Morphometric Study of Genus *Rattus* in Tehran City

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Abstract: Throughout its worldwide range, Norway rat (*Rattus norvegicus*) is the most common species of rat found in Tehran city. It is not native to and like other introduced species has become a serious problem in Tehran and other large cities in Iran. Morphologic differentiation among *Rattus* genus from Tehran city was investigated using morphometric characters. 50 Rats were trapped alive and 15 cranial and body morphological characters were measured. In preliminary evaluations of samples, we certified 99% of individuals as *Rattus norvegicus* and only 1% as other species. In this study, both discriminant function analysis and cluster analysis revealed two distinct groups of *Rattus norvegicus* in Tehran; probably corresponding to two different subspecies. Principal Component Analysis was used in order to group populations. According to this analysis our samples were almost clustered in two partially overlapped groups. Using Canonical Function Analysis for evaluation of morphometric variables separately for their contribution to discrimination of groups we observed that ratio of characters as Zygomatic Width/Least Interorbital Width, Cranial Width/Skull Height, Occipitonasal Length/Conddylobasal Length, Diastema Length/Zygomatic Width, Diastema Length/Tympanic Bullae Width and Zygomatic Width/ Tympanic Bullae Width are the most determinative values for distinction of two groups. Also, Discriminant Analysis showed that character ratios, Diastema Length/Zygomatic Width, Diastema Length/Tympanic Bullae Width and Zygomatic Width/ Tympanic Bullae Width are most significant in groupings according to districts.
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1. Introduction

The genus *Rattus* (Fischer, 1803) are lorg muroid rodents most likely is orginated in Southeast Asia. At present the most extensive areas are scattered in Southeast Asia Island (ISEA) and New Guinea. Black rat (*R. rattus*) and brown rat (*R. norvegicus*) are the best-known rat species. Black rat is orginated from India and South Asia, and then moved to Europe and Europeans have been dispersing throughout the world.

The brown rat Original distribution assumed to be SE Siberia, N China (Heilongjiang), and Hondo region (islands of Honshu, Shikoku, and Kyushu; see [1]) of Japan [2, 3], but introduced worldwide where it is more common in colder climates of higher N and S latitudes [4]; in warmer regions and tropics restricted to habitats highly modified by humans (e. g., new buildings, ports; [5]).

Brown rats are often used as model organisms for scientific research. Since the publication of the rat genome sequence, and other advances, such as the creation of a rat SNP chip, and the production of knockout rats, the laboratory rat has become a useful genetic tool and use for recongnise of diseases [6].

The common species *Rattus* (e. g., *R.norvegicus*) occurs in houses, granaries, cultivated lands, gardens, plantations, scrub areas, and second-growth forest [6-8]. These habits are maintained and disturbed by humans, thus they have been considered always associated with the human habitation [7, 9-14]. From its association with humans, they have been regarded as a commensal species. Most parts of its wide distribution range are thought to have been gained as a result of the transportation accompanying with the human agency such as ships and canoes [7,15,16]. Also they may cause substantial food losses, sewers, buildings, wharves, breakwaters, ports, and large cities especially in developing countries. However, the widely distributed and problematic commensal species of rats are a minority in this diverse genus [17].

Also some of rats can carry many different zoonotic pathogens, such as *Leptospira*, *Toxoplasma gondii*, and *Campylobacter* [18]. SO they are important for human among biologist and enviroment exports and accurate identification of Rattus genus species, including commensal rats with humans is important to combat them.

Three species of the genus *Rattus* have been reported from Iran: the brown rat (*R. norvegicus*), the black rat (*R. rattus*) and the Himalayan rat (*R. pyctoris*).

Although *R. rattus* remains have been reported from Pleistocene deposits in western Iran [19, 20], the black rat has only recently been

transported by ship from south-east Asia to the Persian Gulf and has successively spread in this region, especially on the Iranian border and in Mangrove woods near Bandar Abbas and Gheshm cities. During the 19th century, human activities also flavored its expansion into Shiraz, Esphahan and Tehran, and more recently the species has also been reported from the coasts of the Caspian Sea [20, 21]. The brown rat has also moved from central Asia to the border of the Caspian Sea and to Gorgan and Rasht cities in the north of Iran. It has also been unintentionally introduced to Tehran and Tabriz in the north-west; while recently, it has been transported by train to Mashhad, in the north-east of Iran [20, 22-24]. The Himalayan rat lives in mountainous regions, from Pakistan and Himalaya to Afghanistan and the north-east of Iran [20, 22, 25, 26].

