CYTOTAXONOMY OF SHREWS OF THE GENUS CROCIDURA FROM MEDITERRANEAN ISLANDS

P Vogel, T Maddalena, P J Schembri

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INTRODUCTION

According to the list compiled by Ellerman and Morrison-Scott (1966), 27 species of the genus Crocidura have been described from Europe. Most of these are local forms and modern taxonomists like Jenkins (1976) and Corbet (1978) recognize only three valid species: *C. leucodon*, *C. russula* and *C. suaveolens*. This discrepancy is due to the fact that these species are morphologically very similar whereas intraspecific variability is rather high. The taxonomic assignment of island populations is particularly problematic as morphology is strongly affected by genetic isolation and the particular selective pressures of island environments. The history of the taxonomic interpretation of the shrews of Crete provides a good illustration (Table 1).

When morphological interpretations remain uncertain, other techniques are needed. One of the most effective is determination of the karyotype, which, in the genus Crocidura, is very different between species, but shows minimal intraspecific variation (Reumer and Meylan 1986). As the three continental species of Crocidura have distinct karyotypes (Fig. 1), this method was systematically applied to island populations in an effort to resolve their taxonomy. The results of these studies have been published in many scattered publications and it is useful therefore to present a synthetic review. Four of the five European species here recognized are documented with pictures of the living animals (Fig. 2). A map of the Mediterranean region showing the geographical

### Table I. – The history of the taxonomic interpretation of the shrews of Crete based on morphological analyses.

<table>
<thead>
<tr>
<th>Author</th>
<th>Lowland form</th>
<th>Mountain form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller 1909</td>
<td><em>C. cannea</em></td>
<td></td>
</tr>
<tr>
<td>Bace 1913</td>
<td><em>C. (russula) cannea</em></td>
<td></td>
</tr>
<tr>
<td>Nettstein 1953</td>
<td><em>C. russula cannea</em></td>
<td><em>C. russula zimmermann</em></td>
</tr>
<tr>
<td>Richter 1970</td>
<td><em>C. gueldenstaedtii</em></td>
<td><em>C. suaveolens</em></td>
</tr>
<tr>
<td>Vannini &amp; Rahmann (1978)</td>
<td><em>C. gueldenstaedtii</em></td>
<td><em>C. zimmermann</em></td>
</tr>
<tr>
<td>Rutterer 1981</td>
<td><em>C. suaveolens</em></td>
<td><em>C. russula zimmermann</em></td>
</tr>
</tbody>
</table>
Fig. 1. - Karyotypes of the European species of the genus Crocidura. NF is the number of chromosome arms in the female.

<table>
<thead>
<tr>
<th>Species</th>
<th>Karyotype</th>
<th>NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. zimmermanni</td>
<td></td>
<td>44</td>
</tr>
<tr>
<td>C. russula</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>C. suaveolens</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>C. sicula</td>
<td></td>
<td>56</td>
</tr>
<tr>
<td>C. leucodon</td>
<td></td>
<td>56</td>
</tr>
</tbody>
</table>

Fig. 2. - A. C. russula (from Switzerland), B. C. suaveolens (from Corsica), C. C. sicula (from Gozo), D. C. leucodon (from Georgia, USSR). No photographs of living C. zimmermanni exist.
distribution of the karyologically determined populations is also given (Fig. 3).

MATERIAL AND METHODS

The source of the material which served for chromosomal analysis (carried out either in Lausanne or in Montpellier) is as follows: Corsica: R. Fons (Banyuls, F); Crete: M. Geiger & P. Vogel (Lausanne, CH); Cyprus and Lesbos: F. Catzeflis & C. Doerig (Lausanne); Gozo: P.J. Schembri, M. Borg (Malta) & P. Vogel (Lausanne); Ibiza and Minorca: F. Poitevin (Montpellier, F); Sardinia: A. Geraets & R. Hutterer (Bonn, D.); Sicily: P. Vogel (Lausanne).

In some cases the karyotypes were prepared directly in the field. Two techniques were employed, either the squash method using fragments of the spleen (Meylan 1967) or the air-drying technique using bone marrow (Baker et al. 1982). In order to study other parameters from the same shrews, laboratory breeding populations were established when possible.

DISTRIBUTION OF THE SPECIES

**Crocidura leucodon** (Herman, 1780)

Bicoloured white-toothed shrew. This shrew may occur on Lesbos, Greece (two specimens assigned by Ondrias, 1969, to *C. lasiura*), but Catzeflis et al. (1985) found only *C. suaveolens* on this island. According to an analysis of owl pellets by F. Poitevin (pers. comm.) two species may occur on Lesbos.

