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Distribution and biometry of *Sorex granarius* (Miller, 1910) (Soricinae: Insectivora)

By J. GISBERT, M. J. LÓPEZ-FUSTER, ROSA GARCÍA-PEREA and J. VENTURA

Unidad de Zoología Aplicada, Madrid and
Facultat de Biología, Universitat de Barcelona

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Abstract

The area of distribution of *Sorex granarius* is confined to the Iberian Peninsula, including Galicia, the northern half of Portugal and the Central System. This species occupies forestal and supraforestal biotopes, with an altitudinal distribution from sea level to 2000 m.a.s.l. The interval of altitudes where this shrew is found is smaller and higher in the Central System (500–2000 m.a.s.l.).

Sorex granarius presents marked craniometric homogeneity, although there is a decremental tendency in size from north to south, the largest specimens occurring in Galicia.

Introduction

In the Iberian Peninsula, the shrews of the genus *Sorex* with sexual trivalent (*araneus-articus* group, MEYLAN and HAUSSER 1973, *araneus* group, HAUSSER 1976) are represented by three karyologically and biochemically well-characterized species: *Sorex araneus* Linnaeus, 1758; *Sorex coronatus* Millet, 1828; and *Sorex granarius* (MILLER 1910).

Sorex granarius was described by MILLER (1910) as a subspecies of *Sorex araneus* (*S. a. granarius*, terra typica La Granja, Segovia). Nonetheless, as a result of the karyological and morphological analysis by HAUSSER et al. (1975), the form *granarius* was raised to species rank.

In 1914, CABRERA attributes a specimen from Vilaboa (La Coruña) to this form and postulates that the distribution of *granarius* is the central and northwestern Iberian Peninsula. Later, various authors report the species in Galicia (HEIM DE BALSAC and DE BEAUFORT 1969; NORES 1979; LOPEZ-FUSTER 1983), the Central System (HAUSSER et al. 1975; CAMPOS 1977; CATZEFLIS et al. 1982; ARENAS 1983; CATZEFLIS 1984; HAUSSER 1984) and Portugal (NIETHAMMER 1970; MADUREIRA and MAGALHÃES 1980); MADUREIRA and RAMALINHO 1981; RAMALINHO, in press). The references by ALMAÇA (1968) and GARZON-HEYDT et al. (1971) to *Sorex araneus* in Portugal and the Central System, respectively, in reality correspond to *Sorex granarius*. In contrast, the specimens from Villarreal (Alava) that MALEC and STORCH (1964) consider *Sorex granarius* should be referred to *Sorex coronatus* (HAUSSER et al. 1975).

As for *Sorex* from northern Burgos (Sedano), bibliographic findings are contradictory. According to NIETHAMMER (1956), these specimens pertain to *Sorex granarius* in the light of their coloring and dimensions, while GARZON-HEYDT et al. (1971) assign them to *Sorex araneus* (read *coronatus*). On the basis of HAUSSER's (1984) multivariate analysis, the specimens from Sedano are *Sorex granarius*. Nonetheless, HAUSSER indicates that this diagnosis must be erroneous according to the geographical distribution of *Sorex granarius* and *Sorex coronatus*. In the map of distribution described by HAUSSER et al. (1985), the specific affiliation of these specimens is not mentioned.

The objective of our paper was to establish the morphometric features of *Sorex granarius* and offer our biogeographical findings.

Material and methods

Material analysed

Two hundred thirty-five specimens were studied. The material came from the scientific collections of: the Unidad de Zoología Aplicada, deposited at El Encin, Alcalá de Henares; the Department of Vertebrates of the School of Biology, Universidad Central de Barcelona; and the Department of Vertebrates of the School of Biology, Universidad de Salamanca.

The specific determination was realized on the basis of the cranial criteria proposed by MILLER (1912) and HAUSSER et al. (1975). For the captured material, also was examined the coloration and body measurements (see CABRERA 1914).

Specimens captured: Madrid: Alto de Guarramillas, 1. Segovia: Puerto de Fuenfria, 1. Avila: Laguna de El Barco, 1. León: Lago de la Baña, 1. La Coruña: Vallegestoso, 1; Ferrol, 1. Lugo: San Ciprián, 2.

