Morphometric analysis of the black rat, *Rattus rattus,* from Congreso Island (Chafarinas Archipelago, Spain)

Jacint Ventura
Universitat Autònoma de Barcelona
Departament de Biologia Animal, de Biologia Vegetal i d'Ecologia
08193 Bellaterra (Barcelona). Spain
ivzo2@blues.uab.es

María José López-Fuster
Universitat de Barcelona
Departament de Biologia Animal
Av. Diagonal, 645. 08028 Barcelona. Spain
mjose@porthos.bio.ub.es

Manuscript received in May 2000

Abstract

Black rats, *Rattus rattus*, from Chafarinas Archipelago constitute one of the westernmost insular populations of the species in the Mediterranean region. To evaluate the influence of insular conditions on body and skull dimensions, the biometric characteristics of a sample from Congreso island were determined and compared with nearby mainland populations (Málaga —southeastern Iberia— and Morocco). Results show that Congreso specimens are similar in size to Iberian specimens and in skull shape to Morocco animals. Considering this later fact and the geographical proximity between Chafarinas and the Morocco coastline, it seems likely that Congreso black rats had their source in North-African populations. The size similarity between Iberian and Congreso rats does not appear to be the expression of a genetic relationship but a biometric convergence. Actually, the specimens from Málaga correspond to one of the largest mainland forms of *R. rattus* from western Europe, and the size of Congreso rats might constitute another case of gigantism that appears as an adaptive response to insularity in black rat populations from small western Mediterranean islands. Lack of interspecific competition and low predation pressure in Congreso could have contributed to the black rat size increase.

Key words: craniometry, island syndrome, Mediterranean islands, *Rattus rattus*, rodents, somatometry.

Resumen. *Análisis morfométrico de la rata negra,* Rattus rattus, *de la isla del Congreso (Chafarinas, España).*

La rata negra, *Rattus rattus*, de las islas Chafarinas constituye una de las poblaciones más occidentales de la especie en la región mediterránea. Para evaluar la influencia de la insularidad en las dimensiones corporales y craneanas, se determinan las características biométricas de una muestra procedente de la isla del Congreso y se comparan con las correspondientes a poblaciones continentales próximas (Málaga —sudeste ibérico— y Marruecos). Los resultados indican que los ejemplares de Congreso presentan un tamaño similar a los ibéricos y una forma semejante a los de Marruecos. Esta última circunstancia, y la proximidad geográfica existente entre Chafarinas y la costa marroquí, sugiere que los animales de Congreso proceden de poblaciones norteafricanas. La similitud biométrica observada entre los ejemplares ibéricos y de Congreso no parece ser el resultado de una relación genética sino de una convergencia. De hecho, la población de Málaga constituye una de las formas continentales de *R. rattus* de mayores dimensiones en Europa occidental y el tamaño de los ejemplares de Congreso podría ser la expresión de un caso de gigantismo, como el registrado en otras poblaciones insulares de *R. rattus* del Mediterráneo. La ausencia de competencia interespecífica y la baja presión de predación en Congreso pueden haber influido en dicho incremento de tamaño.

Palabras clave: craneometría, islas mediterráneas, *Rattus rattus*, roedores, síndrome de insularidad, somatometría.

Introduction

The black rat, *Rattus rattus*, was introduced by Man to the Mediterranean islands, at least, 3500 years ago (Cheylan, 1986). Rats exploit a variety of insular habitats because of their adaptive capacity and trophic diversity, and they are often the only mammal found on islands with limited natural resources or extreme environmental conditions. It is the most widespread mammal on the islands in the western Mediterranean region, lacking only on very small isles with poor vegetation diversity, and islands that lie far from the mainland and without maritime traffic (cf. Cheylan, 1986, 1988).

On islands mammal communities are subjected to several evolutionary forces respect to continental populations, referred to as the insular syndrome by Blondel (1986). Rodents from small islands are usually larger than their mainland counterparts. Many hypothesis have been proposed to explain this general pattern (cf. Angerbjörn, 1986), and diverse causal factors, such as the climate and the geographic characteristics of the island (area, latitude, distance from mainland), insular species diversity (predation pressure, competition), intraspecific competition and physiological advantages of immigrants, have been argued (Case, 1978; Foster, 1964; Heaney, 1978; Lomolino, 1985; Melton, 1982; Sondaar, 1977). Like other rodent species, *R. rattus* also shows size variation under the effect of insularity, which has been well studied in many western Mediterranean islands (Alcover, 1983; Cheylan, 1986; Granjon & Cheylan, 1990, 1993; Kahmann & Haedrich, 1957).

