

Coblentz, K. E. and DeLong, J. P. 2020. Predator-dependent functional responses alter the coexistence and indirect effects among prey that share a predator. – *Oikos* doi: 10.1111/oik.07309

## Appendix 1

### Effects of predator dependence on stability

Previous theory has shown that predator dependence is generally stabilizing in predator-prey systems by increasing the resiliency of the system to perturbations and dampening predator-prey cycles (Arditi et al. 2004). Here, we use linear stability analysis to show that this is also the case for the generalist predator-prey models in the main text when predators do not influence the coexistence among prey.

### Linear stability analysis

To assess the effects of predator dependence on the stability of the predator-prey system, we used linear stability analysis (McCann 2012). For the Beddington-DeAngelis and Crowley-Martin functional responses, both when the prey do not interact directly and when the prey compete, we altered the interference parameter of the functional responses and examined how the maximum eigenvalue of the Jacobian of the system evaluated at the equilibrium changed with the strength of interference. The maximum eigenvalue describes the rate of return of the system to the equilibrium following a small pulse perturbation (an acute, one time perturbation to the system). When the maximum eigenvalue is positive, the equilibrium is unstable and a perturbation of the system will cause the system to leave the point equilibrium. If the maximum eigenvalue is negative, the equilibrium is stable, and the system will return to the equilibrium following the pulse perturbation. The more negative the maximum eigenvalue, the faster the system will return to the equilibrium. Thus, the maximum eigenvalue provides a measure of the stability of the system in terms of the resiliency of the system to pulse perturbations. We performed the stability analyses under parameter values in which the prey coexist with one another regardless of predation.

### Effects of predator dependence on stability

Predator dependence stabilizes the system both when prey do not directly interact with one another and when they compete (Fig. 2A, D, 3A, D). This holds for both the Beddington-DeAngelis and Crowley-Martin functional responses (Fig. 2A, D, 3A, D). If the parameters used lead to a limit cycle in the absence of predator dependence, increasing the magnitude of predator dependence can lead to a qualitative change in population dynamics from limit cycles to stable steady states (Fig. 2, 3, 4). Under parameter values that do not lead to a limit cycle in the absence of predator dependence, predator dependence is still stabilizing in terms of increasing the resilience of the system to perturbations (leading to a more negative maximum eigenvalue; results not shown).

The effects of predator dependence can be more complex for the Crowley-Martin functional response than for the Beddington-DeAngelis functional response. Given certain parameter combinations both when the prey do not interact directly and when they compete, a region of bistability exists in which there are two stable steady states: one with low densities of both prey and the predator and another with high densities of the prey and predator (Figure; results not shown for the case in which the prey do not directly interact). Predator dependence is stabilizing (leads to a more negative maximum eigenvalue) for both equilibria (Fig. 3A, 4A). As predator dependence increases within the region of bistability, the equilibrium with lower

predator and prey densities vanishes leaving only the stable equilibrium with greater predator and prey densities (Fig. 3, 4).

## References

Arditi, R. et al. 2004. Does mutual interference always stabilize predator-prey dynamics? A comparison of models. – *Comptes Rendus Biologies* 327: 1037–1057.

McCann, K. 2012. *Food webs*. – Princeton Univ. Press.

