Bonn. zool. Beitr.	Bd. 46	H. 1–4	S. 339–347	Bonn, Juni 1996

The shrews of the genus *Crocidura* on Lesbos, an eastern Mediterranean Island

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Abstract. A new sample of shrews from Lesbos was examinded in order to re-evaluate the contradictory taxonomic conclusions of earlier reports. Based on karyological analyses the syntopic occurrence of *C. leucodon* (2n=28) and *C. suaveolens* (2n=40) is proven. In addition to Crete and Krk, this is a third Mediterranean island with evidence of two sympatric species of the genus *Crocidura*. This situation weakens the hypothesis that competitive exclusion is the explanation why only one species occurs on most islands. Very low probability of island colonization by shrews, exemplified by islands without any *Crodidura*, may account for this situation at least partially.

Key words. Soricidae, chromosomes, zoogeography, competition.

Introduction

The shrews of Mediterranean islands are morphologically so different from the continental populations that for many of them a definitive taxonomical assignment was only possible based on a cytogenetic analysis. All European shrews of the genus *Crocidura* are characterised by a specific karyotype (Vogel et al. 1990), therefore erroneous assignments are practically excluded. Up to now, karyological analyses revealed that with the exception of Crete, all islands seem to be inhabited by only one species of the genus *Crocidura*: *C. russula* (2n=42) occurs on Sardinia (Catzeflis 1983), Ibiza (Catalan 1984, Poitevin et al. 1986) and Pantelleria (Vogel et al. 1992); *C. suaveolens* (2n=40) on Corsica (Catalan & Poitevin 1981, Catalan 1984), Cyprus and Lesbos (Catzeflis 1983, Catzeflis et al. 1985). Menorca (Catalan 1984, Poitevin et al. 1988), and Crete (Vogel 1986); *C. sicula* (2n=36) is an endemic species of Sicily (Vogel 1988) and Gozo (Vogel et al. 1990), and *C. zimmermanni* (2n=38) an endemic species of Crete (Vogel 1986).

This particular biogeographical distribution is the result of historical events (speciation and dispersal) and ecological processes (environmental conditions and interspecific competition). One important point of the history was shown by Alcover (1982) and Vigne & Alcover (1985), who concluded from chronological sequences of remains at archaeological sites that the shrews of the islands were passively introduced by man after the last glaciation (exceptions see Vogel et al. 1990). According to Poitevin et al. (1986, 1987) and Catalan et al. (1988), the almost allopatric distribution of the species is explained by increased competition and mutual exclusion. This could be demonstrated in south European continental populations of *C. russula* and *C. suaveolens*. The former is the more successful competitor in dry, unpredictible environmental conditions, the latter in humid and more stable habitats. This could explain why the more arid Sardinia and Ibiza are occupied by *C. russula*, the more humid Corsica and Menorca by *C. suaveolens* (Catalan et al. 1988). The

only ascertained exception of allopatric distribution is Crete (Vogel et al. 1986) exemplifying the historical aspect as well as the ecological process. The endemic *C. zimmermanni* has been eliminated in the lowlands by *C. suaveolens*, which arrived during the Minoan period (Reumer & Payne 1986). However, in the harsh ecological conditions of the mountains, for which *C. zimmermanni* seems to be well adapted, the endemic shrew is more common than the introduced competitor (Vogel et al. 1986).

