Polynesian Ancestors and Their Animal World

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About four thousand years ago, in an as yet undiscovered homeland in western Melanesia or southeast Asia, a group of seafarers known as the Lapita people set out on a course of migration. The Lapita people produced single outrigger or double canoes capable of crossing hundreds of kilometers of water, and their navigational techniques were sophisticated enough to allow round trips between parent and daughter colonies. Equally important, they had the horticultural, hunting, and fishing technologies needed to sustain fledgling populations on previously uninhabited islands. In the next 2,000 years the Lapita people and their descendants would colonize the rest of Oceania, a vast region spanning 120 degrees of longitude and 70 degrees of latitude—a feat now widely recognized as one of the most far-reaching and rapid of prehistoric migrations (Bellwood 1979; Jennings 1979; Kirch 1984; Rouse 1986).

The movement of the Lapita people and their descendants out of Melanesia and into Polynesia began with settlement of the large, close-set island groups of Melanesia. With no water gap more than 500 km wide between major groups west of Vanuatu and New Caledonia, colonists were able to supplement the diverse resources of their new island homes with materials imported from parent colonies, thus buffering perturbations that might otherwise extinguish a small human population.

This was followed by successful colonization of the remote islands of tropical Polynesia (Fig. 1), beginning with the settlement of Fiji, Tonga, and Samoa by Lapita people some 3,000 years ago and ending with the colonization of Hawai'i by Lapita descendants about a millennium later. The distances traveled by these ancestors of the modern Polynesians were greater than had been navigated ever before—1,200 km of open ocean from Samoa to the nearest of the southern Cook Islands, 1,000 km from there to the main Society Islands, 1,400 km through the drought-prone atolls of the Tuamotu Islands to the Marquesas, and some 3,500 km from the Marquesas to Hawai'i. Atolls encountered along the way may have served as convenient stopping points but may have been poor in resources. Clearly, the survival of founding populations depended on the ability to gather food in their new island homes rather than on periodic assistance from a distant parent community.

Who were the first people to inhabit tropical Polynesia, and how did they manage (or mismanage) the animal resources of these far-flung islands to support a growing population?

The natural resources on which the initial colonists of tropical Polynesia relied for food were much less diverse than those of Melanesia. Native terrestrial mammals (other than bats) were not to be found east of the main Solomon Islands, native snakes were last encountered in Fiji and Samoa, and large-bodied native lizards were not present east of Fiji and Tonga. On these small islands, with their restricted inventories of indigenous plant and animal foods, descendants of the Lapita people developed resources to support densely populated, politically complex societies in which powerful hereditary chiefs ruled polities numbering in the tens of thousands.

The rapid settlement of Polynesia, and the unusual degree to which its natural resources were used to support initial development of politically complex societies, raise intriguing questions for an analyst of the faunal record. To begin with, what kinds of animals were available to the initial colonists of Polynesian islands? Were patterns of human predation consistent from one island to the next? Once viable communities were established and garden lands provided reliable yields, the people would have faced choices on whether and how to manage island faunas. Which species developed into dependable food sources while others became scarce or extinct? As human populations expanded, it became possible to produce sufficient surplus to support a classical Polynesian chiefdom. Which faunal resources were harnessed to sustain this political structure? What role

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did chiefs play in the production of animals for food? Tentative answers to these broad questions emerge from faunal analyses of several archaeological sites in tropical Polynesia.

The colonists' fare

Eight sites, considered by archaeologists to be among the earliest in their respective archipelagoes, have been selected for faunal analysis by means of two criteria. First, their locations, either in calcareous sand dunes or in dry caves, contribute to the preservation of bone. Open sites in volcanic soils, many of which have been disturbed by gardening activities, usually preserve bone too poorly to yield large faunal assemblages. Second, the bones from each site have been analyzed in sufficient detail to be of use in comparisons between sites and taxa. Of first importance here was a report of the weight of remains, from which the relative proportion of meat contributed by each taxon can be estimated. Though meat-weight estimates are rightly viewed with suspicion by faunal analysts (e.g., Grayson 1984), we believe they are important for generalized comparisons between taxa.

Two sites in the sample of eight are found on Tonga: the Tongoleleka site, located in an open dune on Lifuka Island, and the Fakatafenga site, in a sand dune on Tungua Island. It appears from ceramic styles that both date back to the first settlement of Tonga, about 900 B.C. (Dye 1988). Many of the islands of Tonga, such as 'Eua, are being uplifted by tectonic activity. By contrast, no sites from the initial settlement period have been excavated in Samoa, which is located near the subducting margin of the Pacific plate and has been sinking rapidly. The earliest sites there appear to be under water (Jennings 1974).

