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Karyotypic races of the common shrew (*Sorex araneus* L.) from northern Poland

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Summary. Karyotypic races of the common shrew which differed with respect to the combinations of chromosome arms in certain 2-armed autosomes were distinguished in Poland. Two eastern races with the arm combination *ik*, and one western race with the arm combination *hi* in the third pair of autosomes were established. In the contact area of these chromosomal forms, the fourth karyotypic race with the arm combination *hk* was found.
Key words. Shrew; *Sorex araneus;* karyotypic race.

The description of the G-band pattern for the chromosomes of *Sorex araneus* L. greatly facilitated differentiation of particular pairs of chromosomes and comparison of the karyotypes of shrews from different populations. It was found that out of 9 pairs of autosomes in *S. araneus*, 6 exhibit karyotypic polymorphism of the Robertsonian type. Up to the present time descriptions have been given of a large number of karyotypic races in different parts of the range of this species. They are known from England[2], from Sweden and Finland[3,4], from the FRG[5], from Czechoslovakia[6,7], from Switzerland[8] and from Western Siberia[9,10]. Two races have been described from Poland: one in the east and northeast[4,11-13] and the other in the north[13]. Further investigation should yield a more exact understanding of the problem of differentiation in the karyotype of the common shrew in Poland. The results of the first stage of these studies are presented below.

Material and methods. Examination was made of the karyotypes of 21 common shrews caught in six localities in northern Poland in 1984 (table 1, fig. 6). Mitotic chromosome preparations were immediately made on the spot from the spleen by the conventional air-drying technique, and stained with Giemsa. G-bands were obtained by digesting the preparations in 0.25% trypsin solution, using the method of Seabright[14], with some modifications. The chromosomes of all the animals used in this study were examined by means of G-bands. The particular arms of 2-armed chromosomes and 1-armed chromosomes were given letters *a–u*, after Fredga and Nawrin[4].

Results. The karyotypes of the shrews examined differed with respect to the number of autosomes (2- and 1-armed), the occurrence of heterozygous pairs of autosomes and the arm combinations in 2-armed autosomes.

Metacentric pairs of autosomes formed of the following arms: *af, bc, jl, tu* and sex chromosomes were unvarying in the karyotypes of the shrews examined. Chromosome arms indicated by the letters *g-r* (with the exception of the elements *j* and *l*) were subject to variation. Various combinations of these arms were found in the metacentric autosomes of shrews from northern Poland.

Shrews from Popielno were characterized by metacentric autosomes with a combination of chromosome arms *ik, gr, hq* and *mn* (polymorphic pair). The *hq* combination occurred in 2 members of this sample, but in 4 individuals the elements *h* and *q* were not joint and occurred in the form of acrocentrics. Elements *o* and *p*, on the other hand, always occurred as acrocentrics (table 2, fig. 1).

The karyotype of the female caught at Łęgucki Młyn, unlike the preceding, was characterized by the presence of metacentrics *hk* and *io*. In this case also metacentrics were found with the combinations of *gr* (heterozygous pair) and *mn* arms, while only elements *p* and *q* occurred as acrocentrics (fig. 2).

Table 1. Number of animals from localities in northern Poland used for the chromosome studies

No. of locality	Locality	Geographic coordinates of localities	No. of animals studied
1	Popielno	N 53°45′, E 21°37′	6
2	Łęgucki Młyn	N 53°47′, E 20°08′	1
3	Krzewsk	N 54°05′, E 19°28′	1
4	Laska	N 53°55′, E 17°34′	1
5	Słupsk	N 54°29′, E 17°02′	5
6	Stobnica	N 52°42′, E 16°36′	7

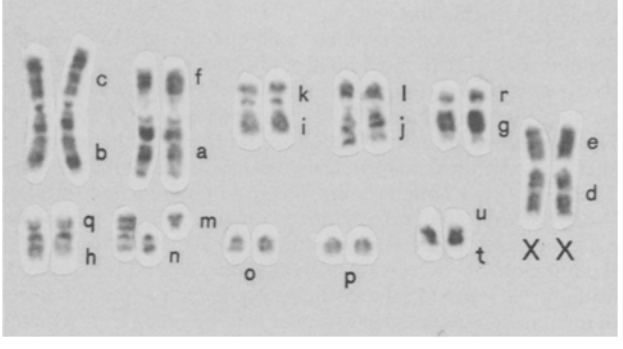

Figure 1. Karyotype of a heterozygous female (2n = 23) from Popielno.

