Not so shocking: the electric fish of South America

Carlo R. Laing

1 Introduction

You have probably heard tales of electric eels in the Amazon capable of stunning a horse. Or maybe you've heard of fish capable of lighting up a 100 Watt bulb. While these tales are true, there are many less–spectacular South American fish that use also electricity — not to shock their prey, but to navigate, detect their prey, and communicate with one another in water too murky for vision to be useful. These "weakly electric" fish are of much interest in the scientific community, as they provide ideal subjects for the study of questions of general interest, for example: how does an animal make sense of the information it receives about the rest of the world?

2 What is an electric fish?

An electric fish i

the existence of WEF in both continents seems to be an example of convergent evolution, i.e. two distinct groups of organisms independently evolving the same feature.

In the Americas, WEF have been found from Mexico in the north to Uruguay and Argentina in the south. Some hundred species have been discovered, and new ones are found each year. Out of the South and Central American countries, outon, ʒ i varies a great deal, depending on whether the fish is feeding or communicating with another fish, for example. Determining whether wave discharge has any advantages over pulse discharge is a subject of current investigation.

The electric organ does not spontaneously generate an electrical field, but is controlled by impulses sent from the brain of the fish. The timing of these impulses is determined by the information the fish receives through *electroreceptors* on its skin. Electroreceptors are specialized clusters of cells on the skin of the fish that detect electric fields and send nerve impulses to the brain of the fish which encode the strength of the field. They are spread o to sound and played though a loud s

Mark Nelson, at the University of Urbana–Champaign, is interested in how an animal's nervous system can extract useful information from the signals received by the sensory organs, at the same time suppressing irrelevant background noise. As part of this, his group has developed techniques for filming and subsequently analyzing the behavior of free–swimming fish capturing single water fleas.

Philip Stoddard, at Florida International University, is interested in the behavior and ecology of WEF, and also the evolution of their electrical signals. One of his findings is that the force of predation seems to have caused WEF to evolve more complex electric organ discharges, in order to reduce the detectability of their electrolocation and communication signals by predators.

Curtis Bell, at the Oregon Health and Science University, studies central processing and memory in WEF. The fish are used because, in a laboratory, their sensory input can be precisely controlled, and because they have been established to have *synaptic plasticity*. Synaptic plasticity refers to changes in the strengths of connections between neurons, and is fundamental to the formation of memory. In the fish, these memories are used to form expectations, which are subtracted from the current sensory input, allowing inputs that are unexpected or novel to stand out more clearly.

Away from North America, there is also a large group of researchers at **Instituto de Investigaciones Biologicas "Clemente Estable"**, in Montevideo. Despite Uruguay's economic problems and a lack of funding for scientific research, much work on various aspects of Uruguayan weakly electric fish is carried out there, particularly in relation to the mechanisms underlying electric organ discharge.

7 Author bio

Carlo Laing has a Ph.D. in applied mathematics from the University of Cambridge, and is currently a research associate at the University of Ottawa, Canada, studying sensory processing and neural feedback in the weakly electric fish *Apteronotus leptorhynchus*. He traveled to Uruguay in 2002 to speak about his work (and to watch candombe and murga music during Montevideo's Carnaval).

