



Sensitivity analysis for an avian reproductive toxicology model

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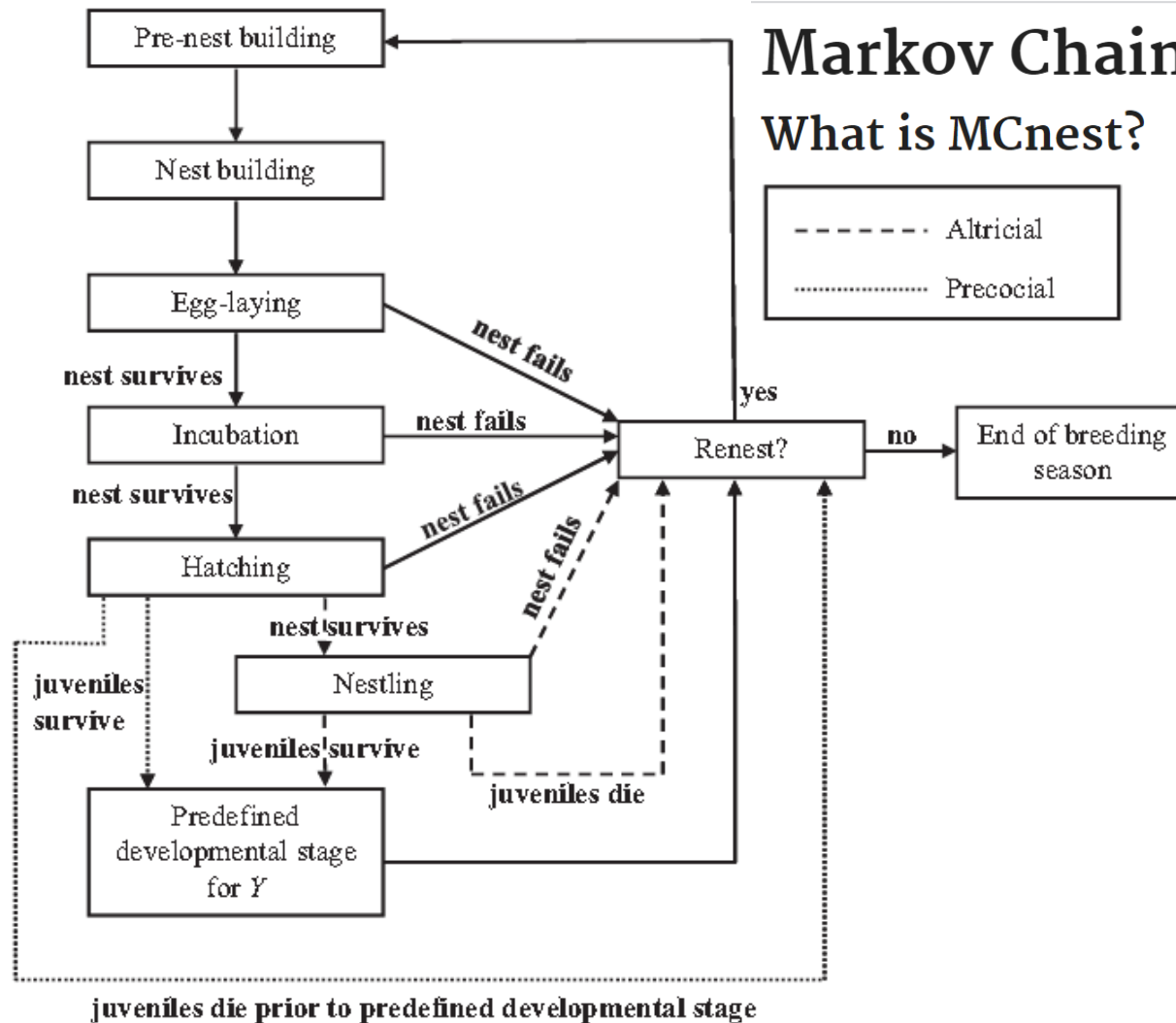
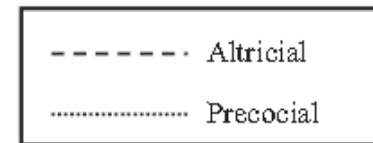


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Markov Chain Nest Productivity Model

What is MCnest?



