

Bifurcation mechanisms leading to the genetic divergence of two populations coupled by migration

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Key words: genetic divergence, population, mathematical modeling, dynamics, migration, bifurcations

Motivation and Aim: The study of evolution in biological populations has a long and rich history. One of the main problems of such works is devoted to the search for factors leading to primary genetic divergence, microevolution and speciation. This work, based on a mathematical model, studies the bifurcation mechanisms of the emergence of the genetic divergence, i.e. stable genetic differences between two adjacent populations coupled by migration.

Methods and Algorithms: We consider the following simple situation. The populations are panmictic with Mendelian rules of inheritance. The fitness of individuals is strictly determined by a single diallelic locus. We use a dynamic model that describes the change in the concentration of one of the alleles in each population and the ratio (weight) of first population to the total size. To study the model, we used the qualitative theory of differential equations studies.

Results: We showed that the genetic divergence is reached only with reduced fitness of heterozygotes and is the result of the subcritical pitchfork bifurcation (period doubling) of the unstable equilibrium state corresponding to polymorphic populations. In free populations with unlimited growth in numbers, solutions corresponding to the genetic divergence are always unstable and are just a part of the transient process to state corresponding to the monomorphic populations. Genetic divergence is stable only for populations that maintain the ratio of their numbers at a constant level. For example, this is possible for populations with limited or fully synchronous dynamics in adjacent sites. In this case, the divergence is preceded by a saddle-node bifurcation. The dynamic is quad-stable, i.e. depending on the initial conditions, the populations are homogeneous in their genetic structure, or there are significant differences between them [1, 2].

Conclusion: Thus, the appearance of genetic divergence is impossible without a significant ecological limitation of population growth in addition to genetic factors.

Acknowledgements: This study was performed in the framework of the State targets of the Institute of Complex Analysis of Regional Problem FEB RAS

References

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