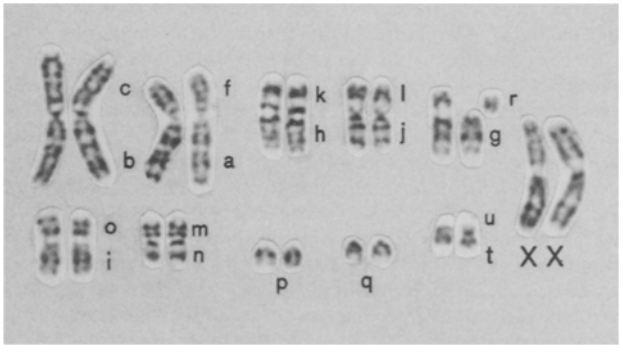

Figure 2. Karyotype of a heterozygous female (2n = 23) from Łęgucki Młyn.

Table 2. Karyotypes of shrews from different localities in northern Poland. Only the autosomes formed from chromosome arms *g-r* have been included in the table. Pairs of 2-armed chromosomes are indicated in format *xy*, while heterozygous pairs (one 2-armed and two 1-armed chromosomes) in format *x/y*, and 1-armed chromosomes are indicated in format *x, y*

Locality	No. and sex of individuals	2N	2Na	Karyotype
Popielno	1♂, 1♀	24, 23	21	ik, jl, gr, hq, m/n, o, p
	3 ♀♀	24	22	ik, jl, gr, mn, h, o, p, q
	1♂	26	23	ik, jl, gr, m/n, h, o, p, q
Łęgucki Młyn	1♀	23	21	hk, jl, g/r, io, mn, p, q
Krzewsk	1♀	27	25	hi, jl, k/o, g, m, n, p, q, r
Laska	1♂	27	24	hi, jl, g/m, k/o, n, p, q, r
Słupsk	2 ♂♂, 2 ♀♀	29, 28	26	hi, jl, g, k, m, n, o, p, q, r
	1 ♀	27	25	hi, jl, g/m, k, n, o, p, q, r
Stobnica	1♂, 2 ♀♀	23, 22	20	hi, jl, gm, ko, np, q, r
	2 ♂♂	24	21	hi, jl, gm, ko, n/p, q, r
	2 ♂♂	25	22	hi, jl, gm, ko, n, p, q, r

Shrews caught in other localities were classified as a separate group. The karyotype of the shrew from Krzewsk was distinguished by metacentrics *hi* and *ko* (heterozygous pair); compare Wójcik and Fedyk[13]. Shrews from Słupsk had *hi* metacentrics, and it was only in one case that a heterozygous pair with combination of *gm* arms was found to be present (table 2, fig. 3). The karyotype of the shrew from Laska had metacentrics with 3-arm combinations *hi, gm* and *ko,* although the combination of *gm* and *ko* occurred in heterozygous pairs (fig. 4). Shrews from Stobnica had these 3 metacentrics, and additionally, in 4 specimens, the arms combination *np* (polymorphic pair) was found. Only arms indicated by *q* and *r* always occurred in the form of acrocentrics (table 2, fig. 5).

Discussion. Two karyotypic races of *S. araneus* from Poland have been described in earlier papers: the 'Białowieża' race[4, 11–13] and the 'Drużno' race[13]. The former, occurring in the eastern and northeastern part of Poland, was allocated by Searle[2] to the East European phylogenetic group, together with the race from Novosibirsk[10]. Shrews from Popielno represent a karyotypic race very similar to the 'Białowieża' race, and should be included in the same phylogenetic group. These 2 races inhabit neighboring areas (fig. 6), and have the same metacentrics *ik* and *gr,* differing only in respect of the combinations of arms in 2 pairs of metacentrics. It could be assumed that those 2 races emerged independently after metacentrics *ik* and *gr* had been formed. This process would be followed separately by further fusions of chromosome arms, giving rise to *hn, mp* and *hq, mn* from Białowieża and Popielno respectively. Another way to explain the formation of the 'Popielno' race could be found also as a result of translocations of chromosome arms in the 'Białowieża' race.

