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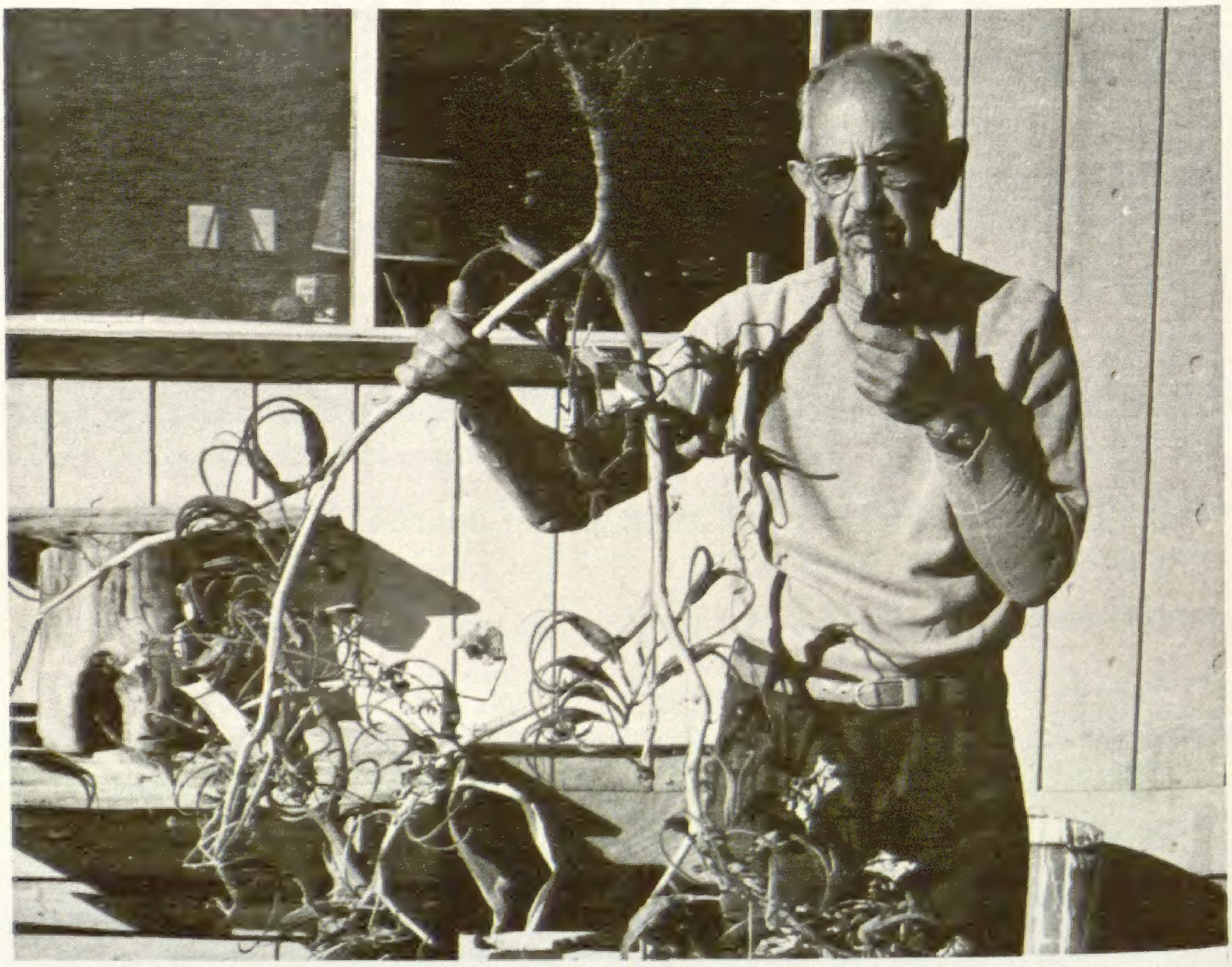
LYNDON LANE HARGRAVE, 1896-1978



ALFRED FRANK WHITING, 1912-1978

INTRODUCTION

The *Journal of Ethnobiology* is a professional journal devoted to the interdisciplinary study of anthropology and biology which will provide a long needed forum for publications of original research by ethnobiologists and other specialists. The journal will consist of papers covering a broad range of topics including ethnotaxonomies and folk classification, ethnobotany, ethnozoology, cultural ecology, plant domestication, zooarchaeology, archaeobotany, palynology, dendrochronology, and ethnomedicine. This volume, which contains articles dealing with nearly all these subject areas, consists of papers presented at the Second Annual Ethnobiology Conference held in Flagstaff, Arizona, 6-7 April 1979. This conference was appropriately held in honor of 2 recently deceased prominent ethnobiologists: Lyndon L. Hargrave and Alfred F. Whiting. This first issue of the journal is also dedicated to these men.

The first article in this issue is an excellent biography and bibliography of Alfred Whiting by Katharine Bartlett of the Museum of Northern Arizona, Flagstaff. Biographies of Hargrave have been published by Dick and Schroeder (1968), Emslie (1979), and Taylor and Euler (1980). The second article by Richard I. Ford was presented as the keynote address at the conference. The next 7 articles by Grayson, Hevly, Yarnell, Pulliam, Rea, Kuhnlein, and Berlin et al. comprised a special symposium of invited speakers to honor Hargrave and Whiting. The remaining papers in this issue are selected papers presented at the conference. The Museum of Northern Arizona is acknowledged for their efforts in organizing this conference and for their considerable help and cooperation in allowing these papers to be published as the first issue of the *Journal of Ethnobiology*. These excellent papers are an ideal collection of research to begin a new journal.

Proceedings of future ethnobiology conferences will be published each year in one issue of the journal. The next issue, Volume 1 Number 2, will contain selected papers presented at the Fourth Annual Ethnobiology Conference held in Columbia, Missouri, 13-14 March 1981. The journal will begin soliciting papers on original research for the first issue of 1982 (Volume 2 Number 1) in September 1981. Authors are referred to the style guide provided on the inside cover of this issue. By 1983, the journal may expand to a quarterly release and include book reviews and news and comments sections. Finally, this journal would not have been possible without the support and cooperation of 12 notable ethnobiologists comprising the Editorial Board; their experience and knowledge are what is required to ensure a successful and high quality journal.

Steven D. Emslie
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ALFRED F. WHITING, 1912-1978

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Alfred Frank Whiting was born in Burlington, Vermont, in 1912. After attending public schools, he went to the University of Vermont, located in Burlington, graduating in 1933 with a Bachelor of Science degree. He at once enrolled in the Graduate School at the University of Michigan and the following spring received an M.A. in Taxonomic Botany. That summer he was included in a University of Michigan Botanical Expedition to San Luis Potosí, Mexico, which may well have been responsible for arousing his interest in ethnobotany, the focal point of his career.

In the summer of 1935, Whiting was appointed Curator of Biology at the Museum of Northern Arizona, where he spent the first few months collecting plants and organizing the herbarium. In September he was joined by Dr. Volney H. Jones, also from Michigan, and together they began a survey of Hopi Indian crop plants for the Michigan Ethnobotanical Laboratory. When the harvest was over, Jones returned to Ann Arbor, but Whiting stayed in Flagstaff to record with Edmund Nequatewa, a Hopi man on the Museum staff, the names and uses of cultivated and wild plants he and Jones had collected on the Hopi mesas. Al, whose title at the Museum had been changed to Curator of Botany, continued to collect and work on the wild plants of Flagstaff and Hopi areas and the Hopi crops until the fall of 1937. At that time he enrolled in the University of Chicago to begin work on a Ph.D. in the combined fields of botany and anthropology.

Whiting returned to Flagstaff in the summer of 1938 and completed his manuscript on the *Ethnobotany of the Hopi* published as Bulletin 15 of the Museum of Northern Arizona in 1939. The school years of 1938-39 and 1939-40 were spent in Chicago working on his Ph.D. Here he married Dorothy J. West, whom he had met at International House at the University, where they both lived. In September 1940, they came to Flagstaff for the next 2 years while Al completed fieldwork among the Havasupai in preparation for his dissertation on their ethnobiology. He also continued to serve as Curator of Botany at the Museum.

In the late summer of 1941, Al was given an unexpected opportunity, unusual for that day and age, to be anthropological advisor to an educational film company, Coronet Productions of Chicago, which was about to produce color sound films of the Hopi, Navajo, Havasupai and Apache Indians. He assisted in arrangements with the tribes for Coronet to make the films and accompanied the photographers to the various reservations. This brought him in contact with the Indian people, their tribal governments, and Bureau of Indian Affairs personnel, altogether an enriching experience.

The Coronet films completed, Whiting undertook a 6 month project, sponsored by the Indian Arts and Crafts Board of the U.S. Department of Interior and the Museum of Northern Arizona, to make an intensive survey of production and marketing problems of Hopi Indian arts and crafts. Although the films and the crafts survey were monetarily successful for the student with a wife and child, unfortunately, they diverted him from his Ph.D. dissertation, which he might have completed while still in Flagstaff. Due to World War II and other unforeseen circumstances, he never completed its writing or his degree.

In July 1942, the Whitings returned to the Midwest where Al continued his graduate work at Chicago until the fall of 1944 when he accepted an Assistant Professorship at the University of Oregon, substituting for a member of the Anthropology Faculty who was serving in the armed forces in World War II. While at Oregon, most of Whiting's time appears to have been occupied with teaching his first college classes and curatorial work at the Oregon State Museum. He published an article in *American Anthropologist*, "The Origin of Corn, an Evaluation of Fact and Theory," based in part on his M.A. thesis at Michigan.

The winter climate in Oregon did not agree with either of the Whitings or their 2 young sons and they were frequently sick. During this time Al and Dorothy separated and she and the 2 boys returned to Chicago where her parents resided; a divorce soon followed. Al wrote to a friend that he longed to get back to the dry Southwest, and so, in the spring of 1947 when his teaching term was up, he moved to Tucson and Tumacacori in the southern Arizona desert to spend the next several years.

At the University of Arizona, in association with the Arizona State Museum where he found many old friends, Whiting settled down to do what he most enjoyed in life: research. Based on the results of some historical studies, he wrote "A Kino Triptych" and "The Tumacacori Census of 1796," the latter published in *The Kiva* of the Arizona Archaeological Society. The cover of this issue of *The Kiva* was illustrated with a water color painting by Whiting (reproduced in black and white) of a reconstruction of the mission church of Tumacacori. During his years in Tucson he painted a number of watercolors of other missions and scenes in the area. A stay at Tumacacori inspired 2 delightful stories based on personal experience with some Spanish-Americans of that vicinity, "The Happy Cemetery" and "Miracle in the Living Room." A trip to visit the Seri Indians, on the west coast of Sonora and Tiburon Island, to collect and study the plants they used, resulted in his reviewing all recorded data on that tribe. Anticipating a future publication on his Seri work, he collected several loose leaf binders of data. In 1950-51, apparently feeling the need of some income, he took a position as a master in the Santa Cruz Valley School.

In the summer of 1951, Al was a member of the Cornell University Cultural Seminar, initiated by Dr. Alexander H. Leighton, which was well described by Bunker and Adair in their book, *The First Look at Strangers*. His friends, John Adair of Cornell University and Edward H. Spicer of the University of Arizona, were field directors of the 5 week summer course, then in its third year. Adair and Spicer may have enlisted Whiting to introduce the international group of students to the Hopis, among whom he had worked many times. The students spent a week each among the Papagos, Navajos and Hopis of Arizona and the Rio Grande Pueblos and Spanish Americans of Truchas, New Mexico. This was an unusual and especially stimulating opportunity for Al to meet students from distant lands, and to observe the imaginative and skillful techniques employed by Adair and Spicer in introducing them to the peoples of the Southwest. In learning how to communicate with American Indians with whose language and culture they were unfamiliar, the students of the Seminar were preparing themselves to exchange ideas and information with native peoples anywhere.

Participation in the Cornell Cross-Cultural Seminar seems to have marked a turning point in Whiting's career, for by then he had given up the thought of returning to Chicago to complete his Ph.D. Early in 1952 he applied for and received a 2 year appointment as District Anthropologist for Ponape, Eastern Carolines, U.S. Trust Territory of the Pacific Islands. While he was in Washington, D.C. being interviewed for this position, he renewed his acquaintance with Marjorie Grant, a nutritionist in the U.S. Public Health Service, who had been a member of the Cross-Cultural Seminar the previous summer. Within a few weeks they were married, and soon left for the South Pacific.

As far as we know Whiting did not publish anything about his work on Ponape, where he was the third anthropologist for the district after World War II. A general description of the duties and headaches of such an anthropologist is to be found in a recent publication by J.L. Fischer (1979). A brief statement indicates that Whiting, as well as others, was often at odds with the policies of the district administrator.

In spite of whatever problems he may have had, Whiting was intensely interested in every aspect of his work with the native people of the island, as attested by his collection of field notes, papers, photographs and correspondence which he presented in 1975 to the National Anthropological Archives of the Smithsonian Institution, where they occupy 7 linear feet of shelf space. Included are diaries recording daily events, correspondence and official reports, answers to questions of persons in the government of the Trust Territory, and summaries of economic conditions of the islands; a card file of notes arranged by subject covering everything from history through material culture, social and legal problems to census data; archaeology, maps, linguistics, negatives and prints; and a collection of books on Micronesia in Japanese. A Ponapean language newsletter was begun by Whiting while on the island, and several copies are in the collection.

When their tour of duty on Ponape was completed, Al and Marjorie decided to go to Guam for a year, Al to teach and Marjorie to make a survey for the U.S. Public Health Service. Leaving Marjorie on Guam, Al returned to the States, visiting Saipan and Japan en route. He planned a brief visit in Vermont with his mother and then to return to the South Pacific. However, he found that his former wife was hospitalized and he went to Denver to look after their 2 young sons. He decided it would not be possible to return to Guam that year, and so he and his sons went East and he sought a teaching position, which he found in the High School at Rockport, Massachusetts. Marjorie returned in August, and they rented a large old farmhouse near the school and close enough to Boston for Marjorie to work on her Ph.D. The following July and August, Al was at the Children's Museum of Bridgeport, Connecticut, where he conducted the Wonder Workshop. About that time he received word that he had been appointed Curator of Anthropology at Dartmouth College Museum. Whiting had at last found a position well suited to his interest and his talents, a museum where he could work with college students and where intellectual curiosity was highly regarded.

When Whiting arrived at Dartmouth College Museum he found a vast quantity of material pertaining to his department in storage, and many of the specimens lacking documentation. He spent most of his time the first years in reorganizing the storage collections, researching the origins of the specimens, and preparing new exhibits. Soon he offered to guide the museum tours for beginning Sociology classes to introduce the students to physical and cultural anthropology. This led to a weekly lab course in the museum to expose students to the various sub-disciplines in anthropology and to teach museology. He enlisted students and others as volunteer curators, who not only helped in organizing and researching the museum collections, but prepared exhibits and major shows.

In 1961 Al was promoted to the rank of assistant professor but retained his title, Curator of Anthropology; 5 years later he became Adjunct Assistant Professor in the Department of Anthropology in addition to continuing as Curator in the Museum. He taught a course each year, usually an advanced seminar, on a variety of subjects: Museum Methods, African Ethnography, Southeast Asia and the Pacific Islands, Primitive Art (which included the development of jazz and blues in America), and Primitive Technology. He supervised students with individual projects covering cultures from the Andes to the Arctic. In all these courses each student was required to prepare an exhibit case, selecting the material, preparing the case and labels, to final polishing of the glass. Whiting never seemed too busy to discuss problems and offer assistance or advice to his students, whether on the preparation of an exhibit or a personal matter. His enthusiasm for the work at hand, innovative methods and imaginative techniques of teaching, combined with his kindly manner and his wit, endeared him to students and colleagues.

During his years in Hanover, Whiting published a number of book reviews, articles on museology, and articles on Hopi life. Occasionally, he returned to the Southwest to spend a summer or a brief vacation to renew old friendships. He and several students made a survey of material culture in the pueblos of Taos and Tesuque for the Museum of New Mexico, purchasing specimens and recording copious notes. Sometimes one or both of his sons accompanied him, but not his wife for they had separated soon after he went to Dartmouth.

When the summer of 1974 arrived Al was ready to retire after 19 very demanding years, and left Dartmouth for Arizona. He spent several months in Flagstaff where he renewed his association with the Museum of Northern Arizona where he was appointed Research Ethnobotanist. He purchased a small house with one acre of land at Cornville, in the Verde Valley, Arizona, where the winters are mild and the summers hot. He especially wished to escape the Flagstaff winters, feeling that he had had enough cold and snow in New England.

He commuted to Flagstaff and the Museum once a week to work on a revision of *Ethnobotany of the Hopi*, the third printing having been sold out. During the summers of 1975-1977, he grew experimental plots of corn, beans, squash, and devil's claw, with seeds he obtained from the Hopi, Havasupai, Apache, and Papago Indians of Arizona. He was studying the genetics of these various Indian crops to determine their relationships.

From Dartmouth, Al brought with him about 12 linear feet of looseleaf notebooks filled to capacity with notes and photographs containing the results of a considerable part of his research for the previous 45 years. He hoped to prepare for publication, during the pleasant Cornville winters, the numerous manuscripts he had accumulated. All his hopes and plans suddenly came to an end when he was taken ill in the late fall of 1977 and died a few months later.

The publications of Whiting that appear in his bibliography represent only a small fraction of his interests. Before his death he arranged to leave his notebooks to Dr. P. David Seaman of Northern Arizona University, with the hope that he could have them published in the future.

Al Whiting had a brilliant, active and creative mind, always far ahead of his manual dexterity. When some exhaustive investigation was written to *his* satisfaction, his agile mind leaped ahead to the next project. He simply could not endure the tedium of writing and rewriting a text to suit an editor and so most of his major research has never appeared in print. His manuscript on the ethnobiology of the Havasupai Indians has been inspected by a number of editors but all have given up in despair upon viewing the "completed" work. Al was constantly being lured away from one interesting project to another, although he was very thorough in conducting his studies and collected vast amounts of extremely valuable information which he planned to publish. Other notes were used for teaching and as the basis for museum exhibits. He had a fertile imagination, which combined with a delightful sense of humor and a talent for words, led him to publish some charming articles and stories and contributed greatly to his success as a professor and museum curator. He also wrote many scientific papers on a variety of subjects.

The anthropological profession lost a brilliant and versatile colleague when Alfred F. Whiting died. It is fitting that the Second Annual Conference on Ethnobiology was dedicated to him as well as to his former associate at the Museum of Northern Arizona, Lyndon L. Hargrave.

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GARDENING AND FARMING BEFORE A.D. 1000: PATTERNS OF PREHISTORIC CULTIVATION NORTH OF MEXICO

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ABSTRACT.—The beginnings of deliberate plant husbandry north of Mexico were not single processes in the Eastern United States and in the Southwest. Instead there were several periods of contact with Mesoamerica which resulted in the diffusion of specific plants into these areas, and they can be grouped into agricultural complexes. The first was the Early Eastern Mexican Agricultural Complex (Gourd Agriculture Complex) arriving in the East before 3000 B.C., resulting in gardens of bottle gourds and pepo gourds. The Eastern Agricultural Complex developed before 1000 B.C. and consists of 2 domesticated plants outside their modern range of distribution. The Upper Sonoran Agricultural Complex appeared in the higher elevations of the Southwest around 1000 B.C. with corn, gourds, and slightly later with beans. Corn and beans later diffused independently from the Southwest to the East where they were added to gardens and corn fields respectively. The Lower Sonoran Agricultural Complex is found in the more arid regions of the Southwest by A.D. 500 and although it includes several species of beans and squashes, cotton, and amaranth, only *Cucurbita mixta* and cotton became important outside areas where irrigation was almost mandatory. By A.D. 1000 prehistoric contacts with Mexico resulted in the Late Eastern Mexican Agricultural Complex with the arrival of tobacco and a domesticated chenopod. In contrast to the East, the indigenous Southwest Agricultural Complex began after Spanish contact and to date only the devil's claw is recognized. The Hispanic Agricultural Complex began when Spanish immigrants transported native tropical domesticates throughout their empire. Chili, tobacco, several squashes, and imported melons, wheat and many garden crops soon were grown beyond their pre-Columbian range. Each complex was grown initially in different ecological situations and had differential impacts on recipient cultures and subsequent cultural developments.

INTRODUCTION

In 1944, when Al Whiting published "The Origin of Corn: An Evaluation of Fact and Theory" (Whiting 1944), the archaeobotanical record was inconclusive in its support of any theory. Whiting assessed the competing ideas for the botanical and cultural beginnings of the domestication of maize, but had to conclude that although some had a higher probability of verification than others, none was sufficient without archaeological plant evidence. At that time the recovery of prehistoric plant remains was mostly happenstance. In the Southwest, for example, the first modern paleoethnobotanical report, Jemez Cave by Volney Jones (1935), had been published only in summary form, and Edgar Anderson had just begun to systematize archaeological maize and ethnographic examples in the Pueblo area (cf. Anderson and Blanchard 1942).

Despite these incipient beginnings, sufficient botanical evidence was accumulating from archaeological contexts, at least in the Southwest, that Carter (1945) was able to organize the available information into a scheme that would stimulate debate for the next decade. His hypotheses, too, remained subject to confirmation from the archaeological record. Sites such as Bat Cave (Mangelsdorf and Smith 1949) supplied the maize that botanists required from archaeologists to test their ideas. In the ensuing 35 years the recovery of archaeobotanical remains has become both sophisticated and commonplace. Whiting correctly emphasized that the archaeological record is the supreme measure of theories of the domestication of plants and as a consequence hypotheses proposed by Carter and others continue to be subjected to re-evaluation.

Today, in place of an emphasis on corn agriculture which typified the era when Whiting began his field studies, attention has turned to the intricate crop history of North America north of Mexico and the cultural and ecological position of each domesticated species within a particular subsistence pattern. The intent of this paper, then, is to delineate the crop complexes of the prehistoric United States based upon the ever increasing archaeobotanical record and to discuss the implications of their addition to prehistoric economies.

DISCUSSION

Prehistoric Agricultural Complexes

The concept of a prehistoric agricultural or crop complex implies a group of species with an apparent common geographic origin and a mutual association within particular environmental parameters in which the complex developed, although afterward an individual species may experience a separate geograhical distribution and history. The idea for geographical-based complexes originated with Linton (1924), but received continental application by Carter (1945), who recognized 2 distinct groups of crop plants in the Southwest, the Gila-Colorado and Plateau, each with separate origins and routes of diffusion. In addition he distinguished an Eastern Mexican Corridor as a source of agriculture in the East, which diffused to the Plateau, and a West Mexican Corridor (Carter 1945:12). Although the importance of each area relative to Linton's and Carter's theories has changed, nevertheless their insights are apparent in the agricultural complexes previously identified by Ford (1973) and expanded and elaborated upon in this paper.

