

Evolution of a quantitative trait in a metapopulation setting: Propagation of chaos meets adaptive dynamics

Amaury LAMBERT, IBENS, CIRB - Paris Hélène LEMAN, CASTING, Inria Lyon & UMPA, ENS Lyon - Lyon Hélène MORLON, IBENS - Paris Josué TCHOUANTI, Lifeware, Inria Saclay - Palaiseau

This talk is about studying the role of migration as a key driver of the evolution of spatially structured populations. To this end, we consider a metapopulation setting where evolutionary processes at the level of each isolated patch is modelled by a Moran model, which describes the evolution of a quantitative trait in a population of fixed size by two main mechanisms : trait resampling and mutations. Migrations are added in order to take into account interactions between patches and the question we would like to answer is : how do these migrations influence the long term evolution of the population at the level of a single patch and at the level of the entire metapopulation ?

For this purpose, we study several scaling limits of the model. Assuming rare mutations and migrations, we adapt a technique from Champagnat & Lambert (2007) in order to get a mean-field network of Trait Substitution Sequence (TSS) describing long-term successive dominant traits in each patch. We derive a propagation of chaos as the metapopulation becomes large. Patches are therefore *i.i.d* copies of each other, with a TSS described by a McKean-Vlasov pure jump process. In the limit where mutations have small effects and migration is further slowed down accordingly, we obtain the convergence of the TSS, in the new migration timescale, to the solution of a stochastic differential equation which can be referred to as a new canonical equation of adaptive dynamics. This equation includes an advection term representing selection, a diffusive term due to genetic drift, and a jump term, representing the effect of migration, to a state distributed according to its own law.

Keywords : Metapopulation \cdot Adaptive dynamics \cdot Moran model \cdot Propagation of chaos \cdot McKean-Vlasov equation \cdot Trait substitution sequence (TSS) \cdot Canonical equation of adaptive dynamics

See the details in Lambert et al. [1]

 A. Lambert, H. Leman, H. Morlon, J. Tchouanti. Evolution of a trait distributed over a large fragmented population : Propagation of chaos meets adaptive dynamics. Preprint https://arxiv.org/abs/2503.13154, 2025.