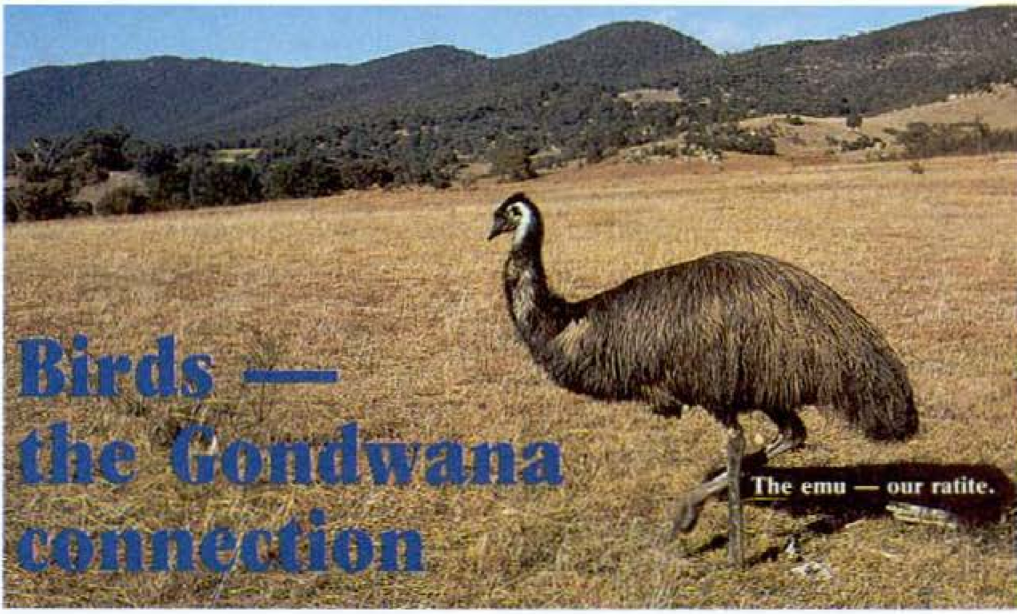
Birds — the Gondwana connection



The emu — our ratite.

Robins, wrens, flycatchers, warblers, and babblers — early European settlers gave some of our birds these names because they provided a reminder of similar birds back home.

Birds of all these groups resemble those of the same name found in Europe or Asia. Of course, ours and theirs are different species, but because of similarities between the two groups, not only in obvious characteristics such as plumage but also in anatomy, biologists thought that they were closely related.

Taxonomy — fundamental to most areas of biology — until recently relied almost exclusively on painstaking measurements and comparisons of various features, especially the skeleton in the case of vertebrates, to establish how organisms were related to one another and to classify them into groups reflecting both this and their evolutionary history. Behavioural characteristics are also sometimes considered.

But now taxonomy — one of the oldest branches of biology — has another tool to help it unravel the derivations of organisms, and that tool comes from the most recent advance in biology, the molecular study of DNA and proteins. This has revealed that much of the conventional wisdom about the interrelations between many groups of birds is completely wrong.

Dr Dick Schodde, an ornithologist, and Dr Les Christidis, a geneticist, both with CSIRO's Division of Wildlife and Rangelands Research, are two scientists who have

It's easy to see how early ornithologists were fooled. Top left: the Eurasian leaf-warbler and the Australian fairy gerygone-warbler. Top right: the Australian white-browed babbler and the Asian scimitar-babbler. Bottom left: the black sunbird of Indonesia and Malaysia and the Australian red-collared honeyeater. Bottom right: the Australian varied sittella and the European nuthatch.

been using these techniques and applying them to Australian birds. Dr Christidis has probed the enzymes (the protein products of genes) and the chromosomes (where the genetic material is kept) of a variety of different bird species — native Australian and Eurasian. Differences in chemical structure between enzymes represent differences in the DNA that codes for them.

As DNA is so important, it is highly protected and conserved within organisms. But changes do occur slowly over time as a result of 'benign' mutations — that is, the very small minority of mutations whose effects are either beneficial or merely harmless to the organism carrying them. The greater the DNA difference between the two organisms, the greater is the 'genetic distance' between them, and the less closely related they are.