On present evidence, the next landfall east of Tonga and Samoa was in the Marquesas Islands, an event dated to the late first millennium B.C. (Kirch 1986) or to about A.D. 300 (Sinoto 1979). The single Marquesan site in our sample—the Hane site, located in a sand dune on Ua Huka Island (Sinoto 1966)—contains deposits from this period. Because the late prehistoric deposits at Hane are not particularly rich, we have augmented the Hane sample with remains from the nearby Manihina dune site, also on Ua Huka Island, which yielded a rich, late-prehistoric faunal assemblage.

The earliest dated site in the Society Islands is found below the water table in a sand dune at Fa'ahia on Huahine Island and is confidently dated to the late first millennium A.D. (Emory 1979; Sinoto 1983; Sinoto and McCoy 1975). This finding prompted Sinoto (1979) to hypothesize that the Marquesas served as the homeland for the initial colonists of the Society Islands and other eastern Polynesian island groups. It is possible that there

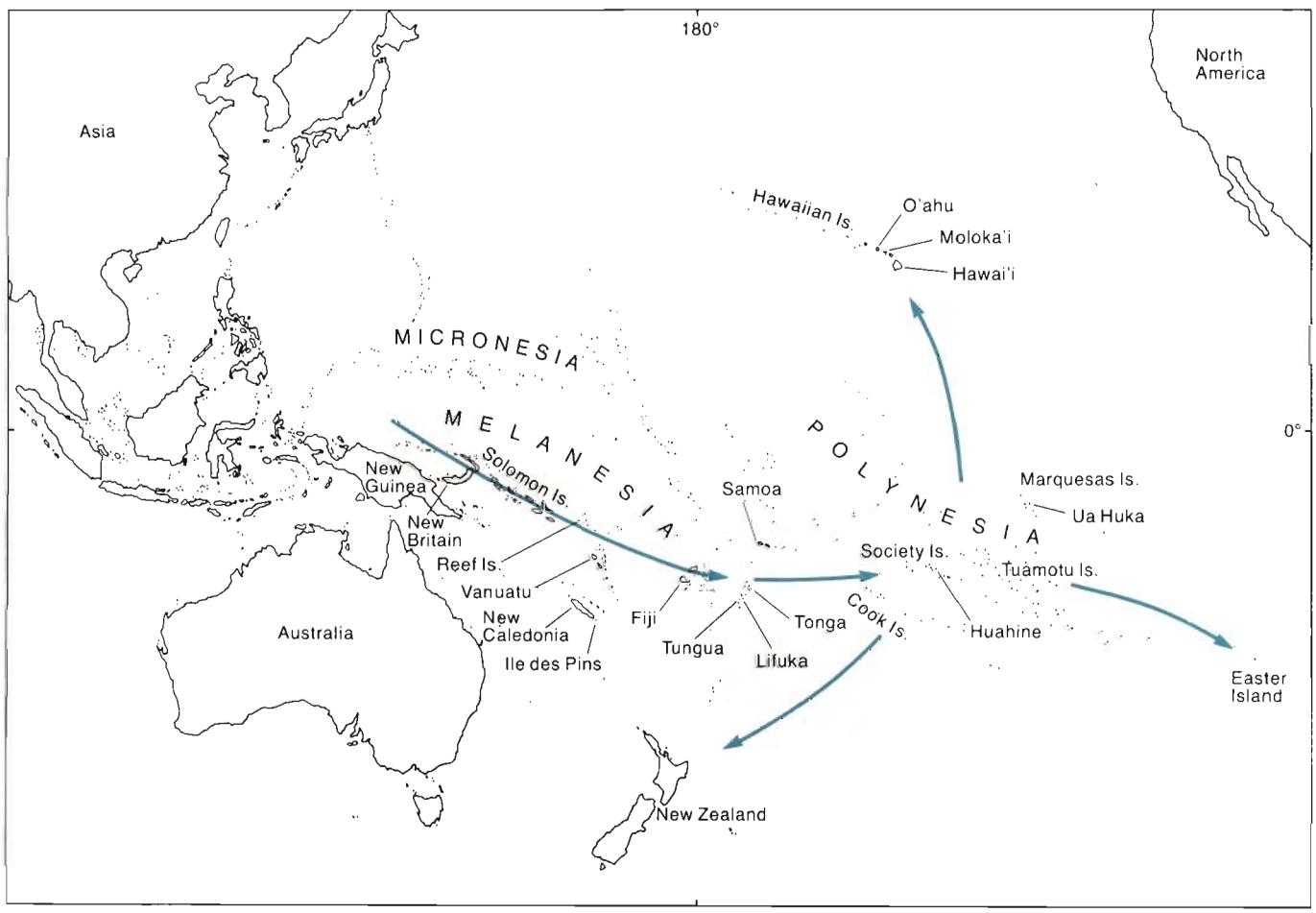

Figure 1. The island groups of Melanesia and Polynesia extend across some 12,000 km of the Pacific Ocean. The Lapita people and their descendants migrated out of western Melanesia or southeast Asia in outrigger or double canoes, reaching as far as Hawai'i by about A.D. 400. The stretches of open ocean between islands in Polynesia, some over 1,000 km wide, called for prodigious feats of navigation and meant that colonists must be able to sustain themselves entirely on the resources offered by their new island home.