Owl pellet material: Segovia: Grado del Pico, 1 skull and 2 mandibles; Riofrío de Riaza, 9 skulls and 9 mandibles. Avila: El Barco de Avila, 75 skulls and 54 mandibles. Cáceres: Hervás, 3 skulls and 3 mandibles; Baños de Montemayor, 1 skull and 1 mandible; Acebo, 1 skull and 1 mandible. Salamanca: Villasrubias, 1 skull and 1 mandible; Candelario, 16 skulls and 13 mandibles. La Coruña: Arines, 1 skull and 1 mandible; Brandonil, 6 skulls and 3 mandibles; Puebla de Caramiñal, 2 mandibles; Montfero, 1 skull and 2 mandibles; Pontedeume, 7 skulls and 2 mandibles. Orense: Castrocaldelas, 5 skulls and 6 mandibles.

Body, skull and jaw measurements

We used the following measurements: CC = head + body length. C = tail length. P = hind foot length. O = ear length. Peso = weight in grams. LCI = condyle-incisor length. LCB = condyle-basal length. LR = rostral length. LCC = length of skull case. LSB = staphylion-basion length. AIO = interorbital width. AZ = zygomatic width. ACC = skull case width. SDS = length of upper dental series. $P^4-M^3 = P^4-M^3$ length. α = labial length of the mandible. β = length of articular process. γ = inclination of the coronoid process. δ = mandibular foramen. LIA = incisor-angle length. LM = mandibular length. LFT = length of internal temporal fossa. SDI = length of lower dental series. $M_1-M_3 = M_1-M_3$ length. LM_3 = maximum M_3 length, LA = articular length of mandible. HC = coronoid height (Fig. 1).

The cranial measurements and mandibular LA and HC were realized with a Mitutoyo caliper, ± 0.02 mm precision. For the other mandibular measurements, a "Reichert Mak MS" stereomicroscope ocular micrometer was used. The precision of this instrument, by lens, was: 1:1 lens, ± 0.065 mm (α , LIA, LM, SDI, M_1-M_3); 1:4 lens, ± 0.015 mm (β , γ , LFT, LM); 1:10 lens, ± 0.006 mm (δ). We used the method described by SANS-COMA (1979) for the measurements with stereomicroscope, which is inspired by that proposed by HAUSSER and JAMMOT (1974), based on use of the "bloc comparateur optique" conceived by JAMMOT (1973).

Biomathematical analyses

Data were processed with an IBM 3083/XE01 computer of the Calculation Center of the University of Barcelona. Sample means were compared by variance analysis – ANOVA – and paired samples by the Tukey method. The degree of intersample affinity for each variable was evaluated by the Student-Newman-Keuls test (DIXON 1983: BMDP program p7D).

Results and conclusions

Distribution and habitat

Sorex granarius is distributed throughout the Central System, from Sierra de Ayllón (Spain) to Serra da Estrela (Portugal), extending throughout Portugal from north of the "Tajo" River to Galicia (Fig. 2).

In the Central System, the species is located at altitudes between 500 and 2000 meters, occupying the supra- and oromediterranean bioclimatic levels (RIVAS-MARTINEZ 1981, 1983). In this area, where captures were scant, *Sorex granarius* was found especially in forest biotopes: woods of *Fagus sylvatica* (Cantalajas), *Pinus silvestris* (Balsain, Hoyos del Espino), *Quercus pyrenaica* (Candelario) and *Quercus rotundifolia* (La Maya). *Sorex granarius* also occupies cultivated lands that replace authochthonous forests, like green

