Karyotype and centric dissociation in water vole *Arvicola sapidus* spp. *sapidus* Miller 1908 (Rodentia, Muridae)

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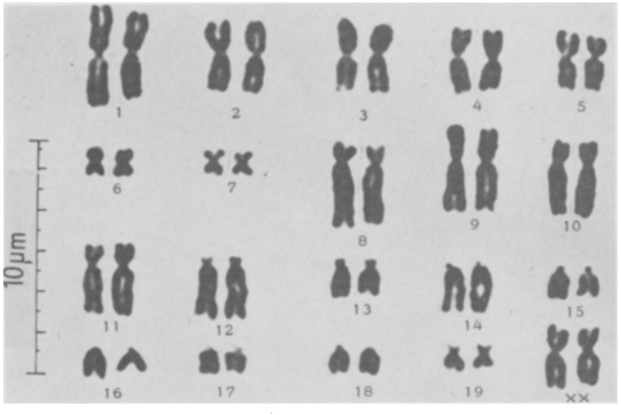
Summary. After being analyzed for the first time with modern techniques, we offer a detailed description of a normal karyotype of the species *Arvicola sapidus* ssp. *sapidus* Miller 1908. A centric fission is described in an individual with abnormal chromosome number (2n = 41).

Chromosomes of the species of genus *Arvicola* have been previously investigated by several workers[1-4]. The species *A. sapidus* was first studied by Matthey[2], although his study makes reference specifically to the subspecies *tenebrosus* and not to the type species *A. sapidus* ssp. *sapidus*. On the other hand, the species *A. sapidus* has not yet been analyzed with modern techniques.

In this paper we give the results of a karyological study performed in 20 water voles (8 males and 12 females). The animals were captured alive in their natural habitats in different localities in the SE of the Iberian Peninsula. Mitotic metaphase plates were obtained by standard bone marrow[5], and male meiosis by air drying techniques[6]. Complete karyotypes from the best plates were constructed, at least 1 for each animal. Chromosomes were classified according to Tjio and Levan[7] criteria. G-banding patterns were produced by Seabright[8] modified procedure.

19 animals displayed chromosome number 2n = 40. The diploid number reported by Matthey[2] for the species was therefore confirmed. 1 individual (male) out of the 20 analyzed displayed an abnormal (2n = 41) chromosome number in all mitotic metaphase plates observed. But the animal was perfectly normal as far as its craneal and body parameters and general behaviour was concerned.

The autosomes of the normal karyotype of *Arvicola sapidus* ssp. *sapidus* are tentatively combined into 5 groups according to their size and centromere position (figure 1). The 1st consists of 5 pairs of long metacentric chromosomes (arm ratio: 1,1), No. 1 being the longest of the set and easily recognizable. The 2nd group consists of 2 pairs (Nos 6 and 7) of rather short metacentrics (arm ratio = 1), No. 7 being SAT. The 3rd consists of 4 pairs (Nos 8–11) of long submetacentrics, Nos 8 and 9 being easily identifiable (arm ratio: 1.6–3.0). The 4th is composed of 2 pairs (Nos 12 and



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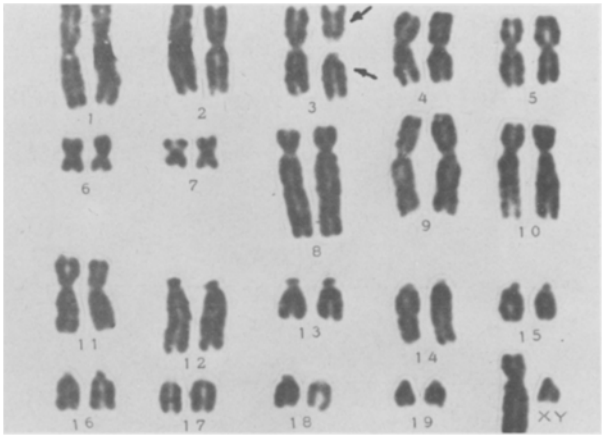