Figure 2. A view of the east coast of the island of 'Eua shows a marine terrace and, below, a sharp drop to the beach. The raised terrace, once a coral reef, marks a period of uplift caused by the Pacific plate subsiding beneath the eastern edge of the Indo-Australian plate, thrusting up the Tongan islands in the process. The cliff below the upper terrace limits human access to the lower level and thus helps to preserve the lush native forest. (Photograph courtesy of J. G. Stull.)

are older sites in the Society Islands, which, like those in Samoa, are now under water (Kirch 1986), although the average rate of subduction is less in the Society Islands than in Samoa. The faunal remains from Fa'ahia support the interpretation that this was an early settlement site in the Society Islands.

Although the Hawaiian Islands have seen more archaeological work than all the other archipelagoes in tropical Polynesia together, the picture of early settlement is not yet clear. The sheer size of the islands, the lack of a highly visible type of early artifact such as pottery, and the extent of modern land development in coastal regions all hamper the discovery and interpretation of early sites. Of the four Hawaiian sites analyzed here, two lie on the southern end of Hawai'i Island: Ka Lae, a sand dune, and Wai 'Ahukini, a cave (Emory et al. 1969). Both appear, on the basis of their artifact types, to date back to the early settlement period, in a range between A.D. 300 and 750 (Emory and Sinoto 1969; Kirch 1985). The other two Hawaiian sites are Hālawa, a sand dune on Moloka'i Island (Kirch and Kelly 1975), and Kuli'ou'ou, a cave on the dry southeastern coast of O'ahu Island (Emory and Sinoto 1961). Both are thought by their excavators to represent early settlements in their respective regions: A.D. 433–859, for Hālawa, and A.D. 680–1392, for Kuli'ou'ou.

Five broad taxa were recovered from the sites: birds, turtles, shellfish, fish, and domesticated mammals. Figure 3 shows the proportion of consumable meat (estimated weight) contributed by each taxon. It is of course possible that problems of differential deposition, preservation, and recovery might call for some revision of the interpretations offered here, although the consistency of the faunal patterns at the eight sites suggests that such changes would be minor.

The estimates presented in Figure 3 show that early colonists relied heavily on the natural resources of their new island homes for food, although the exact mix of taxa varies from archipelago to archipelago and from site to site. At Hane and Kuli'ou'ou the relative contribution of birds overwhelms that of all other taxa combined. At Tongoleleka, Fa'ahia, and Wai 'Ahukini, birds made up a substantial portion of the diet, whereas at Fakatafenga, Ka Lae, and Hālawa birds were insignificant. Shellfish and fish were regularly exploited by the initial colonists throughout Polynesia. The remains of domesticated pig and dog are rare at all sites except Hālawa, where they make up over 10% of the total meat weight in the oldest portion of the cultural stratum and increase steadily in younger deposits.

The "typical" Polynesian island, several or more square kilometers in area, must have supported sizable populations of seabirds and landbirds at the time of human arrival. (See Fig. 4 for a particularly rich site.) These birds evolved in an environment free of mammalian predators, and thus had little defense against man and rats. Early birding may have resembled gathering more than hunting, a circumstance that the initial settlers undoubtedly found to their liking.

Given the extensive exploitation of birds at Hane and Kuli'ou'ou, and the significant presence of bird bones at several other early sites, the relative paucity of bird remains from Fakatafenga, Ka Lae, and Hālawa demands an explanation. At Fakatafenga, the small size of Tungua Island (1.5 km^2) may have limited the size of the bird population, so that it constituted a relatively minor resource in comparison with the fish, shellfish, and turtles found on the extensive reefs surrounding the island. Also, because the avifaunas of small islands could be depleted more rapidly than those of large islands, it is possible that archaeological bone samples from small islands must include the first decades of occupation in order to represent the full range of species taken by the earliest colonists.

