

Review

Revision of *Sorex araneus* L. chromosome nomenclature, and race N new to Finland

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The original chromosome arm nomenclature of the chromosomal races of *Sorex araneus* L. is based on the Kuhmo (Kuusijoki) population, of Northeastern Finland (Halkka et al. 1974). The North-Finnish and North-Swedish chromosome races have prior to this study been thought to be the same chromosomal race, with racial arm combinations *gm*, *lj*, *hn*, *ip*, *kq* and *or*. We have earlier (1987) cautioned of possible differences in the use of arm symbols *m* and *o* in Finland and the rest of Europe. The International *Sorex araneus* Cytogenetics Committee (ISACC, 1991) has decided to adopt the nomenclature most widespread in Europe, based on the figures of Fredga & Nawrin (1977) from Sweden. Thus, the original Finnish racial nomenclature has to be converted to that suggested by the ISACC. Now, we have found a new chromosome race in Finland from Kilpisjärvi, in the Finnish Lapland. This finding corroborates the racial difference between Northern Finland and Northern Sweden. This race is apparently the same as the race N of Swedish Lapland (S-race N = FIN-race N), with racial arm combinations *gm*, *jl*, *hn*, *ip*, *kq* and *or* (ISACC). The other Finnish races have been converted to the following (ISACC): FIN-race I (Northern Finland): *go*, *jl*, *hn*, *ip*, *kq* and *mr*; FIN-race II (Eastern tip of Finland): *og*, *jl*, *hn*, *ip*, *kr* and *mq*; FIN-race III (Southeastern Finland): *gq*, *jl*, *hk*, *ip*, *mo* and *nr*; FIN-race IV (Central and Southern Finland): *gq*, *jl*, *hn*, *ip*, *ko* and *mr*; FIN-race V (Western coast of Finland): *g*, *k*, *jl*, *ip*, *mq* and *or*; FIN-race VI: (Åland Islands): *jl*, *ip*, *g*, *h*, *k*, *m*, *n*, *o*, *q*, *r*. A revised hypothesis on the evolution cascade in the eastern racial group of *Sorex araneus* L. is presented and discussed.

1. Introduction

Sorex araneus L. is a species with very complex chromosomal polymorphism throughout its Eurasian habitat. The chromosomal polymorphism concerns 12 chromosome arms. On one side it is realized as *internal polymorphism* with differ-

ences in chromosome number and karyotype structure between different individuals of the same population, and even inside the same specimen. This polymorphism depends on the existence of any two given chromosome arms in the form of two telocentric (t) or one metacentric chromosome (m). A diploid cell can be either of

(mm), (tt) or (mt) combination in these given arms. Another aspect of chromosomal polymorphism is *racial polymorphism* in which chromosome arms form different metacentric combinations in different geographical areas. Several tens of different chromosomal races of *Sorex araneus* are known in Eurasia.

The original chromosome arm nomenclature of the chromosomal races of *Sorex araneus* L. is based on the Kuhmo (Kuusijoki) population, of Northeastern Finland (Halkka et al. 1974). The North-Finnish and North-Swedish chromosome races have been earlier thought to be the same chromosomal race (Halkka et al. 1974, 1987, Fredga 1973, Fredga & Nawrin 1977) with racial arm combinations *gm*, *lj*, *hn*, *ip*, *kq* and *or*. European researchers have referred mostly to the figures in Fredga's work. We have earlier (Halkka et al. 1987) warned of possible differences in the use of the arm symbols *m* and *o* in Finland and the rest of Europe. The International *Sorex araneus* Cytogenetics Committee (ISACC, Searle et al. 1991) has decided to adopt the nomenclature most widespread in Europe, based on the figures of Fredga & Nawrin 1977. Thus, the original Finnish racial nomenclature had to be converted to that suggested by the ISACC.

We have found a new Finnish chromosome race from Kilpisjärvi, in Finnish Lapland. This finding corroborates the racial difference between Northern Finland and Northern Sweden. This race is apparently the same as race N of Swedish Lapland (S-race N = FIN-race N), with arm combinations *gm*, *jl*, *hn*, *ip*, *kq* and *or* (ISACC). The other Finnish races have been converted to the following (ISACC): FIN-race I (Northern Finland): *go*, *jl*, *hn*, *ip*, *kq* and *mr*; FIN-race II (Eastern tip of Finland): *og*, *jl*, *hn*, *ip*, *kr* and *mq*; FIN-race III (Southeastern Finland): *gq*, *jl*, *hk*, *ip*, *mo* and *nr*; FIN-race IV (Central and Southern Finland): *gq*, *jl*, *hn*, *ip*, *ko* and *mr*; FIN-race V (Western coast of Finland): *g*, *k*, *jl*, *ip*, *mq* and *or*; FIN-race VI (Åland Islands): *jl*, *ip*, *g*, *h*, *k*, *m*, *n*, *o*, *q*, *r*.