1) Early Eastern Mexican Agricultural Complex (Gourd Agricultural Complex). Present evidence suggests that the first domesticated plants in the United States originated in eastern Mexico, probably diffused across Texas, and into the Southeast and the major river systems of the Midwest. This complex consists of *Lagenaria siceraria, Cucurbita pepo,* and perhaps *Cucurbita pepo* var. *ovifera.*

2) Eastern Agricultural Complex. Linton proposed this appellation, but it was Gilmore who in 1931 interpreted enlarged seeds of several indigenous species found in Ozark shelters as prehistoric domesticates. Jones (1936) further elaborated this theme with material from Newt Kash Hollow and suggested a possible independent origin of agriculture in the East. Although Mexican cultigens apparently precede these local domesticates, they did undergo a series of changes resulting in domestication, but they were never grown outside the East and the river valleys in the Missouri drainage. The domesticates are *Helianthus annuus* and *Iva annua.* There is a possibility that *Phalaris caroliniana* and *Chenopodium bushianum* were introduced and cultivated beyond their modern range without recognizable genetic modifications, however.

3) Upper Sonoran Agricultural Complex. Mountainous regions about 2000 m with sufficient precipitation for dry farming in southwestern New Mexico and southeastern Arizona were the first areas where crop plants from Mexico became established in the Southwest. This region coincides with the Upper Sonoran Life Zone in the Southwest and in the Sierra Madre Occidental of northern Mexico. These crops correspond to Carter's Plateau group, although he derived them from the eastern United States (Carter 1945:222). The crops in this complex are *Zea mays, Cucurbita pepo, Lagenaria siceraria,* and *Phaseolus vulgaris.* Corn and beans eventually were brought from the Southwest to the eastern United States.

4) Lower Sonoran Agricultural Complex. The crop plants constituting this group are tolerant of high temperatures but generally require supplemental moisture from irrigation. They probably were introduced from the Sonoran basin-and-range physiographic region of western Mexico characterized as the Lower Sonoran Life Zone into the Sonoran Desert region of southern Arizona. Despite its limited distribution, this complex, which is Carter's Gila-Colorado group, has the greatest variety of crops: *Gossypium hirsutum, Phaseolus acutifolius* var. *latifolius, Phaseolus lunatus,* perhaps *Phaseolus coccineous, Cnanvalia ensiformis, Cucurbita mixta, Cucurbita moschata,* and, *Amaranthus hypochondriacus.*

5) Late Eastern Mexican Agricultural Complex. Two plants, *Nicotiana rustica* and *Chenopodium berlandieri* var. *nuttalliae,* are found growing in Mexico and were part of the latest prehistoric record only in the East.

6) Southwest Agricultural Complex. The domestication of indigenous Southwestern plants has no recognizable archaeological history. Nevertheless, at least one native species, *Proboscidea pariflora,* is a domesticate today.

7) Hispanic Agricultural Complex. European contacts introduced many new crop plants of Eurasian and African origin to the Indians. In addition, these explorers brought previously unfamiliar domesticated plants from Mesoamerica and South America to the northern latitudes. The Spanish, in particular, had a profound impact on the distribution of crop plants, and their role will be described briefly.

Early Eastern Mexican (Gourd) Agricultural Complex (Fig 1)

Until recently it was common knowledge that agriculture was earliest in the Southwest and that corn had priority. This perspective has changed as a result of new excavations, and the East now appears to have received the first crops from Mexico, and its agricultural history was independent of the Southwest for at least 3000 years.

Cucurbita pepo L. and *Lagenaria siceraria* (Mol.) Standl. The evidence for squash and bottle gourd in the eastern United States dates back at least 4500 years and is derived from several contrasting archaeological contexts. Carbonized rind fragments of squash have been recovered through flotation at Koster, surprisingly dated between 6000 and 7000 B.P. (Asch and Asch 1979), at Carlston Annis and Bowles on the Green River in Kentucky (Marquardt and Watson 1977), and at Bacon Bend (21-2400B.C) and Iddins (1500 B.C.) in eastern Tennessee (Ferguson 1978:760). Iddins also yielded gourd. Uncharred, water saturated squash and gourd seeds and rind fragments have been excavated at Phillips Springs dated to 2000-2300 B.C. (Chomko and Crawford 1978; Kay 1979). Elsewhere, desiccated squash and gourd rind and seeds from the yellow flowered egg-gourd (*C. pepo* var. *ovifera*) were excavated in 1978 from early Late Archaic contexts at the Cloudsplitter Rockshelter, Kentucky.

The only comparable plant assemblage in northeastern Mexico is from the Tamaulipas excavations by MacNeish (1958, 1971). The Infiernillo and Ocampo phases, dated between 9000-5000 years ago, both contain squash and gourd and show the absence of corn. Although in Ocampo chili peppers and domesticated beans are present, neither is found north of the lower Rio Grande. The Mexican crop complex was introduced by diffusion from band to band and was grown in gardens as a complement to a pre-existing hunting and gathering economy based on climax forest products (Ford 1974, 1977a). The horticultural disturbance of the native plant communities formed a fertile bed for pioneer annuals and eventually late in the eastern Archaic for 2 tropical farm weeds, purselane (*Portulaca oleracea*) and carpetweed (*Mollugo verticillata*) (Chapman et al. 1974).

Squash and gourd husbandry were disseminated northward and westward during Late Archaic and Early Woodland times. Squash is reported dating back to 1000 B.C. at Sparks Rockshelter (Applegarth 1977), to 870 B.C. at Meadowcroft (Adovasio et al. 1978:649), and from Riverton (Yarnell 1976). Squash and gourd are both reported from 600 B.C. contexts in Salts Cave (Watson et al. 1969) and Newt Kash Hallow (Jones 1936). By 500 B.C. squash was grown at Leimback in northern Ohio (Shane 1967) as evidenced by rind fragments and at the Schultz site in Michigan as evidenced by a *pepo* seed from a sealed, uncharred vegetation lens (Wright 1964) and by a *ovifera* seed cast in an Early Woodland sherd (Ozker 1977). A "Mandan" variety squash seed found in a Woodland context has been identified from Boney Spring, Missouri (King and McMillan 1975).

The importance of the Eastern Mexican Agriculture Complex changed by Middle Woodland times in the Midwest. Prior to this period both squash and gourd were used for containers and the seeds were eaten. However, with an increase in the variety of uses for ceramic vessels, the seeds probably were still consumed, but more squash may have been selected for its edible fleshy quality rather than for a hard rind. Gourd rind remains now predominate (Ford 1980), and a gourd shaped pot was found in the Brangenberg Mound (Struever and Vickery 1973:1205).

Cucurbita pepo var, *ovifera* Alef. The history for the domestication of the egg gourd is not known. Morphologically it is similar to wild *Cucurbita texana* Gray of southern Texas, but whether it is ancestral to the domesticated form is a moot question (Cutler and Whitaker 1961:478). Remains of this small seeded, hard rind squash have been found in Cloudsplitter, the Schultz site, and at several very late prehistoric sites in the East. Otherwise, its actual importance to the prehistoric cultures is unknown.

The Early Eastern Mexican Agricultural Complex was the basis of plant husbandry in the East and continued to be grown until historic times. By A.D. 250 squash agriculture reached westward to Trowbridge in the Kansas City area (Johnson 1976:14) and afterward into the tributaries of the Missouri and into the Northeastern States (Yarnell 1964).

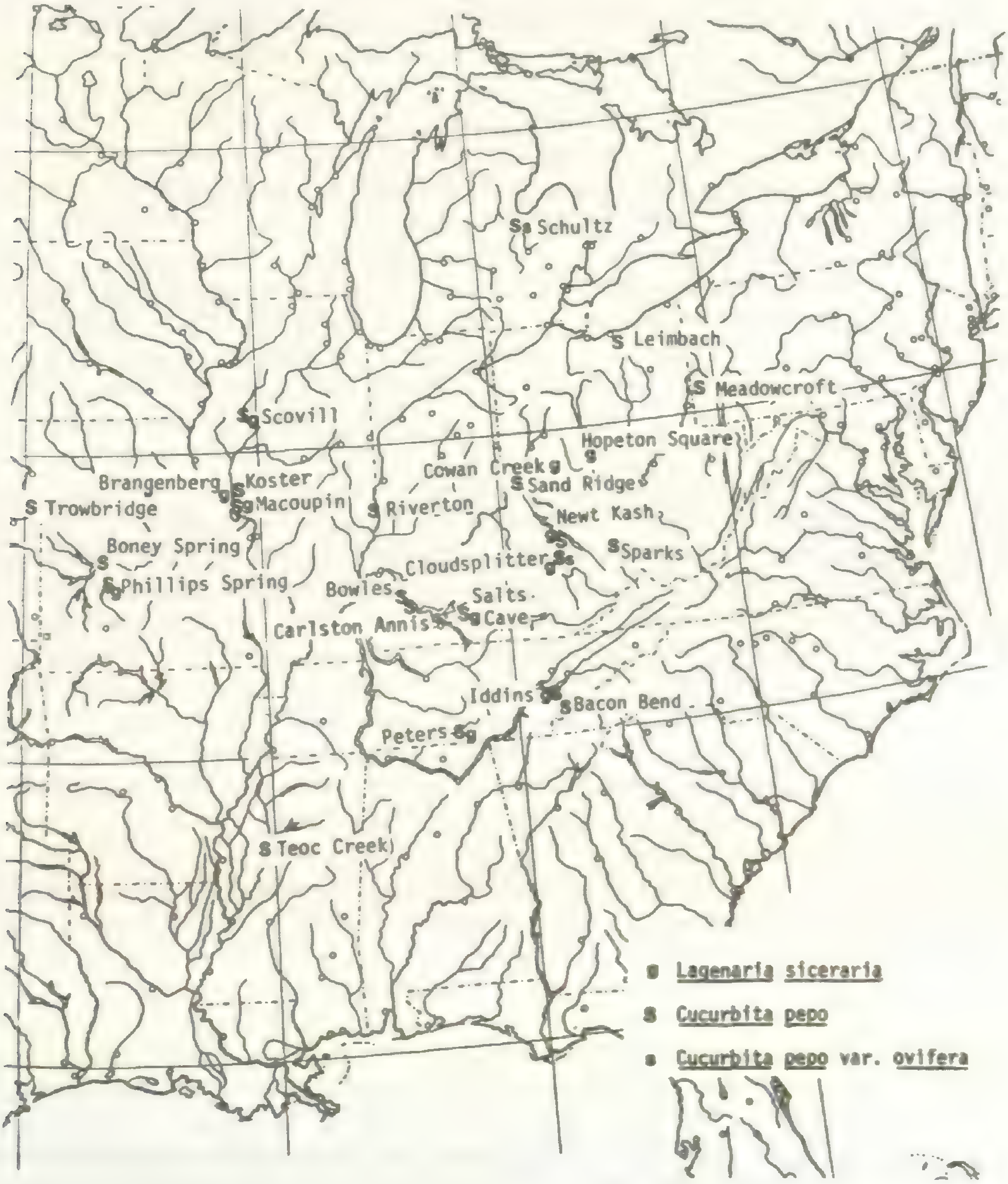

FIG. 1.— Early Eastern Mexican Agricultural Complex (Gourd Agricultural Complex).

Eastern Agricultural Complex

It now appears that the domestication of native plants in the East followed the introduction of tropical cultigens from Mexico. At the Koster site archaeological sumpweed shows no demonstrative change until long after garden horticulture began (Asch et al. 1972) and at Cloudsplitter evidence of squash precedes any seeds of native small seed cultigens.

Helianthus annuus L. Yarnell (1978) recently reviewed the archaeobotanical evidence for the increase in achene size as an indicator of the domestication of the sunflower starting in the Late Archaic. The earliest evidence for this 3500 years of development is derived from Salts Cave and Mammoth Cave in Kentucky and the Higgs Site in Tennessee. Increasing size is recognized in achenes from Middle and early Late Woodland contexts in the same geographical area. The sunflower apparently was another garden plant whose dietary importance was quite differential and localized in the East until Late Woodland times. No sunflower has been found in Ohio Hopewell sites, and it is reported from only one Late Woodland site, Sand Ridge, in Ohio (Featherstone 1977) until after A.D. 900. Then, apparently accompanying the evolution and diffusion in Late Woodland or Mississippian time of field agriculture, it became more important, and further selection produced achenes twice as large as those from Middle Woodland sites, especially in the Plains and Ohio River valley (Yarnell 1964, 1978).

Iva annua L. Unlike sunflower, when Jones (1936) first proposed the aboriginal cultivation of marsh elder or sumpweed, its use was unknown in the ethnobotanical literature. Since then, its botanical status as a domesticate has been established (Blake 1939), its prehistoric distribution beyond its modern range has been described (Black 1963), and its archaeological stages of domestication have been clarified (Yarnell 1972, 1978). Most recently Asch and Asch (1978) have discussed its ecological needs and its nutritional contribution to the prehistoric diet. Its history as a recognized domesticate, *Iva annua* var. *macrocarpa* Jackson, begins in the Late Archaic in Illinois and the Kentucky shelter area and continues in the central Midwest until historic contact. Although it may have been grown in some localities in the absence of other crops, e.g., Fisher-Gabert in Missouri (Robinson 1976:103), it appears to have been supplemental to other crops even when grown in Mississippian fields where its fruits were several times as large as their wild ancestor's.

Chenopodium bushianum Allen. The status of lambs-quarters in the East was ambiguous until Asch and Asch (1977) provided the systematics for most archaeological finds, eliminated *C. album,* an Old World introduciton in historic times, from contention, and demonstrated that no archaeological seeds have been found that are larger than the normal range of natural variability within native seed populations. However, this does not lead to the conclusion that it was not deliberately tended and cultivated in the gardens and fields where it volunteered or was planted. In fact, evidence from Cloudsplitter Rockshelter suggests that, indeed, it may have been planted in that part of Kentucky since an extensive ecological survey and herbarium search has failed to locate it today within miles of the site. Nevertheless, the seeds and even the inflorescence are recovered in quantity from the deposit suggesting its cultivation without concomitant domestication.

Phalaris caroliniania Walt. A similar situation applies to maygrass. Its presence in the Kentucky shelters and sites in eastern Tennessee beginning with the Late Archaic is beyond modern distribution established for it in a review by Cowan (1978). It is rarely recovered outside Kentucky or the Southeast, and has only been found at 2 sites north of the Ohio River (Featherstone 1977). In Arkansas archaeobotanical remains are within its present range. Cowan believes maygrass to be another starchy, small seed annual which attained garden status in the Late Archaic and was brought by humans to the northern limits of its maximal range.

Other plants at one time or another were considered to be native domesticates. Giant ragweed, *Ambrosia trifida,* whose large seeds from the Ozarks, thought by Gilmore to be domesticated, are actually the product of natural hybridization where clines of different seed sizes converge (Payne and Jones 1962). *Amaranthus* spp. is not a common seed in eastern sites and those found are not unusual in any botanical or cultural sense. *Polygonum erectum* was collected in quantity in the Illinois River valley and may have a local status similar to maygrass and chenopod (Asch and Asch 1978). Other plants found in quantity were simply extensively collected or were tended in the course of preparing gardens or fields, but none demonstrates genetic changes or dependence upon humans for the survival of the species (Yarnell 1977:870). To date archaeobotanical evidence demonstrates that only sumpweed and sunflower underwent actual genetic modification while chenopod and maygrass probably were introduced by humans to new environments and maintained there by them.

Upper Sonoran Agricultural Complex (Fig. 2)

Since 4 plants — corn, squash, gourd, beans — were first cultivated below the frost line in southern Mexico, they have been called the Tropical Agricultural Complex. For several thousand years, however, they were not the staple of any prehistoric diet, despite widespread transmission to many areas. In northern Mexico they were grown by nomadic hunters and gatherers who probably learned about each through visitations and through marriage with people from bands who cultivated one or more of these crops. Here an early form of Chapalote-type maize is recognized from an undated preceramic horizon in Swallow Cave, Chihuahua (Mangelsdorf and Lister 1956). Unfortunately, other early agricultural sites in northern Mexico are even less well-documented than this one.

Zea mays L. When maize first entered the southwestern United States remains debatable. A reassessment of Bat Cave maize gave it a post-2300 B.C. chronological placement (Mangelsdorf et al. 1967), but considering the interpretive problems caused by the excavator employing arbitrary stratigraphic units and by the pooled carbon samples for dating from within these 12 inch levels, the most reliable date is A.D. 198 on cobs from the top levels. Cultural evidence does support a preceramic date for most of the site without it necessarily dating before 1000 B.C. Similar difficulties confuse the interpretation of maize pollen from Cienega Creek. At one time a series of solid carbon dates yielded an age as early as 2200 B.C. (Haury 1957; Martin and Schoenwetter 1960). The redating of the deposits by the carbon dioxide gas proportional technique, however, produced dates for the lowest bed (D-1) averaging 500 B.C. (Michael Berry, personal communication, 1979). Other reputed early agricultural sites are equally problematical or have not been adequately published to permit a thorough evaluation. Stratigraphic difficulties caused by arbitrary excavation procedures plague LoDaisKa (Irwin and Irwin 1959), and a description of the stratigraphic association of the cobs from Fresnal Shelter (Wimberly and Eidenbach 1972) and of the maize pollen from En Medio in the Arroyo Cuervo region (Irwin-Williams and Tompkins 1968) as they relate to their assigned dates is lacking. Consequently, available evidence, as meager as it is, from Bat Cave, Tularosa Cave, and the undated deposit beneath the 490 B.C. (Ford 1975) level in Jemez Cave suggest that corn was introduced into the Southwest about 1000 B.C.

The phenotypes of the earliest maize reflect considerable genetic diversity. Although the "tiny" Bat Cave cobs have been reidentified as terminal portions from larger cobs (Mangelsdorf 1974: Figs. 14.1, 14.2), nonetheless the assemblage of preceramic cobs from this site demonstrates a greater range in size and an overall lower productivity than later Pueblo maize. Similar variability is evident in the desiccated cobs from Jemez Cave (Jones 1935), Tularosa Cave (Cutler 1952), and Cordova Cave (Kaplan 1953a). All early corn north of Mexico belongs to the Chapalote series (Winter 1973: 442), a small cob, popcorn.

A major developmental process which occurred in the first millenium B.C. was the introgression of this initial Chapalote type corn with teosinte. No teosinte fruits or plant parts have been found in the southwestern United States so it undoubtedly happened in northern Mexico, and corn with this germ plasm passed from one field of these high elevation hunters and gatherers to the next. The result was that by 500 B.C. even greater variation in row number, cob length, and cupule structure appears in cobs from Bat Cave

(Mangelsdorf et al. 1967), Tularosa Cave (Cutler 1952), and Jemez Cave. Some of the hybrid cobs were larger and more productive than those grown before introgression while others from the same population were less so.

A second influence on early Southwestern maize development is more controversial. This is the presence of 8-rowed corn or Harinoso de Ocho. This corn provided a higher yield, a greater range of adaptability, and easier grinding because of its large flour kernels. Harinoso de Ocho or Maiz de Ocho (Galinat and Gunnerson 1963: 121) is reputed to have originated in South America as the Cabuva race of Columbia, a derivative of Confite Morocho pop corn of Peru (Mangelsdorf 1974:687). However, Brown, in his review of Mangelsdorf (Brown 1974:687), rejects this putative ancestry of 8-rowed maize in North America. Despite its uncertain paternity, an 8-row maize genetic element does interbreed with preceramic maize within centuries of the appearance of teosinte introgressed maize.

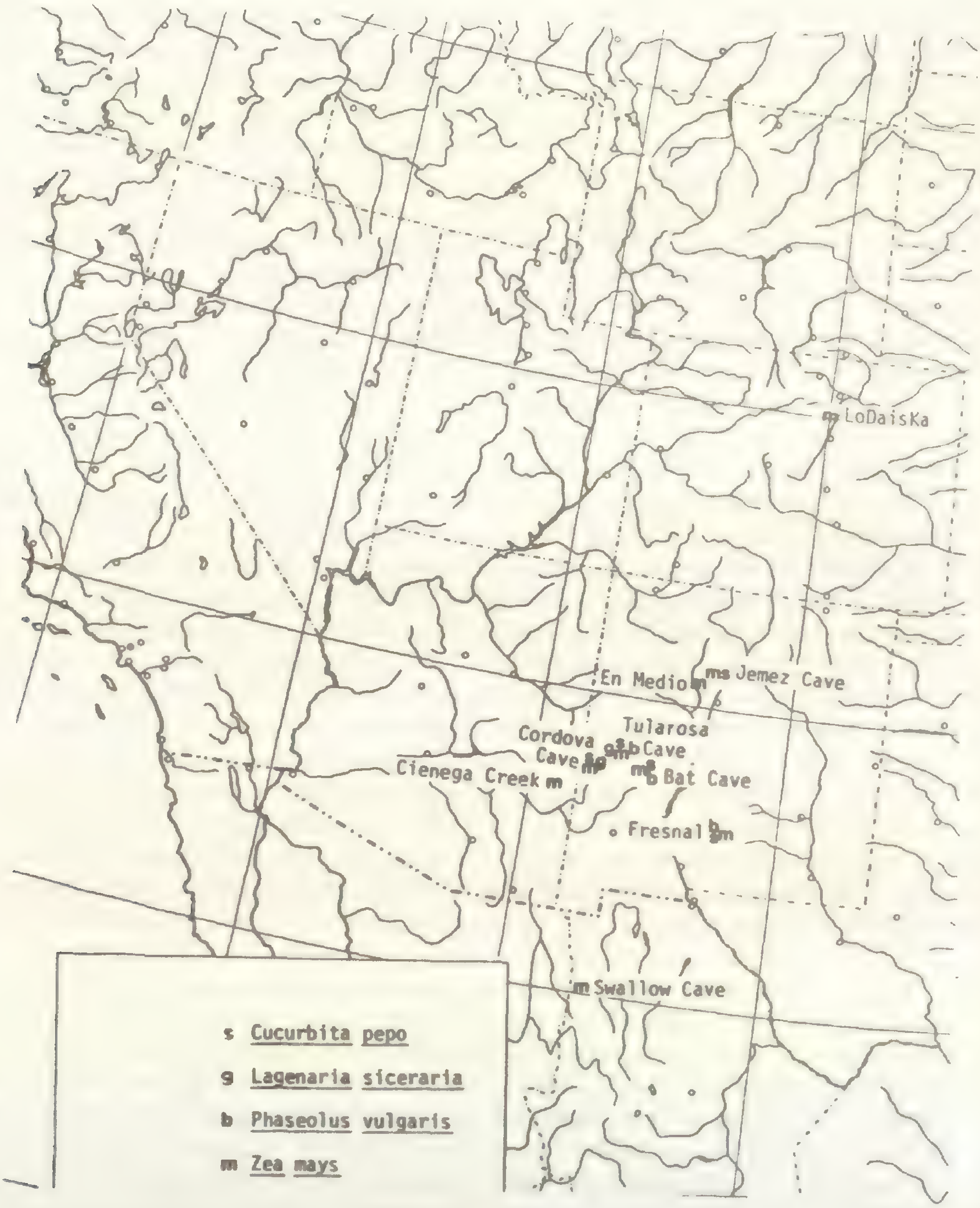

FIG. 2.—Upper Sonoran Agricultural Complex.

