Climate change and Tasmanian lizards

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[4] *CSIRO Marine & Atmospheric Research, Hobart, Tasmania, Australia;*

Climate change

Austral Ecology (2003) **28**, 423–443

Climate change and Australia: Trends, projections and impacts

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Australia lacks the long-term datasets and tradition of phenological monitoring that have allowed the detection of climate-change-related trends in the Northern Hemisphere. Long-term changes in Australian vegetation can be mostly attributed to alterations in fire regimes, clearing and grazing, but some trends, such as encroachment of rainforest into eucalypt woodlands, and establishment of trees in subalpine meadows probably have a climatic component. Shifts in species distributions toward the south (bats, birds), upward in elevation (alpine mammals) or along changing rainfall contours (birds, semiarid reptiles), have recently been documented and offer circumstantial evidence that temperature and rainfall trends are already affecting geographic ranges. Future research directions suggested include giving more emphasis to the study of climatic impacts and understanding the factors that control species distributions, incorporating the effects of elevated CO_2 into climatic modelling for vegetation and selecting suitable species as indicators of climate-induced change.

Reptiles are suitable indicators

As ectotherms, they are strongly influenced by climatic conditions…

- activity patterns (daily, seasonal, annual)
- foraging & breeding
- metabolism, growth rate
- embryonic development

} climate sensitive

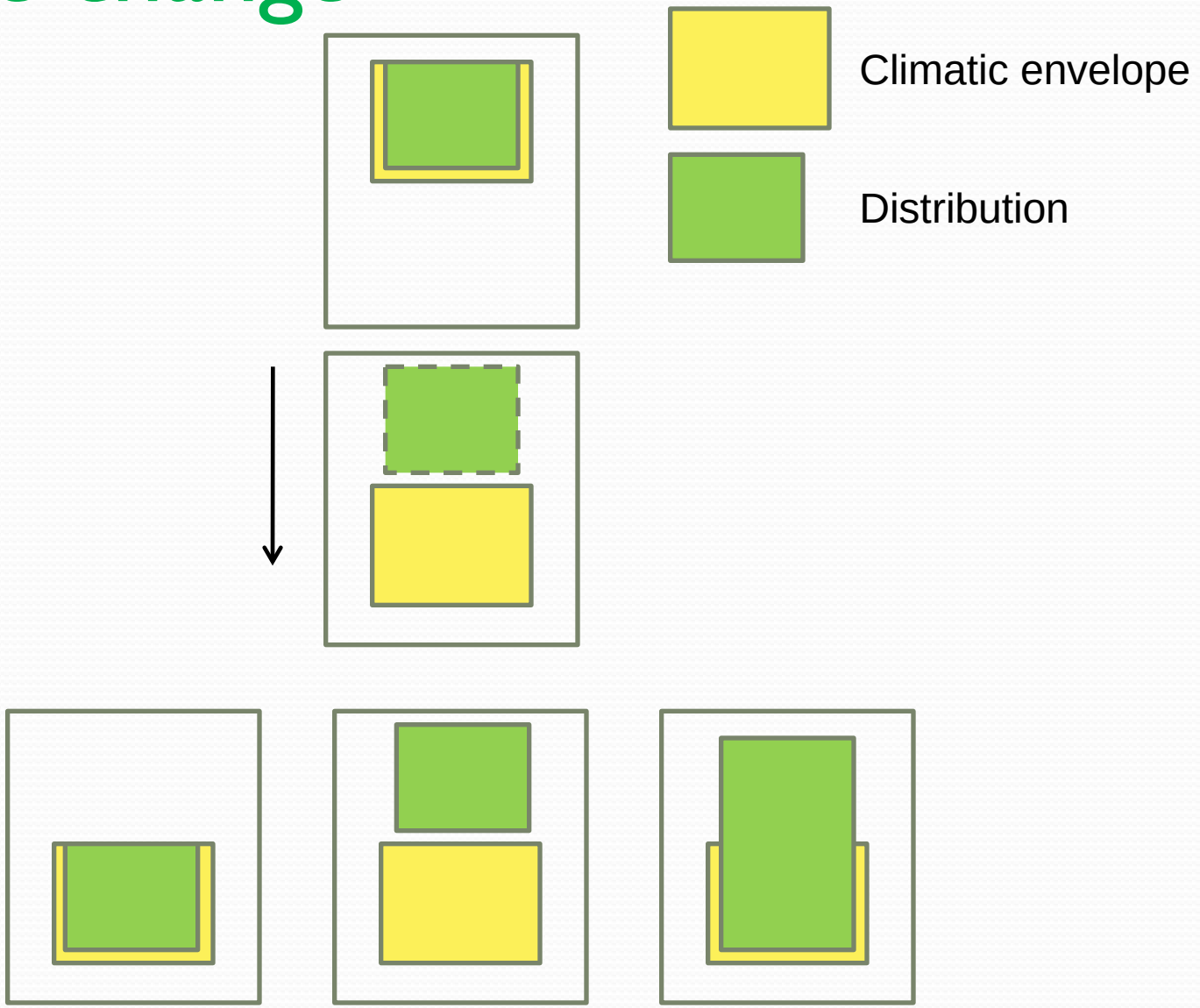
But they are poorly studied in the context of climate change

Why study Tasmanian lizards?

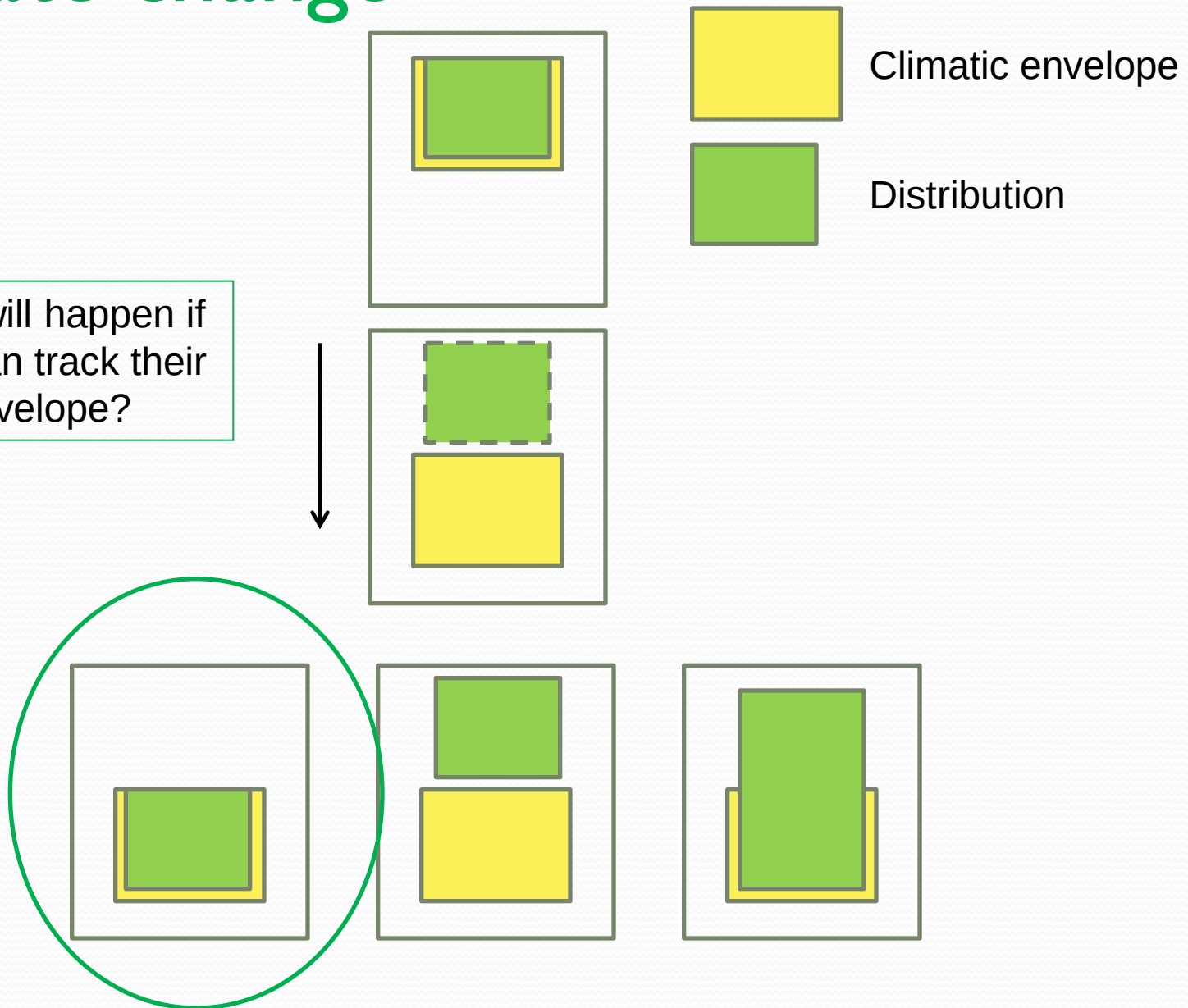
- series of adaptations to cold climates
  - viviparity (rare)
  - changes in reproductive cycles (e.g., biennial)(rare)

- embryonic development is very sensitive to climate
  -e.g. temperature-dependent sex determination (TSD)

Climate change

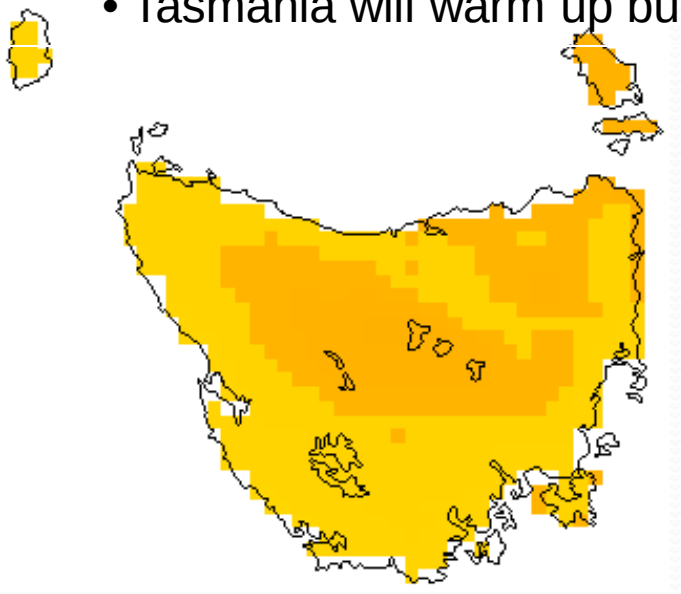


Climate change



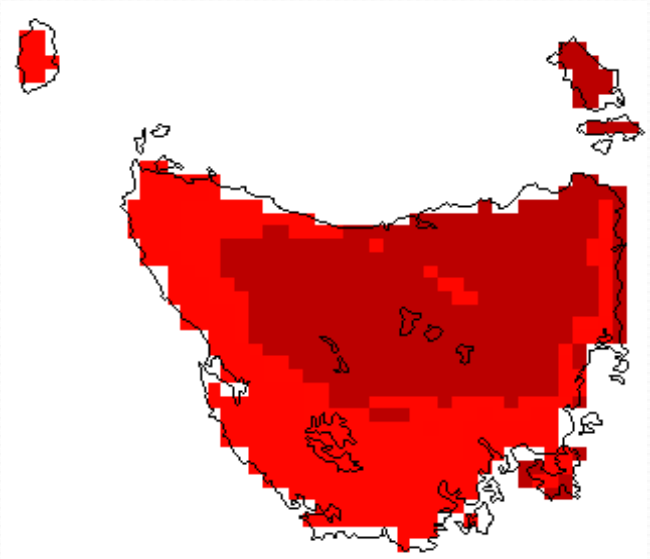
Distribution modelling

- Used Climate Futures for Tasmania predictions of climate
  - very fine scale predictions (14km grid cells) – unique!
  - Tasmania will warm up but not uniformly.