## Figures

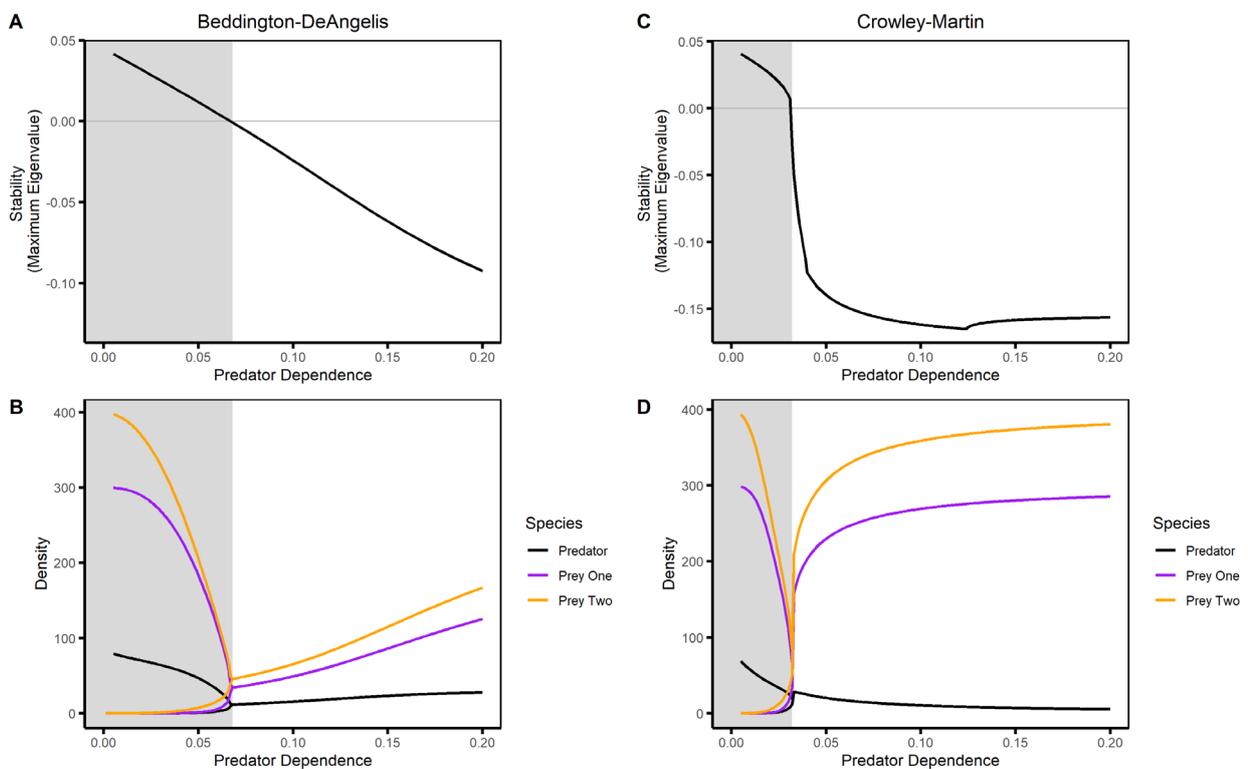


Figure 1. When prey do not directly interact and coexist regardless of predation, increasing predator dependence increases the stability of the system (decreases the maximum eigenvalue; A, C) and can transition the system from limit cycles to a stable equilibrium (B, D). Limit cycles occur within the grey shaded area within the plots. During the limit cycles, the upper branches in the density plots (B, D) are the maximum densities of the species during the limit cycle, while the lower branches are the minimum densities. Parameter values used to produce the figure were:  $r_1 = 0.3$ ,  $r_2 = 0.2$ ,  $K_1 = 300$ ,  $K_2 = 400$ ,  $\alpha_1 = 0.075$ ,  $\alpha_2 = 0.05$ ,  $\eta_1 = \eta_2 = 0.3$ ,  $e_1 = e_2 = 0.2$ ,  $m = 0.3$ .

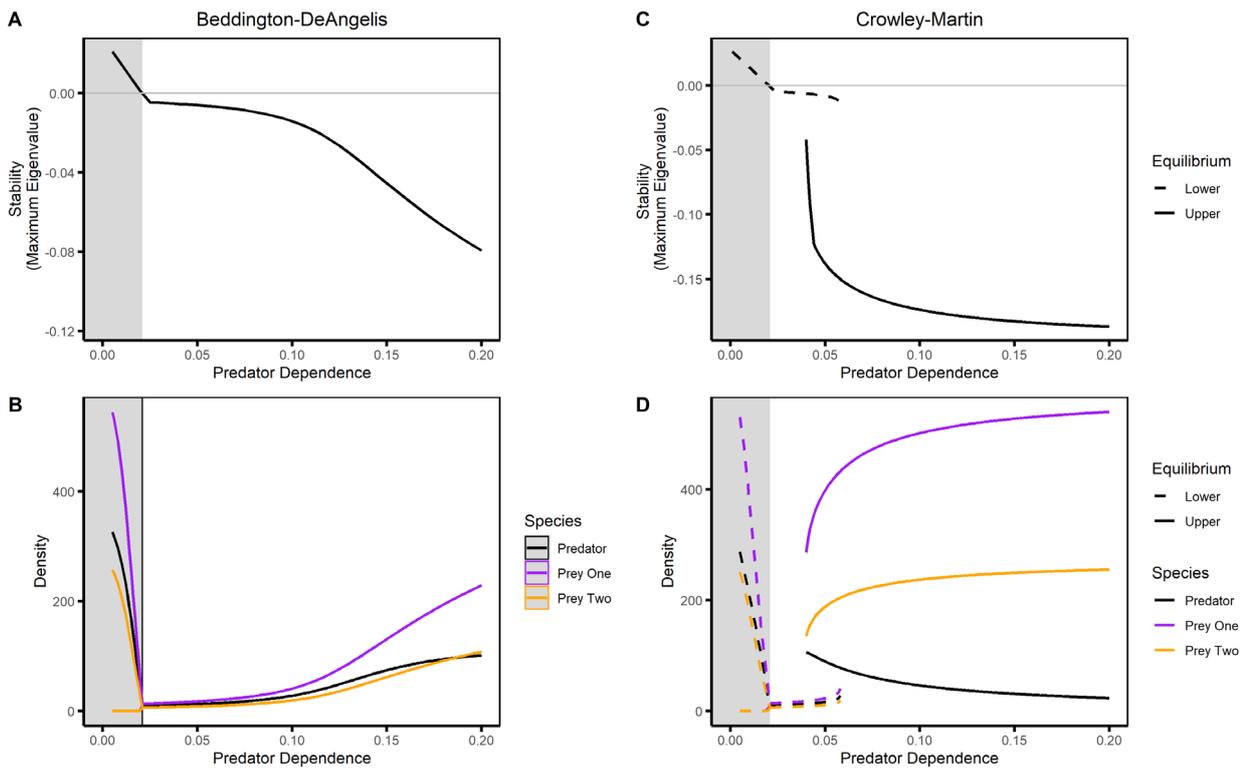


Figure 2. When prey compete directly but coexist in the presence of the predator and the absence of predator dependence, increasing predator dependence increases the stability of the system (decreases the maximum eigenvalue; A, C) and transition the population dynamics from limit cycles to a stable steady state (B, D). Limit cycles occur within the grey shaded area within the plots. During the limit cycles, the upper branches in the density plots (B, D) are the maximum densities of the species during the limit cycle, while the lower branches are the minimum densities. Under the Crowley–Martin functional response there can also be a region of bistability with two steady states: one with higher densities of the species (upper) and one with lower densities of the species (lower; D). As predator dependence increases, the lower equilibrium vanishes. Whether bistability occurs with the Crowley–Martin functional response depends on the parameter values used. The parameter values used to produce the figure were:  $r_1 = r_2 = 0.4$ ,  $K_1 = 600$ ,  $K_2 = 500$ ,  $\alpha_1 = \alpha_2 = 0.06$ ,  $\alpha_{21} = 0.4$ ,  $\alpha_{12} = 0.1$ ,  $\eta_1 = \eta_2 = 0.2$ ,  $e_1 = e_2 = 0.5$ ,  $m = 0.4$ .