From the genetic variability present by 300 B.C. in the Upper Sonoran early maize, all further corn types in the Southwest could be bred. Its potential development was not immediately appreciated by these casual nomadic farmers. Productivity remained variable and seasonal security appears to have been more important than future surplus. Factors other than the presence of a certain type of maize have to be considered for the beginnings of more sedentary communities, increased population sizes, and other cultural developments. If Jemez Cave is illustrative, from 900 B.C. or so until a few centuries A.D., small groups of farmers occupied the shelter for a few weeks to plant and later return to harvest whatever grew. Selective breeding is not evident, competition with field weeds was permitted, and some years the corn was picked before maturity. Maize simply augmented their fall season diet.

With the spread of maize and the beginnings of more sedentary life-ways, corn production is for a surplus and different morphological types can be identified as a result of cultural and natural selection. In the Hohokam area of southern Arizona, for example, the corn did not have to be of Mexican derivation despite the argument for Mexican intrusion (Haury 1976:117). The earliest Vahki phase maize has been identified by Cutler and Blake (1976:365) as Chapalote, the earliest type in the Southwest; Reventador, a by-product of Chapalote crossing with teosinte; and Onaveno, the flint type of Pima-Papago corn which is thought to be a derivative of a Chapalote series corn crossing with 8-rowed maize. Even the drought resistance required for successful reproduction in this desert environment could have evolved north of Mexico. The so-called Pima-Papago corn found in the Hohokam area and elsewhere resulted form Chapalote crossing with 8-rowed maize and consists of flint (Onavena) and flour (Maiz Blando) types which are single gene mutations that can occur anywhere (Anderson 1945:82). Even at Casas Grandes all of these Southwest corn varieties continued to occur (Cutler and Blake 1974:309).

Similar *in situ* developments are detectable elsewhere. In the Rio Grande valley at BR-45, dated to 18 B.C., Maiz de Ocho and Pima-Papago are recognizable (Galinat et al. 1970:328). Chapalote, however, continued as a popular type as late as A.D. 1450 at Rainbow House, Bandelier National Monument (Mangelsdorf and Galinat 1966). In southwestern Colorado Chapalote and Pima-Papago are present from Basketmaker to the abandonment of Mesa Verde, although the relative frequency of various types changed over time (Jones and Fonner 1954; Cutler 1963; Cutler and Meyer 1965). This generalization applies to Glen Canyon as well (Cutler 1966:13). Much more research is required before we can explain the emergence of recognizable morphological types and the reason why some sites have very few types of maize while others at the same time were growing a wide variety.

If the previously described varieties or races of corn had multiple origins in the Southwest proper, the question of continued Mexican sources of new corn types or genetic material must be considered. Certainly it was possible, and the absence of teosinte in the American Southwest provides one clue. Sites such as Cebollita Cave in which the earliest corn, dated A.D. 1050, is Chapalote, but younger maize from here (Galinat and Ruppé 1961) and from Richard's Cave near Montezuma Castle have comparable degrees of apparent teosinte introgression (Galinat et al. 1956). Their cob morphology is better explained by problems, perhaps heat stress, during pollination and growth rather than by any teosinte derived genes.

Fremont Dent maize poses an interesting problem. Cutler (1966:16), following Anderson (1948), proposes that the distinctive pyramidal cob and kernal form are evidence for the diffusion of a Mexican race, Conico Norteno, through western Arizona into the Fremont area 1000 years ago. If true, then this would represent affirmation of Mexican contact. Winter (1973), however, disputes this explanation for several reasons. First, Fremont Dent is actually earlier than the dates given by Cutler and dent corn in Zion and northwestern Arizona could have moved southward, not northward. Second, he concurs with Galinat and Gunnerson (1963) that the effect of early teosinte germ in Chapalote type corn crossing with 8-rowed corn could have produced a variety of mutant forms some of which have been selected for further breeding. The consequence was diversification within the Fremont corn types and an *in situ* rather than an exogenous source for this distinctive maize. Otherwise, dent corn does not appear in the Southwest until the reconquest of New Mexico following the Pueblo Rebellion (Cutler and Blake 1969a).

Cucurbita pepo L. In the Southwest the first squash is as early as corn. It is present in the bottom midden level at Bat Cave (Dick 1965), and with the possible exception of Cordova Cave (Kaplan 1963a:355), it is in all preceramic sites where cobs are found. The earliest examples are of one variety; however, by A.D. 900 several varieties were grown. Whether these were developed locally or represent further contacts with Mexican agriculturalists is unresolved.

This squash was grown everywhere in the Southwest (Cutler and Whitaker 1961:471), including Casas Grandes (Bohrer and Fenner 1974) (Fig. 5), and continued to be grown even with a minimum of care in a variety of climatic situations. Its edible seeds and flesh rendered it an important fruit throughout Southwestern prehistory.

Lagenaria siceraria. The bottle gourd which produces an edible seed and durable rind useful for containers apparently was transmitted into the Southwest after corn and squash; 300 B.C., dates for Tularosa and Cordova caves, is generally given for its arrival. Like squash it was not found at every preceramic agricultural site. For example, it was not present in Bat Cave (Smith 1950) or in Jemez Cave (Ford 1975). Its eventual distribution was conditioned by local climate and cultural practices. Where the growing season in more northern latitudes was cool and short, the gourd could not grow successfully. Thus, it is missing in many Glen Canyon sites (Cutler 1966) and is rare in Mesa Verde (Cutler and Meyer 1965). Thick rinds of *C. pepo* and *C. mixta* were used for containers in these areas. Although gourd rind fragments have been found in many sites throughout the Southwest (Cutler and Whitaker 1961:473), the absence of peduncles and seeds suggests that it may have not been grown that widely and that trade may account for its presence in some localities.

Phaseolus vulgaris L. The appearance of the common bean in the Southwest is after corn, squash, and perhaps gourd, but the date is uncertain. Part of the confusion results from the dating of level IV in Bat Cave in which beans first are found, of Tularosa and Cordova caves where beans are found in all levels, and of Fresnal shelter which yielded beans in preceramic levels. A 300-500 B.C. date may be generally acceptable. Beans were not present in Jemez Cave (Jones 1935) or En Medio (Irwin-Williams and Tompkins 1968). Common beans are found initially in the Mogollon area, and Kaplan (1956) defines the greatest number of his types in this cultural region. Elsewhere common beans were grown by the Hohokam before later species of beans (Bohrer 1970), and they continued to be part of Sonoran Desert sites into historic times (Cutler 1956) (Fig 4). At the higher elevations they were introduced northward into the Durango Basketmaker II after A.D. 400 and westward, and at most Pueblo sites they were the only beans raised.

Kaplan (1965a) has stressed the complementarity of the high lysine amino acid in beans with corn protein. The dietary significance of the Upper Sonoran Crop Complex would have been realized by sedentary communities and pueblos with large populations in Pueblo III time as vegetable protein became increasingly important. Despite their late preceramic presence in the Southwest, common beans increased in frequency in sites with pottery. Kaplan suggests this is a consequence of improved cooking technology and more efficient utilization of their nutritional value.

Eastward Diffusion of Corn and the Common Bean (Figs. 3, 6)

Because squash and gourd husbandry was widely practiced in the East, the only Upper Sonoran Complex crops which are detectable as introductions from the Southwest are corn and the common bean. Available evidence continues to support the established contention that they diffused independently of each other (Yarnell 1964).

Historically, the most frequently asked questions have been when did corn enter the eastern United States? How many types were introduced? How significant was corn agriculture in the cultural development of the Midwest?

Present evidence supports the conclusion that corn was present in the East sometime after 500 B.C. Corn remains, which are awaiting description, have been dated at 340 B.C. and 375 B.C. at Meadowcroft Rockshelter (Adovasio et al. 1978:649). A small cob of Chapalote-like flint corn from Daines II Mound near Athens, Ohio, has a date of 280 B.C. (Murphy 1971), and several cobs are dated 80 B.C. at Jasper Newman in Illinois (Struever and Vickery 1973: 1200). A fragmentary cob is associated with late Early Woodland pottery at Hornung in northern Kentucky. By A.D. 450 examples are found from Ohio Hopewell sites (Culter 1965), including the recently excavated Hopeton Square and Edwin Harness Mound (Ford 1980), from Illinois (Struever and Vickery 1973; Cutler and Blake 1973:26-27), and from the Peters site in southern Tennessee (Ferguson 1978:760). Further west corn is present at Renner and Trowbridge, 2 Kansas City Hopewell sites, around A.D. 250 (Johnson 1976:14).

Perhaps Jones (1968:85) answers the second question best by stating that "...all aboriginal corn types of North America north of Mexico were derived from a highly diverse gene pool in the Southwest." Indeed, the early corn in the Midwest is as diversified as that in New Mexico at the same time (Ford 1980). It has elements identified with Chapalote derived maize as well as Maiz de Ocho. With this range of variation present, it is not necessary to postulate successive introductions of new corn types. As corn was introduced into the northern latitudes, natural and cultural selection favored attributes of rapid germination in cool, moist soil and quicker maturation for a shorter growing season. There is no reason that the Northern Flint (Brown and Anderson 1947), which came to dominate the Upper Missouri and Northeast (Yarnell 1964) and which later was introduced into the Mississippi Valley and the Southeast, could not have evolved in the upper Midwest as suggested by a reduction in row number frequencies from 12- and 14-row to 8-row (Cutler and Blake 1969b).

The significance of maize in the subsistence economies of the Midwest is not appreciable until after A.D. 800. Although direct evidence is absent, corn appears to have been

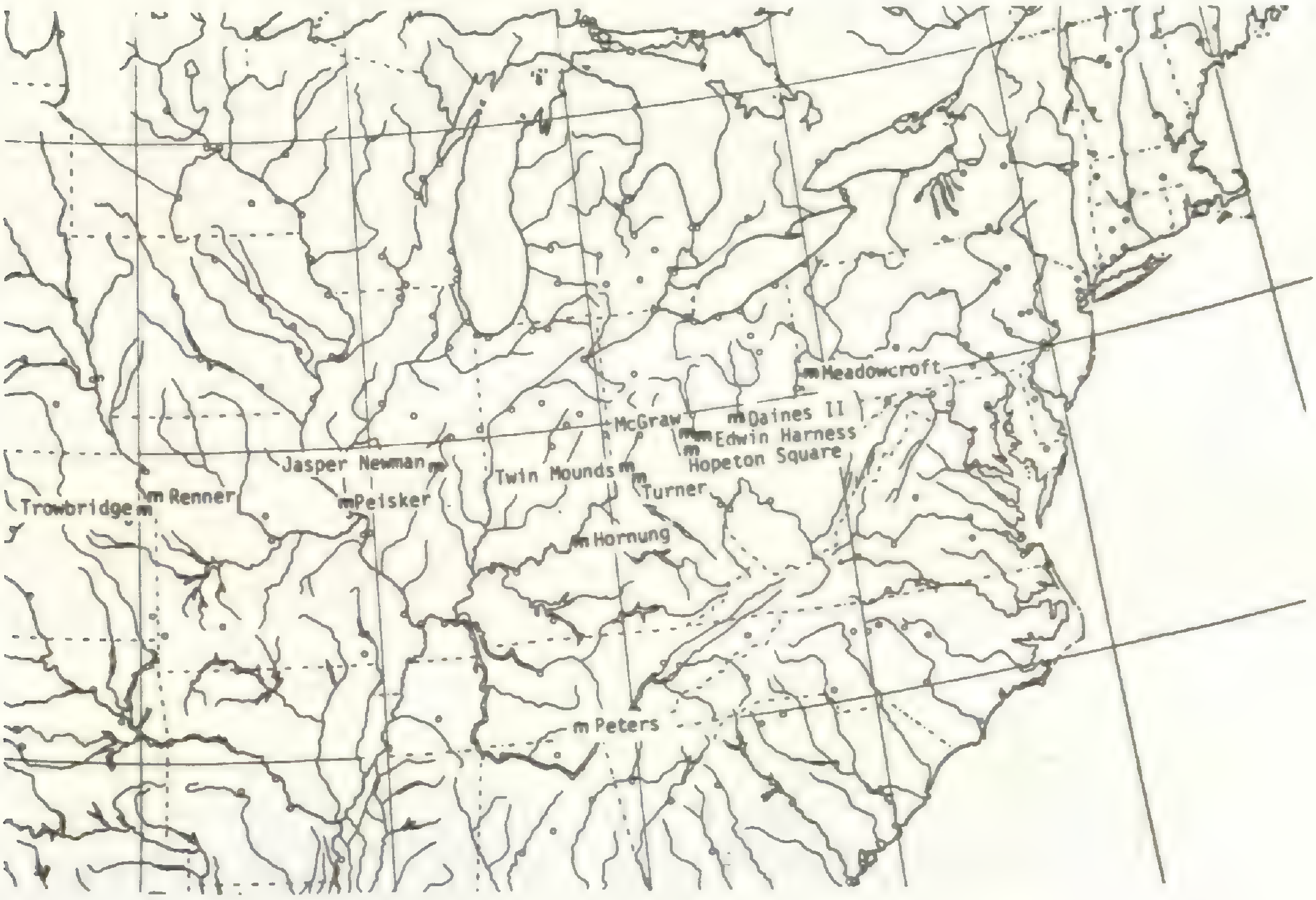

FIG. 3.—Eastward diffusion of maize from the Southwest.

introduced from the Southwest across the southern Plains and into the Midwestern riverine area. In this region gardening was well established and corn apparently was added to the squash, gourd, sunflower, and sumpweed that were already being sown. Initially, it was another garden crop contributing added security against failure of native nut meats and seeds, and did not become a staple until the Late Woodland period (Ford 1977a). The cultural changes which selected for corn as a major subsistence crop with the emergence of Mississippian cultures are presently the focus of extensive investigations (cf. Braun 1977). Ecologically, gardens became secondary to field agriculture in the production of staple calories for the expanding Mississippian populations. As corn became more important , no single race of corn accounts for this transition. In fact, although corn types or races became more distinct through cultural selection and increased dependency, several races continued to be raised simultaneously as Cutler and Blake (1969b) have shown for Cahokia. Even with the high productivity of Maiz de Ocho in the northern latitudes here, too, earlier types of Chapalote-like small flint corn continued to be cultivated as evidenced by maize from Hardin Village (Hanson 1966:169) and Upper Missouri sites (Cutler and Agogino 1960).

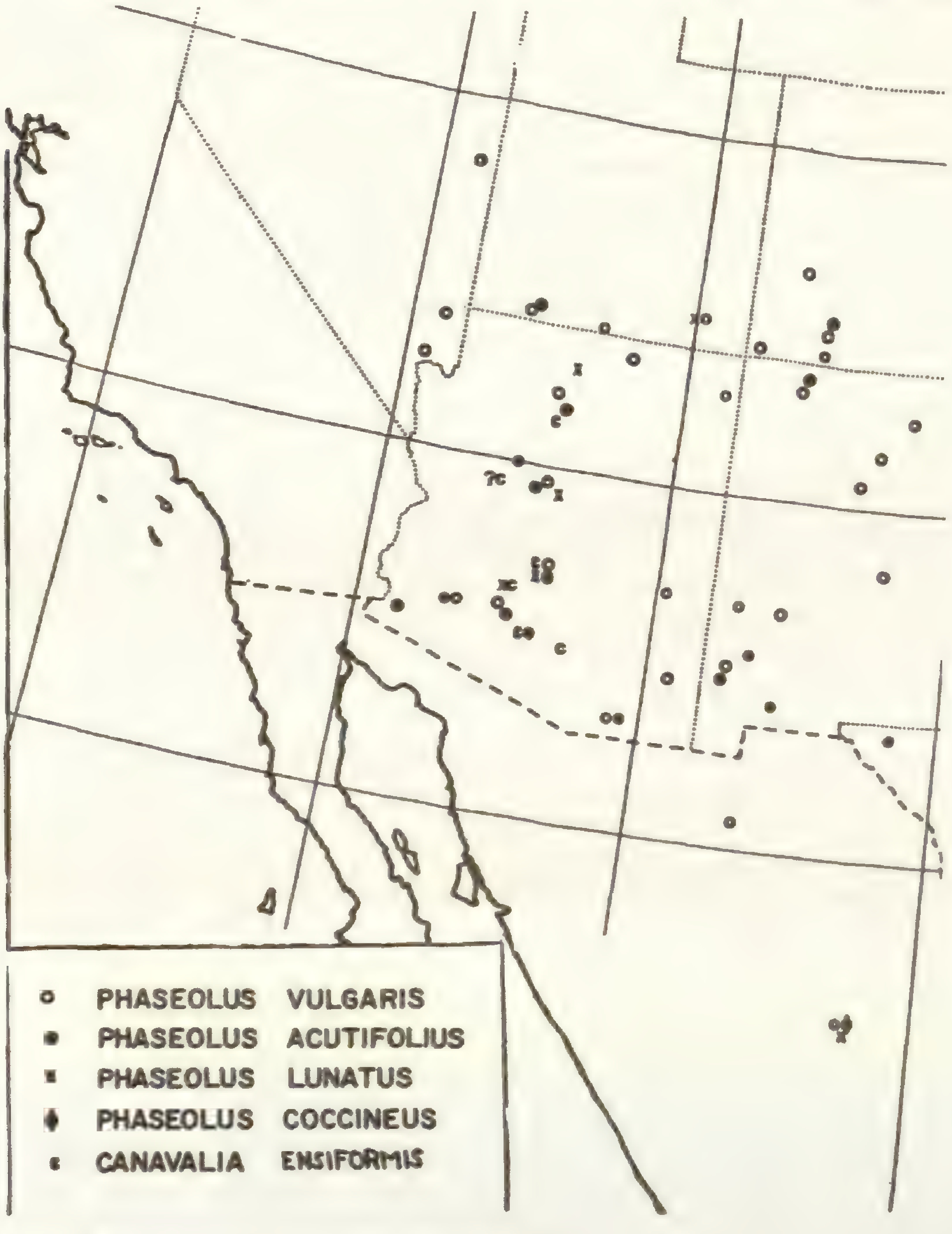

FIG. 4.—Lower Sonoran Agricultural Complex: beans.

Phaseolus vulgaris is the only domesticated bean to reach the prehistoric eastern United States, and it did so by a still undefined route from the Southwest after A.D. 800 (Yarnell 1976:272). By A.D. 1000 (Fig. 6) beans are found in confirmed archaeological contexts from the Mitchell site in South Dakota (Benn 1974:66) eastward to the Blain village in Ohio (Kaplan 1970:228) and the Roundtop site near Binghamtom, New York (A.D. 1070±80) (Yarnell 1976:272). (A single charred "bean" was found at Renner in an A.D. 1-500 context, but its disintegration prevented botanical confirmation [Wedel 1943:26]). With the addition of the common bean the trinity of corn, squash, and beans was complete in the East, and it was undoubtedly incorporated immediately into the field agriculture mode of production (Ford 1974).

Lower Sonoran Agricultural Complex

Unlike the previous complexes which were transmitted to or developed by seasonally nomadic bands, this crop group was introduced to the sedentary canal irrigation farmers of the Sonoran Desert. Although a precise Mexican region for its origin has not been specified, contact, most likely trade, brought cotton, amaranth, and several species of beans and squash to the hot river valleys occupied by the Hohokam and their neighbors. From southern Arizona there was differential introduction of some species to other archaeological areas where the Upper Sonoran Agricultural Complex was already established, but only the green striped cushaw squash attained relative importance as a subsistence item in these regions.

FIG. 5.—Lower Sonoran Agricultural Complex: squash.

Gossypium hirsutum var. *punctatum (Gossypium hopii).* Cultivated cotton and loom weaving first appeared in the Hohokam area at an unresolved date. If Haury's (1976:332-337) Snaketown sequence as suggested by several radiocarbon dates and alternative interpretation of the archaeomagnetic data is employed, then cotton first appears after A.D. 500 which is reasonable since this date reduces the lag between its beginning at Snaketown and its initial eighth century appearance in the Kayenta area (Bohrer In Press). An absence of seeds and plant parts outside southern Arizona supports the hypothesis that cotton textiles and cordage were traded northward to the Anasazi and eastward to the Mogollon for several centuries before they were grown in these areas. Cotton was continually traded throughout the Southwest with certain later sites such as Antelope House (Magers 1975) proposed as production centers. Cotton was grown in the Mimbres area after A.D. 1100 (Paul Minnis, personal communication) and may have been grown as far north as Glen Canyon (Cutler 1966). Most sites with abundant evidence in the form of seeds, bolls, and textiles are dated after A.D. 1100 (Bohrer In Press).

Phaseolus acutifolius Gray var. *latifolius* Freeman (Fig. 4). The tepary bean is associated with the Hohokam and the Pima and Papago (Castetter and Bell 1942). Its adaptation to an arid environment has recently been reviewed by Nabhan and Felger (1978). The history of the tepary bean is somewhat confused because wild forms extend from southern Arizona throughout western and southern Mexico. Until the discovery of tepary beans in the Abejas Phase, dated 5000 years ago, in Tehuacan (Kaplan 1971), archaeobotanical evidence from the Southwest pointed to that area for its domestication. Kaplan, however, recognized 8 varieties in the Southwest, indicative of endemism, which suggests multiple origins including the Southwest and western Mexico, for this domesticate.

The best guess for the beginning of tepary bean husbandry in the Southwest is about A.D. 500. By A.D. 760 it was in the Durango Basketmaker area (Kaplan 1963b:47). The first authenticated tepary from Snaketown actually dates shortly later (Jones 1942:32), and a similar A.D. 900-1100 date is applied to teparies from Punta del Agua (Bohrer et al. 1969:4), but this late occurrence is assumed to be a site sampling problem. After A.D. 1100 teparies occur as far east as the El Paso area (Ford 1977b), in the Mogollon region (Cosgrove 1947), Kiet Siel, at Zion in Utah (Kaplan 1956), and are frequently found in Lower Sonoran sites—Tonto (Bohrer 1962), Tuzigoot and Montezuma Castle (Kaplan 1956), and Babocomari (Jones 1951:16). Tepary has not been found archaeologically in the upper Rio Grande Valley, at Mesa Verde (Kaplan 1965b), or in Glen Canyon and northward in Utah.

Phaseolus lunatus L.(Fig. 4). The sieva bean poses still another question about origins and diffusion into the Southwest. This small lima bean was domesticated independent of its larger relative, the lima bean, of South America (Kaplan 1971:418). It is found in Tamaulipas before 1100 years ago and in northern Durango after A.D. 600, although the type (L-6) is not found in the Southwest (Brooks et al. 1962:359). Gasser (1976:23) reports a possible sieva bean from Pueblo Grande, and like the others excavated at Tonto (Bohrer 1962), Montezuma Castle (Kaplan 1956), and the 2 Anasazi finds, none date before A.D. 1100. Sieva beans have not been recovered in Mogollon sites, and overall this bean is rather rare in the Southwest.