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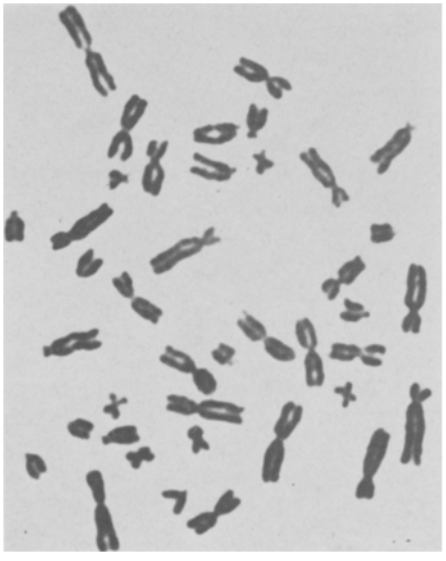

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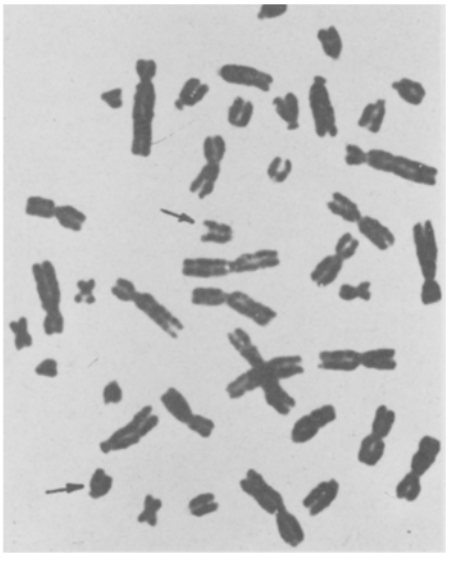

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Arvicola sapidus ssp. *sapidus* Miller 1908.

Fig. 1. Normal karyotype, 2n = 40. Fig. 2. Karyotype of the individual 2n = 41. Dissociated chromosome is indicated by an arrow. Fig. 3. Mitotic metaphase plate (normal 2n = 40). Fig. 4. Mitotic metaphase plate, 2n = 41, with 2 extra acrocentrics.

13) of subtelocentrics. They are very different in size, the 2nd being nearly half the length of the 1st. (Arm ratios: 5.66 and 3.20). Both are easy to recognize. The 5th group consists of 6 pairs of acrocentrics (Nos 14–19). The 19th is easily recognizable as being the longest of this group. X is submetacentric, of a size very similar to that of the chromosome No. 10, impossible to identify with certainty on morphological grounds. Y is acrocentric and the shortest of the complement.

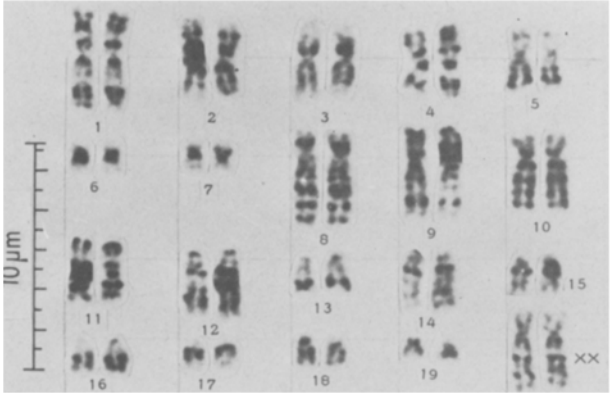
The chromosome set of the unic $2n = 41$ male displays 2 extra acrocentric chromosomes more and 1 long metacentric less, when compared with the chromosome set of the normal ($2n = 40$) individuals.

When the karyotype of this animal was arranged (figure 2), it became evident that the 2 telocentrics roughly corresponded to the 2 arms of a single median chromosome of the pair No. 3. This fact made us think of a centric fission. If the hypothesis of fission is true, a trivalent, formed from a metacentric and its 2 telocentric homologues, would be formed in meiotic metaphase 1. In fact, in 57 nuclei of this individual with well spread chromosomes we always found 18 autosomal bivalents, XY bivalent and 1 trivalent. The latter is a heteromorphic chain of 3, with 2 smaller chromosomes associated 1 on each end of a longer middle chromosome (figure 8). The 2 small chromosomes were not observed to pair with each other directly. In the normal males ($2n = 40$), meiosis was completely regular (figure 7). These displayed at M-1 19 normal autosomal and 1 XY bivalent. The latter forms a linear configuration with terminal association, Y being typically situated perpendicularly to X.