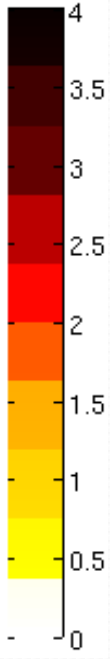
Mean difference

current-**2050**



Mean difference

current-**2085**



Distribution modelling

specialist species: adapted to very cold/extreme conditions

Niveoscincus microlepidotus

Niveoscincus greeni

Niveoscincus orocryptus

generalist species: live in milder climates

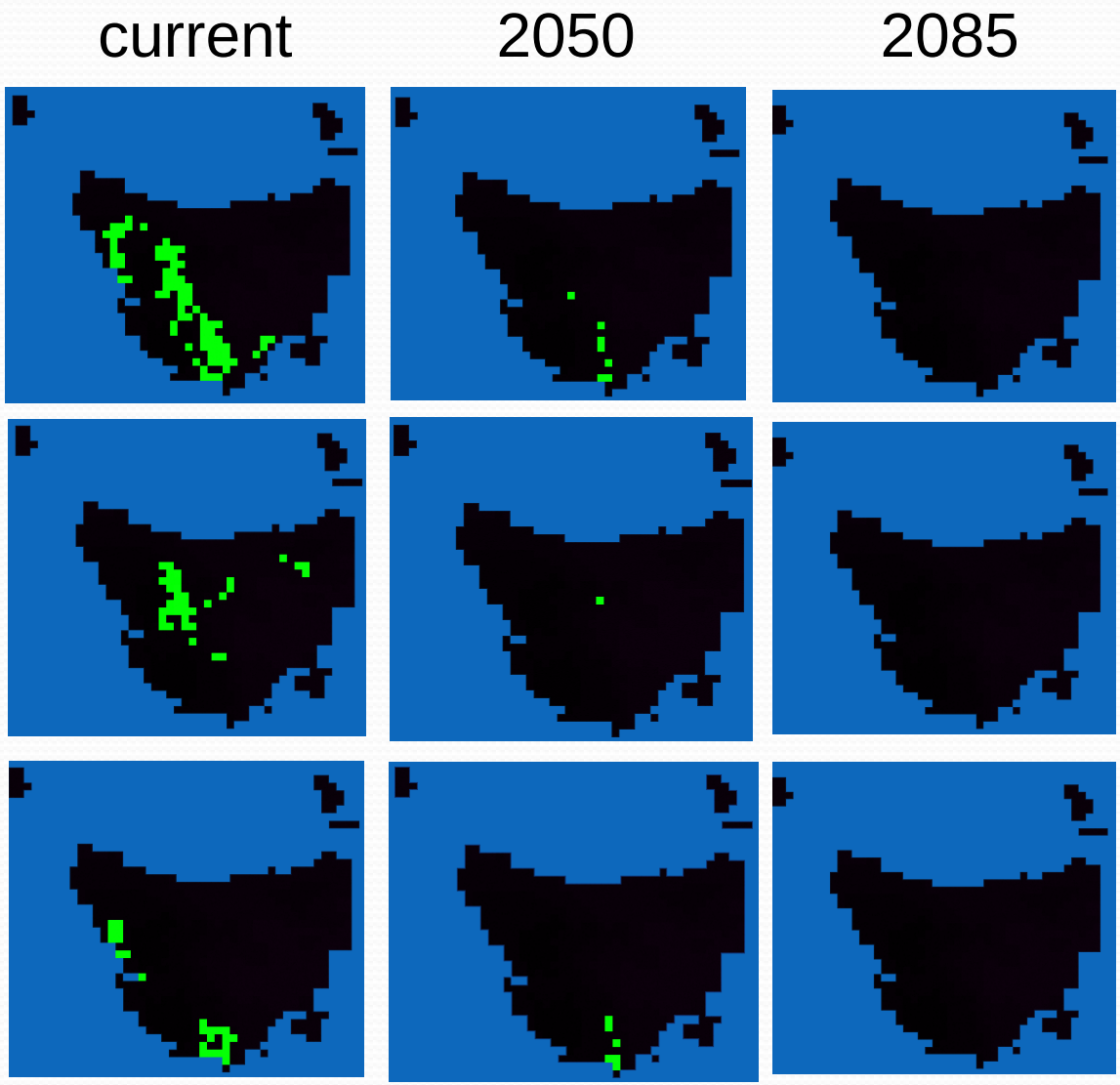
Niveoscincus ocellatus

Niveoscincus metallicus



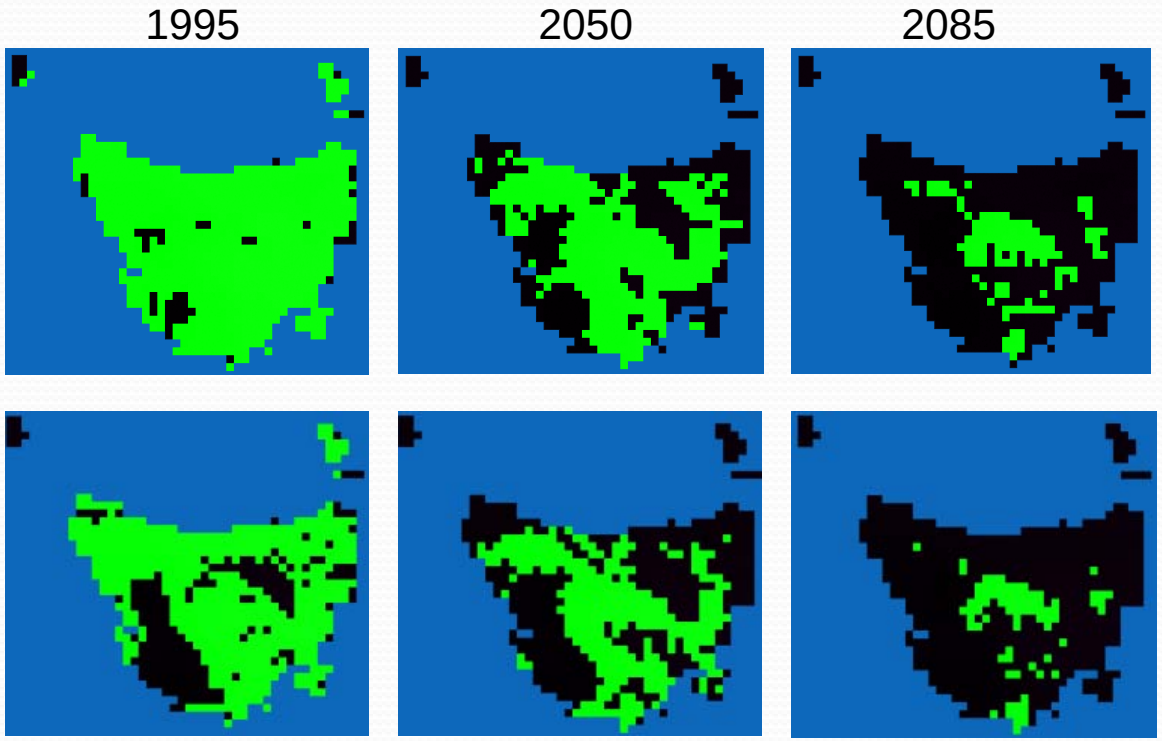

Distribution modelling

Specialist species



Distribution modelling

Generalist species



Distribution modelling

Our predictions are in concordance with predictions for reptiles

Erosion of Lizard Diversity by Climate Change and Altered Thermal Niches

