Current Biology 12(13):R442-443, July 9, 2002

Feature

Eternal vigilance on an Amazon floodplain

Deep and puzzling evolutionary questions are still being raised by the work of systematic biologists. **James S. Albert** describes some such work and argues why we need much more in the face of unprecedented loss of species through human activity.

As the biodiversity crisis accelerates, astute observers have noted an urgent need for systematic biology. At the current rate of description of new species, it will take centuries to complete the task. Yet the ways and means are well known – familiarize yourself with the local ecology, get wet, sample to taxonomic saturation, explore every microhabitat in space and time, with as many tools as you can imagine, and then imagine some more.

The goal is comprehensive collections of specimens deposited and catalogued in natural history museums; photographed, georeferenced, cross-referenced with tissues and field notes, all served up electronically on the internet. Museum specimens are hard facts, vouchers for taxonomic identifications in ecological and conservation studies, the name bearers of biodiversity. John Haseman summarized the strategy in his 1912 report to the Memoirs of the Carnegie Museum: ‘The price of a good collection is eternal vigilance.’

Our contribution is a faunal survey of a floodplain in the Peruvian Amazon. From 20,000 feet above, the floodplain is a mosaic of ox-bow lakes, winding channels and a scroll-swathe terrain of levees, swamps, and flooded forests. What you can’t see under the water is one of the most diverse ecosystems on the planet. What you can see are the bristly red lines of logging roads; Peru is developing rapidly, and in this new millennium such a vast and unexplored region cannot much longer remain protected by its isolation alone. We know that in the span of only a few centuries the great forests of the Mississippi and Yangtze basins were felled. A few centuries is not a long time for a forest. Satellite imaging has revealed that about 12% of the Amazon’s non-floodplain rain forest has been cleared or severely degraded, and that more than 70% of floodplain forests have already disappeared.

Back on the water, however, the project resumes its familiar rhythms; pulling nets, shooting photographs, preserving fishes, crustaceans, mollusks, insects, annelids, flatworms, sponges. The aquatic fauna of these floodplains is almost completely unknown. The target is animals inhabiting the roots of floating meadows – thick mats of unrooted aquatic vegetation that rise and fall with the flood cycle and grow to cover great expanses of the floodplain. Megadiverse tropical aquatic communities are characterized by a log-normal distribution of species abundances in which there are small numbers of common species and many rare species. So to characterize the complete fauna we conduct quantitative sampling; 40 nets per day (at 4 m^2/net), two 60-day samplings per year (one at high and another at low water) for 3 years, to sample around 60,000 m^2 of floating meadows.

A basic question underlies all this toil and trouble: why so many species? Neotropical freshwaters contain an estimated 8,000 fish species, or approximately 13% of all described vertebrates. The processes underlying the production and maintenance of this enormous diversity are poorly known. From an evolutionary perspective, standing species diversity is a function of relative rates of speciation, immigration, extinction, and emigration. Methods to measure these phenomena are well characterized. What we lack in the Amazon are basic observations, in particular, the identity of the evolutionary players themselves.

Despite this paucity of knowledge there are indications that the evolutionary forces at work in megadiverse tropical floodplains differ from those in other parts of the world. For example, there is surprisingly little evidence to

Amazon secrets: One of the world’s most diverse ecosystems is under unprecedented threat from human activity but such systems hold many evolutionary insights in need of study before they are lost. (Picture: Science Photo Library.)

support two of the most widely cited models in biodiversity research; niche partitioning and adaptive radiation.

Many Amazonian fish genera are represented by 10 or more species living together – cheek by jowl – in multi-species assemblages. Even the specialist can hardly tell them apart; they often have very similar shapes and sizes, diets and microhabitats. In the face of this exuberance arguments for competitive exclusion, or 'one species, one niche' are hard to sustain. Further, recent molecular, biogeographic, and paleontological data suggest that most Amazonian fish genera are ancient, dating back tens of millions of years, to a time before the geological assembly of the modern Amazon basin.

Phylogenetic analysis has shown that the closest relatives of floodplain species frequently inhabit non-floodplain streams and rivers. In other words, the co-existence of numerous ecologically similar species in floodplain floating meadows is the result of multiple independent invasions of this habitat, not *in situ* speciation. Niche partitioning and adaptive radiation may be real in Neotropical floodplains and, if so, the signals they yield are quickly overwhelmed by exceptionally high rates of other evolutionary phenomena.

Amazonian floodplains extend over 180,000 km^2, a little larger than the area of England and Wales combined, or about 2.6% of the 7 million km^2 area of the entire basin. I doubt that we as a community will fully document the species of this immense area within my professional lifetime, let alone that of the entire biosphere. But I dare say it is not impossible.

An all-species survey will necessarily be a collective effort – on a scale of the NASA Mars program, or the Human Genome initiative. It will require a collaboration of traditional morphological and biogeographical approaches with novel bioinformatic, remote sensing and genetic technologies. What we most urgently need however is really just a great deal more of what we already have; more taxonomists, more students, more collaborations, more surveys, more museums, more work. We have a good idea of what such a determined effort will yield; pay-off in everything from resource management to basic scholarship. Perhaps such an enterprise could be one of the great contributions from our generation.

James S. Albert is at the Florida Museum of Natural History, University of Florida, Gainsville, FL 32611-7800, USA.

Smell those spots

A widespread strategy among prey species unpalatable to their potential predators, is warning colouration advertising the fact. Research suggests that this has evolved because predators learn more quickly to avoid distinctively marked unpalatable prey than those which give out no such warnings. But interestingly, many species that carry warning colouration also have a second defence strategy: some bees, for example, emit a sound when threatened by a predator and ladybirds emit a particular odour. Why do these organisms use two defensive strategies?

New work carried out by Candy Rowe, at the University of Newcastle, reported in the Proceedings B of the Royal Society, London, (vol. *269*, p1353-1357) suggests that the two signals act together to speed up the unpalatability message. She tested chicks in the laboratory. Birds were trained to look for food rewards under coloured paper 'hats' scattered in an experimental arena. They learned to discriminate between rewarded and non-rewarded hats. But half of the birds heard a sound when they attacked a non-rewarding hat. Rowe found that the presence of the sound improved the speed of colour discrimination. This demonstrates that there could be a selective advantage for potential prey species to emit a second signal when attacked as avian predators may learn to avoid them more quickly. Two strings to a defensive bow might therefore be a sound investment.

Warning signs: New research suggests that multiple signals may help protect prey from potential predators. (Picture: Science Photo Library.)