At Ka Lae, one of the first major excavations in Hawai'i, excavation techniques were not as rigorous as those of today; thus it is difficult, for example, to correlate excavated midden material, which was not collected with fine-mesh screens, with stratigraphic layers. Furthermore, the amount of midden analyzed from Ka Lae is comparatively slight, raising the possibility of sam-

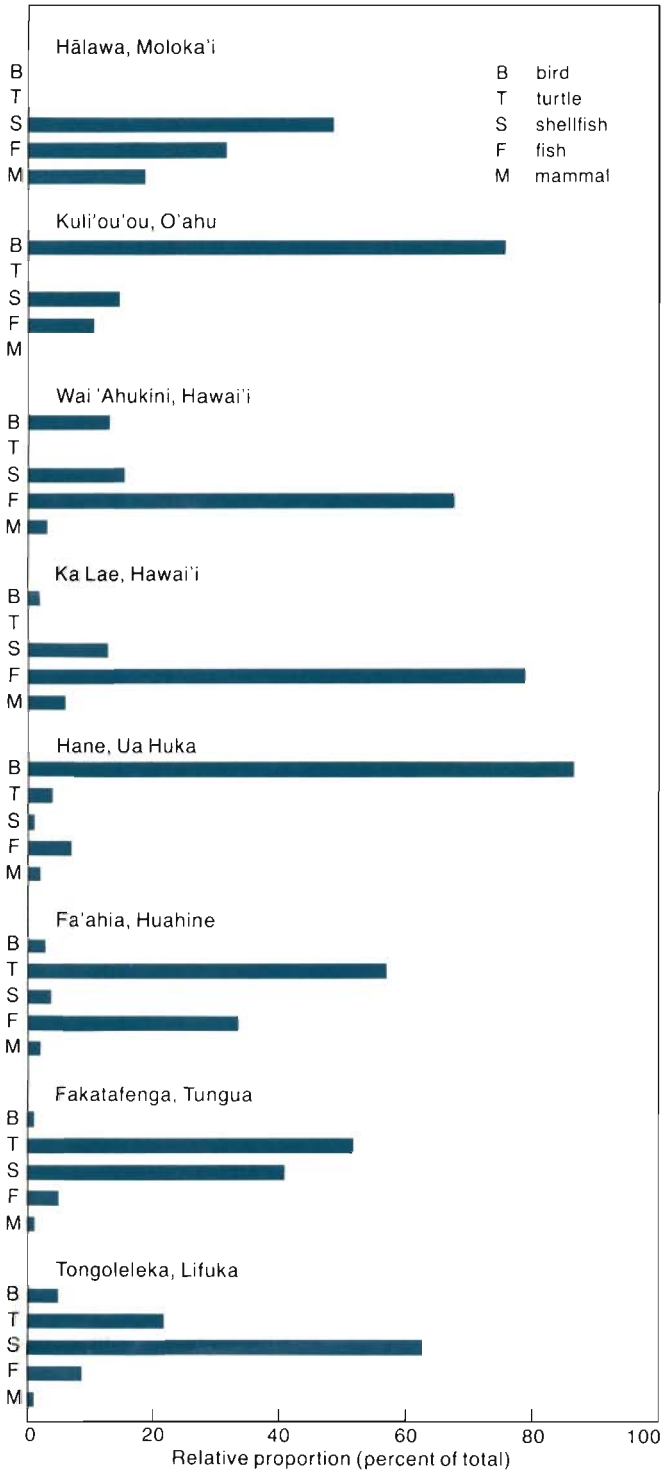

Figure 3. Five broad taxa provided the early Polynesian colonists with food: birds, turtles, shellfish, fish, and mammals. The relative proportion contributed by each taxon can vary considerably, as at the eight archaeological sites plotted here, though a general pattern of reliance on birds and/or turtles and a minor role for mammals can be discerned. The proportions are calculated from estimated meat weights, which are derived by multiplying the weight of bone or shell remains by a taxon-specific constant. The constants for vertebrates are derived from allometric formulas by assuming a reasonable mean weight for individuals (Prange et al. 1979; Wing and Brown 1979:128): 1 kg for fish, 50 kg for turtles, 0.4 kg for birds, and 10 kg for domesticated mammals. The weight of shellfish is assumed to be 25% of shell weight (cf. Salvat 1972).

pling error. As for Hālawa, if this site is accepted as a sample of early settlement in the region, it is difficult to explain the paucity of bird remains. Neither a shortage of territory on the island, nor imprecise methods of excavation, nor sediment type can be invoked to account for the situation at Hālawa, which is located at the mouth of a large valley and was carefully excavated.

A second rich animal resource encountered by the initial colonists of several islands was sea turtles, including the green turtle *(Chelonia mydas)*, the hawksbill *(Eretmochelys imbricata)*, and, to a lesser extent, the loggerhead *(Caretta caretta)*. Sea turtles were an important resource at Tongoleleka, Fakatafenga, Fa'ahia, and Hane—all sites located in sand dunes. The beaches adjacent to these dunes probably were nesting sites where it would have been easy to capture egg-laying females simply by overturning them.