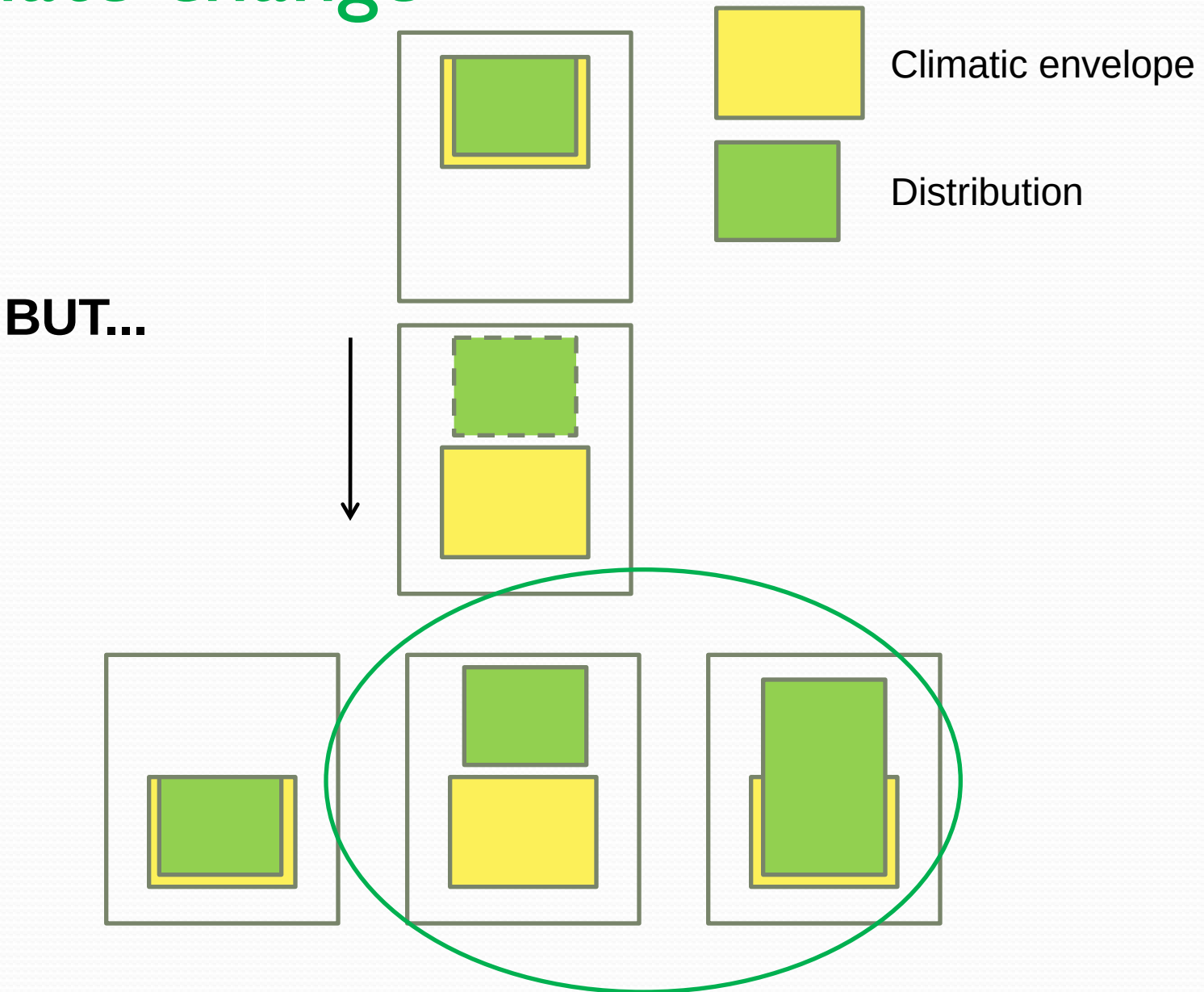
14 MAY 2010 VOL 328 **SCIENCE** Sinervo *et al.* 2010

Climate warming and the decline of amphibians and reptiles in Europe

M. B. Araújo[1,2,3]*, W. Thuiller[4,5] and R. G. Pearson[2,5]†

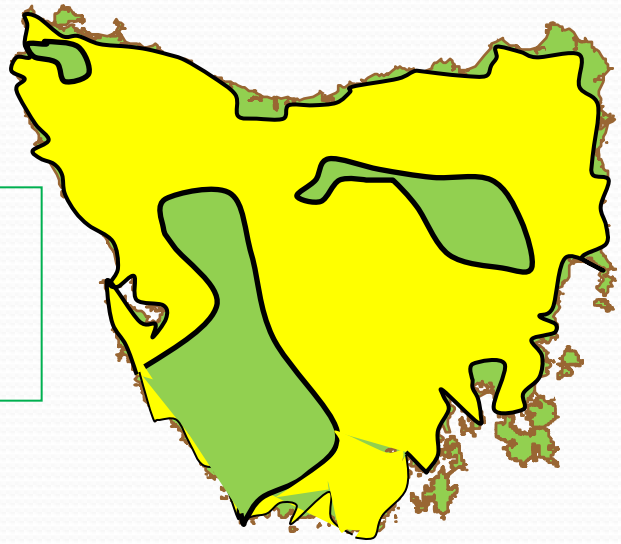
Journal of Biogeography (J. Biogeogr.) (2006) **33**, 1712–1728

Climate change



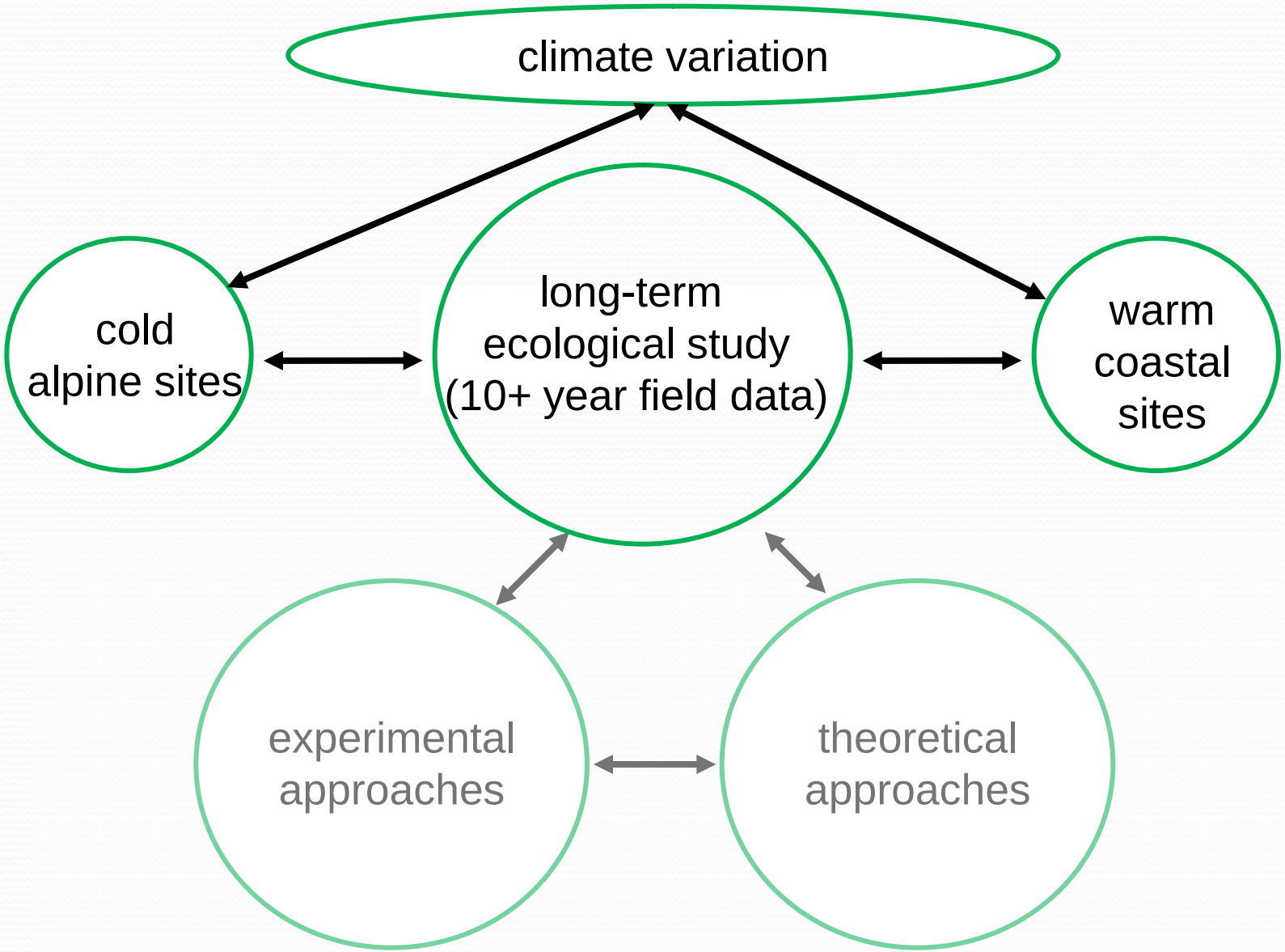
Our model system

- Spotted skink, *Niveoscincus ocellatus*
- viviparous:
  - embryonic development is very sensitive to climate
- widespread in Tasmania

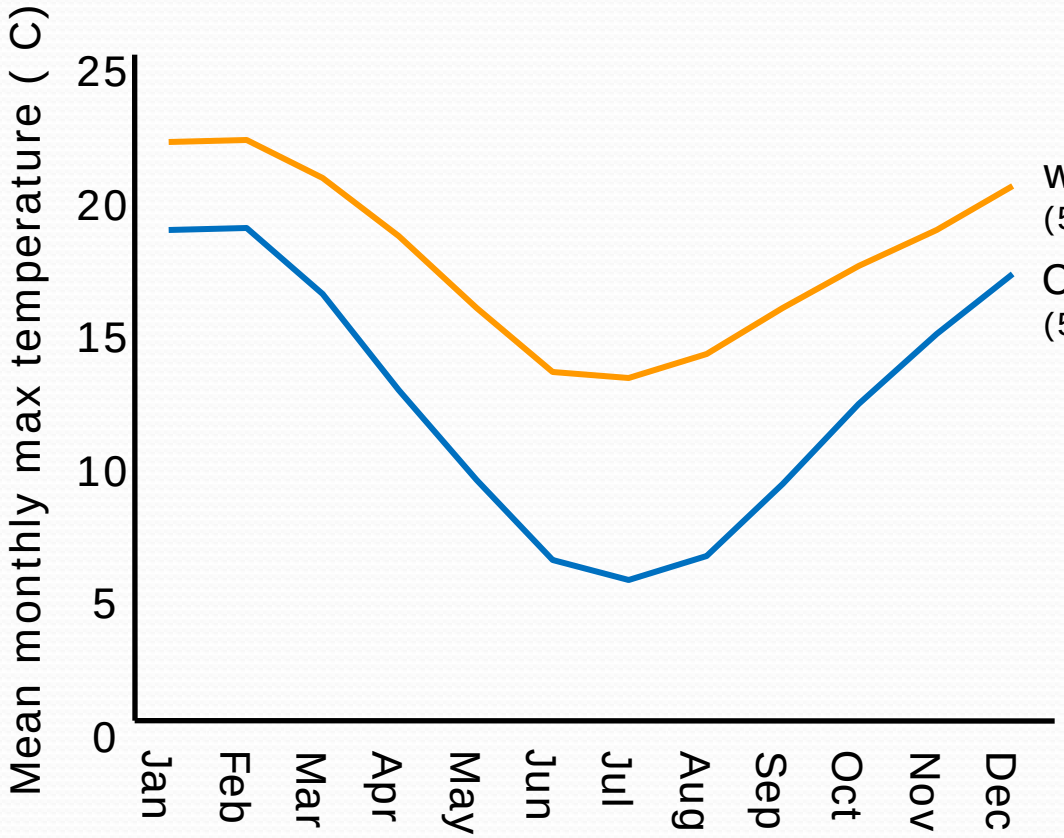


How did it colonize new area?
How did it adjust/adapt?
Could this allow adjusting to CC

