True colours

It's only when you begin to see the world as birds do — detecting light in the ultraviolet spectrum — that the full subtlety of their behaviour is revealed. Rex Dalton catches a glimpse.

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Feed me: Philipp Heeb (below) has shown that starling chicks reflect UV light as a signal to parents.

With bug in beak, a parent starling squeezes into a dark hole in a tree eager to feed her gaping chicks. Turnaround time in the nest is crucial for the adult birds. They must bring as many squirming morsels as they can if their young are to fledge successfully. And in the struggle for survival, it pays to ensure that the fittest are fed first.

Swiss ecologists have now discovered how these birds distinguish their nestlings. The skin and the inside of the gaping beak of starling chicks (*Sturnus vulgaris*) reflect ultraviolet (UV) light, which the parents can see even in the dark nest. The researchers have even shown that nestlings with stronger immune systems reflect more UV — which would promote the survival of the fittest. "The nestling that stands out will be fed first," says Philipp Heeb, a behavioural ecologist at the University of Lausanne, who led the team.

Most birds' eyes are thought to be sensitive to radiation with wavelengths between 320 and 400 nanometres, in the near-UV spectrum, to which we are blind[1]. That's because birds have an extra class of photoreceptor cone cell in their retinas, in addition to the three — sensitive to red, green and blue light, respectively — that we possess.

Although this sensitivity was first discovered in the early 1970s (ref. 2), behavioural ecologists have only started to investigate the consequences of birds' UV vision in the past decade. And they are revealing just how much was missed by earlier studies. "Avian vision is much more complex than we ever realized," says Rick Prum, an evolutionary ornithologist at Yale University in New Haven, Connecticut.

Birds use their UV vision for many things. Kestrels (*Falco tinnunculus*) use the tell-tale UV reflection of vole urine, left as scent marks in the environment, to home in on their prey[3]. Blue tits (*Parus caeruleus*) similarly seem to use their UV vision while foraging, to help detect camouflaged caterpillars[4].

A sensitivity to UV may also have a role in egg recognition: the UV reflectance of the eggs of the African red-chested cuckoo (*Cuculus solitarius*) and those of the birds whose nests they parasitize turn out to be very closely matched[5]. So eggs that don't look especially similar to humans may look sufficiently alike to a bird's eye to fool the cuckoo's victims.

But most of the behavioural work on bird UV vision has focused on the animals' own coloration, and its role in communication between members of the same species. Naturalists have long been fascinated by birds' bright colours, which are involved in camouflage, distinguishing genders and mate selection. But without UV vision, human birdwatchers have been missing an important part of the show. "Birds look great to us, but they look a lot better to themselves," says Prum. "It's humbling."

Rhapsody in blue

In 1996, visual ecologists Andrew Bennett and Innes Cuthill of the University of Bristol, UK, and their colleagues showed for the first time that a bird uses UV vision in choosing a mate[6]. Studying zebra finches (*Taeniopygia guttata*), the researchers put females in an arena in which they could hop towards various males. By deploying filters for different wavelengths among the birds — and in some experiments ornamenting some of the males with UV-reflecting leg-bands — the Bristol team showed that the females use UV reflectance to judge the relative attractiveness of different males.

Male and female zebra finches at least look different to the human eye. But in some other species, UV coloration is all that appears to separate the genders. Male and female blue tits look identical to us — but things look very different to them. In

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Life in the ultraviolet: the zebra finch (above) gave the first clue to how birds use their UV vision in mate choice; female blue tits prefer males (left) with crests that look brightest in the UV spectrum.

separate studies, researchers led by Sarah Hunt, a member of Bennett and Cuthill's Bristol team, and Staffan Andersson of Gothenburg University in Sweden, have found that male blue tits differ from females in the UV reflectance of the blue feathers on the crest of their heads[7,8].

Indeed, the males' crests are brighter in the UV spectrum than they are at visible wavelengths. And Hunt and her colleagues went on to show in laboratory experiments that females prefer males with the brightest UV crests. Male blue tits, the Bristol researchers suggested in their paper, are actually "ultraviolet tits".

"A signal that appears red and yellow to us looks a different colour — one beyond our experience — to its intended recipients."

Such experiments depend on measuring the reflectance of the bird's plumage at various wavelengths using a hand-held spectrophotometer. Once spectrophotometers were bulky and expensive, and could only be used in the lab, but the latest equipment is the size of a cigarette pack and connects to any laptop computer. "It used to take all day to get one reflectance reading, but now it takes only a few minutes," says Bennett.

Skin deep

A bird's UV coloration goes deeper than its plumage. Behavioural scientists have long realized that chicks' gaping red and yellow mouths serve as signals that induce their parents to provide food. But a signal that appears red and yellow to us looks a different colour — one beyond our experience — to its intended recipients.

Last year, Hunt and her colleagues measured the UV reflectance of the gapes of chicks from eight different bird species, including the blue tit, house sparrow (*Passer domesticus*), barn swallow (*Hirundo rustica*), blackbird (*Turdus merula*) and reed warbler (*Acrocephalus scirpaceus*)[9]. In all cases, the nestlings' gapes were highly reflective in the UV spectrum. "I was surprised," says Bennett, "especially as it was consistent across all the species examined." What's more, chicks from species that nest in dark crevices showed especially bright UV reflectance from their 'flanges', the rim around the edge of the mouth.

Heeb's unpublished work, presented last October at the 2nd European Conference on Avian Colour Vision and Coloration at the Museum of Natural History in Paris, has shown for the first time that chicks use their body skin, as well as their gapes, to signal to their parents in the UV spectrum. Heeb's team first demonstrated that the reddish-brown skin of starling chicks reflected large amounts of UV light, and then went on to apply a UV-blocking jelly to some nestlings, and a control gel that didn't filter UV to others. The parents subsequently gave more food to the control chicks.

If chicks' UV skin reflectance is what evolutionary biologists call an 'honest' signal, then nestlings better equipped in the darwinian struggle for survival ought to reflect more UV light. To investigate, Heeb and his colleagues injected chicks with phytohaemagglutinin, a protein that provokes an immune reaction. By measuring the swelling around the site of the injection, the researchers showed that nestlings that reflected the most UV light had the strongest immune systems.

The chicks' UV reflectance may be due to the arrangement of fibres of the protein collagen in their skin. Prum and his colleagues have shown that this is the case for the blue facial skin patches worn by male asities, birds from Madagascar, during the breeding season[10]. In the next phase of their research, the teams at Bristol and at Yale intend to look further into how the structure of feathers and skin in various birds produces the UV reflections.

As researchers try to assemble the picture of how birds use their hues for survival and reproduction, some wonder whether we also need to rethink studies of other groups of animals. Mammals, for instance, do not see in the UV, but photoreceptor cells have evolved differently in various species to respond to different wavelengths of light. Even our close primate relatives may see the world in a very different light to us.

The lesson from the past decade of studies on bird behaviour is: if you want to get inside an animal's mind, it helps to see the world through its eyes. ■

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