Taxonomical and biogeographical problems in Mediterranean shrews of the genus *Crocidura* (Mammalia, Insectivora) with reference to a new karyotype from Sicily (Italy)

BY

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Abstract.- VOGEL P., 1988. Taxonomical and biogeographical problems in Mediterranean shrews of the genus *Crocidura* (Mammalia, Insectivora) with reference to a new karyotype from Sicily (Italy). *Bull. Soc. vaud. Sc. nat. 79.1:* 39–48.
Shrews of the genus *Crocidura* from Sicily revealed a new karyotype from Europe: 2n = 36, NF = 56, NFa = 52. With reference to the revision of VESMANIS (1976), this shrew is provisionally attributed to *C. caudata* Miller, 1901 and it is proposed to call it the "Sicilian shrew". Its chromosome complement is similar to that of shrews from the Canary Islands and a species from Burundi (Central Africa), suggesting that it might have split off from a line of Paleotropical origin. Following these findings, the modern concept of Mediterranean island colonization by shrews must be revised. The distinctive characteristics of Mediterranean shrews should also be revised.

Résumé.- VOGEL P., 1988. Problèmes taxonomiques et biogéographiques des musaraignes méditerranéennes du genre *Crocidura* (Mammifères, Insectivores) avec description d'un nouveau caryotype de Sicile (Italie). *Bull. Soc. vaud. Sc. nat. 79.1:* 39–48.
En Europe, selon les synonymes cités par ELLERMAN et MORRISON-SCOTT (1966), au moins 27 espèces de Crocidures ont été décrites, correspondant selon ces auteurs à quatre espèces réelles. JENKINS (1976) et CORBET (1978) finalement ne retiennent que trois espèces valides: *Crocidura leucodon* (Musaraigne bicolore), *C. suaveolens* (Musaraigne des jardins) et *C. russula* (Musaraigne musette). Si l'attribution spécifique des populations continentales est relativement facile, celle des populations insulaires est

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nettement plus problématique: chez ces populations génétiquement isolées la taille, la coloration et la morphologie sont hautement variables et leur interprétation taxonomique est souvent très controversée. Pourtant, leur appartenance spécifique peut être déterminée sans ambiguïté sur la base des chromosomes, puisque les trois espèces reconnues présentent des caryotypes différents. Mais pour ce faire il faut disposer de musaraignes vivantes. L'application de cette technique nous a déjà permis de montrer que les îles de Chypre, de Crète et, selon CATALAN *et al.* (1981), de Corse sont habitées par *C. suaveolens*, la Sardaigne par contre par *C. russula*. La même technique a permis de démontrer le statut spécifique de *C. zimmermanni*, une musaraigne des montagnes de la Crète, à l'origine décrite comme une sous-espèce de *C. russula* (VOGEL 1986).

Trois musaraignes de Sicile, capturées en été 1987, présentent un caryotype de 2n = 36, encore inconnu pour des espèces européennes. D'après la révision de VESMANIS (1976), cette musaraigne correspond à *C. caudata* Miller, 1901 qui a été considérée comme un synonyme de *C. russula,* et nous proposons de l'appeler "Musaraigne de Sicile". Le fait que sa garniture chromosomique ressemble à celle de la musaraigne des îles Canaries (*C. canariensis*) et aussi à celle d'une espèce trouvée au Burundi, suggère qu'elle est issue d'une lignée d'origine paléotropicale. Ces résultats remettent en question la théorie récente de POITEVIN *et al.* (1986) sur l'origine des musaraignes méditerranéennes insulaires. Selon ces auteurs, à l'exception de la Crète, toutes les îles méditerranéennes ont été colonisées dans un temps historique et grâce à l'activité humaine, par les seules espèces *C. russula et C. suaveolens*. Pour interpréter l'origine de l'espèce sicilienne, les musaraignes d'autres îles et d'Afrique du nord devraient être étudiées avec les mêmes techniques. De plus, il serait nécessaire de trouver des nouveaux critères morphologiques pour distinguer les cinq espèces.