Parameter

Type

Adult mortality

probability

Nest failure

probability

Brood failure

probability

Egg development

duration

Clutch size

egg count

Egg laying interval

duration

Incubation duration

duration

Nestling duration

duration

Renest int (fail)

duration

Renest int (fledge)

duration

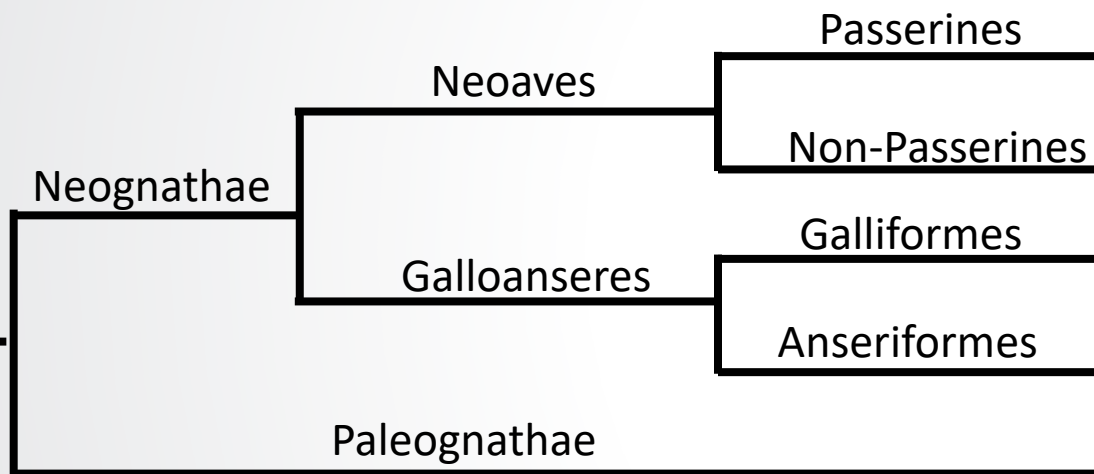


We test a limited & biased subset of species

Avian phylogeny and species names from:

<https://www.worldbirdnames.org/>

Toxicity test results from: <https://cfpub.epa.gov/ecotox/>



Orders	This Analysis	Species	Toxicity Results
1	46	6,456	1,695
32	15	3,952	627
1	7	300	26,980
1	6	177	7,222
5	0	60	0



Precocial – Altricial spectrum

Precocial

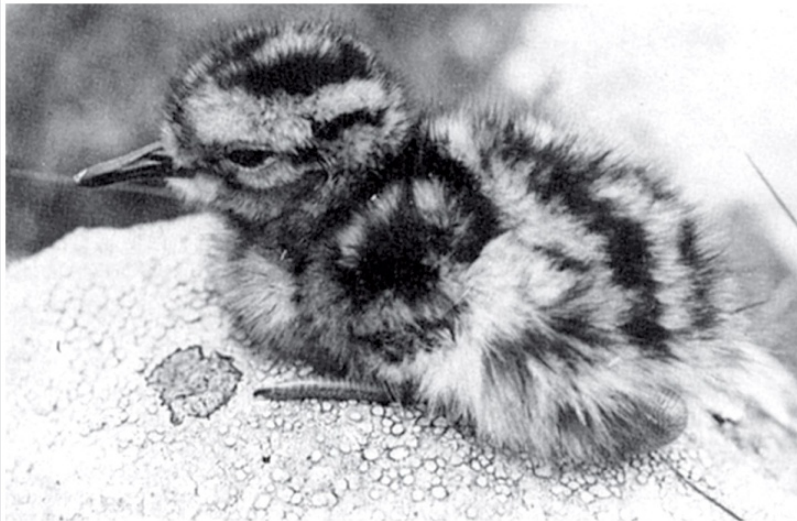


Figure 16-2f
Ornithology, Third Edition
© 2007 W. H. Freeman and Company

Eyes open

Capable of movement/swimming

Dense downy feathers

Endothermic

Capable of feeding

Leave nest immediately

Figures from Gill. 2007. Ornithology 3rd Ed.



Superprecocial

Precocial 3

Precocial 2

Precocial 1

Semiprecocial

Semialtricial

Altricial 1

Altricial 2

Classification from Starck. 1993.
Current Ornith.

Altricial

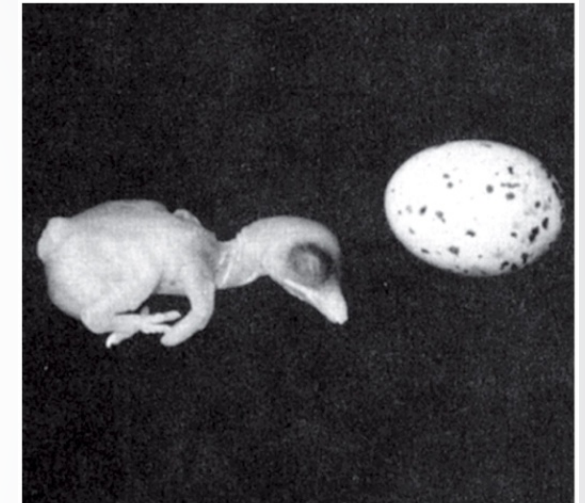


Figure 16-2a
Ornithology, Third Edition
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Eyes closed