**Crocidura russula** (Hermann, 1780)

Greater white-toothed shrew. According to Jenkins (1976) and Corbet (1978), this species occurs from the Near East (Israel, Turkey), through Middle and South Europe, to North Africa. By means of cytotaxonomy it was possible to show its absence south of the Alps (Meylan and Hausser 1974) and to demonstrate that the populations from eastern Europe and the Near East assigned to this species in fact all belong to *C. suaveolens* (Catzeflis et al. 1985). Thus the continental distribution of *C. russula* is limited to parts of Central and southwestern Europe, as well as to North Africa, its probable place of origin (Catzeeflis 1984, Vogel and Maddalena 1987). On Mediterranean islands *C. russula* occurs only on Sardinia (Catzeflis 1983) and Ibiza (Catalan et al. 1988). According to Sans-Coma et al. (1985) and Vigne and Alcover (1985) it was introduced during historical times.

**Crocidura suaveolens** (Pallas, 1811)

Lesser white-toothed shrew. This species originates in Asia (Catzeeflis 1984) but now occupies a wide distributional range from Portugal to Korea (Corbet 1978). In North Africa, *C. whitakeri* was previously considered to be a subspecies of *C.
suaveolens, but this interpretation is no longer accepted (Hutterer 1986, Zerbik-Kowalska 1988). However, Vesmanis (1988) recently assigned one skull of Tunisian origin to C. suaveolens. Because of the uncertain taxonomic value of teeth characters, a cytogenetic investigation of Crocidura of the North African region is needed.

Populations of the Near East still present a taxonomic problem. Russian authors (Gureev 1971, Tembotova 1983, Grafodatskii et al. 1988) consider them as a separate species, C. gueldenstaedtii (Pallas, 1811). Their interpretation is based on morphological variations, whereas the karyotype is absolutely identical to that of C. suaveolens (Catzefflis et al. 1985, Tembotova 1987, Grafodatskii et al. 1988). Considering the interfertility between suaveolens and gueldenstaedtii (Catzefflis et al. 1985), the absence of sympathy (Zaitsev in litt.) and their close biochemical relationship (Maddalena 1990), we include all these populations in the species C. suaveolens.

The presence of C. suaveolens on the following islands was confirmed by cytotaxonomy: Cyprus and Lesbos (Catzefflis 1983, Catzefflis et al. 1985), Corsica (Catalan 1984, Poitevin et al. 1986), Minorca (Catalan et al. 1988), Crete (Vogel et al. 1986). In all cases this species was most probably introduced by man. In the case of Crete this was most probably during the Minoan period, about 1'500 BC (Reumer and Payne 1986). The biochemical similarity of Cretan populations with those from Turkey reveals the origin of this island population (Vogel et al. 1986). On Minorca C. suaveolens arrived about 200 BC (Vigne and Alcover 1985). On Corsica its presence was at first documented only from the Middle Ages (Vigne and Alcover 1985), however new findings provide evidence of a much earlier introduction (Vigne and Marinval-Vigne, in press).

**Crocidura sicula Miller, 1901**

Sicilian shrew. It is only with the cytogenetic analysis of shrews from Sicily (Vogel 1988) and from Gozo that it became clear that all the Crocidura from the Siculo-Maltese archipelago, earlier variously assigned to C. caudata, C. leucodon, C. russula, C. sicula and C. suaveolens, actually belong to the same species, C. sicula (Vogel et al. 1989). Many indications provide convincing arguments that this shrew is a survivor from the Pleistocene (Hutterer, in press). The strong genetical relationship between C. sicula and C. canariensis (Maddalena and Vogel, in press) indicates that these two species are closely related. Their relationship with the so far unkaryotyped North African species needs further investigation.

**Crocidura zimmermanni Wettstein, 1953**

Zimmermann's shrew. This shrew was originally described as a subspecies of C. russula. Based on morphological criteria, Vesmanis and Kahmann (1978) raised this taxon to species rank. The validity of this interpretation was confirmed by the particular karyotype (Vogel 1986). Fossils of this species, together with others of Kritimys, have been found in karst fissures infilled with Pleistocene sediments (Reumer 1986). To day, this shrew is not known from anywhere outside Crete and it is therefore considered endemic to this island. Its numerical dominance in the mountains and its absence in the fertile plains of the island (Vogel et al. 1986, Pieper in press) are probably the consequence of direct competition with the invading C. suaveolens.

**CONCLUSIONS**

Thanks to cytogenetic methods, the systematic status of the shrews of many Mediterranean islands has now been clarified. This has not been without surprising results. In some cases, previous morphological interpretations have been confirmed, e.g. that of Vesmanis and Kahmann (1978) concerning Zimmermann's shrew, at the same time resolving such complex problems as the uncertain interpretation of Miller's type specimens from Sicily. In other cases, previous morphological interpretations have been shown to be wrong as, for example, those of all former authors dealing with the shrews of Gozo. The present state of our knowledge gives a solid basis for further zoogeographical investigations which, sustained by biochemical techniques, can help to determine the genetic relationship between populations and thus, together with palaeontology and archaeology, allow a reconstruction of the exciting history of island colonization.

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