The Signal

Monthly newsletter of the W. M. Keck Center for Behavioral Biology
at North Carolina State University
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The Signal Wishes all its Readers

A Happy, Healthy and Productive New Year!

2018: A Changing of the Guard

The year 2017 was a milestone in the history of the W. M. Keck Center for Behavioral Biology as it marked the 20th year since the establishment of the program. The new year, 2018, will be another major milestone for the Center with a change in leadership. As of June 1, 2018, Dr. Brian Langerhans, Associate Professor of Biological Sciences and member of the Keck Center's Executive Committee, will take on the position of Director. Langerhans was unanimously selected by Keck Center affiliated faculty as Director elect.

"Brian will bring enormous energy and a fresh vision to the Center," says Center director Robert Anholt, "We anticipate the Center to continue to flourish under his leadership and provide a vibrant intercollegiate and interdisciplinary academic environment. Brian will nurture an intellectually stimulating and interactive research and training environment for faculty, postdocs and students."

Langerhans is an evolutionary biologist who combines field work with laboratory experiments. His laboratory employs comparative analyses of multiple populations and multiple species across multiple environments, in combination with experiments examining the links between phenotype, performance, and fitness. Much of his work focuses on the role of predators and other selective agents in the evolutionary diversification of small live bearing fishes in the genus Gambusia, which is native to USA, Central America, and Caribbean. As an evolutionary biologist Langerhans' interest spans the disciplines of ecology, genetics and evolutionary biology with a focus on behavior, while recognizing the importance of behavioral neurobiology. His extensive interactions with the North Carolina Museum of Natural Sciences places him in an ideal position to facilitate outreach programs through the museum.

Dr. Brian Langerhans

"I am looking forward to working with Brian to ensure a smooth transition," says Anholt, "The Center will be in good hands."

Activities for the spring semester will include a series of four distinguished seminars and the annual student/postdoc symposium. The Center will again participate in Darwin Day and the traditional Brain Day with speaker Jeff Lichtman from Harvard University at the North Carolina Museum of Natural Sciences.

Two Model Organisms Are Better Than One: Toward a Better Understanding of Plant/Insect Interactions

by Johanna Elsensohn

Why is herbivory in insects at once seemingly ubiquitous while at the same time relatively rare? Greater than 50% of all described insect species are phytophagous, yet only nine of the thirty insect orders contain herbivores. Plants would seem an obvious choice for exploitation, but physical and biochemical defenses help protect plants against attack. However, once an insect overcomes these defenses, we tend to see species radiations as insects diversify to fill novel niches. The question remains, *how* are these evolutionary hurdles overcome – by leaps and bounds, or in a more stepwise fashion?

Dr. Noah Whiteman's lab at the University of California at Berkeley seeks to answer these questions and more by using a unique plant/insect system. Whiteman recently gave a Keck Center seminar, entitled "My model organism eats your model organism: Evolution of parasitism in *Drosophila* that attack *Arabidopsis*". Whiteman works on one of only three known Drosophilids that exploit the leaves of plants, rather than their fruits or fruit byproducts. This evolution to herbivory seems to have evolved once in the *Scaptomyza*, a trait shared among three closely related *Scaptomyza* species (*S. flava*, *S. nigrita*, *S. graminum*). Interestingly, this switch also came with the loss of ability to detect yeast volatiles, a major nutrition and host finding requirement for other Drosophilidae. Whiteman and his lab work on *S. flava*, a leaf-mining insect attacking mustard plants (Brassicaceae). Both *Drosophila melanogaster* and the crucifer *Arabidopsis thaliana* have been used in the lab for over a century, representing two important model organisms for understanding genetics.

Whiteman walked his audience through two evolutionary questions specific to the *S. flava*/*A. thaliana* complex but that could have broader implications. The first looked at the morphology of the specialized ovipositor female *S. flava* use to insert eggs under the leaf surface. Many drosophilids have evolved sclerotized and saw-like ovipositors, and Whiteman and colleagues looked at the genetic basis for the number of pegs that form the saw shape in *S. flava*. First they used a genome wide association study (GWAS) to look at the variation in peg number within *S. flava* and determined the narrow sense heritability for this trait to be h^2=0.46. They then narrowed their data set to completely re-sequence only those individuals with high or low peg numbers using a pool-GWAS approach and found a number of SNPs and indels within a particular region that associate with peg number. Gene ontologies were enriched for genes with roles in sensory organ precursor development. How these ovipositor pegs evolved and what their ultimate function is remains an active area of study in his lab.

