The Rapid Reproductive Response of Male Rufous-winged Sparrows, *Aimophila carpalis*, to Increased Precipitation: a Role for Termites?

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Timing of Reproduction in Birds

- Changes in day length control the timing of reproduction in most birds studied
- Exposure to long days (LD; >12 h of light per day) stimulates gonadotropin-releasing hormone I (GnRH) release from the hypothalamus, resulting in FSH and LH release from the anterior pituitary gland
- Less is known of the role of non-photoperiodic information on the timing of reproduction
- Gonadotropin-inhibiting hormone (GnIH) is a hypothalamic peptide that can inhibit LH release
- It is presently unknown if and when GnIH influences the reproductive system under natural conditions

Question 1: What physiological and environmental stimuli control reproduction in the flexibly breeding Rufous-winged Sparrow?

Field Study

- Gonad diameter and plasma LH were measured in free-living male Rufous-winged Sparrows between February and October 2003 (Fig 2)
- Testis width is correlated with day length
- Plasma LH is correlated with rain

Captive Photostimulation

- Twenty-eight male sparrows were kept on 8 hours of light per day (8L) for 11 weeks
- Sparrows (n=7/group) were transferred to 16L, 14L, 13L or 8L for 8 weeks (Fig 3)
- 13L, 14L, and 16L exposure caused gonadal development
- 16L exposure significantly increased LH
- Photoperiod is the primary stimulus for testicular development
- Plasma LH is stimulated by increased photoperiod in captivity

Question 2: How rapidly does plasma LH increase with respect to the beginning of the monsoon rains? What environmental cues are correlated with these changes.

Figure 1: A) Adult male Rufous-winged Sparrow. B) Geographical distribution

The Rufous-winged Sparrow

- Sonoran desert resident (Fig 1)
- Timing of breeding varies annually and nesting is closely associated with irregular monsoon precipitation

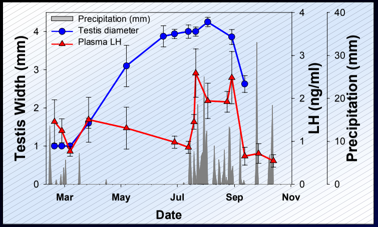

Figure 2: Testis width and plasma LH of free-living male Rufous-winged Sparrows. Points are mean +/- SE.

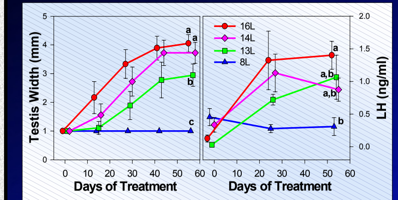

Figure 3: Testis width and plasma LH (mean +/- SE) of captive sparrows exposed to different photoperiods. Points not sharing the same letter on the last day of sampling are significantly different (p<0.05)

Test of Question 2

- Testis and cloacal protuberance (CP) diameter were measured and blood samples were collected from free-living male Rufous-winged Sparrows every three to seven days during the monsoons of 2002, 2003 and 2004
- Temperature, humidity and vegetation growth (ground cover and woody plant budding) was measured on six 100 meter transects in July 2002

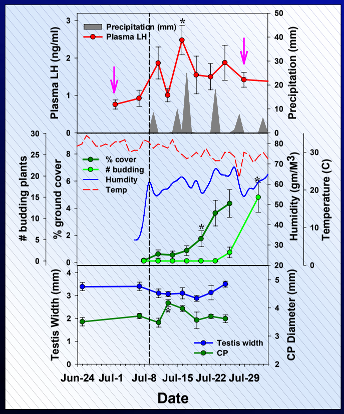

Figure 4: Plasma LH (top panel), testis width and CP diameter (bottom panel) of free-living sparrows from 2002. Precipitation, temperature, humidity and vegetation measurement are also shown. Arrows indicate sacrifice days for Test 3. Points are mean +/- SE.

