Signal Costs and Constraints

- Costs to senders of signaling
- Costs to receivers
- Constraints on senders and receivers
- Transmission constraints
- Reading: Ch. 17

Peer evaluation of group projects

Please evaluate each member of your group with respect to the following criteria.

A. Rate each person's performance including your own on a scale of 0-3 with 0 being few if any contributions, 1, a marginal level of contributions; 2, a reasonable contribution level; and 3, above expectations level of contribution.

B. In the space marked points distribution assign a maximum of 10 points to each member, including yourself. The points each member receives should reflect his/her overall contribution to the project.

Member's name				
Helped write proposal				
Helped collect data				
Helped analyze data				
Helped prepare presentation				
Point distribution				

Please make any additional comments you would like me to consider when grading the group presentation.

Signal detection and mate choice

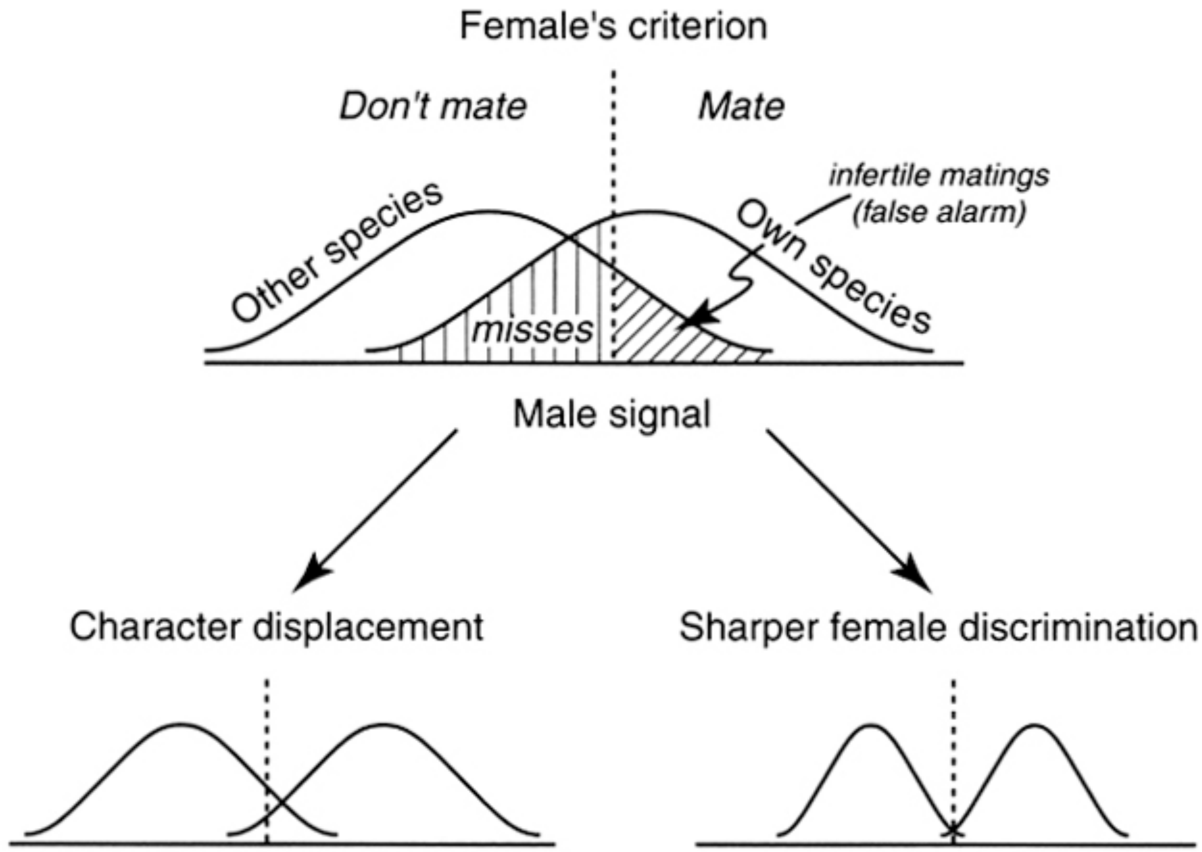


Figure 2.10. Signal detection theory applied to mate choice, showing how false alarms (infertile matings) can be reduced either by males evolving more discriminable characteristics or by females evolving better discrimination.

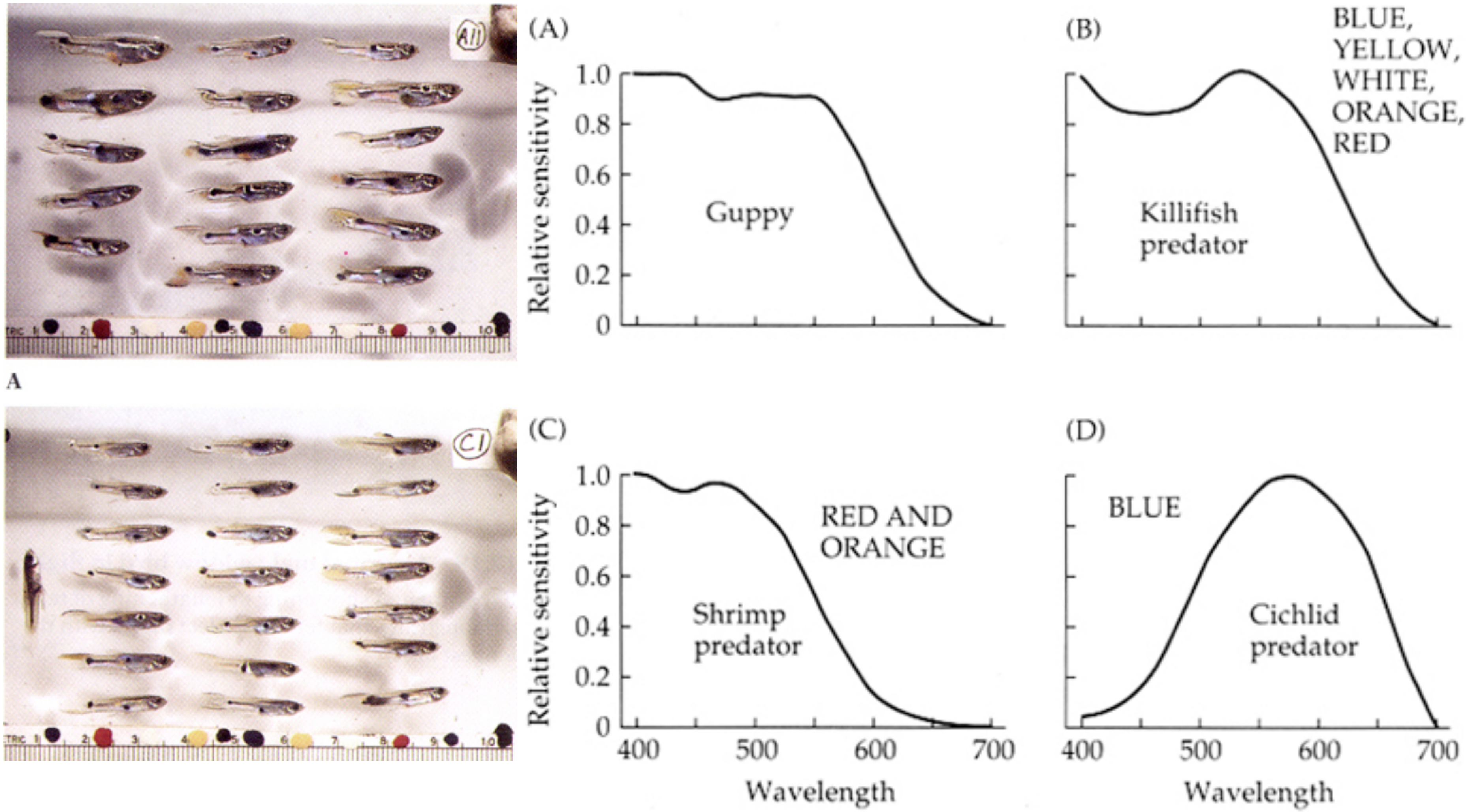
Implications

- Communication is never perfect
- Can improve communication
  - if senders create more distinctive signals
  - if receivers acquire greater discrimination ability
- Which of these will happen depends on the relative costs to sender and receiver as well as constraints on signal production or reception

Sender Costs

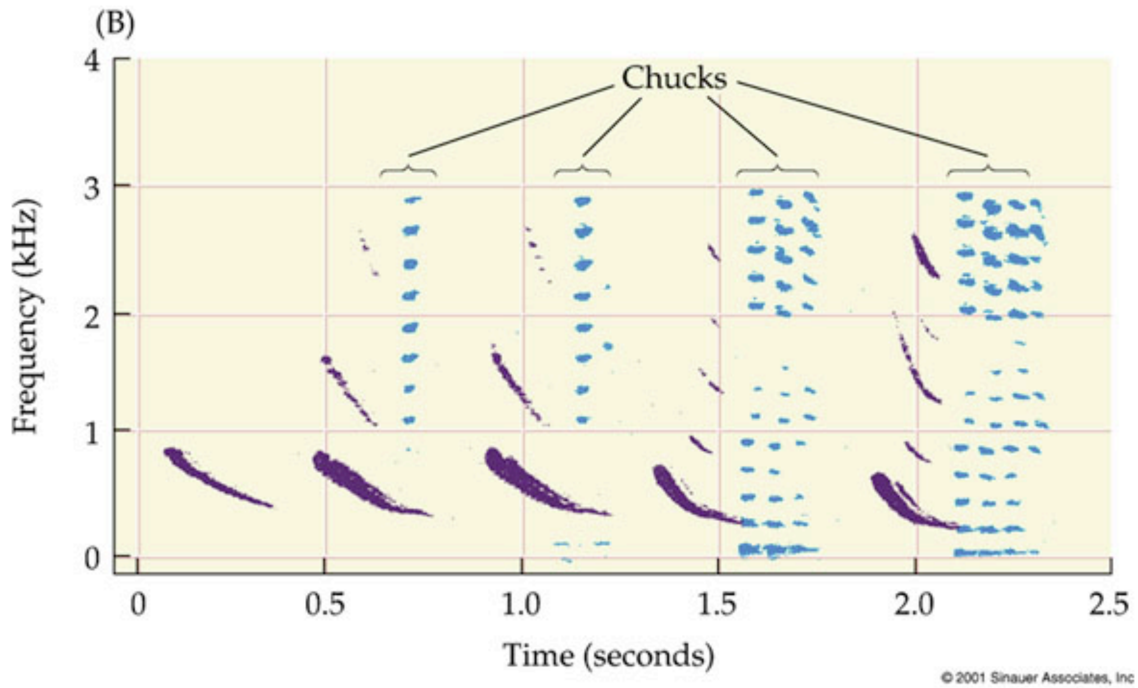
- Conspicuousness to predators and parasites
  - High for visual, auditory, or olfactory signals
  - Low for deposited olfactory marks
- Energetic costs of signaling
  - High for visual or auditory displays with high duty cycle
- Lost time
- Conflict with original function

