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Determinants and variation of the sex ratio in the Eastern Bluebird, *Siala sialis*

By Hilary Franke, Advised by E. Raymond Heithaus, Kenyon College, Department of Biology

Abstract

Female bluebirds can alter the sex of their offspring, and therefore the nest sex ratio, to maximize fitness. Sex ratio is defined as the number of male chicks divided by the number of total chicks in the brood. Parents in good condition tend to have broods with higher sex ratios. We used weight-to-wing length (WT/WL) ratio and immune function as measurements of individual condition. We predicted that sex ratios would decrease over the summer, and that sex ratio would be directly related to the WT/WL ratio and immune function. Since parental condition affects sex ratio, we also expected that WT/WL ratio and immune function would be heritable. Thirteen days after hatching, the sex of each chick was determined, and tarsus and wing length and weight were measured for chicks and parents, and blood samples were taken from chicks and parents. Blood samples were run through an immune assay to quantify immune function. We found no relationship between chick WT/WL ratio and immune function. Immune function was not heritable from either parents, but WT/WL ratio was heritable. Sex ratios decreased over the breeding season, but the weight-wing length ratio increased over the season. Thus, we concluded that females were not manipulating the sex ratios of their chicks to maximize fitness.

Introduction

Female bluebirds can manipulate the sex ratios of their broods to confer higher fitness to themselves and their offspring. The sex ratio is the number of male chicks divided by the total number of chicks in the brood. When there is competition for mates, large, robust males have the highest fitness, followed by females of any size, and small males of poor condition have the lowest fitness. Thus, if conditions permit females to produce robust males, they would be expected to do so. In 2003, L. Kordonowy found male-biased sex ratios among bluebird nests in Knox County, but in 2004-2006 she found no bias towards either sex.

Resource availability, breeding date, and parental condition all affect the sex ratio. Specifically, parents of larger size and better health produce more males. To quantify individual condition, we used the weight/wing length (WT/WL) ratio as a measure of robustness and immune function as a measure of health.

Questions:

- Does the sex ratio change over the breeding season?
- Is the sex ratio related to chick WT/WL or chick immune function?
- Is body size and/or immune function heritable?
- Are there differences in the WT/WL ratio and immune function among chicks from different sites, nests, or sexes?

Hypotheses

- Sex ratio will decrease over the breeding season
- Sex ratio will be positively correlated with the WT/WL ratio and immune function
- Immune function will be heritable
- WT/WL ratio will be heritable

Left, bluebird chicks; Right, an adult male bluebird

Methods

- 44 nest boxes were monitored at the Brown Family Environmental Center (BFEC) at Kenyon College, Miller Observatory trail, and Wolf Run Regional Park in Knox County, Ohio
- 13 days after hatching, sex of each chick was determined; wing length, tarsus length, and weight were measured; blood samples were taken
- Parents were also weighed, measured, and blood samples taken
- Immune assay: blood was mixed with bacteria and spread on an agar plate
  - Blood from birds with highest immune function allowed the fewest numbers of bacterial colonies to grow on the plates

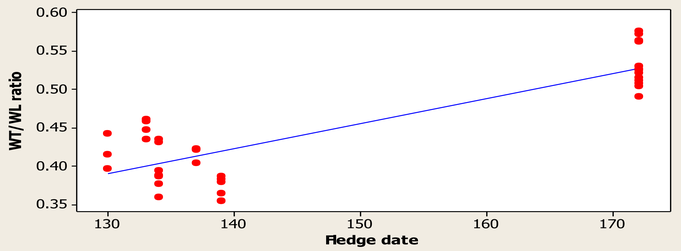

Figure 1: Regression of chick weight to wing length ratio versus Julian fledge date (Jan 1=1, Jan 2=2, etc.) for 2007; y=0.00327x+0.0346, R^2=72.8%, ANOVA p=0.000.