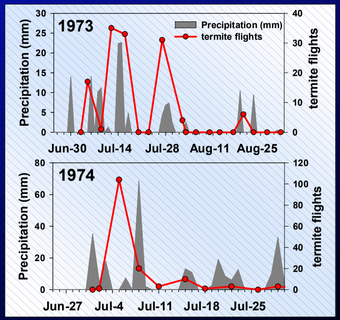

Figure 5: Termite alate flight patterns in the Sonoran Desert in response to rain. Data adapted from Nutting and Haverty *Sociobiology*, 1976.

Results: Question 2

- Plasma LH increased within seven days after the first monsoon rain in 2002-2004.
- In 2002, LH increased prior to significant changes in vegetation growth (Fig 4)
- Rufous-winged Sparrows were observed catching termite alates on July 11, 2002.
- In captivity, increased dietary protein elevated plasma LH in male Rufous-winged Sparrows (data not shown)
- Plasma LH profiles of free-living birds resemble termite alate flight profiles during the onset of the monsoon

Question 3: What is the primary physiological stimulus for increased plasma LH in Rufous-winged Sparrows during the monsoon breeding period?

Hypothesis 1: Increased GnRH secretion increases plasma LH

Hypothesis 2: Decreased GnIH secretion increases plasma LH

Test of Question 3

- Adult male Rufous-winged Sparrows were field-sacrificed before (July 2; n=6) and during (July 29; n=6) the 2002 monsoon season (Fig 4)
- Hypothalamic content of GnRH, ProGnRH, and GnIH were determined using semi-quantitative immunohistochemistry

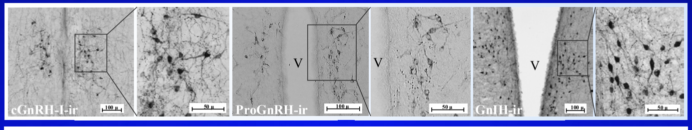

Figure 6: Hypothalamic staining for GnRH like immunoreactive (GnRH-li ir), ProGnRH-li ir and GnIH-li ir cells.

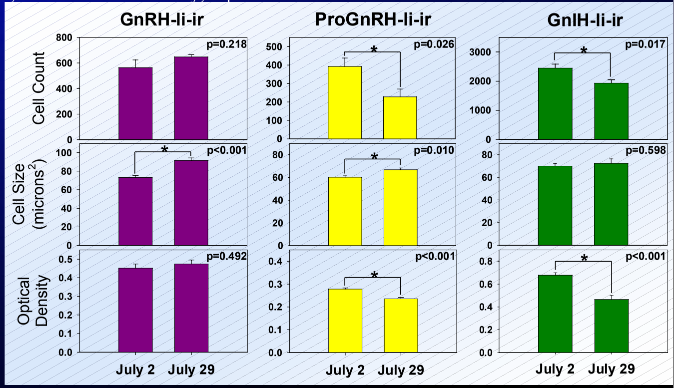

Figure 7: Cell count, cell size and optical density of GnRH-like immunoreactive (GnRH-li ir), ProGnRH-li ir and GnIH-li ir cells (mean +/- SE)

Results: Question 3

- Plasma LH increased between July 2 and 29 (Fig 4)
- Hypothalamic content of GnRH, ProGnRH, and GnIH were determined by cell numbers, cell sizes, and optical density of immunostained material (Fig 6 and 7)
- GnRH cell count and optical density did not change, but cell size increased between July 2 and 29
- ProGnRH cell count and optical density decreased while cell size increased indicating an increase in GnRH cell activity which is consistent with hypothesis 1
- GnIH cell count and optical density decreased while cell size remained unchanged indicating a change in GnIH cell activity which is consistent with hypothesis 2

Conclusion

- Increased photoperiod is the primary stimulus for testicular development
- Plasma LH is primarily under the control of non-photoperiodic information and may be regulated by direct "rain" stimulation or changes in dietary nutrients due to increased termite availability
- Both increased GnRH release and decreased GnIH release may be responsible for increased LH

Proposed Model

- Nutrients may play an important role in the timing of reproduction by regulating LH through GnRH and GnIH (Fig 8)

Figure 8: Model of how different types of information may influence the regulation of reproduction in male Rufous-winged Sparrows.