

## Senses, Brains, and Intelligence

June 23<sup>rd</sup>, 2010

## Hearing

- Territorial Defense
- Mate Choice
- Navigation
- Prey Detection

## Hearing

- Ear Structure
  - External Ear
  - Middle Ear
  - Inner Ear

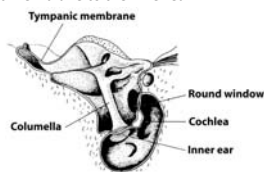
## Hearing

- Ear Structure
  - External Ear
    - Lack external skin structure
    - Auricular feathers cover ear opening
    - Ear Funnel
    - Ear Flaps
    - External ear opening/skull asymmetrical



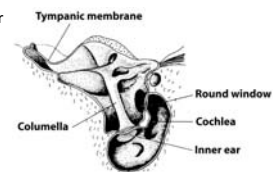
## Hearing

- Ear Structure
  - Middle Ear
    - Single bone: columella (stapes)
      - Connects tympanic membrane to the inner ear



## Hearing

- Ear Structure
  - Inner Ear
    - Cochlea
      - Fluid filled, coiled
      - Hair cells monitor vibrations
      - Transmitted to brain



### Hearing.

- While simpler than mammal ear structure, birds' ears are acoustically comparable

### Hearing.

- Hearing Ability
  - In general, birds hear well over fewer frequencies, compared to humans

### Hearing

- Orientation
  - Barn Owl can locate prey to within 1° in both horizontal and vertical planes
- Asymmetrical Ears
  - Left ear = below
  - Right ear = above

### Taste

- Few taste buds
  - 24 in chickens, 62 in quail
    - Compare to 10,000 in humans
  - Provide basic taste information (sweet, salt, sour, bitter), lipid and sugar presence

### Smell

- Better than once thought
  - Small olfactory bulb
- Olfactory tubercle on conchae

### Smell

- Relative size of olfactory bulb to cerebrum
- Nocturnal birds tend to have better sense of smell


## Smell

- **Foraging**
  - Turkey Vultures
  - Leach’s Storm-Petrel
    - Detects scent up to 12 km




## Smell


- **Nest and Mate Recognition**
  - Seabirds can find their own burrows and recognize each other by smell



[http://alaska.usgs.gov/science/kasatochi/images/birds/auklet\\_flock.jpg](http://alaska.usgs.gov/science/kasatochi/images/birds/auklet_flock.jpg)

## Smell

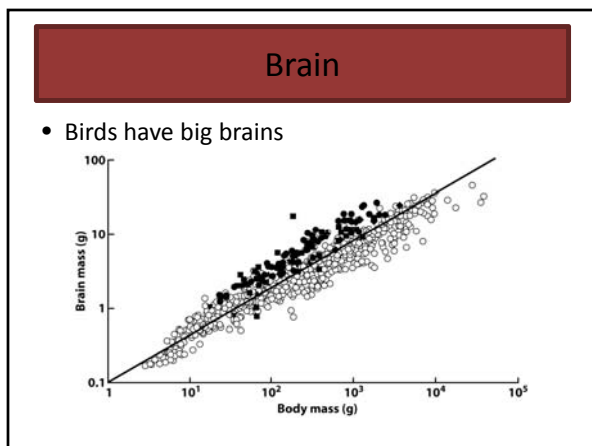
- **Courtship**
  - Tangerines



Philip Witt

## Brain

- **Birds have big brains**
  - 6 to 11 times the size of reptile brains
  - Comparable to mammals
  - 2 to 9% of body mass
  - Parrots, owls, crows, woodpeckers, hornbills have especially large brains



## Brain

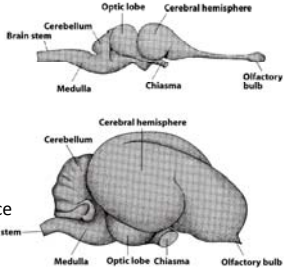
- **Birds have big brains**

**Forebrain**

- Complex behavioral instincts
- Sensory integration
- Learned intelligence

**Midbrain**

- Regulates vision
- Muscular coordination, balance
- Physiological controls



## Brain

- Functional Lateralization
  - Left Hemisphere Dominant
    - Complex integration and learning
    - Suppresses sexual and attack behavior
  - Right Hemisphere
    - Monitors environment
    - Filters stimuli

