Evolution of Species:

Ladies' Choice In a Different Light

by Mike Faden

A striking little black-and-white bird stoops and puffs out his bulky “beard” of feathers, then begins leaping speedily between nearby saplings, emitting odd grunts and loud snaps. All around, rivals follow suit, and soon the area is a blur of little checkered flying objects zipping back and forth and filling the air with buzzes and pops.

This hectic display, by male birds called bearded manakins in a Costa Rican forest, is a high-stakes beauty contest. The judges are drab, olive-brown females quietly assessing the males’ appearance and antics from the foliage above. The few males they deem most attractive may get to do most of the mating.

Dr. J. Albert C. Uy, assistant professor in San Francisco State University’s Biology department, has spent time analyzing these displays too, and he thinks they provide a clue to a bigger puzzle: why females change their minds about what they find attractive, and how that leads to the formation of new species.

Female preferences play a strong role in shaping manakin evolution, because females select which handful of males get the chance to pass on genes to future generations. But a female can only choose a male if she notices him first, and that puts pressure on the males to be conspicuous.

Different colors stand out in different visual environments, such as the varying light conditions in different forest habitats, and Uy thinks that males may evolve distinctively colored feathers that are particularly showy in the habitat where they display. His idea is that as females choose conspicuous males, the differences in male plumage between manakins in different habitats become more established over time, and eventually birds in different environments diverge into separate species.

Uy suspects that this kind of interplay between the visual environment and choosing a mate plays a role in the formation of other species too. To find out, he and his students are running related projects on other birds, and Uy plans to see if similar effects operate in guppies and arrow-head spiders. If it turns out that a similar process is operating in such unrelated organisms, it could be generating new species across the entire animal kingdom, and be responsible for a sizable part of the Earth’s extraordinary biodiversity.

Uy’s work is a new twist on an idea that goes back all the way to Darwin’s magnum opus, *The Origin Of Species*. Darwin’s main theory was natural selection, the idea that new species arise by the evolution of useful characteristics that aid survival. Famous

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examples are Galapagos island birds now called, appropriately, Darwin's finches. These birds are thought to have arisen from a single species which evolved into several species with differently-shaped beaks, each specialized to tackle a type of food found on the islands.

But Darwin also noted that the natural world is full of animals sport ing bright plumage or other showy traits, which seem about as useful for survival as painting a target on your chest. Imagine you're a peacock, for instance, trying to flee a predator while dragging a huge train of dazzling tail feathers. These characteristics are known as mating signals, because they're used by animals to identify and assess mates.

Darwin's explanation was a mechanism called sexual selection–which suggests that showy characteristics can be worth the increased risk of mortality when they enhance the ability to pass on one's genes to more offspring. "It's a fine balance of living long enough to mate–but also being attractive enough to mate with a lot of females," Uy says.

Often the most pronounced examples of sexual selection are in species where there are marked differences between the way males and females look and act. In these species, females choose a mate very carefully, because of their huge maternal investment in the outcome. Often these females raise offspring single-handed, taking on all the chores from nest building to feeding young. In contrast, males are promiscuous because the more females they mate with, the more offspring will carry their genes. They don't raise a finger, or a feather, to help raise the kids, so they're free to expend their energy on flashy displays. "Instead of investing in parental care, they invest in gaudiness," Uy says.

There's still a huge debate over exactly how such exaggerated systems of sexual selection become established, Uy adds. In some cases, attractive mating signals have been shown to be linked to less superficial qualities, such as resistance to parasites. But some biologists think that preferences can also perpetuate themselves simply because females that mate with attractive males tend to have sexy sons, which in turn attract more females. If selection worked the same way in humans, and women chose their mates only by watching male revues in nightclubs, all men might evolve to look like Chippendale's dancers.

Just as controversial–and key to understanding the role of sexual selection in the production of new species–is the question of why mating signals change. If signals change in one population of animals, its members may not be recognized by other populations as potential mates, and eventually may not breed with other populations even if they come into contact. Once animals can no longer breed together and produce viable offspring, biologists consider them separate species.

Historically, Uy says, scientists thought changes in mating signals happened as a by-product of natural selection. As organisms adapted to survive in different environments, their appearance changed and their signals changed too. But recently, biologists have come to think that this process can happen in reverse order –changes in sexual signals can occur first, and so sexual selection may be important in triggering the formation of many new species.

Uy first found evidence that this might be occurring when, as a student working with bowerbird expert Dr. Gerald Borgia at the University of Maryland, he traveled to New Guinea during the late 1990s to observe the extraordinary mating signals of Vogelkop bowerbirds.