Our work

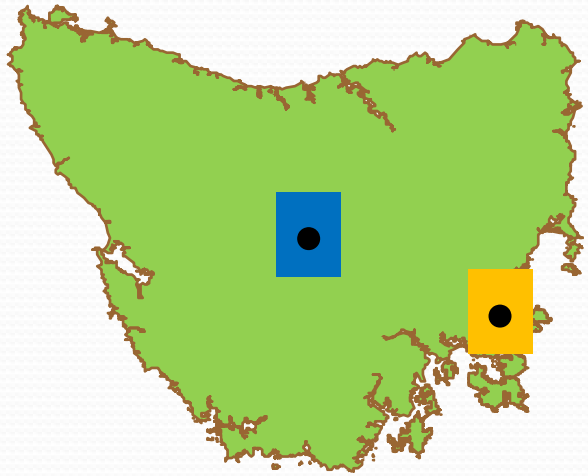

climate variation
cold
alpine sites
long-term
ecological study
(10+ year field data)
warm
coastal
sites
experimental
approaches
theoretical
approaches

Long-term field dataset



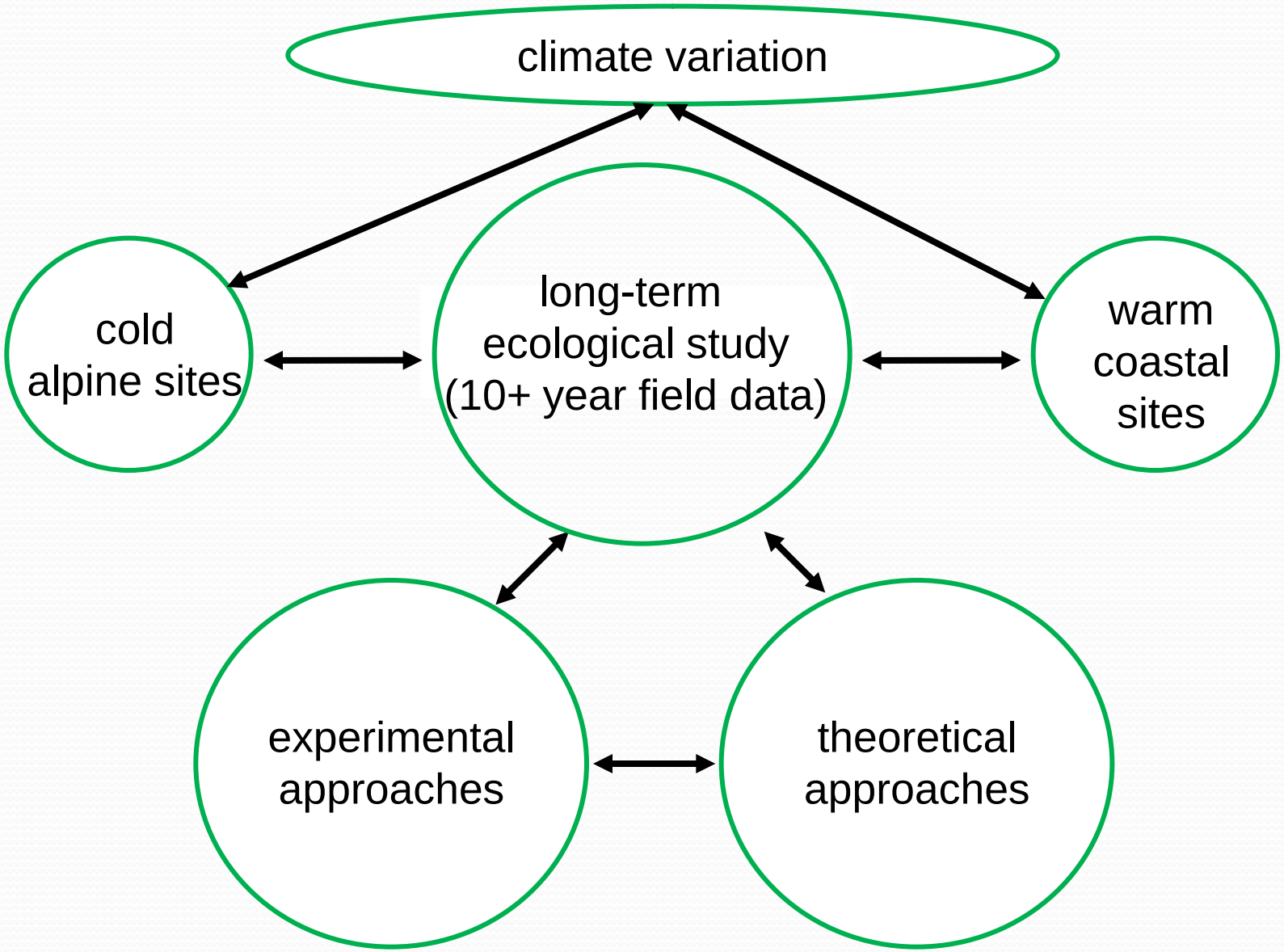
warm coastal site
(50 year average)

Cold alpine site
(50 year average)



- Each year we collect ~ 100 females/site
- caught at end of pregnancy
- offspring measured, sexed

Our work


climate variation
cold
alpine sites
long-term
ecological study
(10+ year field data)
warm
coastal
sites
experimental
approaches
theoretical
approaches

Giving offspring a head start in life: field and experimental evidence for selection on maternal basking behaviour in lizards

J. EVOL. BIOL. **23** (2010) 651–657

E. WAPSTRA*, T. ULLER†‡, G. M. WHILE*, M. OLSSON† & R. SHINE§

ALTITUDINAL DIVERGENCE IN MATERNAL THERMOREGULATORY BEHAVIOUR MAY BE DRIVEN BY DIFFERENCES IN SELECTION ON OFFSPRING SURVIVAL IN A VIVIPAROUS LIZARD

Tobias Uller[1,2], Geoffrey M While[1,3], Chloe D Cadby[3], Anna Harts[3,4], Katherine O'Connor[3], Ido Pen[4] and Erik Wapstra[3]

Journal of Animal Ecology

British Ecological Society

Journal of Animal Ecology 2009, **78**, 84–90 doi: 10.1111/j.1365-2656.2008.01470.x

Climate effects on offspring sex ratio in a viviparous lizard

Erik Wapstra[1]*, Tobias Uller[2,3], David L. Sinn[1], Mats Olsson[2], Katrina Mazurek[1], Jean Joss[4] and Richard Shine[5]

Multi-scale approach to understanding climate effects on offspring size at birth and date of birth in a reptile

Integrative Zoology 2010; 5: 164-175

Chloé D. CADBY,[1] Geoffrey M. WHILE,[1] Alistair J. HOBDAY,[2] Tobias ULLER[3] and Erik WAPSTRA[1]

THE ROYAL SOCIETY biology letters

Maternal basking behaviour determines offspring sex in a viviparous reptile

Erik Wapstra[1,2,3*], Mats Olsson[4], Richard Shine[3], Ashley Edwards[2], Roy Swain[2] and Jean M. P. Joss[1]

LETTER

436 | NATURE | VOL 468 | 18 NOVEMBER 2010

Climate-driven population divergence in sex-determining systems

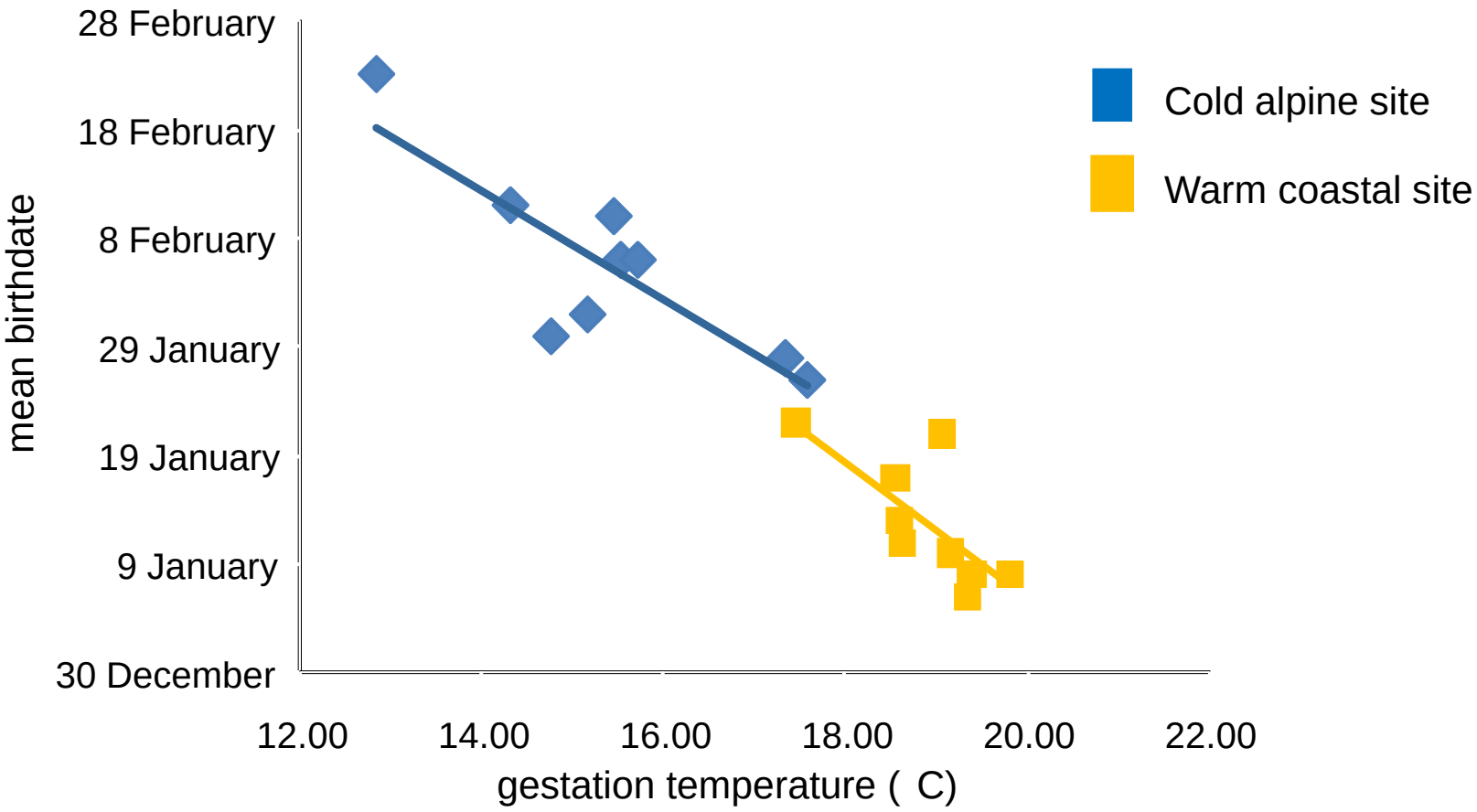
Ido Pen[1], Tobias Uller[2], Barbara Feldmeyer[1]†, Anna Harts[1], Geoffrey M. While[3] & Erik Wapstra[3]