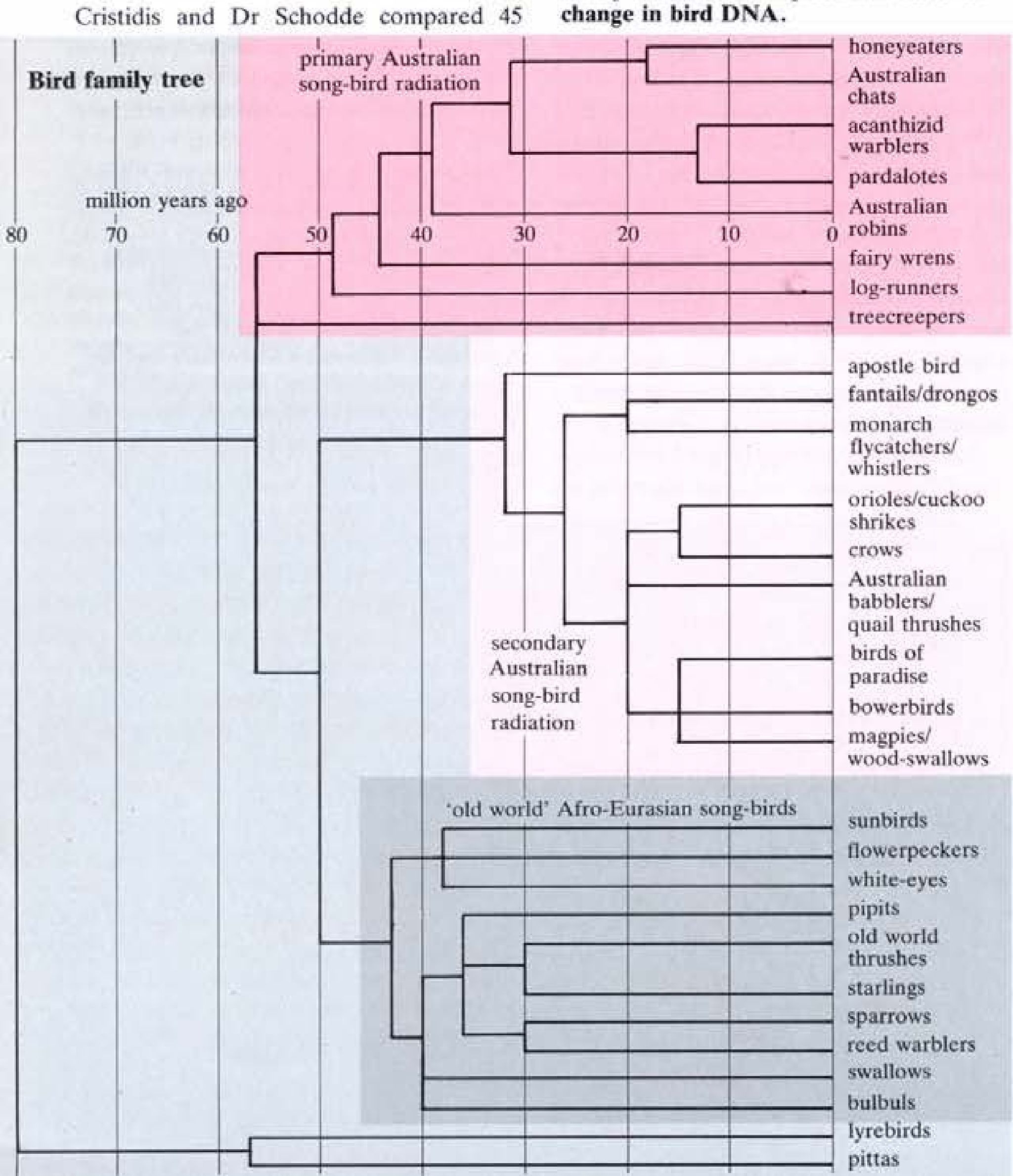
For example, a person and a plant have very little of their DNA sequences in common, but you and I and chimpanzees share a great deal.

Analysis of genetic distance can rely on direct comparisons between DNAs, but is simpler and quicker if enzymes are compared by a technique called electrophoresis. With this technique, and using fresh tissues from birds collected in the field, Dr Cristidis and Dr Schodde compared 45 different enzymes from each of more than 100 bird species. This allowed them to draw up a table to compare any one of the species examined with any other, and determine, with the aid of computers, how closely related the two may be. (They have probed the enzymes of at least one species from every family of Australian and Papuan birds, as well as concentrating in detail on fairy wrens, scrub wrens, and finches.)

To broaden their work, the two scientists are collaborating with Dr Peter Baverstock, of the Evolutionary Biology Unit of the South Australian Museum, who is using immunological techniques to test relationships among bird families.

All the old evidence of anatomy and external appearance suggested that many of our birds are related to Eurasia's. So it seemed logical to assume they had come from Asia, or at least that our present birds — and these were acknowledged to have slight differences — had derived from others originating in Asia. Scientists knew that sea levels had fluctuated in the past, and a low sea level would have connected Australia to Asia by a so-called land bridge, represented now by the islands of Indonesia.

The evolutionary radiation of Australia's families of song-birds, based on the electrophoresis of proteins computed by Dr Christidis and Dr Schodde, applied to a time scale calculated by Professor C.G. Sibley and Dr J. Ahlquist from rates of change in bird DNA.



