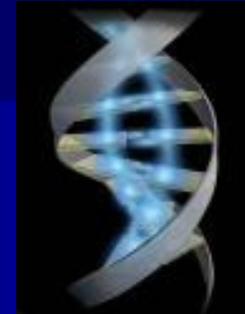


# Eastern Bluebirds

The Effects of Soil and Food Quality on the Health, Growth Rate, and Sex Ratios of Nestlings



# The Importance of Carbon, Nitrogen, and Phosphorus as a Foundation for Life



## Carbon:

- Basic building block of organic matter
- Unit of currency for biological energy (total potential energy)

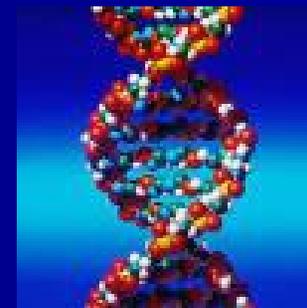
## Nitrogen:

- Amino acids
- Proteins
- Enzymes



## Phosphorus:

- DNA and genetic material
- ATP (useable energy)



# C:N:P Ratios



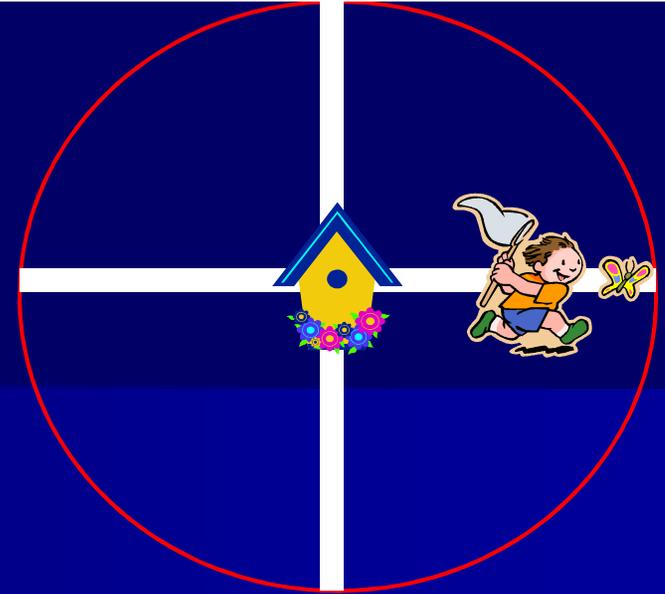
- Both Nitrogen and Phosphorus are limiting reagents, while Carbon is always readily available. Thus, more Nitrogen and Phosphorus in relation to Carbon is beneficial.
- Low C:N and C:P ratios are preferable to high ratios and hold more nutrient value. Large amounts of Nitrogen and Phosphorus indicate food items of higher quality.
- An N:P molar ratio of 16:1 is typical in most organisms. Both Nitrogen and Phosphorus are integral nutrients, so high N:P values mean Phosphorus is limited and low N:P values mean Nitrogen is in low supply.



# Research Questions and Hypotheses

1. Is chick condition (health) related to soil or bug quality?
  - Hypothesis: High soil and bug quality will increase chick health
2. Is chick growth related to soil or bug quality?
  - Hypothesis: Chick growth will be positively correlated with soil and bug quality
3. How does soil and bug quality relate to brood size?
  - Hypothesis: Brood sizes will increase with more nutrient rich environments and foods because more chicks can be supported
4. How does soil and bug quality relate to the number of clutches produced in a year?
  - Hypothesis: More clutches will be produced each year in sites with good soil and bug quality
5. Is the sex ratio (% males) of broods associated with either soil or food quality?
  - Hypothesis: High soil and food quality will result in sex ratios favoring male chicks who are larger and require more energy

## Methods



- Eastern Bluebirds feed in a circle with a 50 M radius around their nest

### Soil:

- Collected 6 random soil samples within the Bluebird's territory (50 M radius circle)

### Bugs:

- Used a sweep net to collect bugs in the feeding range

### Bugs from the Nest:

- Gathered bugs and other food items (such as salamanders and snails) that had been dropped in the bottom of the nest