No locomotory control

No feathers

Ectothermic

Must be fed

Remain in nest



MCnest sensitivity analysis - Methods

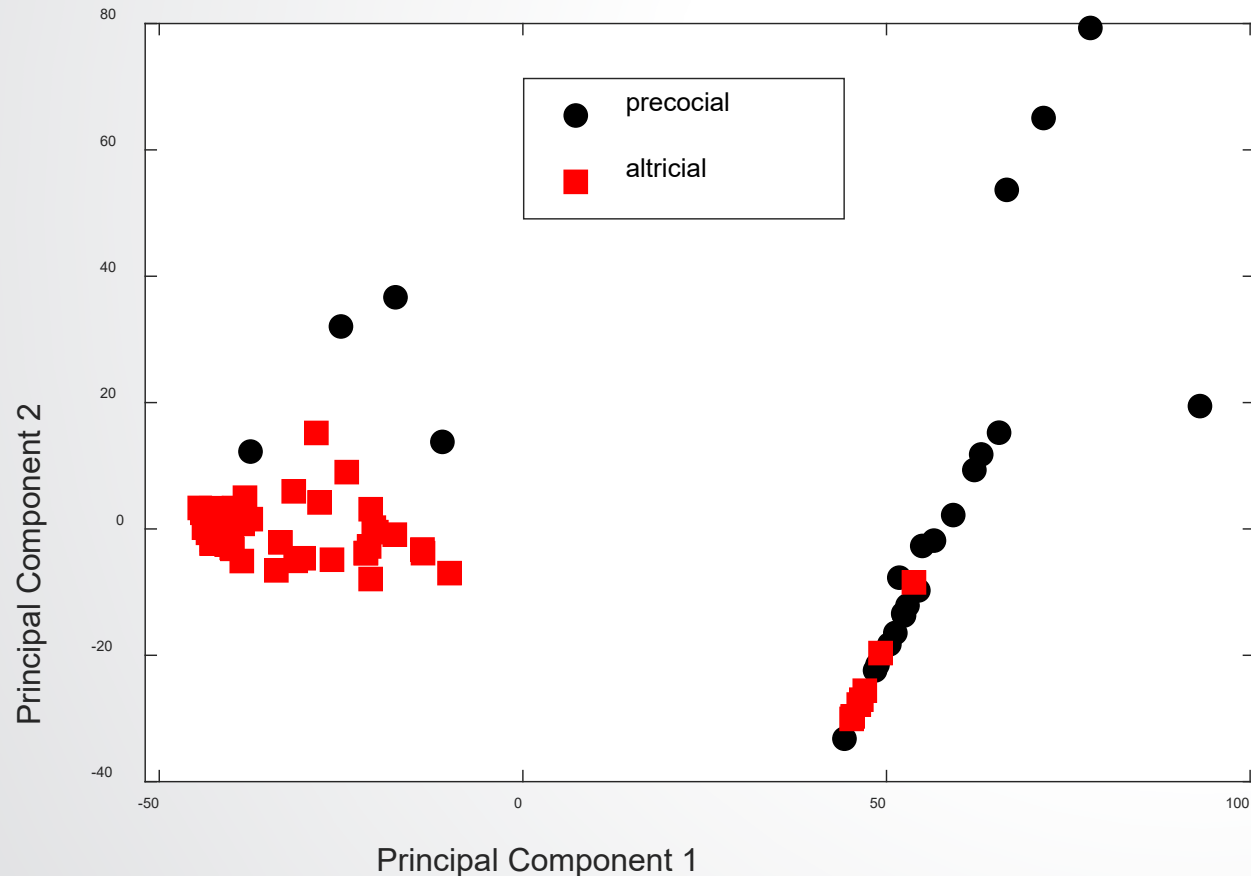
- 74 Species (24 precocial)
- Principal Component Analysis
 - % variance explained
 - Plot scores
- Local (one-at-a-time) sensitivity analysis
 - Response = fledglings/female/season
 - 1% & 10% perturbation
 - Examine sensitivity & elasticity
- Global sensitivity
 - Response = broods/female/season
 - Simultaneous perturbation of all parameters
 - View scatter plots

<i>Parameter</i>	<i>Type</i>
Adult mortality	probability
Nest failure	probability
Brood failure	probability
Egg development	duration
Clutch size	egg count
Egg laying interval	duration
Incubation duration	duration
Nestling duration	duration
Renest int (fail)	duration
Renest int (fledge)	duration



Principal Components Analysis

- 90% of variance explained by PC1 & PC2
- First principal component splits altricial v precocial birds



<i>Parameter</i>	<i>Type</i>
Adult mortality	probability
Nest failure	probability
Brood failure	probability
Egg development	duration
Clutch size	egg count
Egg laying interval	duration
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Renest int (fail)	duration
Renest int (fledge)	duration



Local Sensitivity Analysis (1% perturb.)