The black rats from the Chafarinas archipelago, three small islands near the Moroccan coastline, constitute one of the westernmost insular population of the species in the Mediterranean region. Although the presence of black rats on these islands is known for a long time (Calderón, 1894), to our knowledge their bionomic traits have never been studied. The original purpose of this paper was to investigate whether detectable biometric change was also taking place in this

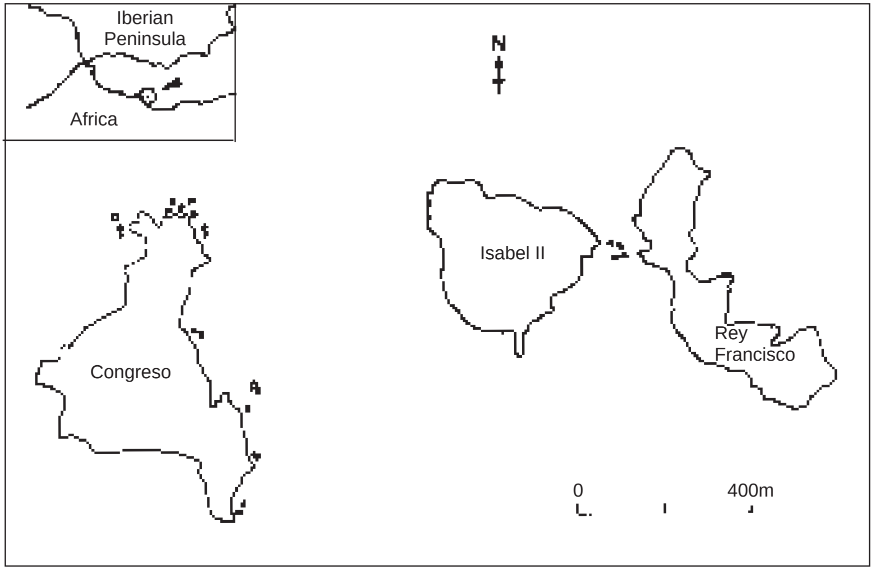

Figure 1. Map of Chafarinas Islands.

population. With this aim, a sample of black rats from one of these islands (Congreso) was analysed and compared with nearby mainland populations.

Study area

The Chafarinas Archipelago (Melilla, Spain) is located off the eastern Mediterranean coast of Morocco (35º 12' N 2º 27' W), about 4.5 Km from the nearest mainland (Ras El Ma, Morocco) and 49.5 Km from Melilla. It is formed by three small volcanic isles named, from West to East, Congreso, Isabel II and Rey Francisco (figure 1). Isabel II (8.5 ha) is separated from Rey Francisco (12.39 ha) at about 200 m, and is the only one that has been inhabited permanently since the settlement of a Spanish military detachment in 1848. Congreso is a rocky island of 950 m long and 500 m wide, with an area of 23.86 ha, and about 900 m from Isabel II. It rises as a slope from east to west, where it has a maximum height of 137 m, and its coastline is composed of steep, rugged cliffs, at the foot of which there are some rocky small beaches. The surface of Congreso is practically covered by vegetation, mainly constituted by *Salsola oppositifolia*, *Atriplex halimus*, *Suaeda vera* (F. Chenopodiaceae), *Pistacia lentiscus* (F. Anacardiaceae), *Lycium intricatum*, *Whitania frutescens* (F. Solanaceae), *Periploca laevigata* (F. Asclepiadaceae) and *Launaea arborescens* (F. Asteraceae). The climate of Chafarinas corresponds to the classical Mediterranean type of the northern coast of Africa: warm or mild, with wet winters and hot, dry summers (for details see Griffiths, 1972).

Material and methods

The sample studied consisted of 42 black rats (18 males, 20 females, 4 sex ?) trapped on Congreso Island during March and April of 1994 and June of 1995. For biometrical analyses, animals were distributed into three age classes (juveniles, subadults, adults) according to the sexual state and considering, additionally, the criteria gived by Kahmann & Haedrich (1957) and Alcover (1983), based on the degree of toothwear. The distribution of the individuals in age classes was as follows: juveniles: 6 (3 males, 3 females); subadults: 14 (6 males, 8 females); adults 22 (9 males, 9 females, 4 sex ?). Each specimen was weighted (BM: body mass in g) and in pregnant females the weight of the embryos was subtracted. Head and body length (HBL), tail length (TL), ear length (EL), and hind foot length (HFL) were also taken (in mm).