In bowerbirds, mating signals are based mainly on behavior, rather than plumage. Vogelkop males make elaborate, brightly decorated bowers, which are used purely to seduce females. A male, weighing only about four ounces, builds a hut-shaped bower up to six feet high of carefully woven sticks. Outside, he lays a welcome mat of green moss decorated with thousands of orange rhododendron

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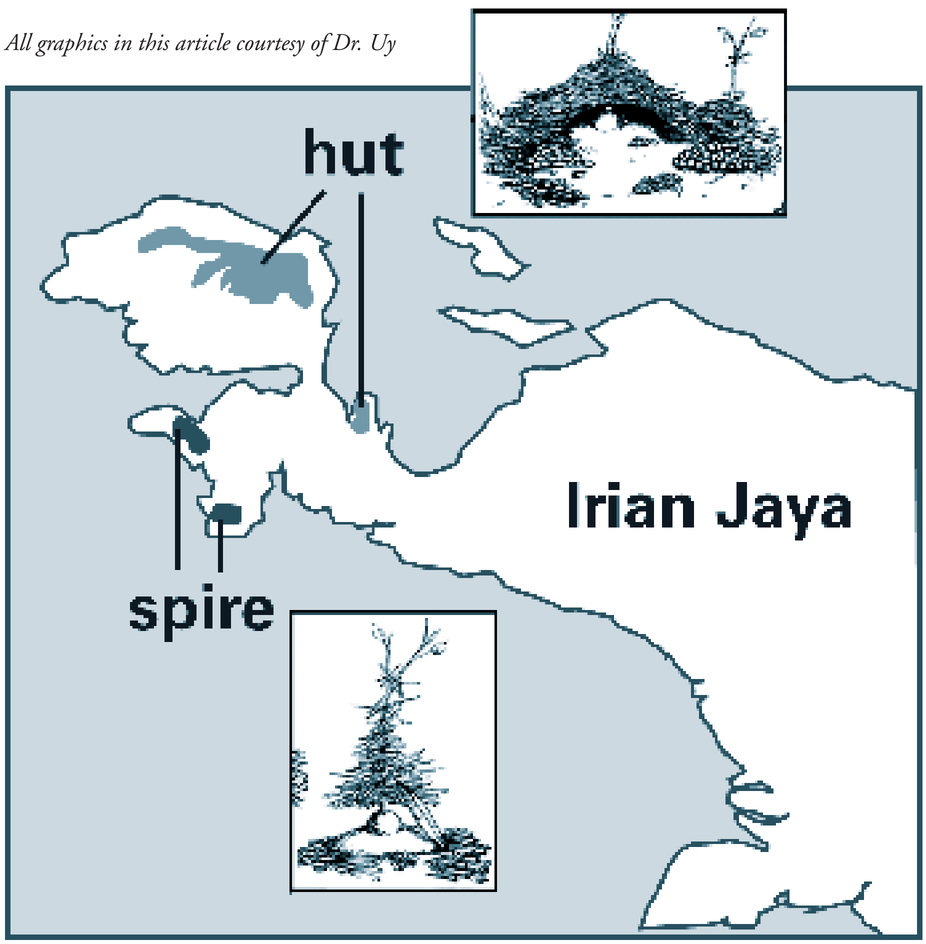
Above: A male white-bearded manakin Manacus manacus *from Ecuador. Isolated populations or subspecies of this bird have diverged in the color of their beards and collars. Some populations have white collars and beards while others have orange or golden collars and beards.*

Below: The distribution of Vogelkop bowerbirds Amblyornis inornatus *in Irian Jaya, the western half of the island of New Guinea. In the northern region, males build hut-like bowers that are decorated with colorful objects. In contrast, males from the southern region build spire bowers that are decorated with dark or drab objects. These populations likely represent new and distinct species.*

All graphics in this article courtesy of Dr. Uy



Drawing on page 44, manakin photograph and map courtesy of Dr. Uy

flowers, blue fruits and beetle carapaces, or feathers from other birds.

Why so much effort? Like bearded manakins, male bowerbirds mate with as many females as they can during a season. But not all males are equally successful. In some bowerbird species, successful males may mate with up to 20 females in a season, while most competitors don't mate at all. By placing video cameras at bowers, Uy found that bower-building skills paid off in a big way– males with the biggest bowers and the most bright blue ornaments did most of the mating.

That finding made the characteristics of one isolated population of Vogelkop bowerbirds even more intriguing. Males in this population designed bowers to completely different standards. Instead of making big hut-shaped bowers, they constructed smaller, slender spires, and in place of bright, attractive decorations they used somber black stones and brown bark. Yet it seemed that they were doing this deliberately, not because they couldn't find any bright ornaments. When Uy offered the two kinds of Vogelkop tiles of different colors, the results confirmed previous ideas about the birds' preferences. The hut-builders chose bright blue and red tiles for their bowers and rejected drab ones, while spire-builders ignored even the bright blue tiles.