In this context the island of Lesbos, for which Niethammer (1989) mentioned two *Crocidura* species, remains a problem. Ondrias (1969) analysed two specimens from this island and assigned them to the Ussuri white-toothed shrew *C. lasiura lasia*. The taxon *lasia* was originally described as a subspecies of the bicoloured white-toothed shrew *C. leucodon lasia* Thomas, 1906 from Trabzon on the Turkish mainland. According to Felten et al. (1973) the author elevated this taxon 1907 to species rank, but Ellermann & Morrison-Scott (1966) listed it as a subsepcies of *C. lasiura*. However, Catzeflis et al. (1985) showed by karyological and enzymatic analyses of shrews from the type locality Trabzon, that *lasia* ist in fact a subspecies of *C. leucodon*, as supposed initially by Thomas (1906). In order to unravel the problem of the shrews of Lesbos, Catzeflis analysed a sample of 11 shrews from Mytilini. With a karyotype of 2n=40 these shrews turned out to belong to *C. suaveolens*. Because ot the general occurrence of only one *Crocidura* species on Mediterranean islands and their high metric variability in the eastern Mediterranean region, Catzeflis et al. (1985) presumed that the specimens of Ondrias (1969) were misidentified. But the identity of the two samples was never confirmed. According to R. Hutterer (pers. comm.) the published measurements of the skulls indicate the existence of two sympatric species on Lesbos. Based on a sample from owl pellets, F. Poitevin (pers. comm.) arrived at the same conclusion. In a synthesis of the taxonomy of the Mediterranean shrews, Vogel et al. (1990) concluded that the situation on Lesbos needs further analysis including karyological techniques. This was done in the present study.

Material and methods

Thirty Longworth traps were set during two nights (8./9. and 10./11. 8. 1990) in Anemotia (Lesbos, Greece) the locality already sampled by Ondrias (1969). The result were 3 relatively small, dark shrews and 4 bigger shrews of contrasting dorsoventral colour. The chromosomes were prepared from bone marrow (Baker et al. 1982) and the karyotype stained with Giemsa an G-banded according to Seabright (1971).

Results

Morphology:

The bigger individuals, with a condylo-basal length of more than 19.0 mm (Table 1), showed a karyotype of 2n=28 (Fig. 1) and thus belong to *C. leucodon*. In accordance with Zima & Král (1984) this karyotype has 3 pairs of metacentrics (No 4, 6, 11), 5 pairs of submentacentris (No 1, 2, 3, 7, 9) and 5 pairs of subtelocentrics (No 5, 8, 10, 12, 13). The X chromosome is a submetacentric, the Y chromosome is a small acrocentric. The banding patterns agree quite well with that reported by Grafodatsky et al. (1987, Fig. 3), with the exception of a possible inversion of the pairs 8/9 and 10/11. The colour of the fur is that of the typical bicoloured white-toothed shrew,

