【Grant-in-Aid for Scientific Research (S)】

Ecological genetics of speciation in natural populations

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Purpose and Background of the Research

●Outline of the Research

Diverse species existing on the earth have arisen through repeated events of speciation. Therefore, speciation is one of the most essential phenomena that life exhibits. In addition, diverse species provide resources for drug discovery and agriculture, and the presence of biodiversity is essential for the sustainability of ecosystem. How does speciation occur in nature? Speciation is the process by which a population divides into two distinct groups and its differentiation is maintained (Figure 1). In this project, we aim at elucidating the speciation process from its initiation to its completion by using various pairs of population/species of stickleback fish (Figure 2). We employ genetic experiments, ecological experiments, and theoretical analysis.

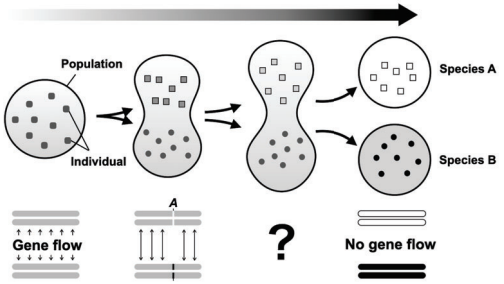

Figure 1. A model of speciation

Figure 2. An example ofsympatric stickleback species pair (upper, *Gasterosteus aculeatus*; lower, *G. nipponicus*).

●Questions to be answered

Populations in contrasting environments, such as marine and freshwater, become differentiated in physiology, behavior, and morphology in order to adapt to different environments. These differences can contribute to the prevention of gene flow between the populations/species (Figure 3). This speciation process is called "ecological speciation". However, it is unclear whether ecological speciation alone can lead to the evolution of intrinsic hybrid abnormality, such as and hybrid sterility, which is generally thought to evolve at the later stage of speciation. Does ecological speciation automatically lead to the evolution of intrinsic hybrid abnormality? Alternatively, is any promoting factor necessary for the completion of speciation?

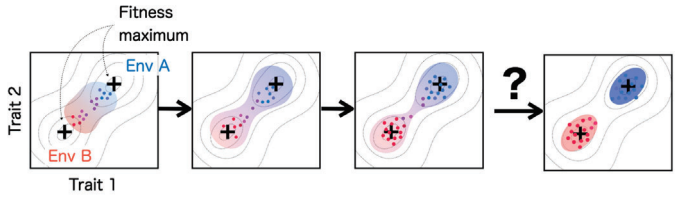

Figure 3. A model of ecological speciation

●Unique study systems

We will use a variety of sympatric and parapatric pairs of divergent population/species of stickleback fish (Figure 4), which we have characterized thus far. We have used genome sequence data to calculate the extent of gene exchange (i.e., gene flow rate) among various population/species pairs. Our results revealed a variety of population/species pairs with varying degrees of gene flow rates (Figure 4). These are referred to as the "speciation continuum". We also found a "tipping point", where the gene flow rate drastically decreased. These systems can help to understand the process of speciation from its initiation to completion.

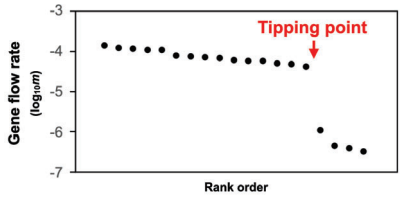

Figure 4. Stickleback speciation continuum

Expected Research Achievements

●Genetic mechanisms

Using linkage analysis, genome-wide association study, population genomic analysis, and genetic manipulation in various stickleback species pairs, we will investigate the genetic basis underlying the prevention of gene flow among populations. Chromosome structure and chromatin analysis will then be conducted to elucidate the relationship between the position of causative genes and chromosome/chromatin structures (Figure 5).

●Ecological mechanisms

Conducting semi-natural ecological experiments, we will investigate the ecological mechanisms that prevent gene flow and test if the speciation is completed (Figure 6). Our goal is to understand what ecological conditions maintain differentiation in the species pairs.

●Theoretical models of speciation

We will conduct theoretical and simulation studies to identify the genetic and ecological factors that promote speciation. Theoretical models will enable comparisons across taxonomic groups and test the generality of our findings

●Possible impacts of the research on human society

Climate changes and human activities are predicted to increase hybridization. Our results may become useful for predicting how species diversity will be maintained under such circumstances. If our research outcome can lead to the development of a technology for making intercrosses between species, it will contribute to the agricultural application.

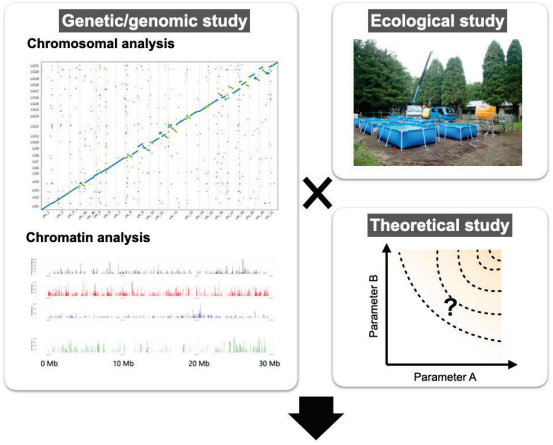

Figure 5. Outline of research

Homepage Address, etc.	http://ecogen.sakura.ne.jp/index-e.html