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Newsletter of the National Evolutionary Synthesis Center, an NSF-funded collaborative research center operated by Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University.

NEXT PROPOSAL DEADLINES:

Dec. 1: postdoctoral fellowships, sabbaticals, meetings and working groups

Jan. 1: graduate fellowships, short-term visitors

For more information, see page 2 or visit **nescent.org/science/proposals.php**

IN THIS ISSUE:

ABOUT NESCENT:

NESCent is a scientific research center dedicated to cross-disciplinary research in evolution. The Center's mission is to promote the synthesis of information, concepts and knowledge to address significant, emerging, or novel questions in evolutionary science and its applications. NESCent achieves this by supporting research and education across disciplinary, institutional, geographic, and demographic boundaries.

Funded by the National Science Foundation (award #EF-0905606), NESCent is a collaborative partnership between Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University. For more information about research and training opportunities at NESCent, visit **www.nescent.org.**

SENIOR LEADERSHIP:

RESEARCH HIGHLIGHTS

Uncovering the genetic secrets that allow Tibetans to thrive in thin air

A new study pinpoints the genetic changes that enable Tibetans to thrive at altitudes where others get sick.

A NESCent meeting led by Cynthia Beall and Peter Robbins has identified a gene that allows Tibetans to live and work more than two miles above sea level without getting altitude sickness. Their results were published in June in the journal *Proceedings of the National Academy of Sciences*.

A previous study published May 13 in *Science* reported that Tibetans are genetically adapted to high altitude. Less than a month later, a second study by NESCent-sponsored scientists from China, England, Ireland, and the United States pinpoints a particular site within the human genome – a genetic variant linked to low hemoglobin in the blood – that helps explain how Tibetans cope with low-oxygen conditions.

The study sheds light on how Tibetans, who have lived at extreme elevation for more than 10,000 years, have evolved to differ from their low-altitude ancestors.

Lower air pressure at altitude means fewer oxygen molecules for every lungful of air. "Altitude affects your thinking, your breathing, and your ability to sleep. But high-altitude natives don't have these problems," said co-author Cynthia Beall of Case Western Reserve University. "They're able to live a healthy life, and they do it completely comfortably," she said.

People who live or travel at high altitude respond to the lack of oxygen by making more hemoglobin, the oxygen-carrying component of human blood. "That's why athletes like to train at altitude. They increase their oxygen-carrying capacity," said Beall.

A new study sheds light on how Tibetans, who have lived at extreme elevation for more than 10,000 years, have evolved to differ from their low-altitude ancestorst.

But too much hemoglobin can be a bad thing. Excessive hemoglobin is the hallmark of chronic mountain sickness, an overreaction to altitude characterized by thick and viscous blood. Tibetans maintain relatively low hemoglobin at high al-

see AIR, p5

UPCOMING EVENTS

Molecular evolution symposium to be webcast live

Date: November 5, 2010
Time: 2:00-6:00 PM EST

If you're interested in molecular evolution, you may not want to miss this year's Evolution Symposium at the annual meeting of the National Association of Biology Teachers (NABT) on Friday, Nov. 5th. Thankfully, you won't have to. Even if you can't make it to this year's meeting in Minneapolis, you can still watch the symposium via live webcast.

This year's symposium will feature four exciting speakers whose research in molecular evolution is revolutionizing our understanding of familiar and compelling examples of evolution. Learn about Butch Brodie's research on the toxin arms race between newts and garter snakes, and Allen Rodrigo's insights on the practical and research value of studies in viral evolution. Hear about Hopi Hoekstra's research into the underlying molecular mechanisms of coat color in beach mice, and Sean Carroll's work in drosophila wing coloration.

To watch the symposium, entitled "Molecular insights into classic examples of evolution," tune in Friday, November 5th from 2:00-6:00 PM EST (1:00-5:00 PM CDT) and go to **dukeuniversity.acrobat.com/nabt2010**.