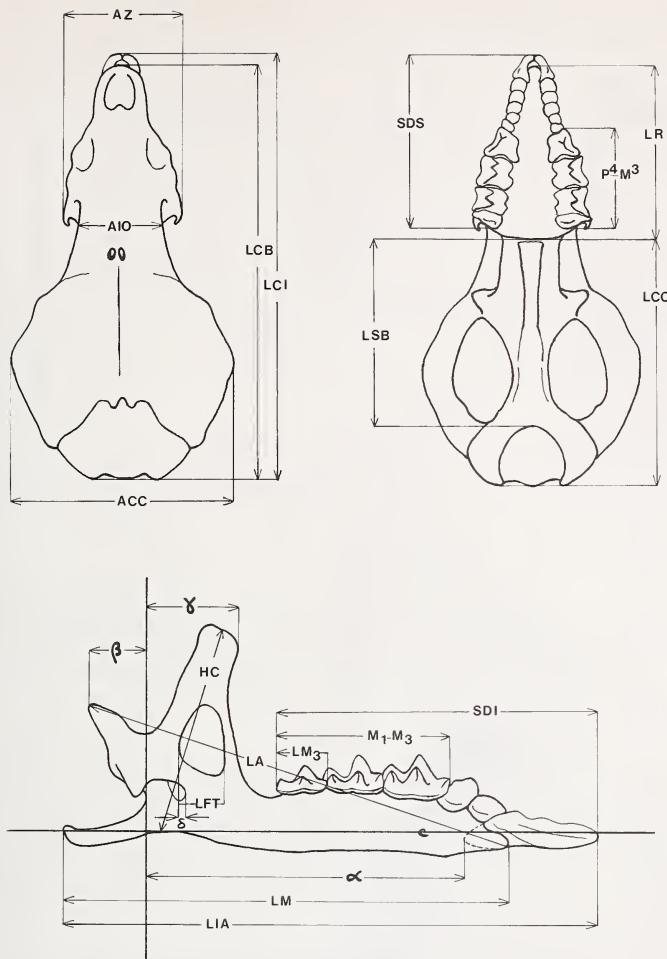
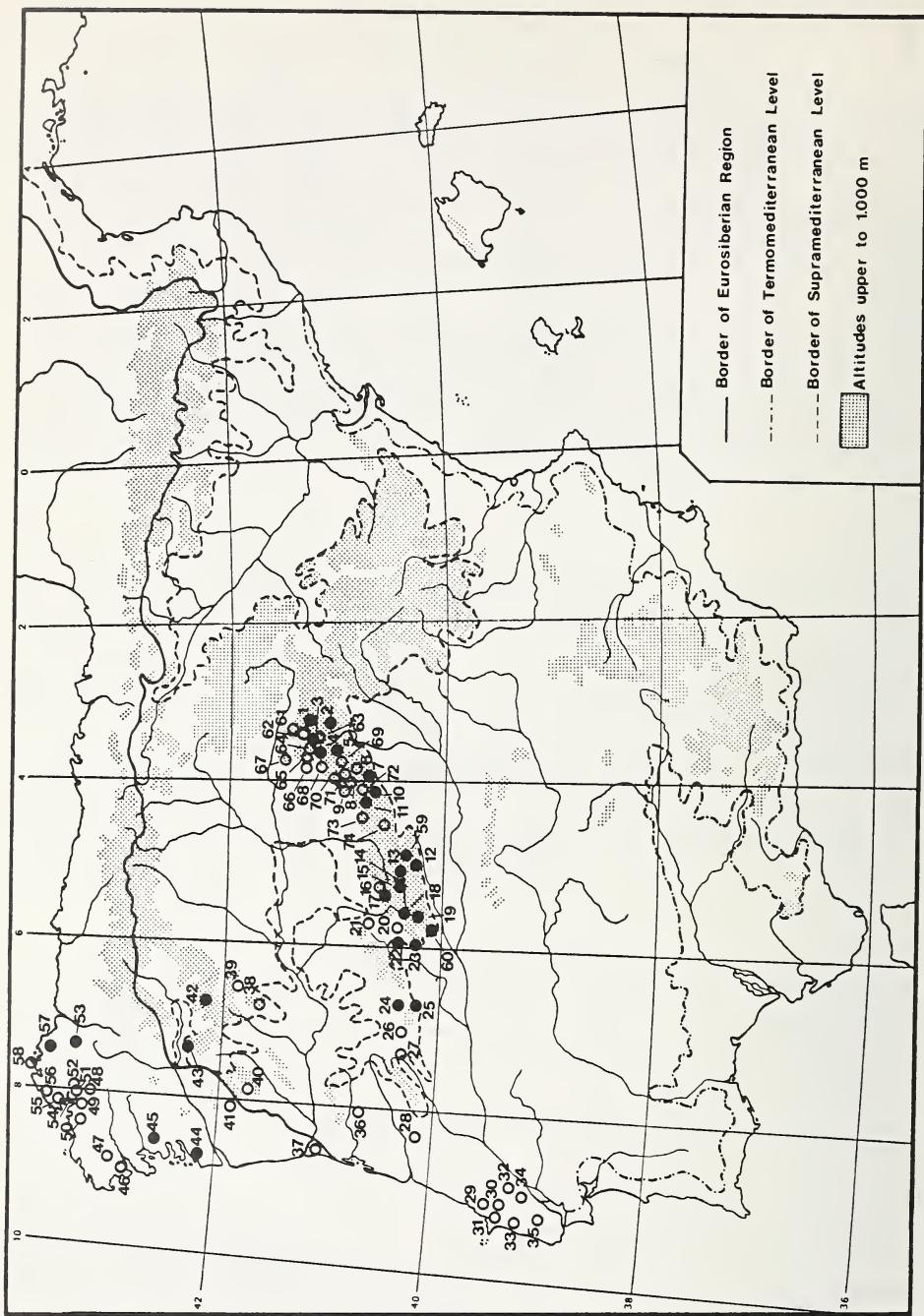


