forever reaching out from the grave and snatching our neatest results?" Gosper asked. Gosper recently devised a new computer algorithm to calculate the number pi to 17.5 million digits. But over and over again, he found that his best ideas were already discovered by Ramanujan. "If Ramanujan were still alive, what I would do is show him my computer and hope to seduce and distract him," Gosper said.

This rediscovery of Ramanujan's work is particularly unexpected because, in his day, Ramanujan was thought to be a genius whose work had been misdirected because of his lack of a formal education in mathematics. "Hardy said that Ramanujan's work would have been greater if it weren't so strange," says Andrews. "We're coming to appreciate it more." For example, R. J. Baxter of the Australian National University found that some of Ramanujan's work was exactly what he needed to solve the hard hexagon model in statistical mechanics. Carlos Moreno of the City University of New York says that Ramanujan's work in the area of number theory known as modular forms is exactly what physicists need when they work on the 26-dimensional mathematical models of string theory.

Some researchers, however, say that they never had to rediscover Ramanujan because he has been a stimulus to them for years. For example, Freeman Dyson says, "many of the things I've been doing over the years, right up to the present, come out of Ramanujan's work." Dyson was introduced to Ramanujan early, when he was still in high school in England. He won a math prize and was awarded a copy of Ramanujan's collected works. "It was such beautiful stuff. I fell in love with it right away," Dyson says.

Since Ramanujan was so poorly educated, mathematicians throughout the years have wondered what he might have become if he had been brought up in different circumstances. There is no answer, of course, but it can at least be argued that, for Ramanujan, a formal education was almost beside the point. "It is nice to say that if Ramanujan had had more education, he would have done more," says Andrews. "But we can't run a controlled experiment on geniuses that occur uniquely in history. It is at least plausible to say that more education would have ruined Ramanujan."

Although Ramanujan was unique in mathematics, some researchers say they never give up hope that a new Ramanujan will appear. "Of course, we're always hoping," says Dyson. "That's one reason why I always read letters that come in from obscure places and are written in an illegible scrawl. I always hope that it might be from another Ramanujan." ■ GINA KOLATA

Mockingbird Song Aimed at Mates, Not Rivals

An opportunity to monitor closely the singing behavior of mockingbirds produced a result that was entirely unexpected

MOCKINGBIRDS can be pretty cheeky creatures. And noisy too. But to Randall Breitwisch and George Whitesides of the University of Miami, these two sometimes annoying habits of mockingbirds presented an opportunity. During the spring of 1985 the researchers were able to monitor closely the birds' singing behavior right on the university campus. And what they found was a big surprise. "The birds appeared to spend a great deal of their time directing their song into their territories rather than out of them," says Breitwisch. "And that is important, because it tells you something about the function of their song."

Bird song traditionally has been interpreted principally as a territorial warning from one male to another. "The idea of a 'keep-out signal' is very popular among biologists," says Breitwisch, "and very often it must operate that way. But not always." The discovery that male mockingbirds spend a lot of time singing into their territories rather than broadcasting out of them from the edges implies that in this case at least, it is probably not true. "This was an unexpected finding," acknowledges Gene Morton of the National Zoological Park in Washington. "The interesting question now is, how common is this?"

When Breitwisch, who is now at the University of Pennsylvania, first observed this pattern he looked into the literature and was surprised to find that no one else had even looked at the question of directionality of singing. Position of the singer within the territory, yes. But not direction of the singing. The problem most observers face in trying to get data on this is simply being able to be close enough to the birds to make reliable and repeated observations of the position of the beak during singing. The relatively habituated mockingbirds of the University of Miami campus offered that opportunity. "Finding out how general a phenomenon this is will therefore be difficult," says Breitwisch.

The northern mockingbird is, of course, famous for its extensive repertoire and its

Hal Harrison/Grant Heilman Photography

The northern mockingbird. *Its varied song is meant to impress its mate.*

mimickry, both of which properties make it more likely that the function of the song is male-female attraction. The starting point for the Miami project was simple: if the function of the song were indeed to attract a mate for the male rather than to ward off rival males, then a comparison of the singing behavior of mated and unmated males should be different and revealing.

It turns out that, although mated and unmated males both direct a lot of their song into rather than out of their territories, unmated males sing more than mated males. They are also more active, flying from perch to perch so as to deliver their song from more different positions. However, mated males chased intruders from their territory more often than unmated males. And, significantly, says Breitwisch, the males are usually silent when they are on these chase and expel missions. "If the function of song really were territorial," he says, "you might expect it to accompany these episodes."