## Brain

- Functional Lateralization
  - Birds may be right or left “handed”
    - Phalaropes
    - Crossbills



Vancouverislandbirds.com

## Brain

- Hippocampus
  - Spatial Orientation and Cognitive Memory
    - Damaged hippocampus prevents homing pigeons from learning a map
  - Corvidae, Sittidae, and Paridae cache seeds
    - Large hippocampus
    - If damaged, continue to hide seeds, but can't find them

## Brain

- Hippocampus



hhhetrick

- Clark's Nutcrackers hide over 30,000 seeds in 2,000 sites; can find them 9 months later

## Brain


- Neuron Growth
  - Birds can grow new neurons!
  - Some new synapses are ephemeral
  - Avian brain dynamic
- Important implications for human medicine

## Brain

- Sleep
  - Essentially all birds sleep (some vertebrates don't)
  - Three Types
    - Slow-wave Sleep
    - Intermediate Sleep
    - Rapid-eye-movement (REM)

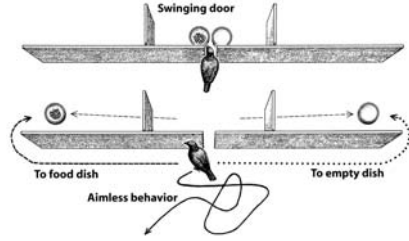
## Brain

- Sleep
  - Slow-wave Sleep
    - Unihemispheric
      - One side of the brain sleeps, other side awake
      - Allows vigilance for predators
    - Unihemispheric sleep combines with short periods of REM allowing some birds to sleep while engaged in active flight
- Birds Dream



## Intelligence


- Birds are smart



Cats, rabbits, and chickens do poorly      Crows and dogs do well

## Intelligence

- Birds are smart
  - Counting
    - Monkeys require 21,000 trials; rats never learn
    - Ravens and parakeets can count to 7



## Intelligence

- Birds are smart
  - Conveying Knowledge



[http://homepage.ntworld.com/engspek\\_birder/Home.html](http://homepage.ntworld.com/engspek_birder/Home.html)

## Intelligence

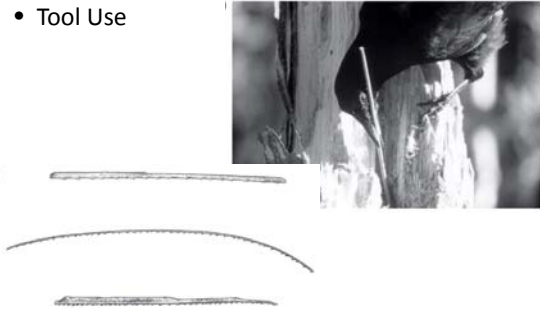
- Birds are smart
  - Problem Solving
    - Darwin's finches move stones
    - 27 g finch moved a 378 g stone

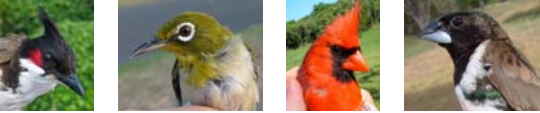


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## Intelligence


- Tool Use





**MORPHOLOGICAL EVOLUTION OF BIRDS  
RECENTLY INTRODUCED TO ISLANDS:  
PATTERNS OF DIVERSIFICATION**


Blake Mathys, Ph.D.  
June 23<sup>rd</sup>, 2010



- Why are birds useful for these questions?
- Why are they difficult?

