Interacting forces of predation and fishing affect species' maturation size

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Abstract

1. Fishing is a strong selective force and is supposed to select for earlier maturation at smaller body size. However, the extent to which fishing-induced evolution is shaping ecosystems remains debated. This is in part because it is challenging to disentangle fishing from other selective forces (e.g. size-structured predation and cannibalism) in complex ecosystems undergoing rapid change.

2. Changes in maturation size from fishing and predation have previously been explored with multi-species physiologically structured models but assumed separation of ecological and evolutionary timescales. To assess the eco-evolutionary impact of fishing and predation at the same timescale, we developed a stochastic physiologically size-structured food web model, where new phenotypes are introduced randomly through time enabling dynamic simulation of species' relative maturation sizes under different types of selection pressures.

3. Using the model, we carried out a fully factorial in silico experiment to assess how maturation size would change in the absence and presence of both fishing and predation (including cannibalism). We carried out ten replicate stochastic simulations exposed to all combinations of fishing and predation in a model community of nine interacting fish species ranging in their maximum sizes from 10g to 100kg. We visualised and statistically analysed the results using linear models.

4. The effects of fishing on maturation size depended on whether or not predation was enabled and differed substantially across species. Fishing consistently reduced the maturation sizes of two largest species whether or not predation was enabled and this decrease was seen even at low fishing intensities (F = 0.2yr-1). In contrast, the maturation sizes of the three smallest species evolved to become smaller through time but this happened regardless 2 of the levels of predation or fishing. For the four medium-size species, the effect of fishing was highly variable with more species showing significant and larger fishing effects in the presence of predation.

5. Ultimately our results suggest that the interactive effects of predation and fishing can have marked effects on species' maturation sizes, but that, at least for the largest species, predation does not counterbalance the evolutionary effect of fishing. Our model also produced relative maturation sizes that are broadly consistent with empirical estimates for many fish species.

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