Maternal basking opportunity affects juvenile phenotype in a viviparous lizard

E. WAPSTRA

Functional Ecology 2000 **14**, 345–352

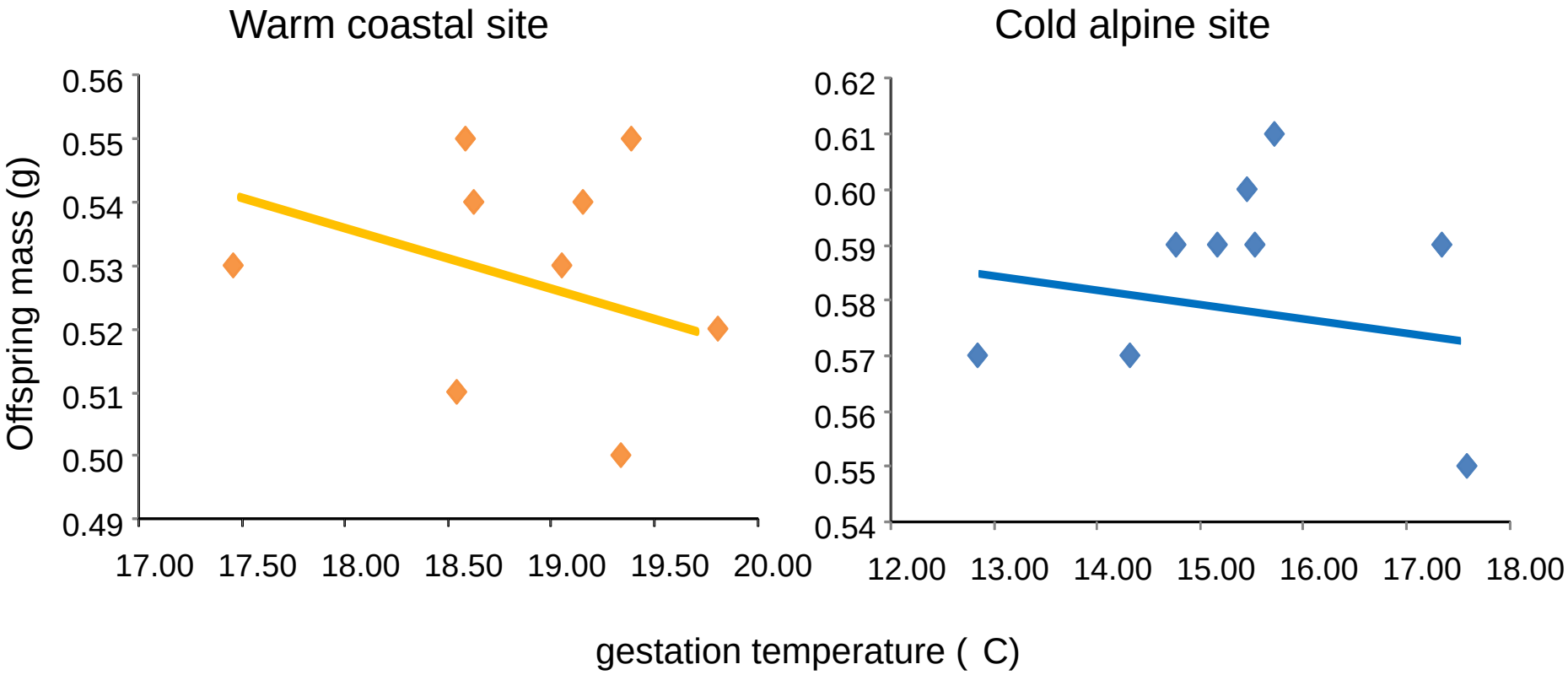
Long-term field study



warm years = early births

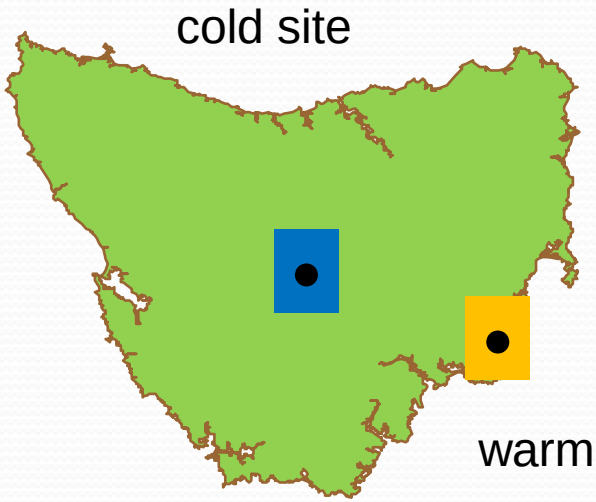
Embryonic developmental speed is a temperature-dependent process

Long-term field study



warm years = larger offspring
Nutrient transfer/metabolism are temperature-dependent processes
>>> Females produce good quality offspring at both sites - How?

Adjusting/adapting

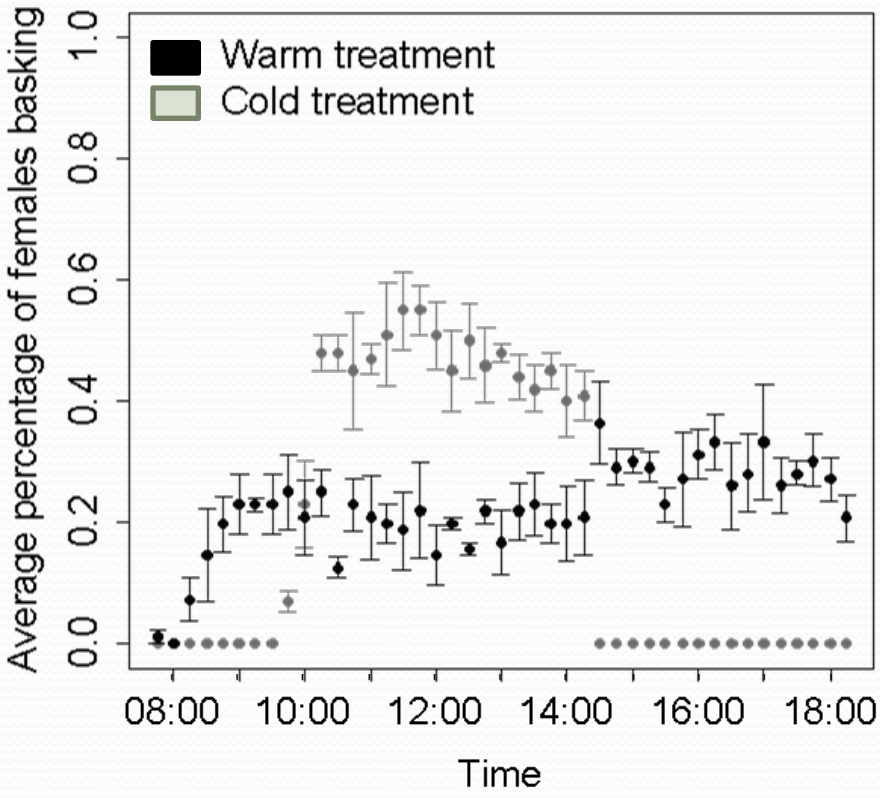


beginning of gestation

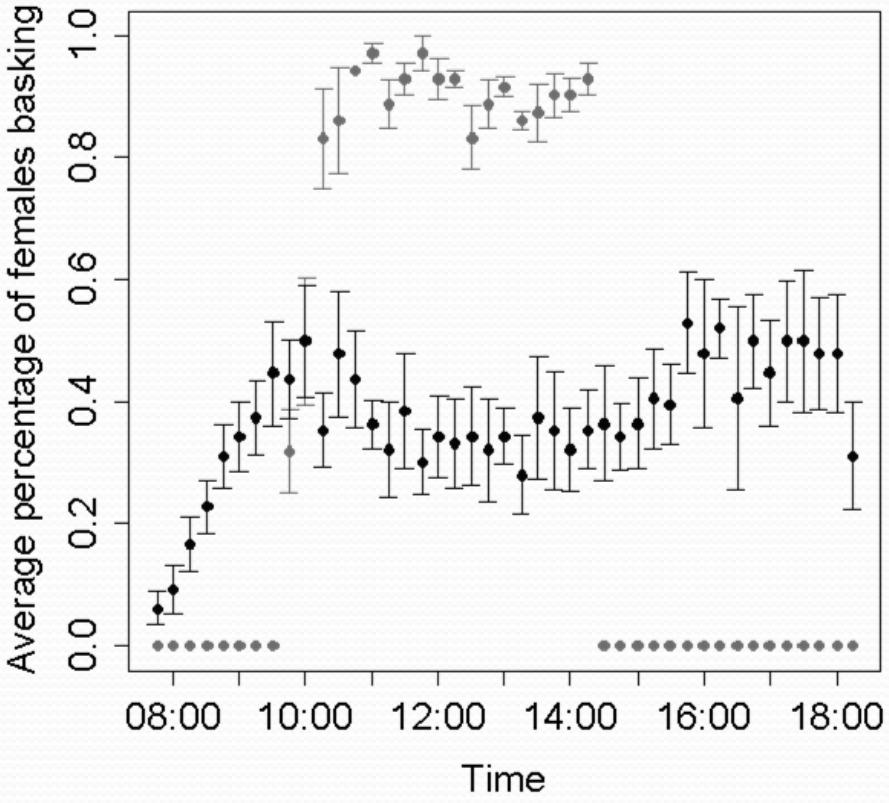
cold treatment: 4h basking
warm treatment: 10h basking

Adjusting/adapting

warm population



cold population



Females do behaviourally compensate: bask more/ maintain higher temp in cold.