**Outline**

- **Part 1** : Island Rule in Bermuda kiskadees
- **Part 2** : Island Rule across multiple island species
- **Part 3** : Morphological divergence among Hawaiian Islands
- Acknowledgments



**My Advisor's Original Suggestions**

~~Mangrove Birds in Florida~~

~~Grassland Birds in New Jersey~~


**Bermuda Birds**




**Bermuda**

Land Area	55 km <sup>2</sup>
Distance to Mainland	1,000 km
Maximum Elevation	76 m
Breeding Birds	22
Native Vascular Plants	165





### Great Kiskadee

- Loud, belligerent, tenacious bird




### Great Kiskadee on Bermuda

- 200 introduced in 1957
- Supposed to eat **lizards** that eat **beetles** that eat **scale insects** that attack **endemic tree**
- Quickly spread to all parts of the island






### What to Study?

- **Genetics**
- **Life History**
- **Ecology**
- **Morphology**
  - Easy to measure
  - Correlates with **genetics** (Roff, 1997), **life history** (Blueweiss *et al.*, 1978), and **ecology** (Miles & Ricklefs, 1984)



### Island Rule

- Large-bodied species get smaller on islands, small-bodied species get larger
- **Mammals** (Foster, 1964, 1965)
- **Other groups** (Lomolino, 2005), including **birds** (Clegg & Owens, 2002)
- “**Point of no change**” estimated to be 70 to 120 grams for **birds** (Lomolino, 2005)





### Island Rule

- **Many mechanisms** have been proposed (Dayan & Simberloff, 1998)
  - Focus on competition, predation, resource availability, and dispersal
- **No resolution**; driven by island attribute(s), but we do not know exactly what

### Island Rule Hypothesis

- Kiskadee < 70 grams
- Therefore, **body size** should **increase** on Bermuda



### Why this is interesting?

- Island Rule not tested in exotic species
- Exotic species may give specific insights into the Island Rule, and general insights about evolutionary mechanisms

### Utility of Exotic Species

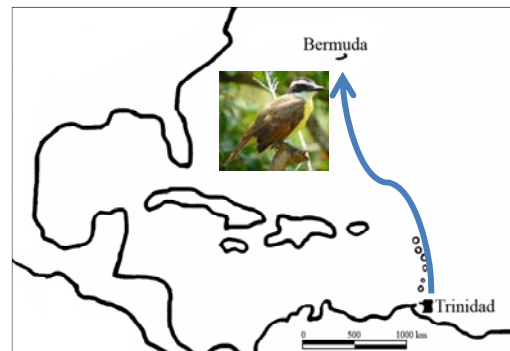
- Known details about exotic species (**source population, date of introduction, and establishment history**) are not available for natural colonizations

### Biogeographical Patterns in Exotic Species

- Bergmann's Rule in exotic House Sparrows in North America (Johnston & Selander, 1971)



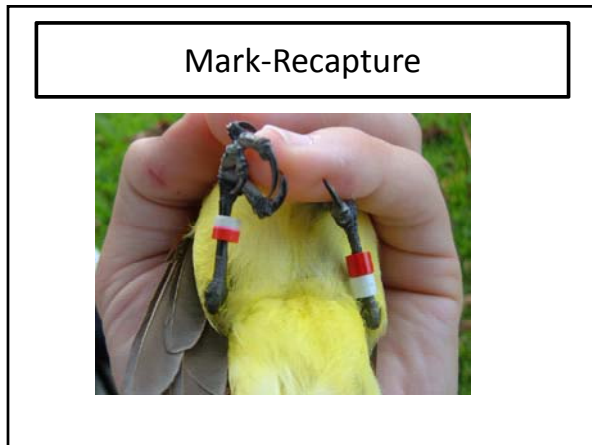
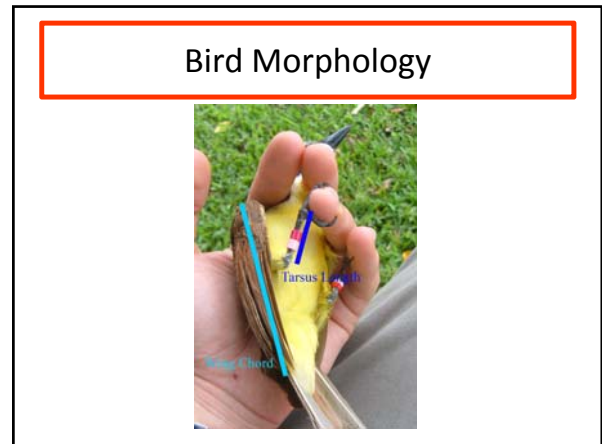
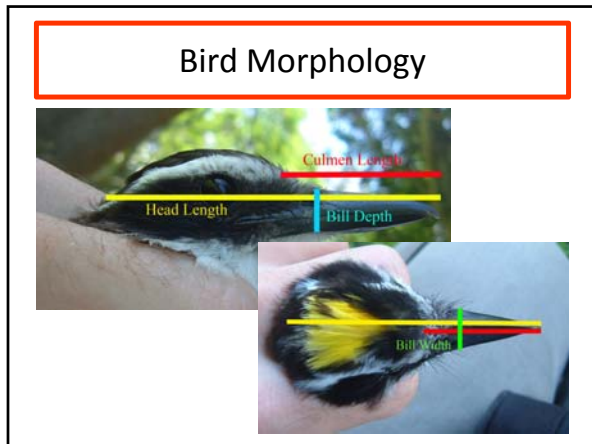
- Cline in wing size in an exotic fruit fly in South America (Huey *et al.*, 2000)



