Atti della Società Italiana di Scienze Naturali
e del Museo Civico di Storia Naturale di Milano

Vol. 131 (1990), n. 13, pag. 225-231 Milano, novembre 1990

L.J. Palomo (*), J.M. Vargas (*) & M.J. López-Fuster (**)

A quantitative study of the coats of the White-toothed shrew (*Crocidura russula*) Hermann, 1780 (Mammalia Insectivora)

Riassunto – Studio quantitativo del pelo della crocidura rossiccia (*Crocidura russula*) Hermann, 1780 (Mammalia Insectivora). In questo studio si analizzano le caratteristiche metriche del diverso tipo di pelo della crocidura rossiccia (*Crocidura russula*) e la densità del pelo durante la vita di questo animale, incominciando da un campione di 15 esemplari catturati nel Delta dell'Ebro (Nord-est della Penisola Iberica). Il pelo di borra (Fh) è il più numeroso (78,8%) tanto nel dorso come nel ventre, indipendentemente dal tipo di pelo e dalla stagione dell'anno. La densità del pelo è maggiore in inverno che in estate e lo stesso si può dire per quanto riguarda la lunghezza e la larghezza del pelo, che aumenta con l'età. Le variazioni stagionali e ontogenetiche nella dimensione e nella densità del pelo della crocidura rossiccia rientrano nella tendenza generale osservata in altre specie di micromammiferi non commensali delle zone temperate.

Abstract – The present work aimed to analyzed the metrics characteristics of different types of hairs of the White-toothed shrew (*Crocidura russula*) and the density of successive coats throughout its life, on basis of a sample population caught in Rio Ebro Delta (NE Iberian Peninsula). Fur hairs (Fh) are the most numerous (78.8 %) both dorsal and ventral surfaces and no coat or seasonal variation was observed. Hair size and density of winter coats were always greater than those obtained in summer ones. Furthermore lenght and width of hairs increase with animal age. For all these ontogenetics and seasonal variations, *C. russula* appears to fit the general pattern described for other small non-commensal mammal species of the temperate zones of the world.

Key words: coats, White-toothed shrew, *Crocidura russula*.

(*) Dept. Biologia Animal, Fac. Ciencias, Univ. Málaga, 29071 Málaga, Spain.
(**) Dept. Biologia Animal (Vertebrados), Fac. Biologia, Univ. Barcelona, Avda Diagonal 645, 08028 Barcelona, Spain.

ISSN 0037-8844

Registrato al Tribunale di Milano al n. 6574
Dir. resp. Giovanni Pinna

Stampa Fusi-Pavia

Introduction

Many authors have studied the moulting processes in mammals, especially in Insectivora and Rodentia. Most of their works establish the topographical sequences and temporal patterns of the moults undergone by these animals (see, among others, Stein, 1954, 1960; Kryltzov, 1964; Fullagar, 1967; Borowski, 1968, 1973; Kahman and Tiefenbacher, 1970; Pernetta, 1976; Baxter et al., 1981; Sans-Coma et al., 1987 and Palomo and Vargas, 1988a, 1988b). However, works which deal with either the factors and causes of the moulting, or the characteristics of the different coats, or both these subjects, are fewer (Johnson, 1958; Borowski, 1959; Khateeb and Johnson, 1971; Haitlinger, 1968; Martin-Dennis and Peitz, 1981; Rougeout and Thebault, 1983; Vargas et al., 1987).

Works which deal specifically with the factors and causes of moulting of *Crocidura russula* are rare. According to López-Fuster et al. (1986), starting with the juvenile coat (JC), acquired in the nest, several changes of coat take place during the life of the animal, each new coat being preceded by one of a well-defined succession of moults, termed MI, MII, MIII and MIV, which precede, respectively, the first-summer coat (FSC), the first-winter coat (FWC), the second-summer coat (SSC), and second-winter coat (SWC). Similar patterns of moulting are described for other species of Insectivora (for example, *Suncus etruscus,* Fons, 1974; *Sorex araneus,* Borowski, 1968; 1973). These different coats have either markedly different, easily identifiable, hair structures, or different colorations and sometimes, they may have both characteristics.

