Flowering phenology of South Australian Diuris (Donkey orchids)

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Tracking phenological shifts and evolutionary impacts relating to climate change

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Research Questions

What is the extent of climatic influences impacting on flowering phenology of South Australian Diuris orchids?

Which weather variables are the main drivers of flowering shifts, and what is the nature of these shifts?

Are shifts constant across regions and elevations?

How might shifts impact on hybridization?

*D. pardina* growing in Belair National Park
Seasonal Temperature trends

Adelaide SA 1893-2009

Mean minimum Winter temperatures have risen by >1°C

Mean minimum Spring temperatures have risen ~1.7°C over the same period
Seasonal Rainfall trends

**Winter rainfall**: evidence of decreasing trend <40 mm over the period 1893-2009

**Spring rainfall**: No significant difference but indications of increased variance i.e. greater unpredictability as the century progressed.
D. orientis
D. behrii
D. pardina
Herbarium vouched specimen of *Diuris pardina*

Electronic data from Australia’s Virtual Herbarium

Total of 305 usable records from 377 documented specimens

Flowering dates: 31 July - 16 November
Flowering shifts for *Diuris orientis*

**GAMLSS model**

Partial residuals

-60 -50 -40 0 10 20 30 40

1900 1920 1940 1960 1980 2000

-\[\text{Observed value} \quad \text{Spline} \quad \text{95\% confidence interval}\]

**D. orientis**: shift in peak flowering over time

# days following winter solstice

1880 1900 1920 1940 1960 1980 2000 2020

Year
Flowering shifts for *Diuris orientis*

GAMLSS model

**MULTIVARIATE ENSO INDEX**

NOAA/ESRL/Physical Science Division - University of Colorado at Boulder/CIRES/CDC
GAMLSS Models

**Basic Model** – all species combined

peak $\sim$ Year + Species + Altitude + minT.mthly + rain.mthly + minT.ssnl + rain.ssnl

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↓ earlier flowering for higher estimates

↑ later flowering for higher estimates

When season of flowering taken into account, temperature becomes much more important as a predictor of PFD.
**GAMLSS Models**

**Basic Model** – all species combined
peak ~ Year + Species + Altitude + minT.mthly + rain.mthly + minT.ssnl + rain.ssnl

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**Temperature**: mean minimum seasonal temperature  
**Rain**: total precipitation for the period indicated.  
**Peak**: peak flowering date; calculated as the number of days following the winter solstice
Seasonal Trends

GAMLSS Model 4, species combined

1°C increase in mean minimum seasonal temperature translates to an advance of 8 days in predicted peak flowering

100mm decrease in seasonal rainfall translates to an advance of between 4 and 5 days in predicted peak flowering
Main plus Interaction effects

Interaction effect of season and seasonal minimum temperature on PFD

Higher minimum temperatures in winter delay predicted PFD

Higher minimum temperatures in spring advance predicted PFD
Main plus Interaction effects

Interaction effect of season and seasonal rainfall on PFD

Spring rainfall has no significant effect on PFD

Lower rainfall in winter advances PFD
Main plus Interaction effects

Differential effect of altitude across species

Low elevations: the predicted PFD of *D. orientis* is in synchrony with *D. behrii*.

Mid elevations: *D. orientis* peaks later - becomes synchronous with *D. pardina*.

Highest occurring altitudes flowering *D. orientis* is further delayed - becomes asynchronous with both other species.
Main plus Interaction effects

Differential effect of latitude with time

A significant delay in PFD in the Southern regions over the period in contrast with the central and northern regions

A temperature, rather than a rainfall, effect
Hybridization

D. orientis & D. behrii

D. X palachila

D. pardina
D. x palachila: named hybrid of D. pardina and D. behrii
Summary

Main drivers of flowering shifts, and the nature of these shifts

Higher mean minimum winter temperatures
⇒ delayed PFD

Higher mean minimum spring temperatures
⇒ advanced PFD

Lower winter rain ⇒ advanced PFD

Spring rain ⇒ no significant effect on PFD

Earlier PFD for hotter and less rainy years
Summary

Shifts are not constant across regions and elevations

**Differential effect of latitude on PFD over time**
PFD advanced in central and northern regions;
PFD delayed in southern regions
A temperature, rather than a rainfall, effect

**Differential effect of altitude across species**
If climate change results in the upward migration of orchid populations,
this will potentially impact on hybridization events
Impact on hybridization

3 species hybridize readily producing an array of morphologically different hybrid forms

Hybridization depends not only on sympatry and flowering synchrony of orchids, but also on the phenology of their pollinators

Possible floral mimicry associated with the deceptive attraction of native bee pollinators $\Rightarrow$ dependence on phenology of the pea family (Fabaceae)
Acknowledgements

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