For comparisons with nearby mainland populations of *R. rattus*, 51 specimens from Málaga (southeastern Spain) and 21 specimens from several localities of Morocco were studied. Specimens from Málaga and Morocco were also aged using the criteria mentioned above. The distribution of these samples by location, age class and sex is as follows: Málaga (shores of the Guadalhorce river; collection of Departamento de Biología Animal, Universidad de Málaga): 10 juveniles (6 males, 4 females), 15 subadults (7 males, 8 females), 26 adults (14 males, 12 females). Morocco (collection of Muséum National d'Histoire Naturelle, Paris): Tiznit, 1 juvenile (sex ?); Meknés, 2 juveniles (1 male, 1 female), 2 adults (1 male, 1 female); Nafifik forest, 1 adult (male); Taddert, 1 juvenile (male), 4 subadults (1 male, 3 females), 3 adults (females); Zagora, 1 juvenile (male), 1 subadult (male); Aoufous: 1 juvenile (female), 3 adults (1 male, 2 females); unknown location, 1 juvenile (sex ?).

Twenty-three measurements were recorded on each skull using a digital caliper capable of measuring to 0.01 mm. Variables considered were: 1 Total skull length (TSL), 2 condylobasal length (CBL), 3 nasal length (NL), 4 frontal length (FL), 5 parietal length (PL), 6 interparietal length (IPL), 7 upper diastema length (UDL), 8 incisive foramen length (IFL), 9 tympanic bulla length (TBL), 10 upper molar series from the alveoles (UMSa), 11 upper molar series from the dental crowns (UMSc), 12 skull case height (SCH), 13 nasal width (NW), 14 interorbital width (IOW), 15 interparietal width (IPW), 16 occipital width (OW), 17 tympanic bulla width (TBW), 18 zygomatic width (ZW), 19 mandible length (ML), 20 lower molar series from the alveoles (LMSa), 21 lower molar series from the dental crowns (LMSc), 22 articular height (AH), 23 articular width (AW). For definitions of measurements 2, 3, 7, 8, 10-14, 16 and 18-21 see Niethammer & Krapp (1978); for 1, 9 and 17 see Granjon & Cheylan (1993); for 22 see Ventura & Gosálbez (1989). Definitions of the remaining measurements are: 4, maximum length of the frontal suture; 5, maximum length of the sagital suture; 6, maximum length of the interparietal bone; 15, maximum width of the interparietal bone; 23, width of the articular process taken at the mid point of its length.

Basic descriptive statistics were calculated for all samples. Characters were tested for univariate normality by use of the Kolmogorov-Smirnov D-statistics, and homogeneity of variances was evaluated by Levene's test. The significance of the differences between sample means was assessed by analysis of variance (test ANOVA); pairwise comparisons of character means were undertaken by Scheffe's method. These analyses were performed by use of SPSS programs (Norusis, 1997). Samples were also subjected to distance analysis, using the average taxonomic distance, to determine the morphometric relationships between geographic populations (Sneath & Sokal, 1973). From the matrix of distances between samples a phenogram was constructed by the unweighted pair-group method (UPGMA; Sneath & Sokal, 1973). A principal-components analysis based on the character correlation matrix of standardized variables was performed. To remove the effect of size, Burnaby's method for size adjustment was used (Rohlf, 1994). The resultant adjusted data matrix was then used for the subsequent cluster analysis. Cluster and principal-components analyses, and Burnaby's method were performed by the NTSYS-PC+ routines (Rohlf, 1994). For all sequential tests, p-values were corrected by the Bonferroni adjustment (Rice, 1989), as modified by Chandler (1995).

Results

Statistical comparisons in adult specimens from Congreso revealed no significant sex differences in the means of body measurements, although in all parameters males showed higher averages than females (table 1). The percentage index between TL and HBL ranged between 100 and 118.03, and adult means did not show significant intersexual differences either (table 1). In none of the specimens studied was TL shorter than HBL. Although the index mean was slightly higher in juveniles and subadults than in adults, the relationship between these lengths did not vary significantly with age, either in males or in females.

Since the sample from Morocco was composed of specimens from different locations and years, and body measurements of individuals from Morocco and Málaga were taken by different researchers, no statistical comparisons between sexes or among geographic populations were undertaken. So, the significance of the differences among samples was tested only on skull variables. Intersexual differences in adults were not significant in each sample, and therefore skull data of males and females were grouped for subsequent analyses. Descriptive statistics for skull variables and interorbital index (Schwabe, 1979) in adult specimens for the samples studied are shown in table 2. It is worth mentioning that although specimens of our Morocco sample came from scattered locations, which in some cases have different ecoclimate, they were homogeneous in skull size, as can be deduced from the absence of significant differences between the variances of the samples.

