Tracking phenological shifts and evolutionary impacts related to climate change

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Sakura (cherry blossom)

Recordings of memorable phenological events, such as the flowering of cherry trees in Japan, represent the oldest known phenological series with records dating back to the 9th Century. This display may have retained some of its cultural and religious significance, but now attracts additional economic benefits from tourism. Photography: Asa Fujimoto.

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Thesis Summary

Phenology is the study of recurring life-cycle events that are initiated and driven by environmental factors, such as the response of flowering time to the prevailing climate. Ongoing climate change is thus expected to impact on the flowering time of plant populations with consequences for reproductive success in the short term and their survival in the long term, along with potentially widespread repercussions for associated ecological health and function. Tracking phenological shifts in response to past climate variability provides a benchmark or reference point for gauging future impacts.

The introductory chapter of this thesis presents a review of the literature as it relates to my research documented in the following three chapters. Chapter 2 provides an exploration of the impacts of climate on the flowering phenology of the South Australian endemic *Diuris* orchid genus. A statistical analysis, trialling the suitability of Generalized Additive Models for Location, Scale and Shape (GAMLSS) for modelling of a long-term, historical dataset showed a significant curvilinear trend, with peak flowering advancing over time. This investigation was extended to determine the main and interactive effects of temperature and rainfall as specific drivers of *Diuris* flowering phenology (Chapter 3). A highly significant flowering response to seasonal temperatures and rainfall was identified, with shifts to earlier flowering in warmer and drier seasons expected under climate change scenarios.

Chapter 4 comprises various analyses of a 44-year replicate data set of 112 *Pyrus* (pear) trees growing at the University of Adelaide Waite Arboretum. This aspect of my research provided a unique opportunity to study the phenological responses of a non-native genus at the species and individual levels, when subjected to identical environmental conditions. A general response to minimum temperature was, on occasions, overridden by an early flowering response initiated by drought-breaking rains. This study also allowed a comparison to be made between *Pyrus* phenology in the northern and southern

hemispheres, and an insight into the potential economic impacts for South Australian horticulture.

Evolutionary implications for all study species arising from climatically-induced phenological shifts are outlined in Chapter 5, including a consideration of the likelihood that the rate of evolutionary change will be sufficient to keep pace with predicted climate change scenarios. Findings from these investigations are then considered in relation to the selection of bioclimatic indicators. In this sixth chapter, I challenge the validity of many assertions and assumptions presented in the literature. This thesis concludes that the stresses of ongoing climate change will have a selective impact on the reproductive fitness of flowering plants growing in South Australia. Outcomes will vary dependent upon individual populations and species, geographic location and evolutionary history.

Originality statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Phyllis Frances MacGillivray and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Phyllis Frances MacGillivray

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