INTRODUCTION

At least 27 species of the genus *Crocidura* have been described from Europe, but most of them have been relegated to synonymy (ELLERMAN and MORRISON-SCOTT 1966). At the beginning of this century, MILLER (1912) recognized only seven species, two of them on the European continent, and five endemic species on Mediterranean islands. With increasing knowledge of the mechanisms underlying evolution, taxonomists recognized that the morphology of island populations might be strongly influenced by founder effects, genetic drift and selection resulting from particular ecological conditions. As a result, the taxonomic status of these forms were reconsidered, and the number of valid species reduced again. ELLERMAN and MORRISON-SCOTT (1966) retained only four species. Finally, in her fundamental revision of the Palearctic shrews of the genus *Crocidura*, JENKINS (1976) recognized only three species, *C. leucodon* (Hermann, 1780), *C. russula* (Hermann, 1780) and *C. suaveolens* (Pallas, 1811). CORBET (1978) follows this interpretation and, later, uses it as a basis for the "Field Guide of British and European Mammals" (CORBET and OVENDEN 1980), a book translated into many languages.

However, the taxonomic status of some island populations remains a

matter of discussion. In order to rule out morphological shift, other techniques are necessary to verify the taxonomic status of the disputed forms. Analysis of the karyotype, as promoted in the fifties in Lausanne by Prof. R. Matthey (e.g. MATTHEY 1973), as well as biochemical comparisons illustrated by AYALA *et al.* (1974), are powerful tools in systematics, but are based on living material. As live trapping of shrews and the application of these techniques in the field are not easy, serious investigations began only ten years ago. Consequently, our knowledge has increased rapidly as can be seen in a comparison of new findings with the distribution maps of CORBET and OVENDEN (1980), and illustrated here by some examples: Corsica and Sardinia, both islands should be inhabited sympatrically by *C. russula* and *C. suaveolens*. A biochemical study showed that the shrew from Corsica, which has changed its status seven times in half a century, actually belongs to *C. suaveolens* (CATALAN and POITEVIN 1981). The shrew in Sardinia, which thanks to R. Hutterer (Bonn) could be analyzed, belongs to *C. russula* (CATZEFLIS 1983a); the shrew from Cyprus belongs to *C. suaveolens* (CATZEFLIS 1983 b). In Crete, where most authors presumed *C. russula* to be present (WETTSTEIN 1953, JENKINS 1976, CORBET and OVENDEN 1980), we now know that there are two species, *C. suaveolens* and *C. zimmermanni*, the latter being endemic of this island (VOGEL 1986, VOGEL *et al.* 1986). All European populations attributed by different authors, especially RICHTER (1970), to *C. gueldenstaedtii* actually belong to *C. suaveolens* (CATZEFLIS *et al.* 1985, VOGEL *et al.* 1986).

Taking into account these important new interpretations, karyological and biochemical studies of other island populations seem to be necessary. In particular, the shrews of Sicily deserve our attention. After complex and contradictory interpretations (summarized in the discussion), VESMANIS (1976) attributed the common form of this island to *C. russula*. First karyological results shown in the present work yield an unexptected situation and cast some doubts on the current concept of exclusively recent colonization of islands by shrews.

MATERIAL AND METHODS

In order to catch some shrews, 40 Longworth traps were set in different localities and habitats of Sicily, during the summer of 1987. Sardines in oil mixed with rolled oats were used as bait. In the region of Giardini, Siracusa, Agrigento, Cefalù and Imera, no shrews were captured. Finally, two shrews were caught in the mountains of Madonie, 9 km from Piano Battaglia in the direction of Petralia, and one shrew in Isnello.

The chromosomes of the three specimens were prepared on the day of capture, using the air-drying technique of BAKER *et al.* (1982) based on bone marrow extractions. Staining with Giemsa and the establishment of the karyotype were carried out in Lausanne. Organs for future electrophoretic

investigation of isoenzymes were preserved in liquid nitrogen. Skins and skulls form part of the shrew collection at the University of Lausanne (IZEA, Lausanne).

RESULTS

Habitat

The shrews from Piano Battaglia were captured at an altitude of 1400 m in a small humid valley with running water, bordered on one side with a *Fagus* forest mixed with oaks and trees of *Ilex aquifolium*. The specimen of Isnello was captured along a hedge bordering a field at an altitude of 600 m.

The low trapping levels are not surprising. A study of owl pellets in Sicily (CATALISANO and MASSA 1987), showed that shrews were practically absent in summer, but their traces were found in up to 25% of the pellets collected in winter.

