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This document is part of a collection that serves two purposes. First it is a public archive for data and documents resulting from evolutionary, ecological, and behavioral research conducted by the Ketterson-Nolan research group. The focus of the research is an abundant North American songbird, the dark-eyed junco, *Junco hyemalis*, and the primary sources of support have been the National Science Foundation and Indiana University. The research was conducted in collaboration with numerous colleagues and students, and the objective of this site is to preserve not only the published products of the research, but also to document the organization and people that led to the published findings. Second it is a repository for the works of Val Nolan Jr., who studied songbirds in addition to the junco: in particular the prairie warbler, *Dendroica discolor*. This site was originally compiled and organized by Eric Snajdr, Nicole Gerlach, and Ellen Ketterson.

Context Statement
This document was generated as part of a long-term biological research project on a songbird, the dark-eyed junco, conducted by the Ketterson/Nolan research group at Indiana University. For more information, please see IUScholarWorks (https://scholarworks.iu.edu/dspace/handle/2022/7911).

Sex ratio and survival in nestlings and adults of a songbird, the dark-eyed junco

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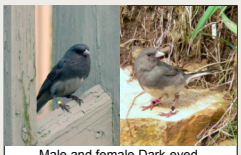
BACKGROUND

- Primary sex ratio is expected to be 50:50 in most populations, although individual females may benefit by producing an excess of either sex.[1]
- Sexes may differ in their survival during various life-history stages, particularly if reproductive costs are higher for one sex.[2]
- Operational sex ratio at reproduction can affect the strength of sexual selection.[3]

Long-term studies are needed to examine the causes and consequences of variation in the sex ratio of free-living populations.

DARK-EYED JUNCOS



Male and female Dark-eyed Juncos (*Junco hyemalis*)

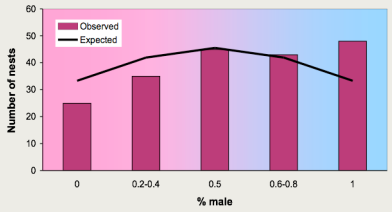
- Breeds across much of Canada and the Northern U.S.
- Socially monogamous territorial pairs.
- Breeds April-August.
- Typically 3-4 eggs per nest; nest predation high.
- Females incubate for 12 days.
- Fledging occurs on day 11 or 12; both parents feed nestlings.
- Juveniles disperse during 1st winter.
- Maximum known lifespan in our population is 9 years for males, 8 for females.

METHODS

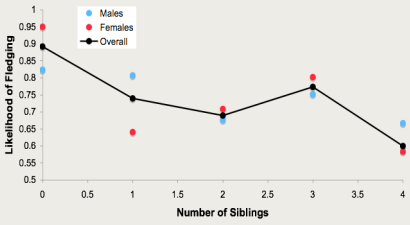
- Mountain Lake Biological Station, Giles County, Virginia
- Population was monitored during springs and summers since 1985; currently more than 12.5k known individuals, including 3200 nestlings, 5900 juveniles, and 3400 adults.
- Adults and juveniles were sexed using morphometric and plumage characters, as well as reproductive condition (in adults).
- Nestlings from 1997-2006 were sexed genetically via amplification of the sex-linked CHD gene, using DNA samples collected at 6 days of age; prior to 1997 nestlings were sexed only if they were recaptured as juveniles or adults.
- Population sizes are based on birds known to be alive in a given year, whether by capture, sighting, or capture in a subsequent year.

NESTLINGS

These analyses were based on 196 nests from 1997-2006 in which the sex of all six-day old nestlings was known.

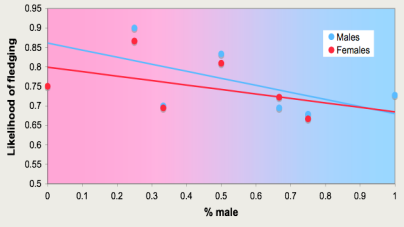


Expected values were generated based on the observed distribution of chicks per nest and a 50:50 sex ratio. The relative lack of all-female nests and the relative surplus of all-male nests led to an **overall male-biased nestling sex ratio**. ($X^2 = 9.73$, $p<0.05$)



"Only children" had the highest likelihood of surviving to fledging, while nestlings with a higher number of siblings of either sex had a lower likelihood of fledging. However, this pattern was not statistically significant.

males: fledge = -0.037 * sibs + 0.819, $r^2 = 0.65$, $F = 5.601$, $df = 4$, $p = 0.099$
females: fledge = -0.057 * sibs + 0.851, $r^2 = 0.39$, $F = 1.947$, $df = 4$, $p = 0.26$
overall: fledge = -0.055 * sibs + 0.849, $r^2 = 0.65$, $F = 5.638$, $df = 4$, $p = 0.098$