Dr. Noah Whiteman

The second question asked how *S. flava* is able to overcome plant defenses typical of brassica plants. Humans experience this defense as a bitter or peppery taste that we associate with kale or arugula. In the plant, two components – a glucosidase enzyme called myrosinase and a water-soluble glucosinolate – are compartmentalized and only interact when damage occurs and the myrosinase hydrolyzes the glucosinolates, forming what we know as mustard oils (isothiocyanates). Whiteman presented work by former graduate student Dr. Andrew Gloss on understanding how *S. flava* use the mercapturic acid pathway to detoxify isothiocyanates. Gloss raised *S. flava* either on *A. thaliana* plants that were altered to not express glucosinolates, or on unaltered, "regular" *A. thaliana*. Flies raised on the unaltered plants – plants that create isothiocyanates – had higher expression of genes expressing specific detoxification enzymes (so-called glutathione *S*-transferases; GSTs) as compared to those raised on non-isothiocyanate producing plants. Furthermore, GSTs appear to be among the most rapidly evolving proteins in *S. flava* in terms of the rate of amino acid changing substitutions. All in all, these specialist flies can detoxify mustard oils using GSTs faster than humans, fungi, bacteria and other flies.

The work Whiteman showcased highlights how this dual model organism system can yield interesting insights into the evolution of plant/insect relationships. Ongoing work in Whiteman's lab is looking at the effects of host adaptation to co-occurring common crucifers on *S. flava* fitness and the maintenance of genetic variation within species. He theorizes that the functional variation within a population of insects will be proportional to the number of habitats (hosts) they occupy, as Dobzhansky and colleagues originally proposed.

Seminars

On **January 22**, 11:30 am, Dr. Patrick A. Guerra from the Department of Biological Sciences at the University of Cincinnati will present a seminar titled "There and back again: The compass mechanisms migratory monarch butterflies use to get to and return from Mexico."

The seminars will be in 3503 Thomas Hall.

Grants

John Meitzen, together with **Benjamin Reading**, **Russell Borski** and **Heather Patisaul,** received a one-year $12,236 Laboratory Research Equipment Program grant from North Carolina State University.

David Tarpy together with J. Milone received a two-year $131,830 grant from the Foundation for Food and Agricultural Research (FFAR) to study the queen exposome and its influence on downstream colony disease response.

David Tarpy received a three-year $934,749 grant from the United States Department of Agriculture, New Frontiers in Pollinator Health program for improving colony health by increasing the reproductive quality of honey bee queens (*Apis mellifera* L.).

Publications

The following publications of the W. M. Keck Center for Behavioral Biology have appeared in print:

Will, T. R., Proaño, S. B., Thomas, A. M., Kunz, L. M., Thompson, K. C., Ginnari, L. A., Jones, C. H., Lucas, S., Reavis, E. M., Dorris, D. M. and Meitzen, J. (2017) Problems and progress regarding sex bias and omission in neuroscience research. *eNeuro* **4:** e0278-17.2017.

Montiel, C. and Meitzen, J. (2017) Interviewing neuroscientists for an undergraduate honors project. *J. Undergrad. Neurosci. Education* **16:** A89-A94.

Kulhanek, K., Steinhauer, N., Rennich, K., Caron, D. M., Sagili, R. R., Pettis, J., Ellis, J. D., Wilson, M. E., Wilkes, J. T., Tarpy, D. R., Rose, R., Lee, K., Rangel, J., and van Engelsdorp, D. (2017) A national survey of managed honey bee 2015-2016 annual colony losses in the USA. *J. Apicultural Res.* **56:** 328-340.

Amiri, E., Strand, M. K., Rueppell, O. and Tarpy, D. R. (2017) Reduced queen quality and honey bee diseases: interactions between two major threats to colony health. *Insects* **8:** 48.

Alburaki, M., Steckel, S. J., William, M. T., Skinner, J. A., Tarpy, D. R., Meikle, W. G., Adamczyk, J. and Stewart, S. D. (2017) Agricultural landscape and pesticide effects on honeybee biological traits. Journal of *Econ. Entomol.* **110:** 835-847.

Guiffre, C., Lupkin, S., and Tarpy, D. R. (2017) Automated assay and differential model of the Western honey bee (*Apis mellifera*) autogrooming using digital image processing. *Computers and Electronics in Agriculture* **135:** 338-344.

