+ $(x)^{1/2}$. "You want enough primes in that interval so that you can find one quickly," says Goldwasser.

A conjecture that number theorists say is probably true is that as numbers grow large, the biggest gap between two primes is bounded by the logarithm of the larger prime. If this conjecture could be proved, then Goldwasser and Kilian's method would always work. The probability of finding a number for which it fails would be zero. Yet, says Lenstra, the conjecture is "fairly strong and it has been around for years. Although it is a reasonable conjecture, I am not sure I will live to see it proved."

Goldwasser and Kilian's method is of particular interest to mathematicians for two theoretical reasons. One is that the method allows mathematicians to recognize, for the first time, members of an infinite set of primes by using a polynomial time algorithm. This set contains nearly all the primes.

The second interesting aspect of the method is that it uses elliptic curves in its proof. This sort of modern mathematics was first used in complexity theory—the search for the fastest possible computer algorithms—by Lenstra. Early this year, Lenstra devised a new way to factor numbers based on elliptic curves. Goldwasser, hearing of this result, was inspired to use elliptic curves for the related problem of testing for primes. "Elliptic curves turn out to be a very useful tool," she says. She and Kilian made use of a method recently developed by Rene Schoof of the Mathematical Sciences Research Institute in Berkeley to determine the order of a group of points on an elliptic curve. This allows them to quickly try different groups of points on a curve in their attempts to find a group whose order is of the form useful in a test for primes.

The computation of the order of a group of points on an elliptic curve, however, is what slows down the new method. "The main problem is making Schoof's algorithm practical," says Lenstra. Still, Odlyzko is optimistic. It is entirely possible that that part of the algorithm might be speeded up. "It will take a lot more work, but they may be able to make their algorithm practical," he remarks.

Odlyzko also speculates that the test might in fact be universally applicable. "There is some hope that you can prove the test will work on all primes," he says. But for now, the new method is of mathematical interest because it is a polynomial time method which is always correct and because, as Ronald Rivest of MIT puts it, "it applies the very modern method of elliptic curves to the very old problem of testing for primes." ■ **Gina Kolata**

Polynesians' Litter Gives Clues to Islands' History

The natural history of many of the Pacific Islands, once thought to be virtually pristine, turns out to have been significantly distorted by recent human activity

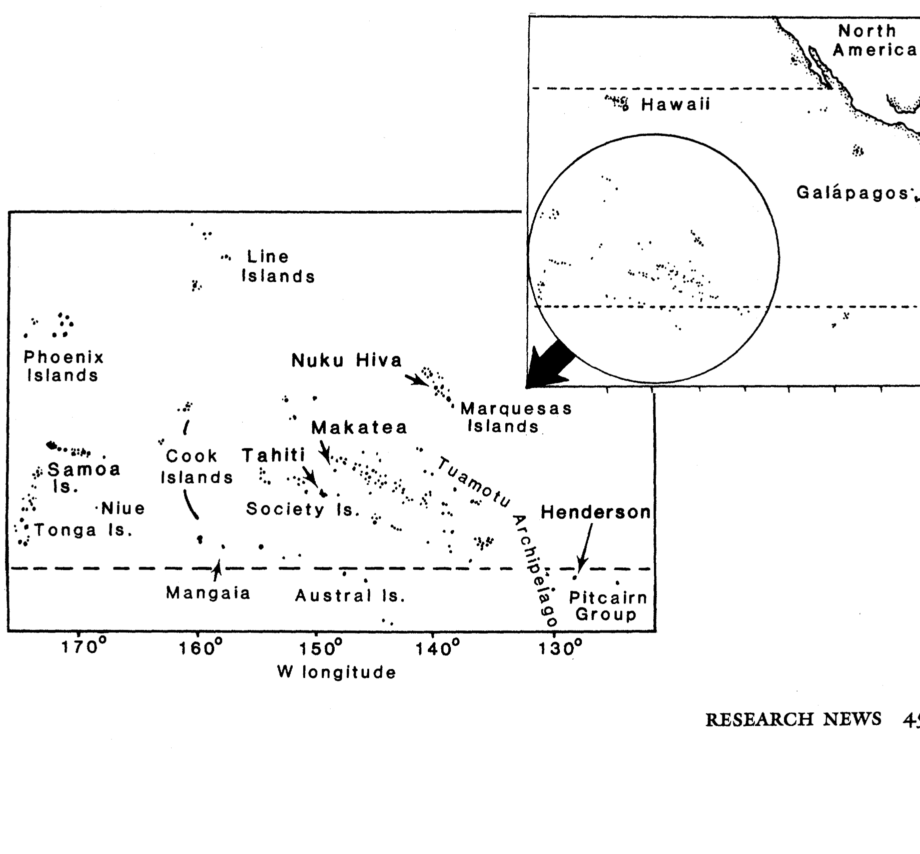
Many of the far-flung islands of the South Pacific have experienced only fleeting human contact, in some cases just a century or so of Polynesian habitation between 800 and 500 years ago. For this reason the islands have often been assumed to be still in, or at least very close to, a natural state. For instance, Henderson Island, a remote outpost of the Pitcairn group, has been described as "one of the few islands of its size in the warmer parts of the world still little affected by human activity," according to one recent observer.

It turns out, however, that the Polynesian presence, albeit brief, had a devastating effect on the natural history of Henderson. The same is almost certainly true for all other islands of the Pacific.