Phaseolus coccineus L. (Fig. 4). The scarlet runner bean has been confirmed from the Rio Zape in Durango (Brooks et al. 1962:364), but other finds, such as the charred cotyledon from Snaketown (Bohrer 1970), Kaplan has questioned (Nabhan 1977:147). Gasser (1976:23) has identified one runner bean from an unprovenienced collection from Pueblo Grande. An assessment of the literature supports Nabhan's (1977:147) conclusion that no uncontested prehistoric runner beans have been found in the Southwest and that those grown by the Hopi were probably introduced in historic times.

Canavalia ensiformis (L.) D.C. (Fig. 4). More archaeological jack beans have been identified in the Southwest than from any Mexican area despite the extreme distance from their putative southern Mesoamerican homeland. Sauer and Kaplan (1969) report an early find dated 320 B.C. from Dzibilchatun and another from Guila Naquita Cave in Oaxaca, although its A.D. 900 provenience is actually later than those from the Hodges site which may date as early as A.D. 700. It has also been confirmed from Punta de Agua (Bohrer 1962:106) and Pueblo Grande (Gasser 1976:23). The distribution of the jack bean is restricted to areas where irrigation farming was practiced, a requirement of this species when grown outside the tropics (Sauer and Kaplan 1969:417).

Cucurbita mixta Pang. (Fig. 5). The history of the green striped cushaw squash in northern Mexico is not very helpful for deciphering its introduction into the Southwest because it occurs in Durango (Brooks et al. 1962) and Chihuahua (Cutler 1960; Lister 1958) after A.D. 1000. It appears in southern Arizona by A.D. 900, perhaps as early as A.D. 700 (Cutler and Blake 1976:365), but is best documented several centuries later at Montezuma Castle and Tonto. Despite its preference for warmer climates than *C. pepo*, more *C. mixta* remains have been found outside the Lower Sonoran area than might be expected. This may be explained, in part, by its responsiveness to a controlled water supply. Although it is not a good dry farming crop, it grows extremely well when irrigated, and is reputed by Pueblo Indians today to produce more large fruits per plant than do other squashes. By A.D. 1000 it was found as far north as Glen Canyon and eastward into the Reserve, New Mexico Mogollon area (Cutler and Whitaker 1961:472). In the Glen Canyon and Mesa Verde provinces many of the rinds are thick suggesting their use as containers in these altitudes where gourd grow poorly (Cutler and Meyer 1965:151). It has been identified as far east as El Paso (Ford 1977b) and the Gallina area (Cutler and Blake 1973:51), and as far north as southern Nevada and Utah. *C. mixta* became the most widespread Lower Sonoran crop.

Cucurbita moschata Poir. (Fig. 5). The warty squash is also intolerant of cooler altitudes and has a high moisture requirement. It may not have been introduced into the Hohokam area as early as *C. mixta* and its eventual distribution was more restricted. Other than Montezuma Castle and Tonto, where it was the most abundant of the 3 species of squash recovered (Bohrer 1962:103), it has only been verified from 6 other sites with Kiet Siel in northern Arizona the farthest north and 2 in the Mogollon region (Cutler and Whitaker 1961:472) the farthest east.

Amaranthus hypochondriacus L. This pigweed has only been identified from Tonto (Bohrer 1962:107) in the United States. It is presumed to have been brought from Mexico as well, but the only other confirmed evidence of this species dates A.D. 500 in Tehuacan. *A. powellii*, which grows native in Arizona, is regarded as its ancestor, and an indigenous domestication is not impossible. Charred amaranth seeds have been found in other Lower Sonoran Life Zone sites (cf. Bohrer et al. 1969:6), but remain unidentified to species.

The Lower Sonoran Agricultural Complex did not spread into southern Arizona as an interrelated crop group. Instead, it developed in the Lower Sonoran Life Zone and is most apparent in the fourteenth century desiccated plant remains from Tonto (Bohrer 1962). It certainly contributed subsistence variety to these desert adapted cultures, but the significance of many species to human survival remains unknown.

Late Eastern Mexican Agricultural Complex (Fig. 6)

After the initial diffusion of cucurbits from eastern Mexico, no other plants are recognized as originating from that source until very late in the prehistory of the eastern United States. Chili peppers, corn, cotton, 2 additional species of squash, 3 species of beans, and tobacco (*Nicotiana rustica)* were found in the Tamaulipas caves by A.D. 1(MacNeish 1971:578), but not in the East. When the final 2 plants were introduced, corn agriculture was already established and large sedentary communities dominated the settlement systems of the Southeast and Midwestern riverine areas.

Nicotiana rustica L. (Fig.6). This cultivated tobacco originated in South America but was grown extensively in Mexico. The only remains north of Tamaulipas are from Late Woodland contexts. The exact date of the Newt Kash material is questionable but assumed to be late (Jones 1936). The seeds from the Mitchell (Benn 1974:56) and Brewster (Stains 1972) sites are dated about A.D. 1000. When Europeans arrived, this tobacco was cultivated from the Plains to southern Canada and the east coast. The presence of pipes in contexts before A.D. 800 does not imply that tobacco was smoked since other plants were used ethnographically for producing ceremonial smoke (Yarnell 1964).

Chenopodium berlandieri var. *nuttalliae* Standl. (Fig. 6). The cultivated chenopod of Mexico has an origin independent from *C. quinoa* in South America (Heiser and Nelson 1974). It produces large seeds indistinguishable from the specimen reported by Gilmore (1931) from the Ozark Bluff shelters (Hugh Wilson, personal communication). It was not recovered in Tamaulipas and has not been found elsewhere north of Mexico. Without additional evidence its significance to the Late Woodland Bluff Dwellers is problematical. Today, it is a cultivated vegetable in the Mexican highlands, but chenopods are typically "double-harvested," that is, the greens are gathered early in the growing season and then the seeds are collected later when they ripen. Undoubtedly, this pattern extends back into the Archaic, and the addition of this domesticate was probably not at variance with established Late Woodland adaptations.

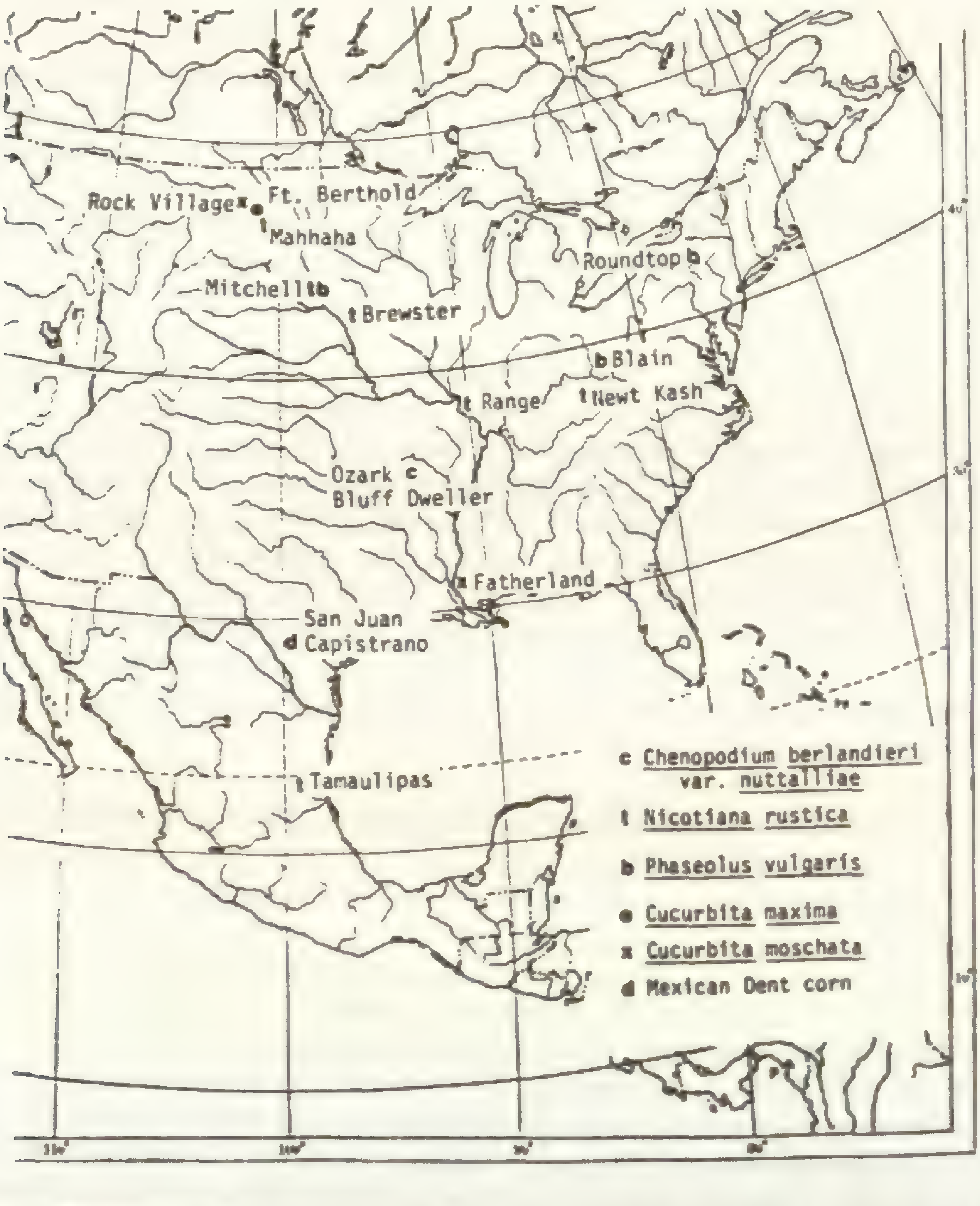

FIG. 6.—Late Eastern Mexican Agricultural Complex: sites in the east with beans, ca. A.D. 1000; Spanish introduced crops.

A Southwestern Agricultural Complex

No indigenous southwestern plant species has archaeological evidence substantiating its domestication in prehistory. Despite the possible domestication of the grain amaranth and tepary bean in the Sonoran Desert region, all archaeobotanical remains are fully domesticated and no antecedent developmental stages have been excavated. A possible candidate is the devil's claw, and perhaps one or more of the intensively collected species was cultivated or had its range extended by prehistoric people.

Proboscidea parviflora Woot. and Standl. Devil's claw pods yield edible seed and important decorative material for baskets. A white seeded cultivated form is raised by Papago and Moencopi villagers, but Castetter and Bell (1942:113) argue that its domestication is a historic response by the Pima and Papago to a commercial demand for baskets. Yarnell (1977:872) is less certain because he feels a minimum of several centuries is required to selectively breed plants with larger pods and white seeds. In this instance, no archaeobiological data are available to support or refute either position, but it remains an interesting possibility.

Helianthus annuus L. The Hopi sunflower produces a large, purple achene which is used for dye and food. Although sunflower seeds have been found in several archaeological contexts, none exceeds an uncultivated, native *Helianthus* in size. In the absence of contradictory evidence, the most parsimonious explanation is that this cultivar was brought to the Hopi in historic times.

Agave parryi Engelm. Minnis and Plog (1976) have noted the disjunct distribution of agave north of its natural range is correlated with the presence of a nearby archaeological site. They suspect that prehistoric people may have extended its range intentionally or accidently. Archaeological evidence for its utilization at these sites has not been forthcoming, but this does not negate the potentially active role Southwestern Indians had in spreading this and other species beyond their modern range.

Recently, Yarnell(1977:872) has enumerated several native southwestern plant species, including *Cleome* and to which can be added *Chenopodium* and *Hordeum pusillum,* which archaeological evidence suggests were collected in quantity by prehistoric people and which may have been encouraged through tending and even planted by them. No evidence demonstrates the genetic changes and human dependency associated with plant domestication.

At present a Southwestern Agricultural Complex has not been demonstrated beyond the devil's claw. However, additional field research combined with botanical analysis may contribute additional species.

Hispanic Introductions

Field, garden, and orchard crops derive their origin in parts of the United States from Spanish contacts. Early Spanish traders, missionaries, and colonists brought several domesticates native to the New World to regions where they were not grown in precontact times. They also brought many European plants to the Southwest in the sixteenth and seventeenth centuries. Wheat, barley, peaches, apricots, plums, walnut, peas, chick peas, and melons are but a few of the crops adopted by the Indians

Considering the contacts prehistoric Southwestern cultures reportedly had with Central Mexican cultures, it is surprising that the chili pepper, *Capsicum annuum* L., and tobacco, *Nicotiana rustica,* were unknown here until Hispanic times. No evidence of chili peppers has ever been found in unambiguous precontact contexts, not even at Casas Grandes. The history of tobacco in the Southwest is more complicated. The native western tobacco, *Nicotiana attenuata,* pioneers disturbed habitats, and Pueblo people still collect and smoke it on ceremonial occasions. Archaeologists have shown that it had a number of prehistoric usages, and plant parts and seeds were collected and stored (Yarnell 1977:871), but morphological analyses indicate no domestication. The Spanish brought *Nicotiana rustica* early in the historic period. An important archaeological specimen has been identified as *N. rustica* from the post-1680 reoccupation of the Bandelier cliff dwellings (Volney H. Jones, personal communication). On the basis of this find it appears that *rustica* was an early crop accepted from the Spanish and that it continued to be grown and used following the Pueblo Rebellion. It still is planted and used ceremonially in complementary relationship to *attenuata*.

Prior to contact the tribes of the Missouri River drainage and the eastern United States grew only *Cucurbita pepo*. However, shortly after contact their complement of cucurbits was completed with the additions of *C. moschata* and *C. maxima*. A peduncle of *Cucurbita moschata* was recovered in the early 1700s Historic Period at the Fatherland site in Mississippi (Cutler and Blake 1973:37) and at the Historic Hidatsa Rock Village site in North Dakota (Cutler and Blake 1973:53) (Fig. 6). *Cucurbita maxima* originated in South America, and is assumed to have been an Hispanic introduction into Mexico, the American Southwest, and the East where the only authenticated find is from Fort Berthold Village, A.D. 1845-1874, in North Dakota (Cutler and Blake 1973:53).

The Spanish were also responsible for the introduction of new corn types from Mexico. The large eared Cristalina de Chihuahua, which apparently evolved in northern Mexico (Cutler 1960), was recovered from a probable historic context at Casas Grandes (Cutler and Blake 1974) and northward in the historic Pueblos. Mexican Dent, an ancestor of the modern Corn Belt dent, also first appears in Spanish contact situations at Picuris in the Post-Rebellion deposits (Cutler and Blake 1969a). Mexican Dent had a profound impact on the maize of the Rio Grande Pueblos where the extremely long cobs found growing today are a result.

The Hispanic Agricultural Complex achieved widespread distribution and was continued during and after the Pueblo Rebellion. New maize types increased productivity and the great array of new annual and orchard crops intensified Pueblo use of arable land and brought relief from failure of prehistoric cultivars.

CONCLUSION

An assessment of crop history, patterns of crop association, and the geographical distribution of domesticates leads to an understanding of prehistoric plant husbandry and to future research activities. The exact date of the independent introduction from Mexico of the first cultivars in the East and the Southwest is less important than their integration into the prehistoric economies. In the East squash and gourd were grown in gardens and supplemented gathered foodstuffs from the forest. In the major river valleys starchy annual seeds were collected, and the exogenous origin of agriculture led to the domestication of sumpweed and sunflower at least. In the West, first corn and squash and later gourd and common beans were grown by nomadic hunters and gatherers as seasonal resources. Perhaps 1000 years passed before corn became an economic stable.

Even with the establishment of sedentary communities in the Midwest and the spread of corn from the Southwest, an agricultural field system did not evolve for many centuries. Again, there is no evidence that any cultivated species or new race of corn immediately changed the cultural patterns where they were introduced.

The sedentary villages of southern Arizona received a númber of crops from Mexico, but these were merely added to an established agricultural pattern which had diffused from mountainous areas. What strategies were used for growing these crops and how they interacted in the subsistence system remain to be explained. To heed Whiting's appeal to the archaeological record, evidence must be obtained to answer these and similar questions.

The importance of changing cultural adapations for understanding plant breeding in prehistory is conspicuous in North America. The achenes of sunflower and sumpweed, for example, increased in size long after they were first domesticated, and they may have undergone their greatest increase in size following the beginnings of field agriculture, 2000 years after their domestication began. Corn demonstrates a similar pattern in both the Southwest and the East. The genetic variability and its adaptive potential was not appreciated by the casual horticultural practices of hunters and gatherers or even by the Midwestern Woodland cultures with their large gardens. However, as cultural pressures changed, the productivity and adaptability of maize was realized and new varieties were developed in both areas.

By A.D. 1000, with the possible exception of the devil's claw, all prehistoric agricultural crops and complexes were in the continent north of Mexico and major farming technologies were well-established. It was not until the arrival of Europeans that new crops were introduced and aboriginal economies underwent substantial change.

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A CRITICAL VIEW OF THE USE OF ARCHAEOLOGICAL VERTEBRATES IN PALEOENVIRONMENTAL RECONSTRUCTION

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ABSTRACT.—Most paleoenvironmental studies based upon archaeological vertebrates have relied either upon simple presence/absence studies of environmentally sensitive taxa, or have quantified the abundances of all taxa present, to infer environmental change. It is argued that it is extremely hazardous to approach paleoenvironmental reconstruction through counts of taxonomic abundance because: 1) the units available for counting taxonomic abundance, and our understanding of the processes which transform a pile of deceased animals into a faunal collection, are not such as to allow a demonstration that the numbers provided by abundance counts have any known relationship to the number of animals in the original pile, and, 2) we rarely, if ever, have any notion of the relationship between the quantitative structure of the living populations from which the sample was drawn and about which we are trying to make inferences, and the archaeological sample itself. It is concluded that only studies which treat taxa as attributes, and not as variables, can routinely be treated as valid. Other major difficulties presented by archaeological vertebrates in paleoecological reconstruction are reviewed, with special emphasis placed upon hazards encountered in presence/absence studies.

INTRODUCTION

During the past few decades, vertebrate remains from archaeological sites have become an increasingly popular source of information about past environments. It is easy to demonstrate this increasing popularity. Assuming that the sample of paleoclimatic literature in Grayson (1975) is representative of the literature of its subject area, and that trends within the paleoclimatic literature are representative of trends within the paleoenvironmental literature as a whole, this bibliography may be used to assess the changing role of archaeological vertebrates in the analysis of past environments in North America. The bibliography lists no archaeological vertebrate faunal studies conducted for paleoclimatic purposes prior to the 1931-1940 decade. Between 1931 and 1940, 2.8% of the published paleoclimatic studies made use of archaeological vertebrates; this figure decreased to 1.0% between 1941 and 1950, then increased to 4.0% between 1951 and 1960, increased again to 4.3% between 1961 and 1970, then increased yet again during the early years of the 1970's to 10.7% (Table 1). While these data are North American, paleoclimatic literature from other parts of the world seems to exhibit the same trends, although the use of archaeological vertebrates in paleoenvironmental reconstruction began much earlier in the Old World.

Given the increasing interest in the use of archaeological vertebrates as a source of information about past environments, it is interesting to note that the critical literature concerning such studies is quite small. While vertebrate paleontology has had a critical literature on paleoenvironmental reconstruction for well over a century (e.g., Dawkins 1869; Owen 1846), and this literature is rapidly becoming quite large (e.g., Behrensmeyer 1975; Shotwell 1955, 1958, 1963; Voorhies 1969; Munthe and McLeod 1975 and references contained therein), examination of the principles and processes of paleoenvironmental reconstruction using archaeological vertebrates are quite rare (for an excellent exception, see Findley 1964).

The lack of such a critical literature might suggest paleoenvironmental reconstruction using archaeological vertebrates is relatively straightforward, and can be conducted with little concern for potential analytic hazards. Northing could be further from the truth, as this paper demonstrates.

DISCUSSION

Basic Approaches

Of the several approaches to paleoenvironmental reconstruction which have been employed using archaeological vertebrates, 2 characterize the vast majority of the literature. In the first of these approaches, the taxa present in an archaeological fauna are identified, and the kinds of animals present are used as the basis of inferences concerning the environments of the region at the time the fauna accumulated (e.g., Guilday and Adam 1967; Guilday and Parmalee 1972; Parmalee and Oesch 1972). In the second approach, each taxon is treated not as an attribute which can be either present or absent, but as a variable whose abundance can vary discretely. In studies which treat taxa as variables, some measure of taxonomic abundance is employed to derive quantitative statements about the relative abundances of all taxa present (e.g., Bate 1937; Butler 1972; Grayson 1976, 1977b; Harris 1963). These 2 approaches are examined in detail here.

Taxa as Variables

It is not hard to see that treating taxa as variables holds a greater potential for providing paleoenvironmental information than does treating them as attributes. Let us say, for instance, that we are studying the history of a simple ecosystem which includes only 2 mammals, taxon A and taxon B. The numbers of both taxa fluctuate faithfully and only with fluctuations in temperature: when it gets hotter, A increases while B decreases, and vice versa. Let us assume we have a fauna which contains a sample of A and B which is representative of the abundances of those animals in the environment surrounding the site during the past 1,000 years. Analysis of this fauna shows both A and B have been present during this entire period of time (Table 2a). All that can be inferred from this observation is that temperature minima and maxima have not exceeded the tolerances of either taxon during the period represented. Further analysis, however, shows the abundances of taxa A and B have fluctuated widely through time. Because the sample is representative of the environment when the sample was accumulating, and because abundances of these animals vary with temperature fluctuations, some fairly detailed statements can be made about temperature in the sampled area during the past 1,000 years — for instance, time periods 4 through 8 were much warmer than the earlier and later periods represented (Table 2b). Clearly, treating taxa as variables holds the promise of providing much more detailed information on past environments than treating taxa as attributes, for the simple reason that presence/absence analyses force the analyst to convert a ratio scale measurement of taxonomic abundance into a nominal scale. When taxa are treated as attributes, only taxonomic presences are used as the basis of paleoenvironmental inference. When taxa are treated as variables, fluctuations in abundances of each taxon, or of groups of taxa, become an additional target of study.

It can be argued, therefore, that paleoenvironmental studies which depend upon counts of taxonomic abundance are preferred over those which treat taxa as presence/absence attributes. Unfortunately, one can argue even more forcefully that paleoenvironmental studies based upon counts of taxonomic abundance are not likely to provide demonstrably valid data about past environments (and here I use the term valid in its statistical sense: are we measuring what we think we are measuring?). There are 2 reasons for this: the nature of counts of taxonomic abundance, and, the nature of the faunal sample itself.

There are only 2 measures available for quantifying the abundances of taxa represented within an archaeological site: counts of identified specimens per taxon (NISP; in earlier publications, I have abbreviated this unit as E), and the minimum number of individuals per taxon (MNI; see Casteel 1978 and Grayson 1979 for a discussion of meat weights as a abundance measure). I have treated these units at length elsewhere (e.g., Grayson 1973, 1978a, and esp. 1979), and will not repeat those discussions here. It is, however, necessary to point out that NISP and MNI are similar in an important way: the relationship between the number provided by either measure and the actual number of animals which contributed

TABLE 1.—*Numbers of paleoclimatic studies in North America using vertebrate remains from archaeological sites (data from Grayson 1975).*

DECADE	ALL STUDIES (a)	STUDIES EMPLOYING ARCHAEOLOGICAL VERTEBRATES (b)	b(100)/a
1881 - 1890	2	0	0.0
1891 - 1900	1	0	0.0
1901 - 1910	2	0	0.0
1911 - 1920	7	0	0.0
1921 - 1930	32	0	0.0
1931 - 1940	144	4	2.8
1941 - 1950	200	2	1.0
1951 - 1960	302	12	4.0
1961 - 1970	559	26	4.7
1971 - (*)	149	16	10.7
TOTALS	1398	60	

(*): while the latest references in Grayson (1975) are dated 1974, coverage comparable to previous decades extends only to 1973.