Aside from their mating signals, birds in the two populations appeared almost identical, and their DNA indicated that they were very closely related. That suggested that the differences between the populations were not a result of natural selection. Instead, it seemed that spire-building population was on the verge of splitting into a separate species, driven by changes in mating signals.

That evidence dovetailed with the growing belief among scientists that sexual selection could be important in species formation–and it also suggested a new research direction. "We need to ask why the signals are changing in the first place," Uy says.

Uy's bowerbird work was interrupted by the worsening political situation

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in New Guinea. But instead, he has found what he thinks may be the ideal system for exploring his new questions, one that is conveniently is located much closer to home: the bearded manakins of Central and South America.

One reason Uy likes manakins is that the lively, noisy sexual displays of the vividly colored little birds are easy to study. Males always congregate to display in the same area, a kind of open-air sex market where females come to select a mate. Within this area each male chooses a small display area, called a court, with a few saplings at the perimeter. He clears the court of debris, defends it against other males, and performs elaborate displays by extending his beard, making a variety of odd sounds and hopping energetically between saplings. A female will watch, and if she's interested enough, she'll follow the male in an acrobatic sapling-to-sapling courtship dance before their brief mating. "Manakins are a great system – they have one court, so you know where they are going to be every day as opposed to having to chase them all over the forest," Uy says.

Uy is particularly interested in four kinds of bearded manakin, which are very similar in most respects and live in neighboring regions of Central and SouthAmerica. The big difference is in the color of the male birds, particularly the plumage that the bird flourishes during sexual display.

Uy suspects these plumage differences are diverging sexual signals, hints that new species are being formed through sexual selection. Changes in these signals could be linked to the light conditions in the habitats that the manakins display in, because different colors are most conspicuous in different types of light.

Orange objects, Uy explains, are orange because they reflect only that portion of the light spectrum. They're most conspicuous in orange light, because they reflect more of the light than surrounding objects do. That logic also applies to male birds vying to be the most visible to females. "You're a slave to light conditions," Uy says. "The conspicuousness of your signal would be directly related to the kind of light that's hitting you."

Forests create a variety of different visual environments. Light on a cloudy day tends to be white. Sunlight that peeks though small holes in the canopy creates flecks of orange-red light on the forest floor. Shade, filtered by leaves, is comparatively rich in green light. If birds live or display in different light conditions, "signals should be changing in response to the visual environment," Uy reasons, "and these changes could then lead to the evolution of new species."

Measuring changes in the colors of light and plumage, however, is not as easy as it sounds. Humans can't be sure simply by looking at male birds whether a female bird would notice the same color differences, let alone whether she would find the changes attractive. That's partly because birds can see parts of the spectrum that we cannot, such as ultraviolet light. To get around this, Uy's graduate students are using portable spectrophotometers that can accurately measure the full spectrum of light even in remote forest study sites.

Gaining a deep understanding of a biological system takes many years. One idea, Uy says, was that differences between birds were associated with the differences in light at different times of the day – but it turned out that the birds all displayed during the middle of the day.

However, it did seem that birds displayed in light conditions that made their plumage most conspicuous. Golden-bearded manakins display most in the golden light of sun flecks, while white-bearded birds display mostly in cloudy conditions.

The spectrophotomers also showed that by clearing a court of debris, manakins create a plain background that makes their high contrast plumage and their displays more conspicuous.

Next, Uy and his team plan to move from simply observing manakins to tinkering with the mating system, to find out if color really is important in influencing how female manakins choose mates. That's why one of Uy's students, Adam Stein, is deep in the forest dying the beards and bellies of white-bearded manakins to a color that's very close to the natural color of golden-bearded ones. Then he'll replace the dyed birds in the white-bearded population and see what the females do. "If color is important, females will start ignoring the golden ones and stick with the white males," Uy says. "Presumably a female will choose a male she likes – and that she would consider the same species."

Scientists also can get a broader perspective about the importance of a process by working on several different species. Uy is planning a project using guppies, which like many birds have colorful displays – and are easier to work with, since they can be raised in the lab. The idea is to manipulate their surroundings and see if that alters the course of evolution. "We plan to raise guppies in different light environments to see if we can drive changes in male coloration," Uy says. Guppies mature quickly, so that over a five-year experiment, sexual selection might operate on 15 generations. "The question is do we come up with new species, in the sense that the males become so different that females would not recognize males in another tank as being of the same species?"

Another planned project centers on arrow-head spiders – an idea of Uy's that came from hiking in Virginia and walking into the webs of spiders that turned out to be yellow and white forms of what are generally regarded as the same species. In this case, Uy wants to test whether color is important for evading predators, as well as in sexual selection.

Combined, Uy says, these projects will help understand how changes in the visual environment can influence sexual selection and the formation of new species. "We have fish, spiders and birds, which are completely unrelated. If the same kinds of processes are going on, it lends support to the idea that this phenomenon may be more general than previously thought. ✣