Feature

Democracy runs deep

Democracy is considered to be a uniquely human invention, but a new model suggests how shared collective decision making could have arisen in a range of animal species. **Nigel Williams** reports.

Most westerners would probably think that the roots of democracy lie in Ancient Athens, when the city state established the process by which all citizens, well, men of Athenian parentage, had an equal say in the decisions of the state. This model of 'equally shared' consensus decision making has wobbled, been ignored and often forgotten in intervening history but the concept has endured.

But was equally shared consensus decision making invented out of the blue by the Athenians? A new paper presents a model of how this process could evolve in the best interests of individuals within a group.

"A consensus decision is when the members of a group choose, collectively, between mutually exclusive actions," the authors write. In humans, consensus decisions are often made democratically or in an 'equally shared' manner, that is, all group members contribute to the decision. But a group can also reach an 'unshared' consensus by accepting the decision of a single dominant member of the group.

"Biologists are only now realizing that shared consensus decisions also occur in social animals. Sharing of decisions is, in principle, more profitable for groups than accepting the 'unshared' decision of a single dominant member," they write.

But the problem is that while shared decisions may benefit the group, some individuals may gain greater benefit from doing something else. So how could such a process evolve?

In the new model, L. Conradt and T. Roper at the University of Sussex (reporting in the Proc. R. Soc. B, published online) use a game theory approach to show that sharing of decisions can evolve under a wide range of circumstances but especially in the following ones: when groups are heterogeneous in composition; when alternative decision outcomes differ in potential costs and these costs are large; when grouping benefits are marginal; or when groups are close to, or above, optimal size.

"Since these conditions are common in nature, it is easy to see how mechanisms for shared decision making could have arisen in a wide range of species, including early human ancestors," they write.

Whereas the Athenians were making shared consensus decisions such as how best to cope with rival city states, Conradt and Roper look at the background to simpler but more

All together: Members of the European parliament reach decisions democratically, but some animal societies may have developed similar strategies. (Photo: Frederick Florina/AFP/Getty Images.)

widespread decisions, such as how a group of primates decide where to travel after a rest period or how a flock of birds decides when to leave a foraging patch. "Unless all members decide on the same action, some will be left behind and will forfeit, at least temporarily, the advantages of group living," they write.

"Thus, in order to maintain group cohesion, social animals — like humans — have to make consensus decisions."

But, as in human consensus decisions, these often lead to a conflict of interest between group members, as individuals vary in their optimum preferences. Therefore, in order to reach a consensus, group members often have to compromise, thereby incurring a 'consensus cost'.

Consensus costs can be substantial: for example, in some circumstances they are sufficient to prevent a consensus from being reached, thereby causing groups to fragment.

The authors claim the new model shows that both equally shared consensus decisions and unshared decision making can evolve through, and be maintained by, individual selection. "An important part of the argument that renders the evolution of equally shared decisions possible is that individual members cannot predict with certainty what other group members are going to do," they write.

Essentially, it pays all individual members of a group to bluff, rather than communicating honestly about their readiness to compromise their own interests. So would-be selfish individuals cannot exploit other group members' readiness to compromise.

The most important conclusion of the model, the authors write, is that while, in principle, both equally shared and unshared decision making can evolve through individual selection, equally shared decisions can evolve under a much wider variety of conditions.

So democracy, on balance, might have a deeper base than previously realised.

Q & A

Armand Leroi

Armand Marie Leroi is Reader in Evolutionary Developmental Biology at Imperial College London. He did his PhD with Michael Rose at the University of California, Irvine and his post-doctoral work with Scott Emmons at Albert Einstein College of Medicine, New York. There he began to work on the evolution and development of growth in nematodes, and still does — but he has also forayed into computational embryology, transmissible cancers and cultural evolution. His popular book, Mutants: On the Form, Variety and Errors of the Human Body *(2004) was turned into a television series. Since then, he has written or fronted several other television programs, and has received awards for doing so.*

How did you get into science? I was a boy naturalist. I spent part of my childhood in South Africa, a country in which the natural world is richly present and endlessly seductive. There were sacred ibises and hoopoes on the lawn, chameleons in the Proteas and a little stream full of *Xenopus* and crabs that one could follow (if one didn't have to be home for dinner) to the great Limpopo itself. And there was a bag of sea-shells that my parents had picked up on their travels. One day an amateur collector came to my school and identified them for me. That was my discovery of the Linnean binomial system; I was 11. Since then, my deepest intellectual impulses have been to determine the logic, the order, that lies beneath the apparent chaos that the natural world presents us with.

Do you have a scientific hero? Aristotle. His genius was simply to invent biology. He was the first to go down to the shore, pick up a snail, ask "what's inside?" — and then cut it up to find out. He did that to around 50 species, wrote the results down, and built a theory of development, physiology and taxonomy from them. To read him is to enter a parallel science, as beautiful and logical as our own, sometimes familiar, sometimes unutterably strange, but always unmistakably the product of a rational, querying, sceptical, systematizing, scientific mind.

What paper has most influenced you? That would be the 1993 paper from Cynthia Kenyon's group reporting the discovery that insulin receptor mutations increase longevity in worms (A *C. elegans* mutant that lives twice as long as wild type. Nature *366*, 461–464). Before this paper it was dogma, at least among evolutionary geneticists, that traits such as longevity and growth were intrinsically polygenic and could only, should only, be studied by quantitative genetics. This was a counsel of despair. Inspired, in part, by the clarity of Kenyon's work, I began to study body size mutations in worms, and continue to do so. Of course, the controls of longevity and growth do, indeed, ramify throughout almost every part of a creature's physiology and structure. So they're not as simple as the vulva. So what?

What paper will influence you? The classical problem of growth is the mystery of how a creature's organs know what size they should be. Last year, a paper was published that gave a remarkably clear and simple account of how compartment size is controlled in the *Drosophila* embryo. The author was Joe Parker; the lab was Peter Lawrence's (though, characteristically, his name doesn't appear on the paper); the journal was a good one: Control of compartment size by an EGF Ligand from neighbouring cells. Curr. Biol. *16*, 2058–2065. I think it's a milestone.

What important questions remain to be answered in your field? I can think of two. The first is: can we predict the course of organic evolution in the long term? The short term is easy: that's just the breeder's equation. But understanding the *longue durée* requires a theory that predicts what phenotypes mutation will