FOR MORE INFORMATION

Visit nescent.org/media/NABT-Symposium2010.php

CALL FOR PROPOSALS

Call for proposals

Looking for support for a sabbatical, graduate student, postdoc, or meeting? NESCent welcomes your proposals. We are looking to support innovative approaches to outstanding problems in evolutionary biology. In particular, proposals that have a clear interdisciplinary focus, or involve evolutionary concepts in non-traditional disciplines, are strongly encouraged, as are proposals that demonstrate international participation and a mix of senior and emerging researchers, including graduate students.

NESCent is now accepting applications for graduate, postdoctoral, and sabbatical fellowships, short-term visitors, and meetings. The next deadline for postdoctoral fellowships, sabbaticals, meetings and working groups is Dec. 1. For graduate fellowships and short-term visitors, the next deadline is Jan. 10.

For more information, visit **nescent.org/science/proposals.php**

Job Openings

Interested in employment opportunities at NESCent? Our Center runs with the help of a dynamic team of programmers, financial experts, event planners, and other specialists. To find out about job openings as they become available, **visit nescent.org/about/employment.php**

CALL FOR ENTRIES

Win a travel award for best evolution-themed blog

Deadline: December 1, 2010

Are you a blogger who is interested in evolution? The National Evolutionary Synthesis Center is offering two travel awards to attend ScienceOnline2011, a science communication conference to be held January 13-15, 2011, in North Carolina's Research Triangle Park.

The awards offer the opportunity to travel to North Carolina to meet with several hundred researchers, writers, editors and educators to explore how online tools are changing the way science is done and communicated to the public. Each winner will receive $750 to cover travel and lodging expenses to attend the conference. For more information about ScienceOnline2011, visit **www.scienceonline2010comindexphp-wiki/2011_Program_Suggestions/**

To apply for an award, writers should submit a blog post that highlights current or emerging evolutionary research. In order to be valid, posts must deal with research appearing in the peer-reviewed literature within the last five years. Posts should be 500-1000 words, and must mention the NESCent contest. Two recipients will be chosen by a panel of judges from both NESCent and the science blogging community. Please send your name, contact information, the title and date of your blog post, and a URL to **travel.award@nescent.org**. Winners will be notified by December 15th, 2010.

For more information contact Craig McClain at **cmcclain@nescent.org,** or Robin Smith at **rsmith@nescent.org**.

NEW AWARDS

Congratulations to the newest award recipients for 2010

NESCent is pleased to announce the following new awards from our April and July 2010 call for proposals:

GRADUATE FELLOWS

Bret Moore (Purdue University)
Do retinal specializations reflect ecology? An evolutionary perspective

Luke Mahler (Harvard University)
Improving and testing ecological models of phenotypic diversification

Paul Durst (Duke University)
Evaluating patterns and trends in insular body size evolution

Sarah Seiter (UNC Chapel Hill)
Distinguishing trait value and trait plasticity in the evolution of reaction norms

Nimrod Rubinstein (Tel-Aviv University)
Detection of clade-specific accelerations and decelerations in gene evolutionary rates

SHORT-TERM VISITORS

Luke Mahler (Harvard University)
New tools for investigating replicated adaptive radiation
August 5-26, 2010

Samantha Hopkins (University of Oregon) **and Samantha Price** (University of California, Davis)
Evolution of mammalian dietary strategies and the importance of omnivory
August 14-27, 2010

Katharina Huber and Vincent Moulton (University of East Anglia, UK)
New applications of phylogenetic combinatorics
August 16-27, 2010