# Wing Chord and Body Mass: Measures of Chick Growth and Condition

- Growth Rate – determined by wing chord length in relation to chick age
- Condition – determined by body mass in relation to wing chord (body size)



Wing chord

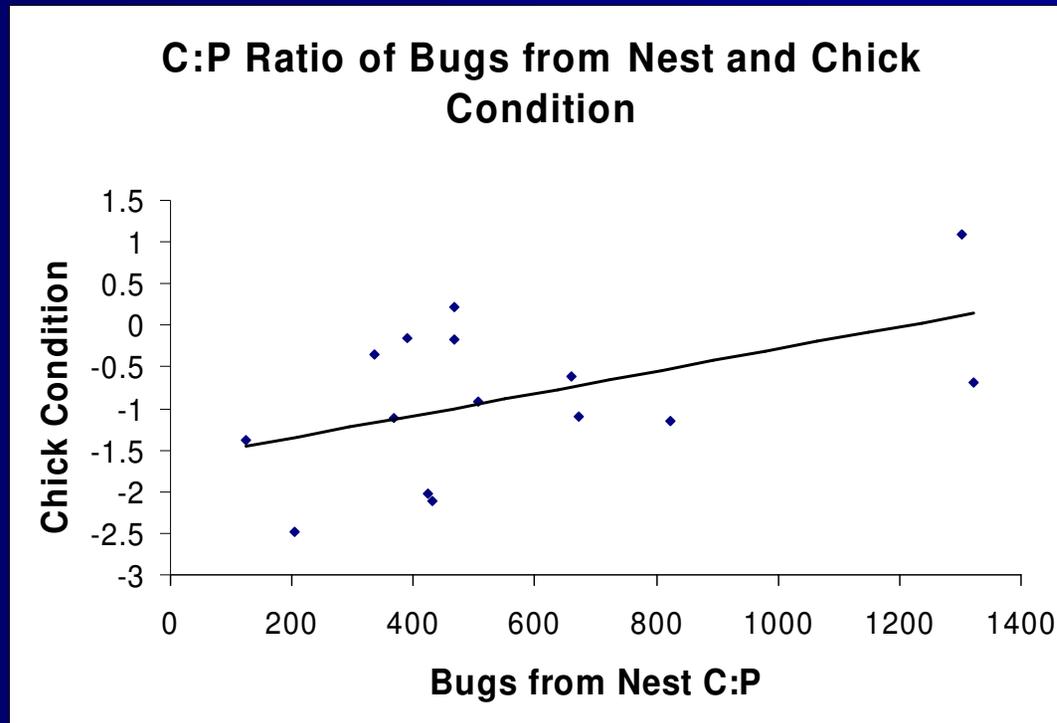


Body mass

# 1. Chick Condition

## C:P of Bugs from Nest

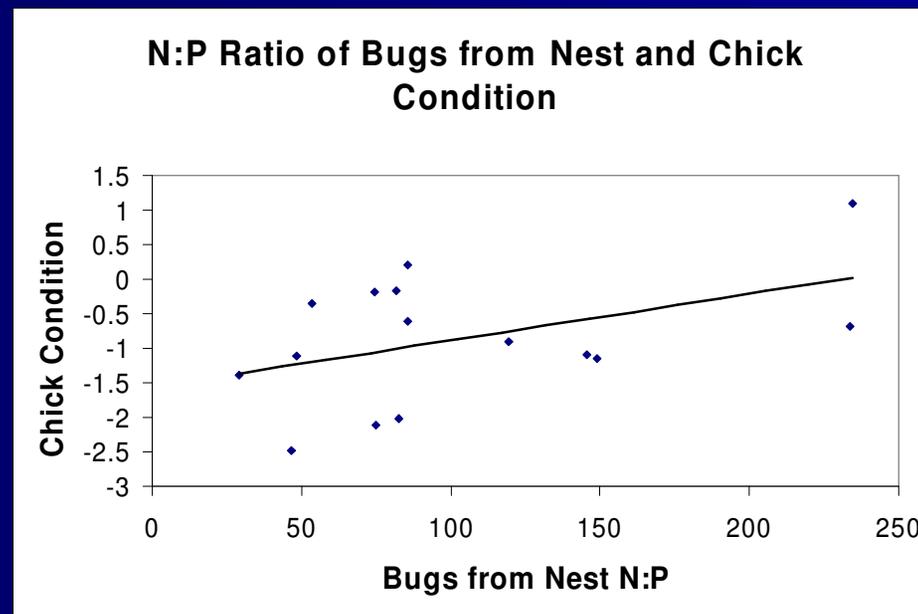
Average brood condition is somewhat positively correlated to the C:P ratio of the bugs from the nest ( $r = 0.449$ ,  $n = 15$ ,  $p = 0.059$ ).



