Ardea

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REASONS

Swallows gathering — how much is migratory behaviour determined by inheritance?

non-migratory Cape Verdean population, produce offspring in which the extent and pattern of migratory restlessness is intermediate between that of the parental populations[2,3]. The differences between the populations are thus largely genetic.

But what of variation within populations? In some, sex and age may largely determine whether an individual migrates but there are also many cases where there is a dichotomy within sex and age classes, with some individuals migrating and others not. Various studies have suggested that the dichotomy is at least partly genetic in some species[4–6] and the new experiment has dramatically confirmed that this is indeed the case. The Radolfzell workers used blackcaps from a French population in which about 75 per cent of the birds migrate. They applied selection, breeding in one line only from birds showing migratory restlessness and in another only from those that did not. In the first line, 100 per cent of the population showed migratory restlessness after only three generations; in the other, migratory restlessness was eliminated in six generations.

The heritability of migratory behaviour revealed in this experiment is 0.6 – 1.0, among the highest values recorded for quantitative characters in bird populations[7]. The ecological conditions experienced during the winter by migrants and residents are very different and the hazards of migration are great, meaning that migration behaviour is probably under strong natural selection. Yet, according to empirical evidence and standard quantitative genetics theory, the heritability of characters strongly associated with fitness is low, because selection erodes the additive genetic variance that gives rise to heritability. The paradox is perhaps explained by the type of selection operating in partially migrant populations. The coexistence of migrants and non-migrants is probably the result of the over-winter survival of at least one of the subpopulations being density dependent; in consequence, the relative fitness of each type declines as it becomes more frequent, leading to a stable equilibrium at the point at which fitnesses are the same. But any change in selection, such as that in the experiments, results in a rapid response because of the persistent genetic variation.

The rapidity of the response fits in with observations that the numbers of migrants in Belgian populations of stonechats (*Saxi cola torquata*) are higher after hard winters, during which mortality of residents may be assumed to be high[8]. As Berthold and his colleagues suggest, it also has implications for the effects of global warming on bird populations: the migrations of some species may rapidly evolve as their environment changes, altering the ecological balance between them and their competitors. Given the extra problems that European migrants may face because of the increasing aridity of the Mediterranean region, through which they must pass to reach Africa[9], we can hope that the Radolfzell group will not only discover more about the genetic architecture of migration behaviour in blackcaps, but extend their work to other species. □

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DAEDALUS

Deep liquid gold

Along the central ridges of the big oceans, where the tectonic plates are separating, intriguing aqueous volcanoes called 'black smokers' occur. Sea-water percolates through the cracking and extending rock, down to the hot magma beneath. At such high temperatures and hydrostatic pressures water becomes a supercritical fluid, and a most ferocious solvent. It dissolves sulphides and other minerals from the magma, convects up the exit pipe of the black smoker, and erupts from the sea-bed as a superheated solution. As it cools and mixes back into the cold ocean, its dissolved and suspended minerals precipitate as black 'smoke'. Impressed by this natural form of deep-sea mining, Daedalus now advocates the construction of an artificial black smoker, or 'Arblasm'.

Many of the technical problems have already been solved by commercial offshore oil practice, and by the planned 'Mohole' submarine deep-drilling project. Two adjacent holes need to be drilled in the mid-oceanic sea-floor. They must reach rock so hot that entering water will dissolve it, and join the holes to form an undersea cavity. The tiniest imbalance in the two boreholes will then start a self-amplifying convective flow. One hole will develop into the down-comer of the Arblasm, delivering cold sea-water into the deep cavity; the other will be its upcomer, in which superheated, mineral-saturated water will surge upwards towards the sea floor.

An Arblasm, of course, would be a wonderful tool for exploring deep sub-oceanic geology. But Daedalus reckons it could make a profit, too. He argues that the heaviest minerals, like the ores of uranium and tungsten, and the dense precious metals like platinum, gold, mercury and so on, must have sunk over geological time to the deepest layers of the Earth's crust. A properly sited Arblasm could mine them.

For this purpose, the Arblasm's exit-pipe would feed a neutrally buoyant pipe leading up to the drilling-rig mother-ship at the surface: a sort of 'chimney' for the water to rise in. In the process it would cool sufficiently to precipitate its content of precious metal as a fine suspension.

To separate the precipitated minerals, the chimney should widen towards the top, so that as the water rises, it steadily loses velocity. Each mineral will accumulate at that point in the chimney where its settling-rate matches the upward velocity. Light minerals, like copper and iron sulphides, will rise fairly high in the chimney. Denser ones like uranium pitchblende and wolf-ramite will accumulate further down, while gold and platinum will be found near the bottom. Offtake-pipes at specific elevations in the big chimney will be able to extract these minerals in almost pure form.

David Jones