Analysis of variance among adults from Congreso, Málaga, and Morocco showed significant differences in most skull variables; in general, the highest averages corresponded to the Iberian sample and the lowest to the Moroccan (tables 2, 3). Comparisons between pairs of samples revealed that specimens from Congreso and Málaga were biometrically very similar, with significant differences only

Table 1. Values of body measurements of *Rattus rattus* from Congreso Island. TL% = (TL/HBL) x 100.

		Males					Females				
		n	x̄	sd	min.	max.	n	x̄	sd	min.	max.
HBL	juv.	3	126.00	13.00	118	141	3	116.33	4.93	113	122
	subad.	6	177.33	16.05	157	199	8	162.00	13.56	146	180
	ad.	9	202.56	14.58	172	224	9	196.00	12.86	179	220
TL	juv.	3	136.67	13.50	123	150	3	131.00	11.79	121	144
	subad.	6	192.83	14.47	169	207	8	181.63	13.32	163	200
	ad.	8	217.00	9.69	201	229	8	213.13	6.08	205	223
HFL	juv.	3	30.50	1.32	29	32	3	29.00	0.00	29	29
	subad.	6	35.50	1.52	33	37	8	33.63	1.51	31	35
	ad.	9	35.63	1.56	32	38	9	34.44	1.01	33	36
EL	juv.	3	18.67	1.15	18	20	3	18.00	1.00	17	19
	subad.	6	21.50	1.05	20	23	8	20.56	0.73	20	22
	ad.	8	23.38	1.49	21	26	9	23.17	1.27	21	25
BM	juv.	3	47.00	15.13	35	64	3	47.33	9.29	37	55
	subad.	6	146.58	29.57	106	176	8	115.00	28.03	85	155
	ad.	9	201.11	49.54	145	290	9	196.73	39.92	135	245
TL%	juv.	3	108.58	5.76	104.24	115.13	3	112.48	5.99	106.14	118.03
	subad.	6	108.99	6.02	102.15	117.83	8	112.21	2.14	108.89	114.65
	ad.	8	107.79	4.38	102.23	116.86	8	108.63	5.56	100.00	114.52

in PL, UMSc, ML, LMSc, and AW. In contrast, divergences between Congreso and Morocco were found in 15 out of 23 variables analysed (table 3).

In the distance phenogram derived from the standardized data matrix (figure 2A), large specimens from Málaga and Congreso formed a separate cluster from the Moroccan sample, which represented small-size individuals. The principal-components analysis identified the characters that define the cluster. The 100% of cranial variation was explained by the first two principal axes (80.22% and 19.78% respectively). Component I discriminated among size groups and had high and positive loadings for all characters except for PL; component II was highly correlated with this last variable and, to a lesser extent, with AW. In order to remove the effect of size, Burnaby's method was used. In this case, the phenogram corresponding to the resultant adjusted data matrix separated the Málaga sample from the cluster formed by Congreso and Morocco samples (figure 2B). The new first two components explained the 95.53% and 4.47% of the variation, respectively.

Table 2. Values of skull measurements for adult specimens of *Rattus rattus* from Congreso (CO), Málaga (MA) and Morocco (MO). Results of IO% (= (IOW/CBL) x 100) correspond to all specimens for each sample.

