

Adaptation

Analysis of form and function

What is adaptation

- Trait, or set of related traits, that increases the fitness of the organism that has it
- Adaptations created by natural selection
 - Requires mutation (genetic variation)
 - Mutation itself not adaptive
 - Drift does not cause adaptation
 - Migration does not cause adaptation

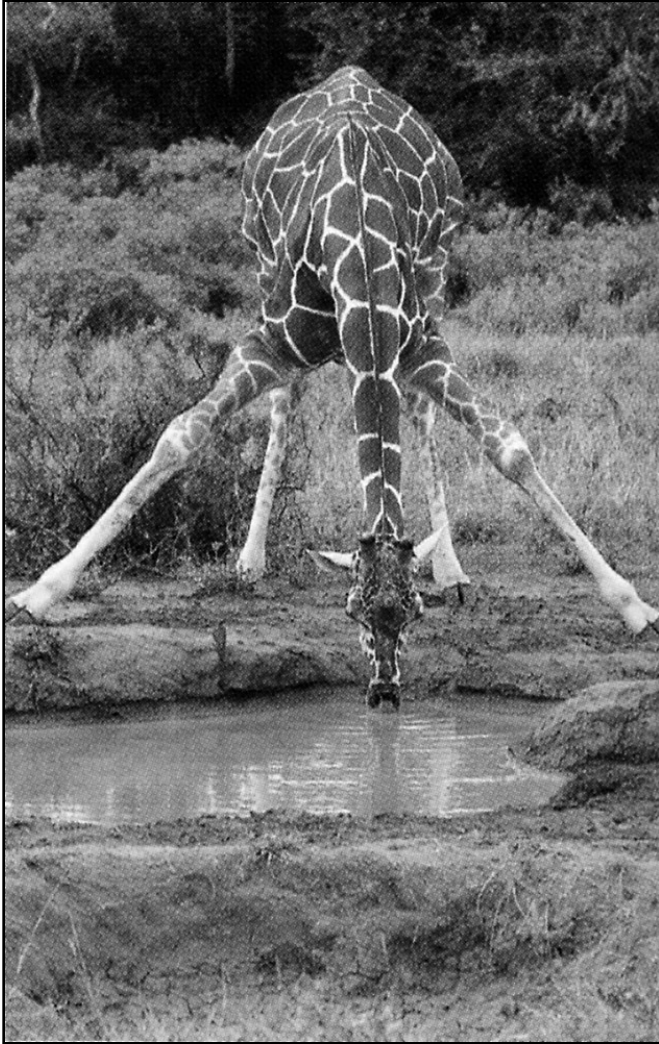
Testing adaptation

- Easy to say, trait X serves purpose Y
 - Giraffe necks
- Methods of testing adaptation
 - Observational
 - Experimental
 - Comparative
- Problems and considerations
 - Phenotypic plasticity
 - Origin of adaptive traits
 - Trade-offs and constraints

Why test adaptation: Giraffe necks



Giraffe necks have a cost



Therefore, it is reasonable to assume there is a benefit that compensates.

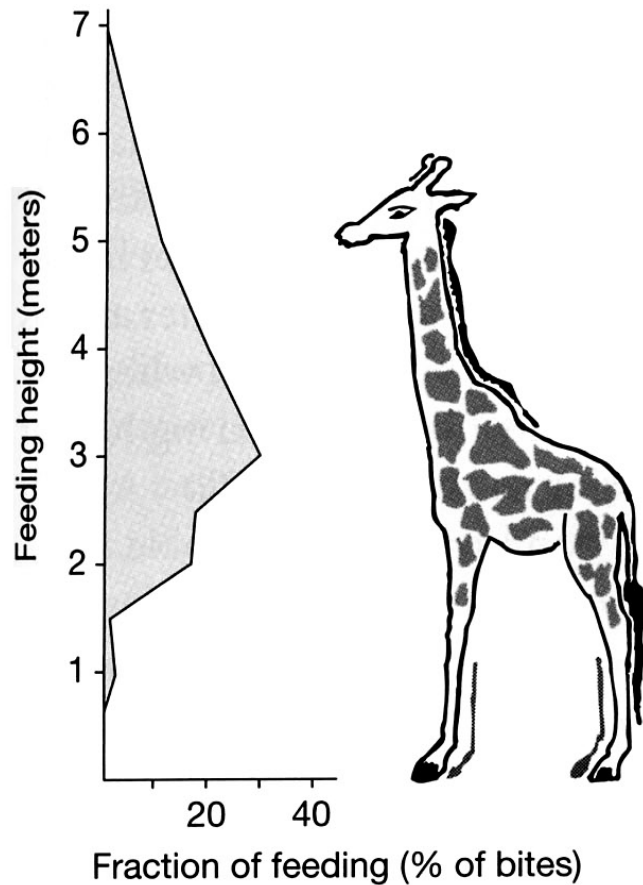
[If no benefit compensated, then natural selection would reduce neck length, and so reduce the cost.]

As everyone knows,

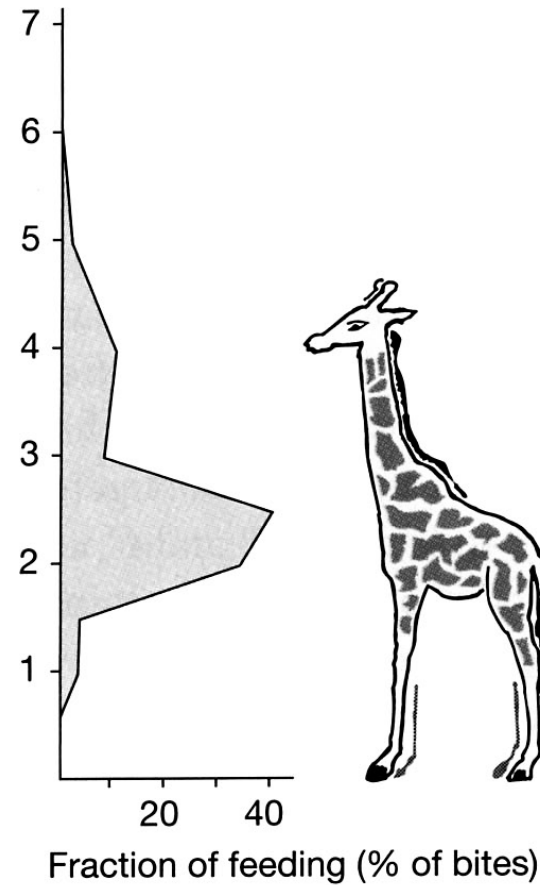
- Long necks enable giraffes to eat leaves way up high
- Predictions:
 - Forage above competitors height
 - Forage to maximum height