This behavioural response has lead to local adaptation in maternal behaviour

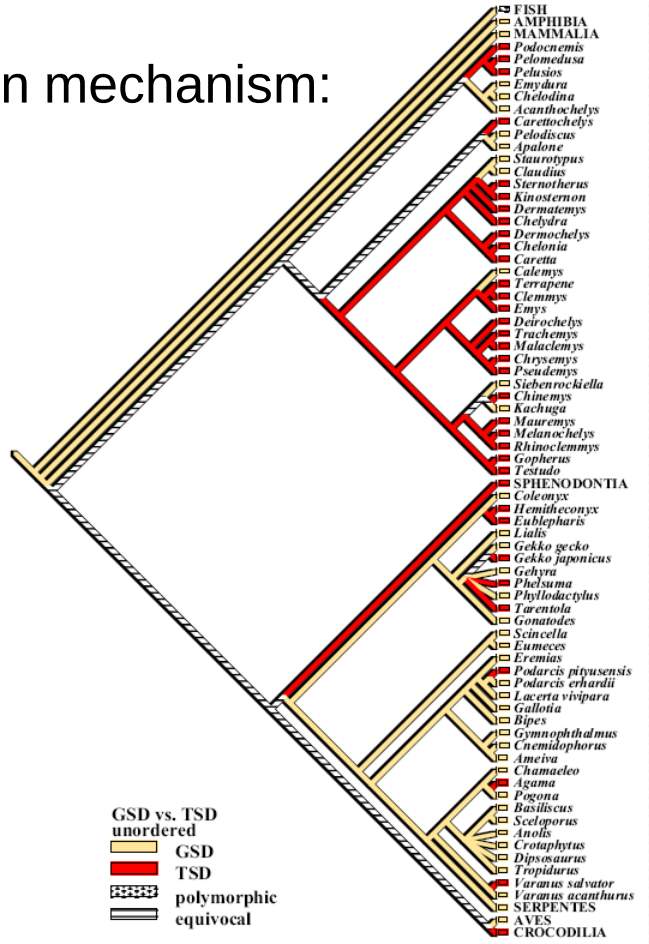
Sex determination

Maternal basking behaviour is not the only adaptation...

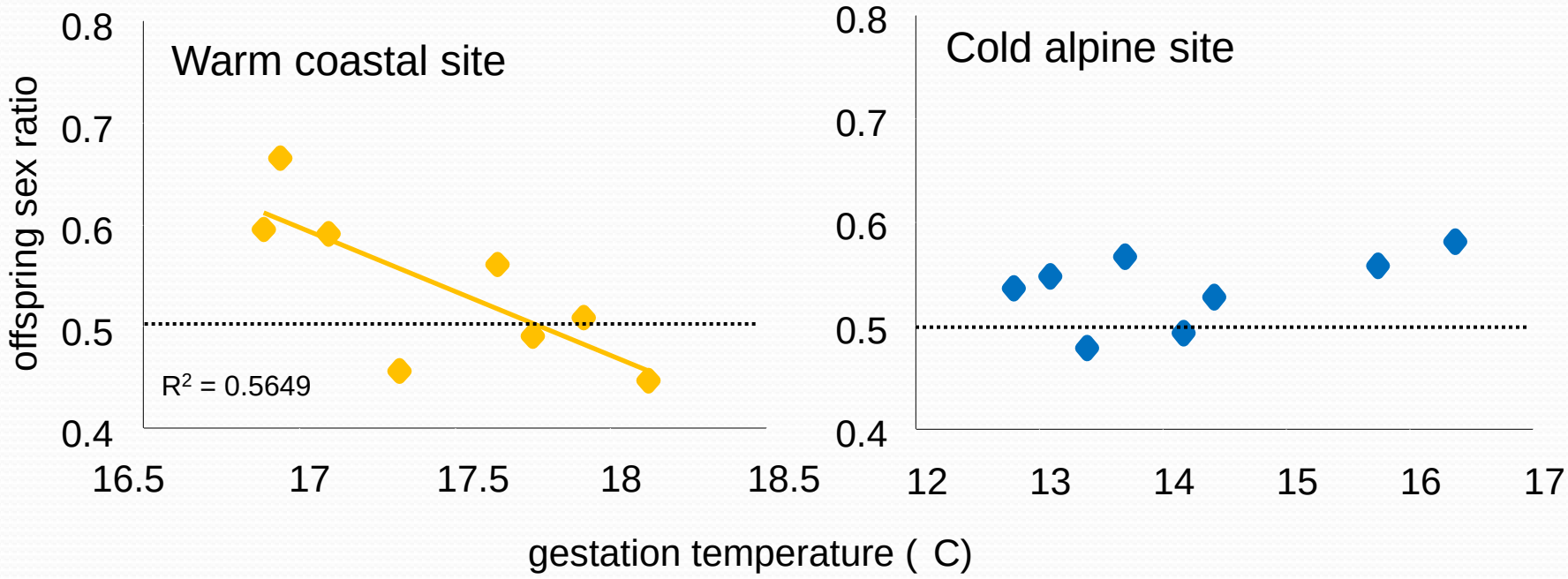
In reptiles there are two types of sex determination mechanism:

- Genotypic sex determination (GSD):
  - sex chromosomes
  - 1:1 sex ratio

- Temperature sex determination (TSD):
  - plastic response to temperature



Sex determination

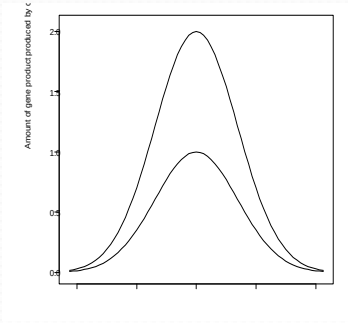


- warm site: link between temperature and sex (TSD)
- cold site: no link between temperature and sex – balanced sex ratio (GSD)

>>> What triggered the evolution of alternate sex determining mechanisms?

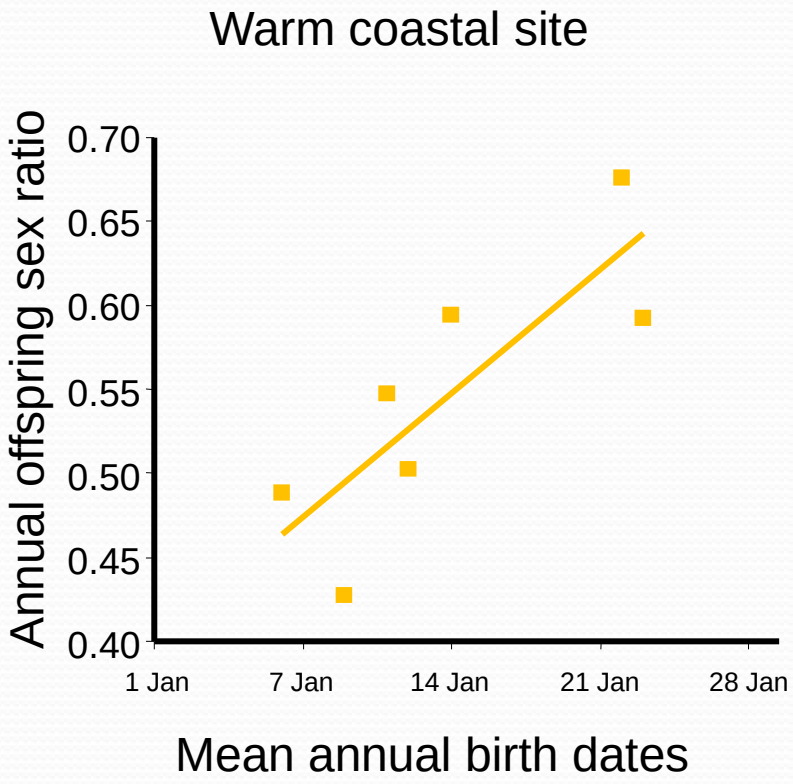
Individual-based simulation model

High variability in climate → Being born early benefits both sexes equally → Emergence of a gene of major effect → GSD



Low variability in climate → Being born early benefits one sex but not the other → Loss of gene of major effect – Evolution of adaptive reaction norms → TSD

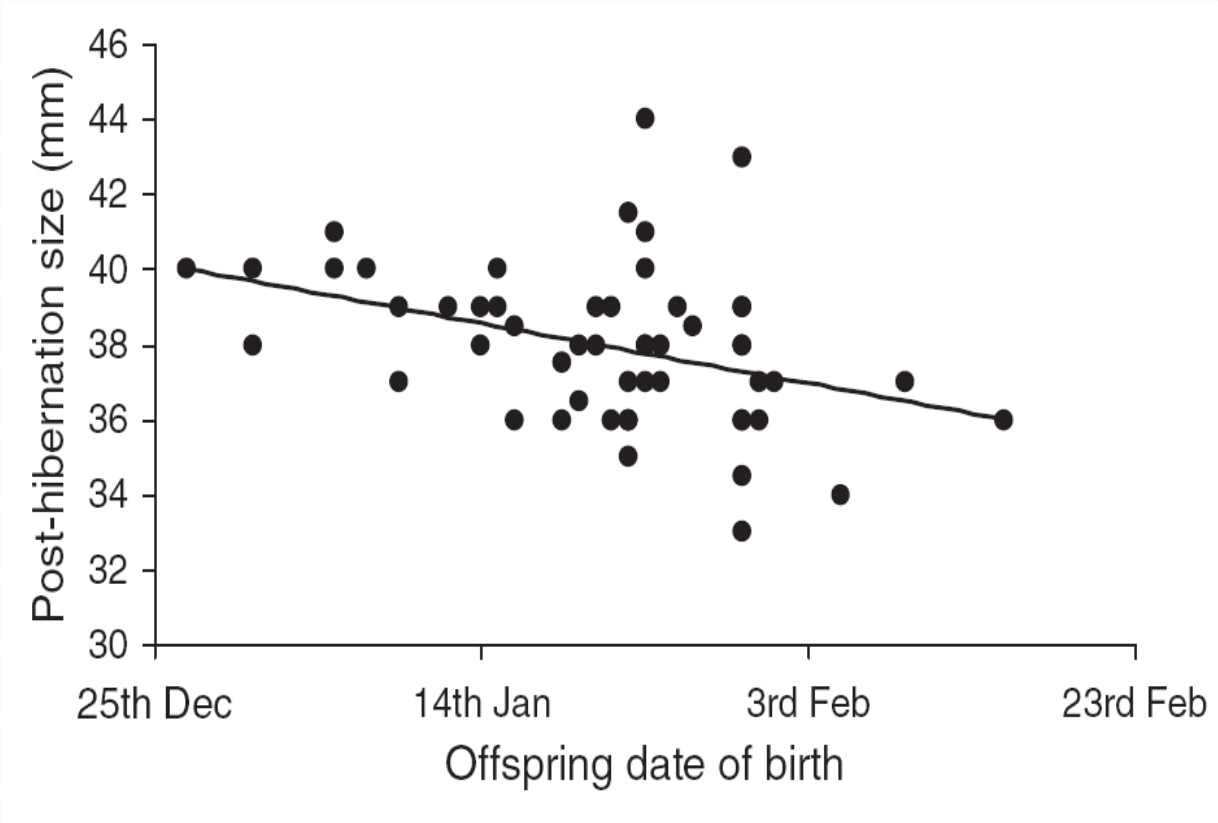
Why did TSD evolve?