Guppy coloration and predation



Guppy coloration differs depending on which predator is present,
This result led Endler to propose sensory drive model

Female choice in Túngara frogs



- Calls consist of ‘whines’ and ‘chucks’
- Females prefer males with deeper chucks
- Chuck frequency constrained by male body size

Sensory exploitation in tungara frogs

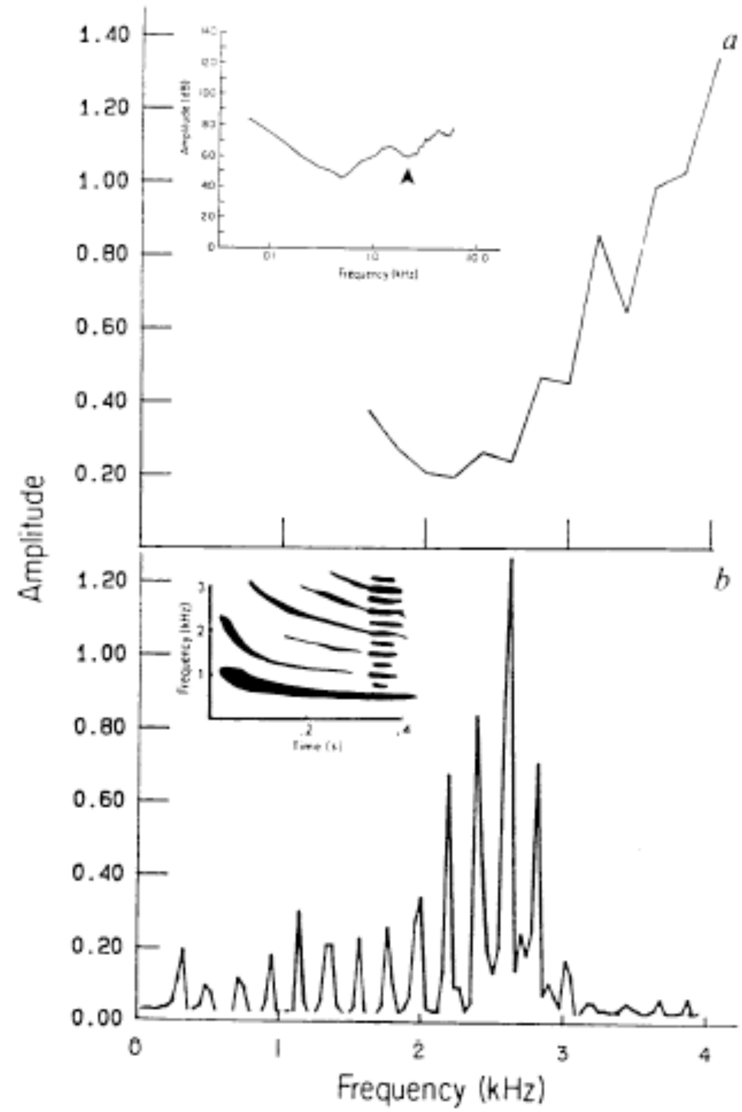
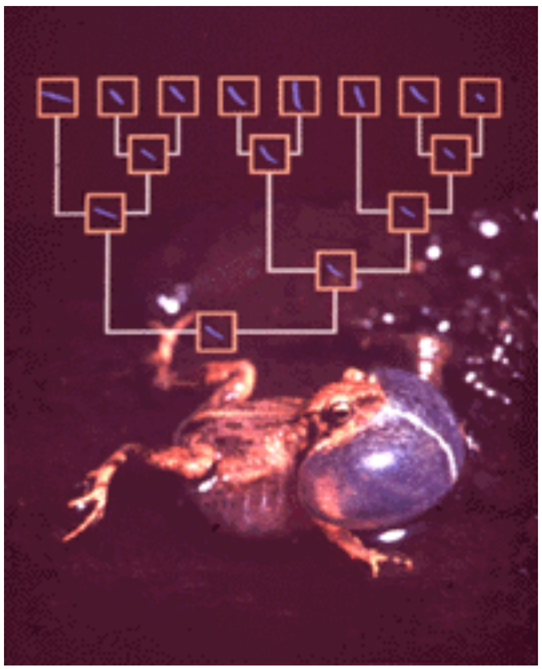
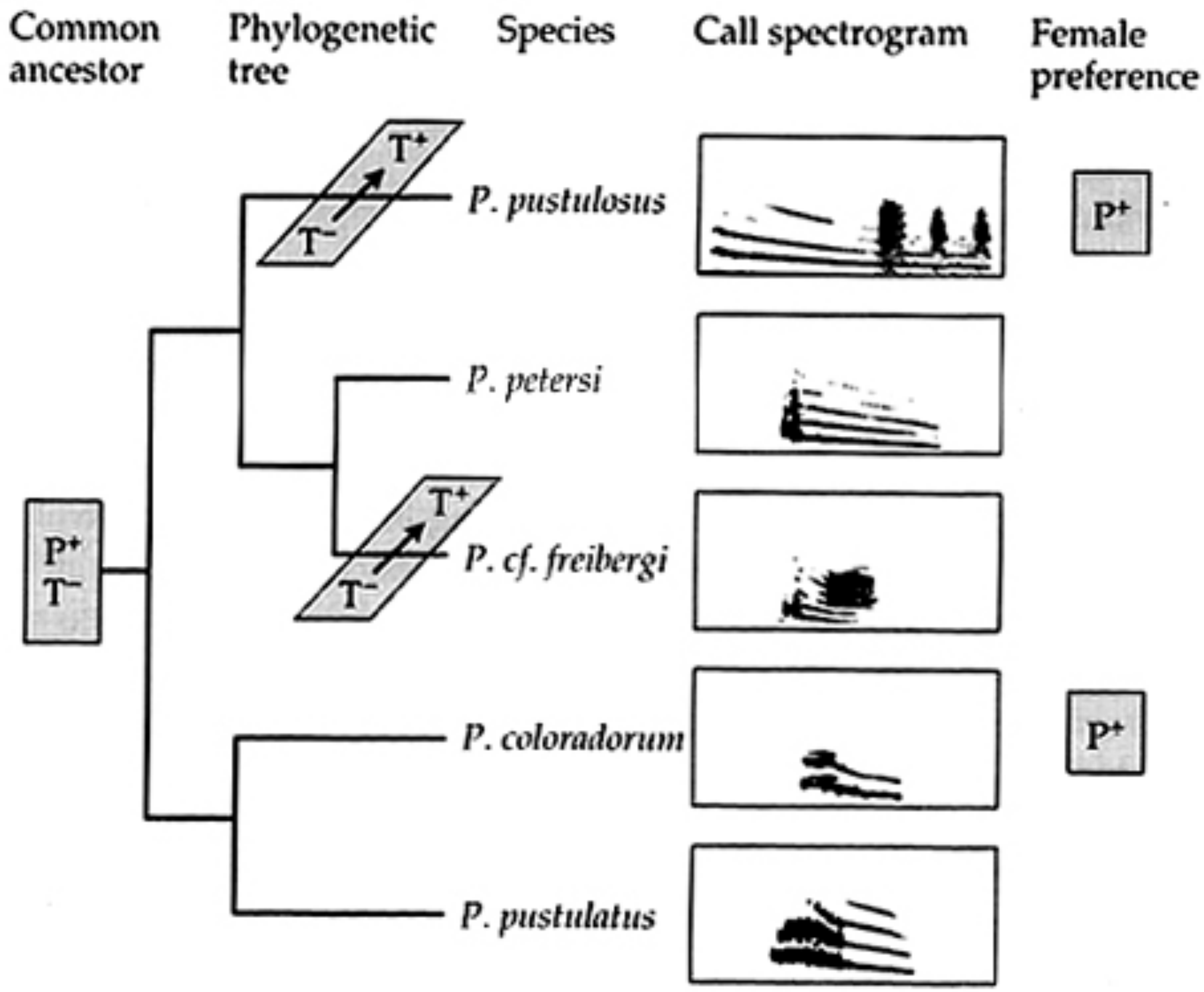


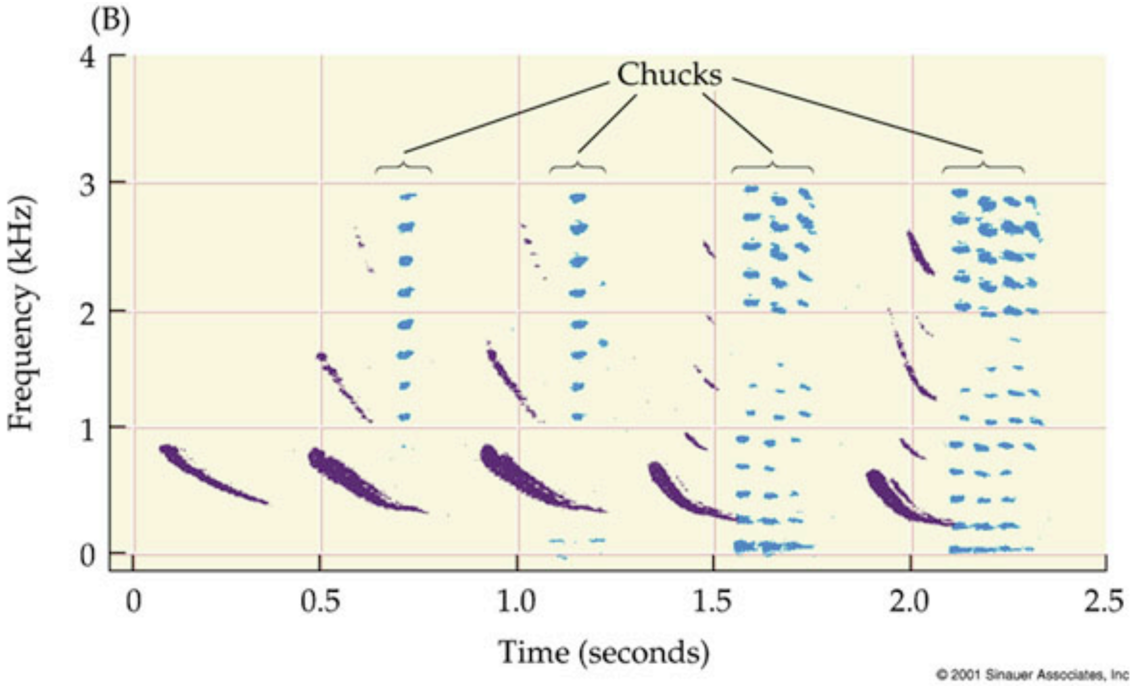
FIG. 1 *a*, The mean audiogram of the basilar papilla of *P. pustulosus* derived from five individuals. Audiograms represent thresholds as a function of frequency, determined for sinusoidal, closed-field stimuli using 1–2 MΩ glass electrodes. The truncation of the audiogram below 1.5 kHz to eliminate influences of amphibian papilla neurons and the slight broadening of the tuning curve resulting from averaging biases the results toward the null hypothesis. Insert, audiogram from a single frog; basilar papilla best frequency is marked by arrow. Male and female audiograms did not differ. *b*, Representative Fourier spectrum of a chuck. Insert, sonogram of a whine plus a chuck.