Fig. 1. Cranial and mandibular measurements of *Sorex granarius*

gardens (El Barco de Avila) and forests of *Castanea sativa* (Hervás) and *Pinus pinaster* (Villasrubias). Above the forest level, the species was captured in granite rock falls adjacent to areas of *Nardus stricta* (Laguna de El Barco, Galayos). From the western extreme of the Central System, the distribution of *Sorex granarius* is at progressively lower altitudes, appearing at the mesomediterranean level and reaching the coast of Portugal and Galicia. According to MADUREIRA and RAMALINHO (1981), the species is present in Portugal in almost all the biotopes with a bushy stratum, being more abundant in densely vegetated, relatively humid terrain. In northern Portugal, *Sorex granarius* introduces itself into the eurosiberian region, penetrating in Galicia, where it occupies the *Quercus pyrenaica* woods and areas where the natural forest has been replaced by *Eucaliptus* and *Pinus pinaster* plantations.

Generally speaking, the territories occupied by *Sorex granarius* are characterized by mean annual temperatures of 3–15 °C with cold to extremely cold winters and mean annual precipitation in excess of 600 mm.



Biometry

The origin of the material, predominantly from owl pellets, precludes our establishing the somatometric and biological characteristics of *Sorex granarius*. Nonetheless, since the bibliographic data on these aspects are restricted to those communicated by MILLER (1912), we consider it interesting to offer the body measurements obtained in 10 specimens from diverse localities (Table 1).

Table 1. Body measurements of *Sorex granarius*

Locality	Date	Sex	CC	C	P	O	Weight
Balsain (Segovia)	23. 04. 1977	♀	64.0	39.0	12.0	7.4	—
Alto de Guerramillas (Segovia)	—	♀	51.0	37.0	12.0	6.4	6.0
Laguna de El Barco (Ávila)	23. 06. 1984	♀	51.0	38.0	12.0	7.6	8.1*
Gontán-Quende (Lugo)	23. 07. 1979	—	50.0	36.0	11.0	5.6	—
Vilas, S. Ciprián (Lugo)	11. 08. 1978	—	61.0	41.0	12.0	6.9	7.5
S. Ciprián (Lugo)	26. 07. 1976	—	61.0	39.0	12.0	7.1	6.5
Ferrol (Coruña)	24. 09. 1973	—	63.0	40.0	12.0	7.6	—
Ferrol (Coruña)	24. 09. 1973	—	58.0	41.0	12.0	7.3	—
Vallegestoso (Coruña)	30. 05. 1976	♀	65.5	46.0	12.0	5.3	—
El Barco de Ávila (Ávila)	29. 08. 1987	♀	68.0	39.0	11.5	6.0	6.5

* = weight corresponding to a pregnant female

Moreover, in view of the fragmentary nature of craniometric information, we list in Table 2 the values of cranial variables obtained in our specimens from Galicia (the data from Gredos and Guadarrama are insufficient). Our findings concur with those commun-