The lack of turtles from the early Hawaiian sites is puzzling, as green turtles occur today in large numbers in the leeward Hawaiian Islands and in much smaller numbers in the main group (Balazs 1980). Several factors may be involved. The Wai 'Ahukini and Kuli'ou'ou cave sites contain volcanic soil, and turtle bone, which is fairly porous, may not have survived the relative acidity of the soil. In this case, however, turtle bone would still be expected at the Ka Lae and Hālawa dune sites. One possible explanation for their absence here is that these are not the first settlements in their respective regions, but were established after human predation had altered the patterns of nesting. Alternatively, it may be that the present pattern of minor nesting sites on Lana'i and Moloka'i islands, with major sites restricted to the uninhabited French Frigate Shoals, is not the result of overpredation in the main Hawaiian Islands as is often assumed, but already existed at the time of initial settlement.

Shellfish and fish were regularly exploited by colonists throughout tropical Polynesia. Although the range of taxa taken by the Lapita people in Melanesia and western Polynesia suggests they were already skilled at many forms of marine exploitation (Kirch and Dye 1979; Green 1986), the poor quality of the evidence from many Lapita sites precludes precise estimates of the contribution of fishing to the earliest Polynesian economy (Butler 1988). The ability of eastern Polynesian colonists to adapt to unusual marine environments further testifies to this skill. Adaptation is evident most clearly in the Marquesas Islands, which, with their rocky shores and steeply shelving nearshore waters, contrast strongly with the reef-rich homeland islands in the west.

Early Marquesan archaeological sites such as Hane yield a wide range of fishhooks in different forms and sizes, unmatched by earlier or contemporary assemblages farther west. This variability may reflect a period of experimentation with angling techniques (Kirch 1980). The early Marquesan assemblages include both jabbing and rotating hooks. The fishbone associated with these hooks represents a diverse catch of bottom-dwelling and inshore fish, along with several free-ranging species, suggesting that experimentation was successful.

The different contributions of fish and shellfish to the faunal assemblages of the early sites may be associated with differences in the environments. The high

relative proportion of fish at Fa'ahia, Ka Lae, and Wai 'Ahukini shows that fishermen exploited the rich fishing grounds near these sites. The high relative proportion of shellfish at the Tongan sites and at Kuli'ou'ou is probably a function of the proximity of these sites to extensive shoal water reefs, where shellfish were plentiful and easily collected.

The early sites generally show a paucity of domesticated mammals, perhaps reflecting the limited cargo capacity of even the largest voyaging canoes and the length of time needed to establish large breeding stocks. The scarcity is most pronounced at early sites in Tonga, where the only report of pig and dog comes from one site, on Niuatoputapu Island (Kirch 1988). At Hane, pig bone is common in the early layers, but dog bone is extremely rare (Kirch 1980). At Fa'ahia and the four Hawaiian sites, the remains of pig and dog are present in roughly equal quantities. In contrast to the general pattern, two sites in our sample, Ka Lae and Hālawa, contain significant quantities of domesticated mammal bone. These exceptions may be explained by the rather crude excavation techniques at Ka Lae, where material from later layers may have intruded into the base of the site and recovery methods were heavily biased toward relatively large bones; another explanation can be found in the relative lateness of the early layers at the Hālawa dune site. In the latter case, the faunal evidence seems to indicate that the Hālawa site was deposited when breeding stocks of domesticated mammals were sufficiently developed to provide a reliable source of food, sometime after the initial exploitation of birds.

Three other animals contributed to the diet of the early settlers. Significant quantities of whale and porpoise bone recovered at Fa'ahia attest to the fishing prowess of the early residents of Huahine (Leach et al. 1984), and a large-bodied, iguanid lizard *(Brachylophus* sp.) appears to have contributed to the diet of the early colonists at Tongoleleka (Pregill and Dye 1989).

Figure 4. The cave of 'Anatu, on the island of 'Eua, contains about 50 cm of archaeological sediment dating to almost 3,000 years ago. Below this, 150 cm of sediment dating from prehuman times has been excavated to reveal the bones of numerous extinct birds, bats, and lizards. Both the limestone of the cave and the undisturbed status of the sediment make for good preservation. 'Anatu is the richest site for bird bones in Polynesia, yielding remains of extinct herons, megapodes, rails, pigeons, doves, parrots, and many species of songbirds. (Photograph courtesy of J. G. Stull.)

The human impact on native faunas

The use of indigenous animals for food, combined with predation by introduced rats, had inevitable effects on animal populations that had evolved in relatively predation-free contexts. The effects are most clearly reflected in the decline of animals that are in some way dependent on terrestrial habitats—birds, turtles, and large-bodied lizards. In the future, estimates of depletion rates will benefit from improved collection techniques, including the use of fine mesh screens and flotation, and improved chronological control through dating of the faunal remains themselves by accelerator mass spectrometry (James et al. 1987).

Predictably, the swiftest declines appear in the large-bodied lizards and birds, the two taxa most directly tied

to terrestrial habitats. Of the two extant iguanid lizards in the region, *B. fasciatus* (Brongniart) occurs locally in Fiji and Tonga, and *B. vitiensis* Gibbons is confined to Fiji. The extinct, large-bodied iguana from Lifuka may be added to the list of Oceanic vertebrate taxa whose large-bodied members have become extinct while smaller-bodied forms survived (Cassels 1984; Steadman 1986).