Giraffe forging in Kenya

Male giraffes feeding
in woodlands



Female giraffes feeding
in woodlands

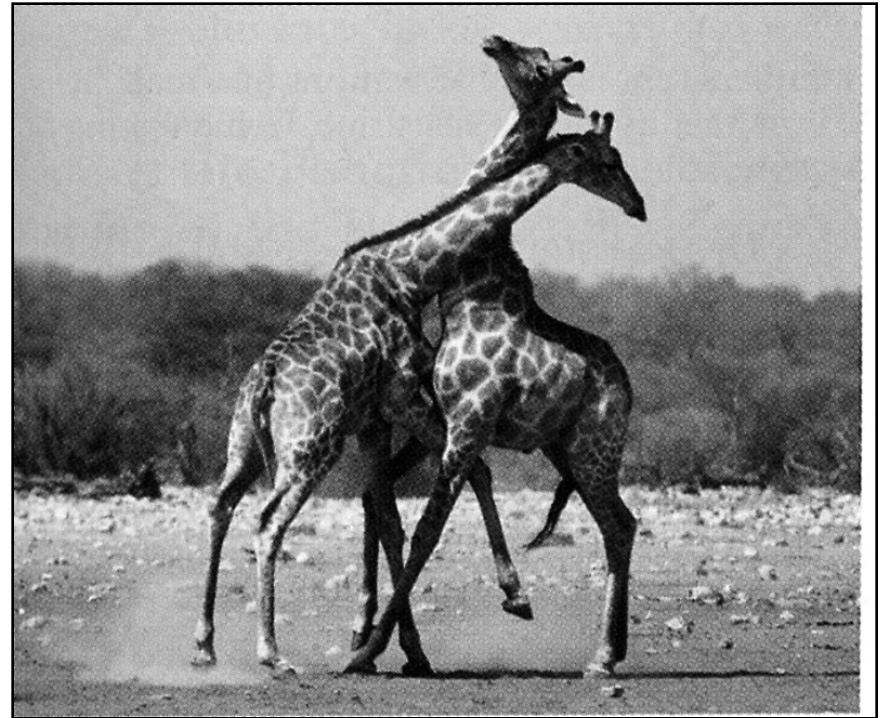


Data say

- Mostly do not forage above competitors height
- Mostly do not forage at maximum height
- Are there alternate explanations?

Neck dimorphism

- Males necks 30 - 40 cm longer and 1.7 times heavier than female necks of same age giraffes
- Males skulls 3.5 times heavier
- Males fight, occasionally to the death, using their heads and necks



Social Evidence

Table 8.1 Neck size and social interactions in giraffes

Males in class C are young adults; males in classes A and B are more mature. Class A males are often larger than class B males, but more importantly, class A males have stouter necks, more massive horns, and more heavily armored skulls.

(a) Neck size and male social interactions. These numbers represent observations of one male displacing another from a social group.

A displaces B, A displaces C, or B displaces C	A displaces A, B displaces B, or C displaces C	B displaces A, C displaces A, or C displaces B
82	39	6

(b) Neck size and female choice. These numbers represent observations of a male attempting to determine whether a female is in heat by tasting her urine. Urine testing of a female by a male requires the female's cooperation.

	Successful	Unsuccessful	% Successful
A bulls	34	22	60.7
B bulls	76	61	55.5
C bulls	45	89	33.6