Precocial

Altricial

Sensitivity

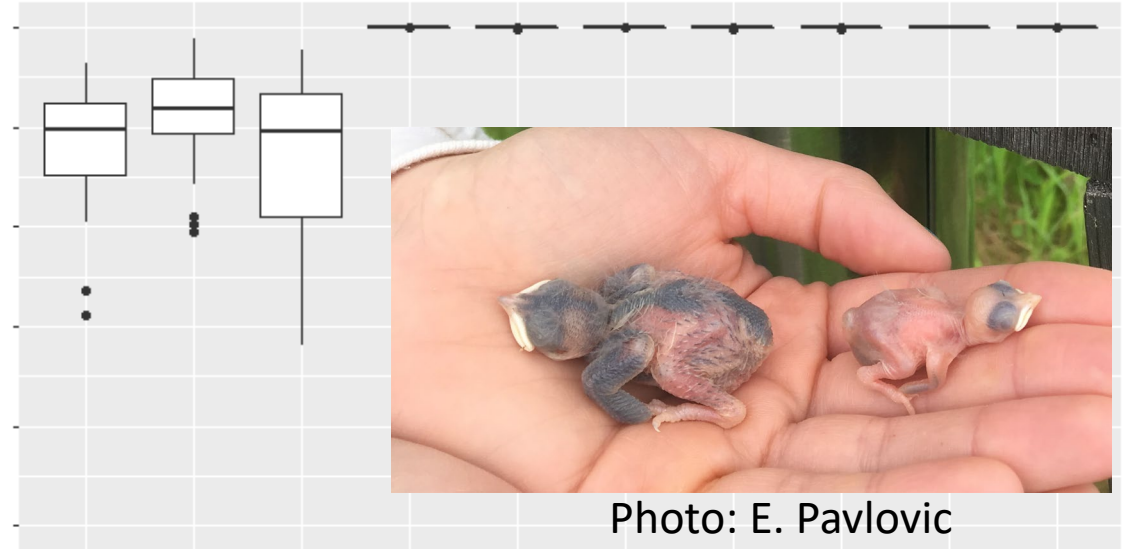
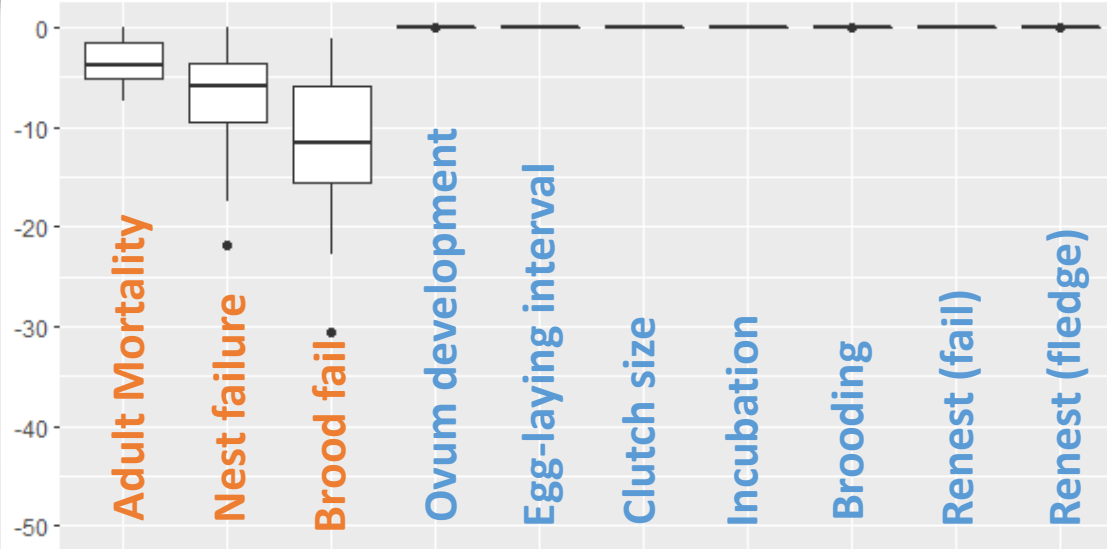