Sensory bias predicts preference precedes trait evolution



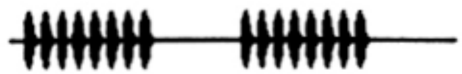
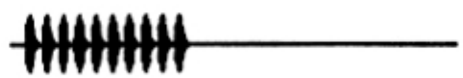
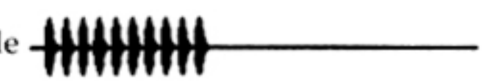


Frog mating calls attract bats

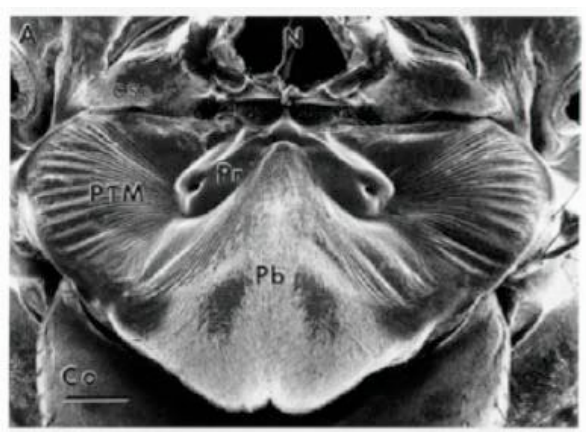


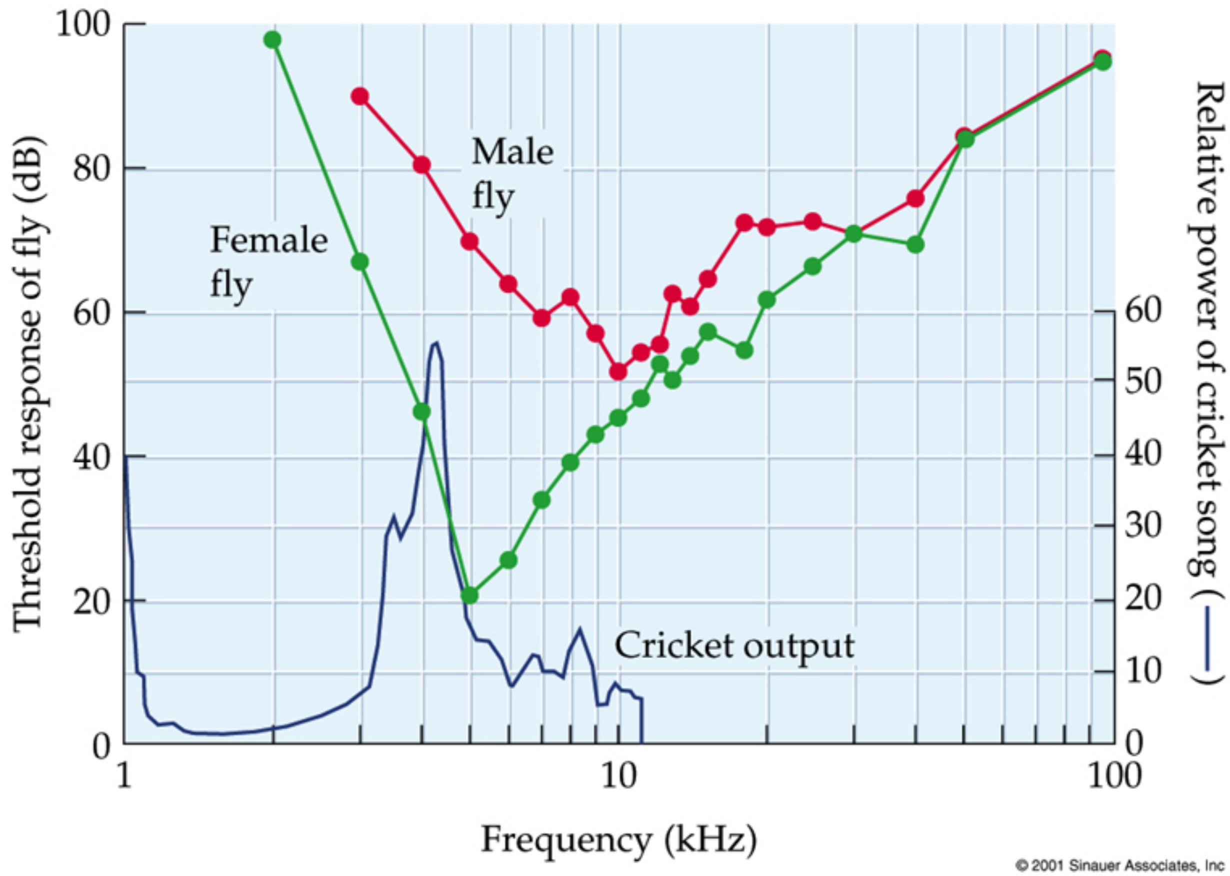
Chucks make calling frogs more vulnerable to eavesdropping by predatory bats

Male crickets attract females and parasitic *Ormia ochracea* flies

Test	Stimuli	Number of female crickets	Number of female flies
(A)			
High chirp rate		13	23
Low chirp rate		2	6
(B)			
Long chirp duration		12	19
Short chirp duration		3	1
(C)			
High chirp amplitude		12	20
Low chirp amplitude		3	4

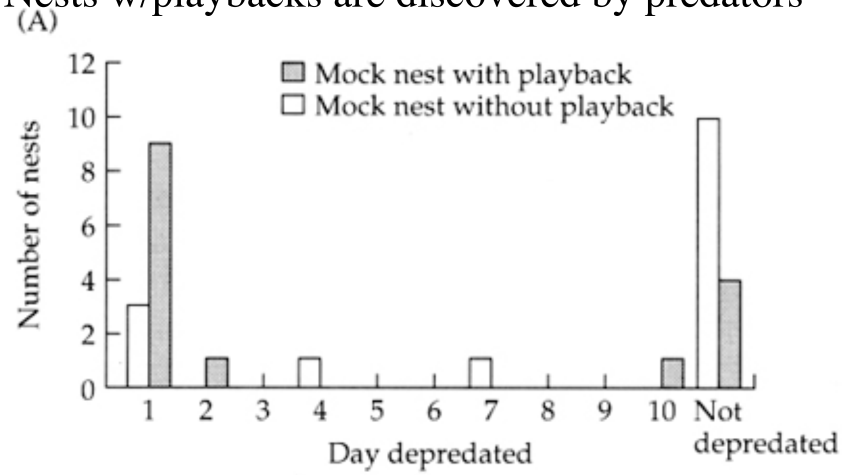
Female fly ears are tuned to hear male cricket calls



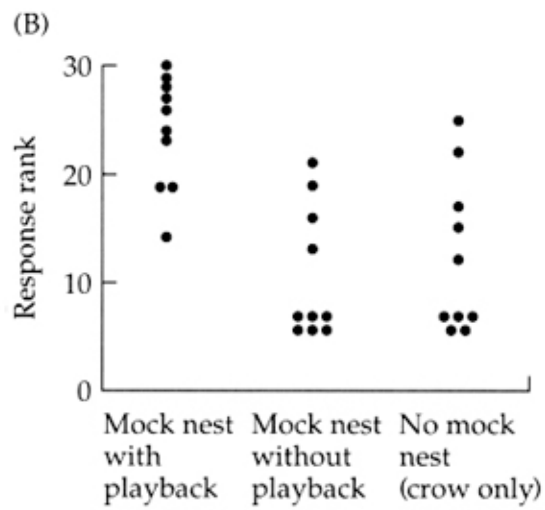


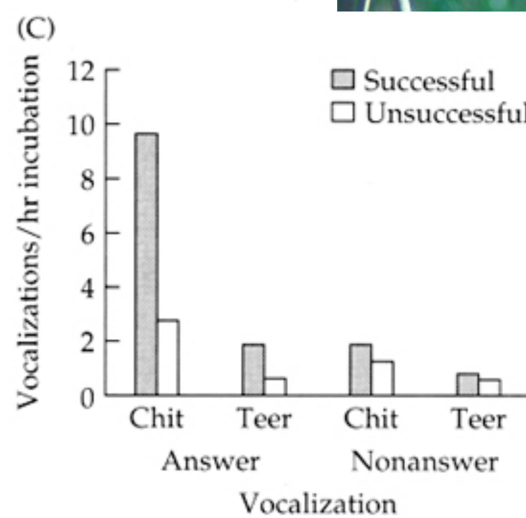
Female red-winged blackbird calls attract predators and defense