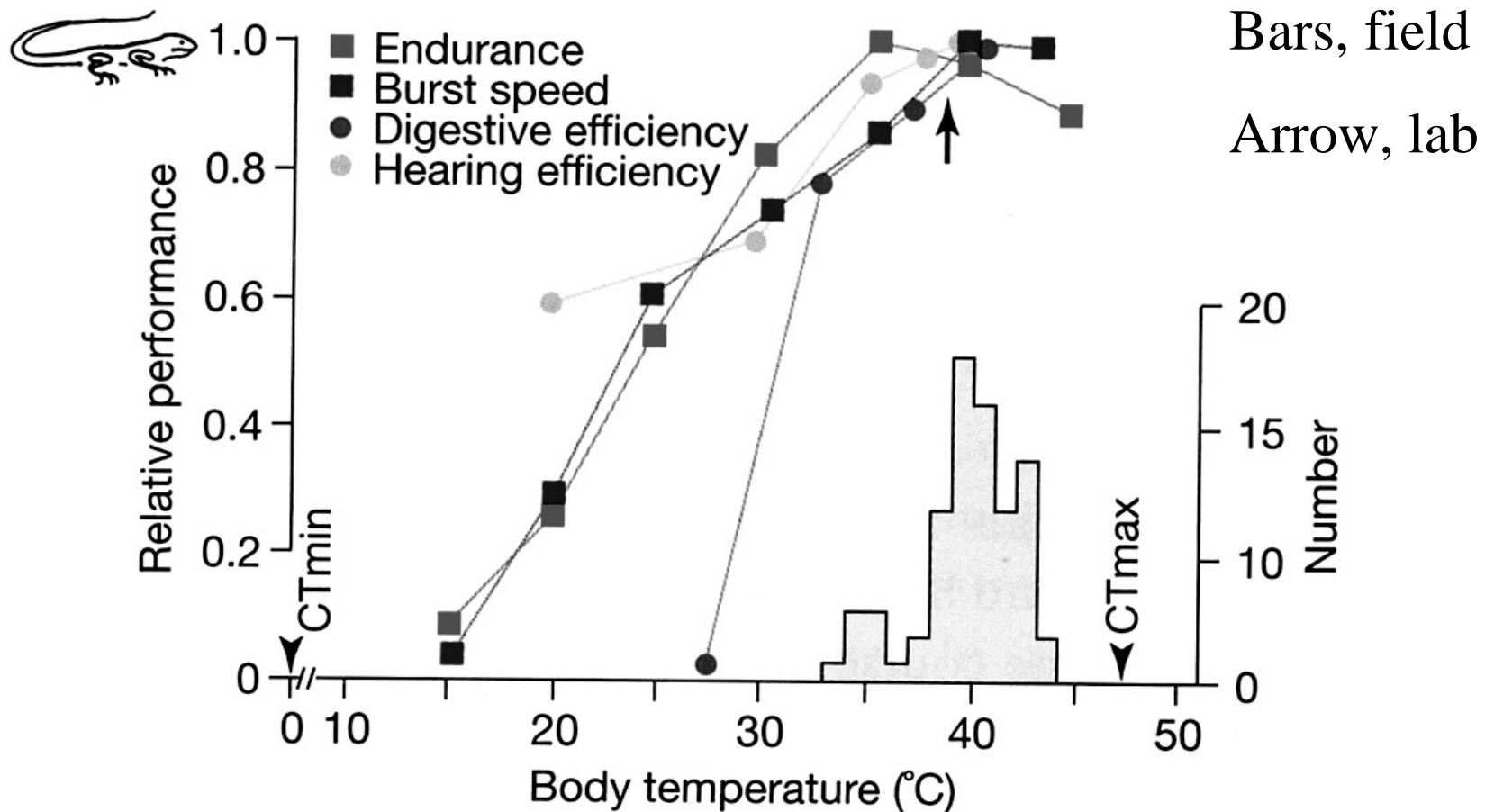
Testing hypotheses

- So perhaps giraffe necks evolved due to differences in success at mating, not differences in foraging success
- Maybe foraging advantage only seen in extreme drought years
- Point is this: without testing, adaptive scenarios are just stories

Observation

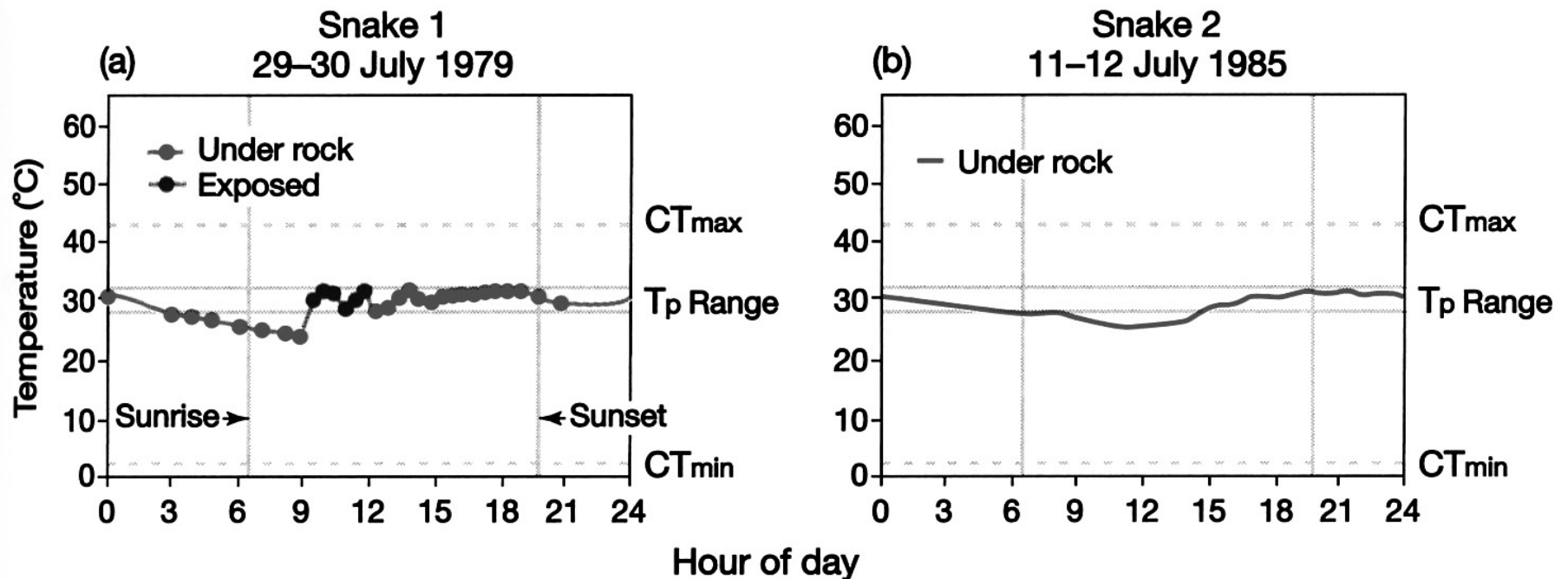
- Develop hypotheses and predictions
- See if natural variation matches predictions
- E.g., thermal preferences
 - Lizards
 - snakes

Temperature and physiological capability, *Dipsosaurus dorsalis*



Garter snake temperatures

- Do snakes keep their body temperature in the preferred range by selecting resting sites?

