Smithsonian

Spotlight on Science at the Smithsonian

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Introduction from the Under Secretary for Science

In this installment of Spotlight on Science, we'll look at the work of researchers from the Smithsonian Astrophysical Observatory who are looking for the best way to identify habitable planets. They argue that identifying planets with infrared emission spectra similar to the Earth will yield planets most likely to be habitable. Next, Smithsonian researchers at the Conservation and Research Center are refining a noninvasive technique for studying endangered species. This technique allows researchers to collect information on wild mammals without having to capture or even directly observe them. Finally, Tropical Research Institute scientists look at the effect the size of "hoods"—large sand or mud structures—built by fiddler crab males have on attracting females.

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Vol. 4, No. 16 | 25 August 2006

This optical image of the Earth from deep space, assembled from a collection of satellite-based observations, shows what our home planet looks like in the visible spectra. (Image courtesy of NASA.)

A Habitable World in Space: Earth

Reference

M. Turnbull *et al*., "Spectrum of a Habitable World: Earthshine in the near infrared", 2006. *The Astrophysical Journal*, **644**, 551.

Although over 150 planets around other stars are now known, none of them appears to be capable of supporting life as we know it. Astronomers want to be certain, however, that they understand what a habitable extrasolar planet would really look like. The optical light and other forms of electromagnetic radiation from planets can be carefully analyzed according to the colors—the spectrum. SAO astronomer Kenneth Jucks, along with seven colleagues (one a recent SAO astronomer), has asked what the spectrum of a habitable planet might look like—would its atmosphere or its surface character be measurable, for example, and might it vary with the planet's seasons or rotation?

The team of astronomers argues in a paper in the *Astrophysical Journal* that the best way to decide if the spectrum of a planet indicates habitability is to compare it to the Earth's spectrum. They further explain that the best way to obtain an accurate measure of the Earth's spectrum—as seen from space—is to measure earthshine, the faint light seen on the night side of the crescent Moon. Earthshine is light reflected from the sunlight-illuminated (day side) of Earth onto the night side of the Moon and back again into telescopes on the night side of Earth. The scientists point out that spectra of Earth taken from satellites are inadequate because they do not include the whole disk of Earth, only small patches, and these are usually only in selected wavelength ranges, not the wide coverage thought to be needed for more certain identification. Building on their previous research efforts, the team studied the faint earthshine at infrared wavelengths to extend their database, and then modeled the results. The dominant signatures in the new spectra are from water, molecular oxygen, and carbon dioxide, with the weak but key presence of methane gas. They conclude that the simultaneous presence of water, methane, and molecular oxygen in a planet's atmosphere is a strong indicator of biological activity, although they caution that some unusual geological process might also be able to reproduce this signature. The results are significant because they help to identify some of the most productive indicators of planetary habitability, and will help to properly design future missions aimed at finding habitable planets.

Spotlight on Science at the Smithsonian

Vol. 4, No. 16 | 25 August 2006


An endangered kit fox.

Smithsonian Scientists Provide Hi-Tech Method to Study Endangered Species

The conservation and management of endangered species is a primary focus for the National Zoo's research staff who have pioneered in research and veterinary science methods for decades. Now Zoo and NMNH scientists and a former Smithsonian predoctoral fellowship student are credited with refining a noninvasive technique, faecal sampling followed by molecular analysis of faecal DNA, to obtain information on wild mammals without the need to capture, handle or observe them. This method has previously been criticized because, if conducted inappropriately, it yields too many scoring problems and genotyping errors making the results unreliable.

The endangered San Joaquin kit fox (*Vulpes macrotis mutica*) population in California, which has been studied by the Zoo for 17 years, was chosen as the research target. Researchers from the Conservation and Research Center and the Genetics Program joined forces with colleagues from the University of Washington and University of Montana along with trained locator dogs to collect hundreds of faecal samples (scats) in the Carrizo Plain National Monument. The location of each scat collected was geo-referenced using a Global Positioning System (GPS) unit. The team's previous research had shown that the trained dogs were 100% accurate at distinguishing kit fox scats from those of other species. DNA was extracted from every scat sample and sex markers and six microsatellite loci were examined; then five previously recommended tests for reducing and tracking error as well as several new spatial tests developed by the Zoo investigators were applied. Results showed very low rates of genotyping error, and analyses of the individual scat genotypes provided information on kit foxes that was in good agreement with data gathered using more traditional, invasive techniques (trapping and radio collaring). Results on fox movement patterns, for instance, agreed with prior field observations.

An important conclusion of this study is that a systematic collection of "fresh" scats followed by molecular typing can provide reliable data on species, differentiate individuals and provide data on sex. Genetic data can further reveal relatedness, movements, and latrine use. The technique, with some further testing, may prove useful in deducing the probable diameter of a fox home range since it was found that 96% of foxes deposited scats within a distance no greater than 2107m. Finally, researchers foresee faecal sampling, when paired with appropriate steps to ensure genotype reliability, as being quite applicable to studies of other elusive or rare animal populations.

Reference

D.A. Smith, K. Ralls, A. Hurt, B. Adams, H.M.. Parker and J.E. Maldonado, "Assessing reliability of microsatellite genotypes from kit fox faecal samples using genetic and GIS analyses," *Molecular Ecology* (2006) 15, pp. 387-406.

Spotlight on Science at the Smithsonian

Vol. 4, No. 16 | 25 August 2006

Studying the sand "hoods" of *Uca terpsichores.*

Bigger Is Not Always Better

Reference

Animal Behavior **71:** 1239-1246.

Males of many animal species express their amorous intentions with excessively loud, colorful or large signals and displays that are designed to attract the attention of potential mates. By demanding extravagance females are thought to benefit because they will mate only with fit males, those that can afford a substantial lay-out in advertising. But a recent study by Smithsonian Tropical Research Institute scientists John H. Christy and Patricia R. Y. Backwell of courtship signaling and female preferences in the tropical fiddler crab *Uca terpsichores* has shown that bigger is not always better when it comes to wooing mates.

The signal in question is a sand "hood," an arching pile of sand that courting male *U. terpsichores* make at on one edge of the opening to their burrow to which they attract females with a claw waving display. At least 18 other species of fiddler crabs (about 97 species world-wide) make courtship structures but the hoods of *U. terpsichores* are the largest relative to the size of their builder. Females usually visit a dozen or more males before they choose a mate by staying in a male's burrow and they strongly prefer to visit males who have a hood at their burrow entrance. While moving between burrows, female crabs are at risk of predation from shorebirds. By running preferentially to burrows with hoods, they reduce this risk because these objects make it easy for females to find the male's burrow and safety. Christy and Backwell recently reported in *Animal Behaviour* on a series of experiments to determine whether bigger hoods are more attractive to females. They replaced natural hoods with super-sized hood replicas and found, surprisingly, that females did not prefer to visit males with these exaggerated signals compared to average-size hoods. The researchers suggest that discrimination between average and unusually large hoods would necessarily cause females to hesitate when moving between males' burrows and that this hesitation might be fatal and prevent the evolution of a preference for ever-larger hoods.

Still, this does not explain why the hoods of this species are so large. Because they are made of pure sand, hoods crumble easily as they dry and some even blow away in the wind. Other species make smaller structures of sticky mud and they seldom fall down. The authors suggest that sand hoods may be unusually large simply to be durable.

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