Nests w/playbacks are discovered by predators



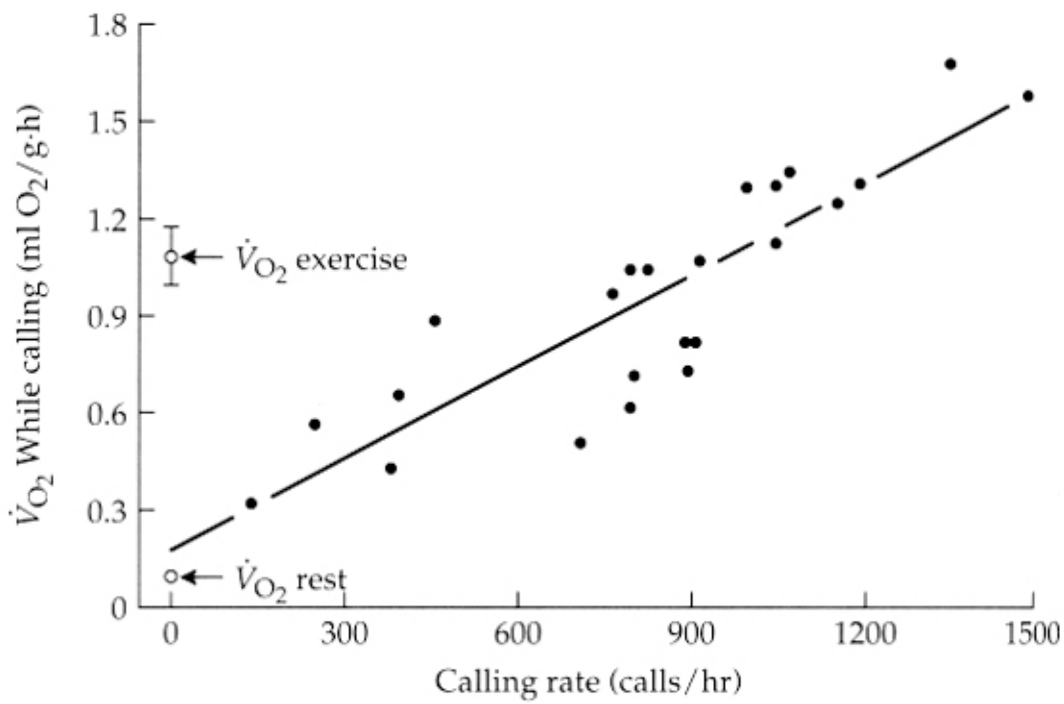
Males defend nests w/chits



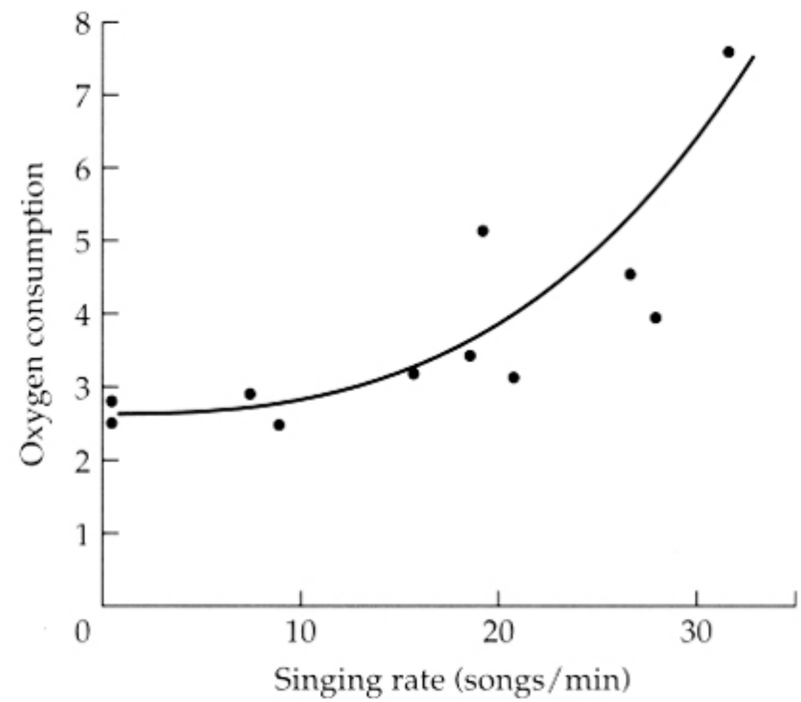


Singing consumes energy

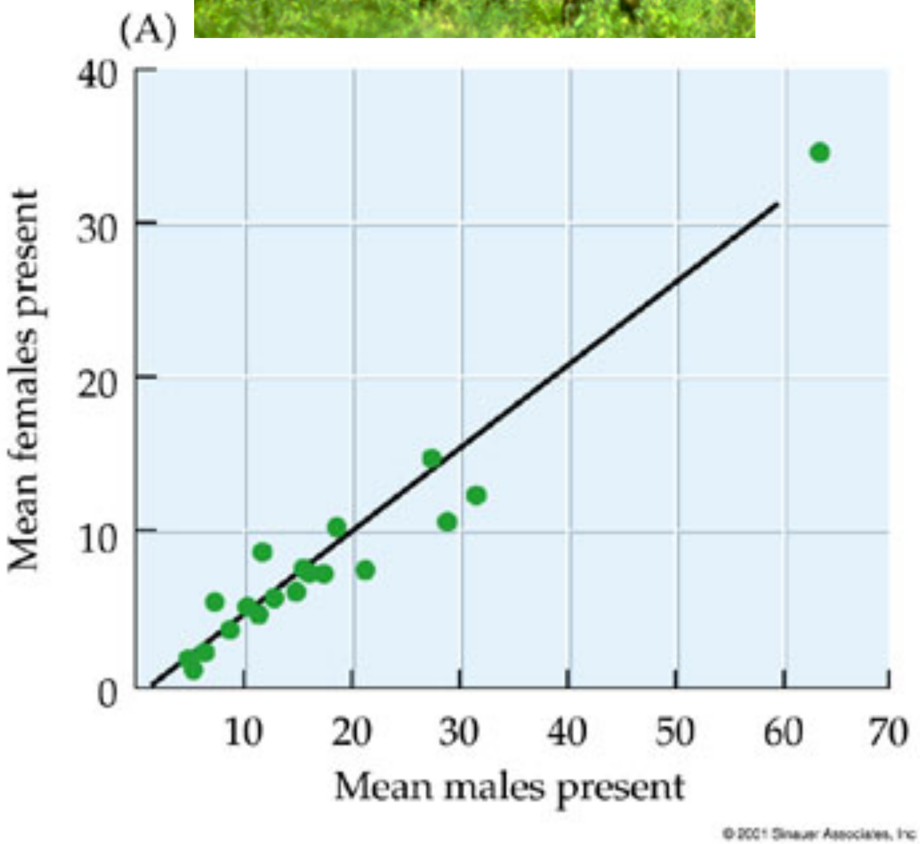
Gray treefrogs

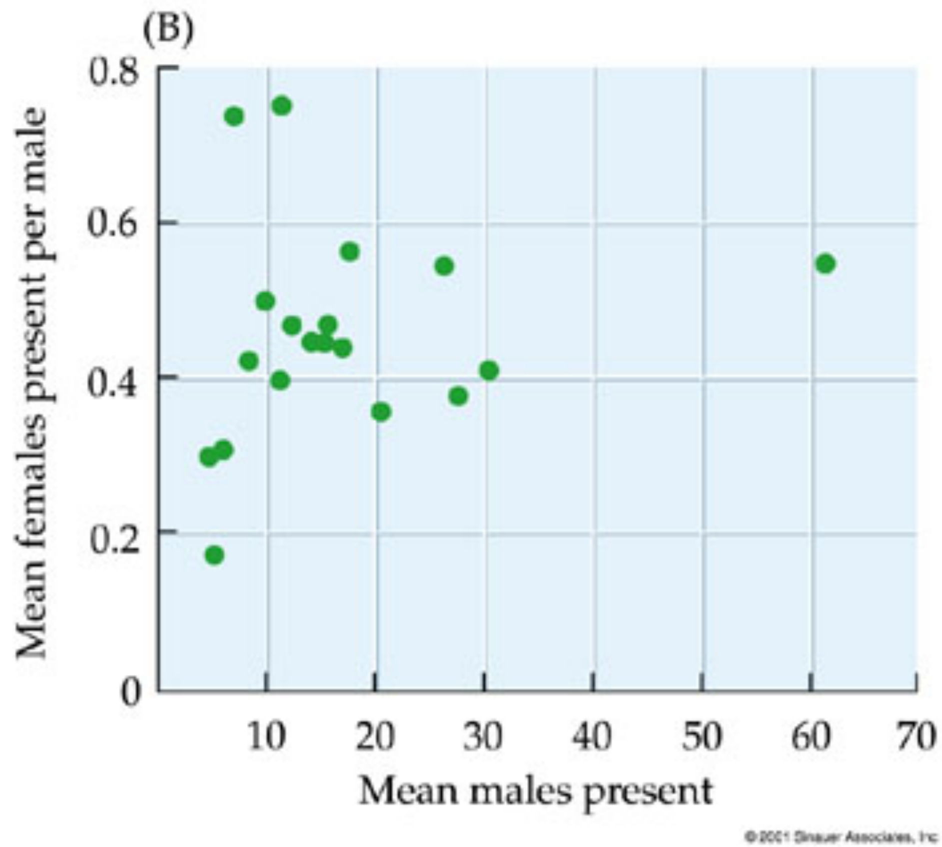


Carolina wrens



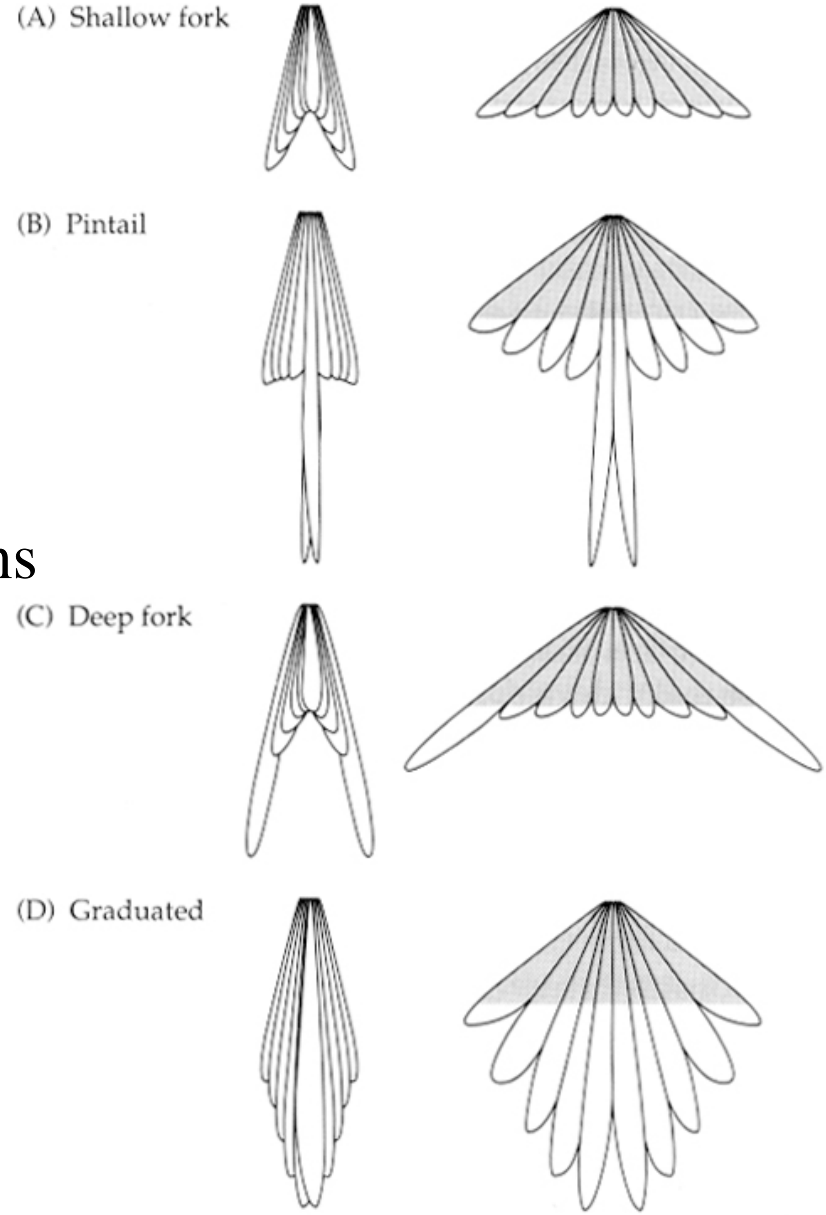
Time lost: lekking antelope males don’t feed