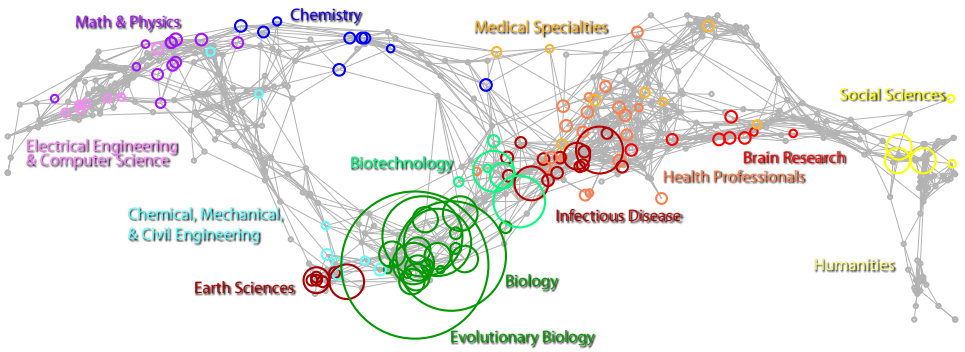
Roi Dor (Cornell University)
Applying new phylogenetic comparative methods to analyze character evolution in swallows
August 30 - September 5, 2010

Matina Kalcounis-Rueppell (University of North Carolina at Chapel Hill
Potential for peripheral populations to mitigate core extinctions: Bats and white nose syndrome
October 1 - December 31, 2010

Katia Koelle (NESCent Triangle Scholar from Duke University)
October 1 - December 31, 2010

Howard Ross (University of Auckland, New Zealand)
Species delimitation using networks
October 18-29, 2010

For more information about the awardees and their research projects, **please visit nescent.org/science/awards.php**



Major research areas represented in NESCent publications, overlaid on a global map of science. NESCent publications cover 12 out of 13 scientific disciplines and 127 of 554 research specialties. *Cyberinfrastructure for Network Science Center. Indiana University, http://sci.slis.indiana.edu (March 2010).*

RESEARCH HIGHLIGHTS

Competition puts the brakes on body evolution in island lizards

Millions of years before humans began battling it out over beachfront property, a similar phenomenon was unfolding in a diverse group of island lizards.

Often mistaken for chameleons or geckos, Anolis lizards fight fiercely for resources, responding to rivals by doing push-ups and puffing out their throat pouches. But anoles also compete in ways that shape their bodies over evolutionary time, says a new study in the journal *Evolution*.

Anolis lizards colonized the Caribbean from South America some 40 million years ago and quickly evolved a wide range of shapes and sizes. "When anoles first arrived in the islands there were no other lizards quite like them, so there was abundant opportunity to diversify," said author Luke Mahler, a NESCent graduate fellow from Harvard University.

Free from rivals in their new island homes, Anolis lizards evolved differences in leg length, body size, and other characteristics as they adapted to different habitats. Today, the islands of Cuba, Hispaniola, Jamaica and Puerto Rico – collectively known as the Greater Antilles – are home to more than 100 Anolis species, ranging from lanky lizards that perch in bushes, to stocky, long-legged lizards that live on tree trunks, to foot-long 'giants' that roam the upper branches of trees.

The Greater Antilles are home to more than 100 Anolis species in a wide range of shapes and sizes. Anolis fowleri, pictured here, is a rare anole from the Dominican Republic.
PHOTO BY LUKE MAHLER

"The islands are like Petri dishes where species diversification unfolded in similar ways. The more species there were, the more they put the brakes on body evolution."
– Luke Mahler, Harvard University

"Each body type is specialized for using different parts of a tree or bush," said Mahler.

Alongside other researchers from NESCent, the University of Rochester, and Harvard University, Mahler and colleagues wanted to understand how and when this wide range of shapes and sizes came to be.

To do that, the team used DNA and body measurements from species living today to reconstruct how they evolved in the past. In addition to measuring the head, limbs, and tail of over a thousand museum specimens representing nearly every Anolis species in the Greater Antilles – including several Cuban species that were previously inaccessible to North American scientists – they also used the Anolis family tree to infer what species lived on which islands, and when.

By doing so, they discovered that the widest variety of anole shapes and sizes arose among the evolutionary early-birds. Then as the number of anole species on each island increased, the range of new body types began to fizzle.

