

## COMMENTARY

### LOW POWER AND IMPLICATIONS FOR FEMALE MATE CHOICE THEORY

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*Key words:* Nestling provisioning; mate choice; power analysis.

Omland and Sherry (1994) hypothesize that female choice of older males in American Redstarts (*Setophaga ruticilla*) may be explained by differences in nestling provisioning for the two groups of males, yearling and older birds. They failed to find differences in number of feeding trips per hour and estimated mass (mg) delivered per hour for the two age classes of males. In lieu of evidence of the provisioning hypothesis, Omland and Sherry suggest five alternative explanations for female preference for older males. Before their provisioning hypothesis is dismissed, however, I argue (1) that the power of the analysis is too low to detect differences in mean or median provisioning, and (2) their results contain some evidence that younger males may be a riskier choice than older males.

Omland and Sherry perform careful statistical analyses of their data, including controlling the overall type I error rate using the Bonferroni method to guard against spurious significance. I performed a power analysis of the feeding trips per hour and mass delivered per hour (Omland and Sherry's Table 2) using Execustat (Strategy Plus, Inc., PWS-Kent Publishing Corp., Boston, MA 02116). I used the two-sample *t*-test procedure with a one-sided alternative.

Table 1 contains the power analysis for feeding trips per hour. Standard deviation is based on the pooled sample variance of the two groups. Detectable difference is a function of the standard deviation, including values less than, equal to, and greater than the standard deviation. Sample sizes are inferred from Omland and Sherry's paper. I estimated the power of each analysis at  $\alpha = 0.05$  and at a protected type I error rate of 0.004. The power is low for most tests. Only in the instance of detectable difference = 3 for the 1988 data and detectable difference = 4 for the combined data is the power near or above the conventional 80% level and that is for the unprotected error rate. These analyses are capable of detecting only dramatic differences in means. The same situation exists for the estimated mass delivered per hour measure (Table 2).

Omland and Sherry use a nonparametric test, the Mann-Whitney *U*-test, to compare medians. It is not possible to determine the power of these tests without specifying the underlying distribution. If the distribution is normal then the two-sample *t*-test gives the most powerful results and the power of Omland and Sherry's analysis is no greater than that reported here. It is possible that the power of the Mann-Whitney *U*-tests reported by Omland and Sherry is as much as 1.5 times that of the *t*-test (Kotz and Johnson 1985) though this would be the case for unlikely distributions (i.e., logistic, double exponential).

My second remark arises from descriptive statistics in Omland and Sherry's Table 2. There is evidence that the variability of the data is unequal for the two male age groups. Table 3 summarizes the results of *F*-tests performed to compare sample variances. Significant results are identified using the sequential Bonferroni method (Rice 1989) which protects the overall type I error rate at  $\alpha = 0.05$ . These results indicate that number of hourly feeding trips are more variable for

TABLE 1. Power analysis for the response variable feeding trips per hour at  $\alpha = 0.05$  ( $\alpha = 0.004$ ).

Year	Detectable difference	Standard deviation	$n_1, n_2$	Power
1988	1	1.80	5, 5	17.8% (1.5%)
	2	1.80	5, 5	46.0% (5.9%)
	3	1.80	5, 5	77.0% (20.4%)
1989	1	3.72	7, 11	12.6% (1.3%)
	2	3.72	7, 11	26.8% (3.7%)
	3	3.72	7, 11	46.9% (9.6%)
	4	3.72	7, 11	68.0% (21.7%)
1988/1989	1	3.43	12, 16	17.7% (2.2%)
	2	3.43	12, 16	43.0% (9.5%)
	3	3.43	12, 16	71.8% (28.3%)
	4	3.43	12, 16	90.5% (57.1%)

TABLE 2. Power analysis for the response variable estimated mass delivered/hour at  $\alpha = 0.05$  ( $\alpha = 0.004$ ).