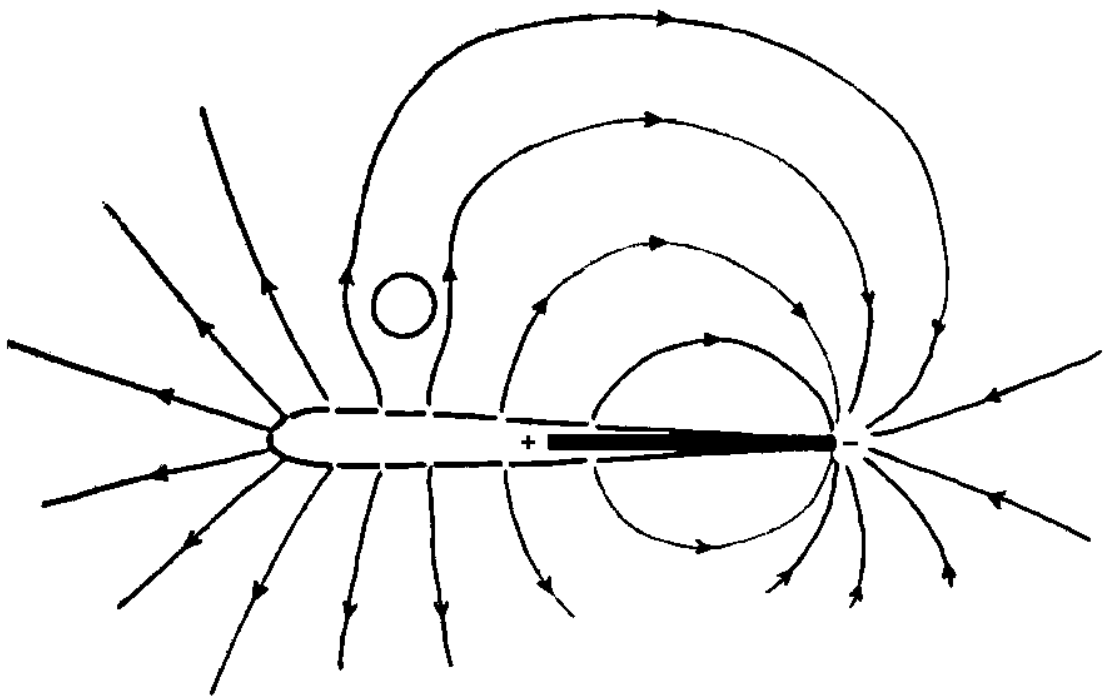

Figure 1: A schematic showing current flowing past an object in the vicinity of an electric fish (as seen from above). The current flows from the head region to the tail, and is deflected around the non–conducting object. The direction of current flow changes at up to 1000 times a second. Picture courtesy of Mark Nelson.

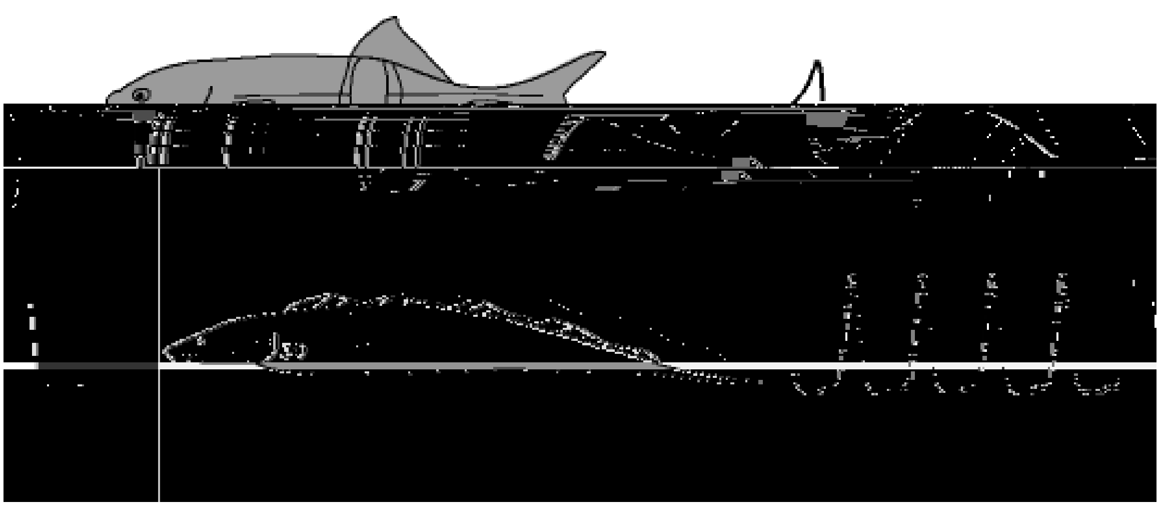

Figure 2: Pulse–type (top) versus wave–type (bottom) fish. On the right are typical electric organ discharges. Picture courtesy of Masashi Kawasaki.