亞及太平洋島上的同物種。因此，此特徵可能有用於瞭解玻里尼西亞鼠分布於最北端臺灣與琉球兩地族群的來源。臺灣的玻里尼西亞鼠之核型與其他地區玻里尼西亞鼠所發表過的核型報告並無差異。

**關鍵詞**：玻里尼西亞鼠，家鼠，臺灣，宮古島，新記錄。

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