Late-comers in lizard evolution underwent finer and finer tinkering as time went on. As species proliferated on each island, their descendants were forced to partition the remaining real estate in increasingly subtle ways, said co-author and NESCent postdoctoral fellow Liam Revell.

"Over time there were fewer distinct niches available on each island," said Revell. "Ancient evolutionary changes in body proportions were large, but more recent evolutionary changes have been more subtle."

The researchers saw the same trend on each island. "The islands are like Petri dishes where species diversification unfolded in similar ways," said Mahler. "The more species there were, the more they put the brakes on body evolution."

The study sheds new light on how biodiversity comes to be. "We're not just looking at species number, we're also looking at how the shape of life changes over time," said Mahler.

Richard Glor of the University of Rochester and Jonathan Losos of Harvard University were also authors on this study.

CITATION: Mahler, D., L. Revell, et al. (2010). "Ecological opportunity and the rate of morphological evolution in the diversification of Greater Antillean anoles." Evolution. doi: 10.1111/j.1558-5646.2010.01026.x

AIR, continued

titude, a trait that makes them less susceptible to the disease than other populations.

"Tibetans can live as high as 13,000 feet without the elevated hemoglobin concentrations we see in other people," said Beall.

To pinpoint the genetic variants underlying Tibetans' relatively low hemoglobin levels, the researchers collected blood samples from nearly 200 Tibetan villagers living in three regions high in the Himalayas. When they compared the Tibetans' DNA with their lowland counterparts in China, their results pointed to the same culprit – a gene on chromosome 2, called EPAS1, involved in red blood cell production and hemoglobin concentration in the blood.

"Altitude affects your thinking, your breathing, and your ability to sleep. But high-altitude natives don't have these problems."

–Cynthia Beall, Case Western Reserve University

Originally working separately, the authors of the study first put their findings together at a 2009 meeting at NESCent. "Some of us had been working on the whole of Tibetan DNA. Others were looking at small groups of genes. When we shared our findings we suddenly realized that both sets of studies pointed to the same gene – EPAS1," said Robbins, who co-organized the meeting with Beall.

While all humans have the EPAS1 gene, Tibetans carry a special version of the gene. Over evolutionary time individuals who inherited this variant were better able to survive and passed it on to their children, until eventually it became more common in the population as a whole.

"This is the first human gene locus for which there is hard evidence for genetic selection in Tibetans," said co-author Peter Robbins of Oxford University.

Researchers are still trying to understand how Tibetans get enough oxygen to their tissues despite low levels of oxygen in the air and bloodstream. Until then, the genetic clues uncovered so far are unlikely to be the end of the story. "There are probably many more signals to be characterized and described," said co-author Gianpiero Cavalleri of the Royal College of Surgeons in Ireland.

For those who live closer to sea level, the findings may one day help predict who is at greatest risk for altitude sickness. "Once we find these versions, tests can be developed to tell if an individual is sensitive to low-oxygen," said co-author Changqing Zeng of the Beijing Institute of Genomics.

"Many patients, young and old, are affected by low oxygen levels in their blood –perhaps from lung disease, or heart problems. Some cope much better than others," said co-author Hugh Montgomery, of University College London. "Studies like this are the start in helping us to understand why, and to develop new treatments."

CITATION: Beall, C., G. Cavalleri, et al. (2010). "Natural selection on EPAS1 (HIF2Đ) associated with low hemoglobin concentration in Tibetan highlanders." Proceedings of the National Academy of Sciences. doi: 10.1073/pnas.1002443107.