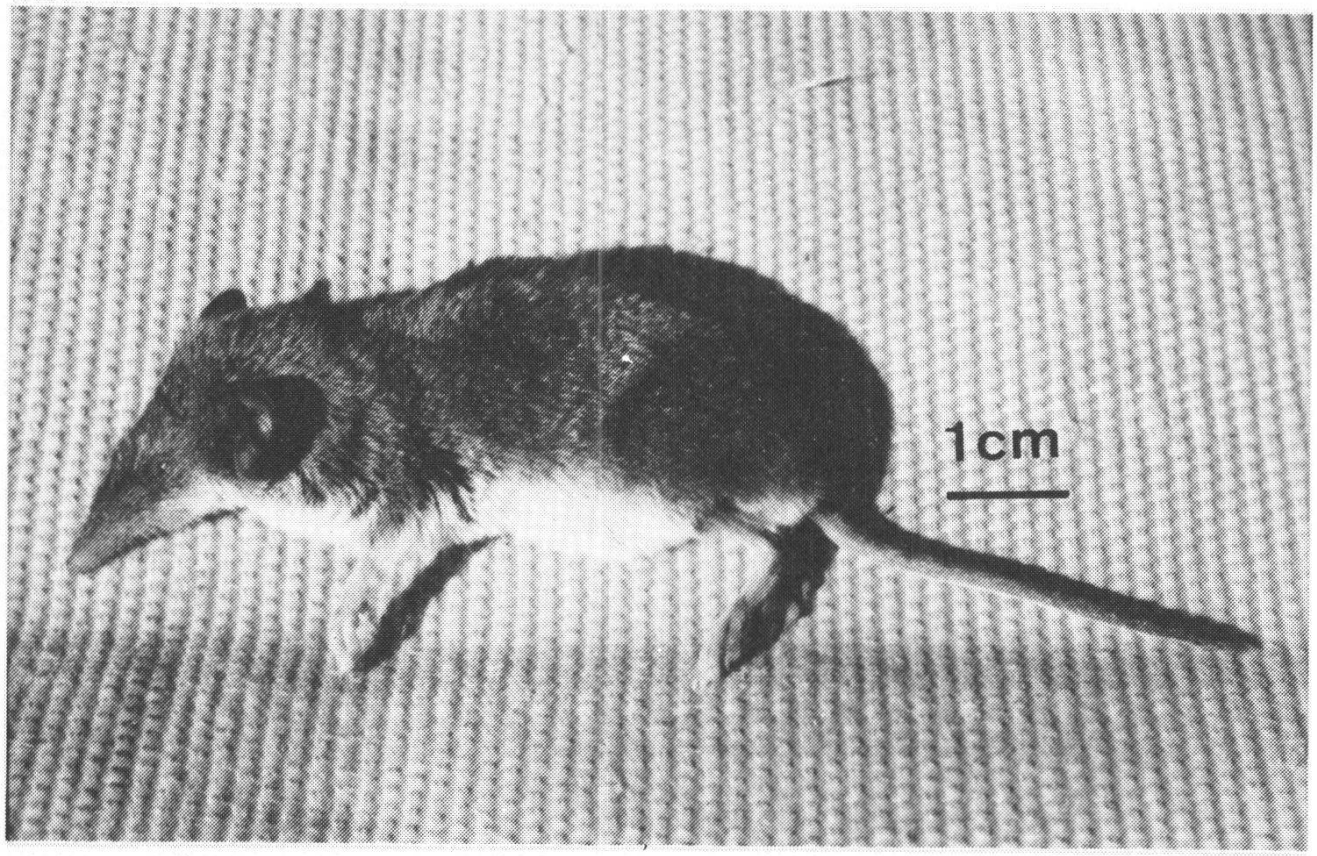

Figure 1.– Anaesthesized shrew (♀ IZEA 2943) from Piano Battaglia (Sicily) showing the bright belly strongly contrasting with the dark back.

Morphology

Some measurements of the specimens are listed in Table 1. A comparison with the values given by VESMANIS (1976) show that our animals belong to the common Sicilian form. The weight of 5.5 to 7.5 g is comparable to that of *C. russula pulchra* or *C. r. yebalensis*. The colour, a dark-grey on the back, contrasting with a very bright belly (fig. 1) resembles that of *C. leucodon*. HAGEN (1954) described the colour pattern as being comparable to that of *C. russula*, an interpretation which does not fit to our individuals.