Fig. 2. Distribution of *Sorex granarius* in the Iberian Peninsula. Black circles: own data. White circles: references in literature. 1: Grado del Pico (Segovia), 2: Cantalajas (Guadalajara), 3: Riofrio de Riaza (Segovia). 4: Cerezo de Arriba (Segovia), 5: Pto. de Somosierra (Madrid), 6: Rascafría (CATZEFILIS et al. 1982). 7: Alto de Guerramillas (Madrid), 8: Balsain (GARZON et al. 1971), 9: La Granja (MILLER 1910), 10: Cercedilla (Madrid), 11: Pto. de Fuenfria (Segovia), 12: Galayos (Ávila), 13: Barajas (Ávila), 14: Hoyos del Espino (Ávila), 15: Navalperal de Tormes (Ávila), 16: Piedrahita (HAUSSER 1984), 17: Santiago del Collado (Ávila), 18: El Barco de Ávila (Ávila), 19: Laguna de El Barco (Ávila), 20: Candelario (HAUSSER et al. 1975), 21: La Maya (CAMPOS 1977), 22: Baños de Montemayor (Cáceres), 23: Hervás, (Cáceres), 24: Villasrubias (Salamanca), 25: Acebo (Cáceres), 26: Sabugal (MADUREIRA and MAGALHÃES 1980), 27: Belmonte (MADUREIRA and RAMALINHO 1981), 28: Miranda do Corvo (MADUREIRA and RAMALINHO 1981), 29: Caldas da Rainha (MADUREIRA and RAMALINHO 1981), 30: Obidos (RAMALINHO in press), 31: Serra d'El Rei (RAMALINHO in press), 32: Rio Maior (NIETHAMMER 1970), 33: Lourinhã (RAMALINHO in press), 34: Epinera-Cercal (NIETHAMMER 1970), 35: Tapada de Mafra (MADUREIRA and RAMALINHO 1981), 36: Torredeira (RAMALINHO in press), 37: Grijo (RAMALINHO in press), 38: Serra da Nogueira (RAMALINHO in press), 39: Cernadilla (HAUSSER 1984), 40: Cabeceiras de Basto (MADUREIRA and MAGALHÃES 1980), 41: Géres (MADUREIRA and RAMALINHO 1981), 42: Lago de la Baña (León), 43: Panjón-Nigrán (Pontevedra), 44: Castrocaldelas (LOPEZ-FUSTER 1983), 45: Caldas de Reyes (Pontevedra), 46: Puebla del Caramiñal (LOPEZ-FUSTER 1983), 47: Brandomil (LOPEZ-FUSTER 1983), 48: Montesalgueiro (NORES 1979), 49: Betanzos (NORES 1979), 50: Vilaboa (CABRERA 1914), 51: Pontedeume (LOPEZ-FUSTER 1983), 52: Caaveiro (NORES 1979), 53: Gontán-Quende (Lugo), 54: Montfero (LOPEZ-FUSTER 1983), 55: Ferrol (NORES 1979), 56: Lagoa (NORES 1979), 57: San Ciprián (Lugo), 58: Estaca de Bares (NORES 1979), 59: San Esteban del Valle (Ávila), 60: Monasterio de Yuste (Cáceres), 61: Estebanvela (ARENAS 1983), 62: Villacorta (ARENAS 1983), 63: Pto. de la Quesera (ARENAS 1983), 64: Riaza (ARENAS 1983), 65: Sequera de Fresno (ARENAS 1983), 66: Encinas (ARENAS 1983), 67: Valdevacas (ARENAS 1983), 68: Sotillo (ARENAS 1983), 69: Gallegos (ARENAS 1983), 70: da Cuesta (ARENAS 1983), 71: Sotosalbos (ARENAS 1983), 72: Peñalara (ARENAS 1983), 73: Revenga (ARENAS 1983), 74: El Espinar (ARENAS 1983)

Table 2. Values of descriptive statistics of cranial variables in *Sorex granarius* from Galicia

	n	\bar{x}	s	Σx^2	min.	max.
LCI	2	18.2	0.1	663	18.1	18.3
LCB	4	17.7	0.1	1246	17.5	17.8
LR	23	7.5	0.2	1285	7.2	7.8
LCC	5	10.2	0.2	516	9.9	10.4
LSB	5	8.0	0.3	317	7.6	8.3
AIO	22	3.8	0.1	317	3.5	4.1
AZ	13	5.3	0.1	363	5.1	5.4
ACC	3	8.7	0.4	229	8.3	9.0
SDS	10	7.7	0.2	590	7.3	7.9
P ⁴ -M ³	19	4.3	0.1	353	4.1	4.5