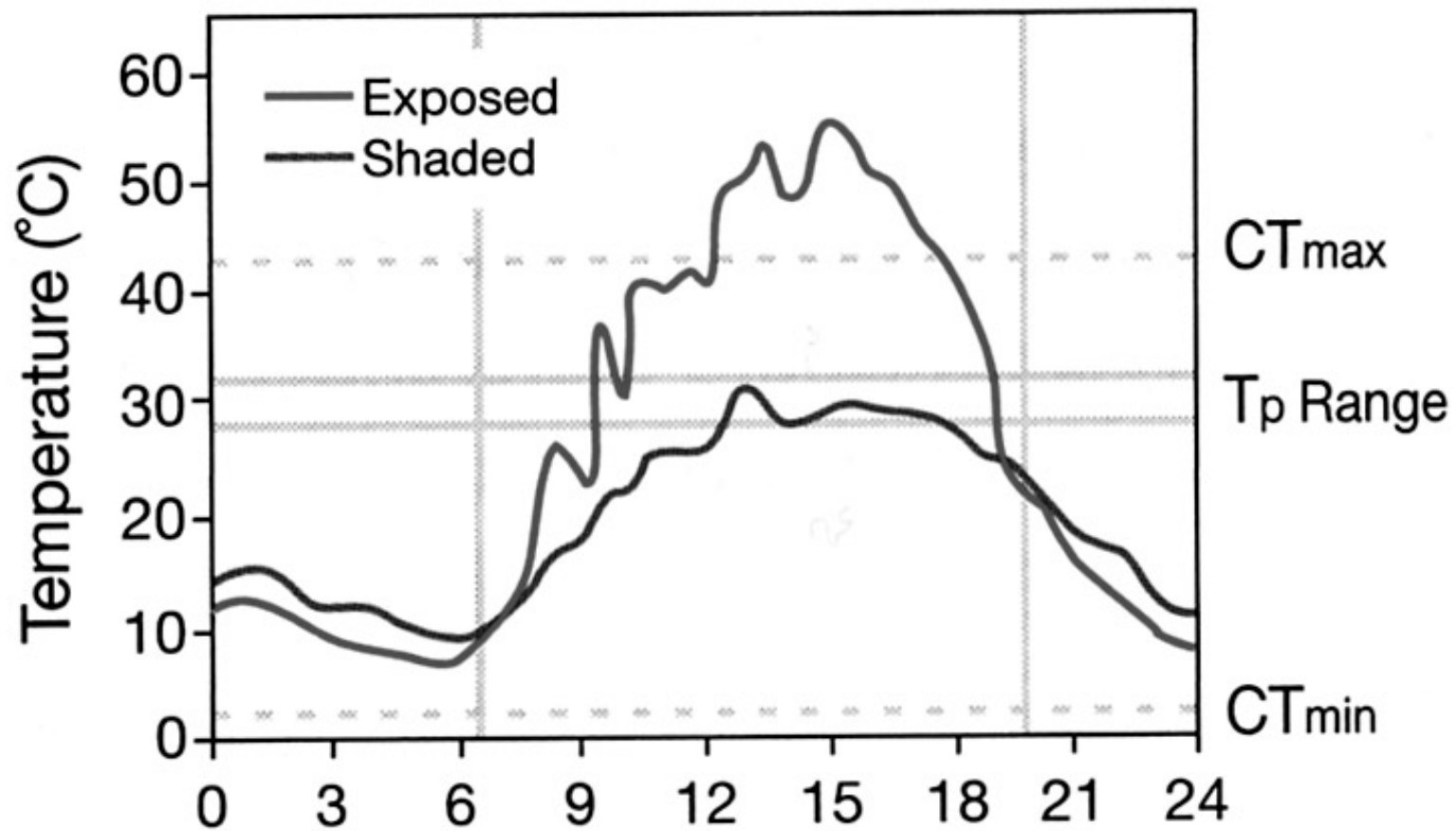


How to test?

- Could be that snakes just randomly select sites
- Need to compare the temperature regime snake actually gets with what it would get if it selected sites at random