An increase in Carbon or a decrease in Phosphorus could indicate an increase in the condition of the chicks.

# 1. Chick Condition N:P of Bugs

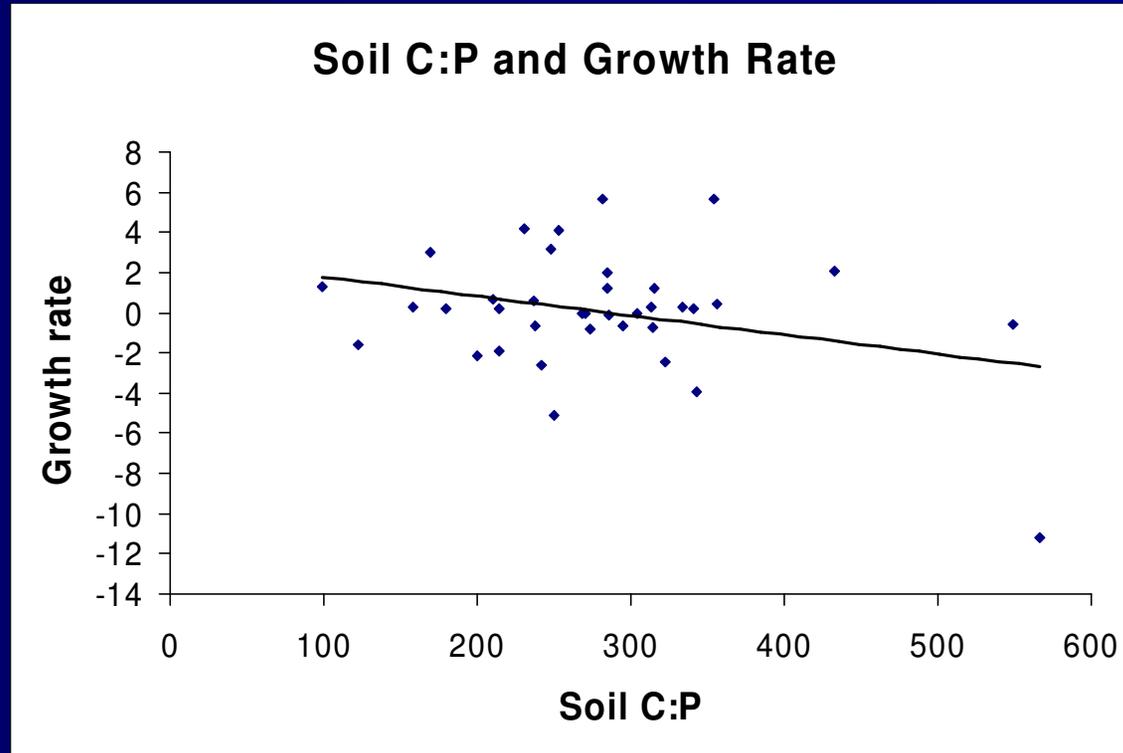
Brood condition is slightly positively related to the N:P ratio of the bugs from the nest ( $r = 0.454$ ,  $n = 15$ ,  $p = 0.089$ ).



An increase in Nitrogen or a decrease in Phosphorus could indicate an increase in the condition of the chicks.

## 2. Chick Growth

Brood growth is slightly negatively associated with the soil C:P ratio ( $r = -0.306$ ,  $n = 37$ ,  $p = 0.065$ ).



An increase in Phosphorus or a decrease in Carbon could indicate an increase in the rate of chick growth.

