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Effects of wind on predator-prey interactions

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ABSTRACT

A long standing interest in ecology has been to understand the effects of abiotic factors on organisms and their interactions within ecological communities. This understanding has become increasingly important in light of rapid anthropogenic climate change. One of the most under-studied aspects of climate change is changing wind speed, which is generally decreasing in terrestrial environments globally. While wind is a nearly ubiquitous part of the environment, little effort has been put into synthesizing our understanding of how wind influences interspecific interactions. We reviewed the literature to synthesize our current understanding of the effects of wind with a specific focus on predators-prey interactions. We identified three primary mechanisms by which wind influences predator-prey interactions: detection of the other species, locomotion, and physical disturbance. We found that wind can have diverse effects that can both strengthen or dampen the effects of predators on their prey. However, these effects are context dependent and forecasting the effects of slowing wind speed on species interactions will depend on specific traits of the predator, prey, and environment in which they interact.

Contents

1. Introduction

Predators have complex interactions within food webs, including behavioral and numerical effects on their prey, and indirect effects on the resources their prey consume. However, these interactions are often context dependent, varying significantly in response to relatively small changes in the environment (Tylianakis et al., 2008). Understanding the nature of these interactions and how abiotic factors modulate their effects has been a long-standing goal of ecologists (Holling, 1959; Hutchinson et al., 1972; Hansson and Henttonen, 1985; Post et al., 1999). Interest in this basic ecological question has been reinvigorated recently, as ecologists attempt to predict the effects of global climate change on species and their interactions within ecological communities (Petchey et al., 1999; Walther et al., 2002; Kortsch et al., 2015). While

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ecologists have studied the effects of abiotic factors on predator-prey interactions for decades, studies have focused mainly on a few factors, such as temperature (Tylianakis et al., 2008; Rosenblatt and Schmitz, 2014). This perennial bias has created large gaps in our understanding of the effects of many abiotic factors on food web interactions, including the effects of wind on predator-prey interactions.

Wind is a ubiquitous component of ecological systems and can have powerful and diverse effects. Much work has gone into understanding the effects of wind in pollination (Regal, 1982), dispersal (Gatehouse, 1997), and as a destructive force on the landscape (Everham and Brokaw, 1996). However, less effort has been given to understanding how wind directly affects interactions among organisms within a community. This is particularly relevant because wind patterns and speeds have changed in recent decades and it is unclear what consequences altered wind may have on ecosystems (Pryor et al., 2009; Vautard et al., 2010; McVicar et al., 2012). Indeed, long-term data sets and climate models have revealed changes in wind speeds due to anthropogenic climate change. This phenomenon is often referred to as "global stilling", although there are areas—particularly marine environments—where wind speeds have increased (Vautard et al., 2010). Across the contiguous United States (Pryor et al., 2009) and worldwide (Vautard et al., 2010; McVicar et al., 2012), wind speeds have decreased by 5–15% during the last 30 years, and are generally expected to continue decreasing during the 21st century. While it is not difficult to imagine that changing wind could affect the way species interact, there is no general theory or synthesis available to understand how wind affects predator-prey interactions.

There is however, a small but growing body of literature exploring the direct and indirect effects of wind on predators and prey. In this paper, we review and summarize that literature and present a synthesis of the diverse ways in which wind affects predator-prey interactions. We grouped the literature in several ways, including the way through which wind affects these interactions, and largely organize our synthesis around the three most common mechanisms: detection, locomotion, and disturbance. For each mechanism, we illustrate the interactions and context dependent complexities of wind using specific case studies (Fig. 1). We use this literature to explore generalities in the effects of wind on predator-prey interactions, identify knowledge gaps, and discuss the possibility of forecasting the effects of a stiller future.

2. Literature review

We used Elsevier's Scopus database to find and review literature on the effects of wind on predator-prey interactions. We searched for papers that included "wind" and "predators" or "predation" in the title, abstract, or keywords. We further refined it by requiring that papers mentioned "ecology" and "wind speed", and excluded aquatic and marine studies and journals. The exact search string used was: TITLE-ABS-KEY (wind AND predator OR predation) AND ecology AND "wind speed" OR mph OR m/s OR km/s OR velocity AND NOT REFTITLE (marine OR ocean OR freshwater OR aquatic).