A temporary land bridge would permit migration of birds to Australia and neatly explained how Australian birds could derive from elsewhere and then become isolated to evolve some of their differences. Birds found in Asia but not here had perhaps arisen in parallel after the flooding of the land bridge. (All of this, of course, would take place over many millions of years.) The theory held that Australia had in fact been colonised from the north — which fitted in perfectly with many early Europeans' conceptions of the continent as an empty southern region that depended on the Northern Hemisphere for everything.

But now the new techniques of molecular biology have revitalised an essentially dormant field. Dr Schodde and Dr Christidis have shown that our birds are not at all closely related to their similarly named and similar-looking counterparts in Eurasia. Genetically, they are far apart. Why then did creatures as different, apparently, as chalk and cheese fool the taxonomists for so long?

The occurrence of superficial similarities between widely differing species is quite common and is not confined to birds. The phenomenon is called convergent evolution: if two organisms are living in similar habitats, with the same factors determining their body build, and eating similar diets, they will come to resemble each other in one or more features.

Dolphins provide a case in point. Although mammals and more closely related to cows than to sharks, dolphins were considered as fish by the ancients because of their superficial similarities such as fins — characteristics imposed upon them by the need to move around in water.

Similarities in anatomy are forced on most birds by the constraints of flight, which dictate a light and relatively aerodynamic skeleton, as well as wings. But apart from the exigencies of flight making many birds adopt a similar form, convergent evolution in many other features has also occurred.

For example, our sittella has the same size as the European nuthatch, together with similar markings and an almost identical bill. In large part this is explained by the fact that they both spend their time on the bark of trees looking for insects wedged therein, and a little camouflage and a curved bill are nifty attributes in such circumstances. But according to the genetic

From left: a male splendid fairy wren, a little wattlebird, and a male flame robin — photographed by Graeme Chapman.

fingerprint revealed by their enzymes, the sittella and the nuthatch are nowhere near as closely related as their great similarities suggested to earlier ornithologists.

Australia drifts

Knowledge of continental drift had already put a nail into the coffin of the colonisation theory of the origin of our birds, before molecular genetics lent a hand. The problem was that at the time when Australia should have been receiving some of the ancestral stocks of its parrots, lyrebirds, and honeyeaters from Asia — 20–40 million years ago — it was closer to Antarctica than to Asia. And earlier still, South America, Africa, India, Australia, New Zealand, and Antarctica were all joined in a southern supercontinent called Gondwanaland.

This is an important fact when you consider the distribution of the giant flightless birds — ratites to zoologists — such as our emu, the southern African ostrich, the New Zealand moa (recently extinct), and the South American rhea. Also, Australasia and South America, both of which separated from Antarctica later than Africa, each possess large numbers of parrot species and birds resembling our tawny frogmouth. (Incidentally, if you think it silly to consider that parrots and emus could have survived among Antarctica's frozen glaciers, you are right. We now know that Antarctica at that time was heavily forested.)

It seems that many of 'our' birds may really be derived from those of the supercontinent of Gondwanaland, and are more closely related to South American and African birds than to those of our present closest neighbour, Eurasia.

Using a computer to analyse the genetic distances derived from enzyme electrophoresis, it is possible to build an evolutionary tree or branching scheme showing the times of separation of various groups. First, however, we have to calibrate an evolutionary clock — that is, to assign a value in millions of years for a certain amount of genetic change caused by mutations, and revealed by the enzyme differences.

We can do this by considering geological events of fairly well-known age; for example if we know the average genetic distance between comparable groups of land-birds in Australia and Africa, and the time when these two continents began to drift apart, we can say that that amount of genetic difference between the two groups required so many millions of years in which to arise. Of course, we must take into account various factors — such as the possibility of an earlier separation of two populations by effective geographical or climatic barriers before the two land masses physically separated, or later dispersal of birds by flight. But if we assume a relatively constant mutation rate, the technique gives figures in agreement with those derived from other means.

All the results tell us that our flycatchers, treecreepers, and robins began to diverge from their fellows about 30–50 million years ago, when Australia was close to Antarctica. They are quite different from the flycatchers and robins of the Northern Hemisphere, which, together with the northern wrens and warblers, form a distinct group.

In the future, Dr Schodde and Dr Christidis would like to perform genetic analyses on the proteins of South American birds, which they have not been able to look at so far. Scientists have always believed that Australian and South American song-birds are not closely related. Perhaps this will soon be tested.

These studies are revealing the hitherto unsuspected fact that our land-bird fauna are as unique to Australia as our well-known marsupials. It follows that we have an international responsibility both to understand and to conserve our Aussie birds.

Roger Beckmann

More about the topic

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