The present work aimed to analyze the qualitive and quantitive characteristics of the successive coast of *C. russula* throughout its life and includes a biometric study of the different types of hair that compose each coat.

Material and methods

1) Material analyzed: The animals employed in the present study came from a sample population caught in different parts of the Rio Ebro delta (Tarragona Province, Spain) during the two years, 1981-1982 (n=15). Using the fur criteria described by López-Fuster et al. (1986), the following five types of animal were selected: juvenile (n=3), first summer (n=3), first winter (n=3), second summer (n=4), and second winter (n=2).

2) Evaluation of the different types of fur and calculation of the density of the coats. The methodology described by Vargas et al. (1987) was used to evaluate the fur on both the dorsal and ventral surfaces of the animal. This method has been used by these authors to study *Mus spretus* and it consists of pulling small bounches of hairs from specific sites on the dorsal and ventral surfaces. The hair bunches were placed on a microscope slide in a fine film of glycerine and gently separated for counting. All the hairs in each bunch were counted (minimum of 150 per bunch) and differentiated to determine the proportions of the different hair types and the numbers of each type hair (Guard hair, Pile hair, and Fur hair) per unit of skin surface (Gh/S, Ph/S and Fh/S).

Unlike in *M. spretus* the active hair follicles filled with melanin are invisible and so it was only possible to calculate hair densities for those parts of the coat in moult. Because of this, the results apply to the new, growing coats. It is difficult to find and capture examples of *C. russula* in the process of growing their juvenile coat because they are inside the nests.

3) Measurements of Hairs. The measurements made of each type of hair were: total length, without root (L); and the width at the point of largest diameter (W). Constricted and bent hairs were straightened before measurement. The length of guard hairs with a constriction was measured distally from the constriction (DL). The number of constrictions on the fur hair shafts was counted.

Results

Two types of easily differentiated guard hairs were identified, one without constriction, termed Guard hair (Gh) and the other, with constriction, termed hair (Ph). The constriction separates the wider and flatter distal portion from the rest of the hair shaft. There is one type of fur hair (Fh) shorter than the other hairtypes and there are several constrictions along the hair shaft. These categories coincide in each case, with those defined in Soricidae by Vogel and Kopchen (1978): «Leithaare, Grannenhaare und Wollhaare» and Sokolov (1982).

The Fur hairs are the most numerous, they amounted to 78.8% of the total number of hairs analyzed (n=3987). Pile hairs formed 18.7% of the total, while Guard hairs formed 2.7%. The percentages were the same for the dorsal and ventral surfaces and no season variation was observed. In no case, were the percentages significantly different ($p > 0.05$) (Lamotte's test for comparing percentages, 1974).

The total number of hairs per unit of skin surface (H/S) presented evident variations in the successive coats of *C. russula* throughout its life (Table 1). Similar differences were observed for the Fur hairs (Fh/S). However, the hair densities of all guard hairs (AGh/S) and also the two different types of guard hairs (Gh/S, Ph/S) were differentiated in the different coats.

In all cases, the minimum density values were found in the summer coats and the maximum values in the winter coats. The density values of the first summer and winter were always greater than those obtained in the second summer and winter coats.

Similar quantitative variations are seen on the dorsal and ventral surfaces, except that the number of hairs of any type in the ventral region is always less that of the dorsal region.

Both lenght and width of the different types of hairs increase with animal age, so that the lowest values correspond to the juvenile coat (Table 2). At the same time, these values display significant seasonal variations. Winter coats show the largest values, while the smallest values correspond to the summer coats; this differentiation is independent of the type of hair or its location; dorsal or ventral.