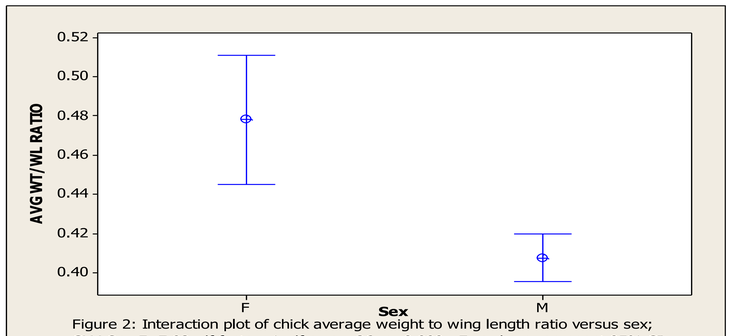

Figure 2: Interaction plot of chick average weight to wing length ratio versus sex; GLM Sex F=7.92, df factor=1, df error=26, p=0.009. Error bars represent 95% CI.

Acknowledgements

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Results

- Sex ratio decreased over the breeding season (R^2=57.4%, ANOVA p=0.011), but the WT/WL ratio of chicks increased (R^2=72.8%, ANOVA p=0.000)
- There was high variation among WT/WL ratios and immune function of chicks:
  - Chicks from BFEC were also 16.1% larger than chicks from Wolf Run; chicks from Miller were intermediate
  - Female chicks were 14.12% larger than male chicks
  - Blood from chicks from BFEC and Miller allowed 50.6% as many cultures to grow as the control and blood from chicks from Wolf Run allowed 90.8% as many cultures to grow
- Immune function was not heritable from either parent (R^2=0.0%, ANOVA p=0.607)
- Body size was heritable from both parents (Father ANOVA, F=32.65, p=0.000, Mother ANOVA, F=34.79, p=0.000)
- There was no correlation between body size and immune function of chicks (R^2=4.1%, ANOVA p=0.000)

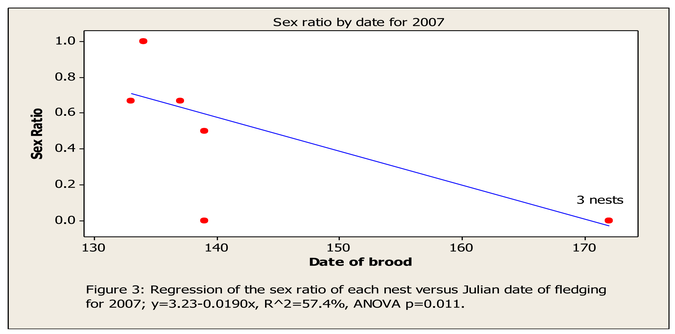

Figure 3: Regression of the sex ratio of each nest versus Julian date of fledging for 2007; y=3.23-0.0190x, R^2=57.4%, ANOVA p=0.011.

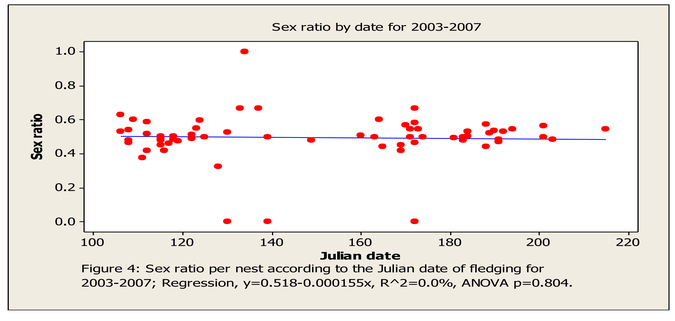

Figure 4: Sex ratio per nest according to the Julian date of fledging for 2003-2007; Regression, y=0.518-0.000155x, R^2=0.0%, ANOVA p=0.804.

Discussion

- In 2007, the sex ratio decreased over the breeding season, but the WT/WL ratios of chicks increased
- Female chicks had significantly higher WT/WL ratios than males (GLM, F=7.92, p=0.009); thus the increased number of larger females both decreased the sex ratio and increased the WT/WL ratio
- Additionally, early in the breeding season, females were producing males that were of poorer condition than chicks produced later in the season; if they produced chicks with smaller WT/WL ratios, we expected these to be females
- We concluded that female bluebirds were not manipulating the sex ratios of their nests to maximize fitness according to the Trivers & Willard hypothesis
- However, when data from 2007 was combined with data from 2003-2006, there was no significant correlation between sex ratio and fledging date (Regression; R^2=0.0%, p=0.804)
- Bluebirds tend to lay three broods per season, so in future experiments we would like to obtain data from all three broods so we could have a larger sample size and look for adults that breed more than once throughout the season