Detecting climate signals in populations across life histories

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Abstract

Climate impacts are not always easily discerned in wild populations as climate change occurs in the context of natural variability. Furthermore, species responses to climate change and variability differ among life histories. The time of emergence (ToE) identifies when the signal of anthropogenic climate change can be quantitatively distinguished from noise associated with natural variability. This concept has been applied extensively in the climate sciences, but has not yet formally been explored in the context of population dynamics. Here, we present a theoretical assessment of the ToE of climate-driven signals in population dynamics (ToEpop) to detect climate signals in populations. We identify the dependence of ToEpop on the magnitude of climate trends and variability and explore the demographic controls on ToEpop. We demonstrate that different life histories (fast species vs. slow species), demographic processes (survival, reproduction) and functional relationships between climate and demographic rates, yield population dynamics that filter trends and variability in climate differently. We illustrate empirically how to detect the point in time when anthropogenic signals in populations emerge from the envelope of natural variability for a species threatened by climate change: the emperor penguin. Finally, we propose six testable hypotheses and a road map for future research.

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