The proportion between the lengths of the distal section of the guard hairs to their total lengths is constant in all the new coats. Both these variables are significantly correlated ($r=0{,}95$, $p < 0.001$).

Fur hairs usually have 3 constrictions along their shafts. Hair lengths of the winter coats (both FWC and SWC) are notably longer and the number of constrictions increases; up to 5 in some animals. This is particulary noticeable on the dorsal aspect where the $\bar{x}$ of constrictions in the FWC is 3.7 ($s=0.3$, $n=40$) and in the SWC 3.9 ($s=0.2$, $n=40$). In both cases, the differences are significant ($p<0.01$) in relation to the values of the juvenile and summer coats (FSC and SSC) ($\bar{x}=3.1$, $s=0.01$, $n=120$).

Table 1 – Hair density in successive coats of *Crocidura russula* throughout its life. FSC: First summer coat; FWC: First winter coat; SSC: second summer coat; SWC: Second winter coat; H/S: Total number of hairs per unit of surface; Fh/S: Fur hair/surface; AGh/S: All Guard hair/surface; Gh/S: Guard hair/surface; Ph/S: Pile hair/surface. Dorsal: dorsal coat; Ventral: ventral coat.

		JC	FSC	FWC	SSC	SSW	n
DORSAL	GhL	4.7±0.7	4.9±0.7	7.9±0.3	5.0±0.8	8.0±0.7	20
	PhL	3.4±0.8	3.4±0.6	6.2±0.8	3.4±0.6	6.5±0.8	20
	DL	2.1±0.4	2.2±0.5	3.3±0.3	2.3±0.5	3.8±0.7	20
	FhL	2.8±0.6	3.0±0.9	5.9±0.4	3.1±0.3	6.4±0.5	40
VENTRAL	GhL	3.4±0.6	3.6±0.7	5.6±0.3	4.0±0.7	5.7±0.4	20
	PhL	2.8±0.8	3.1±0.8	5.0±0.2	3.3±0.6	5.3±0.6	20
	DL	2.0±0.6	2.1±0.6	2.5±0.2	2.1±0.7	4.8±0.9	20
	FhL	2.3±0.5	2.5±0.7	4.5±0.4	2.8±0.7	4.8±0.9	40
DORSAL	GhW	31.7±3.2	27.5±3.5	55.7±5.7	32.3±6.8	62.4±4.5	20
	PhW	21.0±1.3	25.5±4.9	39.0±4.3	27.7±6.9	42.5±5.9	20
	FW	19.6±3.9	23.7±4.7	29.3±3.9	24.9±8.1	35.5±4.9	40
VENTRAL	GhW	21.3±2.9	21.0±3.2	42.4±4.4	27.7±3.2	50.0±5.7	20
	PhW	16.7±2.9	19.9±3.3	34.3±3.4	21.0±3.2	42.0±3.7	20
	FhW	13.5±2.7	21.0±3.2	23.4±5.6	20.0±2.2	30.3±2.2	40

Table 2 – Length (L) and width (W) of different types of hairs (Gh: Guard hair, Ph: Pile hair and Fh: Fur hair) found in *Crocidura russula.* DL: Distal length in Pile hair; Dorsal: dorsal coat; Ventral: ventral coat; JC: Juvenile coat; FSC: First summer coat; FWC: First winter coat; SSC: Second summer coat; SWC: Second winter coat; n: number of hairs measured.

		FSC	FWC	SSC	SWC
DORSAL	H/S	230.4±8.3	276.5±6.9	215.2±7.5	260.8±8.3
	Fh/S	180.4±7.8	227.4±8.5	166.1±5.7	203.4±7.7
	AGh/S	46.3±2.8	48.2±2.6	19.1±2.7	52.1±2.8
	Gh/S	7.8±0.7	8.0±0.8	5.6±0.5	7.0±0.7
	Ph/S	38.5±1.4	40.2±2.8	43.5±1.5	45.1±2.7
VENTRAL	H/S	180.5±7.5	210.3±4.9	165.4±5.7	195.1±8.9
	Fh/S	138.6±7.4	166.1±4.2	123.2±2.3	152.3±2.7
	AGh/S	41.6±1.7	44.1±2.4	42.2±1.5	45.4±1.9
	Gh/S	7.8±0.7	4.4±0.4	2.8±0.2	2.3±0.2
	Ph/S	33.8±1.7	39.7±1.4	39.4±1.2	41.1±1.2