Student software developers showcase their work

For the fourth summer in a row, NESCent offered a number of internships aimed at introducing students to open-source software development. This summer, five interns from the 2010 Google Summer of Code™ program worked remotely on an evoinformatics project of their own choosing, each under the guidance of an experienced mentor. NESCent's 2010 Summer of Code students included Filip Balejko from the University of Warsaw, Kathryn Iverson from the University of Michigan, Lauren Lui from UC Santa Cruz, Anurag Priyam from the Indian Institute of Technology Kharagpur, and Conrad Stack from Pennsylvania State University. Their projects ranged from adding phylogenetics analysis steps to a popular data processing workflow system, to adding support for emerging interoperability standards to programming libraries, to creating a programming toolkit that can create Google Earthcompatible geophylogenies. As their profiles demonstrate, the students put their summers to very good use. Meet the students and learn more about their projects at **hackathon.nescent.org/Phyloinformatics_Summer_of_Code_2010/Summaries.**

Stay tuned for next year's program! Students interested in applying to possible future Google Summer of Code programs should read up on the program at **code google.com/soc/** and watch for announcements on the program on the Google Open Source Blog at **google-opensource.blogspot.com.** The application window typically opens in March.

RESEARCH HIGHLIGHTS

Why you should never arm wrestle a saber-toothed tiger

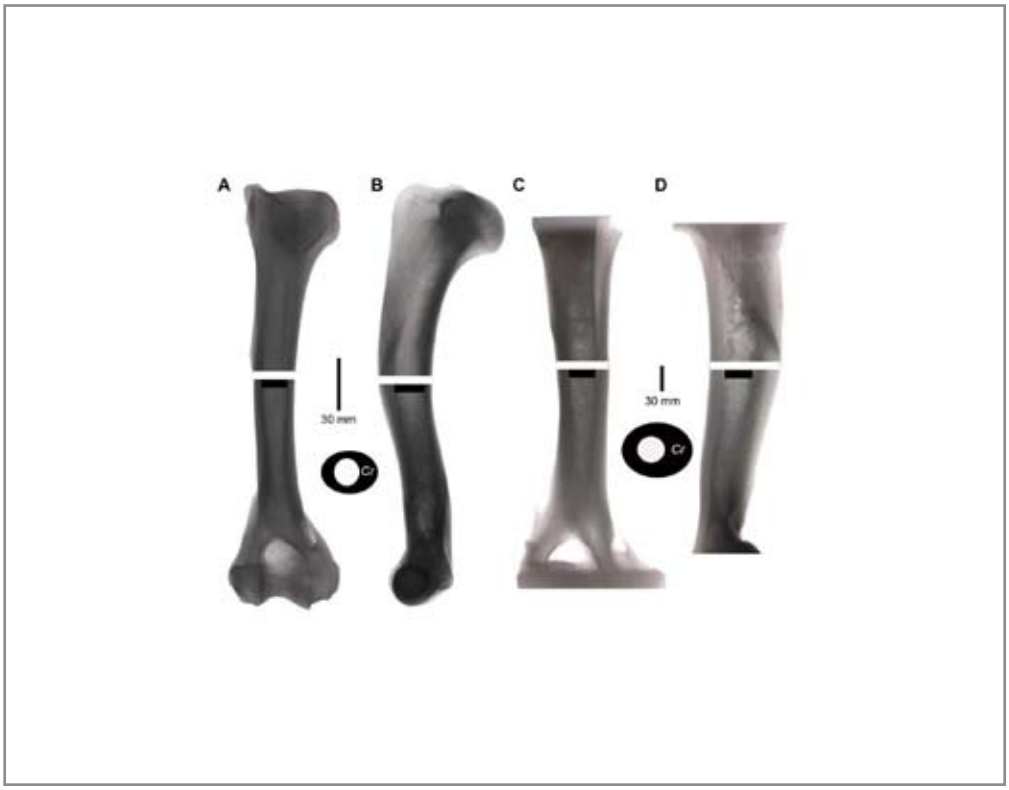
X-ray analysis reveals that sabertooth forelimbs were exceptionally strong compared to their feline cousins

Saber-toothed cats may be best known for their supersized canines, but they also had exceptionally strong forelimbs for pinning prey before delivering the fatal bite, says a new study by NESCent postdoctoral fellow Julie Meachen-Samuels.