	Bermuda	Trinidad
Area (km <sup>2</sup> )	55	4,808
Isolation (km)	1,000	11
Max. Elevation (m)	76	940
Bird Diversity	22	250
Native Vascular Plants	165	2,500

### Field Methods

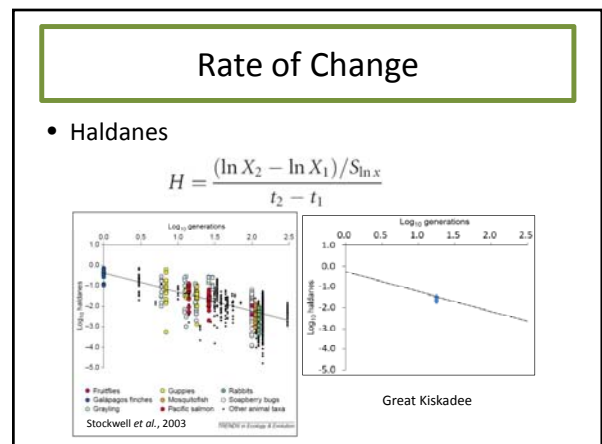




### Kiskadee Results

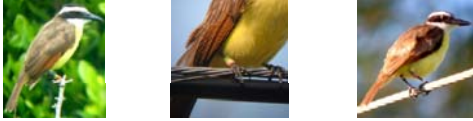
Character	Bermuda	Trinidad	% Larger
Mass (grams)	62.7	59.8	4.9
Wing Chord	109.8	108.1	1.5
Head Length	55.49	54.96	1.0
Bill Depth	8.68	8.53	1.7
Bill Width	9.84	9.50	3.7
Tarsus Length	24.69	24.26	1.8

Kiskadees are **larger** on Bermuda

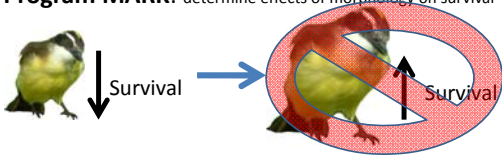


### Survivorship with Mark-Recapture Data

- 30 (out of 89) re-sighted



- Program MARK:** determine effects of morphology on survival



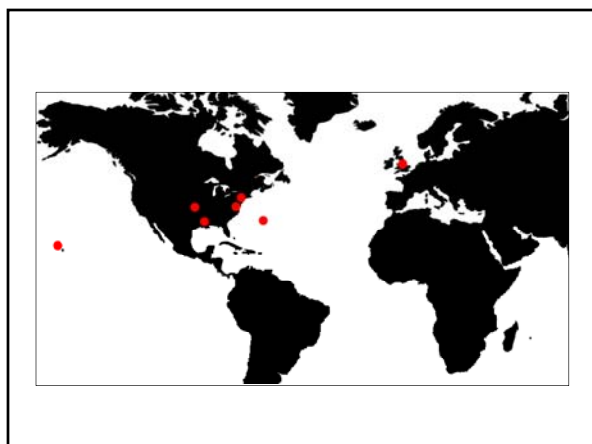
### Summary of Part 1

- Kiskadees on Bermuda follow the Island Rule
- Part 2:** Do other exotic birds?