Our search yielded 89 papers. We evaluated each paper to determine if it included information about the effects of wind on predator-prey interactions. Most papers did not address predator-prey interactions and were on topics outside our interests (e.g., physiology of wind-sensing organs, aerial dispersal, etc.), and therefore were excluded. The Scopus search produced 30 papers that addressed the effects of wind on predator-prey interactions. Additionally, we included seven more papers that our Scopus search did not reveal but we discovered during the course of our review.

In total, we found 37 papers that addressed the effects of wind on predator-prey interactions. We categorized these papers based on predator and prey identity and taxonomic group; terrestrial vs aerial; location of study; the specific traits evaluated; the mechanism by which wind affected the organisms; and the direction of the effect on predation (positive, negative, or none). Some papers included more than one predator-prey combination or addressed more than one aspect of wind effects, so our review produced a total of 44 examples of predator-prey interactions are affected by wind (see Appendix 1 for references and details about each study).

2.1. Study systems

Our review included studies from 21 different countries and every continent except Antarctica. Most studies were conducted in the United States of America (n = 11), followed by Canada (n = 3), France, (n = 3), Scotland (n = 2), and South Africa (n = 2). The remaining 15 countries have only one paper included in this review. Clearly, there was a strong bias towards North American studies and virtually no

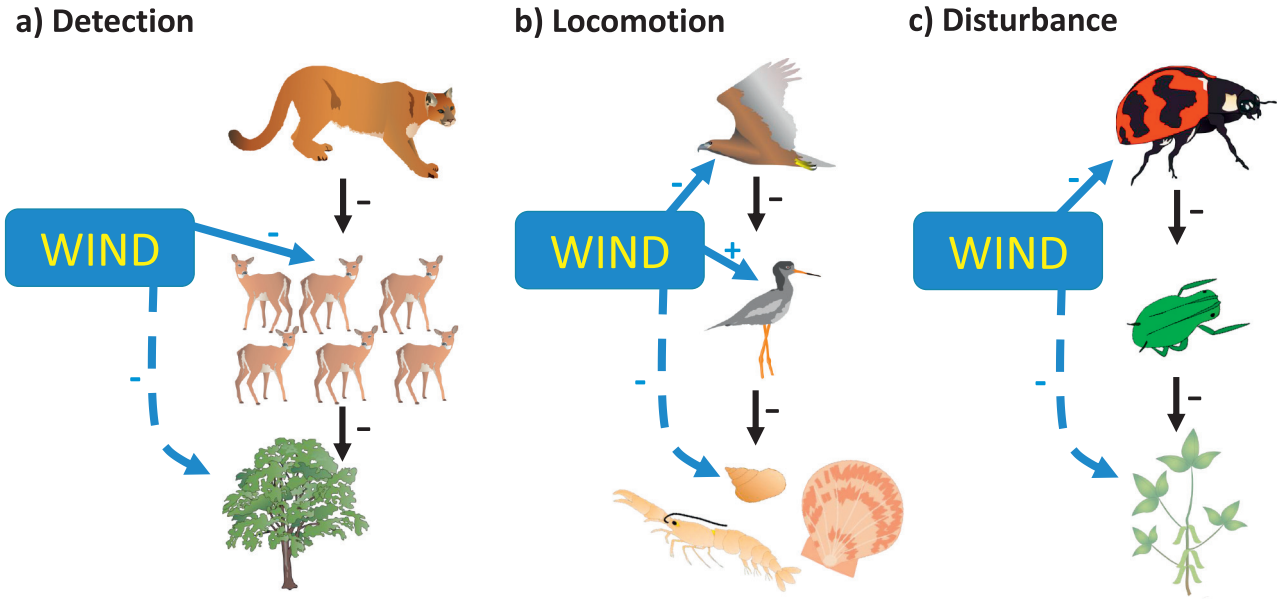

Fig. 1. Wind can generate cascading indirect effects on lower trophic levels. (A) Wind decreases deer ability to detect predators, increasing group size and shifting their distribution to safe habitats (Bowyer and Kie, 2009; Bowyer et al., 2001) (B) wind destabilizes predatory hawks but benefits shorebirds (Quinn and Cresswell, 2004), reducing their predation and potentially increasing consumption of their invertebrate prey. C) Wind jostles soybean plants, dislodging predators, reducing predation rates, increasing aphid density (Barton, 2014), potentially decreasing soybean yield.

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