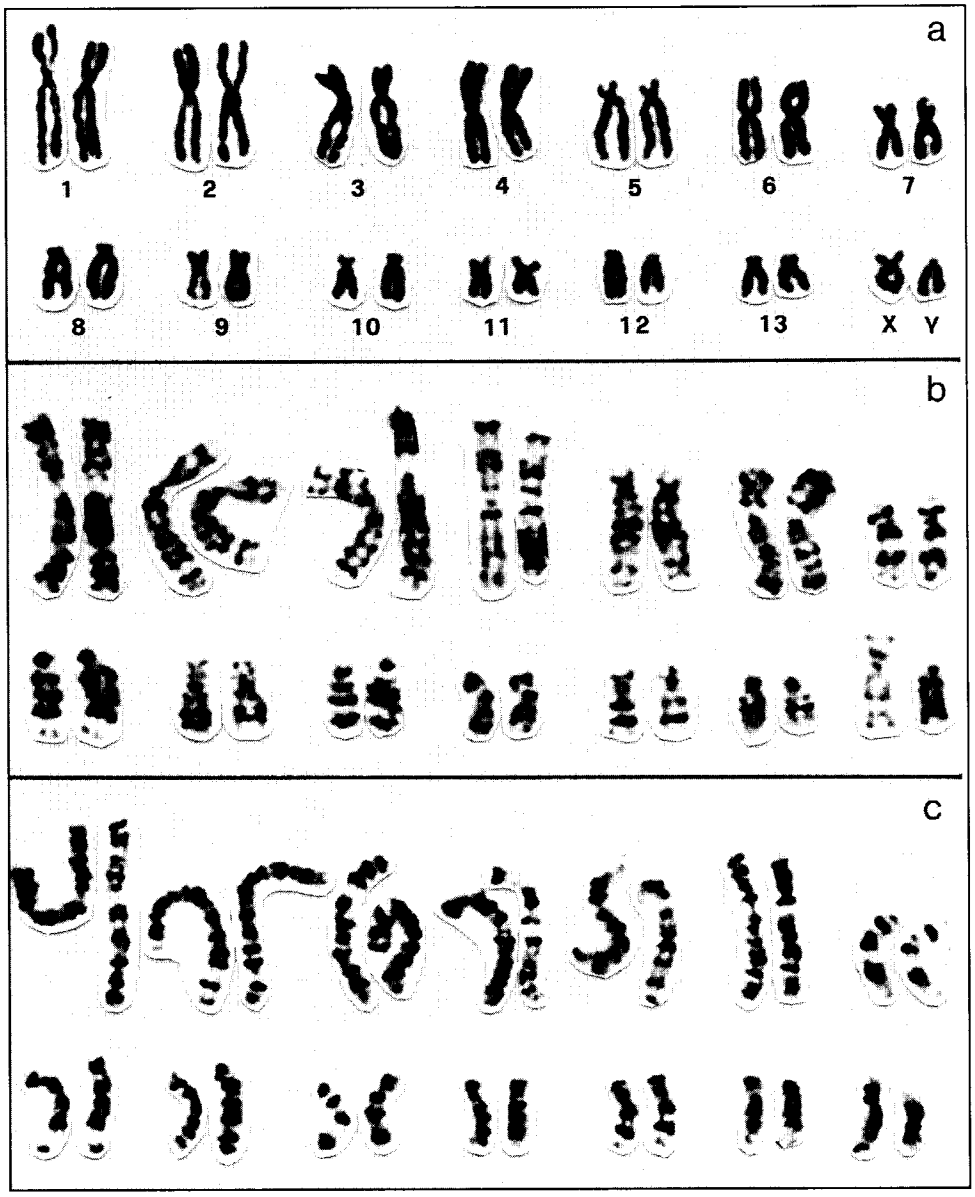

Fig. 1: Karyotype (2n=28) of *C. leucodon* from Lesbos (male, IZEA 3929) presented according to Grafodatsky et al. (1987); a) conventional staining; b, c) G-banding pattern.

dark on the back and very bright on the belly (Fig. 2a, 3). The feet are white. The tail is darker dorsally than ventrally, but not as bicoloured as in the continental form. The smaller shrews, with a condylo-basal length of less than 18 mm (Table 1), showed a karyotype of 2n=40, typical of *C. suaveolens*. The colour is relatively uniform (Fig. 2b, 3).

Ecology:

The village Anemotia, situated at 300 m, lies in a fertile gentle trough between hills (Fig. 4). The traps were set in farm land along hedges separating trails from cultures,