Date	No.IZEA	Sex	Locality	W	HB	T	HF	CB
3.8.1987	2942	m	Piano Battaglia	6.5	77	37	12.0	18.6
3.8.1987	2943	m	Piano Battalia	7.5	77	39	12.5	18.7
6.8.1987	2944	f	Isnello	5.5	68	45	13.0	18.2

Table 1.–Measurements (in g and mm) of the three shrews from Sicily. W: weight, HB: head and body length, T: tail, HF: hind foot, CB: condylo-basal length.

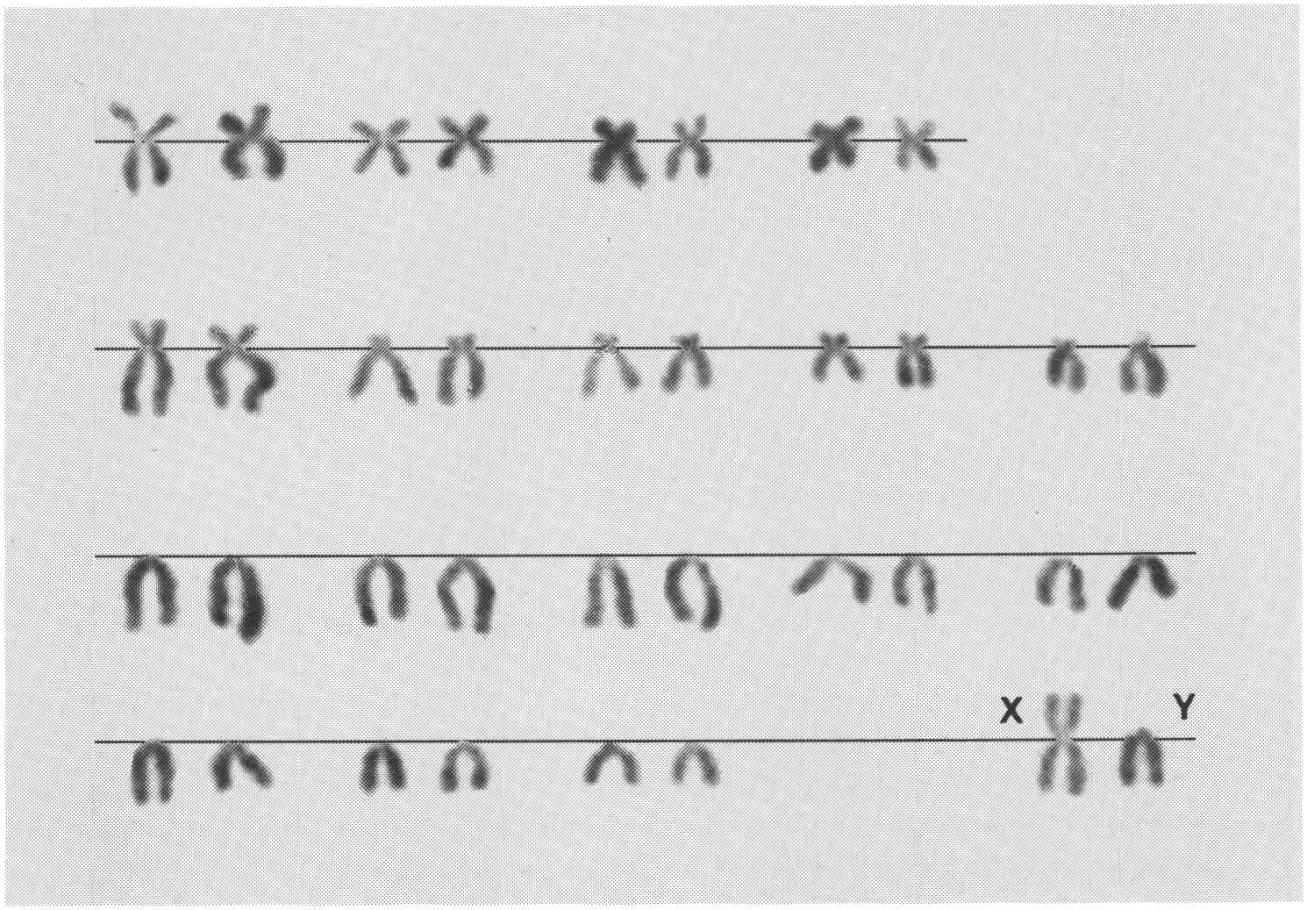

Figure 2. –Karyotype of shrew (♂ IZEA 2944) from Isnello (Sicily).