TABLE 2.—*An example of an archaeological faunal analysis in which taxa are treated both as attributes (Table 2a) and as variables (Table 2b). See text for explanation.*

a: TAXA AS ATTRIBUTES			b: TAXA AS VARIABLES (numbers represent absolute abundances)		
	TAXON			TAXON	
TIME PERIOD	A	B		A	B
1	x	x	1	10	90
2	x	x	2	10	90
3	x	x	3	10	80
4	x	x	4	40	30
5	x	x	5	60	20
6	x	x	6	80	10
7	x	x	7	50	05
8	x	x	8	40	05
9	x	x	9	10	60
10	x	x	10	10	80

(x - taxon recorded as present)

bones to the collection under study is, in all but trivial instances, unknown. That is, the meaning of both these estimators of abundance is severely clouded because the relationship between estimated and actual abundances must always be unknown.

For example, time period 4 of the site presented in Table 2b provides abundances of "40" for taxon A and "30" for taxon B without mention of what measure of abundance is being used. This is clarified by noting that the figures represent minimum numbers of individuals defined from 450 identified specimens of A and 550 identified specimens of B. Knowing this, it is no longer clear what the actual abundances of A and B really are. It is possible to consult the voluminous literature on this point (see Grayson 1979 for a review), and recount the arguments for and against NISP and MNI as abundance measures. Instead, it can be pointed out that this problem cannot be solved because the relationship between both counts and the number of animals which originally contributed to the collection is unknown and unknowable. Unfortunately, it is the original number which is the target of our estimates.

There is, for instance, no reason why the original number of animals deposited in our site could not have been 60 of taxon A and 80 of taxon B. Continuing to assume that the numbers "60" and "80" are an accurate reflection of the abundances of these taxa in the environment surrounding the site, and that these numbers directly provide information on temperature, it is not hard to see how misleading are the NISP values (450 for taxon A and 550 for taxon B), or the MNI values (40 for taxon A, 30 for taxon B). Because there is no way of working back from an excavated collection of bones to when it was deposited, and because there is no way of relating counts of identified specimens or minimum numbers of individuals to the number of animals which contributed to the faunal collection, neither NISP nor MNI is a reasonable quantifier of taxonomic abundance in this case. We simply do not know, and cannot know, what the counts they provide mean in terms of actual abundances. Since there are no other ways available for counting abundance in this setting, it is clear that one of the bases for analyzing the taxonomic abundances of archaeological vertebrates is very weak indeed.

But there is another, even more damaging, problem involved in the paleoenvironmental use of archaeological vertebrates. In the example above, it has been assumed the sample of animals deposited in the site was representative of what was living in the area at the time the sample was accumulating. Unfortunately, the relationship between the archaeological collection and the actual population — the set of animals living in the area at the time the archaeological sample was being deposited (the "target population") — is unknown, except that the animals in the collection probably came from that area. As with the relationship between NISP and MNI and actual abundances, the relationship between the sample which has accumulated in an archaeological site and the target population is usually unknown and unknowable. This presents an insurmountable difficulty for using the quantified abundances of taxa within an archaeological site as a key to past environments.

The problem seems an obvious one. To continue with the example above (Table 2), I shall drop the unrealistic assumption that the collection under study accurately represents the abundances of taxa A and B in the surrounding environment at the time the fauna was accumulating, and note instead that the numbers of animals reaching the site probably had more to do with the mechanism of accumulation than with the actual abundances of those taxa in the sampled area. The abundances of taxa A and B may have been in the ratio of 100 to 1 in the sampled environment, but if the accumulation mechanism sampled taxon B almost to the exclusion of taxon A, then the deposited abundances of 60 individuals for taxon A and 80 individuals for taxon B (as noted above) are entirely possible.

Is it unreasonable to emphasize that the relationship between the target population and the archaeological fauna is unknown? Can that situation really cause problems so severe that it becomes inappropriate in most cases to derive paleoenvironmental information from taxonomic abundances? A simple example serves to demonstrate the problem is, in fact, a severe one.

People are just one in a set of mechanisms which accumulate vertebrate remains in archaeological sites. Other organic accumulation mechanisms include a variety of non-human predators and scavengers (see, for instance, Butler 1972; Guilday and Parmalee 1972; Lundelius 1960; Mellet 1974). It seems obvious that predators and scavengers, including people, cannot be relied on to gather a representative sample of creatures in the surrounding environment. The complications introduced as a result of these varied accumulation mechanisms may be seen by examining the behavior of owls, a class of predators whose collecting behavior seems simple compared to that of humans.

The predation patterns of owls have been particularly well studied. Maser et al. (1970), for instance, studied the food habits of 3 species of owls in central Oregon — Great Horned Owl *(Bubo virginianus)*, Short-eared Owl *(Asio flammeus)* and Long-eared Owl *(Asio otus)*. These authors gathered and analyzed 24 sets of owl pellets from these 3 species between February and July, 1969. With the exception of 2 collections from areas adjacent to springs (one each from *B. virginianus* and *A. otus*), all collections were from habitats "similar in all areas" (Ibid. 1970:4).

TABLE 3.—*Mammalian contents of pellets from 3 species of owls (from Maser et al. 1970).*

	BUBO VIRGINIANUS		**ASIO OTUS**		**ASIO FLAMMEUS**	
	MNI	**%**	**MNI**	**%**	**MNI**	**%**
Peromyscus maniculatus	43	32	20	20	65	19
Microtus montanus	25	19	4	4	37	11
Thomomys talpoides	21	16	6	6	94	27
Perognathus parvus	19	14	64	63	101	29
Reithrodontomys megalotis	10	8	3	3	22	6
Lagurus curtatus	7	5	4	4	14	4
Neotoma cinerea	3	2	0	0	0	0
Dipodomys ordii	3	2	1	1	16	5
Spermophilus beecheyi	1	1	0	0	0	0
S. townsendii	1	1	0	0	0	0
Totals	133	100	349	99	102	101

TABLE 4.—*Modern owl pellets as archaeological strata. Data from Table 3; see text for explanation.*

	STRATUM		
	1	2	3
Microtus montanus and *Thomomys talpoides*	46	10	131
Perognathus parvus and *Dipodomys ordii*	22	65	117

Stratum 1 = *Bubo virginianus* (from Table 3)
Stratum 2 = *Asio otus* (from Table 3)
Stratum 3 = *Asio flammeus* (from Table 3)

χ^2 values: 1 - 2: 44.15 (p .01)
2 - 3: 36.20 (p .01)

Some of the data from these 24 pellet collections are presented in Table 3, which displays the number of mammalian individuals for each owl species calculated from identified skulls and mandibles (C. Maser, personal communication). Rather than treating these data as synchronic, they are viewed as having accumulated over time, the pellets from *B. virginianus* accumulating first, then those from *A.otus*, and finally those from *A. flammeus*. Such a situation is not far-fetched; several species of owls can be found in any given patch of habitat (Bent 1938; Marti 1974), and shifts in the use of roosts by owls can be readily observed today.

A stratified faunal collection from the pellets of 3 species of owls, all of which hunt the same habitat, has now been constructed. Using this collection of pellets as the basis of inferences concerning past environments in the area surrounding the site is accomplished by following the lead of the archaeological literature (Butler 1972; Grayson 1977b; Harper and Alder 1970), and by considering the Montane Vole (*Microtus montanus*) and the Northern Pocket Gopher (*Thomomys talpoides*) as indicators of mesic environments, and the Great Basin Pocket Mouse (*Perognathus parvus*) and Ord's Kangaroo Rat (*Dipodomys ordii*) as indicators of xeric environments.

Statistical analysis of this stratified collection of owl pellets shows the proportion of mesic and xeric rodents change significantly between strata, with greater numbers of xeric rodents in stratum 2 than can be accounted for by chance, a fewer number of mesic rodents than any hypothesis of randomness would allow in that stratum (Table 4). The conclusion of such an analysis would be: stratum 1 accumulated during a time of relatively high effective precipitation, producing a greater abundance of mesic habitats, while stratum 2 accumulated during a time of relatively low effective precipitation which produced a greater abundance of xeric habitats. Stratum 3, in turn, saw a return to conditions approaching those of stratum 1 times. Yet, all that has happened is that I have constructed a fauna using modern data under the reasonable assumption that different species of owl can, through time, use the same roost. That is, it is assumed that accumulation mechanisms can change through time. What this analysis has detected is not environmental change through time, but different predation patterns by a set of sympatric owls. It is perhaps, one of the reasons why these owls can be sympatric.

The relationship between owl pellet accumulations and archaeological faunas is not a forced one. It is true that many archaeological faunas from rockshelters are in part composed of vertebrates from owl pellets. But more important is the fact that owls, and other non-human predators and scavengers, represent one of a myriad of accumulation mechanisms which account for the deposition of bones in archaeological sites, and that changes in the accumulation mechanisms lead to changes in composition of the fauna which faunal analysts ultimately study. Clearly, any paleoenvironmental analysis of archaeological vertebrates must take into account that the relationship between the taxonomic abundances which characterized the living community at the time a fauna accumulated, and the abundances of animals which became incorporated in that accumulating fauna is dependent upon the accumulation mechanisms. Because those mechanisms are rarely known, the relationship between the population of animals in the site and the target population cannot be known with any precision. This is true even when problems relating to differential preservation of deposited materials are set aside. As a result, the validity of any paleoenvironmental reconstruction based on counts of abundance must always be in question.

There are 2 reasons, then, why paleoenvironmental reconstruction based upon the quantification of taxonomic abundances is exceedingly hazardous. First, the units available for counting taxonomic abundances, and our understanding of the processes which transform a pile of deceased animals into a faunal collection, do not allow a demonstration that the numbers provided by those units have much relationship to the number of animals in the original pile. Second, we rarely, if ever, have any notion of the relationship between the quantitative structure of the target population, from which the sample was drawn and about which we are trying to make inferences, and the archaeological sample. Because of these problems, it is rare that counts of taxonomic abundance can tell us anything about known environmental parameters. If this is the case, taxa should be treated as attributes which can be either present or absent, rather than trying to interpret taxonomic abundances as if they necessarily provided information concerning known evnvironmental parameters. This position is very similar to that taken by Sir Richard Owen (1846:XXVII) over a century ago:

> The multitude of coexisting individuals is not to be reckoned from the absolute quantity of their fossil remains in a given locality. As reasonably might we infer the former populousness of a deserted village from the quantity of human bones in its churchyard.

The Taphonomic Solution?—In 1940, Efremov suggested that greater attention be paid to "the study of the transition (in all of its details) of animal remains from the biosphere to the lithosphere" (Efremov 1940:85), a study which he termed taphonomy. Since that time, a wealth of studies on the taphonomy of archaeological and paleontological sites has appeared (Behrensmeyer 1975, 1978; Brain 1969; Clark and Guensburg 1970; Gifford and Behrensmeyer 1977; Dodson 1973; Noe-Nygaard 1977; Shotwell 1955,1958; Voorhies 1969; Wolff 1973). These studies accept as a working principle that the solution of taphonomic problems is logically prior to the use of archaeological and paleontological vertebrates for the extraction of paleoenvironmental information.

It is difficult to disagree with this principle. However, it would be optimistic indeed to think that taphonomic approaches will ever become sufficiently refined to allow the easy interpretation of taxonomic abundances from archaeological sites. Returning to the modern owls, and the fauna which they provided, makes this point more forcefully.

As Maser et al. (1970) point out, fresh owl pellets from their study area were easily recognized as they were whole, held together by shiny mucous covering. After about a month, the pellets were rapidly disintegrated, in part because of the activities of a tineid moth which feeds on the mucous covering on the pellets, and what remains is not an owl pellet, but the often fragmented contents of that pellet. In analyzing owl pellet remains from archaeological sites, there are 2 immediate difficulties: first is a need to recognize bones that were once part of an owl pellet; second, in order to establish continuity in accumulation mechanisms, there is a need to recognize that all owl pellets did, or did not, come from the same species of owl. If these difficulties could be solved and bones could be separated from pellets of different and known species of owls, there would still be no usable information about taxonomic abundances except that a given taxon was present. This is true because owls take non-random samples of what is in the environment (Errington et al. 1940; Marti 1974). In the study examined here, Maser et al. (1970:5-6) note that "although the deer mouse is generally the most common small mammal in central Oregon . . . the owls caught far more pocket mice than deer mice." In other words, it is impossible to go from the data presented by Maser et al. (1970) to the abundances of the captured mammals in the hunted environment. Since that is the case, if would clearly be impossible to do so in the archaeological setting. Indeed, it may even be difficult to use the number of individuals represented in an owl pellet to the number of individuals which were eaten to produce that pellet (Raczynski and Ruprecht 1974). The only reliable information about the local mammalian population in either the modern or the archaeological setting is the simple observation that since a taxon was present in the faunal collection, it was probably present in the immediate vicinity.

Owls have been used as examples here because they are well-studied. The behavior of other raptors (Craighead and Craighead 1956), and of carnivores, wood rats, streams, and other mechanisms — including people — which accumulate faunas are no less complex. No matter how precise taphonomic statements become, there is one question which they can not answer: what is the relationship between the abundances of taxa in an accumulating fauna and the abundances of those taxa in the surrounding environment? This is no criticism of the taphonomic literature as taphonomists do not have this goal in mind. It is, however, a criticism of any attempt to facilely interpret taxonomic abundances in archaeological faunas which requires something be known of the relationship between those abundances and the abundances of the animals in the area from which those faunas were derived.

Taxa as Attributes

Since the paleoenvironmental meaning of taxonomic abundances from single archaeological faunas can never be known, presence/absence studies become the only acceptable approach to the paleoenvironmental analysis of those faunas.

Such studies are actually quite simple; in fact, it is this simplicity which accounts for much of their value. In presence/absence faunal studies, one simply identifies what is present in a fauna and interprets the paleoenvironmental meaning. Even if abundances are calculated, as they usually are, they are not interpreted (e.g., Guilday and Adam 1967; Parmalee and Oesch 1972). Instead, the attributes of the represented animals are used as the basis for statements about the environment surrounding the site of deposition at the time of deposition. Guilday and Adam (1967) provide a good exmple of such a study. After noting the presence of the collared lemming, *Dicrostonyx*, at Jaguar Cave, southern Idaho, they note this animal is "an obligatory tundra form with a long evolutionary association with a boreal climate" (1967:29), whose presence in the Pleistocene deposits of Jaguar Cave "is indicative of a former tundra biome" (1967:29).

It would be hard to disagree with Guilday and Adam's statement. In fact, presence/absence studies (which are asymmetrical in that the interpretive emphasis is usually placed on presences) are usually quite sound. However, these studies are not trouble free. There are hazards in conducting presence/absence paleoenvironmental analyses of archaeological vertebrates, most of which are shared with approches that treat taxa as variables. Among these hazards are:

1) Assuming that the present ecology of specific mammals is the same as the ecology of those mammals in the past. It is extremely difficult to reconstruct the ecology of ancient mammals, though there have been attempts (e.g., Shotwell 1955, 1958, 1963; but, see also Grayson 1978b). If faunal analysts had to demonstrate the present ecologies of mammals were the same in the past for each time and place they conduct a paleoenvironmental study, they would not get very far. The ecologies of past animals may not be directly knowable, but this problem can in part be circumvented if suites of taxa, which have the same relationship to a given environmental parameter today, are used as the basis of statements concerning that parameter in the past. While habitat preferences of a single taxon might change through time, it is less likely that all members of a suite of taxa would change, and that all would change in the same direction. Findley (1964) has discussed this issue as well.

2) Assuming that ecological relationships remain stable across space and competitive settings. However, these relationships are not stable. In Oregon, for instance, the White-tailed Antelope Squirrel (*Ammospermophilus leucurus*) is an inhabitant of "the open, barren valleys far from timber, but usually where tufts of greasewood, sagebrush, and low desert shrubs furnish cover, protection, and food" (Bailey 1936:142). Not far to the south in central Nevada, they are seen in a different setting, pinyon-juniper woodland well above valley floors (Hall 1946). To infer an area "treeless" or "treed" from these squirrels would be hazardous. Such adaptational plasticity may often be due to changing competitive relationships. As Cody (1974:131) noted, "often no compelling innate-genetic or physiological constraint restricts a species to a particular section of the resource gradient, but rather ... its position is flexible, and is determined by the restraints of its competitors." Thus, on Bear Island, Iceland, Brunnich's Guillemot (*Uria lomvia*) nests on cliff ledges, while the Common Guillemot (*U. aalge*) rests on flat ground. To the south, in Europe, where only *U. aalge* is present as a breeder, this species nests on both cliff ledges and flat ground (Lack 1968). Such examples of *competitive release* are common and well known. Much of what animals do is determined by competitive relations; and this lability in adaptation must be recognized in paleoenvironmental studies. Again, the danger of error from this source decreases as the number of animals used as the basis of inferences concerning some environmental parameter in the past increases. When possible, suites of taxa, not single taxa, should be used as the basis of any paleoenvironmental argument.

3) Stratigraphic mixture. Any study based upon analysis of presence/absence data from archaeological sites must be conducted with the realization that such studies are extraordinarily prone to error as a result of stratigraphic mixture; i.e., a single element identified for a given taxon carries as much weight as a thousand of those elements. Although it is appropriate to point out that only careful excavation can prevent such difficulties, it is also true that many sites are so stratigraphically complex that even the most careful excavations may not be able to detect all instances of mixture. Once again, the use of suites of taxa can help avoid errors due to this source.

4) Poor stratigraphic resolution. While mixing of contents from originally separate strata can cause difficulties, so can the analysis of materials from deposits which never had detailed stratigraphic resolution. Interpretive difficulties arise in this instance because statements are made which require finer stratigraphic resolution than was present or documented. This issue is becoming more important and increased attention is paid to the argument that Pleistocene climates were more equable than Holocene climates (Axelrod 1967; Dalquest

1965; Hibbard 1970; Slaughter 1967), since one of the arguments used to support this hypothesis is that currently allopatric animals were sympatric during the Pleistocene. For example, Pleistocene sympatry of boreal and deciduous forest species has been argued to support the hypothesis of Pleistocene climatic equability (Graham 1976; Graham and Semken 1976). Yet, it is extremely difficult to argue that "stratigraphically sympatric" taxa in a single stratum of an archaeological or paleontological site were truly sympatric animals, and not actually allopatric or allochronic. A convincing demonstration of sympatry in this setting would take remarkably fine stratigraphic resolution of a sort which is rarely encountered in either archaeological or paleontological sites.

5) Long distance transport of skeletal remains. The ethnographic literature abounds with examples of animals transported by humans to areas outside of their natural range. Other forms of long distance transport are also possible: movement by water provides one obvious mechanism. Although some instances of transport are readily detected (as the transport of *Haliotis* from the Pacific coast of North America to interior localities as Arizona [Haury 1976]), others will not be. The use of a suite of taxa, all of which inform on a single environmental variable, provides one means of circumventing this difficulty, as does the reasonable application of the principle of parsimony. For instance, it is far simpler to suggest that Guilday and Adam's *Dicrostonyx* was a local resident than it is to argue that long distance transport was involved. In many cases, however, the local presence of a taxon whose historic range was not far removed from that area might be of concern for strictly biogeograhic reasons (e.g., Grayson 1977a). Here, it might be considerably more difficult to convincingly argue that long distance transport did not play a role in bringing the animal to an area in which it would not otherwise have occurred (see, for instance, the discussion by Alcorn [1940] of the introduction by man of *Spermophilus townsendii* into areas outside of its natural range).

Clearly, these and other potential difficulties demonstrate that paleoenvironmental analyses of archaeological faunas which depend only upon presence/absence data are not trouble free. Nonetheless, the hazards associated with these studies are of a lesser magnitude than those which necessarily accompany studies which proceed by quantifying taxonomic abundances. Unlike the latter, the basic unit with which analyst deals in presence/absence studies — the demonstrated presence of a taxon — often presents little interpretive difficulty.

CONCLUSIONS

Two approaches to the paleoenvironmental analysis of vertebrate faunas from archaeological sites are in common use. In one of these approaches, the abundances of the taxa in the fauna are quantified using either counts of identified specimens or minimum numbers of individuals, and changing abundances through time are examined for paleoenvironmental meaning. This approach, while seeming to offer great precision in paleoenvironmental analyses, has 2 debilitating attributes:

1) The relationship between the abundance measure (NISP or MNI) and the actual numbers of animals which contributed skeletal remains to the collection is always unknown; as a result, the meaning of these abundance measures is, with trivial exceptions, always unknown;

2) The relationship between taxonomic abundances in the environment surrounding the site at the time of fauna accumulated and the abundances of the animals present in an archaeological fauna is always unknown. As a result, even if the relationship between NISP or MNI and the number of animals originally deposited in a site were known, the meaning of changes in these abundances through time would not be interpretable. This is because it is rarely known if changing abundances are reflecting actual changes in taxonomic abundance in the surrounding environment, or if these abundances are reflecting changes in the mechanisms of accumulation which are unrelated to the environment changes the analyst is attempting to monitor.

Because of these shortcomings, it is difficult to have faith in the validity of these studies. As a result, analyses which depend only upon the taxa recorded as present within a fauna are to be preferred. While such studies also have pitfalls, they are by far and large pitfalls associated with all paleoenvironmental studies dealing with fossil or subfossil remains. Most importantly, presence/absence studies are not characterized by the 2 major and seemingly insurmountable shortcomings associated with vertebrate faunal studies which treat taxa as variables. Until ways of eliminating these shortcomings are found, it is difficult to see that it will be possible to improve paleoenvironmental studies of archaeological vertebrates which proceed simply on the basis of treating vertebrates as belonging to taxa which can either be present or absent, but whose abundance cannot be meaningfully counted.

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POLLEN PRODUCTION, TRANSPORT AND PRESERVATION: POTENTIALS AND LIMITATIONS IN ARCHAEOLOGICAL PALYNOLOGY

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ABSTRACT.—Within the past quarter century palynology has become an increasingly important component of archaeological research. Applications have included elucidation of site and room functions, ceremonial and medicinal practices, prehistoric diet and food preparation, correlative construction and chronologies, human modification of the local environment and the nature, magnitude and duration of climatic perturbations, particularly as related to human demography and subsistence strategies. Apprehension concerning the nature and magnitude of palynological bias related to human activities, particularly as reflected by the sources of pollen commonly employed in such studies, is justified but remained largely unexplored. Examination of pollen production, dispersal and preservation leads to the conclusion that once the probability and magnitude of limitations are assessed, they can often be obviated or even be exploited as new potential application of palynology in archaeology.