		n	x̄	sd	min.	max.			n	x̄	sd	min.	max.
TSL	CO	18	43.42	1.61	39.93	46.85	NW	CO	21	4.60	0.35	3.86	5.38
	MA	19	44.32	1.59	41.55	47.94		MA	26	4.41	0.23	4.04	4.89
	MO	8	40.84	1.79	37.56	42.97		MO	8	4.30	0.26	3.90	4.70
CBL	CO	20	41.82	1.65	38.49	45.24	IOW	CO	22	6.17	0.27	5.68	6.59
	MA	23	42.50	1.39	39.94	45.54		MA	26	6.25	0.24	5.73	6.77
	MO	9	39.15	1.73	35.95	41.55		MO	9	6.00	0.15	5.83	6.34
NL	CO	21	16.01	0.76	14.37	17.43	IPW	CO	20	11.67	0.43	11.09	12.58
	MA	23	16.34	0.73	15.10	18.24		MA	22	11.21	0.71	9.82	12.58
	MO	8	14.53	1.01	13.27	16.00		MO	9	10.55	0.49	10.01	11.50
FL	CO	21	14.27	0.62	12.87	15.50	OW	CO	19	17.09	0.52	16.18	17.99
	MA	23	14.58	0.77	12.83	15.73		MA	24	17.13	0.52	16.19	18.08
	MO	7	13.78	0.87	12.90	15.10		MO	9	15.59	0.87	14.44	16.84
PL	CO	18	7.20	0.19	6.82	7.56	BW	CO	22	7.38	0.23	6.85	7.77
	MA	20	8.05	0.44	7.36	8.91		MA	26	7.28	0.22	6.80	7.72
	MO	9	7.84	0.43	7.14	8.44		MO	9	7.02	0.18	6.69	7.24
IPL	CO	18	6.63	0.31	6.12	7.13	ZW	CO	19	21.63	1.07	19.67	23.33
	MA	22	6.36	0.47	5.65	7.07		MA	26	21.68	0.78	20.26	23.06
	MO	8	6.24	0.65	5.35	6.99		MO	8	20.03	0.80	19.07	21.20
UDL	CO	23	11.91	0.76	10.42	13.25	ML	CO	22	25.60	1.16	23.32	27.58
	MA	26	12.00	0.55	11.06	13.34		MA	26	26.65	0.93	24.98	28.69
	MO	9	10.97	0.56	9.99	11.87		MO	8	23.87	1.07	22.05	25.17
IFL	CO	23	7.84	0.42	7.01	8.46	LMSa	CO	22	7.14	0.37	6.48	7.81
	MA	26	7.87	0.45	7.15	8.79		MA	26	7.16	0.24	6.66	7.60
	MO	9	7.48	0.48	6.49	8.18		MO	9	6.43	0.33	6.01	6.90
BL	CO	22	7.99	0.29	7.33	8.54	LMSc	CO	21	6.35	0.19	5.60	6.68
	MA	26	7.76	0.33	7.16	8.40		MA	25	6.59	0.21	6.18	7.04
	MO	9	7.38	0.13	7.12	7.56		MO	9	6.21	0.18	5.98	6.59
UMSa	CO	23	7.28	0.32	6.69	7.81	AH	CO	22	14.19	0.73	12.85	15.28
	MA	25	7.48	0.34	6.69	8.06		MA	26	14.67	0.61	13.06	15.62
	MO	9	7.01	0.32	6.31	7.42		MO	9	12.98	0.74	11.90	14.46
UMSc	CO	23	6.34	0.26	5.83	6.81	AW	CO	22	3.62	0.15	3.37	4.02
	MA	26	6.65	0.28	6.00	7.23		MA	26	3.27	0.16	3.01	3.64
	MO	9	6.20	0.29	5.60	6.71		MO	9	3.19	0.21	2.92	3.56
SCH	CO	17	11.88	0.40	11.27	12.67	IO%	CO	33	15.31	0.34	14.21	18.41
	MA	21	11.92	0.41	11.42	12.61		MA	42	15.10	0.29	13.98	17.04
	MO	8	11.16	0.43	10.68	11.96		MO	17	15.48	0.30	14.50	16.56

Table 3. Results of analysis of variance and individual comparisons between pairs of samples. CO: Congreso; MA: Málaga; MO: Morocco. *: p<0.05; **: p<0.01; ***: p<0.001; —: no statistical significance. P-values corrected by the Bonferroni adjustment for columns.

	F	p	CO-MA	CO-MO	MA-MO	> $\bar{x}$ >
TSL	12.78	***	—	**	***	MA CO MO
CBL	15.27	***	—	***	***	MA CO MO
NL	15.86	***	—	***	***	MA CO MO
FL	3.45	—	—	—	—	MA CO MO
PL	27.13	***	***	***	—	MA MO CO
IPL	2.79	—	—	—	—	CO MA MO
UDL	9.14	***	—	**	**	MA CO MO
IFL	2.81	—	—	—	—	MA CO MO
BL	14.19	***	—	***	*	CO MA MO
UMSa	6.99	**	—	—	**	MA CO MO
UMSc	12.20	***	**	—	**	MA CO MO
SCH	10.95	***	—	**	***	MA CO MO
NW	4.44	—	—	—	—	CO MA MO
IOW	3.69	—	—	—	—	MA CO MO
IPW	11.71	***	—	***	—	CO MA MO
OW	24.60	***	—	***	***	MA CO MO
BW	8.41	**	—	**	—	CO MA MO
ZW	11.36	***	—	***	***	MA CO MO
ML	22.56	***	*	**	***	MA CO MO
LMSa	20.64	***	—	***	***	MA CO MO
LMSc	15.34	***	**	—	***	MA CO MO
AH	20.83	***	—	***	***	MA CO MO
AW	33.83	***	***	***	—	CO MA MO

Discussion

General body and skull dimensions of *R. rattus* from Congreso Island fall within the range given for the species in the western Mediterranean region (e.g. Alcover, 1983; Cheylan, 1986; Granjon & Cheylan, 1990, 1993; Kahmann & Haedrich, 1957; Zamorano, 1985; Zimmerman, 1953). Although males were, on average, slightly larger than females, there was no significant sexual dimorphism, which agrees with the general trends shown by western Mediterranean black rat populations (e.g. Granjon & Cheylan, 1990; Zamorano, 1985).