Discussion

Undoubtedly, there is a relationship between hair growth, renewal of coat and environmental change (see Johnson, 1984). In *C. russula*, as in other species of Insectivora, the principal function of the change of coat, besides replacing worn hairs, is to increase the insulating power of the coat in winter and to decrease it in summer so that the animal can adapt to the extremes of the climatic range. The moults appear to be related to temporal environmental variations and consequently, are often referred to as seasonal moults (see Borowski, 1968, 1973; Fons, 1974; Baxter et al., 1981; López-Fuster et al., 1986). However, this does not mean that it is seasonal variation, in the widest sense, that initiates the moulting process. One has to admit the possibility that there might be a secondary, genetical, regulatory control mechanism that perhaps coincides with or reinforces the seasonal environmental stimuli. It is a fact that the temporal and topographical succession of the different moulting processes follows a well established rhythm through out the animals' life-spans (see the bibliography contained in the previsious paragraph).

The insulating capacity of the hair coat depends principally on its vertical thickness. Consequently, fur hair contributes more insulation than the less numerous guard hairs. In this way, the numbers of fur hairs and the numbers of other hairs per unit skin surface are greatest in winter and lowest in summer, with significant differences in each case, while the numbers of guard hairs are more constant throughout the year. Hair dimensions fallow a similar pattern. All 3 hair types are considerably longer in winter coats than in summer coats. Consequently, in the whitetoothed shrew, the increase in both number and size hairs in the 2 winter coats gives them a «thickness and density» that is easily detected by simple visual inspection. Similar differences in structure, but either more or less marked, have been reported for other species of Insectivora and Rodentia (Borowski, 1973; Haitlinger, 1978; Khateeb and Johnson, 1971; Sokolov, 1972 and Vargas et al., 1987), thus *C. russula* appears to fit the general pattern described for other small non-commensal mammal species of the temperate zones of the world.

Aknowledgements. The authors wish to thanks to Mr. David W. Schofield for the English translation. This work was finaced by DGICYT, PB86-0581-C03-00.

References

Baxter R. M., Dippenaar N. J. & Meester J., 1981 - The moult pattern of some southern African Soricidae. *Mammalia,* 45, pp. 355-361.

Borowski S., 1959 - Variations in density of coat during the life cycle of *Sorex araneus araneus* L. *Acta Theriol.,* 2, pp. 286-289.

Borowski S., 1968 - On the moult in the Common Shrew. *Acta Theriol.,* 13, pp. 483-498.

Borowski S., 1973 - Variations in Coat and colour in representatives of the genera *Sorex* L. and *Neomys* Kaup. *Acta Theriol.,* 18, pp. 247-279.

Fons R., 1974 - La mue chez les crucidurinae. I. - Changement de pelage dans la nature et en captivite, chez la pachyure étrusque *Suncus etruscus* (Savi, 1822). *Mammalia,* 38 (2), pp. 265-284.

Fullagar P. J., 1967 - Moult in field mice and the variation in the chest markings of *Apodemus sylvaticus* (Linné, 1758) and *Apodemus flavicollis* (Melchior, 1854). *Säugetierkdl. Mitt.,* 15, pp. 138-149.

Haitlinger R., 1968 - Seasonal variation of pelage in representatives of the genus *Apodemus* Kaup, 1829, found in Poland. *Zool. Pol.,* 18 (3), pp. 329-345.