Conflict with original function

Elongated tails create drag during turns



Gray - generate lift
White - produces drag

Receiver costs

- Vulnerability to predation while inspecting or comparing signals
  - Choosiness may decline in presence of predators
- Time lost in assessment
- Susceptibility to exploitation, i.e. code-breakers

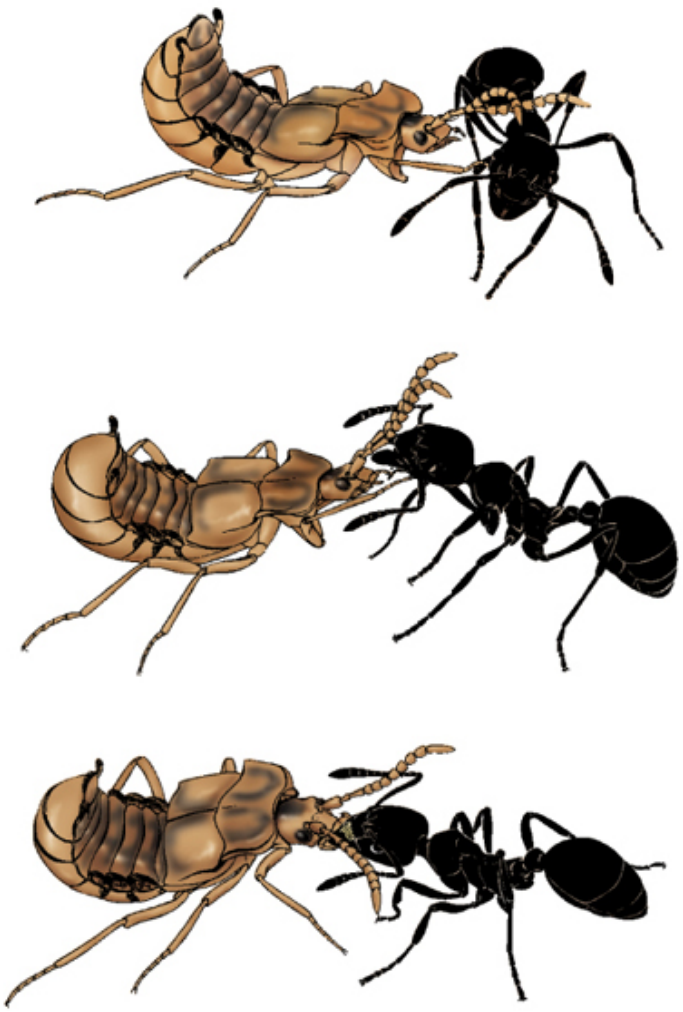
Predator presence influences mate choice in guppies

FIGURE 9.1: Risk taking and cooperation in guppies

Principles of Animal Behavior

Code-breaking

Rove beetle mimics ant pheromone



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Photuris fireflies imitate *Photinus* female flashes to catch *Photinus* males

Constraints

- Phylogenetic
  - Implies insufficient time or genetic variation for evolution to modify trait
- Physical
  - Production of signal is impossible given the organism's morphology and physiology

Transmission constraints

Table 17.3 Signal transmission characteristics for each modality

Modality	Medium requirements	Maximum range	Localizability	Temporal modulation	Complexity	Signal duration
Visual	Ambient light	Medium	Good	Rapid	High	Variable
Auditory	Air or water	Large	Medium	Rapid	High	Short
Chemical	Current flow	Large	Variable	Slow	Low	Long
Electric	Water	Short	Good	Rapid	Low	Short
Tactile	None	Short	Good	Rapid	Medium	Short

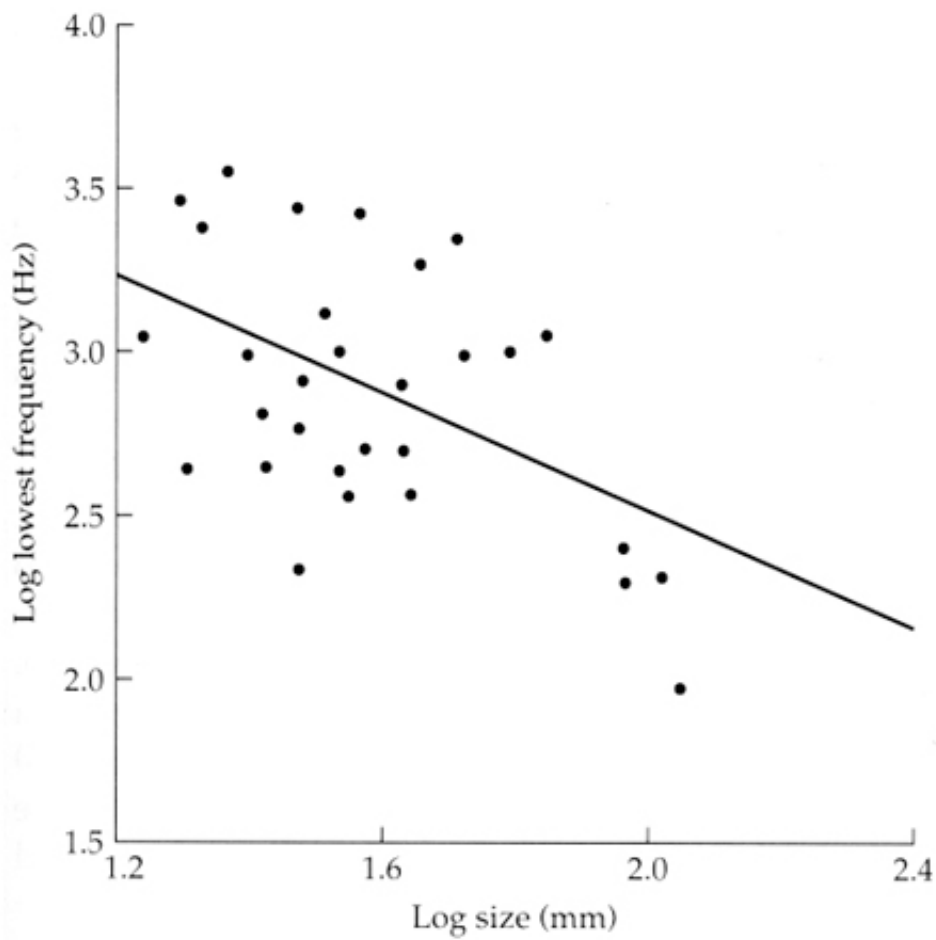
Sender constraints

Table 17.1 Constraints on senders in each modality

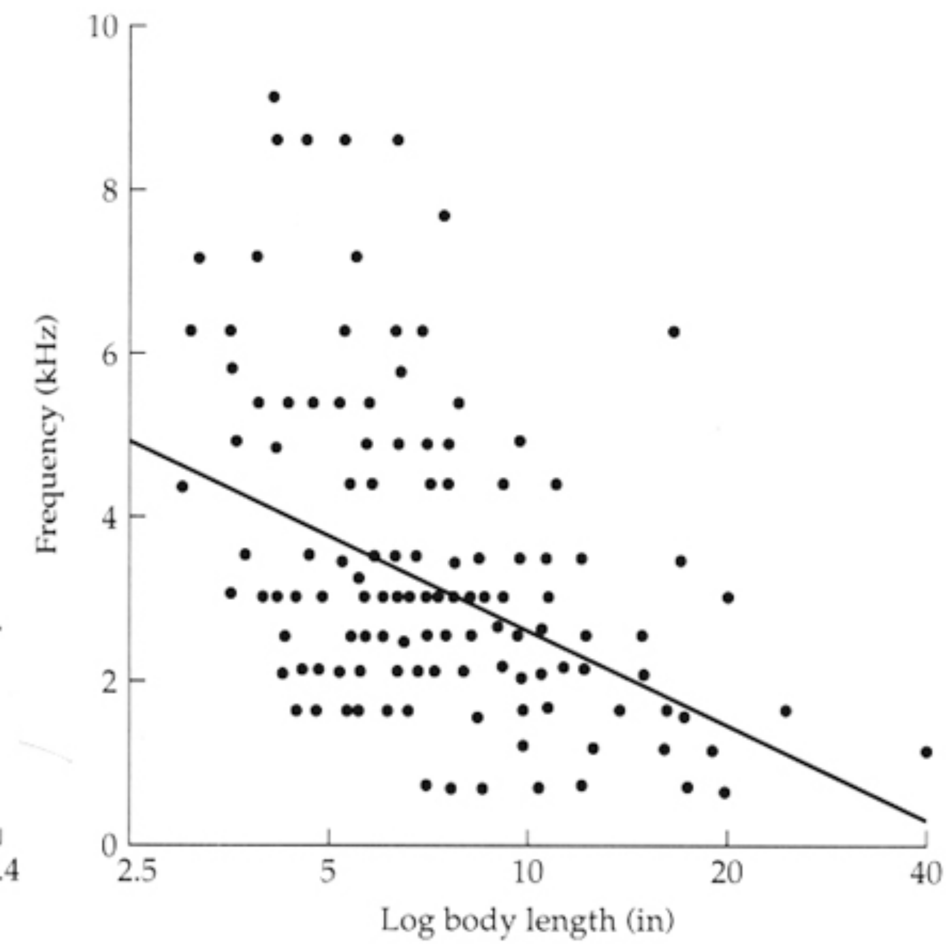
Modality	Signal feature	Constrained by
Visual	Intensity/transmission distance	Small body size
	Display structures	Body form
	Movement displays	Neuromuscular preadaptations
	Carotenoid-based color	Access to dietary sources of pigment
Auditory	Low frequency	Small body size
	Intensity	Small body size
	Stridulation	Lack of hard exoskeleton or skeleton with moveable joints
	Vibration of membranes	Low-flow respiratory system, poikiothermy
	Frequency modulation	Stridulation and percussion sound production mechanisms
	Note shape and variation	Structure of vocal apparatus
Chemical	Transmission distance of airborne signals	High and low molecular weight
	Duration of deposited marks	Low molecular weight, nonpolarity
	Novel chemicals	Lack of metabolic pathways
Electric	Signal intensity/range	Body length