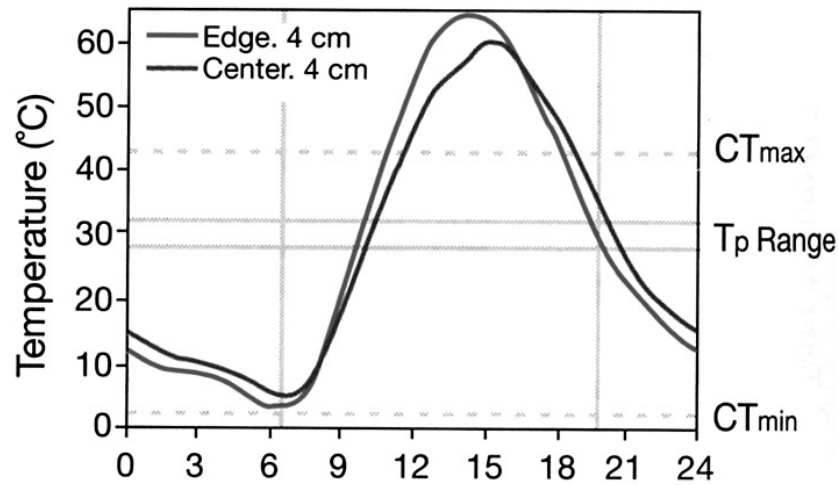
Snakes temperature if on surface

(e) Temperatures for a model on the surface

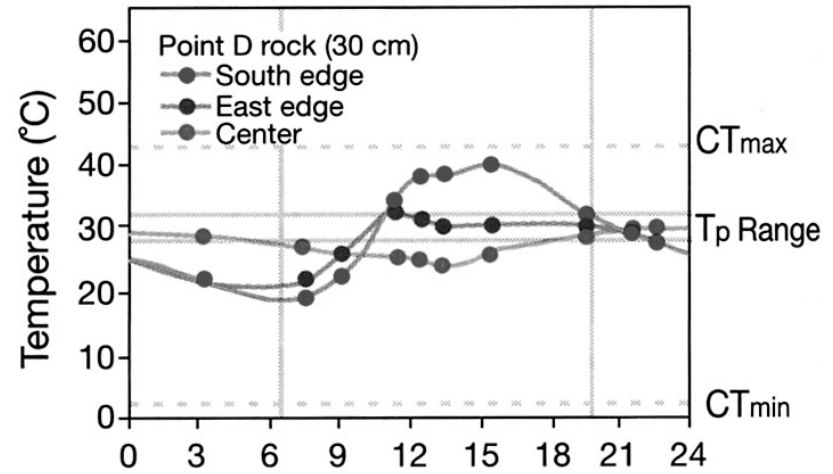


Temperatures under various rocks

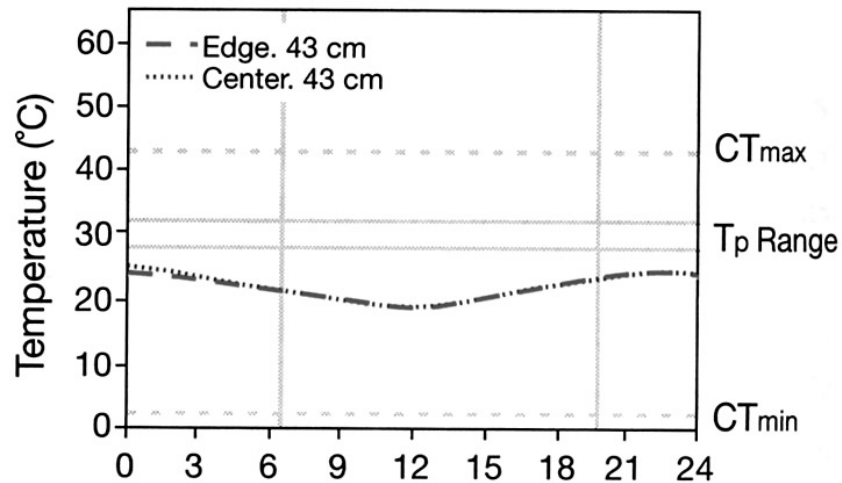
(a) Temperatures under a thin rock



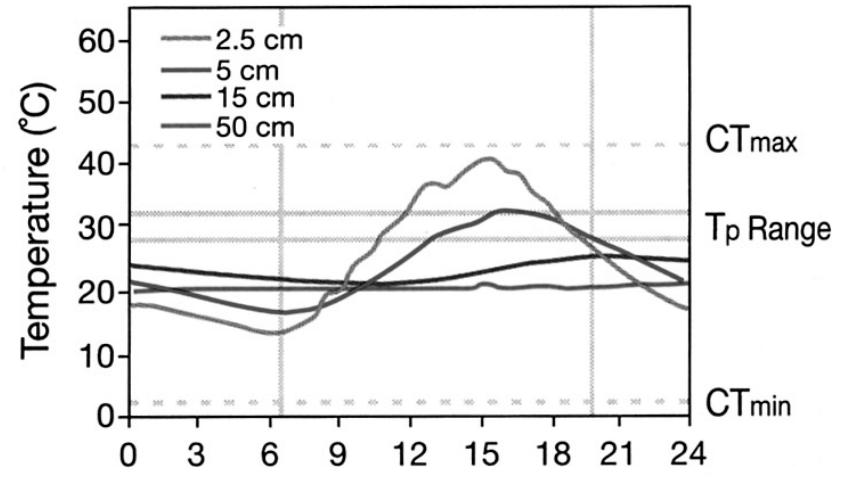
(c) Temperatures under a medium rock



(b) Temperatures under a thick rock



(d) Temperatures in a burrow



Compare observed with expected under null hypothesis (random)

Table 8.2 Distributions of rocks available to snakes versus rocks chosen by snakes

Thin, medium, and thick rocks are equally abundant at Eagle Lake, but garter snakes retreating under rocks at night show a strong preference for rocks of medium thickness ($P < 0.05$; chi-square test with thin and thick rocks combined because of small expected values).

	Thin (<20 cm)	Medium (20–40 cm)	Thick (>40 cm)
Rocks available to snakes	32.4%	34.6%	33%
Rocks chosen by snakes	7.7%	61.5%	30.8%

What is an even better way to test ideas?

- Conduct an experiment!
- Manipulate variable of interest, keeping other things the same
- E.g., wing markings on Tephritid fly *Zonosemata*

Spiders and flies



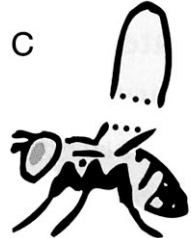
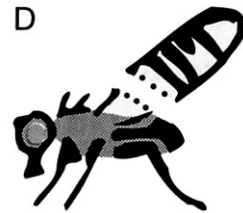



Salticid *Phidippus apacheanus* Tephritid, *Zonosemata vittigera*

Mimicry or intimidation?

Hypotheses, predictions

- H1: do not mimic jumping spiders
 - Other species of fly have markings, but not wave display
- H2: mimic spiders, deter other predators
- H3: mimic spiders, deter spider predation

	A	B	C	D	E
Treatment	 <i>Zonosemata</i> untreated	 <i>Zonosemata</i> with own wings cut and reglued	 <i>Zonosemata</i> with housefly wings	 Housefly with <i>Zonosemata</i> wings	 Housefly untreated
Purpose	Test effect of wing markings plus wing waving	Control for effects of operation	Test effect of wing waving without wing markings	Test effect of wing markings without wing waving	Test effect of no wing markings and no waving

Predictions under Hypothesis 1: No mimicry

Jumping spider will:	Attack	Attack	Attack	Attack	Attack
Other predator will:	Attack	Attack	Attack	Attack	Attack