### Museum Visits







North America



Asia



Europe



South America



Africa

### Island Rule Hypothesis

- All birds I examined < 70 grams
- Therefore, **body size** should **increase** on islands



### Data Set

- **38** exotic populations
  - Average of ~39 individuals/population

Bermuda	Big Island	Kauai	Maui	Oahu	Puerto Rico	Mauritius	Jamaica
4	8	4	2	11	7	1	1

- Compared to individuals from native range
  - Average of ~28 individuals/population

### Principal Components Analysis

Mass data were unavailable for most museum specimens

PCA summarizes variability in the data into a few axes

In birds, the first axis (PCI) represents **overall body size** (Rising & Somers, 1989)

Species	Island	PCI	Species	Island	PCI
<i>Cardinalis cardinalis</i>	Bermuda		<i>Leiostrix lutea</i>	Big Island	
	Big Island		Oahu		
	Kauai		Oahu		
<i>Copsychus malabaricus</i>	Oahu		<i>Paroaria coronata</i>	Oahu	1
	Oahu		Bermuda		
<i>Carpodacus mexicanus</i>	Big Island	1	Big Island		
	Kauai		Maui		
	Oahu		Oahu		
<i>Estrilda astrild</i>	Oahu	1	<i>Passer domesticus</i>	Oahu	1
<i>Estrilda melipoda</i>	Puerto Rico		<i>Pycnonotus cafer</i>	Oahu	
<i>Euplectes franciscanus</i>	Puerto Rico		<i>Pycnonotus jocosus</i>	Maui	1
<i>Lonchura cantans</i>	Big Island		<i>Pitangus sulphuratus</i>	Bermuda	1
<i>Lonchura cucullata</i>	Puerto Rico		<i>Sicalis flaveola</i>	Big Island	
<i>Lonchura malabarica</i>	Puerto Rico	1	Jamaica		
<i>Lonchura malacca</i>	Puerto Rico	1	<i>Sturnus vulgaris</i>	Bermuda	
<i>Lonchura p. punctulata</i>	Puerto Rico	1	Puerto Rico		
<i>Lonchura p. topela</i>	Big Island		Oahu		
	Kauai		Big Island		
	Oahu		Kauai		
			Maui		
			Oahu		

