Phenological shifts of the invasive annual weed *Bidens pilosa* var. *pilosa* in response to climate warming

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Research Article

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Abstract

The synergistic impacts of climate change and biological invasions pose major threats to biodiversity. However, although previous studies have revealed that climate warming enhances the invasiveness of non-native plants, little is currently known regarding the eco-physiological mechanisms underlying the changes in invasiveness promoted by a changing climate. In this study, we aimed to clarify the effects of warming on the phenology and eco-physiological background of the invasive annual weed *Bidens pilosa* var. *pilosa* in temperate regions. We compared the timing of germination, seedling growth, and flowering phenology at two study sites characterized by different temperatures (difference in mean annual temperature: 2.8°C). From winter to early spring, germination commenced earlier and seedling growth was more rapid at the warmer site than at the cooler site. In the former site, some seedlings bore flowers in winter to early spring (spring flowering), whereas spring flowering was rarely recorded at the cooler site. The results of laboratory experiments indicated that spring flowering occurred when the daylength was sufficiently short for induction of flowering and when the growth stage exceeded a threshold size. To assess the impact of phenological shifts on invasiveness, we constructed a simple model for estimating the number of seeds produced annually (propagule pressure). Model estimates indicated that even partial spring flowering resulted in an exponential increase in propagule pressure. These findings indicate that phenological shifts caused by climate warming could result in a substantial increase in invasiveness, which is considerably more pronounced than that caused by growth promotion only.

Full Text

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Tables

Table1 is available in the Supplemental Files section.

Figures

Figure 1

Total number of seedlings recorded in five quadrats (1 m × 1m) at monthly intervals (from December 2019 to April 2020). The growth stage of seedlings was defined in terms of the number of unfolded leaf pairs

Figure 2

The percentage of spring-flowering seedlings at the two study sites (December 2019–April 2020)

Figure 3

The time-course of germination under five different constant temperatures ($n = 5$). Vertical bars represent $\pm$ SD

Figure 4

The effects of daylength on flowering. The number of flowering seedlings in short-day (SD, 12L/12D) and long-day (LD, 13.5L/10.5D) systems were recorded at weekly intervals

Figure 5

A schematic diagram illustrating the life history of *B. pilosa* var. *pilosa*. Phenological shifts such as an advance in germination and spring flowering will occur under climate warming

Figure 6

The effects of climate warming on the propagule pressure of *B. pilosa* var. *pilosa*. We estimated the number of seeds produced in 1 year under three scenarios. Scenario 1: normal life history; Scenario 2: climate warming advances germination and extends the growth period; and Scenario 3: climate warming advances germination and the proportion of seedlings that flower in spring

Supplementary Files

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- [Table1.pptx](#)