Karyotype

Chromosome morphology could be studied in male N° IZEA 2944, which showed many good metaphasic spreads. The karyotype (fig. 2) has four pairs of metacentric chromosomes, five pairs of submetacentric or subtelocentric chromosomes and eight pairs of acrocentric chromosomes. The X chromosome is metacentric, and the Y chromosome seems to be subtelocentric. The karyotype is therefore 2n = 36, NF = 56 and NFa = 52. In the preparation of No IZEA 2942 and 2943, the chromosomes were not well spread. Therefore, the morphology of the elements could not be verified in detail, but the diploid number matches that of the male.

DISCUSSION

Confirmed by chromosomal studies (reviewed by REUMER and MEYLAN 1986), the following shrews of the genus *Crocidura* are currently recognized in Europe: *C. russula* 2n = 42, *C. suaveolens* 2n = 40, *C. zimmermanni* 2n = 34 and *C. leucodon* 2n = 28. The karyotype presented here is not comparable to any of these chromosome complements and it cannot be explained as the expression of an intraspecific polymorphism of any of these species. In conclusion, the three specimens analyzed from Sicily provide evidence for the existence of a fifth European species of the genus *Crocidura*.

However, the karyotype is only new for Europe. The shrew recently discovered on the Canary Islands (MARTIN *et al.* 1984) and at first sight interpreted as *C. russula*, also presents a karyotype of 2n = 36 (HUTTERER *et al.* 1987). This characteristic, among others, has been used for the description of this species under the name of *C. canariensis* Hutterer, Lopez-Jurado and Vogel, 1987. Since then, another similar karyotype has been found in a shrew from Burundi (T. MADDALENA, pers. comm.). The similarity of the three karyotypes with exactly the same morphology of the chromosomes implies a closer phylogenetic relationship. The large geographic distances which separate the three localities, as well as the morphological differences, do not suggest conspecificity. A biochemical comparison of the three populations (MADDALENA *et al.* in prep.) should help to clarify this problem.

The question of denomination still remains to be resolved and, in doing so, the rather complicated historical facts should be considered. MILLER (1901), who had two specimens from Sicily, described them as two different species: *C. sicula*, based on the specimen with a short tail (32 mm), and a small skull, and *C. caudata* with a long tail (52 mm) and a larger skull. Later on, only shrews with short tails were found and consequently attributed to *sicula* (e.g. MILLER 1912), a taxon which was, after the publication of WETTSTEIN (1925), considered a subspecies of *C. leucodon*. The review of VESMANIS (1976) not only gives a summary of the succeeding interpretations, but shows

that, of all known material, only the type from Palermo and a specimen from Siracusa found by B. Hagen, can, in fact, be attributed to *sicula*, which he considers a valid species. However, he does not totally exclude the possibility that *sicula* belongs to *C. suaveolens* which occurs on the small offshore island of Sicily (I. VESMANIS *in litt.*), interpretation which was also adopted by HUTTERER (1981). Consequently, following VESMANIS, all known material of the common species must be attributed to *C. caudata*, even if the mean tail length of 15 individuals is 35.7 mm (range: 28 - 42 mm). Obviously, the measurement of the type´s tail was erronneous (VESMANIS 1976).

Based on morphological observations and craniometrical data, VESMANIS relegated *caudata* to synonymy with *C. russula*.

Considering all these facts or interpretations and awaiting the possibility of inspecting the type material described by Miller, and deposited in the National Museum of Natural History, Washington, I would provisionally group our shrews with *C. caudata*, Miller, 1901, which is now defined by a karyotype of 2n = 36. As the derivatio nominis is based on a problematic character, I propose to call this locally common species the "Sicilian shrew" in English, "Toporagno di Sicilia" in Italian, "Musaraigne de Sicile" in French, and "Sizilienspitzmaus" in German.

The existence of a European shrew, of which the biogeographic origin might be the Ethiopian region raises the question of initial colonization and ensuring survival. If the survival of endemic species in Crete was favoured by its distance from the mainland which protected this island from the northern elements during the Pleistocene (VOGEL *et al.* 1986), then Corsica, Sardinia and perhaps Sicily, have on the contrary, been invaded by Pleistocene species such as *Tyrrhenicola* (Arvicolidae) and *Nesiotites* (Soricinae). Upon their arrival, they eliminated older elements and, later on, they in turn, were eliminated by other new-comers. Sicily is separated from the mainland by a distance of only 3 km, and has therefore actually a richer mammalian fauna than Corsica and Sardinia (CHEYLAN 1984).