As well as singing more than mated males, males who are still looking for a female also vary the direction of their song more. "If song were a form of male-male communication (that is, a keep-out signal)," note Breitwisch and Whitesides, "there would be no reason to expect unmated birds to display a greater variability in the direction of singing within bouts than mated birds." But if the song were a broadcast to potential mates in the vicinity, but who might not be visible to the singing male, then the bird might be expected to cast its vocal net as wide as possible. "This is what they appeared to do."

Although unmated males were apparently casting their voices around in an attempt to snare a mate, sometimes they appeared to focus quite intensely in one direction. "This observation suggests that events on adjacent or nearby territories may stimulate unmated males to sing in the direction of those territories," note Breitwisch and Whitesides. For instance, they might be attempting to exploit an opportunity to mate with a neighboring female.

That opportunity might be signaled by the singing behavior of the neighboring male, say the two researchers. "Unmated males could monitor the nesting stage for neighboring pairs and direct song at neighboring females at the most opportune time for luring these females away from their mates," suggest Breitwisch and Whitesides. ■ ROGER LEWIN

ADDITIONAL READING

R. Breitwisch and G. H. Whitesides, "Directionality of singing and non-singing behavior of mated and unmated northern mockingbirds," *Anim. Behav.* **35**, 331 (1987).

Hand of Man Seen in Birds

Because of "a peculiar set of circumstances," the environmental impact of the first human habitation of the Hawaiian islands has been revealed in stark detail. That impact, say a team of researchers from half a dozen institutions around the United States, was "catastrophic." At least two-thirds of the species of land birds on the islands became extinct following Polynesian settlement some time between 400 and 600 A.D., notes Storrs Olson, of the Smithsonian Institution, one of the investigators in the project. As a result, the number of bird species in the world at the present time—usually given as 9000—is substantially impoverished compared with relatively recent times.

This latest report by Olson and his colleagues emphasizes further the realization that many so-called pristine ecological communities—particularly island communities—are not pristine at all, but are merely the surviving remnants of previously much richer habitats. This is important both for basic ecological theory, in terms of trying to understand what elements are significant in the assembly of communities, and for gaining an insight into how drastically communities can be altered by human intrusion. That intrusion involves "some combination of human-related predation, habitat alteration, or introduced pathogens, predators, or herbivores," explains Olson.

Many habitats have changed dramatically in the past 10,000 years, at least part of which was the result of climatic shifts following the end of the last glaciation. But it is becoming clear that some of these changes occurred long after the continental ice sheets had disappeared and may have coincided with the first arrival of humans. The disappearance of many of the Americas' large mammals—such as the mastadon and the giant ground sloth—is a good example here. The application of high precision dating techniques has in recent years helped test the climate versus human impact hypotheses in this case, with the finger pointing more and more accusingly at humans. Olson's recent project in Maui also benefited from precision dating, specifically tandem particle accelerator-mass spectrometry (TAMS).

"The great advantage of TAMS dating is that you can date the bones themselves," says Olson, "and you need only a very small quantity of bone to do it." The alternative to direct dating of bone in a deposit, which is to do conventional carbon-14 dating on organic material that becomes buried alongside the bones, is often unreliable because of uncertainties of the association. The use of TAMS therefore represented a breakthrough, as its application to material from Maui was the first time it had been used on an island deposit. "The importance of this site, and potentially of many other island fossil sites, was greatly enhanced by the ability to date small bones," say the researchers.

The deposit that Olson and his colleagues sampled had accumulated in a lava tube, the orientation of which allowed for a very gentle accumulation of deposit, which provided a clear window into the past 10,000 years or so. So far, excavations have gone back almost 8000 years, and they reveal a clear picture. Two things are apparent. First, the number and abundance of introduced species explodes in recent times: these include lizards, rodents and some land snails. Second, the diversity of bird species that were native to the island in prehistoric times was as much as three times greater than it is now or in the recent past. For instance, the excavations produced at least 23 species of endemic land birds—including a flightless ibis, two or three geese, a flightless rail, an owl, a crow, a thrush, a honey eater, and 15 finches—most of which are now extinct. The count for endemic birds that lived on the islands within historic times to the present is ten, most of which do not occur in the fossil deposit.

The coincidence of appearance of introduced species and the extinction of endemic species is strong circumstantial evidence of the hand of man, says Olson. And he points out that, this "occupation signal" occurs in the virtual absence of archeological material. "Therefore," he and his colleagues suggest, "this kind of deposit may become increasingly important to the study of human prehistory in Oceania." ■ ROGER LEWIN

ADDITIONAL READING

H. F. James *et al.*, "Radiocarbon dates on bones of extinct birds from Hawaii," *Proc. Natl. Acad. Sci. U.S.A.* **84**, 2350 (1987).