The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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Summertime - Recess after a Successful Season

As we are concluding another academic year, we can look back at the significant accomplishments of our Center. During the 2014/2015 season, Keck Center affiliated students, postdocs and faculty published more than 70 peer reviewed articles. Keck Center members received 11 new grants and awards, including grants from the National Science Foundation to Nadia Singh and Reade Roberts, a Beckman Young Investigator award to Reade Roberts, a K99/R00 award to Beth Dumont, and an NSF fellowship to Margarita Lopez-Uribe. Two members of the Center's executive committee, Coby Schal and Trudy Mackay, were honored with the Alexander Quarles Holladay Medal, the highest honor bestowed on faculty by North Carolina State University. Once again, we had an excellent distinguished speaker series, an annual student/postdoc symposium with record participation, and several highly successful outreach activities at the North Carolina Museum of Natural Sciences, notably a well-attended event during Brain Awareness week. Next year will be equally exciting thanks to strong support from the College of Sciences and our corporate and private donors. I would also like to thank Suzanne Quick and Christine Epps for their excellent administrative support.

Finally, in keeping with the NC State Wolfpack tradition let me remind you that "the wolf is for the pack and the pack is for the wolf". In other words, we all must contribute individually, but together we can form a strong mutually supportive and synergistic community. Thank you all for your active participation in and support for the Keck Center. I wish you a productive and enjoyable summer.

Robert Anholt, Center Director

The Signal will not be published during the summer recess.

The first issue of Volume 17 of The Signal will appear in September, 2015.

A Bird's Eye View of Monogamy

by Erin Harris

On April 16, 2015, the W. M. Keck Center for Behavioral Biology hosted Dr. Elizabeth Adkins-Regan, a professor in the Department of Psychology and Department of Neurobiology and Behavior at Cornell University. She gave a seminar titled "Neuroendocrinology of Socially Monogamous Pairing: A Bird's-Eye View." Dr. Adkins-Regan's lab studies the neuroendocrine mechanisms of social and reproductive behaviors in an avian model.

Adkins-Regan began her talk by outlining the many advantages of using birds, particularly the zebra finch, to study social behavior. Unlike mammals, 90% of bird species form close male-female pairs, which she described as the "mammal-bird paradox". The zebra finch (Taeniopygia guttata) is among the 10% of socially monogamous songbird species that are also genetically monogamous.

Prairie voles, the now-famous mammalian monogamists, have long been used to study pair bonding and social behaviors. Similar to the prairie vole, zebra finches exhibit biparental care of offspring. Unlike prairie voles and rodents that depend on olfactory cues to identify conspecifics, however, zebra finches primarily use visual and vocal cues. This bird species is preferred for laboratory studies because it readily breeds in captivity, and many of its natural, distinctive social behaviors are maintained in laboratory conditions.

Adkins-Regan initially sought to understand how sex hormones modulate pairing behavior in zebra finches. She explained how pharmacologically inhibiting estradiol and testosterone actions in adult zebra finches affects some courtship behaviors but does not significantly affect pair bond formation or maintenance. However, the same manipulations in pre-pubertal animals result in significantly altered social preferences. Juvenile males given estradiol and testosterone inhibitors develop a preference for unpaired females significantly earlier than control males, while treated females never develop a preference for unpaired males over unpaired females or family members. These findings showed that sex steroids are more important for the development of pairing behavior than maintenance in adulthood.

Next, Adkins-Regan discussed the behavioral and physiological consequences of separating pairs. Separation from a pair mate, as might naturally happen in the wild if the partner died, is a highly stressful event for zebra finches. During a separation, the hypothalamic-pituitary-adrenal (HPA) axis mounts a stress response to promote locating the partner or re-pairing. In the laboratory when paired zebra finches are separated, levels of the stress hormone corticosterone significantly increase, but will return to baseline if the pair is reunited. Adkins-Regan has found that the offspring of finches that have been forced to re-pair had a less reactive HPA axis and significantly decreased vocalizations during social isolation compared to control offspring. Pair disruption also boosted growth of female offspring and delayed the development of sexually dimorphic plumage in male offspring. Interestingly, these effects do not appear to be mediated by stress hormones, since there were no differences in yolk corticosterone concentrations.

Dr. Elizabeth Adkins-Regan

Next, Adkins-Regan discussed the neural pathways underlying avian monogamy. She focused on the mesolimbic dopaminergic reward system, since it is known to play an important role in courtship and pairing behaviors in voles. Newly paired zebra finches had significantly more dopamine in the medial striatum, an important mesolimbic brain area, than unpaired animals. Additionally, paired birds had a higher percentage of dopaminergic cells expressing the immediate early gene fos, a marker of neuronal activity, in the ventral tegmental area than unpaired birds. These results indicate that the dopaminergic system of zebra finches is activated in response to pair bonding.

Adkins-Regan went on to describe ongoing experiments testing how the bird analog of vasopressin, vasotocin, acts during development to regulate social behaviors. Newly hatched chicks were given

intracranial injections of either vasotocin or Manning compound, a vasotocin receptor 1A antagonist. As juveniles, they were observed during a social isolation period and subsequent reunion with their fathers. Manning compound-treated fledglings had a substantially diminished vocal response during the separation period compared to controls. As adults, vasotocin-treated birds spent significantly more time engaging in affiliative behaviors with their paired mate when reunited following separation as compared to vehicle-injected controls. These experiments demonstrate that vasotocin has a significant organizational effect on social behaviors in zebra finches, similar to prairie voles.

