

# MINIGRANT APPLICATION FORM

Title of Proposal:

Visual and vocal learning in a hummingbird species

Principal Investigator:

Timothy F. Wright

Department:

Biology

Proposed Project Period:	Total Minigrant Request:	\$ 1,997.00	RC -
Start Date: January 1, 2011	Total Cost Sharing:	\$ 1,305.00	
End Date: May 31, 2011	Total Project Cost:	\$ 3,302.00	

Abstract of Proposal (a maximum of 100 words and underline key words):

Visual learning may be an important evolutionary precursor to the vocal learning that underlies human language, but the co-occurrence of these two forms of learning has been rarely investigated in animal models. We will survey geographic variation in visual displays in a hummingbird species known to exhibit variation in learned song over the same scale. These data will provide critical pilot data for planned proposals to investigate the fitness effects and neural mechanisms of vocal and visual learning.

Proposed Research (a maximum of 1,500 words):

**Background and Significance:** The phenomenon of vocal learning presents an intriguing evolutionary puzzle. Although we humans take it for granted as the basis of our remarkable linguistic abilities, it is absent in our closest primate relatives. It then appears again in three other mammal lineages: cetaceans (whales and dolphins), bats and elephants (Janik & Slater 1997). A similar pattern occurs in the birds, where songbirds, parrots and hummingbirds are each known to learn their vocalizations but their closest relatives do not (Catchpole & Slater 2008; Suh *et al.* 2011). All of these lineages with vocal learning are only distantly related to each other, suggesting that the ability to learn vocalizations has evolved independently multiple times in the history of life. These different taxa are thus useful models for understanding what evolutionary forces led to the emergence of language in humans, and what neural and genetic mechanisms underlie our language capacity (Jarvis 2004).

One hypothesis for the evolution of spoken human language is that it arose from gestural, or visual displays (Arbib *et al.* 2008). This hypothesis suggests that learning also plays a role in the acquisition of visual displays in taxa with vocal learning. Intriguingly, recent neurobiological studies of the brains of songbirds, parrots and hummingbirds have found that in all three of these taxa vocal learning centers are located in close physical proximity to motor centers, suggesting a mechanistic link between pathways governing vocal and visual displays (Feenders *et al.* 2008). Surprisingly, there have been few investigations of the role of learning in development of the visual displays of animals. One way in which vocal learning is commonly diagnosed in animals is to assess geographic variation in vocalizations; when such variation occurs on a small scale it is attributed to the cross-generational learning of local vocal traditions, often terms 'vocal dialects', rather than evolved genetic differences among populations (e.g. Wright *et al.* 2008). Similar geographic surveys should be useful as a first approach to assess the importance of learning in the acquisition of visual displays.

The hummingbirds are an intriguing and relatively unexplored group in which to investigate these questions. Hummingbirds are well-known for their bright, jewel-like colors that are used by males in striking visual displays to attract mates and deter other males (del Hoyo *et al.* 2001). Males also will use songs for similar functions; there is growing evidence that these songs are acquired through vocal learning (Baptista & Schuchmann 1990; Jarvis *et al.* 2000; Gonzalez & Ornelas 2005). One species in which both visual displays and vocal learning have been well

characterized is the long-tailed hermit of Costa Rica. Males of this tropical rain forest species form leks: areas in which 9-20 males sing and display on small, closely-packed territories to attract visiting females. Pioneering work by noted tropical ornithologists Stiles and Wolf documented the basic form of five different displays and the existence of vocal dialects that consisted of 2-5 males within leks that shared similar song types (Stiles & Wolf 1979). Displays occurred chiefly at the song perches of the resident males, when intruders (territorial or non-territorial males) approach a singing resident male. Certain movements within the displays are often accompanied by vocalizations (see video of display posted on YouTube at <http://www.youtube.com/watch?v=VeuzTytGwG8>). In 2010 my PhD student Marcelo Araya Salas reinitiated work on this species. In his first field season he found nine different leks, trapped and banded males, mapped territories, recorded songs and taped visual displays. His pilot work has demonstrated the feasibility of all aspects of the present proposed work. This project is related to, but distinct from, Marcelo's dissertation work on the function of song and visual displays in this species. It will benefit greatly from the field methodology he has established and in turn will provide pilot data for future grants to support our collaborative studies in this species.

**Objectives:** I will investigate geographic variation in vocal and visual displays of the long-tailed hermit by video-taping displays of territorial males on leks and measuring variation in components of displays.