Commonly called the "saber-toothed tiger," the extinct cat *Smilodon fatalis* roamed North and South America until 10,000 years ago, preying on large mammals such as bison, camels, mastodons and mammoths. Telltale clues from bones and teeth suggest they relied on their forelimbs as well as their fangs to catch and kill their prey.

The size and shape of sabertooth canines made them more vulnerable to fracture than cats living today, said Meachen-Samuels.

"Cats living today have canines that are round in cross-section, so they can withstand forces in all directions. If the prey is struggling it doesn't matter which way it's pulling – their teeth are unlikely to break," she explained.



These X-ray images show cross-sectional dimensions of the upper arm bone of a jaguar (A and B) compared to a saber-toothed cat (C and D).

"This is the first study to look inside sabertooth arm bones to see exactly how much stress and strain they could handle."

– Julie Meachen-Samuels, NESCent

In contrast, the elongated canines of saber-toothed cats were oval in cross-section, which made them more vulnerable to breaking than their conical-toothed cousins. "Many scientists infer that saber-toothed cats killed prey differently from other cats because their teeth were thinner side-to-side," said Meachen-Samuels.

Despite their vulnerable canines, prominent muscle attachment scars on sabertooth limb bones suggest the cat was powerfully built. Saber-toothed cats may have used their muscular arms to immobilize prey and protect their teeth from fracture, she explained.

To estimate how strong sabertooth forelimbs were relative to other cats, Meachen-Samuels and co-author Blaire Van Valkenburgh of UCLA used x-rays to measure the cross-sectional dimensions of the upper arm and leg bones of fossils recovered from the La Brea Tar Pits in Los Angeles. They also measured the limb bones of 28 cat species living today – ranging in size from the 6-pound margay to the 600-pound tiger – as well as the extinct American lion, the largest conical-toothed cat that ever lived.

The researchers used their cross-sectional measurements to estimate bone strength and rigidity for each species. When they plotted rigidity against length for the 30 species in their study, species with longer limbs generally had stronger bones. But the data for the saber-toothed cat fell well outside the normal range – while their leg bones scaled to size, their arm bones were exceptionally thick for their length.

"When I looked at the arm bones, *Smilodon fatalis* wahs way out in left field," said Meachen-Samuels.

Sabertooth arm bones were not only larger in diameter than other cats, they also had thicker cortical bone, the dense outer layer that makes bones strong and stiff. Thicker cortical bone is consistent with the idea that sabertooth forelimbs were under greater stress than would be expected for cats their size, Meachen-Samuels explained. Just like weight-bearing exercise remodels our bones

continued on next page

Tiger, continued

and improves bone density over time, the repeated strain of grappling with prey may have resulted in thicker and stronger arm bones in saber-toothed cats.

"As muscles pull on bones, bones respond by getting stronger," said Meachen-Samuels. "Because saber-toothed cats had thicker arm bones we think they must have used their forelimbs more than other cats did."

"The findings give us new information about how strong their forelimbs were and how they were built," she added. "This is the first study to look inside saber-tooth arm bones to see exactly how much stress and strain they could handle."

The findings wereh published this July in the journal *PLoS ONE*.

CITATION: Meachen-Samuels, J. and B. VanValkenburgh (2010). "Radiographs reveal exceptional forelimb strength in the saber-toothed cat, Smilodon fatalis." PLoS ONE 5(7): e11412. doi:10.1371/journal.pone.0011412