Lopez-Uribe, M. M., Appler, R. H., Frank, S. D. and Tarpy, D. R. (2017). Linking genetic diversity and immunocompetence in feral and managed honey bee colonies (*Apis mellifera*). *Conserv. Genet.* **18:** 659–666.

Strange, J. P., Delaney, D. A., Tarpy, D. R. and James, R. R. (2017). Novel microsatellite loci reveal high genetic diversity yet low population structure for alfalfa leafcutting bees in North America. *Conserv. Genet.***18:** 679-687.

Alburaki, M., Steckel, S. J., Chen, D., McDermott, E., Weiss, M., Skinner, J. A., Kelly, H., Tarpy, D. R., Meikle, W. G., Adamczyk, J. and Stewart, S. D. (2017). Pesticide effects on honeybees: *In situ* and *in vitro* honeybee survival and expression of brain oxidative stress genes. *Apidologie* 48: 556-571.

de Mattos, I. M., Soares, A. E. E. and Tarpy, D. R. (2017) Effects of synthetic acaricides on honey bee grooming behavior and natural resistance to the parasitic Varroa destructor mite. *Apidologie* **48:** 483-494.

Long, K., Keller, J. J., Cao, T. T., Tarpy, D. R., Shin, M. and Schneider, S. S. (2017). Levels of selection shaping caste interactions during queen replacement in the honey bee. *Apis mellifera*. *Insectes Sociaux* **64:** 227-240.

Wilson, L. R., Panda, S., Schmidt, A. C. and Sombers, L. A. (2018) Selective and mechanically robust sensors for electrochemical measurements of real-time hydrogen peroxide dynamics *in vivo*. *Anal. Chem.* **90:** 888-895.

Roberts J. G. and Sombers, L. A. (2018) Fast-Scan Cyclic Voltammetry: Chemical sensing in the brain and beyond. *Anal. Chem.* **90:** 490-504.

Mackay, T. F. C. and Huang, W. (2018) Charting the genotype-phenotype map: lessons from the *Drosophila melanogaster* Genetic Reference Panel. *Wiley Interdiscip. Rev. Dev. Biol.* **7:** e289.

van Wijk, M., Heath, J., Lievers, R., Schal, C. and Groot, A. T. (2017) Proximity of signallers can maintain sexual signal variation under stabilizing selection. *Sci. Rep.* **7:** 18101.

Langerhans, R. B. (2017) Predictability and Parallelism of Multitrait Adaptation. *J. Hered.* **109:** 59-70.

Barrett, E. S. and Patisaul, H. B. (2017) Endocrine disrupting chemicals and behavior: Re-evaluating the science at a critical turning point. *Horm. Behav.* **96:** A1-A6.

Arambula, S. E., Fuchs, J., Cao, J. and Patisaul, H. B. (2017) Effects of perinatal bisphenol A exposure on the volume of sexually-dimorphic nuclei of juvenile rats: A CLARITY-BPA consortium study. *Neurotoxicol.* **63:** 33-42.

Of note…

John Meitzen gave a presentation in the Life Sciences Seminar Series at Virginia Tech University, Blacksburg, VA. He was also a moderator and speaker at a Professional Development Workshop in Public Engagement at the 2017 Society for Neuroscience Conference in Washington, DC. He also participated in the Receptor Mechanisms Discussion Group at the National Institute of Environmental Health Sciences.

Christie Lee, **Samantha Smith**, **Leslie Wilson**, **Carl Meunier**, **Catie Mason**, **Saahj Gosrani** and **Sambit Panda** gave presentations at the 2017 Society for Neuroscience Meeting, in Washington, D.C.

Jaime Willett, **Ashlyn Johnson**, **Opal Patel**, **David Dorris** and **John Meitzen** presented a poster on estrous cycle-dependent sex differences in rat dorsal striatal MSN excitability at the 2017 Society for Neuroscience Meeting, in Washington, D.C.

Stephanie Proaño, **Lindsey Kunz** and **John Meitzen** presented a poster demonstrating no evidence for sex differences in intrinsic electrophysiological properties of nucleus accumbens core medium spiny neurons in the gonadectomized adult rat at the 2017 Society for Neuroscience Meeting in Washington, D.C.

Jinyan Cao, **David Dorris** and **John Meitzen** presented a poster on electrophysiological properties of male and female medium spiny neuron subtypes in the nucleus accumbens core of *Drd1a-tdTomato* line 6 BAC transgenic mice at the Society for Neuroscience Meeting in Washington, D.C.

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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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