Body size constrains frequency

Leptodactyline frogs



Birds



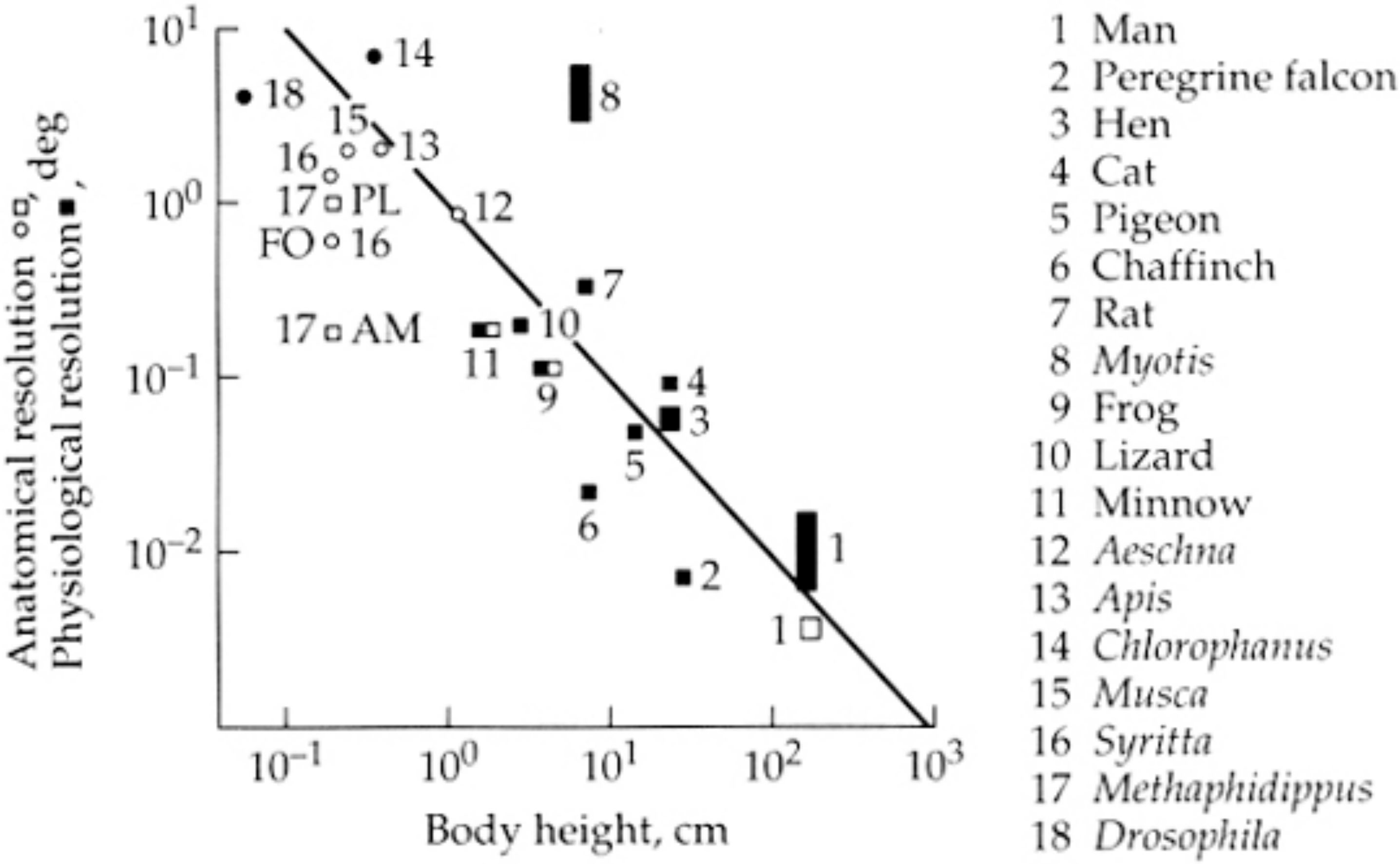
Receiver constraints

Table 17.2 Constraints on receivers in each modality

Modality	Receiver feature	Constrained by
Visual	High resolving power	Small body size
	Low-light sensitivity	Degree of summation of receptor cells
	Good temporal resolution	Speed of rhodopsin recovery
	Polarized light sensitivity	Ciliary receptor cells
	Good frequency resolution	Number of receptor pigment types
	Distance estimation	Monocular vision
	Wide field of view	Binocular vision
Auditory	Frequency range	Particle detector, pressure-differential detector
	Directionality	Body size
Chemical	Sensitivity	Number of receptor cells
	Chemical resolution	Number of receptor types
Electric	Sensitivity, directionality	Body length

Phylogeny, memory

Visual resolution and body size



Is learning a cost or constraint?

- Neural tissue required for learning and memory is energetically costly to maintain
- Learning is often time-consuming and mistake-prone
  - And often restricted to a limited sensitive period
- Evidence for enlargement of specific regions devoted to specific processing or memory tasks

Constraints on sender learning? HVC and repertoire size

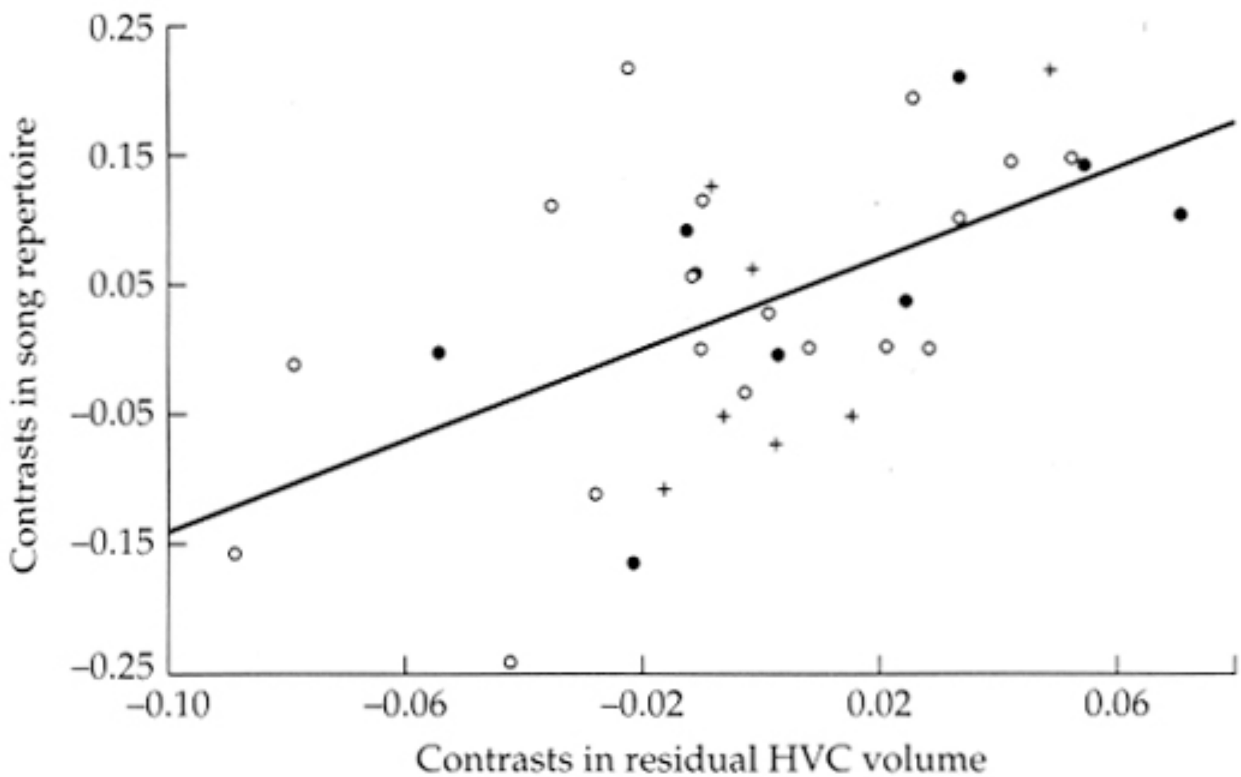


Figure 17.7 Relationship between HVC (higher vocal center) nucleus size and repertoire size in passerine birds. A larger repertoire size is associated with a larger brain area for vocal learning. Each point represents an independent contrast between two related species (•), genera (○) or families (+) with different repertoire sizes. The effect of overall brain size (telencephalon) on HVC volume has been statistically removed. (From DeVoogd et al. 1993.)

Hippocampus size and caching

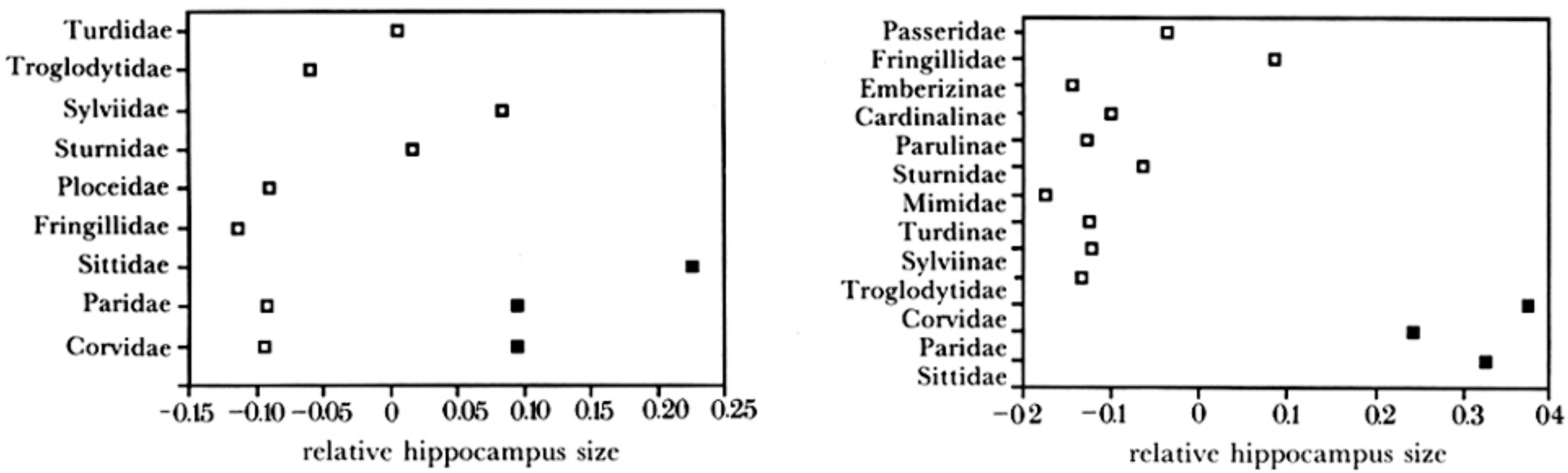
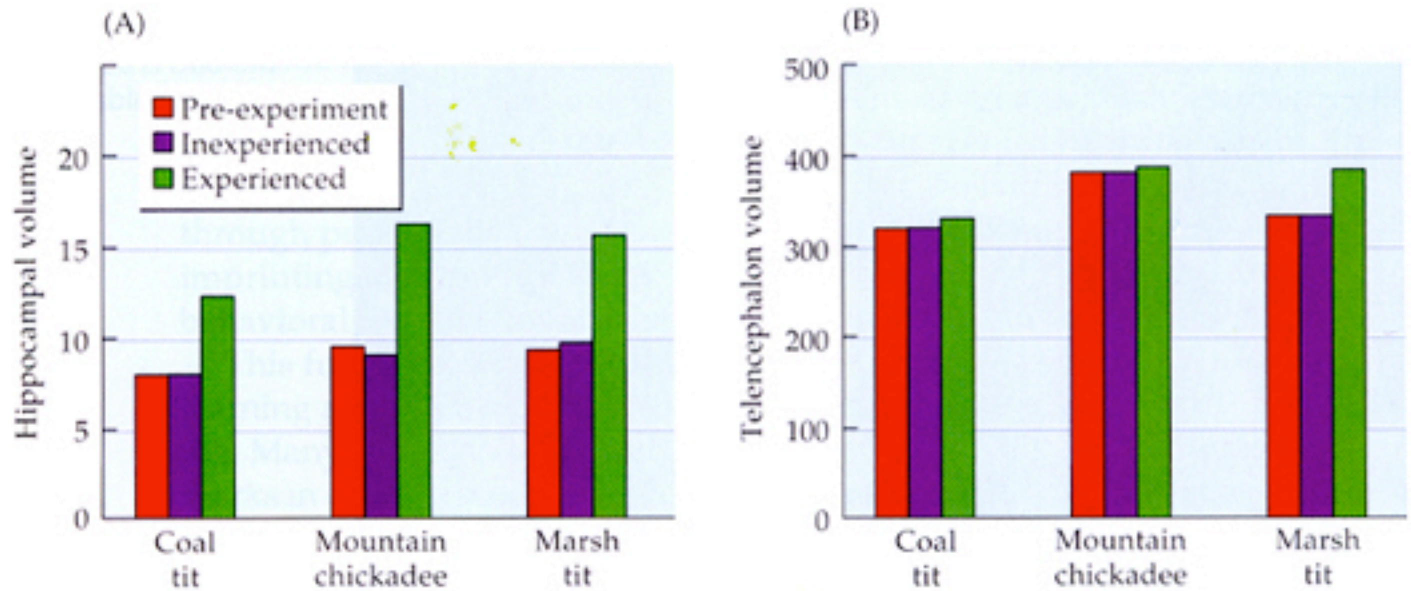