Digital data repository goes international

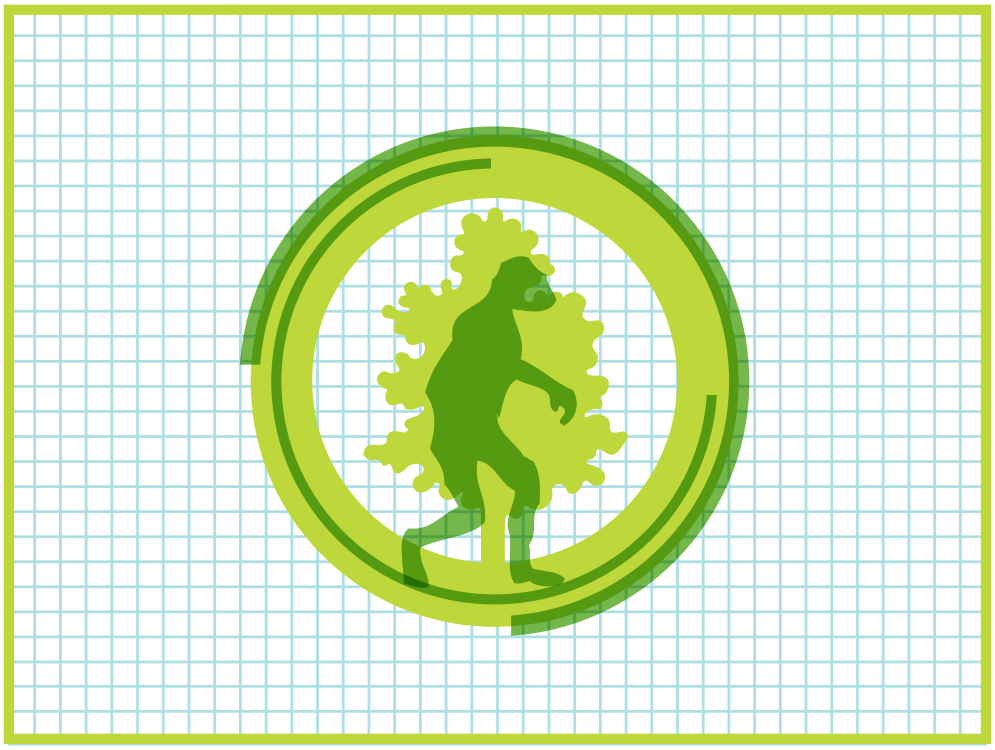
When you publish your research, do you also publish the data behind it? A digital repository known as Dryad (datadryad.org) enables authors in ecology, evolution, and related fields to archive their data at the time of publication. Developed in large part at NESCent, Dryad makes it possible to preserve, share, and re-use research data. Now, thanks to an award from the **Joint Information Science Committee (JISC),** the Dryad repository will soon have a mirror at the British Library in London. The project will expand the disciplinary range of participating journals – particularly into epidemiology and infectious diseases – and further develop an international framework for long-term data preservation.

Read more at blog.datadryad.org/2010/08/06/dryad-goes-international

Find out what Dryad is doing to make data submission as easy as possible for authors. Visit blog.datadryad.org/2010/01/12/making-data-submission-almost-as-easy-as-falling-off-a-log/

Big boost for 'Evo-Devo-Eco'

Researchers working across the fields of evolution, development, and ecology can look forward to new opportunities and initiatives emerging from the recently-funded Evo-Devo-Eco Network (EDEN). The National Science Foundation has awarded a $500,000 "Research Coordination Network" grant to better coordinate research efforts in the field of Evolutionary and Ecological Developmental Biology. Arising out of conversations held during the NESCent working group "Building tools for emerging model systems in development, evolution, and ecology," (coordinated by Elena Kramer, Scott Hodges and Hopi Hoekstra), one of the network's main aims is to help transfer and adapt technologies developed for traditional model species to lesser-known systems. For more information about EDEN, contact principal investigator Cassandra Extavour at extavour@oeb.harvard.edu, or visit **www.edenrcn.com.**



IN THE MEDIA

"Male spiders are all bark, female spiders fight to kill" (Wired Science) In most animals the bigger, better fighter usually wins. But a new study of the jumping spider Phidippus clarus suggests that size and skill aren't everything – what matters for Phidippus females is how badly they want to win. NESCent postdoctoral fellow Carlos Botero and co-author Damian Elias tell the full story in Behavioral Ecology. **wired.com/wiredscience/2010/06/female-spider-fights/**

