Two Ways of Speciation

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INTRODUCTION

Speciation is a multifactorial process. Causal factors, forming species in space and time, are different. Natural selection and neutralism, genetic drift and isolation, geographical and chromosomal speciation and allopatric and sympatric ways are not exclusive or alternative explanations of evolutionary processes. All these factors, as well as forms and ways of speciation have a distribution in various groups and in various stages of evolution.

It was thought until recently that chromosomal mutations play only a minor role in the process of speciation (Mayr, 1963). Evolution is described as a process of change in allelic frequencies in many textbooks. It was presumed that speciation takes place as a consequence of geographical isolation, and the divergence of isolated populations is explained on the basis of minor mutations or on the basis of the change of allelic frequencies. A system of isolating mechanisms was thought to develop as a barrier only during the final stage of speciation.

In contrast to Mayr's conception of geographical speciation by changes of allelic frequencies in separate populations, the first author of this publication proposed the conception of two pathways of speciation (Vorontsov, 1960):

1) The "traditional" or "ordinary" pathway, which is associated with the gradual accumulation of interpopulational differences and culminates in the development of reproductive isolation;

2) The "genetic" pathway, which starts with the development of reproductive isolation as a consequence of chromosomal rearrangements and culminates in the divergence of allelic frequencies and ecological differences, as well. Chromosomal speciation is a speciation without changes in genetic information - without changes in DNA - but with principal changes in probability of gene flow between forms with similar gene pools but with different chromosomal complements.
Various groups of animals and plants are characterized by the predominance of different speciation mechanisms. Some groups such as frogs among Amphibia, jerboas (Dipodidae), among rodents and most Pinnipedia, for example, are characterized by an amazing uniformity of their chromosome complements. It is obvious that divergence and maintenance of reproductive barriers in these groups is ensured by different, non-chromosomal mechanisms. Frogs, for example, have great differences in sexual songs, jerboas in structure of genitalia, etc. Behavioral, ecological and seasonal isolation plays a special role in the realization of reproductive isolation in many amphibian, bird, pinniped and other groups.

Not all types of chromosomal rearrangements interrupt gene flow between populations with different karyotypes. Differences in the heterochromatic regions of chromosomal sets, such as deletions or duplications of heterochromatic arms of chromosomes, have small isolating effects. Other groups of chromosomal mutations, such as inversions and translocations of euchromatic parts of chromosomes, have great reproductive influence. As a result of such reproductive separation, reproductively isolated populations with different karyotypes and primary identical gene pools initiate diversification not only in chromosomal characters, but also in allelic frequencies.

It is clear now, that chromosomal speciation is very important, but not the only way of evolution. There has been an intensive discussion in the last two decades between gradualists and punctualists. This discussion was stimulated by a publication of Eldredge and Gould (1972). The problem was the subject of a special symposium in Dijon (Chaline, 1983). To resolve the problem by either punctualism or gradualism is an oversimplification. In our earlier (Timoffeef-Ressovsky, Vorontsov and Yablokov, 1969) and recent publications (Vorontsov, 1980, 1987, 1988) it was emphasized that "gradual" ("common") and "explosive" ("punctuated", "sudden") speciation are not mutually exclusive, both forms being observed in evolution. Here, we will present processes of subspeciation by the action of natural selection under isolation as evidence of gradual speciation, and data on sudden speciation based on the chromosomal mechanisms of speciation.