Table 3. Values of descriptive statistics of jaw measurements of *Sorex granarius* from Galicia (GA), Gredos (GR) and Guadarrama (GU)

		n	\bar{x}	s	Σx^2	min.	max.
α	GA	20	6.3	0.2	793	5.80	6.72
	GR	73	6.3	0.2	2901	5.80	6.59
	GU	13	6.1	0.1	486	5.93	6.33
β	GA	20	1.2	0.1	27	1.00	1.29
	GR	73	1.1	0.1	96	0.87	1.29
	GU	13	1.1	0.1	16	0.94	1.26
γ	GA	20	1.9	0.2	72	1.52	2.23
	GR	73	1.9	0.1	256	1.51	2.29
	GU	13	1.9	0.2	49	1.68	2.26
δ	GA	20	0.2	0.1	1	0.04	0.37
	GR	73	0.2	0.1	3	0.00	0.41
	GU	13	0.1	0.1	0	0.00	0.38
LIA	GA	15	11.7	0.2	2058	11.33	12.13
	GR	60	11.4	0.3	7832	10.94	11.99
	GU	10	11.3	0.3	1276	10.94	11.60
LM	GA	15	9.6	0.2	1387	9.36	10.02
	GR	64	9.5	0.3	5791	9.09	10.15
	GU	10	9.4	0.2	886	9.23	9.62
SDI	GA	15	7.2	0.2	774	6.85	7.38
	GR	58	6.9	0.2	2764	6.33	7.25
	GU	11	6.9	0.2	522	6.59	7.25
LFT	GA	20	1.0	0.1	21	0.90	1.16
	GR	73	1.0	0.1	75	0.78	1.23
	GU	13	1.0	0.1	12	0.81	1.13
M_1-M_3	GA	16	3.7	0.1	219	3.56	3.82
	GR	62	3.6	0.1	810	3.43	3.95
	GU	11	3.6	0.1	144	3.56	3.82
LM ₃	GA	16	1.0	0.0	16	0.94	1.07
	GR	55	1.0	0.0	55	0.94	1.10
	GU	11	1.0	0.0	11	0.97	1.07
LA	GA	20	9.1	0.3	1661	8.70	9.60
	GR	71	9.1	0.2	5816	8.60	9.50
	GU	13	9.1	0.2	1070	8.80	9.40
HC	GA	20	4.3	0.2	369	4.00	4.60
	GR	73	4.2	0.1	1309	3.90	4.60
	GU	13	4.3	0.2	236	4.00	4.50

Table 4. Individual comparison between paired samples for each analysed variable, according to Tukey's method

	GA-GR	GA-GU	GR-GU	GU	GA	GR	\bar{x}
α	0	<0.05	<0.01	6.11 13	6.29 20	6.30 73	n
β	0	0	0	GU 1.09 13	GR 1.14 73	GA 1.15 20	\bar{x} n
γ	0	0	0	GR 1.87 73	GA 1.89 13	GU 1.93 20	\bar{x} n
δ	0	0	0	GU 0.14 13	GA 0.19 20	GR 0.19 73	\bar{x} n
LIA	<0.01	<0.01	0	GU 11.29 10	GR 11.42 60	GA 11.71 15	\bar{x} n
LM	0	0	0	GU 9.41 10	GR 9.51 64	GA 9.63 15	\bar{x} n
SDI	<0.01	<0.01	0	GU 6.89 11	GR 6.90 58	GA 7.18 15	\bar{x} n
LFT	0	0	0	GU 0.97 13	GR 1.01 73	GA 1.02 20	\bar{x} n
M_1-M_3	<0.01	0	0	GR 3.61 62	GU 3.62 11	GA 3.70 12	\bar{x} n
LM_3	0	0	0	GR 1.00 55	GA 1.01 16	GU 1.02 11	\bar{x} n
LA	0	0	0	GR 9.05 71	GU 9.07 13	GA 9.11 20	\bar{x} n
HC	0	0	0	GR 4.23 73	GU 4.26 13	GA 4.29 20	\bar{x} n

Results of Student-Newman-Keuls multiple test of rank for Galicia (GA), Gredos (GR) and Guadarrama (GU). 0 = Not significant differences

cated by MILLER (1912), HAUSSER et al. (1975), MADUREIRA and MAGALHAES (1980), NORES (1979) and RAMALINHO (1981).