### 3. Clutch Size

Clutch size (number of chicks/brood) is somewhat positively related to % P of bugs ( $r = 0.481$ ,  $n = 15$ ,  $p = 0.069$ ).

Clutch size is also slightly negatively related to % C of bugs ( $r = -0.442$ ,  $n = 15$ ,  $p = 0.099$ ).



## 4. Number of Clutches/Year

The number of clutches per year (0, 1, or 2) is significantly negatively related to the C:N ratio of the bugs ( $r = -0.489$ ,  $n = 20$ ,  $p = 0.029$ ).

As Nitrogen increases or Carbon decreases, the number of clutches each year increases.



# Mini-Summary

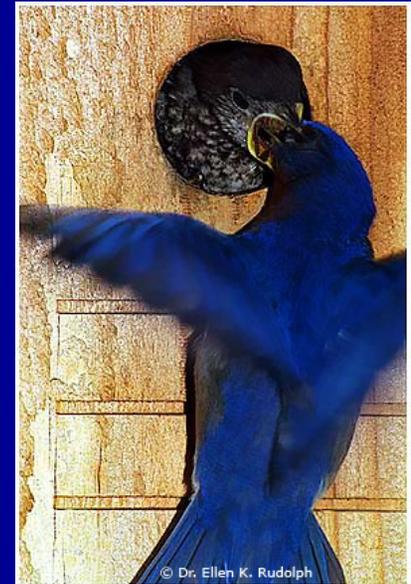
1. Chick condition is positively correlated to C:P and N:P ratio of the bugs from the nest. An increase in Carbon or Nitrogen, or a decrease in Phosphorus, in the food of the chicks improves their health.
2. Chick growth is negatively correlated with C:P ratio of soil. An increase in Phosphorus or a decrease in Carbon corresponds with an increase in growth.
3. Clutch size is positively related to % P and negatively related to % C of bugs.
4. The number of clutches per year is negatively related to C:N ratio of bugs.



# Manipulation of Sex Ratios: How?<sup>1</sup>

Sex ratios can be manipulated during the various stages in development:

- Non-randomly determined meiosis
- Sex-specific selection against gametes or fertilized eggs
- Parents differentially destroying or investing in certain eggs, nestlings, or fledglings



# Adaptive Manipulation of Sex Ratios: Why?<sup>1</sup>

Certain sex ratios are more evolutionarily beneficial than others, based on ecological and social circumstances such as:

- Sex ratio of the total population
- Nutritional resource availability
- Health of the parents



# Sex Ratio Differences in the Eastern Bluebird<sup>2</sup>

Three types of sex ratio:

- Primary – proportion of sexes at fertilization
- Secondary – proportion of sexes at hatching
- Fledgling – proportion of sexes when birds leave the nest

In a study by Pinkowski, females outnumbered males by 1.3 to 1 in all three sex ratios. This unbalanced sex ratio is explained by lower adult female survival and greater turnover due to breeding costs such as egg laying, incubation, and nestling care.



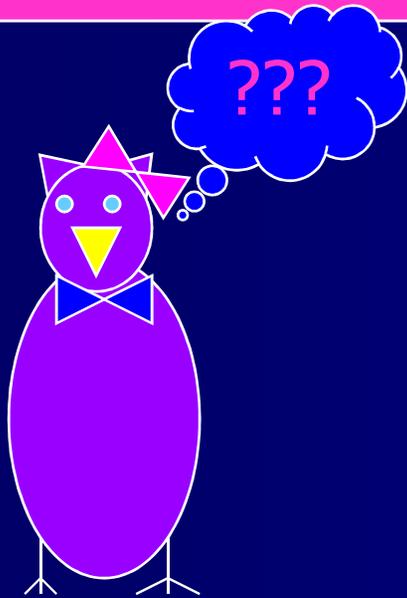
# Seychelles warbler<sup>3</sup>

The Seychelles warbler (*Acrocephalus sechellensis*) has the ability to vary the sex ratio of their young to the extremes – anywhere from 13% to 77% sons – depending on the availability of food at the nesting site.



