Maturation delay with a fecundity-survival trade-off in a discrete population model

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A delay between an organism's birth and sexual maturity (maturation delay) is a common life history trait of many species and has important population consequences. Yet, increasing the maturation delay, with all else being equal, has the potential to decrease the total probability of survival, leading to extinction with a long enough delay. The fact that most species have a maturation delay beyond one breeding cycle suggests a trade-off to counterbalance this decrease in survival probability. We explore such a trade-off by deriving a class of discrete single species models with a maturation delay and the realistic assumption of a reproductive trade-off. In this reproductive trade-off, although a prolonged maturation delay decreases the total probability of survival, the delay results in larger body sizes which we assume, based on some fish species, to be proportional to egg production. We consider two different survival functions for mature and immature individuals, the Beverton—Holt and the Ricker model. Overall, we found an optimal maturation delay where the population size was maximized, with further increases in the maturation delay leading to extinction. Depending on the modelling framework, increasing the maturation delay, while keeping all other parameters constant, also allowed the existence of an interior equilibrium where previously only the trivial equilibrium existed. A further increase in the maturation delay destabilized this interior equilibrium, followed by stabilization again and then extinction.

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