Density dependence in matrix population models: consequences for life history evolution and population management

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Density independent matrix models provide a convenient and elegant way of modelling populations. Elasticity and sensitivity analysis of such models have yielded valuable insights into life history evolution and the management of field populations. However, density dependence of population growth is common, and inclusion of this may greatly alter patterns of elasticities and sensitivities [1]. Our previous work has shown that a density independent analysis often (but not always) gives a good guide to life history evolution when density dependence is present. However, density independent analyses can produce misleading guidelines for population management if density dependence occurs. An intervention that produces an increase in population size in a density independent model may have no effect on a density dependent population or may even produce a decrease in population size. So this work using simple population models suggests that ignoring density dependence may be dangerous.

Do these concerns also apply to field populations? Or do density independent analyses usually give useful insights into evolutionary biology and management of density dependent populations, as Caswell [2] has asserted? Here we investigate these questions using the LPA model of laboratory populations of *Tribolium* [3], and realistic models of field populations including Soay Sheep and a number of commercial fish stocks.

Analysis of these examples confirms that a density independent analysis of the equilibrium or mean projection matrix will often be a good guide in studies of life history evolution. An exception is that when non-equilibrium population dynamics occur, an individual can gain an advantage by tracking population fluctuations, for example by producing more offspring in time periods when density dependent juvenile mortality is relaxed. A density independent, or stage-based density dependent, analysis will often overlook this, and the LPA model of *Tribolium* provides examples of this. In several field populations, the pattern of density independent elasticities is markedly different to that of density dependent elasticities of population size, so the former would provide a relatively poor guide to population management. *Tribolium* provides examples of the extreme case in which changes in demographic parameters that increase individual fitness *decrease* population size.

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References

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