It has never been found in urban regions of Iran. It has been recently reported from the northeastern part of Kerman province, and included in the same group of *R. norvegicus* [27]. *R. norvegicus* differs from the two other species in having the tail shorter than body-length and short ears [28]; also its skull is distinctly different from those of *R. rattus* and *R. pyctoris. R. norvegicus* has brown dorsal hair, while the dorsal fur of black rats from Shiraz and Mangrove forests is lighter than that of *R. norvegicus* [20, 29]. *R. rattus* and *R. pyctoris* are, however very similar in both external morphology and skull. *R. pyctoris* has a shaggy, dense fur, six pairs of teats and a reduced antrolabial cusp (t3) relative to two adjacent cusps forming the anterior lamina (Musser and Carleton, 2005).

Karyological studies have shown that brown and Himalayan rats have 42 chromosomes, whilst in the black rat 2n = 38 [20, 29]. While morphologic, morphometric and karyologic and molecular studies have been carried out on Iranian rats by different investigators [20, 22, 29], until now no morphologic and morphometric studies have been attempted to Iranian rats of Tehran city answer the questions concerning taxonomic status. A molecular study on Tehran rats is recently done by Rajabi-Maham *et al.* Since Tehran, the capital city of Iran, is a metropolitan, studying the taxonomy and identification of its rats is a necessary step towards planning an effective control plan of their populations.

2. Methods and Material

The studied sample included 50 rats (25 males, 25 females) which were trapped in Tehran city from January 2010 to September 2011. The districts from which the rats were trapped along with their body length, tail length were recorded. For our cranial biometric studies, after preparing the skulls, 15 measurements were taken using a digital caliper with a 0.01 mm precision: occipitonasal length (ONL), conddylobasal length (CBL), zygomatic width (ZW), least interorbital width (LIW), cranial width (CW), nasal length (NL), diastema length (DL), anterior palatine foramina length (APFL), tympanic bullae length (TBL), tympanic bullae width (TBW), upper cheek teeth (UCT), lower cheek teeth (LCT), skull height (SH), rostrum width (RW) and mandible length (ML).

Characters normality was tested using the Kolmogorov-Smirnov D-statistics and the homogeneity of variances by the Levene's test. The significance of differences between sample means was evaluated by the ANOVA test. A hierarchical cluster analysis was also performed on the variables (standardized) using squared Euclidean distance interval and between-groups linkage method. A principal component analysis (PCA) of characters was performed based on character correlation matrix of standardized variables.

A discriminant analysis was also done on the samples based on their belongings to Tehran's districts; we had samples from 11 out of 22 districts of Tehran, specifically from districts 1, 4, 7, 9, 12, 13, 14, 15, 17, 18 and 19. All analyses were done using IBM SPSS Statistics Version 20.

3. Results

The statistical comparison showed no significant differences in characters among males and females. Therefore, the data of male and females were pooled together for further analyses. The descriptive of the characters is shown in Table 1.

The ANOVA results show that among the different districts of Tehran there is a significant difference in TBW, ZW, DL and RW. Still, performing the principal component analysis showed the first three components explain 75% of the total variance. The values of eigenvectors in the first three components are shown in table 2. In axis 1, CBL, LIW, CW, NL, DL, APFL, SH, RW and ML had the highest loadings (positive). In the second axis, the highest loadings are assigned to TBW and ZW (positive).

The discriminant analysis (DA) was performed on the rats based on the city districts they were trapped. The initial analysis performed only using the 15 characters measured showed a 76% of group cases as classified correctly. A second DA was performed using the possible determinant characters ratios: DL/TBW, DL/ZW and ZW/TBW. Using these three ratios, the success of correct classification based on the geographical initial classification of the cases increased to 86%.

Table 1. Descriptive values for cranial measurements of *Rattus norwegicus* from Tehran city.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
ONL	50	39.59	52.76	46.8386	3.14503	9.891
CBL	50	37.87	48.51	43.7736	2.93232	8.599
ML	50	21.41	29.72	25.7962	1.90827	3.641
ZW	50	17.43	25.28	21.6370	1.74864	3.058
NL	50	14.85	20.60	18.0068	1.57378	2.477
DL	50	10.76	15.95	13.7680	1.09972	1.209
CW	50	15.44	19.07	16.8944	0.88985	0.792
SH	50	11.55	14.81	12.7862	0.80126	0.642
RW	50	4.39	7.94	6.0732	0.71921	0.517
APFL	50	6.27	9.37	8.0440	0.64349	0.414
LIW	50	6.16	8.82	7.0386	0.58348	0.340
TBL	50	6.34	8.82	7.8040	0.55957	0.313
TBW	50	4.49	6.55	5.3210	0.47713	0.228
UCT	50	6.58	8.19	7.3896	0.37238	0.139
LCT	50	6.60	8.18	7.0954	0.29590	0.088