Marked declines are also found in the birds from Hane and Kuli'ou'ou, the two sites with the greatest proportion of birds in early layers. At Hane, the relative contribution of birds to the diet is more than halved within the first 550 years and declines to insignificance in just over a thousand years. The decline at Kuli'ou'ou is even more rapid. The decline of birds is less marked at Wai 'Ahukini, where fish always made up the bulk of the diet, and at Tongoleleka, where the relatively small size of Lifuka Island (11.4 km^2) may have contributed to a decline of birds too rapid to be detailed in available collections.

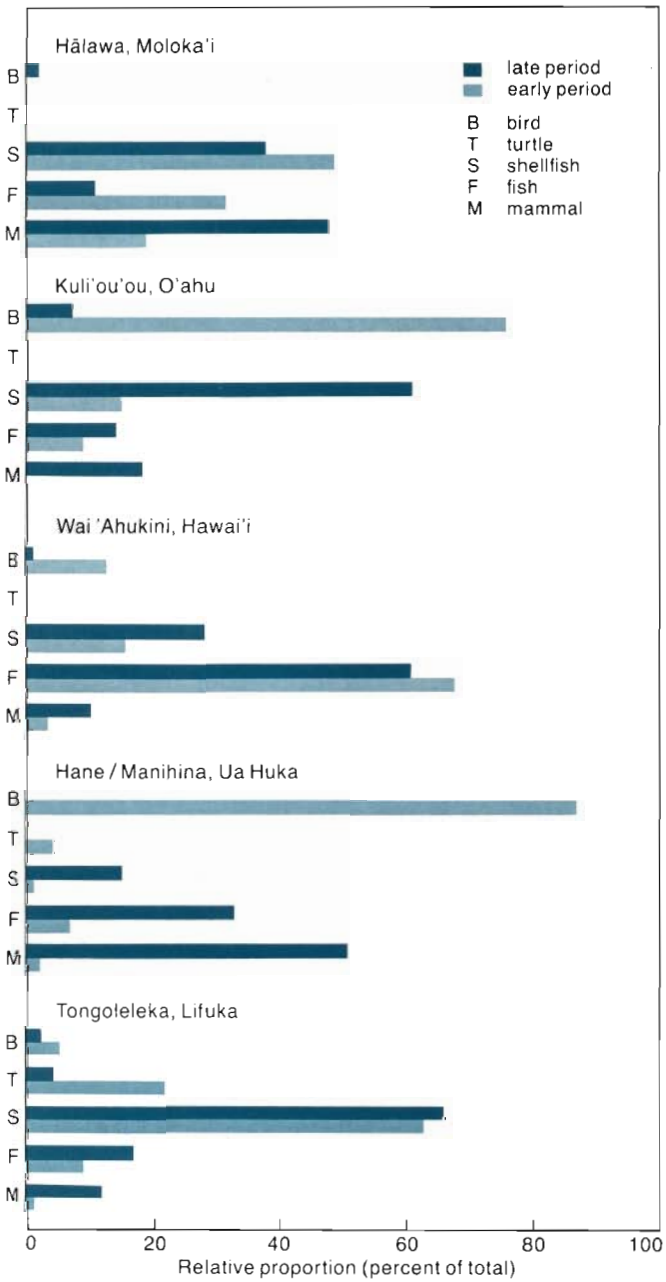

Figure 5. The relative proportions of the main taxa used for food by the settlers of Polynesia—bird, turtle, shellfish, fish, and mammal—change over time. In the late prehistoric period, domesticated mammals account for a much larger proportion of the total meat weight at each of five sites, whereas birds and turtles account for a smaller proportion than formerly. (Data from the early period, which were plotted in Fig. 3, are shown here in a lighter shade for comparison.)

The decline of bird populations overall was accompanied by the extirpation and extinction of many species. Of the resident species whose bones are recovered at Hane, eight of the 20 seabirds, including shearwaters, petrels, and boobies, are extirpated on Ua Huka, as are 14 of the 16 landbirds, primarily flightless rails, pigeons, doves, parrots, and songbirds (Steadman 1989). A similar pattern of extirpation and extinction of birds is found at Fa'ahia.

The contribution of turtles at Tongoleleka falls quickly at first, but is followed by continued exploitation at a stable low level. Sea turtles, like seabirds, are dependent on a specific terrestrial microhabitat for nesting sites, and the females are easily taken as they lay their eggs. The seasonal nesting of turtles at selected sand beaches would have been quickly noted and exploited by human colonists. Initially, sea turtles would have seemed an inexhaustible resource. Because of the sea turtle's long maturation period, it would have been possible to take every nesting turtle and egg for 20 to 30 years without affecting the number of recruits arriving at the nesting beach (Bjorndal 1985). After this, however, population declines would be evident, and the hunt for turtles would turn to the open waters, where hunting success by netting, spearing, and hooking would be much lower.