In 50% of the M-1 plates, the trivalent was oriented with the normal chromosome towards one pole and the 2 smaller ones towards the opposite one (figure 8). It was not possible to analyze an A-1 in colchicinized animals, but this particular mode of orientation allows us to infer that in these cells the normal middle chromosome segregates at A-1 from the 2 smaller ones, giving daughter nuclei with 2 small telocentrics, plus 19 normal chromosomes, and 20 chromosomes respectively. If so, both kinds of sperm cells would be viable and result in functional gametes. Linear orientation was observed in the other 50% of meiotic metaphase plates. Disjunction in such cells should give daughter nuclei with deficiencies or duplications of chromosome arms, i.e. to non-functional gametes.

Comparison of a G-banded karyotype of the $2n = 41$ individual with normal ones, throws into relief the correspondance between G-banding patterns of the 2 arms of a single metacentric No. 3 and the 2 extra telocentrics found in the aneuploid (figures 5 and 6). This fact gives additional proof to confirm the hypothesis of fission.

While centric fusion, understood in terms of Robertsonian translocation, has played, a preponderant role in the evolution of a considerable number of animal taxa as is plentiful in literature, the opposite case, i.e. the case of centric dissociation, seems to be extremely rare. Nevertheless, centric fissions are conceptually important as a means for explaining evolution from the lower to higher diploid number. In this process, common in plants[10] and among some Lepidoptera[11], fragmentation of metacentric chromosomes occurs to produce 2 acrocentrics and thereby increase the chromosome number. Marks[10] suggests that fragmentation may arise from transverse and oblique break at certain position at quatripartite centromere. In contrast, White[11] developed a theory according to which fissions usually require the presence of supernumerary chromosomes to provide an additional centromere, and that fission



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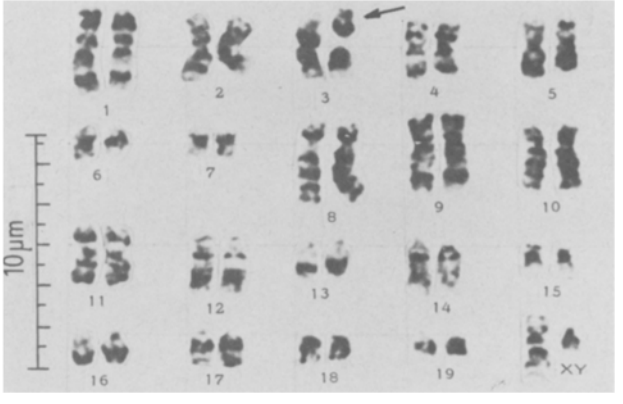

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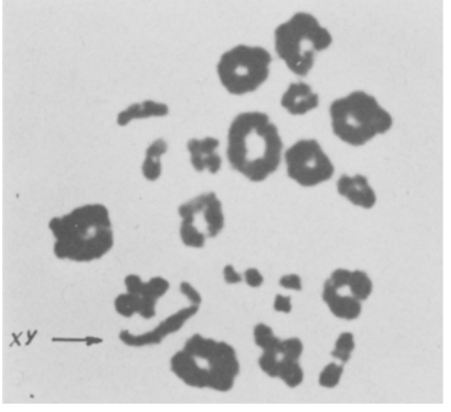

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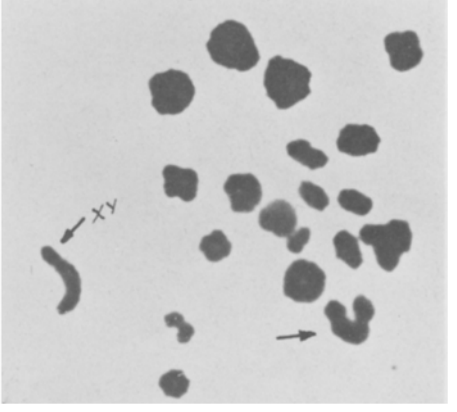

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Fig. 5. G-bands. Normal karyotype, $2n = 40$. Fig. 6. G-bands. $2n = 41$ karyotype. Fig. 7. Normal meiotic metaphase-1 plate with 20 bivalents. Fig. 8. M-1 of the individual $2n = 41$. A trivalent is indicated by an arrow.

thus behaves as reciprocal translocation between a small supernumerary and a metacentric.

The view that telocentrics are unstable in nature[11,12] does not seem to apply necessarily to all telocentrics. Stable telocentrics by centric fission were reported by several workers[13-15].