INTRODUCTION

Fossil pollen used in early studies of paleoecology was usually obtained from lacustrine sediments because of excellent preservation of pollen in such environments. It was through such studies that the potential of palynology to yield paleoecological and paleoethnobotanical data was recognized (Clark 1954; Deevy 1944; Dimbleby 1955; Faegri 1944; Godwin 1956; Iversen 1949; Jessen 1935, 1949; Sears 1937, 1952; Troels-Smith 1956, 1960).

Non-lacustrine sediments were considered unsuitable for palynology due to low pollen concentration and poor pollen preservation despite the demonstration by Sears (1937) of their actual potential in the American Southwest (Dimbleby 1957, 1961). Modified extraction procedures finally permitted a number of palynologists to recover adequately preserved pollen in suitable quantities from aeolian and alluvial sediments and extend the application of palynology into archaeological sites where often more precise temporal control was available than in non-archaeological environments (Anderson 1955; Leopold et al. 1963; Martin 1963; Martin and Byers 1965; Schoenwetter 1960, 1962; Sears 1952, 1961; Sears and Roosma 1961).

Within the last 20 years, palynology has become an important component of archaeological research. Applications have included the elucidation of site and room functions (Berlin et al. 1978; Hevly MS*a*, *b*; Hill and Hevly 1968), ceremonial and medicinal practices (Hevly 1964; MS*a*; Hill and Hevly 1968), prehistoric diet and food preparation (Halbirt MS*a*; Hevly 1964; Kelso 1970, 1976; Martin and Sharrock 1964; Ward 1975), correlative construction and chronologies (Hill and Hevly 1968; Ward 1975), human modification of the local environment (Martin and Byers 1965; Wyckoff 1977), and the nature, magnitude and duration of climatic perturbations particularly as related to demography and subsistence strategies (Bohrer 1972; Dickey 1971; Euler et al. 1979; Hevly et al. 1979; Schoenwetter and Dittert 1968; Schoenwetter and Eddy 1964; Ward 1975; Weber 1981; Zubrow 1971).

Increasing concern has developed about the potentials and limitations of these new applications in paleoethnobotany, particularly in regard to the production, transport and preservation of pollen (Bradfield 1973; Hevly 1964, 1968a; Bohrer 1972; Kelso 1976; Lyttle-Web 1978; Potter 1967; Solomon 1976). This concern is justified because the nature and magnitude of palynological bias related to human activities, particularly as reflected by the sources of pollen commonly employed in such studies, (e.g., room and ramada floors, human coprolites, trash deposits, burials and artifacts) has remained largely unexplored.

MATERIALS AND METHODS

In an attempt to provide at least partial answers to some of the expressed concerns, data from a number of sites in Arizona, Utah, and New Mexico have been re-examined. The samples providing these data were obtained from ground stone artifacts, mummies, human coprolites, various pits and cists, ceramic bowls, floors and midden deposits as well as modern and prehistoric soils outside the archaeological structures. The pollen data from these sites were obtained by standard extraction procedures (Gray 1965). Pollen was identified using standard illustrations, keys and a small reference collection (Faegri and Iversen 1975; Erdtman 1952; McAndrews et al. 1973; Kapp 1969; Martin and Drew 1969, 1970). When possible a count was made of the first 200 pollen grains encountered while mechanically scanning the slide in non-overlapping rows. Records were also obtained of the number of grains per aliquot of pollen rich residue scanned, pine pollen preservation and ratios of AP/NAP (tree pollen/non-tree pollen), pine/juniper, and large/small pine (mostly referable to ponderosa and pinyon pines respectively). The fossil data were compared to modern pollen samples obtained from the plant community in which the site was located.

DISCUSSION

Pollen Production.—Pollen is produced in vastly different numbers by different kinds of plants. Anemophilous (wind pollinated) plants usually produce large numbers (e.g. 500 million per shoot of *Cannabis*; 350 million per 10-year branch system of *Pinus*) of generally small, smooth non-sticky pollen, while zoophilous (animal pollinated) plants usually produce low numbers (100s to 1000s per year per inflorescence) of generally large, rough, sticky pollen (Faegri and Iversen 1975).

Production of pollen is influenced by both climatic, edaphic and biotic factors and consequently varies from stand to stand and from year to year within a stand (Faegri and Iversen 1975). Cone (both male and female) production in conifers, for example, closely parallels climate influenced growth, and even after the production and maturation of cones, both seed and pollen can be aborted by climatic factors such as relative available moisture (Daubenmire 1960; Leiberg et al. 1904; Lester 1967; Roeser 1942; Shoulders 1967).

Many of these factors are manifest as individual plant variations rather than stand characteristics and hence are not reflected by pollen data from soil samples which incorporate the accumulative pollen of many years or several decades (Faegri and Iversen 1975). To be manifest in the pollen record, the effect must extend to a major portion of the stand and the effect must be either frequent or of long duration, increasing or decreasing the density of the pollen producing population, its geographic area or the abundance of flowers. Ecological factors which meet these criteria may be limited to fire, climatic change, edaphic modification (e.g. volcanism and altered drainage patterns or water tables) and biotic exploitation, including disturbance by man and grazing by livestock or insects. Presented below are some data which provide evidence that these effects can be detected in the pollen records of archaeological sites.

Citadel Sink is located in Wupatki National Monument on the northern edge of the Sunset Crater ash fall area. Sediment and pollen analysis permits detection of various environmental modifications known to have occurred there: eleventh century volcanic eruption, an eleventh-thirteenth century rise and fall of prehistoric agricultural population and the twentieth century grazing and juniper chaining (Fig. 1). The aboreal pollen (AP) is composed of 2 principal types, *Pinus* and *Juniperus*. Pine does not occur locally and its pollen is therefore a long distance transport type. High proportion of pine pollen therefore reflect poor local pollen production, while low pine proportions reflect good local pollen production (Solomon 1976). Pine proportions (relative to locally occurring juniper) do increase twice in the pollen record (during the eleventh and twentieth centuries) at times atypical for such phenomena in the Colorado Plateau pollen chronology (Euler et al. 1979). Disruption of the local juniper population (which results in higher pine proportions in

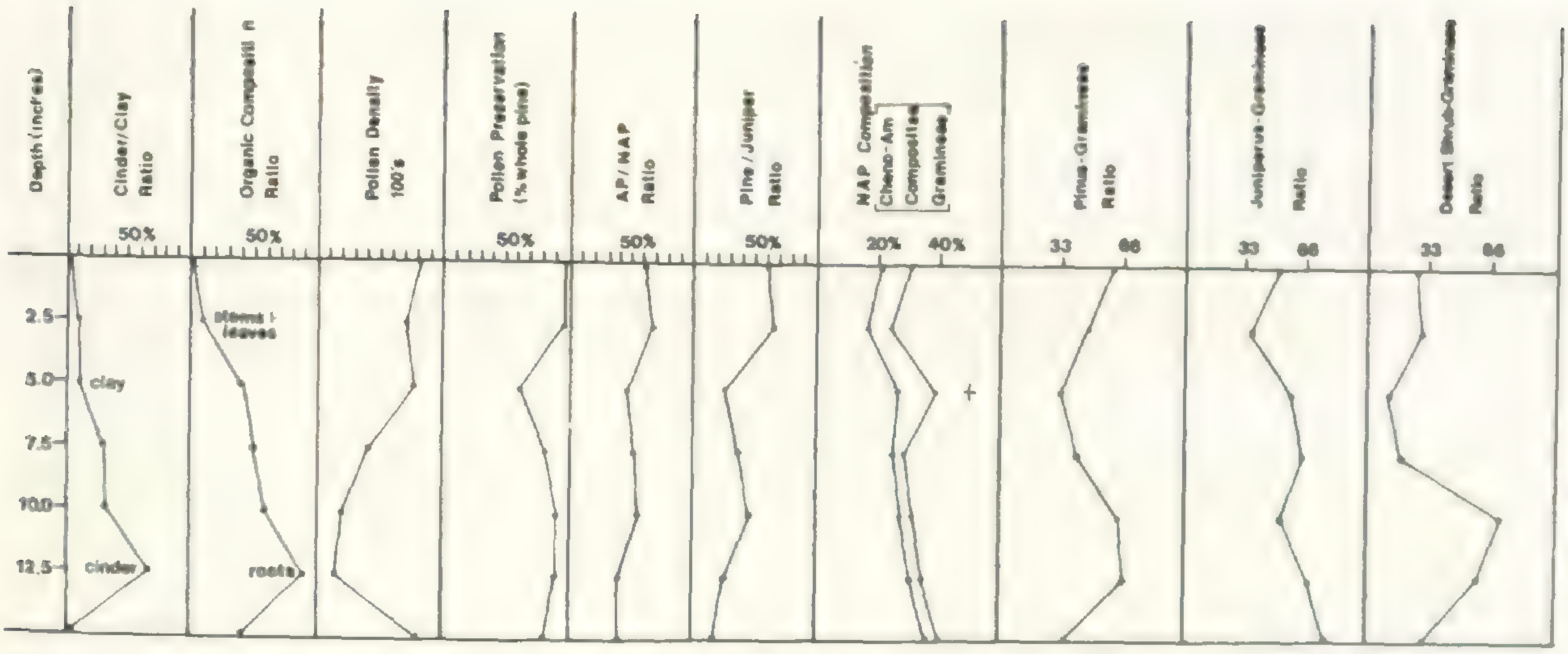


FIG. 1.—Sediment and pollen from Citadel Sink, Wupatki National Monument, reflecting the disturbances associated with volcanism, prehistoric agriculture and modern juniper chaining and cattle grazing (Hevly, Schley, and Barry MS). The abrupt increase of cinder at a depth of 31.75 cm resulted from the eruption of Sunset Crater about A.D. 1066 (Colton 1962). The cinder contains little pollen, few stem and leaf fragments, but abundant roots, indicating that it is an original air fall rather than being secondarily deposited. The deposition of cinder initially favored the growth of desert shrubs, but increasing proportions of Gramineae pollen suggest a progressively more grassland-like environment. The change in pollen preservation, increased relative abundance of Compositae and the occurrence of corn pollen at a depth of 12.7 cm probably reflects prehistoric agriculture. The changes in pine-juniper, pine-grass and juniper-grass ratios in the upper 6.35 cm probably reflect twentieth century floristic modifications associated with chaining of juniper and grazing of livestock.

pine-juniper ratios) in the twentieth century is probably due to local chaining operations. The eleventh century disruption of juniper is not likely to have been the direct result of damage from volcanic eruption considering the 22.5 km distance to the crater and the relatively shallow deposit of ash in the study area. Instead, the disruption of juniper is more likely to reflect the cutting of juniper for construction purposes by the prehistoric inhabitants whose local population underwent explosive growth at this time due perhaps in part to displacement of neighboring farmers from their former homesteads recently covered by lava and cinder (Berlin et al. 1978; Hevly et al. 1979; Pilles 1977).

While juniper recovered from this disruption, other plant types did not fair so well due to the permanently altered edaphic condition of this site. In particular, members of the Cheno-Am group (Chenopodiaceae-*Amaranthus*) diminished in relative abundance as grasses became more abundant. A second modification of the floristic composition of this site (increased proportions of Compositae) appears to occur coincident with cultivation and probably reflects disturbance not unlike that detected at the nearby prehistoric cornfield where also the effect of man's activity has persisted to the present (Berlin et al. 1978). The diminished proportions of Gramineae pollen in the latest twentieth century (surface) level could likewise reflect man's activity, in this case grazing by domestic livestock which has resulted in a local deterioration of rangeland.

While the above examples appear to reflect change of pollen production due to generally persistant changes of the floristic community resulting from volcanic eruption or disturbance by man, it is also possible to have changed pollen production with very little, if any, change of the local plant community. For example, the proportion of pine in a pine-juniper ratio (where both pine and juniper co-occur) parallels as expected the average moisture controlled growth trends of nearby trees but at a rate that is too fast to accommodate changed floristic composition involving establishment and growth of trees to sufficient maturity for cone production (Fig. 2a).

The significance of the local environment relative to pollen production and transport is also manifest in the arboreal pollen proportions, particularly those of pine composition.

When local growing conditions were favorable, locally produced pinyon pine pollen exhibits high proportions in the fossil pine data (Fig. 2b). However, when local growing conditions were not favorable, a larger proportion of yellow pine pollen transported a number of km from nearby mountains becomes the predominate pine type. Likewise, the local community of weedy annuals is comprised of species which flourish and flower successionally, different taxa predominating from year to year in response to seasonal changes of temperature and moisture availability (Hevly and Renner In Press; McDougall 1967; Solomon and Hays 1972). Persistant changes of their proportions over many decades, like those of pine-juniper ratio, probably reflect altered climatic conditions, such as seasonal distribution of moisture or succession within the local plant community coincident with abandonment and altered edaphic conditions. Incidentally it should be noted that the species composition of the flora of some areas of northern Arizona as well as the phenology of these plants is such that the seasonal indicator roles of Cheno-Ams and Compositae as described by Schoenwetter (1962), Martin (1963), Solomon and Hayes (1972) for southern Arizona are reversed in northern Arizona (Hevly and Renner In Press).

In final analysis, changes in pollen production do occur in response to physical (e.g. edaphic or climatic) and biotic modification of the environment. Such alterations may be essentially permanent (e.g., deposition of volcanic cinder or depletion of soil minerals through cropping); however, most are short term resulting from such phenomena as climatic perturbations, fire, and biotic exploitation. Distinction of the particular ecological factor(s) responsible for the observed nature, magnitude and duration of palynological

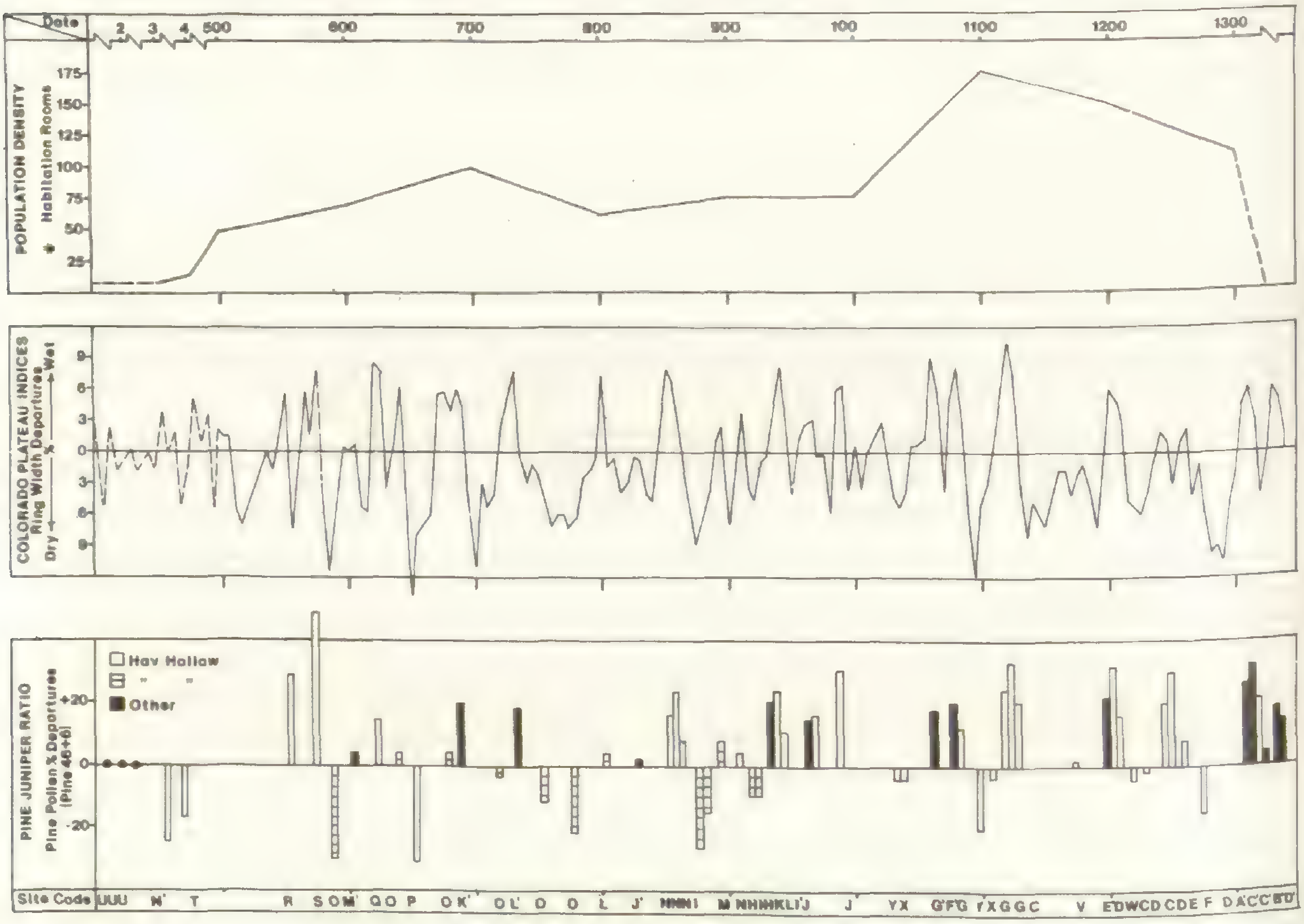
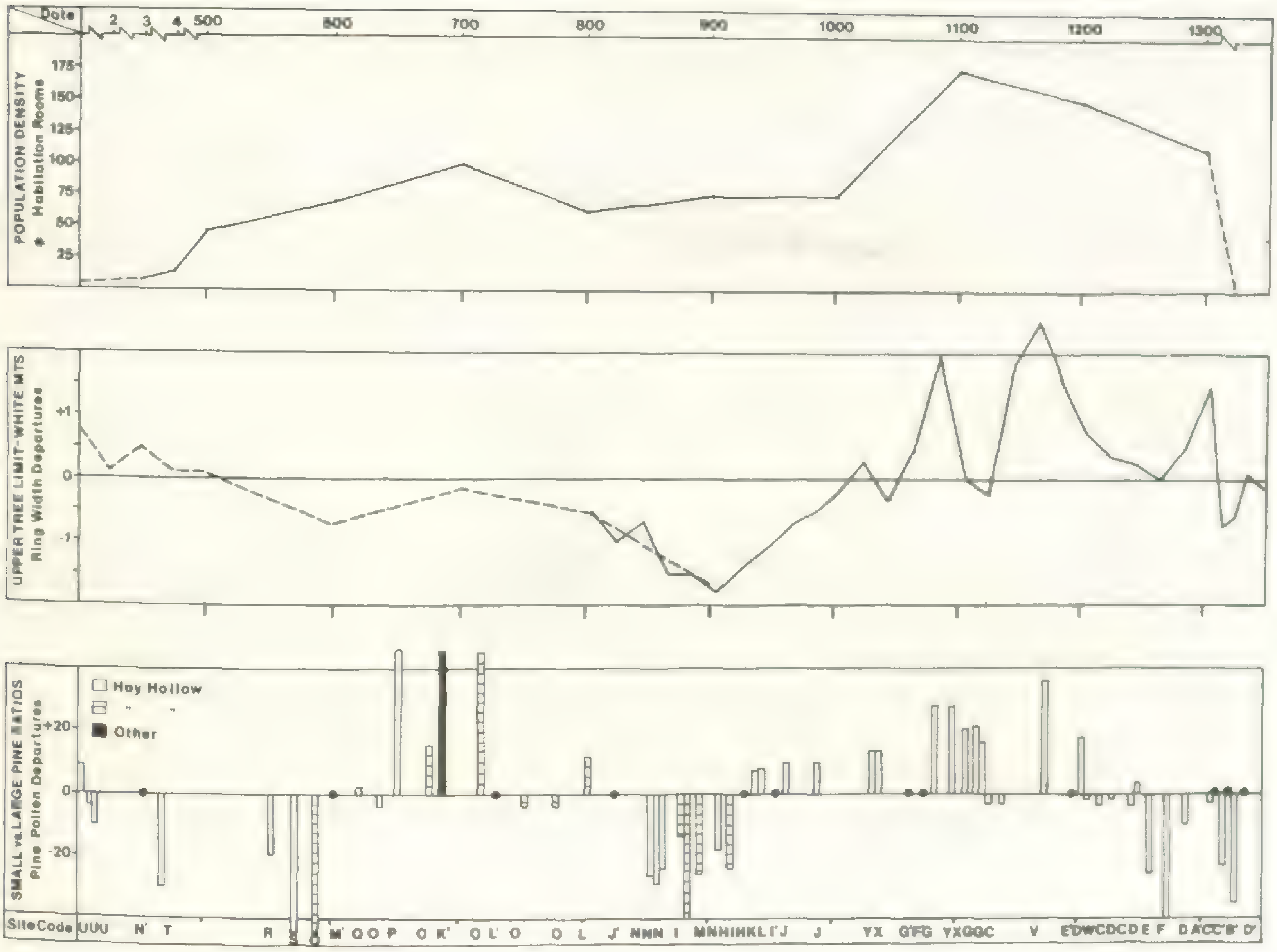


FIG. 2.—Comparisons of the demographic record and pollen records from Hay Hollow Valley (Bohrer 1972; Dickey 1971; Hevly 1964; Ward 1975) with tree-ring records from the Colorado Plateau (Fritts 1965) and the White Mountains of California (Lamarch 1974). Each site code letter reflects a different site (identical letters reflect different rooms of the same site.)

2a. Departures of pine pollen proportions from the modern mean in pine-juniper ratios probably reflect relative pollen production of these 2 genera locally, pine proportions declining during drought episodes as demonstrated in a study of historic pollen (Hevly et al. 1980).



2b. Departures of small pine proportions from the modern mean of small-large pine pollen ratios in the study area probably reflect local versus regional production of pine pollen and long-term trends of effective moisture.

change(s) in the fossil pollen record can often be accomplished by evaluation of additional biological, geological, and archaeological data. Such analysis permits more accurate paleoenvironmental reconstruction in which the relative effects of climatic perturbations, fire, biotic impacts by man and insects, as well as volcanism can be derived (Hevly et al. 1979).

Pollen Transport and Deposition.—The majority of pollen does not travel far from the plant producing it. Even in wind pollinated taxa most of the pollen falls immediately beneath the canopy (Silen 1962; Wright 1953). Nevertheless, wind transported pollen travels further (10s-100s km vs. 10s of cm to 100s of m)than insect transported pollen which appears in very low concentration in soil samples from open situations, being recovered most frequently in close proximity to the plant producing it or where it may on occasion have been dropped by insects transporting it. In archaeological sites or caves entomophilous pollen can be more abundant than in modern soils (Fig. 3a) and is most likely to have been introduced there by man or rodents (Briuer 1977; Hevly 1970; Hevly et al. 1979; Kelso 1970, 1976; Lyttle-Web 1978).