# The Amazingly Adaptable Purple Swamp Owl

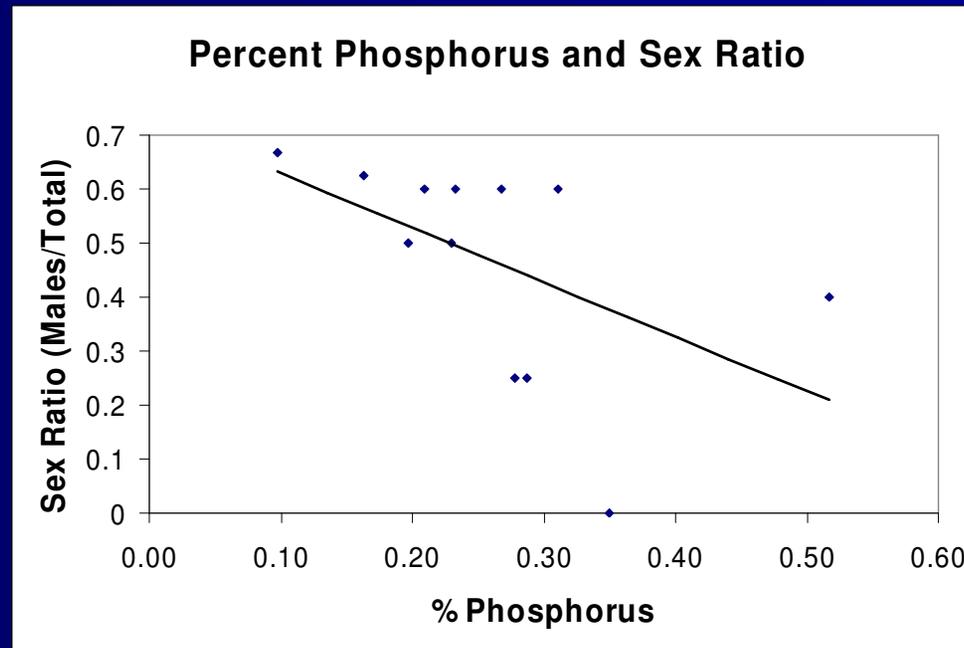
The versatile Purple Swamp Owl has the incredible ability to change the gender of its chicks at will throughout its offspring's life, depending on the mood of the mother. This amazing fact sheds light on the extreme gender confusion of Purple Swamp Owl juveniles that has baffled biologists for years.



# 5. Sex Ratio

## More Phosphorus Means More Females

Sex ratio (proportion males) is moderately negatively related to the percent of Phosphorus in the bugs from the nest ( $r = -0.524$ ,  $n = 12$ ,  $p = 0.080$ ).