As far as our case of *A. sapidus* ssp. *sapidus*, $2n = 41$, is concerned, the animal had to be sacrificed to make the bone marrow and testes analyses. Consequently, we were not able to study more closely the behaviour and heredity of these particular telocentrics originated by centric fission.

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Chromosomal translocations in 2 Italian populations of *Reticulitermes lucifugus* (Rossi) (Insecta, Isoptera: Rhinotermitidae)

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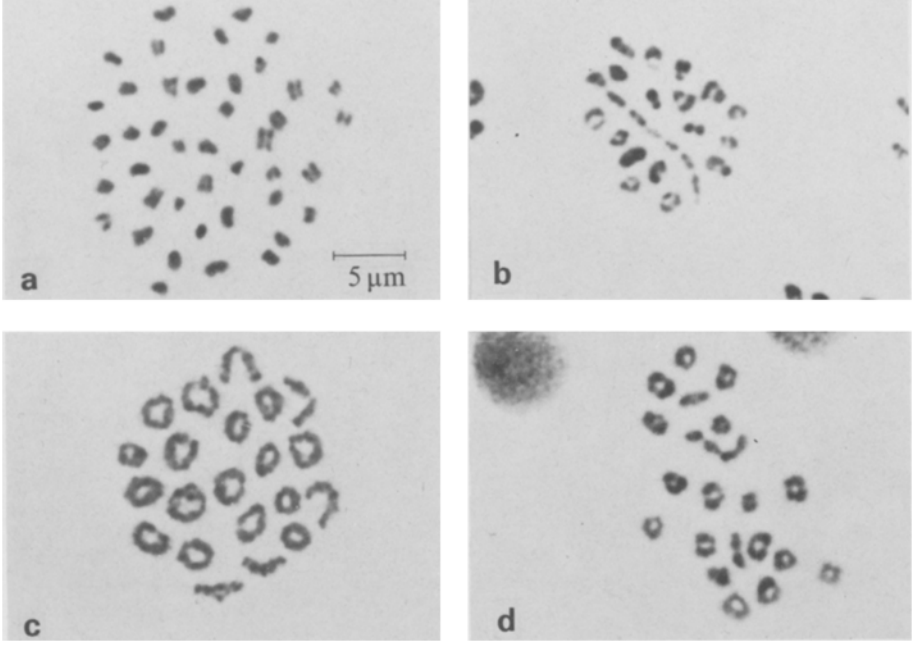
Summary. The chromosomes of 2 Italian populations of *Reticulitermes lucifugus* (Rossi) were studied in both spermatogonial and oogonial divisions. The diploid chromosome complement is $2 = 42$. All the first meiotic metaphases in Sardinian males show a complex translocation arranged in chains of 4 bivalents. The Apulian males show either 21 bivalents or 19 bivalents and a chain of 2.

Reticulitermes lucifugus (Rossi) is ubiquitous over the Mediterranean area, and it is found in almost all regions of Italy[2]. Differences were found among samples collected in Italy, France and Portugal, both in chaetotaxis[3] and in quantitative traits[4]. *R. lucifugus* can be subdivided in geographically isolated subspecies[4]. In the Italian populations primary royal pairs were never found. The colonies are formed by budding or fragmentation of the mother colonies[5], and inbred local populations are very likely. Breeding experiments are difficult with these insects; therefore, we hoped to gain significant information through a cytogenetic approach. In this paper the first results of a cytogenetic investigation on *R. lucifugus* Italian populations are reported.

Material and methods. The Sardinian insects were collected in 1968 and those from Apulia, southern Italy, in 1974 and maintained in the laboratory in wood sticks steeped in moist ground. Supplementary royal individuals were collected as soon as they appeared. Cytological analyses were made on 4 supplementary kings, 2 of which were of 2nd form and 2 of 3rd, and 4 supplementary reproductive queens from Sardinian colonies, and on 6 supplementary kings of 2nd form and 2 supplementary reproductive queens from Apulian colonies. The gonads were dissected



Mitotic and meiotic chromosomes of *R. lucifugus*. *a* Spermatogonial metaphase plate of a Sardinian male. *b* First meiotic metaphase with a linearly orientated chain of 4 bivalents of a Sardinian male. *c* First meiotic metaphase with 21 bivalents in an Apulian male. *d* First meiotic metaphase with a linearly oriented chain of 2 bivalents in an Apulian male.