Photo: E. Pavlovic

Elasticity

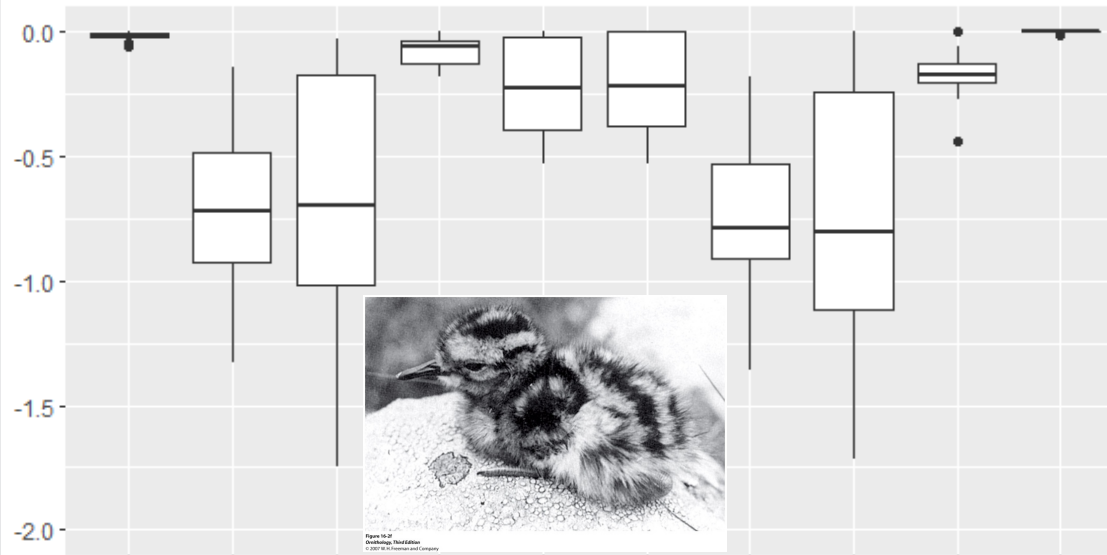