Figure 2. Residual variation in hippocampal volume after removing (by multiple regression) effects of body size and telencephalon volume (see text). ■, food storers; □, non-storers. (*a*) Data from Krebs *et al.* (1989). (*b*) Data from Sherry *et al.* (1989).

But, hippocampus also shows experiential changes

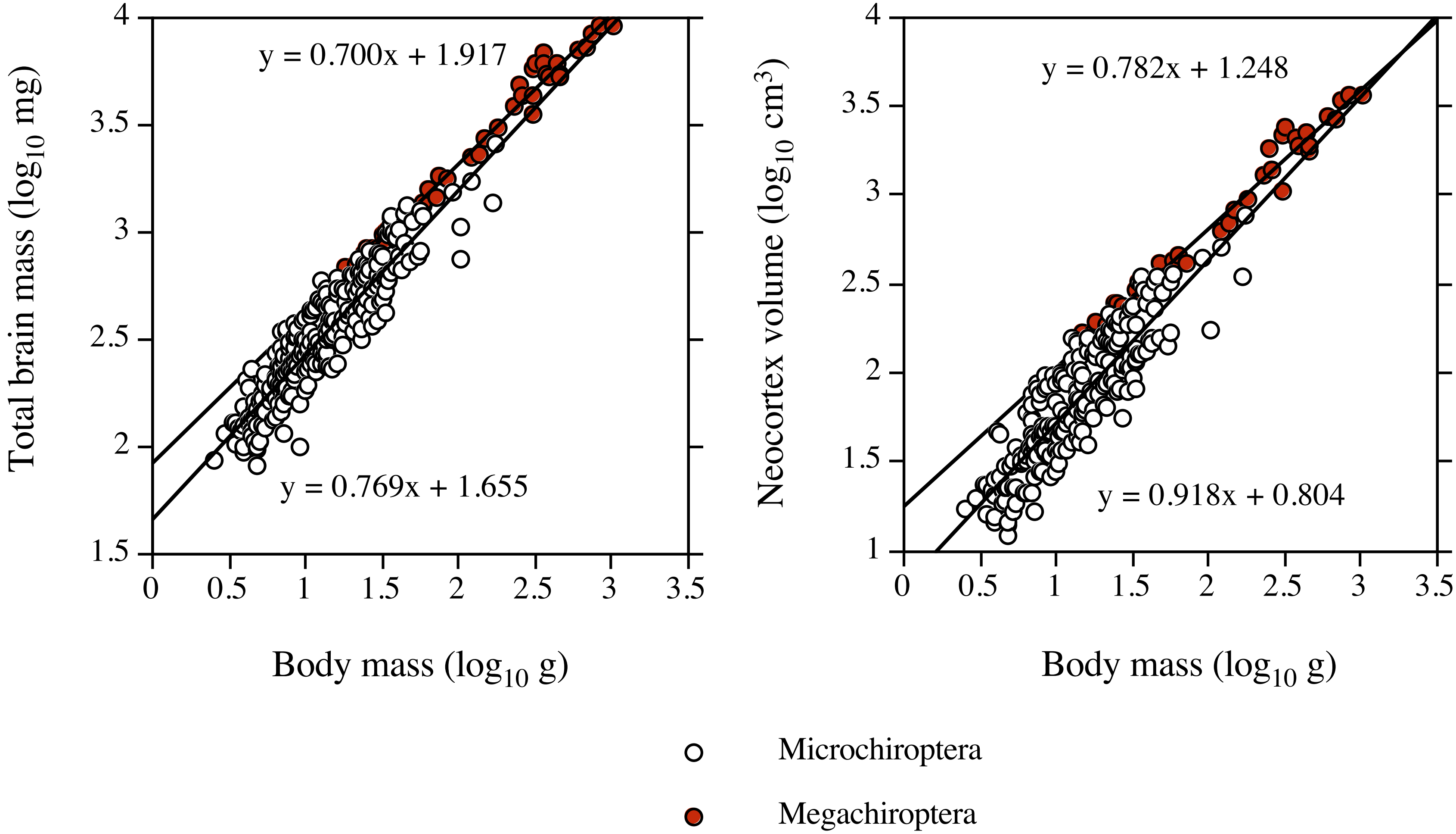
Coal tit

Mountain chickadee



17 Changes in hippocampal volume as a result of food storing experience in coal tits, mountain chickadees, and marsh tits. (A) The volume of the hippocampus was greater in birds that had had the opportunity to store food than in young birds whose brains were examined before the experiment began or in birds that had little experience in storing food. (B) The volume of the telencephalon, another brain structure not involved in spatial learning, did not vary for these three categories of birds. After Clayton [224].