The modern concept on the origin of the recent mammalian fauna of Mediterranean islands, is largely based on anthropic introductions (ALCOVER *et al.* 1981, VIGNE 1982, CHEYLAN 1984, VIGNE and ALCOVER 1985). Accordingly, POITEVIN (1984) et POITEVIN *et al.* (1986) state that all recent *Crocidura* on western Mediterranean islands belong either to *C. russula* or *C. suaveolens* and have been introduced by man. However, the endemic shrew of Crete (REUMER 1986, VOGEL 1986) and the shrew of Sicily show that the situation is more complex and merits further investigation. In order to increase our knowledge of the history of island colonization by mammals, karyological studies should focus on the following shrews: the presumed *C. leucodon* from Calabria and Monte Gargano (WITTE 1964), *C. russula* from Pantelleria (CONTOLI and AMORI 1986), *C. russula* or *C. suaveolens* from Malta (STORCH 1970, VESMANIS and VESMANIS 1981), *C. whitakeri* from North Africa and *C. tarfayaensis* from the south of Morocco. Moreover, it is time to reconsider now the distinctive characteristics and biometrics of the

skull, taking into account not only the three classical European species of the genus *Crocidura*, but all five.

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REFERENCES

ALCOVER J.A., MOYA-SOLA S. and PONS-MOYA J., 1981. Les Quimeres del Passat. Els Vertebrats fossils del Plio-quaternari de les Balears i Pitiüses. Ed. Moll, Mallorca, 260 p.

AYALA F.J., TRACEY M.L., HEDGECOCK D. and RICHMOND R.C., 1974. Genetic differentiation during the speciation process in Drosophila. *Evolution 28:* 576-592.

BAKER R.J., HAIDUK M.W., ROBBINS L.W., CADENA A. and KOOP B.F., 1982. Chromosomal studies of South American bats and their systematic implications. *Special Publ. Pymatuning Lab. Ecol. 6:* 303-327.

CATALAN J. and POITEVIN F., 1981. Les Crocidures du Midi de la France: leurs caractéristiques génétiques et morphologiques; la place des populations corses. *C. R. Acad. Sc. Paris, Série III. 292:* 1017-1020.

CATALISANO A. and MASSA B., 1987. Considerations on the structure of the diet of the barn owl (*Tyto alba*) in Sicily (Italy). *Boll. Zool. 54:* 69-73.

CATZEFLIS F., 1983a. Relations génétiques entre trois espèces du genre *Crocidura* (Soricidae, Mammalia) en Europe, *Mammalia. 47:* 229-236.

CATZEFLIS F., 1983b. Analyse cytologique et biochimiques des Crocidures de l´île de Chypre (Mammalia, Insectivora). *Rev. suiss. Zool. 90:* 407-415.

CATZEFLIS F., MADDALENA T., HELLWING S. and VOGEL P., 1985. Unexpected findings on the taxonomic status of East Mediterranean *Crocidura russula auct.* (Mammalia, Insectivora). *Z. Säugetierkunde 50:* 185 -201.

CHEYLAN G., 1984. Les mammifères des îles de Provence et de Méditerranée occidentale: un exemple de peuplement insulaire non équilibré ? *Rev. Ecol. (Terre Vie). 39:* 37-54.

CONTOLI L. and AMORI G., 1986. First record of a live *Crocidura* (Mammalia, Insectivora) from Pantelleria Island, Italy. *Acta theriol. 31:* 343-347.

CORBET G. B., 1978. The Mammals of the Palaearctic Region: a taxonomic review. British Museum (Natural History), Cornell University Press, London.

CORBET G. B. and OVENDEN D. 1980. Mammals of Britain and Europe. Collins, London.

ELLERMAN J. R. and MORRISON-SCOTT T. C. S. 1966. Checklist of Palearctic and Indian mammals 1758 to 1946. 2 ed. London.

HAGEN B., 1954. Zur Kleinsäugerfauna Siziliens. *Bonn. zool. Beitr. 5:* 1-15.

HUTTERER R., 1981. Der Status von *Crocidura ariadne* Pieper, 1979 (Mammalia: Soricidae). *Bonn. zool. Beitr. 32:* 3-12.

HUTTERER R., LOPEZ–JURADO L. F. and VOGEL P. 1987. The shrews of the eastern Canary Islands: a new species (Mammalia: Soricidae). *J. Nat. Hist. 21:* 1347-1357.