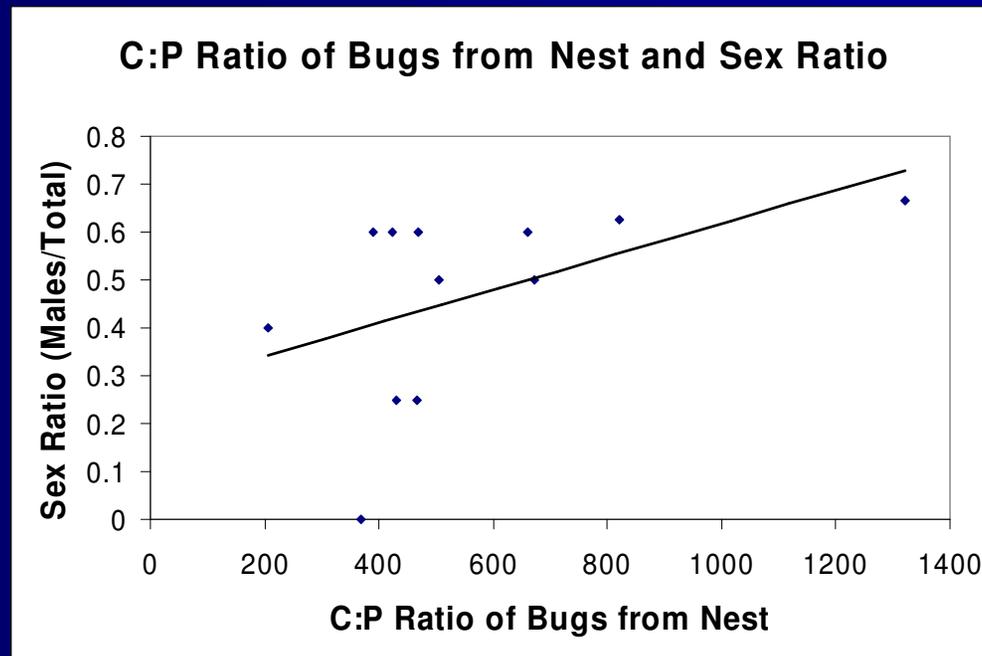


This trend indicates that increasing levels of Phosphorus is correlated with increasing proportions of females in a brood.

# 5. Sex Ratio

## C:P Ratio of the Bugs from the Nest

The C:P ratio of the bugs from the nest is significantly positively related to the proportion of males ( $r = 0.614$ ,  $n = 12$ ,  $p = 0.034$ ).

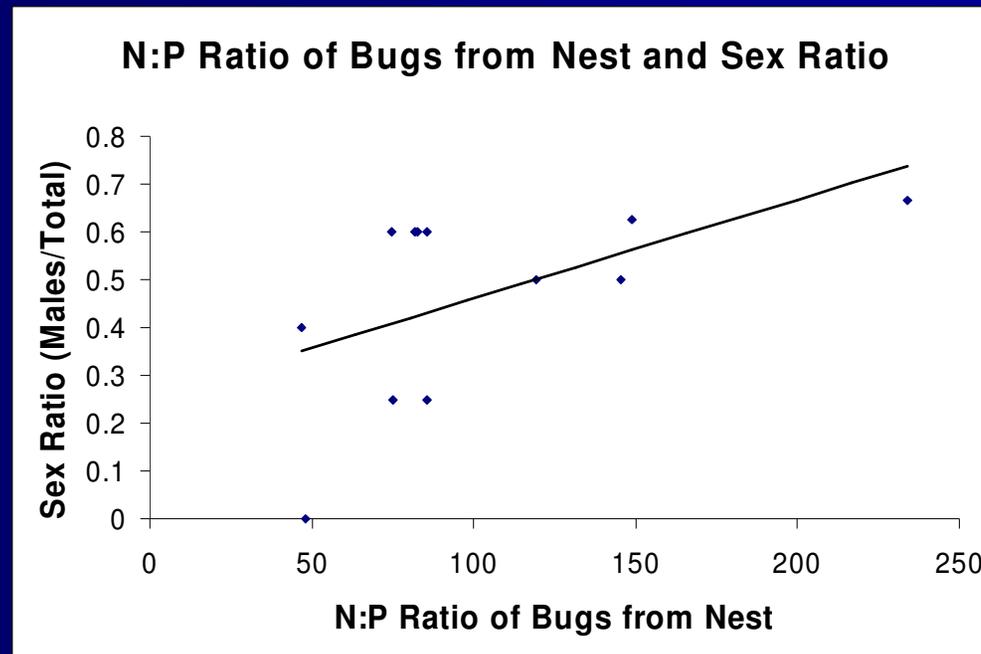


As Carbon increases or Phosphorus decreases, the proportion of males increases. Again, more Phosphorus indicates more females.

# 5. Sex Ratio

## N:P Ratio of Bugs from the Nest

The N:P ratio of the bugs from the nest is significantly positively related to the proportion of males ( $r = 0.593$ ,  $n = 12$ ,  $p = 0.042$ ).



As Nitrogen increases or Phosphorus decreases, the proportion of males increases. Females love that Phosphorus!!