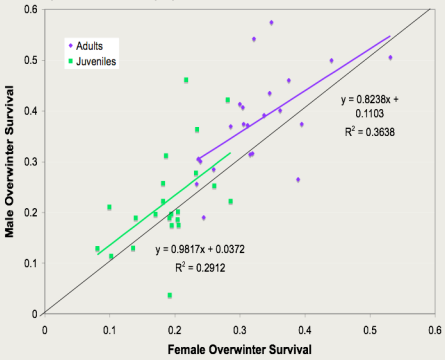


In general, it appears as if the likelihood of fledging for both males and females decreased with an increasing male-biased sex ratio in the nest. However, this pattern was not statistically significant for either sex.

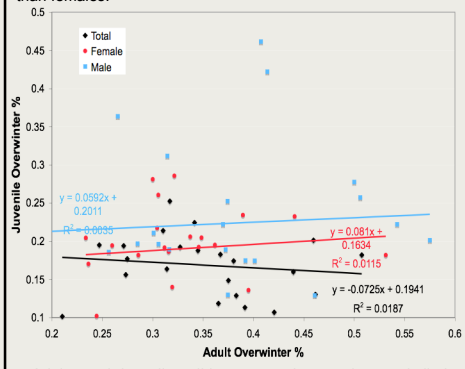
males: fledge = -0.181 * SR + 0.861, $r^2 = 0.32$, $F = 1.843$, $df = 5$, $p = 0.25$
females: fledge = -0.115 * SR + 0.799, $r^2 = 0.18$, $F = 0.895$, $df = 5$, $p = 0.40$

OVERWINTER

Each data point represents one yearly overwinter period between 1985 and 2007. Overwinter survival was calculated as the percent of individuals alive in a given year who were also known to be alive in the subsequent year. These values therefore underestimate true survival, since they do not account for dispersal to other populations.



- Juveniles had lower overwinter return than adults in both sexes - most likely due to higher rates of dispersal.
- Males and females experienced the winters similarly: years in which few males survived, few females survived.
- Most years, males of both adults and juveniles were more likely to return than females.

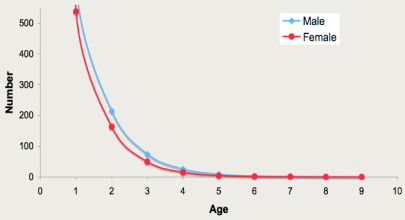


- Adults and juveniles did not experience winters similarly. Years in which a high percentage of juveniles returned to the population were not necessarily the same years in which a high percentage of adults returned.
- The true relationship between adult and juvenile overwinter survival may be obscured by winter dispersal of juveniles. That is, harsh winters may similarly affect adult and juvenile survival, but varying dispersal rates may mask the effect.

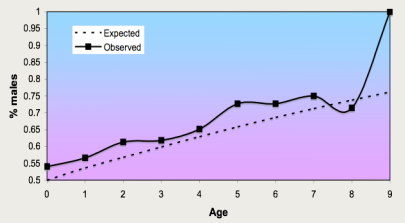
POPULATION

Overall yearly survival rates (1985-2007):

- Males:
  - Juvenile to A_1 = 20.76%
  - A_n to A_{n+1} = 34.58%
- Females:
  - Juvenile to A_1 = 17.93%
  - A_n to A_{n+1} = 30.45%



Starting with an initial cohort of 3000 juveniles of each sex (roughly equal to the number of banded juveniles in this population), a predicted survival curve shows a male-heavy population with extinction by age 10.



Even small differences between male and female yearly survival can lead to an population with an increased male-bias in the older age classes.

FUTURE RESEARCH

- Nestling data were based on the secondary sex ratio - is the primary sex ratio actually male biased? If yes, why? If not, what is causing selective attrition of female eggs/nestlings prior to day 6?
- What environmental factors contribute to variation in yearly survival, and do both sexes experience them in the same way?
- Does the increasingly male-biased sex ratio influence the strength of sexual selection on males?

REFERENCES

1. Trivers R. L. and D. E. Willard. 1973. Natural selection of parental ability to vary the sex ratio of offspring. Science 179 (4068): 90-92.
2. Breitwisch, R. 1989. Mortality patterns, sex ratios, and parental investment in monogamous birds. Current Ornithology 6: 1-50.
3. Shuster, S. M. and M. J. Wade. 2003. *Mating Systems and Strategies*. Princeton University Press.

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