JENKINS P. D., 1976. Variation in Eurasian shrews of the genus *Crocidura* (Insectivora: Soricidae). *Bull. Brit. Mus. (Nat. Hist.), Zool. 30:* 271-309.

MATTHEY R., 1973. The chromosome formulae of eutherian mammals. In: Cytotaxonomy and vertebrate evolution. Ed. A. B. Chiarelli and E. Capanna. Academic Press, London: 531-616.

MILLER G. S., 1901. Five new shrews from Europe. *Proc. biol. Soc. Wash. 14:* 41 - 45.

MILLER G. S., 1912. Catalogue of the mammals of Western Europe (Europe exclusive of Russia). Brit. Mus. Nat. Hist., London, 1 repr. 1966.

POITEVIN F., 1984. Biogéographie et écologie des Crocidures méditerranéennes (Insectivora, Soricidés) Crocidura russula (Hermann, 1780) et Crocidura suaveolens (Pallas, 1811). Importance de la compétition interspécifique dans la compréhension de leur distributions. Thèse, Univ. Sci. Techn. Languedoc, Montpellier.

POITEVIN F., CATALAN J., FONS R., and CROSET H., 1986. Biologie évolutive des populations ouest-européennes de Crocidures. 1.- Critères d´identification et répartition biogéographique de *Crocidura russula* (Hermann, 1780) et *Crocidura suaveolens* (Pallas, 1811). *Rev. Ecol. (Terre Vie). 41:* 299-314.

REUMER J.W.F., 1986. Notes on the Soricidae (Insectivora Mammalia) from Crete. I. The Pleistocene species *Crocidura zimmermanni. Bonn. zool. Beitr. 37:* 161-171.

REUMER J.W.F. and MEYLAN A., 1986. New developments in vertebrate cytotaxonomy IX*, Chromosome numbers in the order Insectivora (Mammalia). *Genetica 70:* 119-151.

RICHTER H., 1970. Zur Taxonomie und Verbreitung der palaearktischen Crociduren (Mammalia, Insectivora, Soricidae). *Zool. Abh. staatl. Mus. Tierkde. Dresden 31:* 293 -304.

STORCH G., 1970. Holozäne Kleinsäugerfauna aus der Ghar Dalam-Höhle, Malta (Mammalia: Insectivora, Chiroptera, Rodentia). *Senkenbergiana biol. 51:* 135-145.

VESMANIS I., 1976. Beitrag zur Kenntnis der Crociduren-Fauna Siziliens (Mammalia: Insectivora) *Z. Säugetierkunde 41:* 257-273.

VESMANIS I. and VESMANIS A., 1981. Zum Vorkommen der Gartenspitzmaus, *Crocidura suaveolens* (Pallas, 1811), auf der Mittelmeerinsel Capraja (Italien). *Zool. Abh. Mus. Tierk. Dresden, 38:* 83-93.

VIGNE J. D., 1982. Nouvelles données sur le peuplement de la Corse par les Rongeurs subactuels et actuels. *Mammalia. 46:* 261-264.

VIGNE J. D. and ALCOVER J. A., 1985. Incidence des relations historiques entre l´homme et l´animal dans la composition actuelle du peuplement amphibien, reptilien et mammalien des îles de méditerranée occidentale. 110e Congrès national des Sociétés savantes, Montpellier, 1985, sciences, fasc. II: 79-91.

VOGEL P., 1986. Der Karyotyp der Kretaspitzmaus, *Crocidura zimmermanni* Wettstein, 1953 (Mammalia, Insectivora). *Bonn. zool. Beitr., 37:* 35-38.

VOGEL P., MADDALENA T. and CATZEFLIS F. 1986. A contribution to the taxonomy and ecology of shrews from Crete and Turkey (*Crocidura zimmermanni* and *C. suaveolens*). *Acta theriol. 31:* 537-545.

WETTSTEIN O. von, 1925. Beiträge zur Säugetierkunde Europas I. *Arch. Naturgesch. (A). 91:* 139-163.

WETTSTEIN O. von, 1953. Die Insectivora von Kreta. *Z. Säugetierkunde 17:* 4-13.

WITTE G., 1964. Systematik der Insektenfresser des Monte Gargano Gebietes (Italien). *Bonn. zool. Beitr. 15:* 1-35.

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