Table 3 shows the statistics for the descriptive mandibular parameters of the Galicia, Gredos and Guadarrama samples. Comparison of the sample means (ANOVA test) discloses notable biometric similarity among populations. Significant differences were detected only in α ($F = 6.24$, $p < 0.01$), LIA ($F = 8.71$, $p < 0.01$), SDI ($F = 10.30$, $p < 0.01$) and M_1-M_3 ($F = 4.76$, $p < 0.01$).

Individual comparisons between pairs of samples (Table 4) also confirm the scant divergence of peninsular *Sorex granarius* populations. Between the populations of Galicia

and Gredos, we only found statistically significant differences in LIA ($p < 0.01$), SDI ($p < 0.01$) and M_1-M_3 ($p < 0.01$). Between the Galicia and Guadarrama samples, the most marked divergences were in α ($p < 0.05$), LIA ($p < 0.01$) and SDI ($p < 0.01$). Between Gredos and Guadarrama, there was an even greater degree of biometric similarity, only α showing significant differences ($p < 0.01$).

In view of the mean values obtained for all these populations (see Table 3), the specimens from Galicia generally evidence the largest mandibular dimensions, although these differences lack statistical significance (observe values of β , LIA, LM, SDI, LFT, M_1-M_3 , LC and HC). Due to their biometrical similarity, the relationship between the sizes of the Gredos and Guadarrama samples has not been completely defined.

To determine the degree of intersample affinity in each parameter, mean values were processed by the Student-Newman-Keuls test. In the graphic representation of results (Table 4), the populations with mean values not significantly heterogeneous are underlined (SOKAL and ROHLF 1979). The resulting diagrams evidence the close relationship among the populations analysed. The only variable to statistically separate the Guadarrama population was α , which was smaller in this sample. The specimens from Galicia differ from Gredos and Guadarrama in LIA, SDI and M_1-M_3 , the mean values of these parameters being higher in the Galicia samples.

On the basis of these findings, although there was no evidence of intraspecific mandibular biometric differences in *Sorex granarius*, there was a general tendency to smaller size from north to south. It is interesting to point out that in the Iberian Peninsula, *Crocidura russula* and *Crocidura suaveolens* have been found to present a clinal variation consisting in progressive reduction of craniometric values to the south (REY and LANDIN 1973; REY and REY 1974; SANS-COMA et al. 1987).

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Zusammenfassung

Verbreitung und Biometrie von Sorex granarius (Miller, 1910) (Soricinae: Insectivora)

Die Verbreitung von *Sorex granarius* ist auf die Pyrenäen-Halbinsel beschränkt. Hier ist diese Art in Gallizien, der nördlichen Hälfte von Portugal und im Zentralgebirge anzutreffen. *Sorex granarius* bewohnt vorwiegend Waldgebiete. Die vertikale Verbreitung erstreckt sich von der Meereshöhe bis zur Höhe von 2000 m. Im Zentralgebirge ist dieses Intervall kleiner (500–2000 m). Die Biometrie der Schädel von untersuchten Individuen ist sehr gleichartig, obwohl sich eine Tendenz zur Größenabnahme von Norden nach Süden beobachten lässt. Die größten Schädel wurden in Gallizien gefunden.

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Authors' addresses: J. GIBERT and ROSA GARCÍA-PEREÀ, Unidad de Zoología Aplicada, El Encín, Apdo. 127, Alcalá de Henares, Madrid, Spain; M. J. LÓPEZ-FUSTER and J. VENTURA, Departamento de Vertebrados, Facultad de Biología, Av. Diagonal 657, E-08028 Barcelona, Spain

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Autor(en)/Author(s): Ventura Jacint, López-Fuster María José, Gisbert J., García-Perea Rosa

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