In order to evaluate size relationships between Congreso rats and other Mediterranean populations, comparisons with literature data were performed.

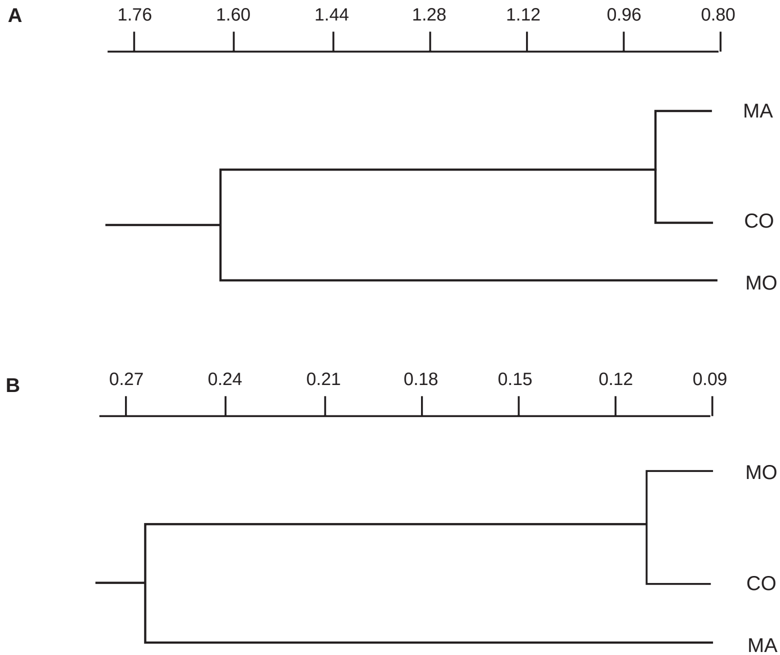

Figure 2. Distance phenograms depicting the craniometric relationships between samples from Congreso (CO), Morocco (MO), and Málaga (MA). A: after standardized data matrix; B: after adjusted data matrix obtained by Burnaby's method. Cophenetic correlation coefficients are 0.996 and 0.874, respectively.

Thus, HBL and CBL were used as a measure of general body and skull sizes, respectively. Since comparisons of this kind do not allow us to establish precise conclusions, the biometric relationships deduced must be taken as approximate. Respect to island populations (cf. Alcover, 1983; Granjon & Cheylan, 1990, 1993; Kahmann & Haedrich, 1957), adults from Congreso showed a high average of HBL, even higher than the means given for largest rats of the western Mediterranean region (Provençal islands; cf. Granjon & Cheylan, 1990, 1993). Although differences with the results given by other authors may be due to several factors, such as the criteria used in age determination, physiological state of the individuals or ecological factors, the HBL mean obtained in Congreso specimens corresponds to a large form of *R. rattus*. This average is higher than 170 mm, which agrees with results reported for rats from other small western Mediterranean islands (surface<1500 ha; Granjon & Cheylan, 1990). Respect to mainland populations, the HBL mean obtained in Chafarinas specimens is also higher, even of the same order as the highest averages reported for European populations (cf. Becker, 1978; Zamorano, 1985), including animals of our sample from Málaga (HBL of adults: $\bar{x}$ = 198.15, sd = 9.09, range 177-216, n = 35; from measurements taken by Zamorano). The mean of the relative tail length (TL%) of adults from Congreso fits into the lowest values reported for European populations (cf. Alcover, 1983; Granjon & Cheylan, 1990; Kahmann & Haedrich, 1957; Zamorano, 1985). Comparisons with literatura data do not allow us to deduce any relationship between insularity and the variation of this index.