7 increases : 3 decreases P = 0.34

### Not the Island Rule, but...

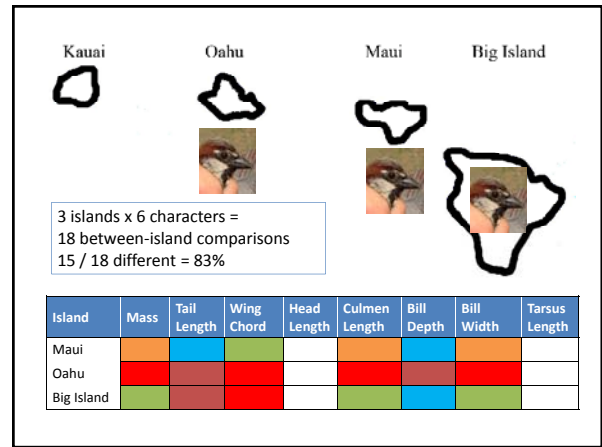
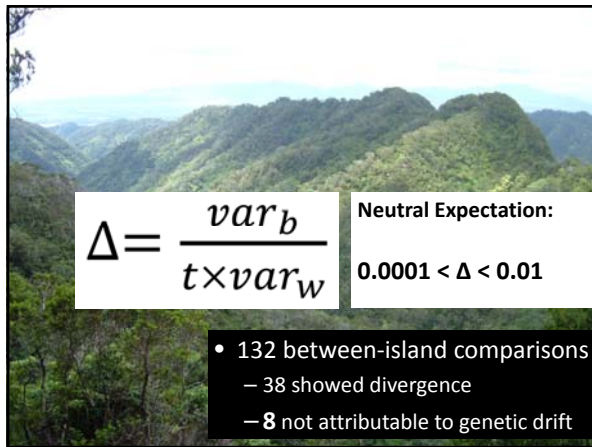
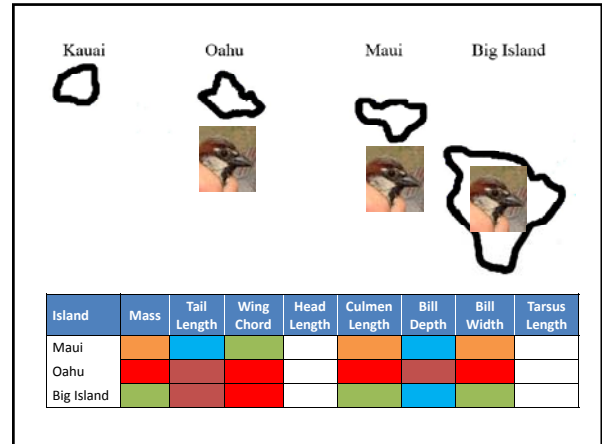
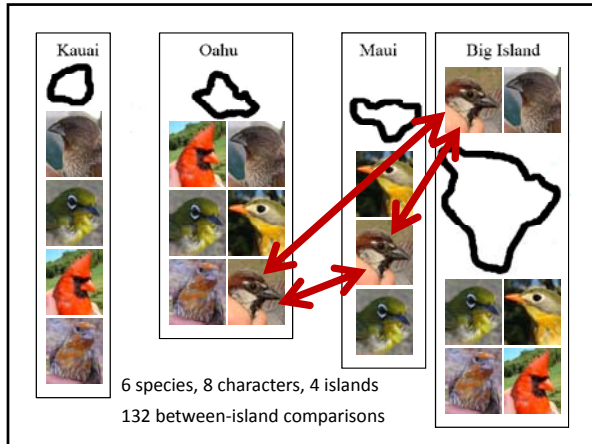
- May be losing adaptations for dispersal ability, in favor of agility



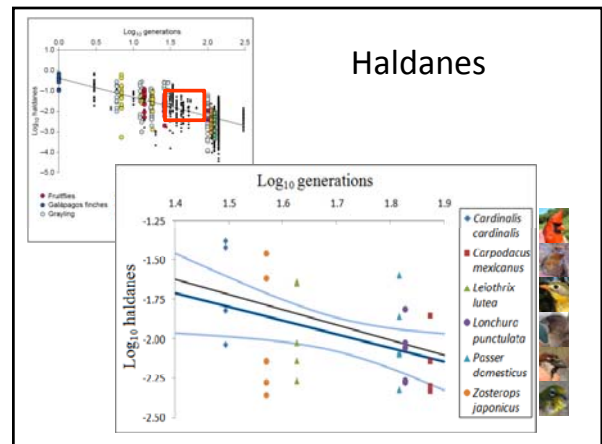
Character		# of Changes	P value
Tail Length	Increase	19	<0.001
	Decrease	2	
Wing Chord	Increase	2	<0.001
	Decrease	19	
Culmen Length	Increase	6	0.455
	Decrease	10	
Bill Depth	Increase	4	0.077
	Decrease	12	
Bill Width	Increase	11	0.118
	Decrease	4	

### Summary of Part 2

- Exotic birds on these islands **do not** follow the Island Rule
- However, some characters (**wing** and **tail**) have changed
- **Part 3:** Diverged from source, maybe from each other?



Species	% Diverging	Character	% Diverging
	83	Mass	70
	50	Wing Chord	43
	24	Culmen Length	29
	17	Bill Width	24
	17	Tail Length	19
	9	Bill Depth	17
	0	Tarsus Length	11
	0	Head Length	0



### Summary of Part 3

- Exotic birds on Hawaii have diverged among islands
- Some of these changes **can not** be attributed to genetic drift
- Variability in divergence among species and characters
- Rates of change similar to those found in other studies of contemporary evolution



**Acknowledgments**

- **Julie Lockwood**
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- **Friends:** Amy, Elena, Jesse, Carrie, Aabir, Charlie, Holly, Dave, Kristen, Emilie, Ai, Wes, Zac, Brooke, Maria, Kenneth
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