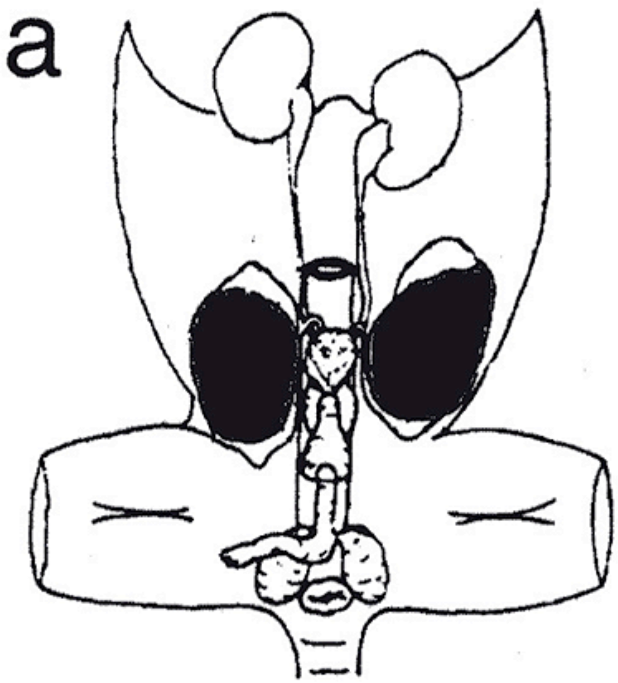
Brain allometry in bats

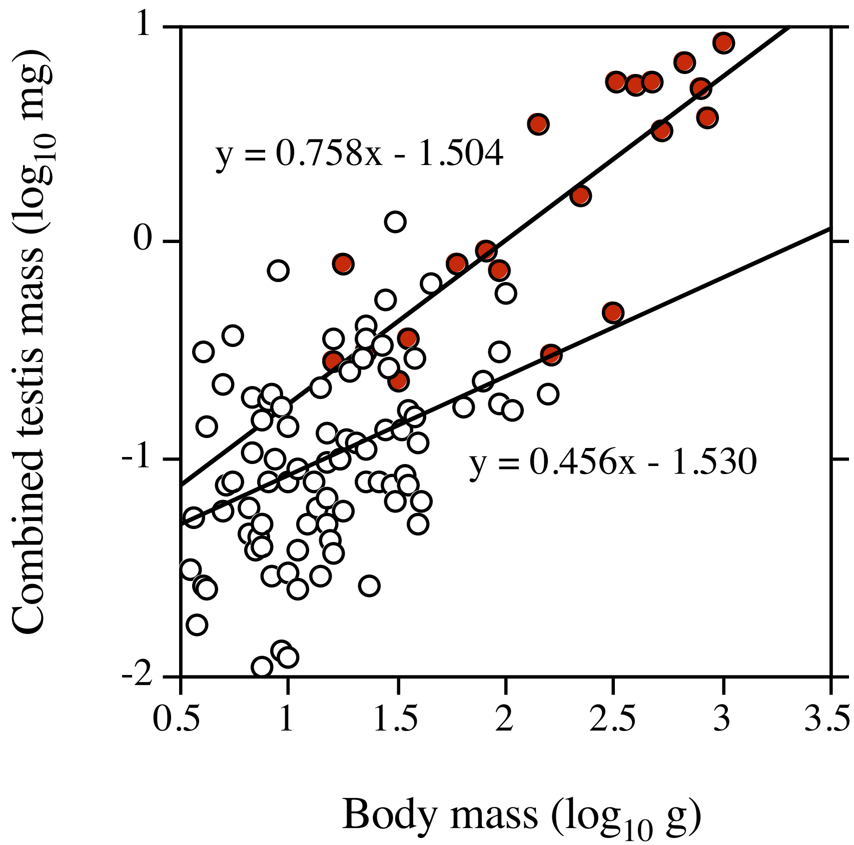


Calculate "encaphalization quotients" as observed/fitted values

Testes allometry in bats

Combined testis mass varies across species from 0.1% to 8.4% of body mass



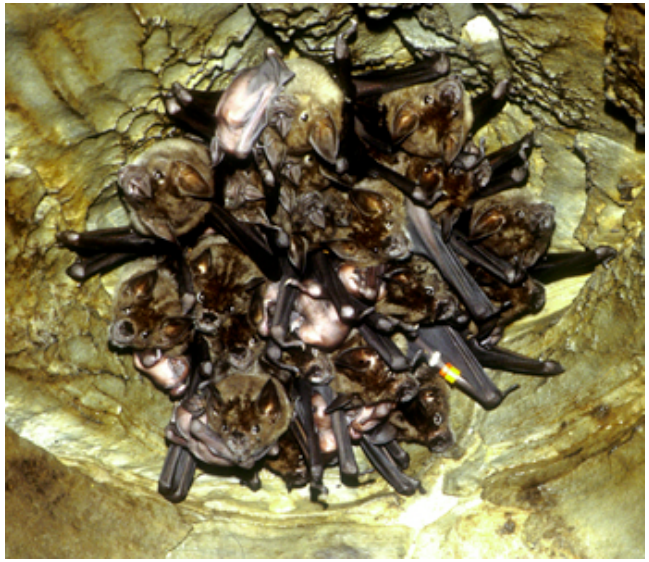


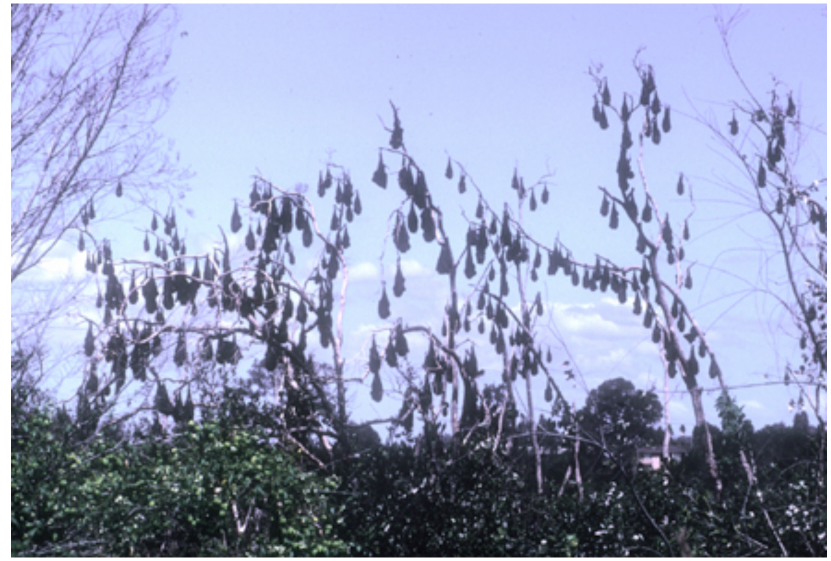
N = 87, F = 16.22, R^2 = 0.16, P < 0.0001 ○ Microchiroptera

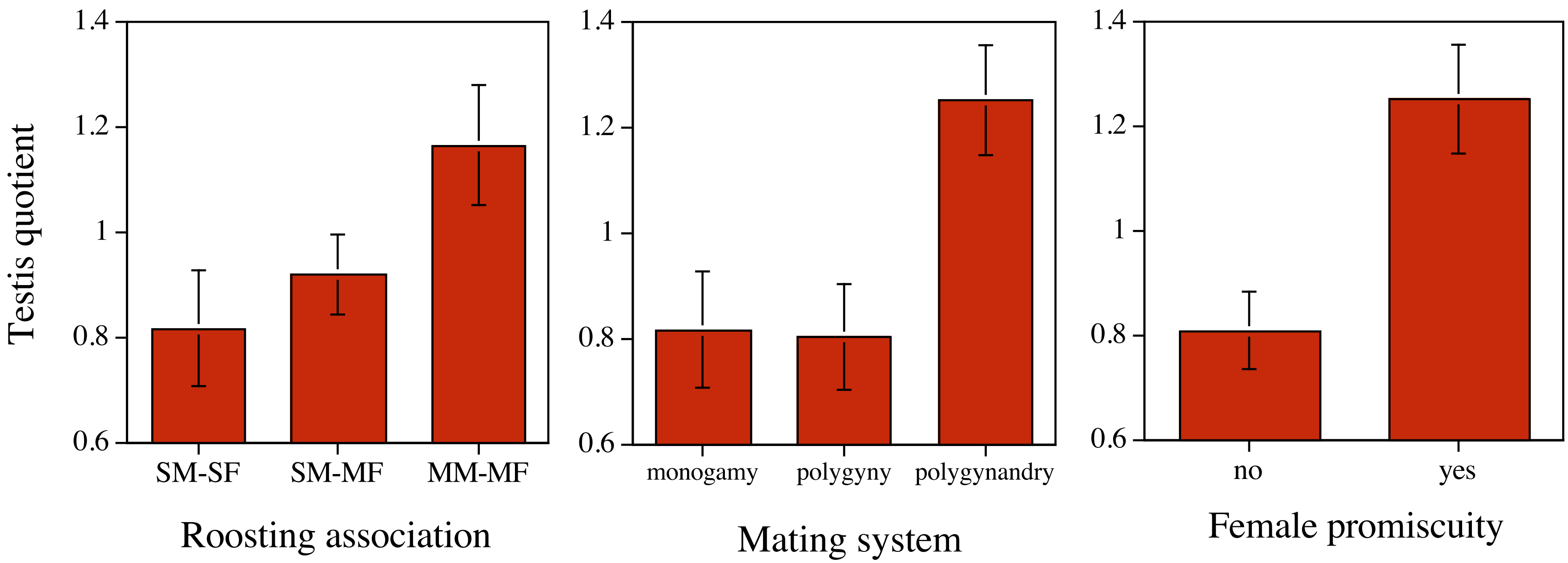
N = 20, F = 38.93, R^2 = 0.68, P < 0.0001 ● Megachiroptera

Calculate "testis quotient" as observed/fitted values

Breeding system correlates with testis size

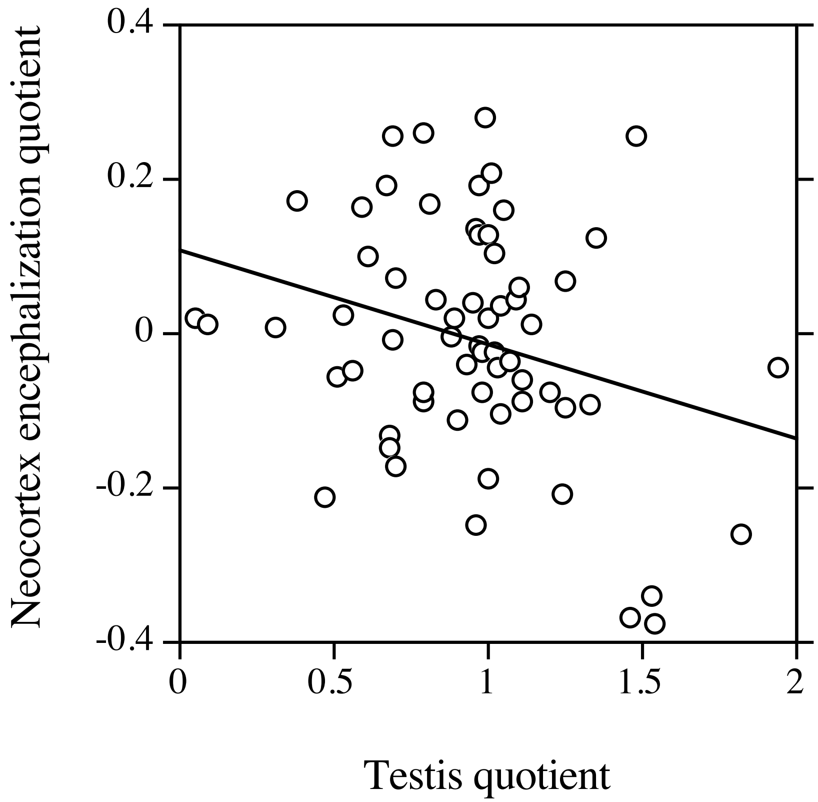




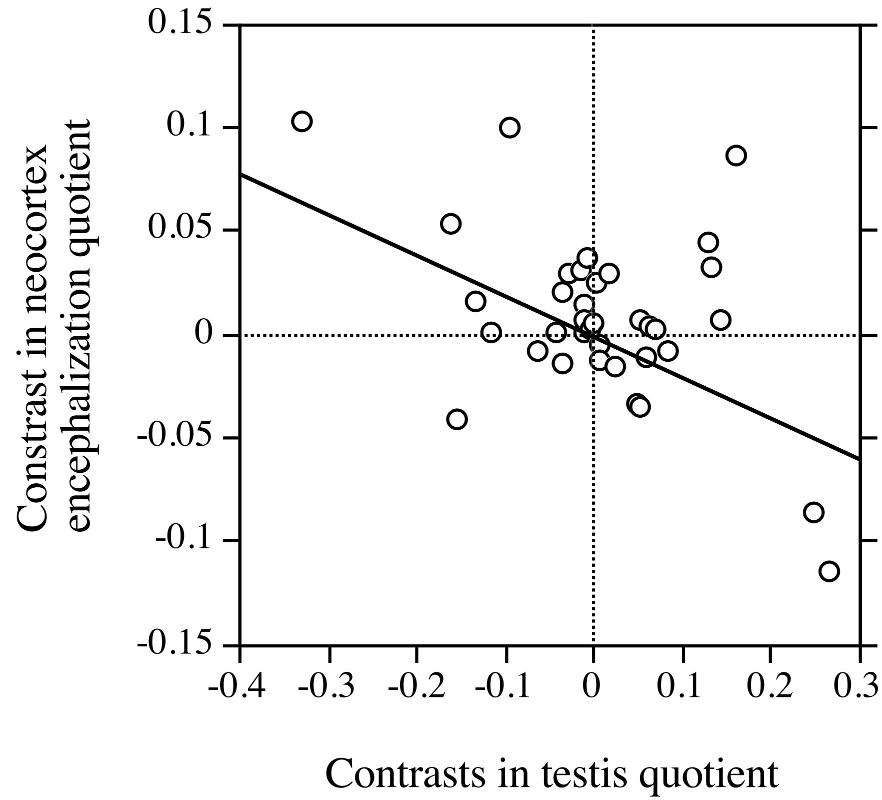


Testes constrain brain size?

N = 63, F = 5.38, R^2 = 0.08, P = 0.024



N = 36, F = 10.06, R^2 = 0.22, P < 0.005



Significant trade-off exists only for echolocating bats