The finding of the difference between the North Swedish and North Finnish races (S-race N ≠ FIN-race I) necessitates changes in the evolution hypothesis through a cascade of reciprocal translocations as well (cf. Halkka et al. 1987). A revised evolution hypothesis in the eastern racial group of *Sorex araneus* L. is presented and dis-



Fig. 1. Location of the northernmost *Sorex araneus* populations in Finland studied cytologically. Numbers (1)-(3) refer to the populations of the Finnish race I studied earlier (cf. Halkka et al. 1987). Populations of the northern race N are Kilpisjärvi (31, new) and Abisko (A, cf. Fredga & Nawrin 1977).

cussed. The Finnish races are now more naturally connected with the East European chromosomal races from Eastern Poland to the Urals (cf. Searle 1984).

2. Material and methods

Between 1989–92, new cytological material of *Sorex araneus* L. (Mammalia, Insectivora, Soricidae) has been collected from Kilpisjärvi, Finnish Lapland (coordinates 69°45'N, 20°45'E). The karyotype has been analyzed and population balance determined from a total of 21 specimens. G-banded chromosome preparations were made from spleen cell suspension as previously described (Halkka et al. 1974, 1987). In a few cases, spleen cell cultures were used (2–3 days in M199 (Gibco) supplemented with 20% Foetal calf serum, 1:100 Pokeweed mitogen (Gibco) and antibiotics.

3. Results and discussion

3.1. FIN-race N from Kilpisjärvi, Finnish Lapland

The specimens of *Sorex araneus* from Kilpisjärvi (Fig. 1, population no 31, FIN-race N, new to

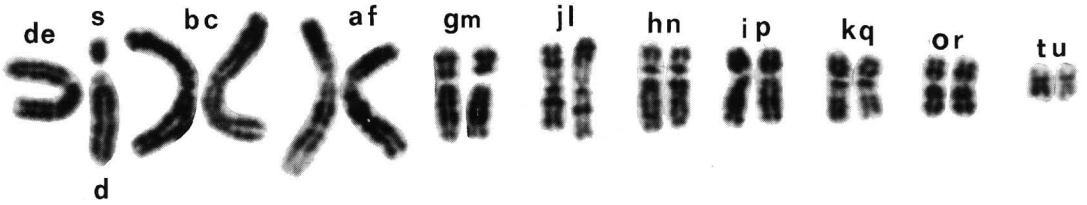


Fig. 2. Karyotype of a specimen (Sx9041) belonging to Kilpisjärvi population (no. 31, race N) with racial marker chromosomes *gm or*. (Please note! The Y2 chromosome is taken from another metaphase of the same specimen).

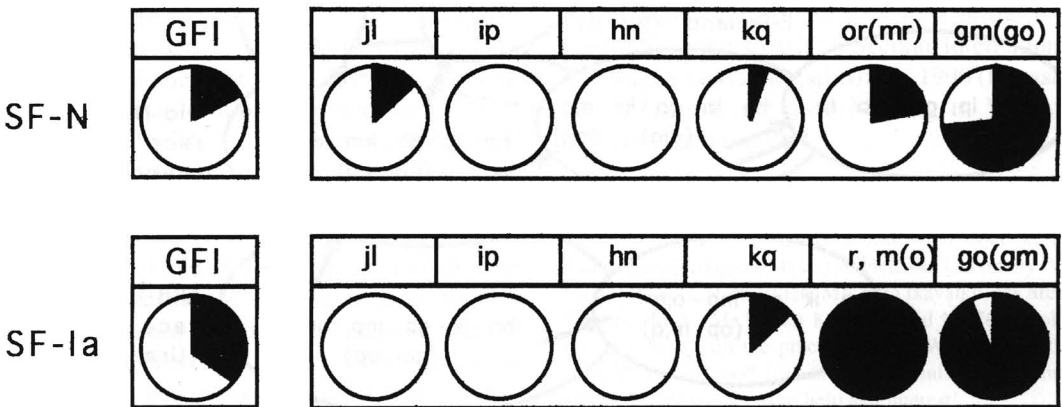


Fig. 3. Relative frequency of metacentrics (white) and telocentrics (black) in the racial gene pool of *Sorex araneus*. GFI (general fission index) shows the frequency of telocentrics (black) in the pool of six arm pairs which are polymorphic in Finland. FIN-N: Kilpisjärvi population (as studied from 11 specimens) and FIN-Ia: the nearest racial area Ia (populations 1, 2, pooled data of 9 specimens). For other Finnish races, cf. Halkka et al. 1987. The arm nomenclature is presented according to the ISACC 1991 (the original Finnish arm nomenclature is in parentheses).