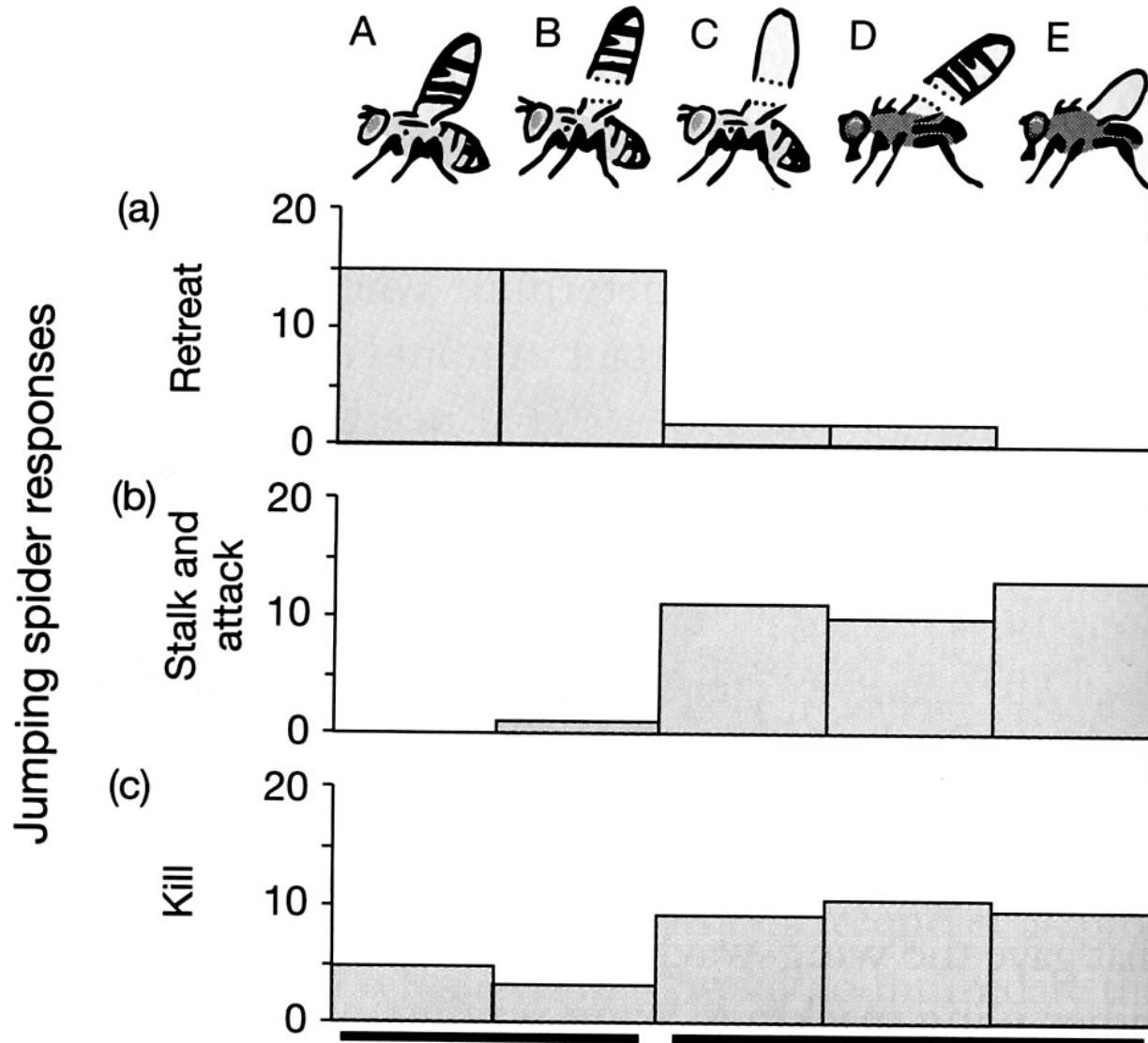
Predictions under Hypothesis 2: Mimicry deters other predators

Jumping spider will:	Attack	Attack	Attack	Attack	Attack
Other predator will:	Retreat	Retreat	Attack	Attack	Attack

Predictions under Hypothesis 3: Mimicry deters jumping spiders

Jumping spider will:	Retreat	Retreat	Attack	Attack	Attack
Other predator will:	Attack	Attack	Attack	Attack	Attack