**Methods:** This work will take place in La Selva Biological Station and surrounding preserves in the Caribbean lowlands of northern Costa Rica. All resident males on six leks will be captured by mistnetting, individually marked with colored leg flags, and territories and preferred perches mapped by observation by Araya Salas. During a two-week field trip in February, 2012, I will place five different motion-sensitive high-speed video cameras next to preferred perches for each male on a rotating basis until several 7-10 displays for each male on the lek have been recorded. During subsequent video analysis, undergraduate assistant and I will classify displays following Stiles and Wolf (1979). To measure variation in the structure of specific display types, we will measure the duration and intensity of individual components of each display and the number and types of any associated vocalizations (e.g. Fusani *et al.* 2007). I can then use Discriminant Function Analysis to test for variation in display parameters at the level of individual males, neighborhoods, and leks. Standard sound analysis methods will be used to record the songs of males, measure acoustic parameters and test for variation (Wright *et al.* 2008). To measure variation in performance, we will measure the number of repetition for each display type, the number of displays types used in an interaction and the sequence of the displays. These data can be summarized in a matrix of transitions between display types at the level of males, neighborhoods and leks and variation between matrices can be compared using Mantel tests. I predict that, if long-tailed hummingbirds learn their visual displays from social interactions, then we will see consistent variation in the displays at either the level of neighborhood or at the level of leks. We are particularly interested to see whether this variation will map onto the song dialects we have previously mapped.

**Budget Justification:** Funds are requested for support of a two-week field research trip by the PI to Costa Rica for field station fees, and for field equipment and supplies (5 Stealth Cam Prowler HD video cameras, 5 hard drives for video data storage and bird banding pliers) for a total request of \$1997. Cost sharing will be provided by the PI's startup funds for the PI airfare and Costa Rican research permit, by the PI's personal funds for per diem and by PI's NIH grant funds for 2 new tripods (3 are available in the lab) for a total cost share of \$1405.

**Summary:** We propose to map variation in vocal and visual displays in a hummingbird. This foundational work will strengthen planned grant proposals in a highly tractable system with rich potential for investigating questions concerning both the fitness effects of vocal and visual learning, and the neural and physiological mechanisms underlying these abilities.

#### References:

- Arbib, M. A., Liebal, K. & Pika, S. 2008. Primate vocalization, gesture, and the evolution of human language. *Current Anthropology*, 49, 1053-1076.
- Baptista, L. F. & Schuchmann, K. L. 1990. Song learning in the Anna hummingbird (*Calypte anna*). *Ethology*, 84, 15-26.
- Catchpole, C. K. & Slater, P. J. B. 2008. *Bird Song: Biological Themes and Variations*, 2nd edn. Cambridge: Cambridge University Press.
- del Hoyo, J., Elliott, A. & Sargatal, J. 2001. *Handbook of the Birds of the World. Vol. 5: Barn-owls to Hummingbirds*. Barcelona: Lynx Edicions.
- Fusani, L., Giordano, M., Day, L. B. & Schlinger, B. A. 2007. High-speed video analysis reveals individual variability in the courtship displays of male golden-collared manakins. *Ethology*, 113, 964-972.
- Gonzalez, C. & Ornelas, J. F. 2005. Song structure and microgeographic variation in wedge-tailed sabrewings (*Campylopterus curvipennis*) in Veracruz, Mexico. *The Auk*, 122, 593-607.

Feenders, G., Liedvogel, M., Rivas, M., Zapka, M., Horita, H., Hara, E., Wada, K., Mouritsen, H. & Jarvis, E. D. 2008. Molecular mapping of movement-associated areas in the avian brain: a motor theory for vocal learning origin. *PLoS ONE*, 3, e1768.

Janik, V. M. & Slater, P. J. 1997. Vocal learning in mammals. *Advances in the Study of Behavior*, 26, 59-99.

Jarvis, E. D., Ribeiro, S., da Silva, M. L., Ventura, D., Vielliard, J. & Mello, C. V. 2000. Behaviourally driven gene expression reveals song nuclei in hummingbird brain. *Nature*, 406, 628-632.

Jarvis, E. D. 2004. Learned birdsong and the neurobiology of human language. *Ann N Y Acad Sci*, 1016, 749-777.

Stiles, F. G. & Wolf, L. L. 1979. Ecology and evolution of lek mating behavior in the long-tailed hermit hummingbird *Ornithological Monographs*, 27.

Suh, A., Paus, M., Kiefmann, M., Churakov, G., Franke, F. A., Brosius, J., Kriegs, J. O. & Schmitz, J. Mesozoic retroposons reveal parrots as the closest living relatives of passerine birds. *Nature Communications*, 2, 443.

Wright, T. F., Dahlin, C. R. & Salinas-Melgoza, A. 2008. Stability and change in vocal dialects of the yellow-naped amazon. *Animal Behaviour*, 76, 1017-1027.

Please list your previous minigrant awards with titles and year of award:

I have received two previous minigrants. Both provided pilot data for successful grant applications to federal funding agencies.

- 1) Temporal stability of vocal dialects in the parrot *Amazona auropalliata* in Costa Rica, 2005. Resulted in NSF RIG-0725032 (PI Wright) *Dispersal, vocal convergence and the maintenance of vocal dialects* (\$180,297)
- 2) Social disruption, stress and vocal learning. 2009. Resulted in NIH 1SC1HD068128-01 (PI Wright). *The role of stress and FoxP2 in adult vocal learning: tests using a parrot model* (\$1,018,087).