"Fat daddy's best – for penguins" (New Zealand Herald) Courtship calls help penguin females decide which males are likely to be devoted dads, says a new study by NESCent Director Allen Rodrigo and colleagues. **nzherald.co.nz/environment/news/article.cfm?c_id=39&objectid=10659300**

"Saber-Tooth Tigers Add Powerful Arms to Their Arsenal" (Science) Saber-toothed cats may be best known for their supersized canines, but they also had exceptionally strong forelimbs for pinning prey before delivering the fatal bite, says a new study by NESCent postdoctoral fellow Julie Meachen-Samuels. **http://news.sciencemag.org/sciencenow/2010/07/scienceshot-saber-tooth-tigers-a.html**

"Scared snails opt for single parenthood rather than wait for a mate" (Dallas Morning News) Solitary snails change their dating and mating strategy when danger is near, says a new study by NESCent postdoctoral fellow Josh Auld. His results were published this July in the journal Evolution. **topics.dallasnews.com/ article/0fCa3iP30y3Hn**

"Scientists square off on evolutionary value of helping relatives" (The New York Times) Why do some animals help their relatives raise kids, rather than raise kids of their own? The question continues to spark debate. Sabbatical scholar Jim Hunt hopes to move the debate toward resolution during a meeting he is organizing at NESCent this October on the evolution of insect sociality. **nytimes.com/2010/08/31/science/31social.html?_r=1**

Recent publications by NESCent authors

Auld, J. (2010). "The effects of predation-risk on mating system evolution in a freshwater snail." Evolution doi: 10.1111/j.1558-5646.2010.01079.x.

Auld, J. and R. Relyea (2010). "Adaptive plasticity in predator-induced defenses in a common freshwater snail: altered selection and mode of predation due to prey phenotype." Evolutionary Ecology doi: 10.1007/s10682-010-9394-1.

Beall, C., G. Cavalleri, et al. (2010). "Natural selection on EPAS1 (HIF2Đ) associated with low hemoglobin concentration in Tibetan highlanders." Proceedings of the National Academy of Sciences doi: 10.1073/pnas.1002443107.

Botero, C., I. Pen, et al. (2010). "The evolution of individual variation in communication strategies." Evolution doi: 10.1111/j.1558-5646.2010.01065.x.

Dahdul, W., J. Balhoff, et al. (2010). "Evolutionary characters, phenotypes and ontologies: curating data from the systematic biology literature." PLoS ONE 5(5): e10708.

Gudelj, I., J. Weitz, et al. (2010). "An integrative approach to understanding microbial diversity: from intracellular mechanisms to community structure." Ecology Letters 13(9): 1073-1084.

Lindenfors, P., L. J. Revell, et al. (2010). "Sexual dimorphism in primate aerobic capacity: A phylogenetic test." Journal of Evolutionary Biology 23: 1183-1194.

McClain, C. R. and S. M. Hardy (2010). "The dynamics of biogeographic ranges in the deep sea " Proceedings of the Royal Society B doi: 10.1098/rspb.2010.1057

Meachen-Samuels, J. and B. VanValkenburgh (2010). "Radiographs reveal exceptional forelimb strength in the sabertooth cat, Smilodon fatalis." PLoS ONE 5(7): e11412.

Pfennig, D., M. Wund, et al. (2010). "Phenotypic plasticity's impacts on diversification and speciation." Trends in Ecology and Evolution 25(8): 459-467.

Revell, L. J. (2010). "Phylogenetic signal and linear regression on species data." Methods in Ecology and Evolution doi: 10.1111/j.2041-210X.2010.00044.x.

Stearns, S., R. Nesse, et al. (2010). "Evolution in health and medicine special feature." Proceedings of the National Academy of Sciences 107(suppl 1).

Vision, T. J. (2010). "Open data and the social contract of scientific publishing." BioScience 60(5): 330-331.

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