Finland) belong to the morphologically more robust “Ruja” type, which is found along the northernmost coast of Fennoscandia. The robust Ruja-type *S.a. norvegiensis* has been thought to have survived the Ice Age in island refugia along the Norwegian coast (Siivonen 1967). Morphologically pure or at least mixed representants of this type have been found from Kilpisjärvi (Siivonen 1968). A cline in body size and tail length reaches quite far southwards in Finnish Lapland (a lecture held in the Finnish *Sorex* Symposium, Lammi; Hanski & Pankakoski (eds.) 1989).

The Kilpisjärvi population from Finnish Lapland has the racial arm combinations (ISACC): *g/m, j/l, hn, ip, k/q, o/r* (Fig. 2, race N). The Kil-

pisjärvi population belongs cytologically to the same race as the populations of Swedish Lapland (S-race N, eg. the Abisko karyotype, Fredga & Nawrin 1977, Fredga 1982).

In the Kilpisjärvi population, Internal polymorphism is seen in four arm pairs (very low in pair *kq*). Specimens of the Kilpisjärvi population have low chromosome numbers and a high frequency of metacentrics (Fig. 3), what is characteristic of a racial centrum. The nearest Finnish populations of FIN-race Ia have the arms *g, m, o* and *r* almost only in telocentric form. These populations probably represent marginal or buffer populations between the FIN-race N and FIN-race I in Finnish Lapland.