Two ornithologists, David Steadman, of the New York State Museum, and Storrs Olson, of the National Museum of Natural History, Washington, discovered this state of affairs when they recently examined the contents of archeological material recovered a decade ago from a cave and five shelters located along the north shore of the island. This glimpse of the record reveals that at least one third of the species of land birds that once lived there no longer do so.

From the limited amount of information available so far on some of the other remote Pacific islands, it seems that the pattern evident on Henderson is typical: human habitation caused significant local extinctions. For instance, the much more complete fossil studies on the Hawaiian islands show that in historic times there were more than twice as many bird species as there are now.

The implications of these results are several. For instance, an overall survey of the modern distribution of bird species (and presumably of other organisms, too) throughout the area is both impoverished and distorted compared with the true, natural state. Theoretical inferences about the composition and dynamics of natural ecosystems are therefore likely to be, at best, incomplete. From a practical point of view, this historical perspective of species distribu-



tion allows more flexibility in conservation projects of endangered species in the islands, partly because of an improved appreciation of potential habitats.

Henderson is a relatively low island, some 37 square kilometers in area, and is separated from its nearest neighbors Pitcairn (west-southwest), Oeno (west), and Ducie (east) by between 200 and 360 kilometers. Steep limestone cliffs rise from deep water, and the terrain is uneven and densely vegetated. Of the 63 plant species on the island, nine are endemic. About a third of the insect and gastropod species recorded so far are known only from Henderson. Not surprisingly, there are no native mammals, though the Pacific rat survives from the earlier human contacts. There is no arable land to be tilled, nor any plentiful supply of fresh water.

B. P. Bishop Museum, Honolulu. Painting by H. Douglass Pratt.

Victims of human activity on the Hawaiian Islands

The flightless ibis (left) and the flightless rail (right), both extinct.

The fact that, in common with many of its neighbors, Henderson was occupied only briefly and then abandoned has earned them the label of "mystery islands." Why did the Polynesians leave so hurriedly? Was it, as some have suggested, a combination of water shortage, lack of women, illness, homesickness, murder, and suicide? In many cases, however, the mystery is more how the settlers survived for so long, as the resources are so meager and so different in character from the traditional Polynesian diet, which includes taro, breadfruit, and sweet potato and, of course, pork.

Judging from the archeological evidence, these early settlers depended heavily on birds for their food, some of which were apparently eaten to extinction on the island. With food supplies thus depleted, perhaps this is why the settlers left.

Among the seabirds in the archeological material, the Christmas Island shearwater and the red-footed booby no longer breed on Henderson. The nearest colony for these species is on Oeno, 200 kilometers to the west. The white-throated storm petrel, another seabird, has not previously been recorded in the Pitcairn group of islands, and now breeds no closer than the Marquesas, some 2000 kilometers to the northwest. Fossils of this storm petrel have been found on Mangaia, in the Cook Islands, but apparently was driven from there by human activity too.

Two other bird species that the Polynesians apparently ate to local extinction are pigeons, one of which was quite large and weighed around 800 grams. Steadman and Olson identify the smaller species as the Society Islands pigeon (*Ducula aurorae*), or the Pacific pigeon (*D. pacifica*), and the larger one as the Marquesas pigeon (*D. galeata*). These pigeons provide some of the more interesting insights into the way modern bird distribution is distorted compared with historic times.

Although the Pacific pigeon now occurs from the Bismark Archipelago east to the southern Cook Islands, its counterpart, the Society Islands pigeon is known only on Tahiti and Makatea. The large species lives only on one island in the Marquesas, Nuku Hiva, where it was thought to have evolved and remained isolated.

From the fossil record on Henderson, and some preliminary results from one of the Cook Islands by Steadman, it is now clear that both the small and the large species of pigeon were much more widely distributed in earlier times than they are now. Moreover, the large and small species apparently coexisted, which was not previously suspected. The evolutionary picture that had been inferred for these birds from their modern distribution assumed that they evolved locally and were pretty much restricted geographically. The large Marquesas pigeon, for instance, was said to be the most extreme form of the general group, or superspecies, *D. pacifica,* the result of its geographic isolation. As the large species very probably lived throughout much of the Pacific island area, frequently overlapping in range with the distribution of the smaller species, the evolutionary picture must have been somewhat more complex.

There is a great deal of concern about the future of the Marquesas pigeon, restricted as it is today to less than 100 individuals living along forested mountain ridges in Nuku Hiva. Conservation efforts have focused on the preservation of the modern habitat, whereas it is apparent from the Henderson data that the birds can also thrive in lowland settings. Perhaps the mountain forest represents a refuge into which the birds have been forced by human activity on Nuku Hiva? In any case, the data from Henderson and Cook Islands indicate that if relocation is to be planned for this species, a wider range of habitats can be contemplated for their reception. Moreover, the argument that it is somehow improper to introduce species to islands that have never supported them can in some cases now be overcome, given the historical perspective derived from the archeological material.

Although this more complete record of bird species distribution that is being provided by the work of Steadman, Olson, and their colleagues is being applauded by many biologists, it is still overlooked by some. Ernst Mayr of Harvard University says that the data are extremely valuable and agrees that theoreticians must beware of using modern species distributions to develop mathematical models of ecosystems. For instance, biogeographic models of island populations use island area and number of species in their computations of community structure. Similarly, tests of potential competition between species depend on comparing modern distributions.

If, as now seems probable, modern species distributions are often not only impoverished but also distorted because of recent human activity, inferences drawn from such theoretical models must be viewed with some caution. ■ ROGER LEWIN

ADDITIONAL READING

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