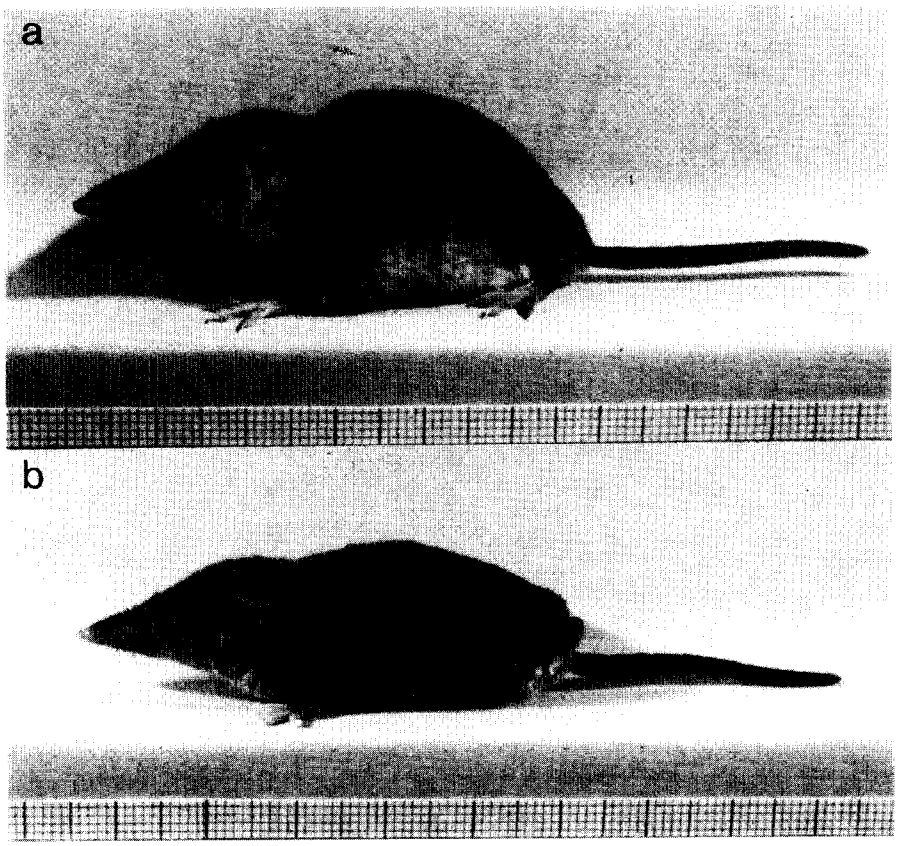

Fig. 2: Shrews from Lesbos: a) *C. leucodon* (IZEA 4153); b) *C. suaveolens* (IZEA 4154).

but also along irrigation pipes, inducing a more luxurious vegetation. In this type of habitat we captured twice both species in neighbouring traps 5 to 10 m apart from each other. Obviously, the two species occur not only in syntopy, but even at a similar frequency (3:4)

Discussion

For the first time our karyological results show unequivocally the occurrence of *C. leucodon* on a Mediterranean island. Moreover, they clearly prove that on the island of Lesbos two *Crocidura* species, *C. leucodon* and *C. suaveolens*, live in syntopy and thus confirm the morphological interpretations of Hutterer (1993) and Poitevin (1994).

Figure 3 and table 1 allow a comparison of our shrews with samples from Turkey and continental Greece. Following Ondrias (1969), *C. leucodon* from Lesbos is as big as *C. leucodon lasia.* But the latter is characterized by a dark belly, dark feet and a monochrome dark tail, whereas the former has a bright belly like the typical form of continental Greece. As regards *C. suaveolens*, the population from Lesbos and from continental Greece (region of Thessaloniki) are similar in size and colour. They are much smaller than the very peculiar Turkish *C. suaveolens monacha.* However, the similarity with the population of the Greek mainland tells nothing about the origin of our island populations, which most probably stem from the close Turkish