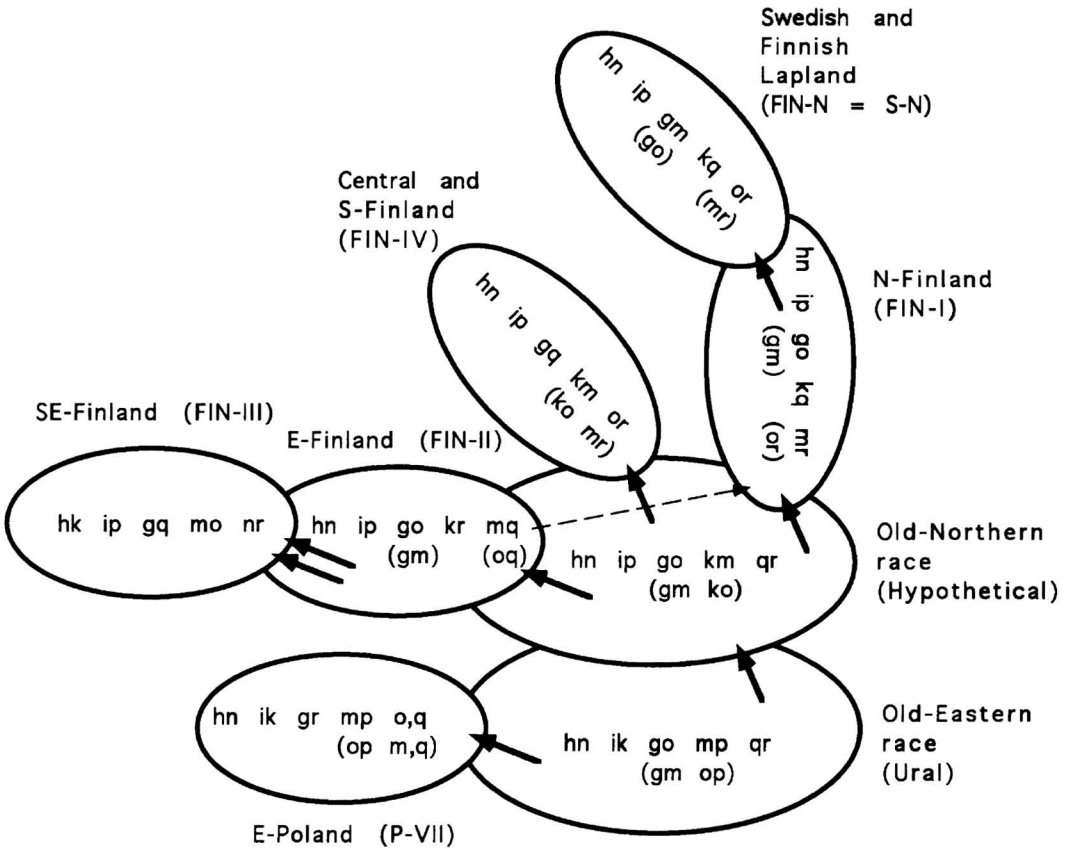


Fig. 4. Eastern translocation cascade. Evolution hypothesis of the East to North European chromosomal races of *Sorex araneus* L. The widespread Old-Eastern race is thought to be the ancestor, from which the other races have evolved during postglacial times. The Old-Northern race is hypothetical. Each pile denotes an evolution step corresponding to one reciprocal translocation or two independent centric fusions between races. Racial arm combinations are presented according to the ISACC 1991 (the original Finnish arm nomenclature in parentheses). FIN = Finland, S = Sweden, P = Poland.

3.2. Revision of arm nomenclature

The history of the chromosome arm nomenclature has been briefly described in the Introduction, and in more detail in the ISACC’s article (Searle et al. 1991). A revised nomenclature for Finnish chromosomal races is presented in Introduction and more detail in Fig. 4.

3.3. Eastern translocation cascade

This last piece of the racial puzzle (FIN-race N from Finnish Lapland) will make the evolutionary picture of *Sorex araneus* L. clearer. The evo-

lution hypothesis of the Finnish chromosomal races presented in Halkka et al. 1987 needs revision. The proposed evolution among the eastern racial group is shown in Fig. 4. The arm combinations of the Finnish chromosomal races and the nearest races belonging to the eastern racial main group are listed both according to the ISACC’s nomenclature (open letters) and according to the Finnish nomenclature (in parentheses).

The Finnish areal and local races (FIN-races I, II, IV and N) are now naturally connected to each other and to the East European chromosomal races through a series of logical steps corresponding to one reciprocal translocation between

two metacentrics, or two independent centric fusions between different races. As a cytological event, each translocation needs two cuts, but two centromeric fusions need four cuts in centromeric areas of the chromosomes. The centromeric mechanism and the translocation cascade hypothesis will be developed further in another studies (e.g. Halkka et al. 1994).

In Fig. 4, each translocation step is indicated by a connecting pile between the ovals representing different races. The Finnish race I (FIN-race I) may have evolved either directly or via race FIN-race II from an Old-Northern race (or arm pool). The same Old-Northern race has given rise to races FIN-race IV and FIN-race II. The FIN-race III does not fit in this series of "one reciprocal translocation between races". It is, however, naturally derived from race FIN-race II through two non-overlapping reciprocal translocations. These races (FIN-race II and FIN-race III) live adjacent to each other in eastern to southeastern Finland. The main centrum of these races lies outside the Finnish area. A possible intermittent race has not yet been found. Race III immigrated later than the other main races via the Karelian peninsula (cf. Halkka et al. 1987).

The logical *translocation cascade* reaches from Poland to the Urals and through Finland to Northern Sweden. Only one hypothetical race (the Old-Northern race) is needed to connect the Northern and Eastern racial groups. A representative of the Old-Eastern race is to be found in Novosibirsk, East of the Urals (Kral et al. 1981, Pack et al. 1993). The widespread (?) Old-Eastern race is most probably the ancestor from which the Eastern Polish and North-European races have evolved during the postglacial period. The Eastern Polish P-race VII (Fedyk 1986) is also only one translocation step away from the Old-Eastern race. Searle (1984) leaves open the position of the Finnish *S. araneus* races between Western and Eastern phylogenetic groups. Knowing the postglacial geological history and migration routes of animals to Finland, we believe that the Finnish *S. araneus* races belong indisputable to the Eastern phylogenetic group (Donner & Eronen 1981, Voipio 1963, Halkka et al. 1987).

The Western and Eastern phylogenetic main groups meet in Poland and form a buffer zone, inside which several mixed or hybrid races have

arisen (Fedyk 1986, Wojcik 1986, 1993). (A corresponding meeting zone is found in Northern Sweden (Fredga & Nawrin 1977, Fredga 1982).

Reviews citing relevant studies on the chromosomal raiation of *Sorex araneus* L. has been lately published by Hausser et al. (1990), Brünner (1991) and Wojcik 1993. Data concerning the Finnish races (Halkka et al. 1974, 1987) are in need of revision which is given in the present study. Searle (1984), Bengtsson & Frykman (1990) and Zima et al. (1988) have reviewed the racial mechanisms more theoretically. The newest findings concerning *Sorex araneus* chromosomal polymorphism are presented in the Proceedings of the ISACC's Second International Meeting in Lausanne and Arzier, 1990 (Hausser, ed. 1991), and the third Meeting in Warsaw, 1993 (forthcoming).

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