Behavioural ecology

Sex among the dunnocks

from Paul H. Harvey and David S. Wilcove

ON FIRST encounter, the dunnock (*Prunella modularis*) seems a most uninteresting small brown bird. Yet, within a single population, this species can show astonishing diversity in its breeding behaviour. Working in Cambridge University's botanic garden, Nick Davies and Arne Lundberg have found breeding groups of dunnocks that are polygynous (several females, one male) polyandrous (several males, one female), polygynandrous (several females, several males) and monogamous. This variation has allowed them to test, in a specific case, the hypothesis that female vertebrates often distribute themselves according to the spatial distribution of resources, while males respond to the distribution of females. The result is published in a recent issue of the *Journal of Animal Ecology*[1].

Between January and March dunnock males set up singing territories which they vigorously defend against other males. In the spring, the females also begin to form territories which they defend against other females. The females' territorial boundaries are not constrained by those of the males, but the overlap of the territories of the two sexes seems to determine the diversity of mating systems. Some females range entirely within the territory of a single male and the two birds form a monogamous pair. Occasionally, the range of a female encompasses the contiguous territories of two males and this results in polyandry. Initially the males squabble and each wins the encounters that occur on its own turf, but one male gradually emerges as the dominant member of the pair, their territories coalesce and the dominant male subsequently copulates with the female more often than does its rival. When the ranges of several females are small enough to be contained within the territory of a single male, the result is polygyny. The final type of mating system, polygynandry, occurs when two or more male territories fuse to encompass the ranges of two or more females. In the polyandrous and polygynandrous systems, where more than one male mates with a single female, the males do not seem to be related, unlike in most such avian breeding systems.

Clearly, the dunnock's breeding system is influenced in large part by the size of female territories. What, then, determines female territory size? The answer is food. Dunnocks feed on small seeds and invertebrates which they glean from the ground in patches of dense vegetation. Within the botanic gardens of Cambridge University, the size of a female dunnock's territory is inversely related to the local density of such patches. Davies and Lundberg were able to manipulate female territory sizes by altering the food supplies of some birds and demonstrated a consequent change in the breeding system of individual dunnocks. Thus, supplementing the food supply results in smaller female territories that are more often monopolized by males. This shifts the mating system away from polyandry; the proportions of unpaired males and polyandrous associations decline, while monogamous pairs and polygynandrous associations increase sharply.

Other experiments have successfully tested the resource dispersion hypothesis[2,3], but not in a species with such a diversity of mating systems as the dunnock. Davies and Lundberg's study is one of a growing number to show that many bird species have quite diverse sexual habits. It also provides an example of a species that is not restricted to only one or two mating systems by psychological, life history or phylogenetic constraints, contrary to the conclusions of a recent review[4]. □

1. Davies, N.B. & Lundberg, A. *J. Anim. Ecol.* **53**, 895 (1984).
2. Pleszczynska, W.K. & Hansell, R.I.C. *Am. Nat.* **116**, 821 (1980).
3. Ewald, P.W. & Rohwer, S. *J. Anim. Ecol.* **51**, 429 (1982).
4. Lott, D.F. *Behaviour* **88**, 266 (1984).

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Solitons

Optic fibres, water tanks and the hydrolysis of ATP

from John Elgin

A SOLITON is a rather special type of large-amplitude solitary wave, the integrity of which is maintained by a balance between nonlinearity and dispersion within the medium through which it propagates. Although observed well over a century ago in connection with water waves, the ubiquity of the soliton has emerged only in the past twenty years or so, and the stable nonlinear excitation that is the soliton has now been observed in many physical systems. Three new developments in the theory and application of solitons were of particular interest at a recent conference*.

L.F. Mollenauer (Bell Laboratories, Holmdel) offered one of the more exciting applications of soliton physics. A soliton laser is used to produce pulses of 210 fs duration at a wavelength of about 1.5 μm. Simple extensions to the basic experimental scheme could reduce the width to a mere 25 fs (about 5 optical cycles). The basic experimental scheme (Mollenauer, L.F. & Stolen, R.H. *Opt. Lett.* **9**, 13; 1984) is a synchronously-pumped colour-centre laser (homogeneously-broadened) that is tunable from 1.4 μm to 1.6 μm and produces output pulses typically of about 8 ps full width at half maximum. To operate as a soliton laser, the output pulses from the laser are first inserted into a length L of single mode optical fibre and then reinjected back into the laser cavity for further amplification. The optical fibre introduces the 'soliton' aspect into the system. It is well known that the appropriate equation governing the evolution of the field E, for optical pulses propagating through a fibre, is the nonlinear Schrödinger equation, where the nonlinearity arises from the refractive index ($n = n_0 + n_2|E|^2$). This equation has both single- and multi-soliton solutions. In particular, for the double-soliton solution, the input pulse becomes two solitons, both of which propagate with the same velocity, and which 'beat' against each other somewhat in the manner of two tuning forks. The result is that the pulse profile within the fibre is (spatially) periodically modulated, becoming extremely narrow at the half-period point. When reinjected back into the laser cavity, these narrow pulses force the laser to produce still narrower pulses, and so the cycle repeats. The periodicity length L' scales as the square of the input pulse duration, and hence decreases as the pulses narrow. When L' is equal to the fibre length L, a stationary state results. Mollenauer presented recent experimental results that clearly demonstrate these effects, but he indicated that a proper theoretical treatment of the problem is outstanding. More generally, the work has useful consequences for information technology systems based on optical fibres.

The role played by solitons in biological systems was discussed by A.C. Scott (Los Alamos). They have been implicated by A.S. Davydov (*Phys. Ser.* **20**, 387; 1979) because of the following problem. The hydrolysis of adenosine triphosphate (ATP) to adenosine diphosphate releases about 0.42 eV of free energy. A basic biological resonance is the double-bonded carbon-oxygen (or amide-I bond) which has a quantum energy of 0.205 eV (1,650 cm^{-1}), and is found in every peptide group of every protein. It is tempting to postulate that the amide-I bond takes up the energy released during ATP hydrolysis (in either single or double quanta) and stores or transports it along the polypeptide

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* 'New Developments in the Theory and Application of Solitons', Royal Society, London, 1-2 November 1984.