to give a nucleus with 114 protons and 173 neutrons, which falls into slightly deeper water off the island. So far there have been two events. But the beauty of this experiment is that the decay properties of the new isotope could be calculated from the observed properties of the first isotope of element 114. The prediction of a single α-decay followed by spontaneous fission is confirmed convincingly.

In the latest LBNL experiment, the previous philosophy of using a 208Pb target was adopted. This nuclide has a closed shell of neutrons (N = 126) and of protons (Z = 82) producing an unusually stable nucleus (see Box 1). The extra binding energy of this double-closed-shell system leads to a cooler compound nucleus that needs to evaporate only one neutron to survive fission. A projectile with 36 protons (36Kr) enabled the group to leapfrog element 114 and reach Z = 118 (seen in three events), which then decays to Z = 116, 114 and so on. In terms of the question “Just how many stable elements is it possible to make?”, this increases the maximum atomic number by a further four units. But, for the isotope of Z = 114 observed in the long Dubna decay chain (Fig. 2), the lifetime is over four orders of magnitude greater than that for the Z = 114 isotope in the LBNL chain. Similar comparisons hold for Z = 112 and Z = 110. Even the 114 isotope in the short Dubna decay chain (Fig. 2) has a lifetime enhanced by over three orders of magnitude. So, in terms of reaching the island of stability, the Dubna experiments appear so far to be the closest.

Neil Rowley is at the Institut de Recherches Subatomiques, 23 rue du Loess, F-67037, Strasbourg Cedex 2, France.

e-mail: Neil.Rowley@ires.in2p3.fr


Figure 1 Signalling in electric fish. The waveform of a monophasic (a) and biphasic (c) electric-organ discharge (EOD) with the corresponding power spectra (monophasic, b; biphasic, d). The arrows show the sensitivity of two types of electro sensitive predators, catfish at about 8 Hz (blue) and gymnotiforms at about 30 Hz (red). The biphasic EOD is from Brachycephalus pinnicaudatus, gymnotiform prey; the monophasic waveform is that same waveform with the negative component deleted. The figures are modified from Figs 3c and 3d of Stoddard2, who argues that predation has favoured an increase in the complexity of EODs because the biphasic signals are less detectable by predators than are the monophasic signals.

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explain why three species of gymnotiform still produce monophasic EODs. These, Stoddard argues, might be the exceptions that prove the rule. Of the three monophasic species, one is an electropredator, one lives in an area devoid of electropredators, and one produces an EOD which resembles that of an electric eel.

This study describes a convincing way in which predation may have promoted rather than constrained signal diversity. But it is not a unique case, as predation is known to have had similar effects in other systems. It caused moths to evolve ears to detect, and signals to deter, bat predation; these traits were then co-opted for communication, resulting in males that communicate their presence to females with ultrasonics (in some species, males and females even conduct an ultrasonic duet). Also, it has been suggested that offspring might evolve signals that are more conspicuous to predators in order to manipulate parental behaviour; bird nestlings giving loud, conspicuous begging calls, and children holding their breath in parental defiance, are two examples.

Stoddard’s study gives us a glimpse into the complicated world of signal evolution of one system; a more general understanding, however, is far off. Consider Zuk and Kolluru’s review of the predation costs of sexual signals. They pointed out that there are many more examples of predators attracted to signals in the acoustic mode than in the visual mode (electrical communication is more similar to acoustic than visual communication). This bias is probably because it is easier to study acoustic than visual communication. Nevertheless, it is crucial to know how predator effects on communication systems might vary among sensory modalities.

For example, it is as likely that potential prey can evolve electrical (say, biphasonic pulses) or acoustic (say ultra- or subsonic) signals out of the range of their predators than it is for prey to evolve visual signals (say in the ultraviolet) to escape predators in that modality? One part of the answer might depend on the lability of signals in a given modality. Another must derive from the predator’s receiving systems. Do the demands of communication on a sensory system constrain the uses of that system in other tasks, and does this vary among sensory modalities? For example, does tuning an electoreceptive or auditory system to one type of signal, a weak electric field or an echolocation call, constrain this system from being used to locate prey making very different types of sounds? It might be so in electric eels, but appears not to be in frog-eating bats.

Also, more generally, we can ask how constrained different sensory systems are in their ability to evolve. Can we compare the changes in the inner ear of a vertebrate, needed to allow that animal access to ultrasonic emissions made by its prey, to changes in the retina of the same animal that would give it access to ultraviolet signals of different prey?

Probably not. Only studies of the entire biology of communication systems can allow an appreciation of their diversity — an argument that provides strong support for the kind of integrative approach taken by Stoddard.

Michael J. Ryan is in the Section of Integrative Biology, University of Texas, Austin, Texas 78712, USA.

e-mail: mryan@mail.utexas.edu