In contrast to the patterns in terrestrial animals of extirpation, extinction, and reduced populations, marine animals appear to have been a relatively stable resource. Shellfish, especially those restricted to shallow nearshore habitats, occasionally show a diminution in the mean size of individuals deposited in archaeological sites over time, although it may be difficult to distinguish the effects of human predation from environmental change (Spennemann 1987). To date, no changes in fish catches attributable to overexploitation or habitat alteration have been discovered.

The susceptibility of indigenous terrestrial faunas to predation and the alteration of their habitat, and their consequent demise after human colonization, meant that meat needed to support growing human populations now had to come mainly from domesticated mammals, fish, and shellfish. This general pattern is documented in the late prehistoric layers of five sites from Hawai'i, the Marquesas, and Tonga, as shown in Figure 5. In contrast to the early layers of these sites, the late layers contain few bones of native birds or of sea turtles.

The late assemblages from Hane/Manihina and Tongoleleka both lack dog bones, reinforcing historical reports that dogs were not found in the Marquesas or Tonga at the time of European contact (Urban 1961). In the Marquesas, dogs are present in the early prehistoric periods, and although sample sizes are small it appears likely that dogs were extirpated sometime early in the second millennium A.D. (Kirch 1980). Tongan dog populations, if present in prehistory, must have been small

Figure 6. The excavations at Fa'ahia, on Huahine, uncovered evidence of human culture dating back to the late first millennium A.D. Much of this material lay below the water table, a factor that helps to preserve organic materials. The pit in the foreground features the plank of a wooden canoe (the long brown beam), together with other canoe parts. (Photograph courtesy of Y. H. Sinoto, B. P. Bishop Museum.)

and would have played an insignificant role in the economy. In contrast to the patchy distribution of dog bones in tropical Polynesian archaeological sites, pig bones are found in all the late sites.

Fish and shellfish continue to figure importantly in the late assemblages, with relative proportions of the two taxa still a function of environmental conditions. The results of fishing appear to have been fairly constant over time at most sites, with the exception of Hane, where bottom-dwelling and inshore species come to predominate over free-ranging species, a change associated with a striking reduction in the diversity and sizes of fish hooks.

A basis for social stratification

The ability of the Lapita seafarers to exploit the pristine marine environments of newly colonized islands has never been in doubt, and the presumed richness of the sea's resources has traditionally provided a ready explanation for their ability to colonize so successfully. Recent analyses of the faunal remains from archaeological deposits reveal, however, that the earliest colonists of tropical Polynesian islands also found rich and diverse terrestrial faunas, and that species captured on land often played a larger role in subsistence than did fish or shellfish, which became more important later in prehistory. A similar pattern of subsistence change characterized temperate New Zealand as well (Anderson 1983).

For many early colonists, the primary prey was seabirds that nested on or near the ground and landbirds that thrived in virgin forests once devoid of significant predators. Although much has been learned about species richness and diversity (Steadman 1989), reliable data with which to estimate the size of pristine bird populations in tropical Polynesia may never be recovered. Common sense argues that smaller islands would have supported smaller bird populations and that these would decline relatively quickly after human colonization, thus decreasing the probability of yielding a representative archaeological sample. We may infer, too, from the great number of seabird bones recovered from several archaeological deposits, that the present pattern of fewer nesting seabirds on large islands than on small offshore islands reflects pressures brought about by long-term human habitation of the large islands rather than a natural preference of the seabirds.

The pattern of extirpation and extinction of birds described above for Hane and Fa'ahia is repeated at archaeological and paleontological sites through much of tropical Polynesia (Olson and James 1982, 1984; Steadman 1989). Species-level identifications of bones from

archaeological sites indicate that a remarkable variety of birds was available to the first human colonists of these islands. The historically surviving avifauna of tropical Polynesia is so badly fragmented by the effects of human colonization that it alone does not reflect natural distributional patterns. Most species of landbirds that occurred in tropical Polynesia before the advent of humans are now extinct, and most of the extant species of seabirds and landbirds are found over greatly reduced ranges. Perhaps the most dramatic example is Abbott's booby *(Papasula abbotti)*, known historically only from the Indian Ocean. Bones of this large seabird from Hane and two other Marquesan sites have extended its range about 11,200 km to the east.

The decline of indigenous land-based animals is one result of the widespread transformation of natural environments into culturally managed landscapes. On most islands this transformation meant that tropical Polynesian societies worked harder to produce animal foods, trading raids on bird and turtle nesting grounds for the full-time responsibilities of tending pigs and organizing the production, maintenance, and use of sophisticated boats and other fishing gear. The excavation of a canoe, from Fa'ahia, is shown in Figure 6.