Results were



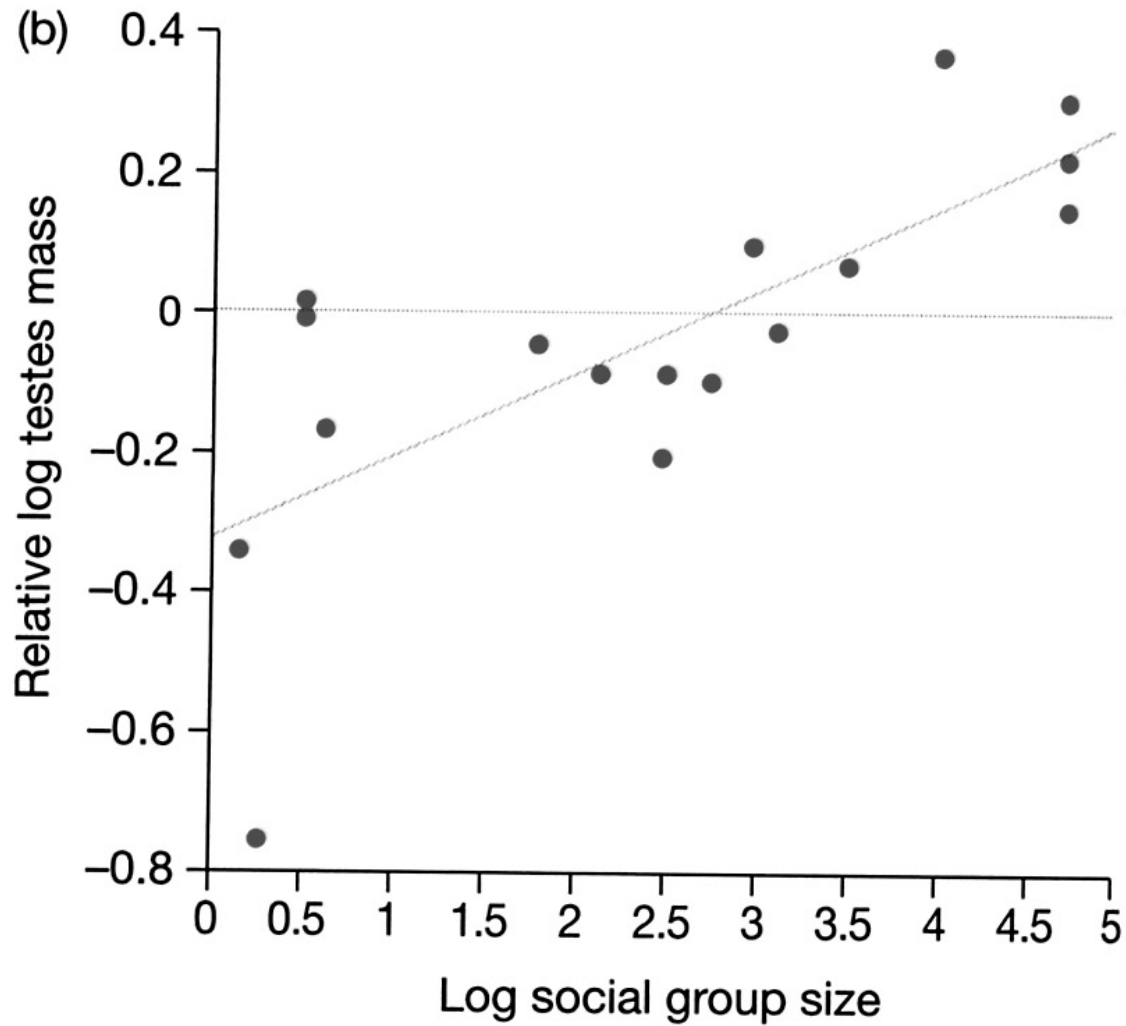
Experimental design

- Control groups
 - Manipulation per se no effect
- Standardization
 - All else held constant; randomization of order
- Replication
 - Random chance in small samples

Comparative studies

- Across species
- Across populations etc.
- Hypothesis might suggest comparative test
- E.g., bats and testes size
 - Larger testis = more sperm
 - Perhaps larger testes favored by more competition for fertilization

