Investigating the relationship between respiration rate and learned vocal communication in adult male zebra finches

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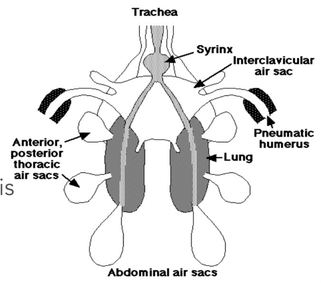
1. ABSTRACT

Male zebra finches are observed to sing at a variety of rates; the reason behind this is unknown. It has been hypothesized that increased singing capabilities may denote an evolutionary advantage. There is a direct relationship between oxygen (O_2) consumption, and seconds singing in male zebra finches. In this study I measured the resting O_2 consumption rate of adult male zebra finches and analyzed their rate of singing. I uncovered that adult male zebra finch O_2 consumption/mass is higher in birds with higher rate of oxygen consumption with respect to their mass.

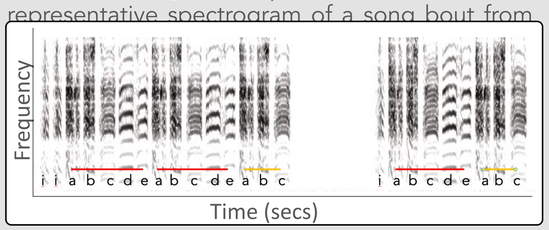
2. INTRODUCTION

Zebra finches have a unique respiratory system which allows for air to pass through the trachea under the control of their syrinx to produce learned sounds. The syrinx vocal organ is analogous to the larynx in humans. Oxygen (O_2) in air travels through air sacs in addition to the lungs where gas exchange occurs, which

Some male zebra finches sing more often than others. However, the physiological differences associated with this behavioral difference are not well understood.



Here investigate the relationship between O_2 metabolism and the singing rate in male zebra finches. I test the hypothesis that a lower metabolic cost of song production is advantageous, which predicts that birds with a lower rate of O_2 consumption sing more often. A representative spectrogram of a song bout from



3. MATERIALS & METHODS

Vernier BioChamber 2000, Go Direct O_2 Gas Sensor, and Graph Analysis Pro were used to collect oxygen consumption rates for each bird across at least three 80 second sessions on different days and averaged together.

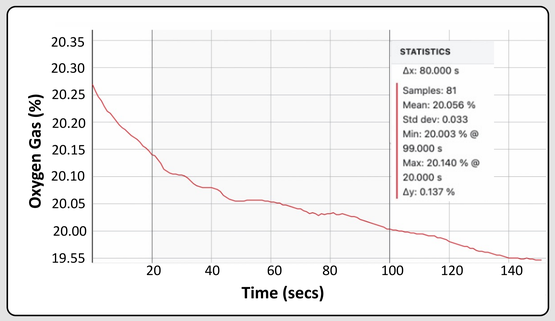
Sound Analysis Pro was used to record songs produced during an hour of observation at the onset of a 14:10 light:dark cycle. Avisoft Sound Analysis Software was used to calculate song duration over two different one-hour observation periods for each of seven adult male zebra finches.

As O_2 consumption is linked to metabolism as well as mass, we normalized O_2 consumption rates using the following equation:

$$\frac{Rate\ of\ O_2\ Consumption}{Mass} = \frac{\frac{Change\ in\ O_2\ Consumed\ (\%)}{Time\ observed\ (seconds)}}{Mass\ (grams)}$$

$$Singing\ Rate = \frac{Time\ Spent\ Singing\ (seconds)}{Time\ Observed\ Singing\ (hours)}$$

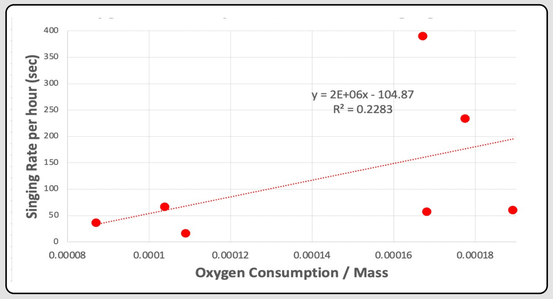
4. RESULTS



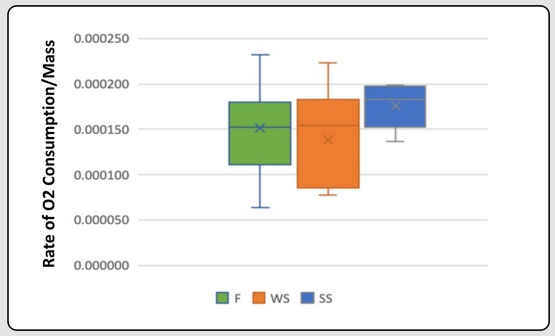
Percent O_2 consumption for an individual bird measured within an 80 sec window (Δy = 0.137%).

4. RESULTS (cont'd)

Bird	Singing Rate per Hour	[O2]/Mass (g)
RPrP4	15.6973	0.0001091
RPrO18	35.5700	0.0000871
M37621	56.3200	0.0001681
RGY16	60.0700	0.0001892
M26921B	65.7600	0.0001039
M26921A	232.8500	0.0001776
RWGy24	389.8400	0.0001671



The relationship between singing rate and oxygen consumption rate over mass for seven birds. A weak positive correlation was observed.

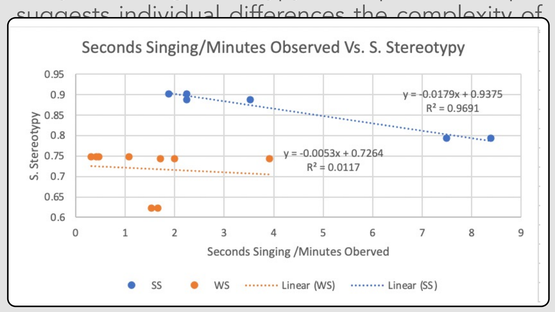


We identified birds with two distinct levels of singing in our sample: weak singers (ws, orange) and strong singers (ss, blue). In addition, we measured O_2 consumption in non-singing females.

5. DISCUSSION & FUTURE DIRECTIONS

Our study set out to determine if measurements of basal O_2 metabolism could be used to predict singing strength in individual adult male zebra finches. We found a weak positive correlation between the two. Although we did not find support for our hypothesis, only seven birds were evaluated. Nevertheless, our results are consistent with previous research reporting that the volume of O_2 consumed during singing increases with song bout duration (1).

We intend to include more birds in this investigation. We also aim to analyze the relationship between respiration rate and vocal complexity. One approach to quantifying the complexity of vocalizations in zebra finches could use measures of song stereotypy (2). An initial analysis of song stereotypy in the present sample suggests individual differences the complexity of



6. CONCLUSION

We found that male zebra finches with a stronger rate of singing tended to have a higher mass-normalized rate of O_2 consumption compared to males with a weak rate of song production. These results could be useful to predict singing performance in animals under experimentation. This work also highlights the physiological constraints that may influence the evolution of vocal complexity.

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