Enviromental pollution

Reproductive success of eagles and organochlorine insecticides

from Robert M. May

A VARIETY of studies have suggested that the insecticide DDT and associated compounds into which it is metabolized are responsible for diminished reproductive success in many species of birds. These problems tend to be most pronounced for birds of prey, which sit at the top of food chains in which the toxins are concentrated from link to link. The metabolite dichlorodiphenyl-dichloroethylene (DDE) probably poses the greatest physiological threat to birds of prey, being the most persistent contaminate both in the environment and in the bodies of birds. Indeed, so stable in the environment is DDE that Beyer and Gish (*J. appl. Ecol.* **17**, 295; 1980) could not detect any significant rate of decay over an 11-year study.

In the US, the Environmental Protection Agency banned further use of DDT at the end of 1972. There have subsequently been reports of increased reproductive success (and decreased DDE contamination) in several species of birds of prey, notably in the ospreys in Connecticut and on Long Island (P. Spitzer *et al. Science* **202**, 333; 1978).

It is perhaps fitting that the most detailed study yet published is for the bald eagle, *Haliaeetus leucocephalus,* the national bird whose symbolic representation is so ubiquitous in the US, while the species itself is on the endangered list. The study by Grier (*Science* **218**, 1232; 1982) is actually for a population in northwestern Ontario; the birds nest in a part of Canada that has suffered little exposure to DDT, but they spend the winter in the US where they consume prey contaminated with DDT.

Grier presents data, reaching back to 1966, on the average number of young produced annually in each 'breeding area'. The breeding areas are akin to nesting territories: an area 'may contain several alternative nests, but only one nest is used for raising young during any year'. The production of young is defined as the number raised to the late nestling stage, which is the last stage at which they can reliably be counted. Grier shows that reproduction declined steadily throughout the late 1960s and the early 1970s, from 1.26 young per breeding area in 1966 to a low of 0.46 in 1974. The subsequent history is one of steady increase, to 1.12 in 1981. The patterns can be confirmed by several kinds of statistical analysis. For example, if the 16 years of the study are divided into two segments, corresponding to years before the ban and to years after, both segments can be well fit by a linear regression line (with slopes of -0.07 and +0.07 young per breeding area per year respectively); the difference between these slopes is highly significant.

Associated with this increasing reproductive success following the banning of DDT is a marked decline in the mean concentration of DDE residues found in addled eggs. Specifically, the DDE concentration in eggs averaged around 100 parts per million (by weight) before 1972 and dropped very significantly to an average of around 30 p.p.m. after 1975.

As Grier emphasizes, these results raise new questions every bit as interesting as the questions they answer. Even if DDE is diffusing comparatively rapidly out of the bald eagles' food web — by settling into sediments, for instance — we would expect the toxin to be flushed slowly from the bodies of the birds themselves, as it is 'thought to be eliminated from female birds only through fat deposited in eggs'. In black ducks, *Anas rubripes,* the shell thinning and general reproductive impairment caused by DDE has been shown to persist long after the birds resume an uncontaminated diet (J. Longcore & R. Stendell *Arch. environ. Contam. Toxicol.* **6**, 293; 1977). The simplest way to reconcile such persistent contamination of individuals with the pattern of population recovery seen above is to assume that young uncontaminated female eagles are replacing older contaminated breeding females significantly more rapidly than is thought to be the case for such populations. Of course, it could be that the conventional wisdom is at fault, and turnover always has been relatively rapid. But it could equally be that such faster turnover in the breeding population is associated with decreasing survival rates among adults.

In short, a full understanding of the dynamical behaviour of a population requires knowledge about both birth rates and survivorship. Grier has shed important light on fertility patterns among his bald eagles, but we also need information about age-specific survival rates. It could be that these bald eagle populations have troubles beyond those associated with DDT. □

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Earth science

The origin of ribbon radiolarites

from Peter J. Smith

RIBBON radiolarites are rocks that derive their name from their characteristically repetitive bedding — they comprise layers of radiolarian chert (grossly recrystallized radiolaria in a microcrystalline quartz matrix) centimetres to tens of centimetres thick, usually alternating with layers of argillite (clay) generally no more than a few millimetres thick. Complete sequences are typically tens to hundreds of metres thick. Very occasionally the clay layers are comparable in thickness with the chert layers; but more often the argillite is not there at all, only a parting separating one quartzose layer from the next. Where the chert–argillite couplet is present, however, the two elements sometimes form a single graded unit and sometimes appear to be independent.

The origin of the chert–argillite pairing is a puzzle, but it is not the only one associated with ribbon radiolarites. For example, no rock remotely resembling ribbon radiolarite has ever been found in cores taken from present-day ocean basins. No thick, stratigraphically continuous chert sequences have been recorded there at all, and there is no sign of chert–argillite couplets. (Cherts do, of course, exist in the ocean basins but they are lenticular, not ribboned.)

As for the time dimension, ribbon radiolarites are characteristic of the Mesozoic and parts of the Palaeozoic, radiolaria having reached their peak in the Jurassic. The siliceous record of the Cenozoic, by contrast, is dominated not by radiolarian cherts but by diatomites, diatoms having originated during the Jurassic but having been particularly well developed during the Tertiary (Miocene).

The other conspicuous characteristic of ribbon radiolarites is that they are apparently restricted to orogenic belts, most commonly occurring as parts of thrust sheets, as olistoliths (exotic blocks), or in *mélanges.* They exist, for example, throughout the Alpine–Mediterranean (Tethyan) region, although on a small scale they are highly diachronous — they formed in different localities over slightly different periods. Nor do they all share quite the same associations. In the western Tethys they often lie on Jurassic pelagic limestones which pass downwards through other sedimentary rocks to continental basement; the complete sequences can be regarded as foundered Atlantic-type continental margins. In some Tethyan areas, on the other hand, ribbon radiolarities lie above ophiolite sequences, as they also do in Cyprus and the Oman; the sequences there lie above material of oceanic origin. In parts of California they also lie above