The majority of the pollen found in features with restricted openings (e.g., caves, shelters, fissures and man-made structures) is transported into such features primarily by wind but also by man and rodents. Pollen and sediment transport into such features should be slower than in open sites, but pollen will enter more freely than the larger and heavier inorganic sediment. Hence, if sediment accumulation is slow and a given sample reflects the accumulation of many decades or centuries, its pollen concentration should be high compared with that observed in open sites. These trends appear to be observable in the pollen concentration data available from Southwestern archaeological sites (Table 1). Continuously open sites such as rock fissures, caves and shelters have high pollen concentrations for individual samples, while man-made structures such as pithouses and

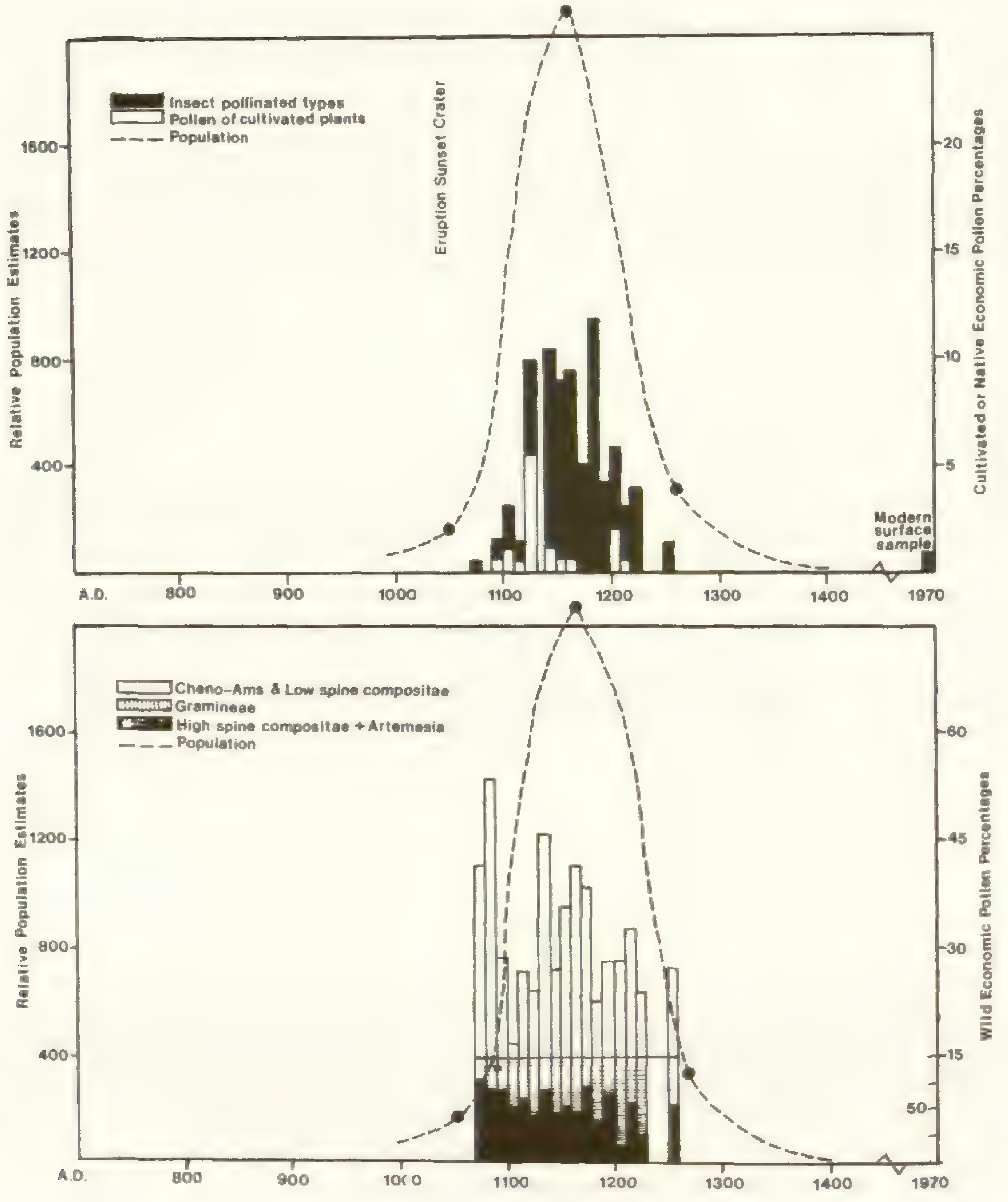


FIG. 3.—A comparison of prehistoric human demographic trends of the Flagstaff area (Colton 1962) with the proportion of non-arboreal pollen types from Elden Pueblo (Hevly et al. 1979).

3a. The rise and fall of human population at Elden Pueblo closely parallels the pollen records of cultivated plants and insect pollinated plants which both greatly exceed modern proportions. If the pollen of cultivated plants actually reflects the relative agricultural success of the local human community, some change of environment is suggested.

3b. Change in relative proportions of pollen from other largely annual non-arboreal taxa whose germination, seedling establishment and abundance are largely controlled by the seasonal distribution of moisture and temperature. The proportion of late-spring and early summer flowering Cheno-Am and Low-spine Compositae pollen in the total non-arboreal pollen sum is shown by the long, open bars. The proportion of Gramineae pollen (spring-summer flowering) to High-spine Compositae and *Artemesia* (late-summer and early-autumn flowering) is shown by the shorter bars and shorter scale at right. The data suggest replacement of Cheno-Ams and Compositae by Gramineae and could reflect secondary succession on the site, coincident with gradual abandonment and reduced disturbance; however, the data might also be interpreted to reflect a long-term trend of altered distribution of seasonal distribution of moisture. The latter interpretation could provide at least a partial explanation for the putative diminishment of agriculture inferred from pollen data of cultivated plants shown above.

pueblos with limited duration as a space within which to trap sediment have floor samples with more limited pollen content. Objects such as a small storage jar with a small hole open for centuries has accumulated a high concentration of pollen. Objects such as storage pits and cists open only for limited times during the occupation of the site and sealed for centuries by burial have low pollen concentrations. Comparison of contemporaneous fossil soils in an open situation with the pollen content of floor sediment of a pithouse or pueblo room and of storage pits or cists manifests a progressive reduction in pollen concentration. This phenomena is called attenuation and probably reflects progressively smaller target openings for pollen transport and also briefer periods for pollen deposition (original pollen content of soils on or in which man-made structures are built appears to be diminished by oxidation and mechanical breakage during construction (i.e. fossil soil, floors, cists, pit and subfloors in Table 1).

Since wind transported pollen can travel so far it might be anticipated that such pollen would enter structures with restricted apetures with great facility; however, contrary to expectations, different wind transported types appear to be transported differentially (Currier and Kapp 1974; Hevly 1970; Hevly et al. 1978; Tauber 1977). When the sediments of rock fissures are compared with outside soils, not only does the concentration of pollen change, but there is also an increase in the proportion of some wind pollinated types and decline in others (Fig. 4). The increase in pine pollen and decrease of other types is most noticeable in the Grand Falls Fissure, which has remained open for centuries collecting pollen. The magnitude of differential transport appears less in the structures occupied by man where pollen collected for more brief periods of time. Pine pollen is slightly under represented, while the NAP types, which were generally under represented in the fissure, are

TABLE 1.—*Pollen concentration and Preservation in Archaeological Sites. Preservation is expressed as the percentage of entire pine pollen. Concentration is expressed as mean numbers of grains per aliquot of pollen rich residue, numbers of grains per gram of extracted sediment and as numbers of grains counted while counting 150 grains from a known number of added exotic pollen* (Eucalyptus).

Provenience	Concentration aliquot	Pollen/ gram	150 Eucalyptus	Preservation	Spores/ aliquot
Fecies (Sheep) 1	1094	41,572	547	98%	210
Fecies (Human) 2	1050	53,200	315	99%	850
Mummy Alimentary Canal 3	1128-2198	45,050-55,650	—	100%	—
Grand Falls: 4					
Rock Fissure Floor	10,000	11,000	—	84%	17
Storage Jar	20,000	22,000	—	100%	513
Rock Springs Shelter 5	500-1500	506-1520	—	70-80%	—
Modern Soil 6	1061	1075	135	87%	275
Fossil Soil 7	2250	2280	—	75%	—
Pithouse Floor 7	332	336	—	69%	—
Pueblo Floor 7	658	666	—	66%	—
Hogan Floor 1	212	214	—	84%	300
Metate 1,7	227	—	—	—	—
Mono 1	127	—	—	—	—
Fire Pit 8	207	210	—	87%	—
Storage Pit 8	116	117	—	93%	—
Cist 8	50	50	—	90%	—
Subfloor 3	47	47	—	65%	—

1. Hevly et al. 1980; 2. Hevly and Hudgens MS; 3. Hevly MS*a*; 4. Hevly 1970; 5. Hevly et al 1979. 6. Hevly unpubl data. 7 Hevly 1964 and unpubl. data; 8. Hevly MS*b-d*.

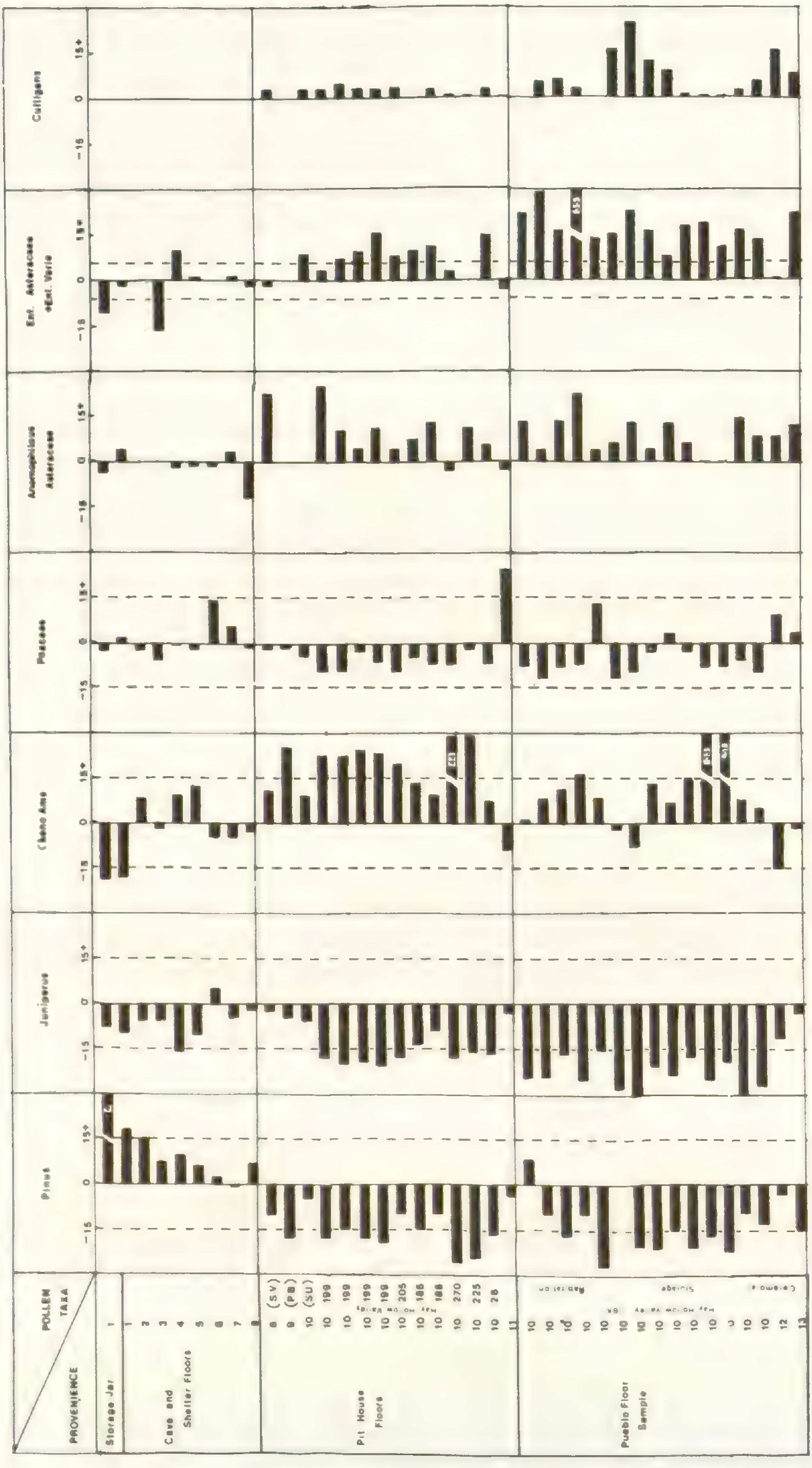
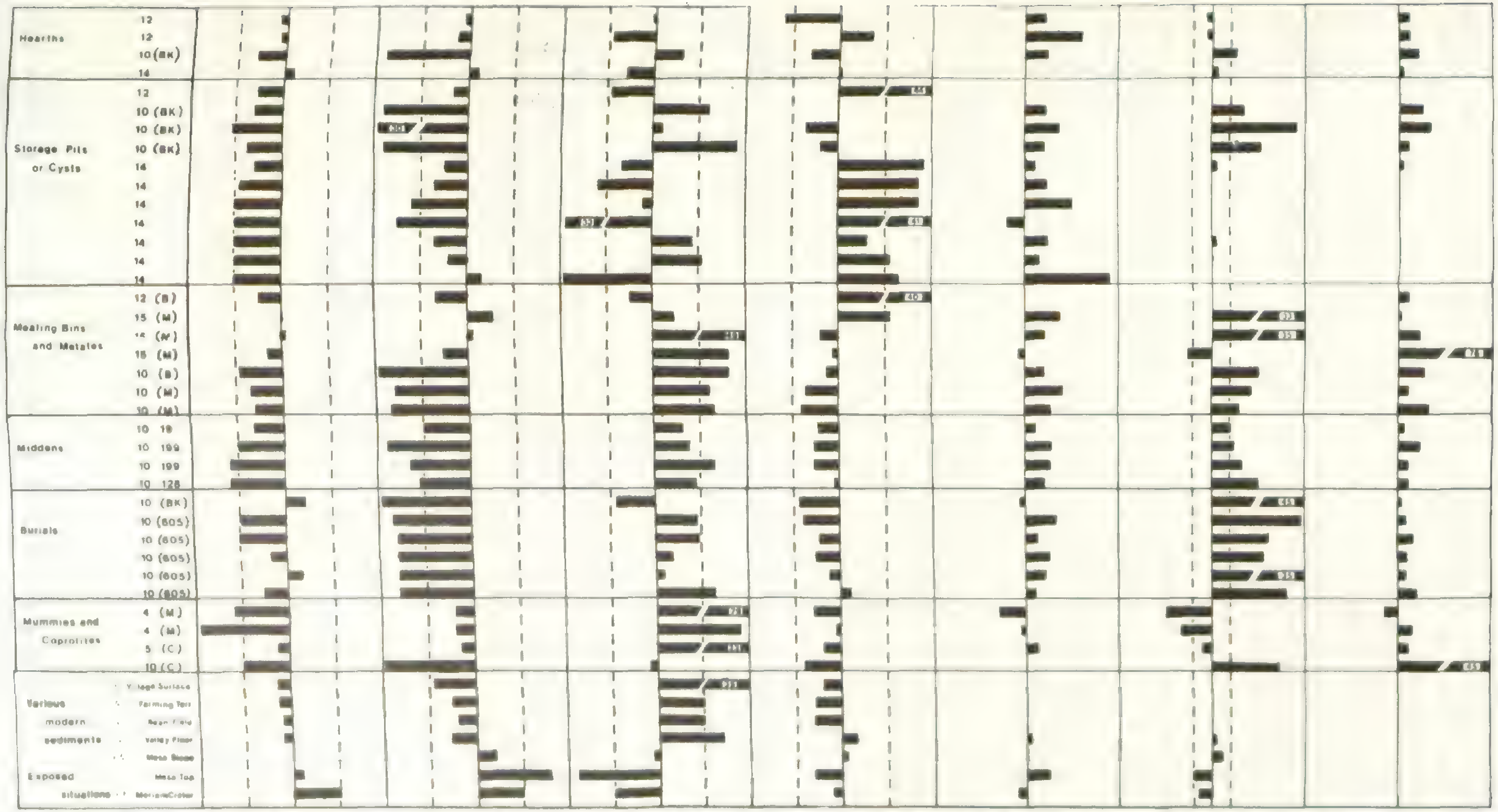


FIG. 4.—Departures of fossil pollen proportions (%) in various proveniences from the proportions of pollen in contemporaneous soils. Departures exceeding 15% for wind pollinated and 5% for insect pollinated types are significant at 0.05 level.



1. Hevly 1970, 2. Hevly et al. 1979, 3 Hevly 1968b, 4. Hevly MSa, Hevly and Hudgens MS, 6. Bruner 1977, 7. Hevly MSe, 8. Hevly MSa, 9. Hevly and Rogge MS, 10. Hevly 1964, 11. Bohrer 1972, 12. Ward 1975; 13. Dickey 1971; 14. Hevly MSc; 15. Halbirt MSb; 16. Scott 1979; 17. Berlin et al. 1978

frequently over-represented in the structures occupied by man, particularly when comparisons are made with modern rather than ancient soils (Fig. 4). Such over-representation reflects natural or human (Fig. 5) disturbance favoring growth of pioneer species at least in part (Diggs 1979; Gish 1979; Halbirt MS*a*; Scott 1979).

Macroscopic evidence from human feces and food storage and preparation features suggests that such pollen over-representation may also reflect the introduction of wild (or even encouraged or semi-cultivated) plant parts bearing pollen into the occupation areas (Bohrer 1972; Cutler 1964; Hevly MS*c*; Hill and Hevly 1968).

Recognition that the pollen record of archaeological sites is not identical to that of contemporaneous soils due to differential transport of pollen might seem a critical if not fatal blow to all attempts of paleoenvironmental reconstruction. However, selection of indicator species least affected by such differential transport and using samples from proveniences exhibiting minimal transport bias such as small sites may obviate such problems. Furthermore, when the general patterns of transport capability are recognized, various statistical procedures may be used to correct for over or under representation of particular types (Mosimann 1963).

Comparison of various man-occupied structures and non-archaeological sites permits recognition of general patterns in pollen transport and deposition, departures from which can be interpreted as changed modes of transport (Fig. 6). In archaeological contexts such changed modes of transport, which often are reflected by significant over-representation of particular types (Fig. 4), provides information regarding human activity (e.g., storage, food preparation and medicinal or ceremonial).

Pollen Preservation.—Different pollen types are not equally well preserved, being subject to chemical, mechanical, and biological degradation (Havinga 1971). It has been suggested that juniper pollen is less well preserved than pine pollen (Bradfield 1973; Potter 1967). This is contrary to experimental studies of relative pollen preservation and has not been substantiated in modern pollen studies of soils (Havinga 1971; Hevly 1968a). The explanation for these conflicting results may relate to the different seasons of pollen dispersal in pine (early summer) and juniper (early spring) and perhaps even to the nature of the depositional environment. If juniper pollen were to lie on an exposed soil surface for several months prior to burial by wind mixing of sediments or secondary transport into a cistern with the onset of summer rains shortly after the pollination of pine, it would be expected that differences of preservation might be manifest. If, on the other hand, juniper and pine pollen are both buried shortly after their wind transport and deposition, preservation would be about equal as found in the experimental studies. The problem is worthy of much further examination since no one has checked the relative preservation of pine and juniper in different depositional environments. Preliminary studies would suggest that differences might occur since pine pollen is not equally well preserved in wet vs. dry sediments of different plant communities (Fig. 7).

Preservation of pollen could be an important factor in fossil pollen studies of archaeological sites, since relative abundance of a pollen type such as pine appears to be negatively correlated with the percentage of broken grains in both modern and fossil samples (Fig. 7). Fortunately, the range of preservation found in modern and archaeological samples is about equal (except in samples from burned structures) despite the generally lower pollen concentrations of archaeological samples compared with that of modern soils from open environments (Table 1; Fig. 7).

The variability of pollen preservation might also seem a fatal blow to environmental reconstruction; however, the types critical for environmental reconstruction appear to be about equally well preserved. Preservation of pollen in different depositional situations is also variable, but archaeological sites, particularly in grassland or woodland situations, seem to provide best preservation. In fact pollen often provides the only record of plants whose macroscopic record is totally lacking in archaeological context having been decomposed by bacteria or fungi, eaten by animals or destroyed by fire (Bohrer 1972; Schoenwetter 1962; Hevly 1964, 1968b, MS*c*; Martin and Byers 1965).

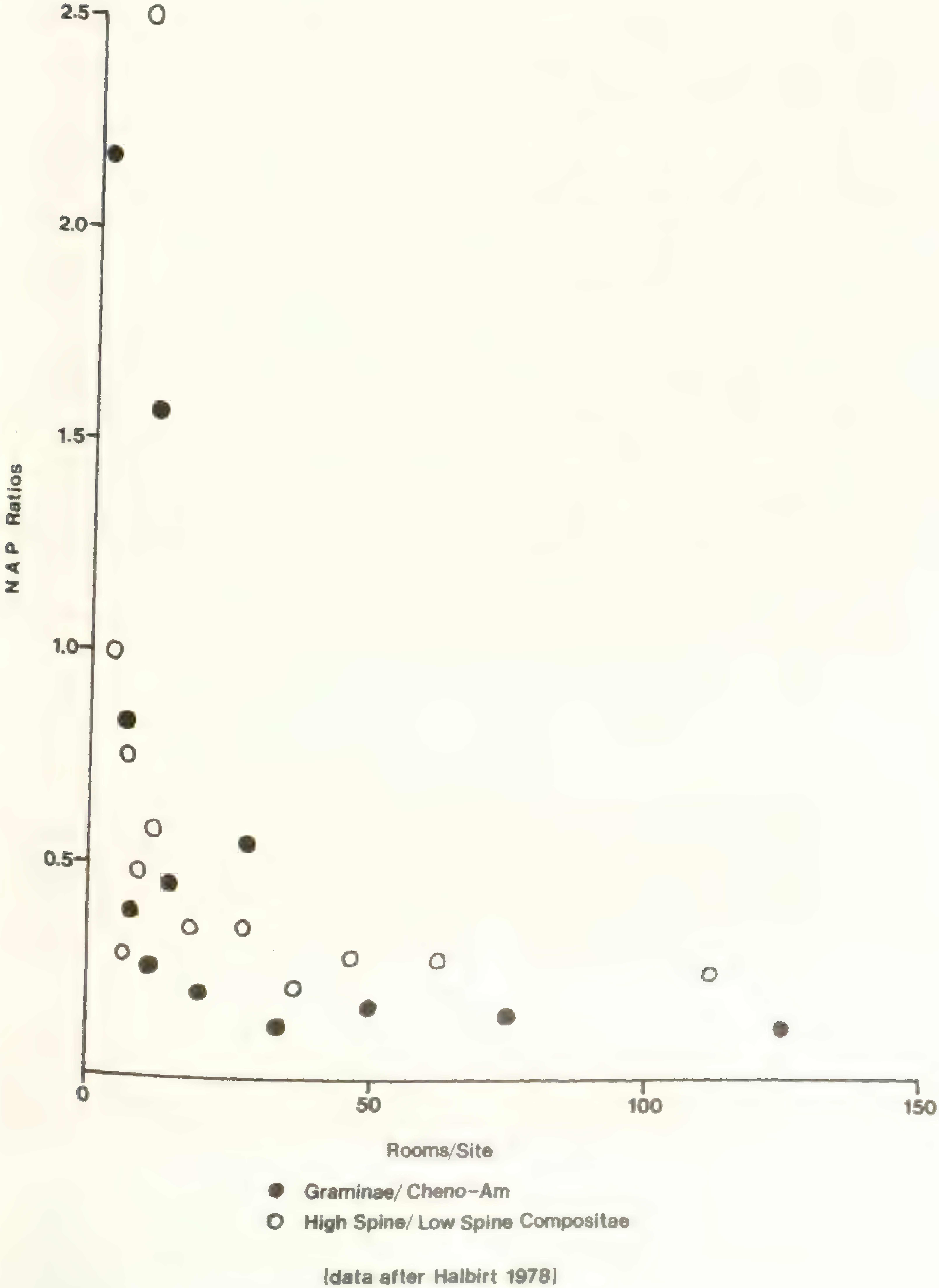


FIG. 5.—A comparison of non-arboreal pollen ratios with the size of archaeological sites (rooms/site). Smaller sites are characterized by higher proportions of Gramineae and High-spine Compositae pollen, while larger sites are characterized by higher proportions of Cheno-Am and Low-spine Compositae pollen. The latter plants are characteristic pioneer plants favored by disturbance.