The hierarchical cluster analysis of characters showed the separateness of tympanic bullae width (TBW), lower cheek teeth (LCT), tympanic bullae length (TBL) and zygomatic width (ZW), respectively.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ZW		54.064	10	5.406	2.202	0.039
		95.765	39	2.456		
		149.830	49			
DL		20.508	10	2.051	2.064	0.050
		38.751	39	0.994		
		59.260	49			
TBW		4.718	10	0.472	2.859	0.009
		6.436	39	0.165		
		11.155	49			
RW		9.435	10	0.944	2.313	0.030
		15.911	39	0.408		
		25.346	49			

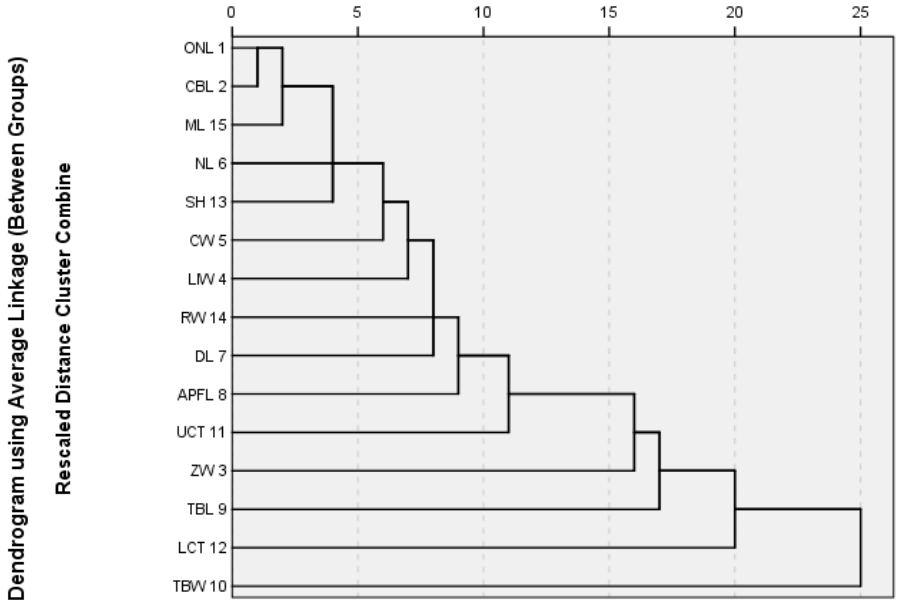

Figure 1.

Table 2. Rotated Component Matrix of *Rattus norvegic*us from Tehran city

Rotated Component Matrix[a]			
	Component		
	1	2	3
ONL	0.934	0.097	0.205
CBL	0.940	0.131	0.180
ZW	0.354	0.676	0.305
LIW	0.824	0.165	-0.008
CW	0.832	0.271	0.053
NL	0.826	0.050	0.373
DL	0.729	0.390	0.192
APFL	0.791	-0.028	0.087
TBL	0.517	0.298	-0.312
TBW	-0.105	0.858	-0.095
UCT	0.571	0.148	0.539
LCT	0.115	0.013	0.871
SH	0.878	0.010	0.208
RW	0.834	-0.345	0.180
ML	0.896	0.084	0.135

ONL=occipitonasal length, CBL=conddylobasal length, ZW=zygomatic width, LIW=least interorbital width, CW=cranial width, NL= nasal length, DL=diastema length, APFL=anterior palatine foramina length, TBL=tympanic bullae length, TBW=tympanic bullae width, UCT=upper cheek teeth, LCT=lower cheek teeth, SH= skull height, RW=rostrum width and ML=mandible length.

4. Discussion

There is cranial variation among different districts of Tehran. This difference in means is significant in TBW, ZW, DL and RW. As so the ratios of these characters are introduced to be the best aids to correct classification of Tehran rats according to the different districts. Such significant differences in these characters could be assigned to the different environments dominant in Tehran's districts.

The 22 districts of Tehran each possess different environments which either provide or deprive the rats from flourishing freely. For instance, district 1 of the city is one of the cleanest districts which puts several pressures on the rats, the results of which could be seen on their outer morphology. Districts like district 12 of Tehran in which the bazaar of Tehran is located are among the districts which provide copious amounts of resources for the rats and therefore put less pressure on these animals to flourish. This by itself could be accounted as a major cause of the cranial differences seen in the rats of the different districts. These differences in size are well represented in the ZW character which is an important cranial character in studying the rodentia.

There were no significant differences seen in cranial characters between males and female rats studied. This shows that males and females were equally affected by the environmental factors which in turn worked on their genetic makeup.

5. Conclusion

In conclusion, in order to better classify Tehran's brown rats which have become a major problem in the city we introduce three ratios to be considered in studies along with traditional characters measured: DL/TBW, DL/ZW and ZW/TBW. This could be seen as the primary step toward the control of the population of these rodents in the different districts of the city which are already posing great threats on the health of the citizens.

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