

Behaviourally Structured Populations are Less Prone to Extinction Under Harsh Environmental Conditions

Sergei V. Petrovskii¹ and Rod P. Blackshaw².

Population persistence under adverse environmental conditions arising from human activity or from natural hazards has become an important issue in contemporary ecology. One of the factors which potentially adds plasticity to a population is the existence of different individual behaviours. There is now considerable evidence that individual behaviours can be considered as fixed although they may be context-specific [1-3].

In our talk, we address the conditions of population persistence under harsh conditions taking into account different behavioural responses between the individuals which have been described as "aggressive" and "paranoid" [1]. We assume that harsh conditions are linked to habitat fragmentation so that the conditions are favorable inside the fragmented habitats but essentially unfavorable in the rest of the environment which results in a much higher mortality rate. We also assume that inside the habitat there is a direct agonistic interaction between the individuals. We consider two cases. In the behaviourally homogeneous case, each individual, when meeting another individual, chooses between the following two behaviors: either to fight (= aggressive) or to run away and to take refuge from fighting outside of the habitat (= paranoid). In the behaviourally structured case, the population consists of two subpopulations corresponding to the two fixed behaviours. We first consider the population dynamics subject to short-term adverse conditions falling within a generation and

¹Shirshov Institute of Oceanology, Russian Academy of Science, Nakhimovsky Prosp. 36, Moscow 117218, Russia (e-mail: spetrovs@sio.rssi.ru).

²University of Plymouth, Seale-Hayne Campus, Newton Abbot, Devon TQ12 6NQ, U.K. (e-mail: rblackshaw@plymouth.ac.uk).

show that behaviourally structured populations exhibit lower rate of decay compare to corresponding behaviourally homogeneous population and thus appear to be intrinsically less prone to extinction. Surprisingly, the optimal conditions for the population persistence are shown to be reached when a significant number of the individuals exhibit aggressive behaviour. Then we introduce a more general class of hierarchically structured population. The hierarchy consists of several ranks which are strictly ordered in the sense that higher ranks affect the lower ones but are not affected by them. Such ranks can be associated with different types of behaviour [4]. We fulfill a rigorous mathematical analysis of this system and show that its relative stability (with respect to the stability of a behaviourally homogeneous population) on the large-time scale essentially depends on the type of density dependence in population growth. While in the case of logistic growth both populations exhibit equivalent stability, in the case that growth is damped by the Allee effect the stability of hierarchical populations appears to be remarkably higher than the stability of unstructured populations.

References

- [1] Mather, J.A. & R.C. Anderson, 1993, Personalities of octopuses (*Octopus rubescans*), *Journal of Comparative Psychology*, 107, 336-340.
- [2] Wilson, D.S., 1998, Adaptive individual differences within single populations, *Philosophical Transactions of Royal Society of London Ser. B*, 353, 199-205.
- [3] Schwaibold, U. & N. Pillay, 2001, Stereotypic behaviour is genetically transmitted in the African striped mouse *Rhabdomys pumilio*, *Applied Animal Behaviour Science*, 74, 273-280.
- [4] Petrovskii, S.V. & R.P. Blackshaw, 2003, Behaviourally structured populations persist longer under harsh environmental conditions, *Ecology Letters*, in press.