Adkins-Regan also shared preliminary data from a collaboration with Mike Goldstein and Sam Carouso, who study how the interactions of juvenile males with their parents affect song learning. Young males learn unique songs from their fathers, so the strength of their parental bond may influence their ability to learn song patters. Song learning in Manning compound-treated males appears to be disrupted, as their mature songs do not accurately resemble their fathers', whereas the songs of vasotocin-treated and vehicle-injected males are more similar to their fathers' songs. She hopes to address the interesting connection between early social behaviors and zebra finch song production in future experiments.

Publications

Arya, G. H., Magwire, M. M., Huang, W., Serrano-Negron, Y. L., Mackay, T. F. C. and Anholt, R. R. H. (2015) The genetic basis for variation in olfactory behavior in *Drosophila melanogaster*. *Chem. Senses* **40:** 233-243.

Crowley, J. J., Zhabotynsky, V., Sun, W., Huang, S., Pakatci, I. K., Kim, Y., Wang, J. R., Morgan, A. P., Calaway, J. D., Aylor, D. L., Yun, Z., Bell, T. A., Buus, R. J., Calaway, M. E., Didion, J. P., Gooch, T. J., Hansen, S. D., Robinson, N. N., Shaw, G. D., Spence, J. S., Quackenbush, C. R., Barrick, C. J., Nonneman, R. J. , Kim, K., Xenakis, J. Xie, Y., Valdar, W., Lenarcic, A. B., Wang, W., Welsh, C. E., Fu, C. P., Zhang, Z., Holt, J,, Guo, Z., Threadgill, D. W., Tarantino, L. M., Miller, D. R., Zou, F., McMillan, L., Sullivan, P. F. and Pardo-Manuel de Villena, F. (2015) Analyses of allele-specific gene expression in highly divergent mouse crosses identifies pervasive allelic imbalance. *Nat. Genet.* **47:** 353-360.

Dembeck, L. M. (2015) Leadership by Nurture Not Nature. *AWIS Magazine* **46:**14-15.

Didion, J. P., Morgan, A. P., Clayshulte, A. M. F., Mcmullan, R. C., Yadgary, L., Petkov, P. M., Bell, T. A., Gatti, D. M., Crowley, J. J., Hua, K., Aylor, D. L., Bai, L., Calaway, M., Chesler, E. J., French, J. E., Geiger, T. R., Gooch, T. J., Garland, T., Harrill, A. H., Hunter, K., McMillan, L., Holt, M., Miller, D. R., O'Brien, D. A., Paigen, K., Pan, W., Rowe, L. B., Shaw, G. D., Simecek, P., Sullivan, P. F., Svenson, K. L., Weinstock, G. M., Threadgill, D. W., Pomp, D., Churchill, G. A. and Pardo-Manuel de Villena, F. (2015) A multi-megabase copy number gain causes maternal transmission ratio distortion on mouse Chromosome 2. *PLoS Genet.* **11:** e1004850.

NESCent Working Group on the Evolutionary Biology of the Built Environment, Martin, L. J., Adams, R. I., Bateman, A., Bik, H. M., Hawks, J., Hird, S. M., Hughes, D., Kembel, S. W., Kinney, K., Kolokotronis, S. O., Levy, G., McClain, C., Meadow, J. F., Medina, R. F., Mhuireach, G., Moreau, C. S., Munshi-South, J., Nichols, L. M., Palmer, C., Popova, L., Schal, C., Täubel, M., Trautwein, M., Ugalde, J. A. and Dunn, R. R. (2015) Evolution of the indoor biome. *Trends Ecol. Evol.* **30:** 223-232.

Jensen, K., Schal, C. and Silverman, J. (2015) Adaptive contraction of diet breadth affects sexual maturation and specific nutrient consumption in an extreme generalist omnivore. *J. Evol. Biol.* **28:** 906-916.

Of note…

Robert Anholt chaired a symposium on Adaptive Evolution of Insect Olfactory Systems at the 37th Association for Chemoreception Society (AChemS) meeting in Bonita Springs, FL.

Fred Gould gave a presentation at a conference on "New Genomic Solutions for Conservation Problems." He also gave the Charles Chesley Doane Lecture at the University of Wisconsin. He also gave an invited symposium talkat the 37th Association for Chemoreception Society (AChemS) meeting in Bonita Springs, FL.

Margarita Lopez-Uribe received a postdoctoral fellowship from the National Science Foundation to study the evolutionary consequences of sociality with **David Tarpy, Rob Dunn** and **Steve Frank.**

Trudy Mackay gave an invited talk at the Genetic and Environmental Mutagenesis Society's spring meeting at the Environmental Protection Agency, Research Triangle Park, NC.

John Meitzen, Lisa McGraw, Heather Patisaul and **Leslie Sombers** and their collaborators presented posters at the Society for Neuroscience Research Triangle Meeting (Research Triangle Park, NC).

Meghan Rebuli started her postdoctoral position at UNC in Ilona Jaspers' lab at the University of North Carolina in Chapel Hill. She also received the UGSA Award for Conferences, a $1500 prize.

Ayako Wada-Katsumata gave an invited symposium presentation at the 37th Association for Chemoreception Society (AChemS) meeting in Bonita Springs, FL.

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To contribute to The Signal, to be placed on our mailing list or for information about the W. M. Keck Center for Behavioral Biology, contact Dr. Robert Anholt, Department of Biological Sciences, Box 7614, North Carolina State University, Raleigh, NC 27695-7614, tel. (919) 515-1173, anholt@ncsu.edu.

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