Shrews of the 'Drużno' race[13] and those described in the present paper from Krzewsk, Laska, Słupsk and Stobnica represent another chromosomal form. The karyotypes of these shrews do not differ in respect to arms combinations in metacentrics, but only in respect to the number of acrocentrics and metacentrics. Under this circumstance no additional races should be distinguished, even though considerable differences in the number of autosomes among these populations may sometimes occur. I consider that those shrews represent one polymorphic karyotypic race and I refer to them as the 'western' race. These shrews inhabit neighboring areas (fig. 6), and are probably derived from a common phyletic group. Assuming that the ancestral karyotype of *S. araneus* was of an acrocentric character, and metacentrics formed chiefly as a result of Robertsonian translocations[2], conclusions may be drawn as to the order of formation of metacentrics occurring in the western race, during the expansion of shrews into Polish territory. These metacentrics probably formed in the following order: *hi, gm, ko* and *np*. This assumption agrees with the frequency of occurrence of these combinations of arms in the karyotypes examined.

Chromosomal forms of *S. araneus;* very similar to the western race, have been found in many localities from central and northwestern Europe[2–7]. They are considered to be a natural taxonomic group, and Searle[2] treated them as the 'West European phylogenetic group'. In accordance with this, the western race from Poland should be included in the same phylogenetic group. Probably all the races of the West European phylogenetic group derive from the same refuge during the glacial period, located somewhere in southern Europe[2].

The shrew from Łęgucki Młyn presents a very interesting karyotype characterized by the presence of metacentrics *hk* and *io,* which so far have not been observed in other populations of shrews in Poland. It is difficult to say at present whether the 'Łęgucki Młyn' race was formed independently, or as result of hybridization between eastern and western races, in the contact zone. The second hypothesis is most likely, since this race is surrounded by eastern and western chromosomal forms. There-

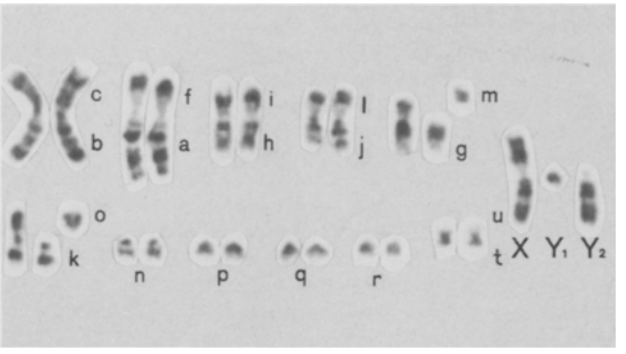

Figure 4. Karyotype of a heterozygous male (2n = 27) from Laska (2 heterozygous pairs).

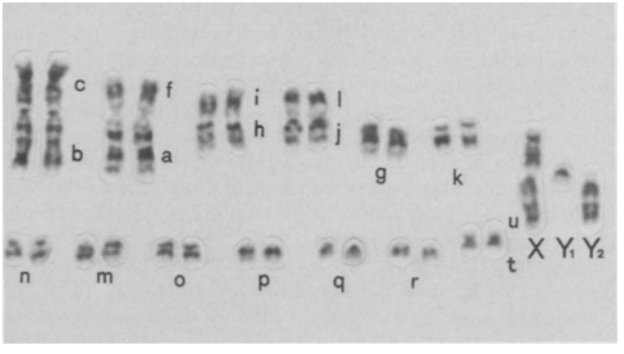

Figure 3. Karyotype of a homozygous male (2n = 29) from Słupsk.

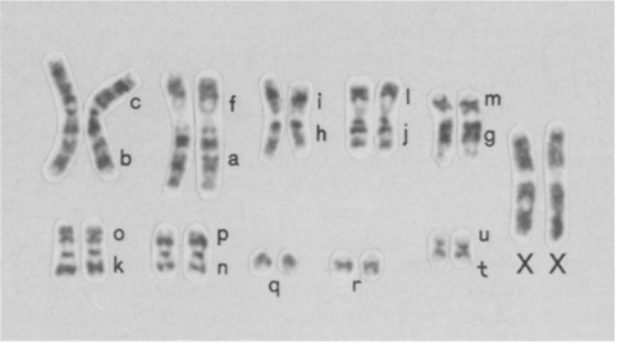

Figure 5. Karyotype of a homozygous female (2n = 22) from Stobnica.