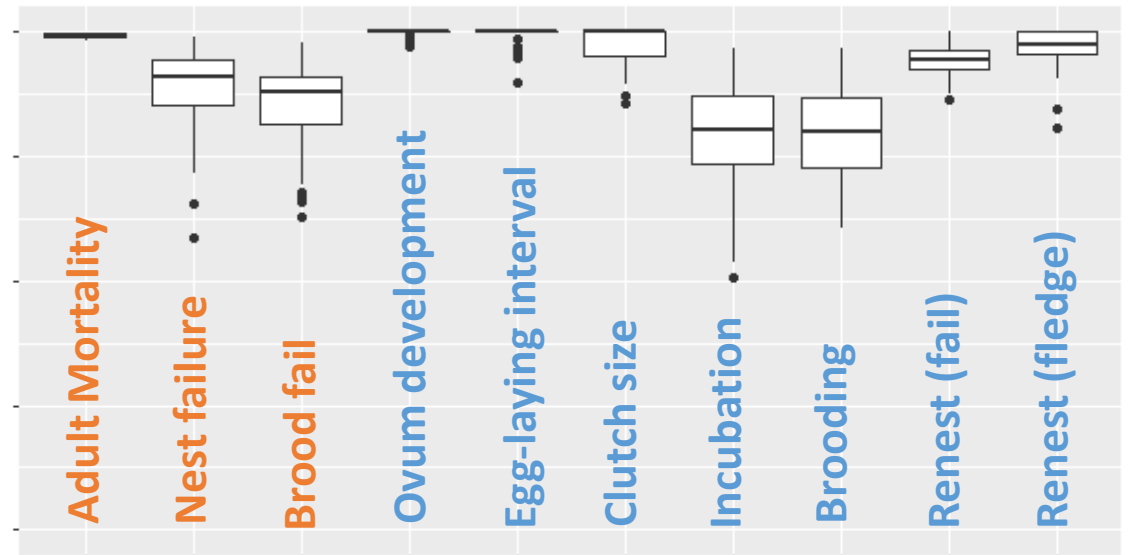
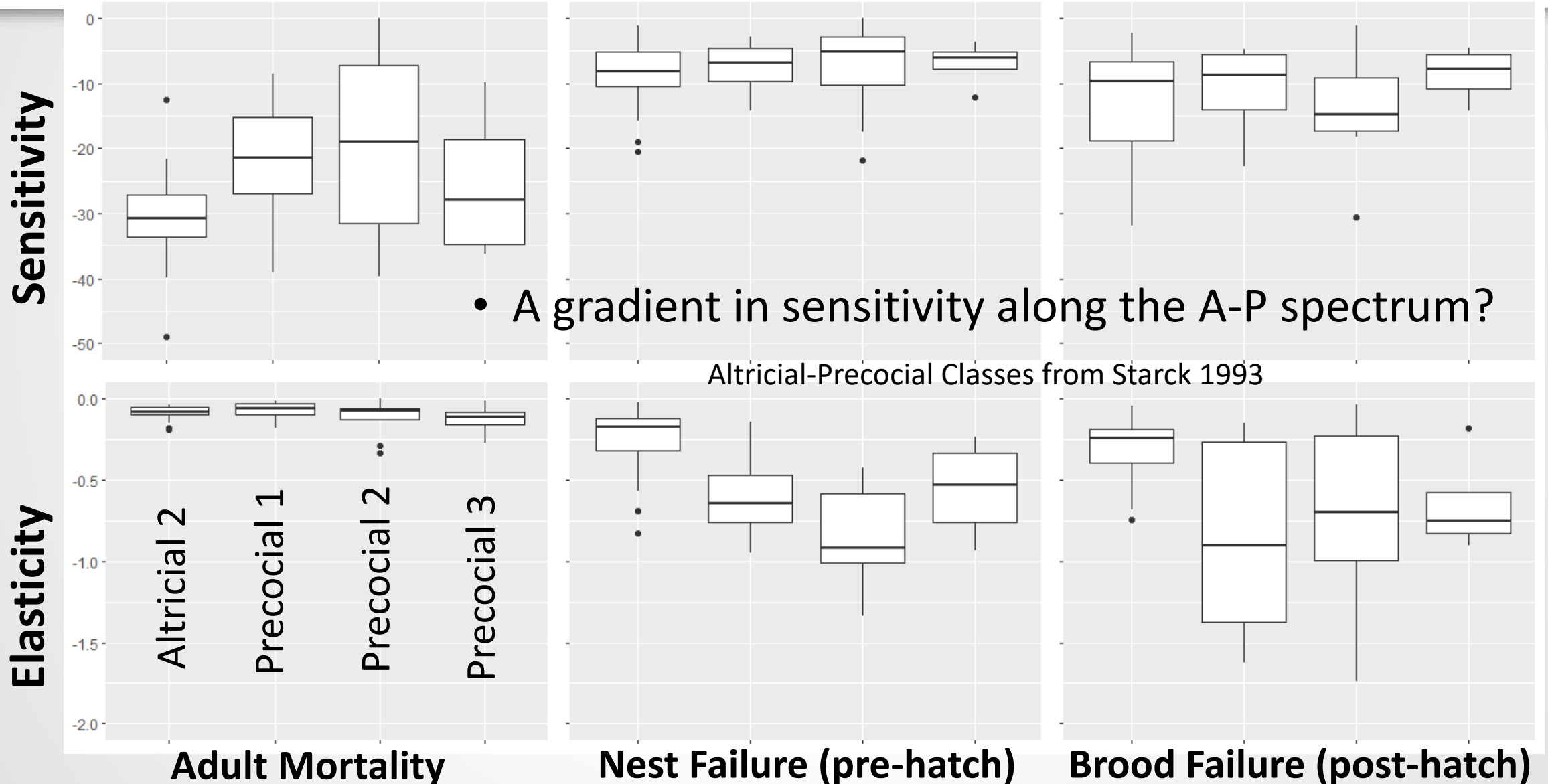