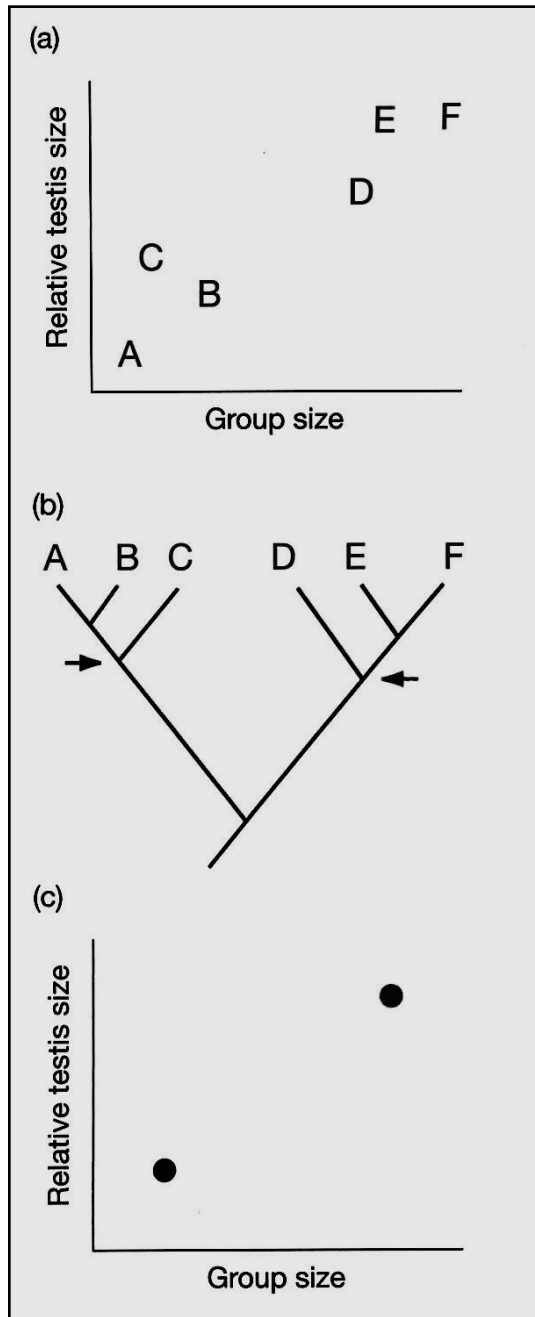
Comparative testis size in bats



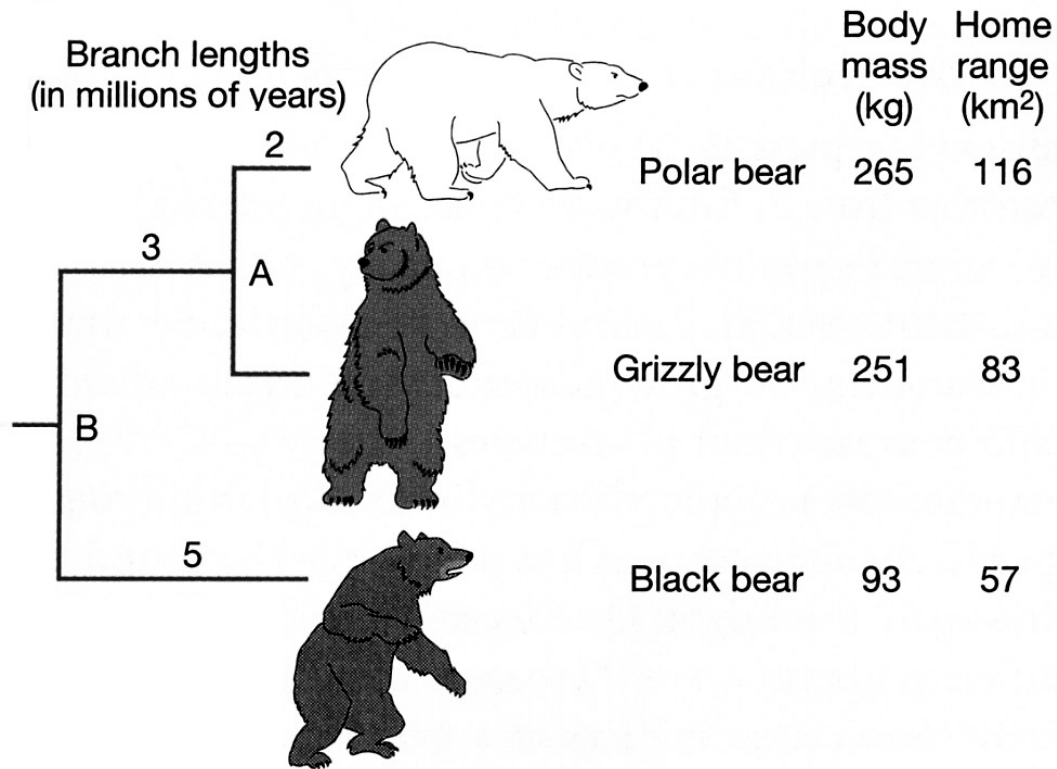
How good are those data?

- Recall that species are not independent
 - Evidence of evolution, shared ancestry
- What if the ones with big testes are all closely related?
- E.g., vertebrates, hair and milk

The independence problem

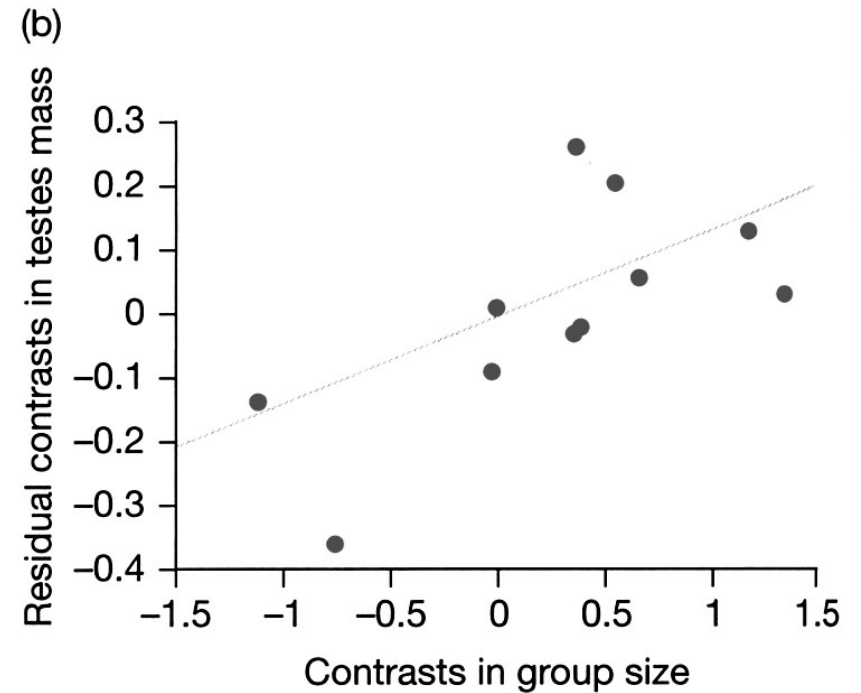
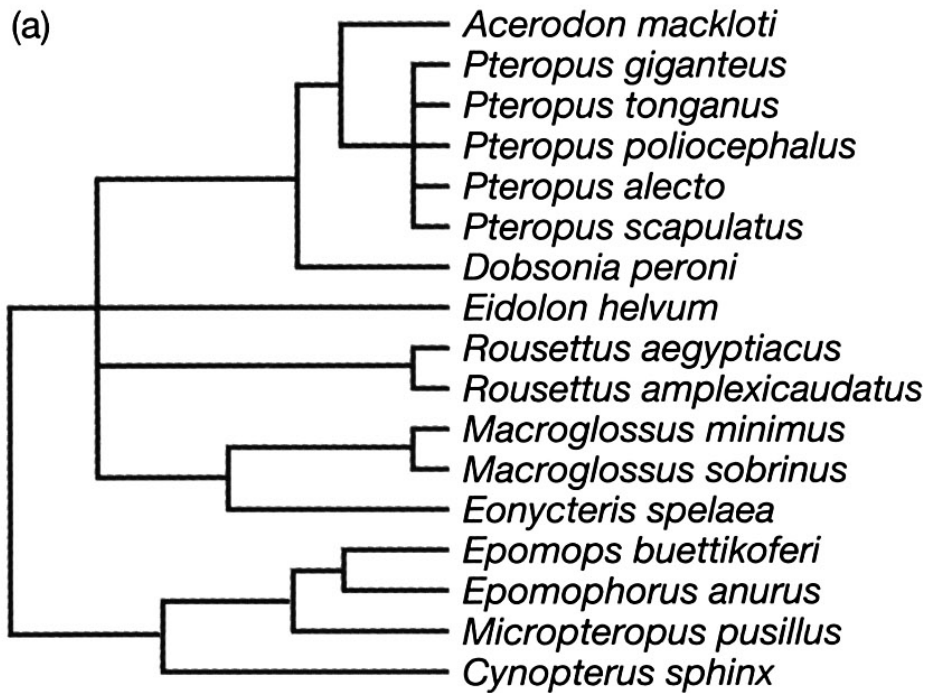


Independent contrasts



Species traits are NOT independent; but the *differences* between species are independent

Bat, testes size phylogenetic results



Major message

- In comparative studies species (or populations) are NOT independent points for analysis
- Phylogenetic differences (contrasts) between species are independent
- Can be used to test the correlated evolution of traits