Johnson E., 1958 - Quantitative studies of hair growth in the albino rat. I. Normal males and females. II. The effect of sex hormones. III. The role of the adrenal glands. *J. Endocrin.,* 16, pp. 337-350, 351-359, 360-368.

Johnson E., 1984 - Seasonal adaptive coat changes in mammals. *Acta Zool. Fennica,* 171, pp. 7-12.

Kahmann H. & Tiefenbacher R. L., 1970 - Über Haarwechsel und Haarkleid des Gartenschläfers *Eliomys quercinus* Linnaeus, 1776. *Z. Säugetierk.,* 35 (2); 89-103.

Khateeb A. A. & Johnson E., 1971 - Seasonal changes of pelage in the vole (*Microtus agrestis*). I. Correlation with changes in Endocrine glands. II. The effect of daylength. III. The role of the endocrine system. *Gen. Com. Endocr.,* 16, pp. 217-228, 229-235, 236-240.

Kryltzov A. I., 1964 - Moult topography of Microtinae, other Rodents and Lagomorphs. *Z. Säugetierk.,* 29, pp. 1-17.

Lamotte M., 1974 - Estadística biológica. Principios fundamentales. *Toray-Masson,* Barcelona.

López-Fuster M. J., Gosálbez J., Fons R. & Sans-Coma V., 1986 - The moult of the Whitetoothed shrew *Crocidura russula* (Hermann, 1780) (Insectivora, Mammalia) from the Ebro Delta (Catalonia, Spain). *Mammalia,* 50 (4), pp. 541-552.

Martin-Dennis G. & Peitz B., 1981. Development of the adult pelage in normal and hormone-injected spiny mice (*Acomys cahirinus*). *J. Exp. Zool.,* 218, pp. 381-386.

Palomo L. J. & Vargas J. M., 1988a - Deroulement topographique et temporel des mues reguliers de la souris a queue courte *Mus spretus* Lataste, 1883. *Mammalia,* 52 (1), pp. 75-83.

Palomo L. J. & Vargas J. M., 1988b - On the irregular moult in the Algerian Mouse, *Mus spretus* Lataste, 1883, *Acta Theriol.,* 33, pp. 67-86.

Pernetta J. C., 1976 - A note on the moult of Common shrew, *Sorex araneus,* and Pygmy shrew, *Sorex minutus* with observations on the patch moults of the White toothed shrew, *Crocidura suaveolens. J. Zool.,* 179, pp. 216-219.

Rougeout J. & Thebault R. G., 1983 - Variation saissonières de la composition et de la structure du pelage: exemple de la toison du lapin angora. *Ann. Zootech.,* 32. pp. 287-314.

Sans-Coma V., Zamorano E., Vargas J. M. & Antúnez A., 1987 - Über den Haarwechsel freilebender Hausratten *Rattus rattus* (L., 1758), in Südspanien. *Zool. Abh. Mus. Tierk. Dresden,* 42 (8), pp. 125-136.

Sokolov V., 1982 - Mammal skin. *University of California Press,* Los Angeles.

Stein G. H. W., 1954 Materialen zum Haarwechsel deutschen Insectivoren. *Mitt. zool. Mus. Berlin,* 30, pp. 12-34.

Stein G. H. W., 1960 - Zum Haarwechsel der Feldmaus, *Microtus arvalis* (Pallas, 1778) und weiterer Muroidea. *Acta Theriol.,* 4 pp. 27-43.

Vargas J. M., Palomo L. J. & Sans-Coma V., 1987 - Estudio cuantitativo de los pelajes del ratón moruno, *Mus spretus* Lataste, 1883. In: Mamíferos y Helmintos. Volumen homenaje al Prof. Dr. Dr. Herman Kahmann en su 81. aniversario. *Ed. Ketres,* Barcelona, pp. 131-142.

Vogel P. & Köpchen B., 1978. Besondere haarstrukturen der Soricidae (Mammalia, Insectivora) und ihre taxonomische deutung. *Zoomorphologie,* 89, pp. 47-56.