Figure 10-20
Benthic Invertebrates
© 2010 by the National Academy of Sciences

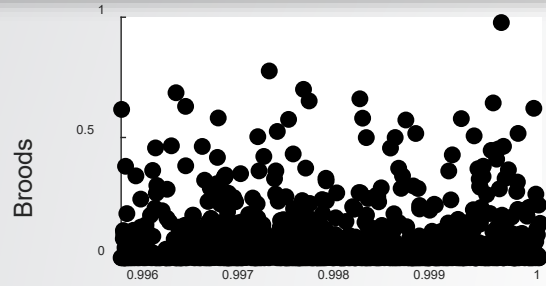




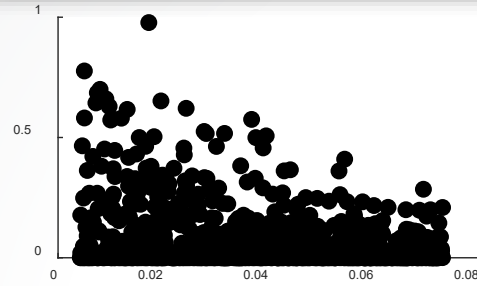
Local Sensitivity Analysis (1% perturb.)



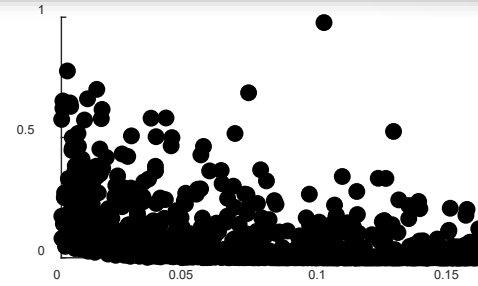
Global Sensitivity Analysis



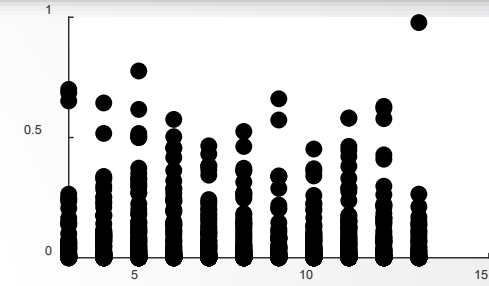
Adult Mortality



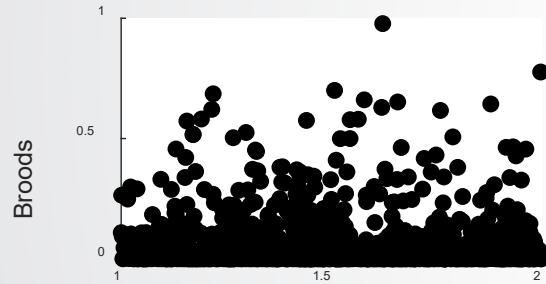
Nest Failure



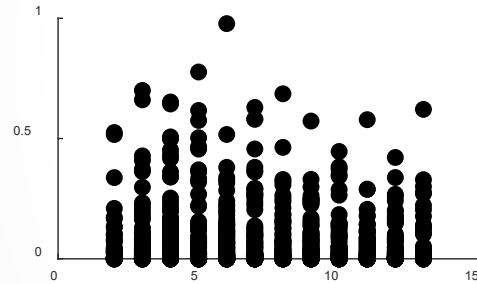
Brood Failure



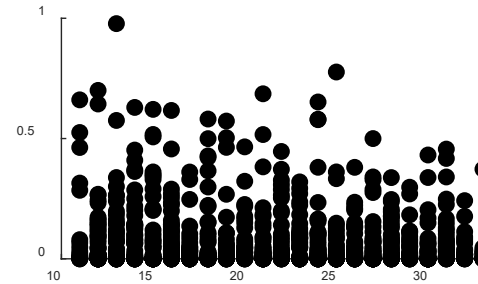
Ovum Development



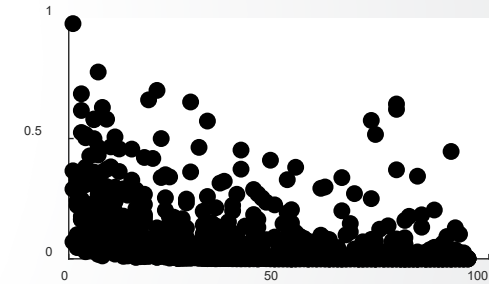
Egg-laying Interval



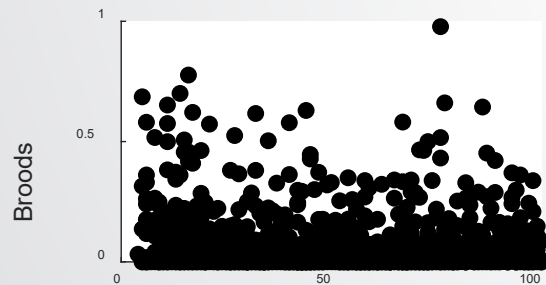
Clutch Size



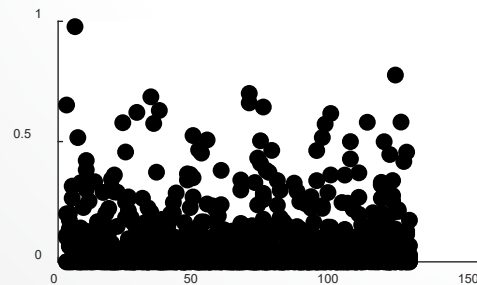
Incubation



Brooding



Renest (fail)



Renest (fledge)

- Effects of **Nest Failure** and **Brood Failure** similar to local sensitivity
- Effects of **Adult Mortality** minimal

- Principal Components Analysis (10 reproductive parameters)
 - 90% of variation explained by PC1 and PC2
 - PC 1 strongly correlated with Altricial-Precocial dichotomy
- Local Sensitivity
 - Reproductive success is more sensitive to **transition probabilities** than **developmental durations**
 - Sensitivities to **transition probabilities** *may* show a gradient across Altricial-Precocial spectrum
- Global Sensitivity
 - **Nest Failure** and **Brood Failure** similar to local sensitivity
 - Similarity in **Adult Failure** during breeding minimizes global sensitivity



EPA is planning to reduce/eliminate vertebrate testing

News Releases from Headquarters > Chemical Safety and Pollution Prevention (OCSPP)

EPA Takes Important Step to Reduce Unnecessary Animal Testing

Agency releases final guidance intended to reduce pesticide testing on birds while ensuring continued protection of public health

02/19/2020

Office of Pesticide Programs Update



EPA Continues Efforts to Reduce Animal Testing, Announces Guidance on Fish Testing