As for CBL, adult specimens from Congreso showed higher means than black rats from large western Mediterranean islands, such as Majorca, Minorca, Ibiza (Alcover, 1983), Corsica (Kahmann & Haedrich, 1957), Sardinia (Cheylan, 1986) or Crete (Zimmermann, 1953). Taking into account the correlation between HBL and CBL in black rat populations deduced from literature data, there is an important discord between the CBL average obtained in Congreso and the means given by Granjon & Cheylan (1990) for several insular Mediterranean populations. Although in this latter paper CBL is not defined, on the basis of the descriptions of the skull measurements given in a further paper by the same authors (1993), we believe that their CBL corresponds to our TSL. Under this assumption, black rats from Congreso have a relatively large skull, whose average length is of the same order as the values reported for Provençal island populations. Respect to western Europe continental rats, the mean of CBL of Congreso animals is also relatively high (cf. Schwabe, 1979; Zamorano, 1985). As for the interorbital index (Schwabe, 1979), values of our sample fall within the range of the 38-chromosome type of *R. rattus*, which is the most frequent karyotype in the Mediterranean region (Capanna & Civitelli, 1971; Cheylan, 1986; Yosida, 1980; although cf. Ladrón de Guevara & Díaz de la Guardia, 1981; Pretel & Díaz de la Guardia, 1978).

Statistical comparisons reveal that Congreso and southeastern Iberian specimens show very similar averages for most measurements, which, in general, are significantly higher than the means obtained in the sample from Morocco. This biometric similarity explains that in the phenogram constructed from the standardized data matrix, samples from Congreso and Málaga formed a separate cluster from the Moroccan sample. Nevertheless, when the size effect was removed Congreso and Morocco samples were grouped. For geographical proximity, it seems very likely that Chafarinas' rats had their source in North-African populations, which might explain the similarity in shape between Morocco and Congreso animals. If so, dimensions of *R. rattus* from Congreso agree with the size increase that small mammals may show in particular insular conditions (cf. Lomolino, 1985). The similar size pattern observed in rats from Congreso and Málaga would not appear to be expression of a genetic relationship, but rather a biometric convergence. Literature data concerning skull size of *R. rattus* from western Europe (cf. Granjon & Cheylan, 1990; Schwabe, 1979; Zamorano, 1985) suggest that this convergence is not a function of a latitudinal variation.

Information on rat population from Congreso is not enough to test most of the mechanisms that act on body size variation in insular small mammals, although the influence of some of them, especially those related to insular species diversity (see Angerbjörn, 1986), can be presumed. Black rat and rabbit (*Oryctolagus cuniculus*) are the only mammals in Congreso. Therefore, taking into account that there are no other small mammal species or carnivores, it can be assumed that *R.*

rattus has neither competitors nor predators on this island; despite the presence of a couple of peregrine falcons, *Falco peregrinus* (Mayol, 1978), and the occasional consumption of juvenile rats by the herring gull, *Larus cachinnans* (Pedrocchi & González-Solís, in verbis), the predation pressure of these birds on rats must be irrelevant. So, the lack of interespecific competition and the very scarce predation may operate on a size increase, as reported by Granjon & Cheylan (1990) for other western Mediterranean black rat populations.

Since data on the biometric characteristics of black rats from Isabel II and Rey Francisco Islands are not available, it is not possible to determine whether the size increase reported for Congreso animals is a general event in Chafarinas. It should be taken into account that differential population densities, immigration rates, and anthropic influence (food availability, introduction of predators, environmental changes, etc.) may lead to biometric divergence among insular populations. As these factors act in a different way in the three islands, inter-insular biometric differentiation cannot be ruled out.

Acknowledgements

We are grateful to X. Ruiz for kindly giving up the specimens from Congreso Island; J. Cuisin and M. Vargas for allowing us to examine the specimens in the Muséum National d'Histoire Naturelle de Paris and Departamento de Biología Animal at Universidad de Málaga, respectively; L. Granjon (Paris) for their comments and criticisms on an early draft of the manuscript; and Robin Rycroft (Servei d'Assessorament Lingüístic, Universitat de Barcelona) for improving the English. This study was funded by grants from the Instituto para la Conservación de la Naturaleza (ICONA).

References

Alcover, J.A. 1983. Contribució al coneixement dels mamífers de les Balears i Pitiüses: Carnivora, Rodentia. Tesi doctoral. Universitat de Barcelona.

Angerbjörn, A. 1986. Gigantism in island populations of wood mice (*Apodemus*) in Europe. Oikos 47: 47-56.

Becker, K. 1978. Gattung *Rattus*. *In*: J. Niethammer; F. Krapp (ed.). Akademische Verlagsgesellschaft. Wiesbaden, p. 382-400.

Blondel, J. 1986. Biogéographie évolutive. Masson. Paris.

Calderon, S. 1894. Las Chafarinas. An. Hist. Nat. 23: 903-917.