More daughters early in the season
More males late in the season

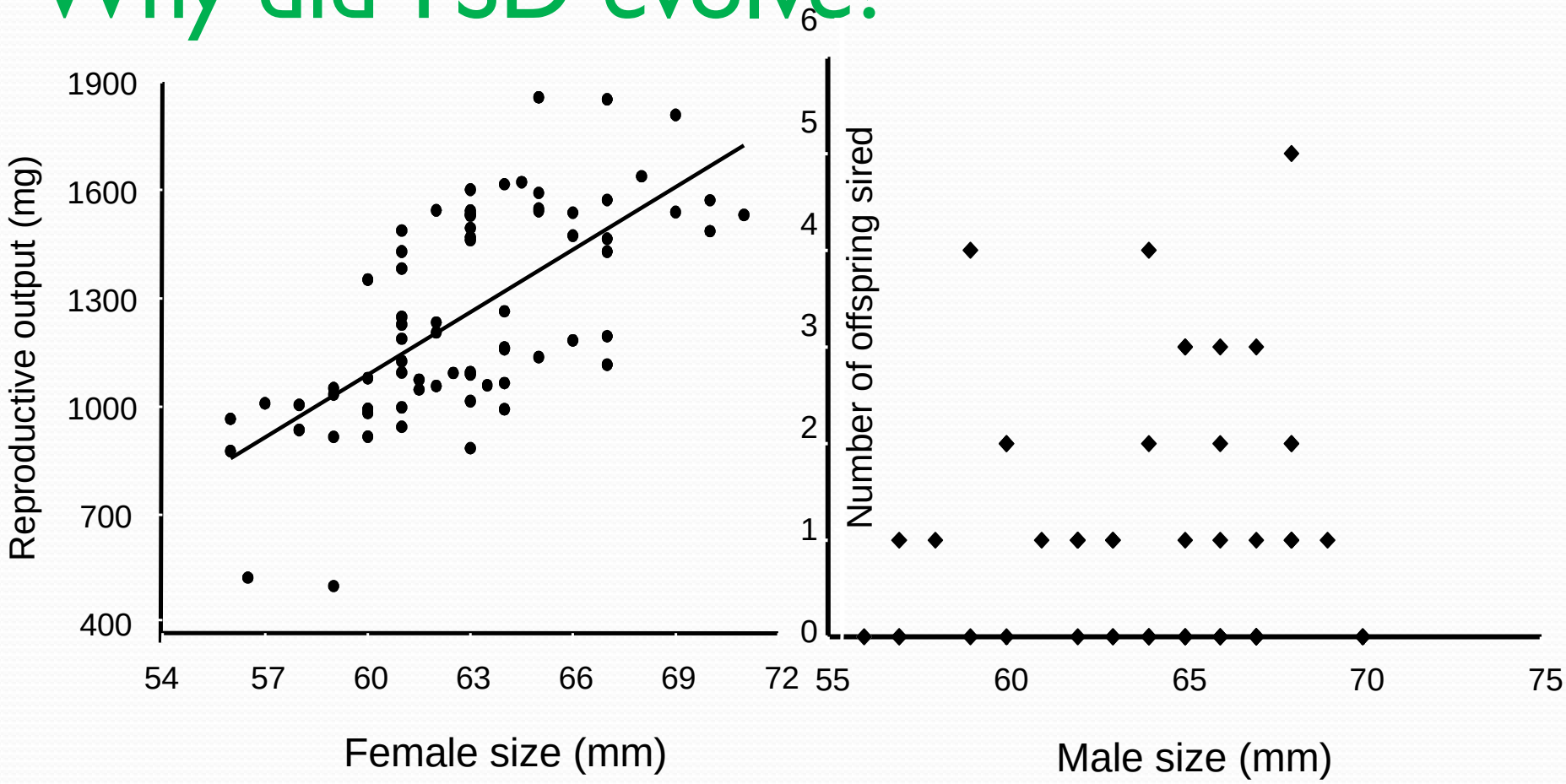
sex ratio is linked to birth date at the warm site...

Why did TSD evolve?



early born offspring become larger adults

Why did TSD evolve?

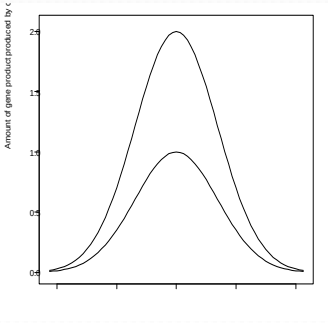


Reproductive output is <u>strongly</u> size-dependent in females…

…but not in males

Individual-based simulation model

High variability in climate → Being born early benefits both sexes equally → Emergence of a gene of major effect → GSD



Low variability in climate → Being born early benefits one sex but not the other → Loss of gene of major effect – Evolution of adaptive reaction norms → TSD

Concluding remarks

- Some reptiles are predicted to go extinct as their climatic envelopes disappear.

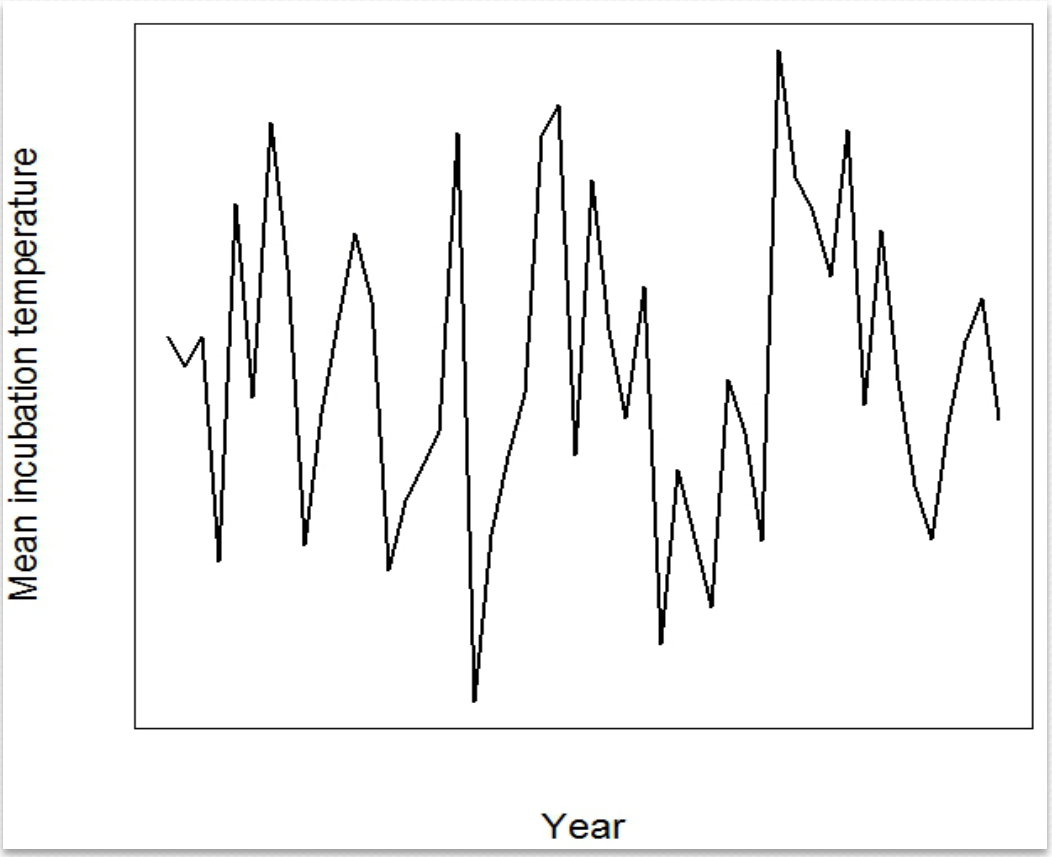
- But the spotted skink shows potential for adaptations to new climatic conditions: basking behaviour and sex determination mechanisms

- There is an evolutionary potential... but at what speed did evolution occur? Will evolution be quick enough with this rapid change in climate?

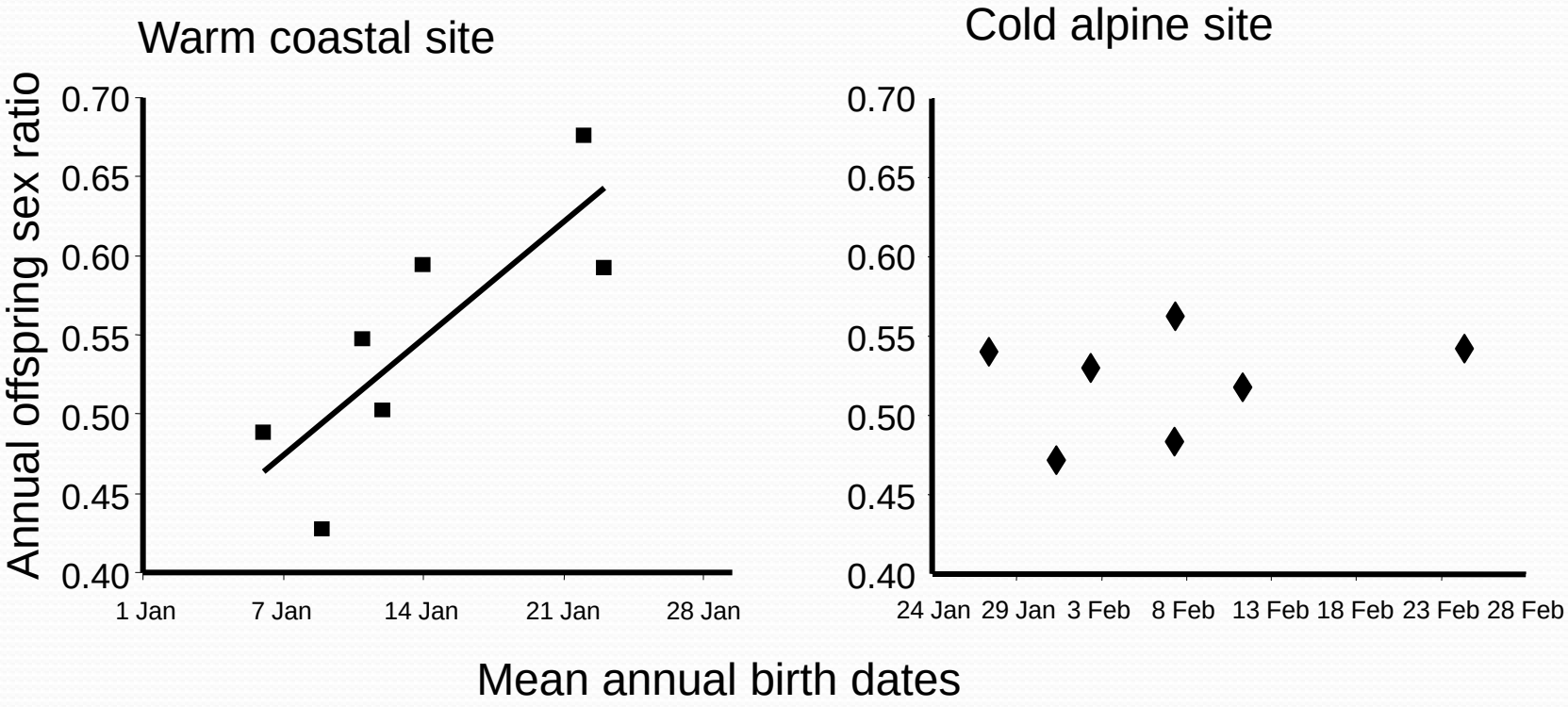
- If not then we will observe changes:
    - in phenology (e.g. dob)
    - in physiology (e.g. offspring mass, sex ratio)
    - in distribution (extinction?)