# Research Questions and Answers

1. Is chick condition (health) related to soil or bug quality?
  - Soil quality is not related to chick condition
  - Chick condition improves with increased Carbon and Nitrogen, or decreased Phosphorus, in the bugs from the nest
2. Is chick growth related to soil or bug quality?
  - Chick growth improves with increased Phosphorus or decreased Carbon in the soil
  - Chick growth is not related to bug quality when controlling for clutch size, lay date, and sex ratio of brood
3. How does soil and bug quality relate to brood size?
  - Soil quality is not related to brood size
  - Brood size increases with increased % P or decreased % C of bugs

# Research Questions and Answers

4. How does soil and bug quality relate to the number of clutches produced in a year?
  - Soil quality is not related to the number of clutches per year
  - The number of clutches per year increases as Nitrogen increases or as Carbon decreases
5. Is the sex ratio (% males) of broods associated with either soil or food quality?
  - Soil quality is not related to sex ratio
  - The proportion of males decreases with the amount of Phosphorus and increases with more Carbon and Nitrogen in the bugs from the nest

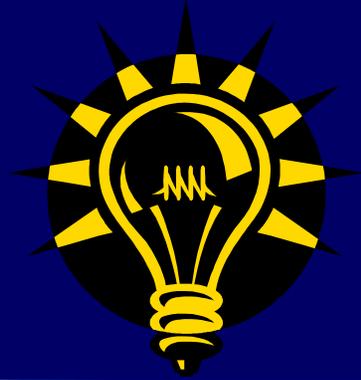


# Summary



In general, soil quality has little direct impact on Bluebird chicks, while the quality of their food has a much more noticeable influence.

- Carbon, the basic building block of organic matter, increases along with chick condition and the proportion of males, but decreases with increased chick growth, clutch size, and the number of clutches per year.
- Nitrogen, used in amino acids, proteins, and enzymes, increases with condition, the number of clutches per year, and the proportion of males in a clutch.
- Phosphorus, used for DNA and ATP, increases along with growth, clutch size, and the proportion of females, while decreasing when chick condition improves.



## Future Research

- Collect bugs using throat-collaring methods on the chicks to get larger sample sizes and determine what chicks are being fed
- Compare bugs from multiple years to determine if there are any differences in food quality
- Analyze bug samples from golf courses with other sites to determine if there is a difference in food quality
- Study affects in bug availability and bug diversity on health and growth on chicks
- Perform controlled experiments to determine how efficiently chicks process food items, what nutrients they retain, and how this affects chick health and growth
- Perform controlled experiments to determine if relationships between correlated variables are also causal
- Determine if adult birds return to sites with poor food quality



# Acknowledgements

- **John Swaddle**, who was an excellent advisor and helped me with all levels of my research, including formulating a question, determining methods, data analysis, interpretation, and computer and stats help.
- **Randy Chambers**, who helped me in the lab with all the machines and chemicals – mixing reagents, fixing the temperamental elemental analyzer and freeze drier, and coming to my aid in emotional crises – and who helped me outside of the lab with data interpretation.
- **Tim Russell**, who was my guide through the confusing world of computers, gave me plenty of practical advice about field work, provided me with chigger medicine in my dire hour of need and, most importantly, amused me and kept me sane through everything with his stories, almost-funny jokes, and antics.
- **Tondra Robinson**, who kept me company doing field work and maintained my sanity during long, fruitless hours of watching bird boxes.
- All the **Bluebirds**, who put up with me stealing their food and molesting their chicks in the name of science. I didn't appreciate the dive-bombings, but that's forgiven.
- All the **Purple Swamp Owls**, who have done their part in keeping us all amused and reminded us not to take life too seriously.
- The other **REU students** who encouraged me and kept me going.
- **Anyone else** who helped me that I'm too forgetful to mention.

# The “Thinker”



“Hey! I’m funny! What is she talking about?” - Tim

# References



1. Gowaty, P.A. 1991. Facultative Manipulation of Sex Ratios in Birds: Rare or Rarely Observed? *Curr. Ornithol.* 8: 141-171.
2. Pinkowski, B.C. 1977b. Breeding Adaptations in the Eastern Bluebird. *Condor* 79:289 – 302.
3. Komdeur, J, Daan, S., Tinbergen, J. and Mateman, C. Nature. 385, 522 – 525 (1997).



		Growth	Condition	# Clutches	Clutch Size	Sex Ratio (% M)
Soil	C:N					
	C:P	-				
	N:P					
Bugs	C:N			-		
	C:P					
	N:P					
Bugs from Nest	C:N					
	C:P		+			+
	N:P		+			+
Bugs	% P				+	
	% C				-	
	% N					
Bugs from Nest	% P					-
	% C					
	% N					

 = Significant