The spatial organization of animal food production also changed. In the natural environment birds would have been a dispersed resource, with the nesting grounds and favored habitats of many species spread over most of an island's surface. In contrast, pig herds probably were concentrated near settlements, and most of the shellfishing and fishing took place in the relatively narrow band of shoal water immediately offshore. These changed circumstances meant that resources could be monitored with relative ease and thus provided Polynesian leaders an opportunity to expand their control over the production of animal foods.

Figure 7. The Hane site on Ua Huka, in the Marquesas Islands, is typical of calcareous sand dunes in its good preservation of bone and artifacts. Here, the earliest strata containing evidence of culture, including a rich assemblage of fishing gear and a large sample of bird bones, many of extinct species, are marked by water-worn cobbles and boulders immediately below the chalkboard. They are separated from the late cultural strata at the top by 80 cm of dune sand that contains little cultural material. (Photograph courtesy of Y. H. Sinoto, B. P. Bishop Museum.)

The authority of tropical Polynesian chiefs derived partly from their ability to oversee the production of food to support a coterie of faithful, who in turn helped the chief administer the realm. The testimony of traditional historians, sea captains, beachcombers, and missionaries all points to the important role played by chiefs in controlling the production of animal foods. The primary tools used for this were taboos against consumption of various flesh foods, and the coordination of labor to produce specialized tools and facilities.

In eastern Polynesia, taboos against the consumption of domesticated mammals were especially stringent, often dividing the community on the basis of gender and social class. In Hawai'i, for example, it was taboo for women to eat pork, and they were allowed to eat dog only in certain ritual contexts (Valeri 1985:115 ff.). Similar restrictions applied in the Society Islands, where pork and dog were further reserved for high-status men (Oliver 1974). Such taboos would have moderated demand for domesticated mammal meat and may have played a major role in preserving herds.

Much fishing in tropical Polynesia seems to have been done by individuals and small groups who possessed the requisite gear and had access to fishing grounds. Nevertheless, various measures carried out under the auspices of chiefly authority served to expand marine production on many islands. Perhaps the most dramatic example comes from Hawai'i, where chiefs organized the construction and maintenance of some 449 fishponds (Kikuchi 1976). These ponds, constructed on reef flats or in shallow bays by work gangs numbering in the hundreds and organized by prominent chiefs, produced an estimated yield of almost a million kilograms of fish annually, most of which was consumed or distributed by chiefs. On a smaller scale, chiefs of the Society Islands financed the production of large seine nets and regulated their use in the extensive net-fishing grounds by asserting exclusive rights (Handy 1932). In Samoa the *va'a alo*, a fishing canoe specialized for taking skipjack tuna *(Katsuwonus pelamis)*, was believed to be ineffective without a decorative row of white *pule* shells *(Ovulum* sp.), which were difficult to obtain and "came in the way of presents to high chiefs" (Hiroa 1930:401).

The widespread use of authority by Polynesian chiefs to increase fishing production lends the Marquesan situation a particular interest. (The site of Hane, in the Marquesas, appears in Fig. 7.) At the time of first extended contact with Europeans, Marquesan chiefs exercised a virtual monopoly over a fleet of fishing canoes that were inferior to canoes elsewhere in Polynesia, and they strictly controlled access to nearshore marine environments, thus strongly curbing the role of individual initiative. In contrast to most other island groups in tropical Polynesia, where fishing skill afforded an individual some measure of prestige, Marquesan fishermen appear to have had low social status. Antagonistic social relations between tribes in neighboring valleys made fishing outside the deeply indented bays a risky adventure, exposing a fisherman to enemies out "fishing for men" *(e ika)* to sacrifice. These social con-

straints seem to have rendered the Marquesan fishing industry incapable of intensifying production when prolonged droughts ravaged agricultural production, and many people died of starvation (Dye, in press).

It is significant that the archaeological evidence for stratified societies appears in tropical Polynesia after indigenous land animals have been depleted and the natural environment has been transformed into a cultural landscape. This transformation was incomplete in most large islands of Melanesia, where societies were usually composed of small, politically autonomous groups. However, in Polynesia, because the authority of the chiefs was rooted in controlled access to important resources, increased opportunities for the control of animal foods may have influenced the development of political institutions. Melanesians generally had the option of striking off on their own if the exactions of a political leader grew onerous; new settlements could be established in the large remaining patches of unaltered environment. In Polynesia, the often complete transformation of natural environments precluded this course.

Future analyses of carefully collected faunal assemblages may add a wealth of interesting detail to the patterns of exploitation outlined here, refining our understanding of the relationships between faunal exploitation and the development of complex societies. The demise of indigenous insular faunas in tropical Polynesia is a fascinating chapter in natural history. By providing an index for the biotic conditions that favor the development of social stratification, it has proved important to cultural history as well.

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