Year	Detectable difference	Standard deviation	$n_1, n_2$	Power
1988	10	19.65	5, 5	16.1% (1.3%)
	20	19.65	5, 5	40.4% (4.7%)
	30	19.65	5, 5	70.3% (15.3%)
1989	10	37.10	4, 11	10.7% (1.0%)
	20	37.10	4, 11	20.6% (2.3%)
	30	37.10	4, 11	35.3% (5.2%)
	40	37.10	4, 11	53.0% (11.1%)
1988/1989	10	29.88	9, 16	18.6% (2.3%)
	20	29.88	9, 16	45.8% (10.4%)
	30	29.88	9, 16	75.3% (31.3%)
	40	29.88	9, 16	92.6% (62.0%)

TABLE 3. Results of *F*-tests to compare sample variances for number of feeding trips and mass delivered for the two male age groups.

	Number of feeding trips/hour			Estimated mass delivered/hour		
	<i>F</i> -statistic	df	<i>P</i> -value	<i>F</i> -statistic	df	<i>P</i> -value
1988	1.25	4, 4	0.4170	2.94	4, 4	0.1606
1989	7.56	6, 10	0.0029*	4.66	10, 3	0.1160
1988/1989	4.37	11, 15	0.0048*	3.42	15, 8	0.0423

\* Significant at overall type I error rate of  $\alpha = 0.05$ .

yearling males than older males in 1989 and for combined years. Perhaps younger males are a more risky choice for females in that their behavior is not as consistent as older males.

The *F*-test requires that the data come from populations with normal distributions and is sensitive to deviations from this assumption (Zar 1984). Whether the normality assumption is violated in this case is unknown. Therefore, these results should be tentatively accepted. Nonetheless, the results are interesting in that they indicate an additional hypothesis for mate choice by female American Redstarts.

Dismissing the provisioning hypothesis is premature given the low power of the analyses performed by Omland and Sherry and evidence of differences in variability of the provisioning behavior of the two age groups. Collection of additional data would enhance the power of the analysis and place conclusions regarding this hypothesis on sounder ground.

### PARENTAL CARE NOT LIKELY TO EXPLAIN POOR MATING SUCCESS IN YEARLING MALE AMERICAN REDSTARTS

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We welcome Beal's (1995) commentary on our paper (Omland and Sherry 1994) investigating age-specific parental care in American Redstarts (*Setophaga ruticilla*). Her assessment, based on a statistical power analysis, is that additional data are needed before we can conclude confidently that no difference exists in nestling-provisioning behavior by yearling versus older males. Her remarks echo our own caution interpreting our results, in which we stated, "It is possible that our methods and sample sizes were not capable of detecting minor differences in provisioning rates between the two age classes . . ." (p. 611, Omland and Sherry 1994). Her power analysis is useful because it indicates the

Thanks to Kevin Omland and Joel Chaney for comments and discussion.

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exact level of detectable mean difference in our study. Beal's second finding, that yearling male provisioning behavior was more variable than that of older males in both 1989 and the two years combined, suggests the interesting possibility that yearlings may be relatively risky as potential mates, an idea we discuss below in the context of polygyny. While Beal's analyses aid our understanding of parental care behavior in redstarts, we nonetheless stand by the main conclusion of our study, which was that male contributions to nestling-provisioning are unlikely to be an important factor in females' choice of mate.

First, we argue that the small age-related difference in male nestling-provisioning behavior makes it unlikely to be important in females' choice of mate. Success in mating is dramatically different in the two ages of male American Redstarts in our study area: Unmated older males are nearly impossible to find, whereas about half the yearlings remain unmated on average (Omland and Sherry 1994; and TWS, unpubl. data). Such disparity is unlikely to be explained by differences in parental nestling-provisioning behavior, unless older male nests are provisioned at a consistently higher rate than yearling male nests. We originally expected such a difference in provisioning for the following reasons, (1) Yearlings tend to be in different habitats than older males due to social constraints (Sherry and Holmes 1989, and unpubl. data), which could in turn constrain