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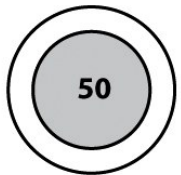
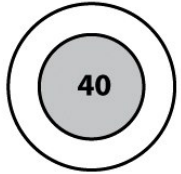
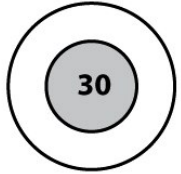
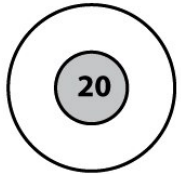
ISTOCK.COM/ UNOL

U.S. EPA to eliminate all mammal testing by 2035

By David Grimm | Sep. 10, 2019 , 6:00 PM

Maternal investment differs along A-P

Yolk Content (%)



Hatchling



Bohemian Waxwing



Aretic Tern



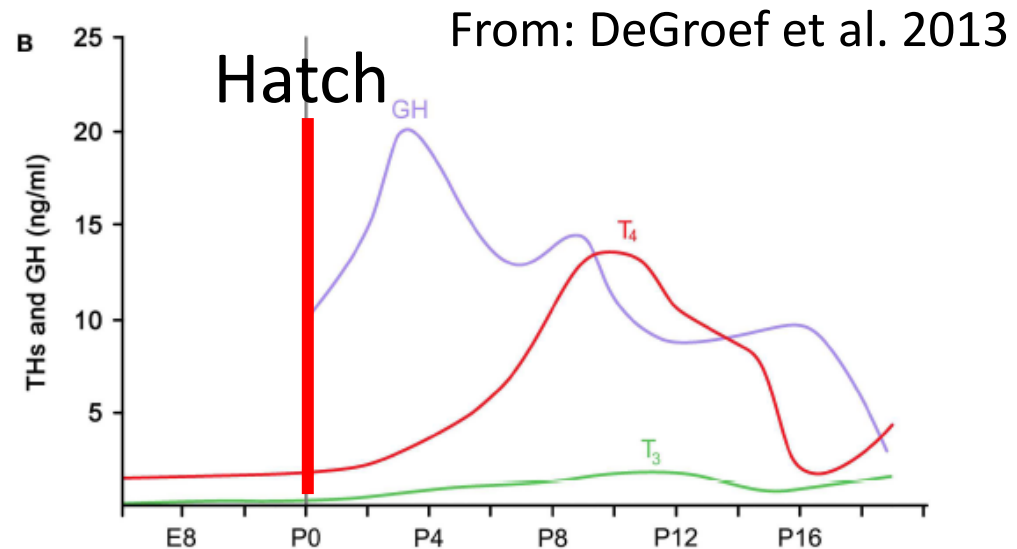
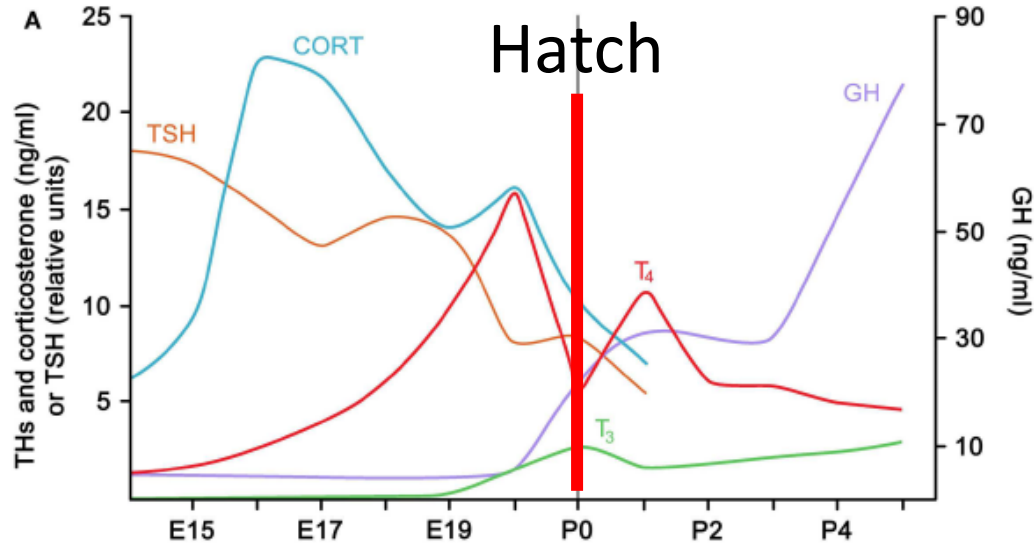
Ruddy Duck



Malleefowl



Brown Kiwi



- Model available here: <https://www.epa.gov/chemical-research/markov-chain-nest-productivity-model>
- Too few populations have complete datasets. Info needed on:
 - Renesting intervals (all birds)
 - Time to independence (especially precocial)
 - Post-hatch survival rates (especially precocial)
- Brood parasites, polygynous, polyandrous, & promiscuous birds do not fit well in this modeling framework