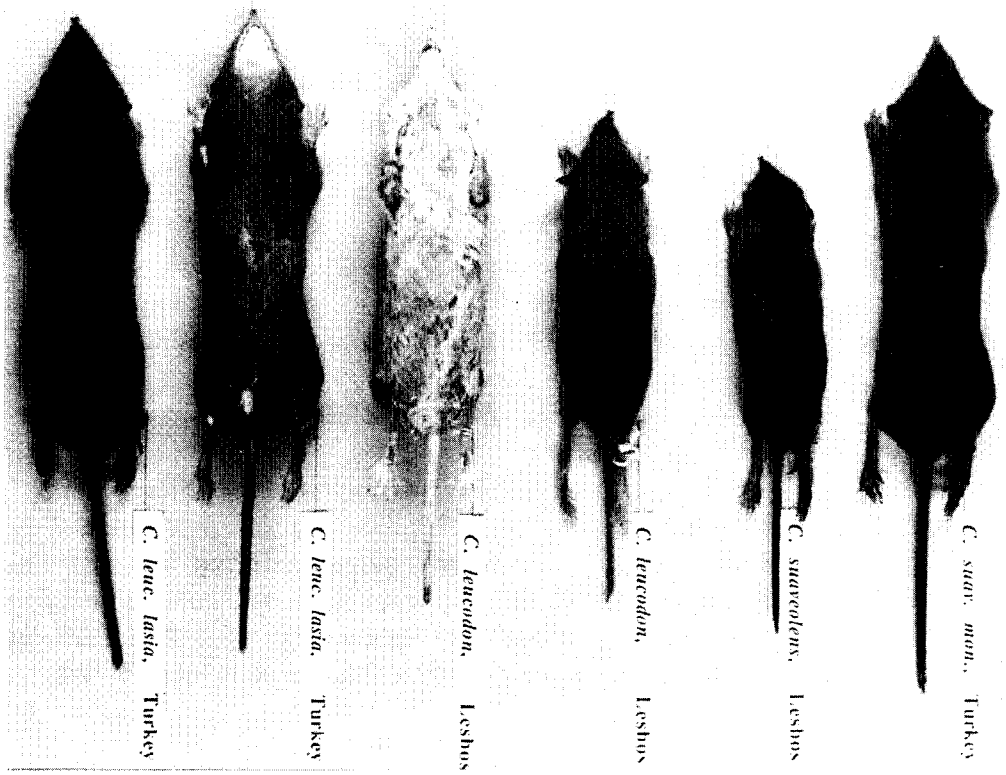

Fig. 3: Comparison of skins of *C. suaveolens* and *C. leucodon* from Lesbos with specimens from continental Greece and Turkey. References according to Table 1 (from left to right: IZEA X1349, X1337, 4153, 3923, 3924, X1321).

Fig. 4: The fertile agricultural landscape of Anemotia (Lesbos) in August.

mainland which is only 10 km away. In Turkey both species are found in different morphological forms which, according to Felten et al. (1973), seem to have a mosaic-like distribution. The comparison of the skins (Fig. 3) clearly shows the intraspecific variation of colour and size in both species and explains the difficulty of taxonomic identification based on morphological characters alone.

The most interesting problem is the question of co-existence of two species on the same island. In Crete, the endemic *C. zimmermanni* and the introduced *C. suaveolens* have occured in sympatry and partial syntopy for at least 3500 years. With Lesbos a second island is known, where two species live in sympatry and synopty. Moreover, *C. suaveolens* and *C. leucodon* seem also to occur on the Yugoslavian island Krk (Trvkovic et al. 1985). Is this fact compatible with the hypothesis of competitive exclusion mentioned in the introduction? Three alternative hypotheses are put forward to explain the present situation:

— The first one postulates that Lesbos was colonized rather recently and simultaneously by the two species, most probably from Turkey. Therefore, the competitive exclusion may work only in the future, perhaps during a severe climatic deterioration which may restrict the ecological conditions and reduce niche width. The island Chios could serve as a model. In an analysis of a Holocene fauna, Besenecker et al. (1972) found fossil remains of *C. suaveolens* and *C. lasia* (= *C.*

Table 1: Some measurements (in g and mm) of shrews from Lesbos. For comparison, samples from Thessaloniki (Epanomi and Gephyra) and *C. suaveolens monacha* and *C. leucodon lasia* from Trabzon (specimens shown in Fig. 3) are also given. Abbreviations: CBL condylobasal length, HB head-body length, HF hindfoot length, TL tail length.

Locality	Species	N°-Coll.	Sex	Mass	HB	TL	HF	CBL
Anemotia/Lesbos	*C. leuc.*	IZEA 3923	m	8.6	72	45	13.0	19.8
Anemotia/Lesbos	*C. leuc.*	IZEA 3939	m	9.1	74	36	13.0	20.3
Anemotia/Lesbos	*C. leuc.*	IZEA 4153	m	13.0	79	43	13.0	20.6
Anemotia/Lesbos	*C. suav.*	IZEA 3924	m	6.0	66	46	12.0	17.8
Anemotia/Lesbos	*C. suav.*	IZEA 3930	m	5.7	62	39	12.0	17.2
Anemotia/Lesbos	*C. suav.*	IZEA 4145	m	7.5	72	44	12.0	17.9
Gephyra - GR	*C. leuc.*	BG - 1941	f	9.0	71	38	12.4	19.2
Gephyra - GR	*C. leuc.*	BG - 1942	f	10.0	73	39	12.4	19.1
Gephyra - GR	*C. leuc.*	BG - 1954	m	11.0	75	41	13.3	20.2
Gephyra - GR	*C. leuc.*	BG - 1965	f	10.0	78	37	12.6	19.0
Gephyra - GR	*C. leuc.*	BG - 1969	f	9.0	80	38	12.8	19.4
Gephyra - GR	*C. leuc.*	BG - 1989	m	9.0	75	40	12.7	19.6
Gephyra - GR	*C. leuc.*	BG - 1990	f	9.0	78	44	12.8	19.6
Epanomi - GR	*C. suav.*	IZEA 3911	f	5.0	65	41	11.0	17.4
Epanomi - GR	*C. suav.*	IZEA 3914	m	6.7	64	42	11.0	17.4
Epanomi - GR	*C. suav.*	IZEA 3916	f	9.0	71	39	11.5	16.9
Epanomi - GR	*C. suav.*	IZEA 3917	m	6.5	66	46	11.0	17.2
Epanomi - GR	*C. suav.*	IZEA 4155	f	8.1	74	44	12.0	17.7
Epanomi - GR	*C. suav.*	IZEA 4156	f	5.3	65	42	11.0	17.1
Trabzon - TR	*C. l. lasia*	IZEA X1337	m	14.0	90	46	14.5	21.1
Trabzon - TR	*C. l. lasia*	IZEA X1349	f	11.6	90	42	13.0	20.1
Trabzon - TR	*C. s. mon.*	IZEA X 1321	m	11.5	87	48	15.0	19.2