Capanna, E.; Civitelli, M.V. 1971. On the chromosomic polymorphims of *Rattus rattus*. A study in West European populations. Experientia 27: 583-584.

Case, T.J. 1978. A general explanation for insular body size trends in terrestrial vertebrates. Ecology 59: 1-18.

Chandler, C.R. 1995. Practical considerations in the use of simultaneous inference for multiple tests. Anim. Behav. 49: 524-527.

Cheylan, G. 1986. Facteurs historiques, écologiques et génétiques de l'évolution de populations méditerranéennes de *Rattus rattus* (L.): Discussion des modèles de spéciation. These d'Etat. Université de Montpellier.

— 1988. Les adaptations écologiques de *Rattus rattus* à la survie dans les ilôts méditerranéennes (Provence et Corse). Bull. Ecol. 19: 417-426.
Foster, J.B. 1964. Evolution of mammals on islands. Nature 202: 234-235.
Granjon, L.; Cheylan, G. 1990. Différenciation biométrique des rats noirs (*Rattus rattus*) des îles ouest-méditerranéennes. Mammalia 54: 213-231.
— 1993. Différencitation génétique, morphologique et comportementale des populations de rats noirs *Rattus rattus* (L.) des îles d'Hyères (Var, France). Sci. Rep. Port-Cross natl. Park, Fr. 15: 153-170.
Griffiths, J.F. 1972. Climates of Africa. *In*: H.E. Landsberg (ed.). Elsevier Scientific Publishing Company. London.
Heaney, L.R. 1978. Island area and body size of insular mammals: evidence from the tricolored squirrel (*Callosciurus prevosti*) of Southeast Asia. Evolution 32: 29-44.
Kahmann, H.; Haedrich, B. 1957. Eine Untersuchung an *Rattus rattus* Linnaeus 1758 (Mamm., Rod.) auf der Insel Korsika. Zool. Anz. 158: 233-257.
Ladrón de Guevara, R.G.; Díaz de la Guardia, R. 1981. Frequency of chromosome polymorphims for pericentric inversions and B-chromosomes in Spanish populations of *Rattus rattus frugivorus*. Genetics 57: 99-103.
Lomolino, M.V. 1985. Body size of mammals on islands: the island rule reexamined. Am. Nat. 125: 310-316.
Mayol, J. 1978. Observaciones sobre la gaviota de Audouin, *Larus audouinii* Payr, en el Mediterráneo occidental (primavera de 1978). Naturalia Hispanica 20: 1-34.
Melton, R.H. 1982. Body size and island *Peromyscus*: a pattern and a hypothesis. Evol. Theory 6: 113-126.
Niethammer, J.; Krapp, F. 1978. Handbuch der Säugetiere Europas. 1. Akademische Verlagsgesellschaft. Wiesbaden.
Norusis, M.J. 1997. SPSS professional statistics 7.5. SPSS Inc, Chicago.
Pretel, M.A.; Díaz de la Guardia, G.R. 1978. Chromosomal polymorphism caused by supernumerary chromosomes in *Rattus rattus* ssp. *frugivurus* (Rafinesque, 1814) (Rodentia, Muridae). Experientia 34: 325-327.
Rice, W.R. 1989. Analyzing tables of statistical tests. Evolution 43: 223-225.
Rohlf, F.J. 1994. NTSYS-pc. Numerical Taxonomy and Multivariate Analysis System. Exeter Software. New York.
Schwabe, H.W. 1979. Vergleichend-allometrische Untersuchungen an der Schädeln europäischer und asiatischer Hausratten (*Rattus rattus* L.). Z. Säugetierkunde 44: 354-360.
Sneath, P.H.A.; Sokal, R. R. 1973. Numerical Taxonomy. Freeman. San Francisco.
Sondaar, P.Y. 1977. Insularity and its effect on mammal evolution. *In*: M.K. Hecht; P.C. Goody; B.M. Hecht (ed.). Plenum Press. New York. p. 671-707.
Ventura, J.; Gosálbez, J. 1989. Taxonomic review of *Arvicola terrestris* (Linnaeus, 1758) (Rodentia, Arvicolidae) in the Iberian Peninsula. Bonn. zool. Beitr. 40: 227-242.
Yosida, H.S. 1980. Cytogenetics of the Black Rat. Univ. Park Press. Baltimore.
Zamorano, E. 1985. Estudio taxonómico-sistemático de *Rattus rattus* (L. 1758) en el Sur de la Península Ibérica. Tesis de licenciatura. Universidad de Málaga.
Zimmerman, K. 1953. Die Rodentia Kretas. Z. Säugetierkunde 17: 21-51.