Thank you

Why GSD in the mountain populations?

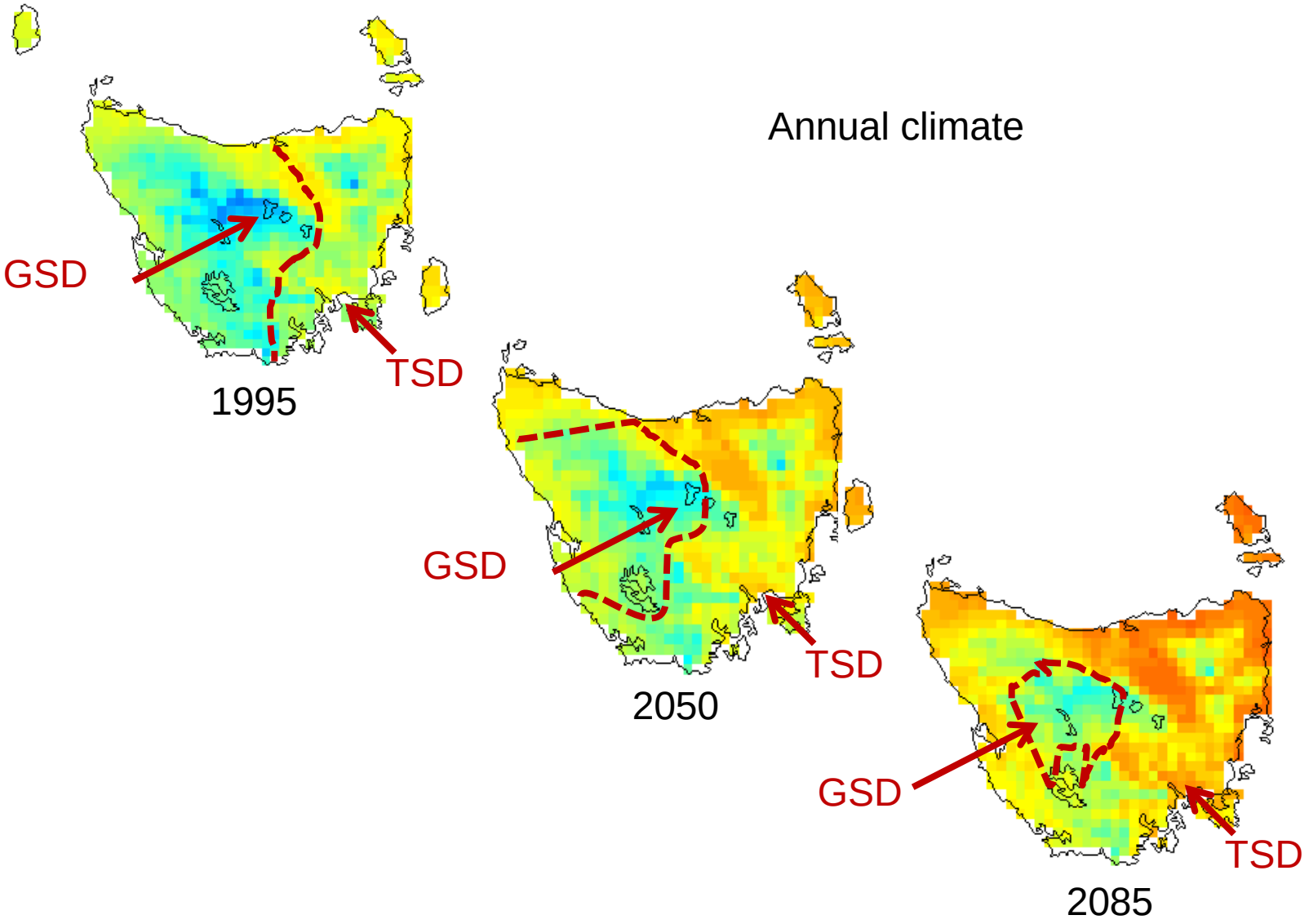


Why GSD in the mountain populations?

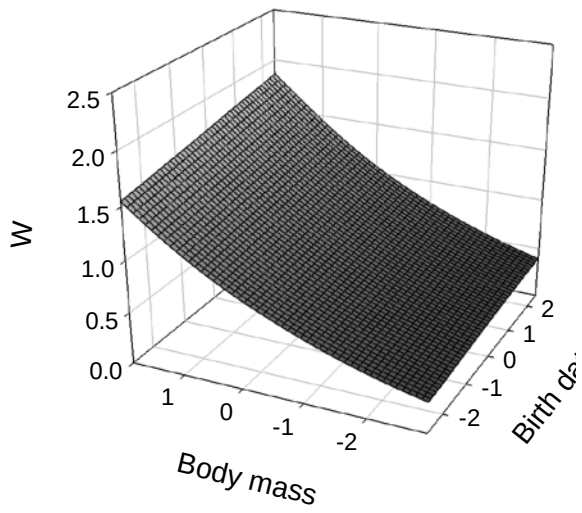


Date of birth is not linked to sex ratio at the cold site

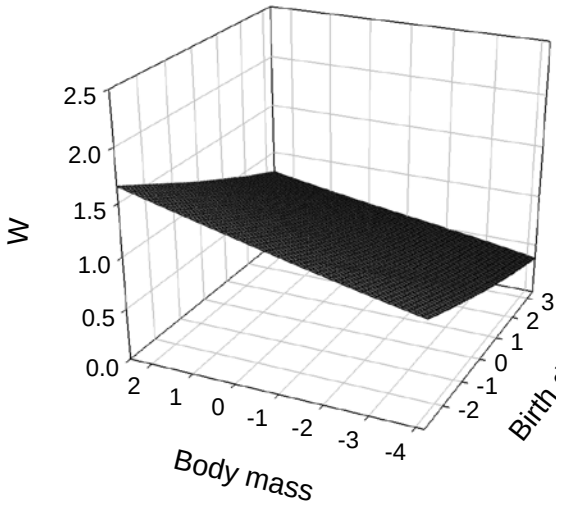
TSD-GSD


Annual climate
GSD
TSD
1995
GSD
TSD
2050
GSD
TSD
2085
25
20
15
10
5

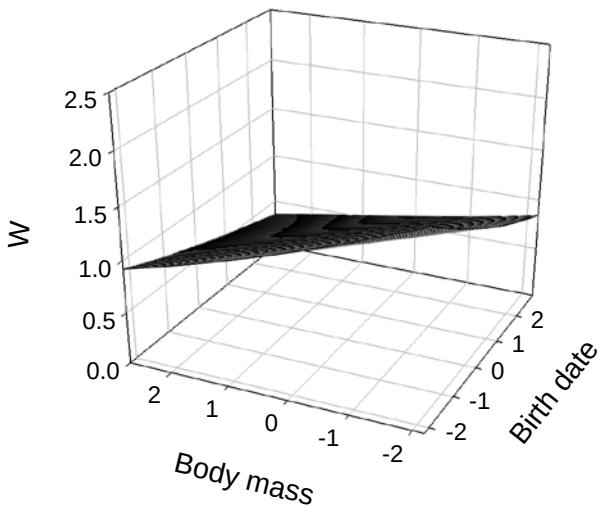
Lowland 2000



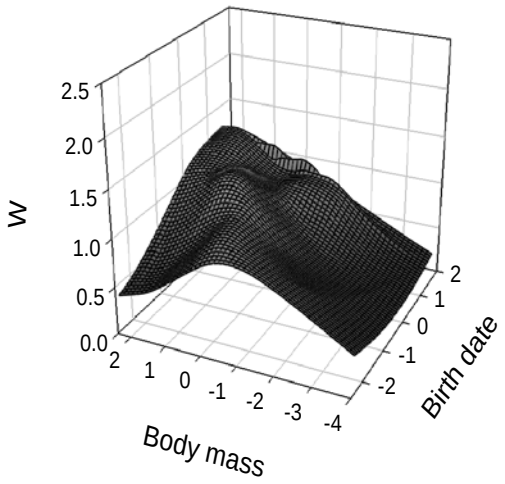
Lowland 2001



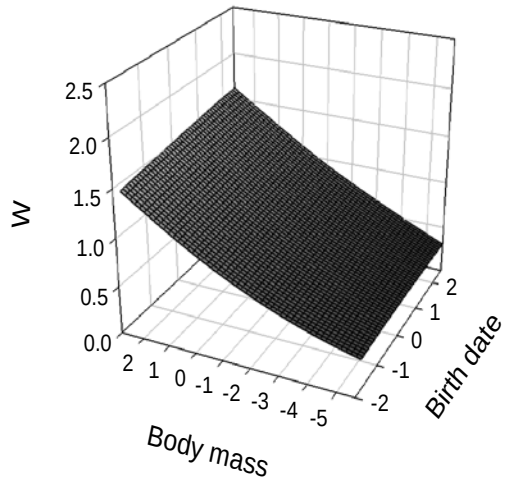
Lowland 2007



Highland 2000



Highland 2001



Highland 2007