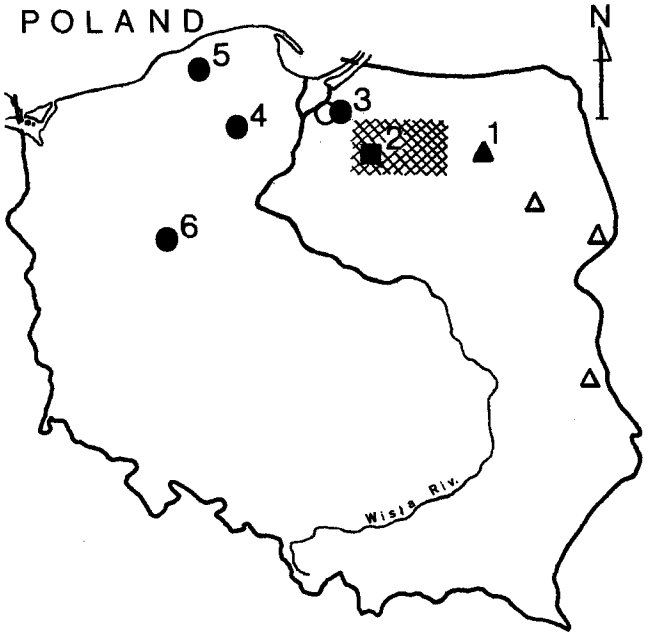

Figure 6. Distribution of karyotypic races of *S. araneus* in Poland. Triangles: eastern races, circles: western race, square: probably a hybrid race, shading: region of contact between the eastern and western races. Open symbols: data from earlier papers[12,13], and closed symbols: present data. Numbers of localities as in table 1.

fore the emergence of the 'Łęgucki Młyn' race can be explained as follows: The first step was the reciprocal translocation of arms in metacentrics *hi* and *ko* from the western race, which resulted in the arms combinations *hk* and *io*. Then the second step would have involved the appearance of the arms combinations *gr* and *mn* as in the 'Popielno' race, as the result of the contact with eastern races.

The foregoing justifies the statement that in northern Poland the contact zone between the eastern and western karyotypic races of *S. araneus* occurs in the region defined by coordinates E 19°30–E 21°30 (fig. 6). Further studies will improve the knowledge of more precise boundaries of this contact zone crossing through Poland. More data gathered by the author, not yet published, suggest that the greater part of Poland is inhabited by shrews of the western race, and only the eastern and north-eastern fringes are occupied by shrews of the eastern races.

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The cloning of more highly productive fungal strains: a factor in the speciation of fungus-growing ants[1]

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Summary. Paired-culture tests and productivity estimates were made on isolates of fungal symbionts from four species of attine ants. No interactions between different isolates in paired-cultures were observed. Significant differences in productivity were recorded between all isolates. A strong correlation was found between fungal productivity and mature colony worker population of the respective symbiotic ant species.
Key words. Ants; Attini; fungi; symbiosis; cloning; productivity; populations; speciation.

The New World myrmicine tribe Attini contains some 190 species in 11 genera which cultivate fungi as a source of larval food. The relationship is one of obligate symbiosis both for ants and fungus. Several features, including mature ant colony size and the material used as substrate for fungus cultivation, suggest an evolutionary trend. Whereas primitive genera with small colonies use insect frass and dead vegetable material, advanced types such as *Acromyrmex* and *Atta*, cut fresh plant material and their colonies may attain vast size[2] and pest status. New attine colonies are established by claustral foundation. Prior to the nuptial flight each gyne secures a sample of mycelium in the infrabuccal pocket[3] and later, as a foundress queen, uses it to establish a new culture. From this, future generations of gynes will in turn derive their own inocula. The fungus cultivated by attines is characterised by the production of small globular bodies known as gongylidia which constitute the principal supply of larval food[4]. Chemical analysis has shown the mycelium to be a nutritious food, rich in amino acids and carbohydrates[5].

The identity of the fungus cultivated by the higher attines remains obscure. It competes poorly with other fungi, and, on the removal of the ants, their cultures are rapidly overrun. Competition from fungal contaminants is eliminated by the secretion of β-hydroxydecanoic acid (myrmicacin) which has been shown to suppress spore germination[6]. Records of taxonomically essential sporophores derived from mycelia associated with advanced attines are few, and their true origins in doubt due to the high probability of contamination and the failure of authors to propagate gongylidia-bearing mycelia from the spores. Most recent authors have chosen to use the name *Attamyces bromatificus* Kreisel. This is based on descriptions of the symbiont of the Cuban *Atta insularis* which in the absence of diagnostic sporophore characters was placed in the Mycelia Sterilia[7]. We have recently[8] examined mycelia from 12 attine species and subspecies