leucodon) in the same cave. According to Kock (1974), only *C. suaveolens* lives on Chios at present. This means that we have here one of the rare cases where the extinction of one shrew occurred in the presence of a potential sympatric competitor. However, it cannot be excluded that the lack of recent observations is due to the scarcity of the second species.

— The second hypothesis admits that *C. leucodon* is not in strong competition with the smaller *C. suaveolens* and that a coexistence does not lead to exclusion. Vohralík & Sofianidou (1987) stated for Macedonia: "In the lower altitude we collected it [*C. leucodon*] both on the outskirts of the villages (Lagadas, Lagadikia) and in open landscape (Gephyra), always together with *C. suaveolens* which predominated numerically." In comparison, *C. russula* may be a much stronger competitor, because on the continent, syntopy with other congeneric species rarely occurs and on a local scale, this species is often parapatric with *C. suaveolens* (Niethammer 1979, Poitevin et al. 1986, 1987) or *C. leucodon* (Meylan 1967, Frank 1984).

— As a third hypothesis, it may be possible to explain the monospecific occurrence of *Crocidura* on many Mediterranean islands as a consequence of a stochastic and very low immigration probability. As an example, the island of Mallorca has never been colonized by *Crocidura*, whereas Menorca was colonized by *C. suaveolens*, and Ibiza by *C. russula* (Alcover 1982). If the immigration probability is really very low, then competitive exclusion may play a smaller role in the explanation of the almost exclusive distribution of shrews on Mediterranean islands than formerly suggested.

A final conclusion on the value of these hypotheses will only be possible when we know more about the probability of single and multiple colonizations as well as extinction probability to test deviation from a random distribution of the shrews on Mediterranean islands.

Acknowledgements

We would like to thank Anne-Marie Mehmeti and Patrick Moratal (Lausanne) for technical assistance and V. Vohralík (Prague) for the data of *C. leucodon* from Gephyra. We are also grateful to J. Hausser (Lausanne), R. Hutterer (Bonn), G. Peters (Bonn) and M. Ruedi (Lausanne) for improvements of the manuscript.

Zusammenfassung

Neue Spitzmausfänge von der Insel Lesbos wurden analysiert, um die widersprüchlichen Folgerungen früherer Arbeiten abzuwägen. Dank einer karyologischen Untersuchung kann gezeigt werden, daß *C. leucodon* (2n=28) und *C. suaveolens* (2n=40) syntop vorkommen. Nach Kreta und Krk ist Lesbos somit eine dritte Mittelmeerinsel, die von zwei sympatrischen *Crocidura*-Arten bewohnt ist. Diese Tatsache schwächt die Hypothese vom Konkurrenz-Ausschlußprinzip, mit welcher bisher erklärt wurde, warum auf Mittelmeerinseln in der Regel nur eine *Crocidura*-Art lebt. Inseln wie Mallorca, auf denen bisher keine *Crocidura*-Arten Fuß faßten, zeugen von einer sehr geringen Kolonisationswahrscheinlichkeit, die vermutlich für diese Situation mitverantwortlich sein dürfte.

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