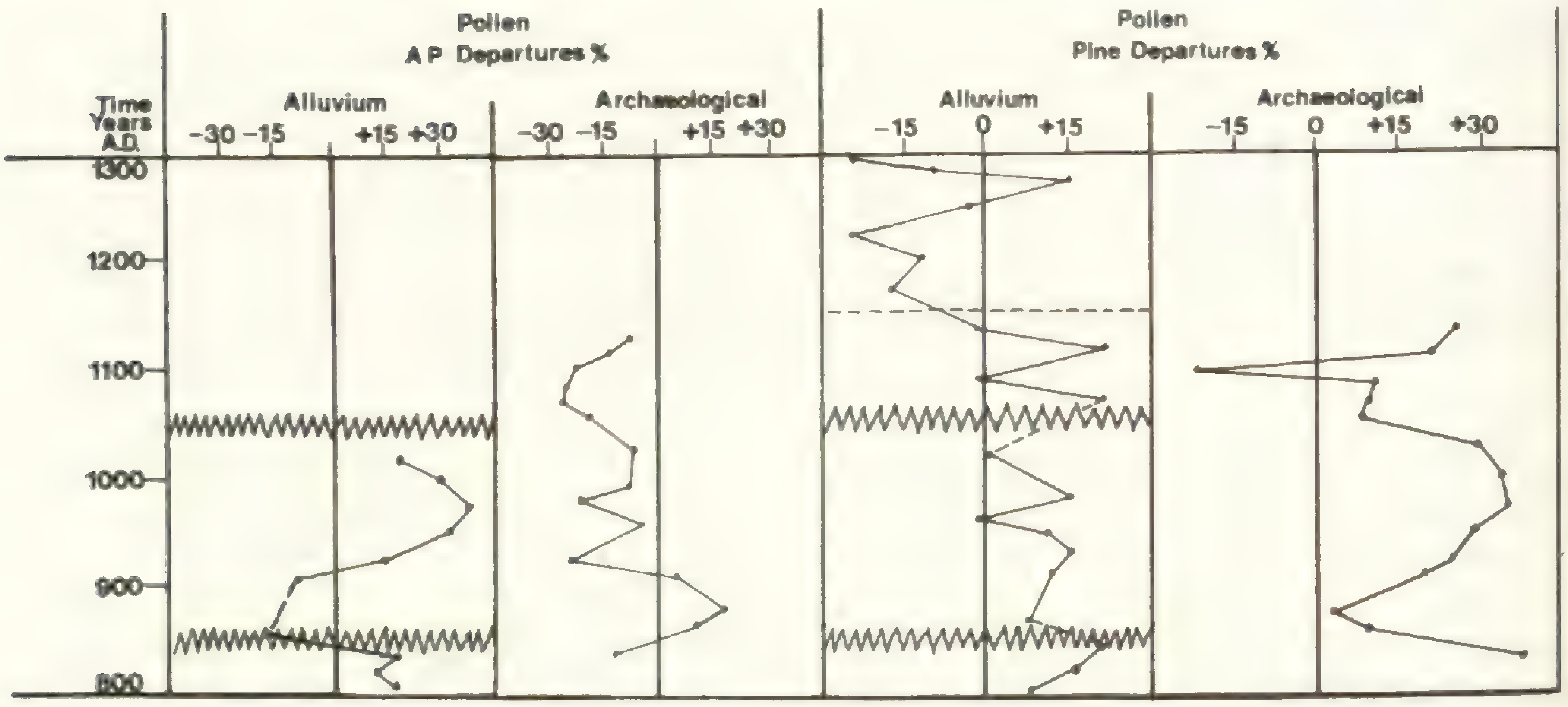


FIG. 6.—Comparisons of the arboreal pollen data from alluvial and archaeological proveniences in the same locality (Black Mesa, Hevly, unpubl. data). Unadjusted departures of arboreal pollen from the modern mean of the study area are negatively correlated between alluvial and archaeological sites, reflecting perhaps the differences of mode of pollen transport into such environments. Departures of pine in pine-juniper ratios from the modern mean of the study area exhibit generally parallel trends. The few differences which can be noted probably reflect ambiguities introduced by sampling intervals. The data suggest that pine-juniper ratios can reasonably be substituted for AP/NAP ratios in environmental reconstructions if the latter ratio is biased, for example by NAP over-representation.

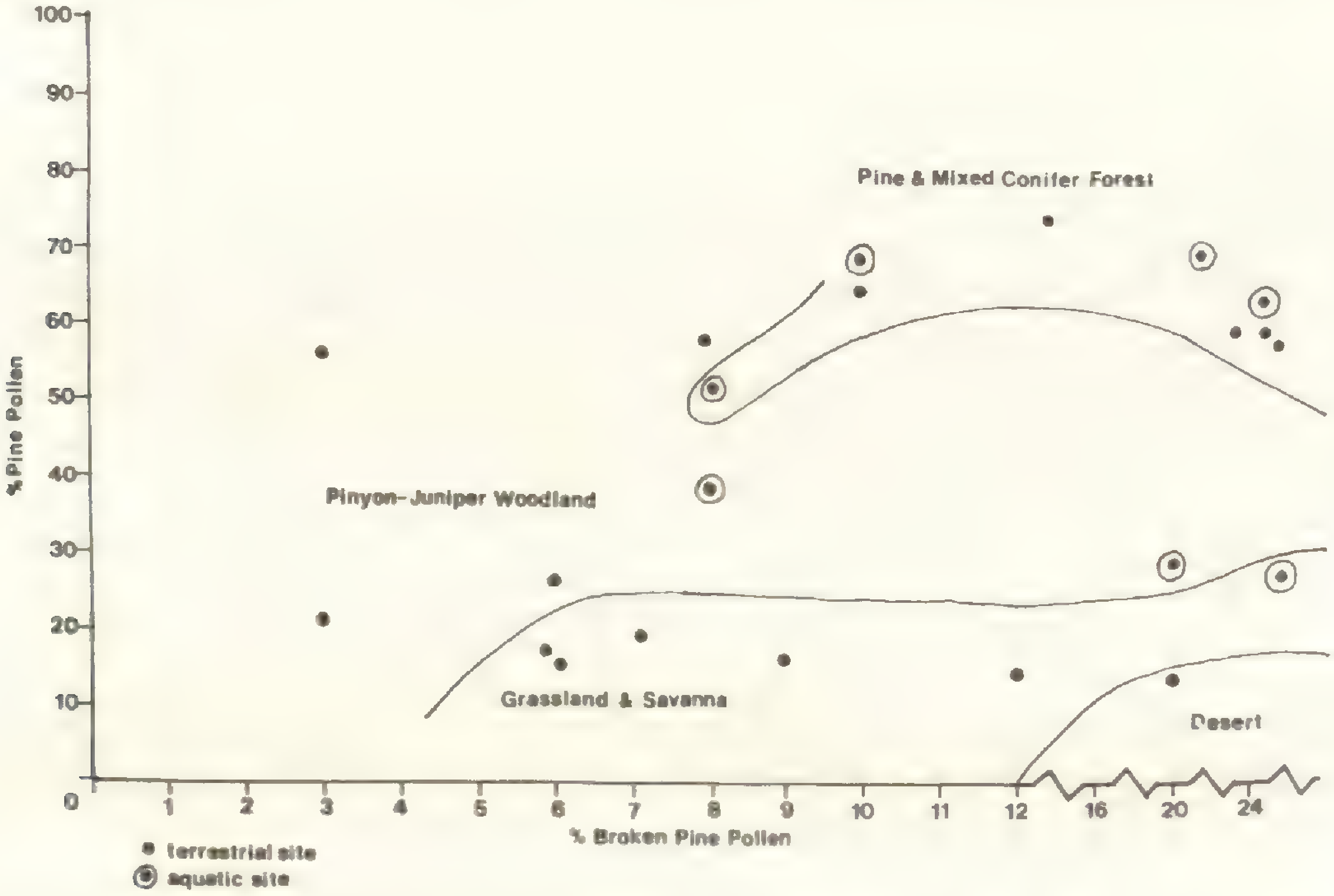
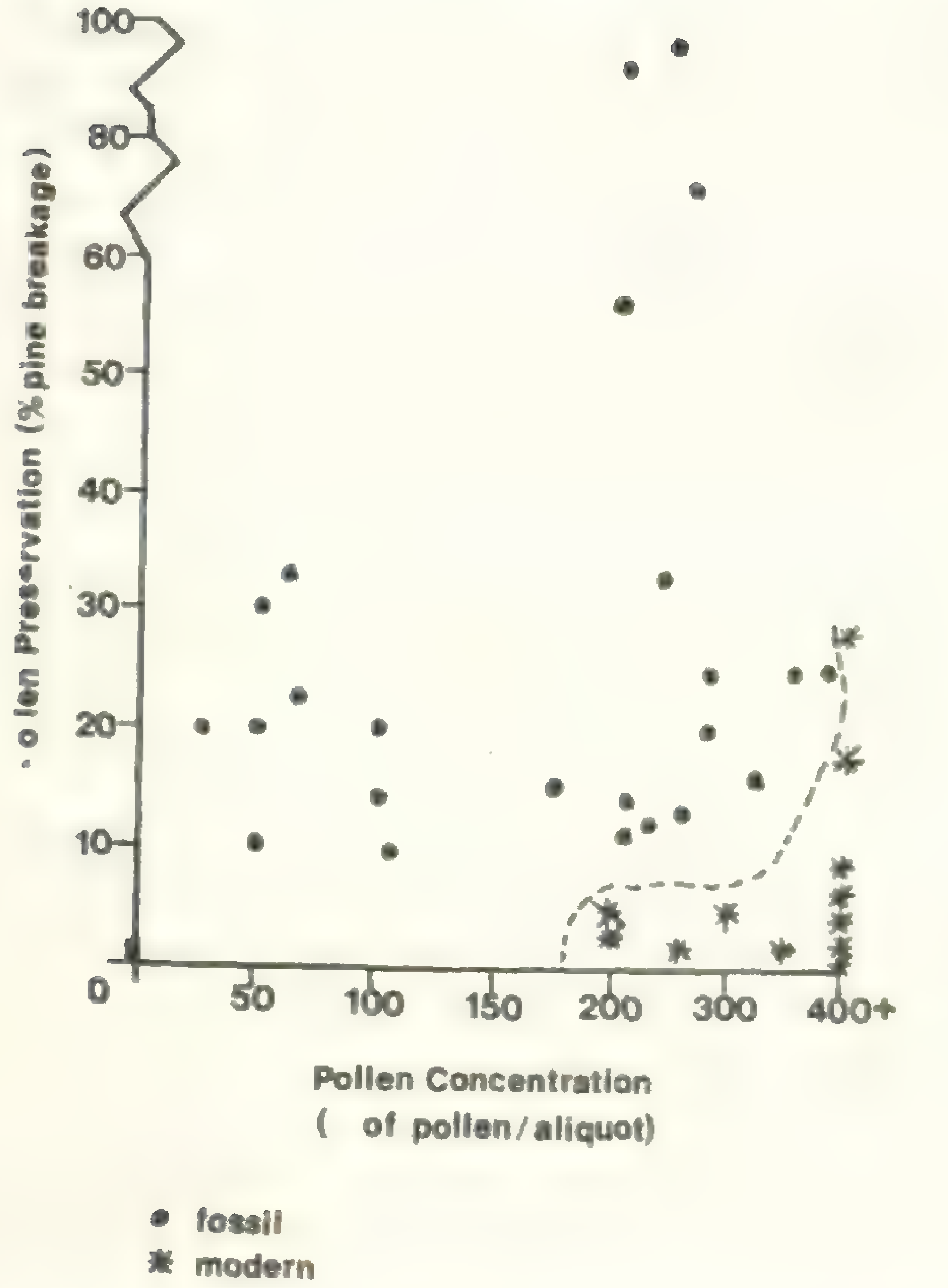
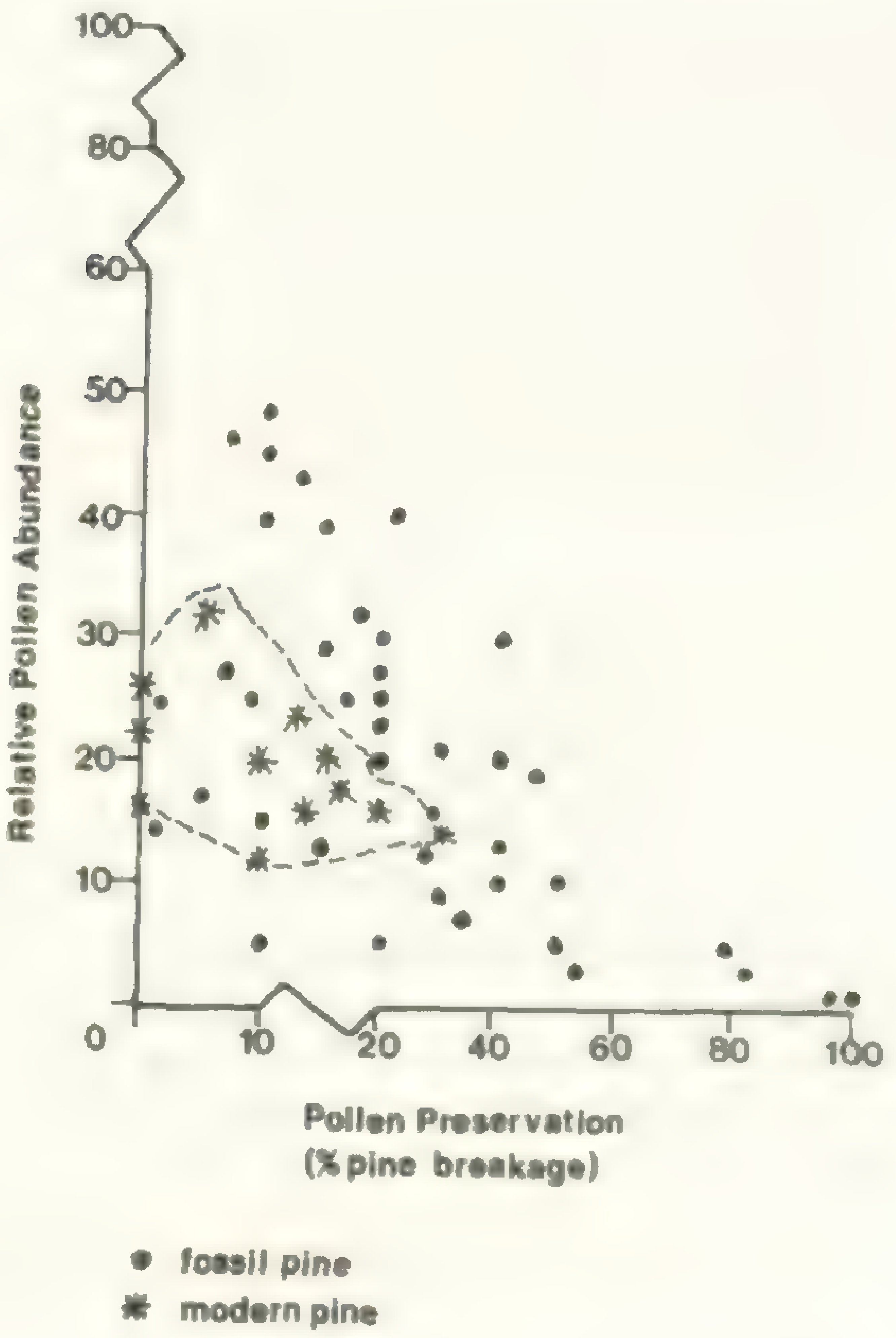


FIG. 7.—Preservation of pine pollen (data from Dickey 1971; Hevly 1964; Ward 1975).

7a. A comparison of the preservation of pine pollen with the percentage of pine recovered in different depositional environments within different plant communities. Generally, the proportion of pine increases as expected in the higher elevation conifer. However, pine proportions may also be high in depositional environments characterized by low plant cover and correspondingly low pollen production as compared with depositional environments characterized by high plant cover and correspondingly high pollen production (compare aquatic vs. terrestrial sites in grasslands and savanna). Preservation is approximately equal in aquatic and terrestrial sites within the pine and mixed conifer forests. Within the Pinyon-Juniper Woodland and Grassland or Savanna communities preservation was generally better than in the pine and mixed conifer forests except in aquatic sites.





7b. A comparison of pine pollen preservation and total pollen concentration. Pollen concentration is lower than in modern soil samples, however, the range of preservation is about the same except in burned sites where more than 50% of the pine pollen is broken.

7c. A comparison of the relative abundance of pine pollen and pine preservation. Generally the relative abundance of pine pollen diminishes as the breakage of pollen increases.

CONCLUSION

The pollen record contained in archaeological sites, like that of any other depositional environment, is influenced by such factors as pollen production, dispersal and preservation. Interpretation of fossil pollen data from archaeological sites for either behavioral or paleoenvironmental inferences requires elucidation of the significance of such factors relative to individual pollen types. Acquistion of such data is just now beginning in the Southwest; however, preliminary data now in hand clearly indicate trends of the potentials and limitations of archaeological palynology.

Changes in pollen production do occur in response to physical and biotic modification of the environment. Such alterations may be of very long duration, but most are short term, resulting from such phenomena as climatic perturbations, fire and biotic exploitation. Distinction of the particular ecological factor(s) responsible for the observed nature, magnitude and duration of the palynological change can often be accomplished.

The pollen record of archaeological sites is not identical to that of contemporaneous soils due to differences of mode of pollen transport into different depositional environments and even of differential capability of pollen to enter archaeological sites due to location, size and seasonality of openings. Comparisons of pollen taxa with other previously demonstrated sensitive environmental indicators reveals that some pollen types are useful for purposes of paleoecological reconstruction. Comparisons of pollen taxa within and without archaeological sites indicates that other pollen types are probably more useful as indicators of human behavior.

Different pollen types are not equally well preserved and the preservation of pollen in the archaeological record may not be assumed to be similar for all time periods. Experimental studies are badly needed in the American Southwest, but data which are at hand suggest the pollen types which appear to be of greatest utility for paleoenvironmental reconstruction are fortunately about equally well preserved. Thus, if preserved by incorporation in soil soon after dispersal, such pollen types should retain their utility as paleoecological indicators.

Thus, in final analysis, the potential limitations posed by improving understanding of pollen production, dispersal and preservation are real but not so limiting as to preclude reasonable inferences of human behavior and attempts of paleoenvironmental reconstructions.

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INFERRED DATING OF OZARK BLUFF DWELLER OCCUPATIONS BASED ON ACHENE SIZE OF SUNFLOWER AND SUMPWEED

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ABSTRACT.—Samples of cultigen sunflower and sumpweed achenes recovered from archaeological sites in eastern North America gradually increase in average size during the last 3000 years of prehistory. Although there are apparent exceptions, achene collections from the same general time period fall within a relatively restricted mean size range. Achene samples of both sunflower and sumpweed have been recovered from several Ozark Bluff Shelters, but the dating is highly problematical. The sumpweed samples fall into 2 distinct size categories which indicate that they derive from 2 separate time periods, one during Mississippian times and the other during early Late Woodland times. The sunflower samples display a more continuous mean size variation and seem less reliable as chronological indicators.

INTRODUCTION

Seeds and achenes of cultigen sunflower (*Helianthus annuus* var. *macrocarpus* Ckll.) and sumpweed (*Iva annua* var. *macrocarpa* Jackson) have been recovered from many archaeological sites in eastern North America ranging in age from about 1500 B.C. to late prehistoric times. Sunflower husbandry has continued to the present, but there are no reports of historic sumpweed husbandry. The prehistoric record of these plants has been extensively reported by Asch and Asch (1979), Black (1963), Heiser (1951, 1955), Struever and Vickery (1973), Yarnell (1972, 1979), and others. What is of concern here is the gradual increase in size of achenes as a result of domestication during the last 3000 years of prehistory as indicated by more than 30 series of measurements each for archaeological sunflower and sumpweed.

DISCUSSION

Sunflower achenes apparently increased in mean size from approximately 6 x 3 mm up to about 12 x 7 mm, while sumpweed achenes increased from 3.5 x 2.5 mm up to 7.5 x 5 mm. Taking into account an apparent doubling of thickness, the overall increase in sumpweed achene size was approximately eight-fold, while sunflower achene size increased twice that much. Overall increase in sumpweed achene size from the wild progenitor appears to have been approximately twelve-fold, which again is only half the comparable increase for sunflower.

These increases can be interpreted as having been more or less regular and continuous through time even though the available data are still less abundant than preferred, even though there are exceptions to the expectations. The summary data portrayed in Table 1 present a preliminary indication of the patterns of size increase of sunflower and sumpweed achenes. (See Yarnell 1972 and 1979 for more detailed data and sources.) It shows that the average of means of achene length times width gets progressively larger from Terminal Archaic through Early Woodland, Middle Woodland, and early Late Woodland to Mississippian times.

Sunflower and sumpweed achenes from the Ozark Bluff Dwellings and from Newt Kash Hollow shelter in eastern Kentucky are not clearly placed chronologically. Neither are the sunflower achenes from the Mammoth Cave vestibule or the sumpweed achenes from Cloudsplitter and Hooton Hollow shelters in eastern Kentucky. In addition, sample size is too small to be reliable for 8 sites with sunflower and 4 sites with sumpweed. This leaves 17 sumpweed samples (N = 11 to 879) and 11 sunflower samples (N = 9 to 1000) which were used

TABLE 1.—*Average size of sumpweed and sunflower achenes from different time periods as compared to Ozark Bluff Shelter achenes.*

SUMPWEED **no. of pop. means averaged**	**average of means in mm**	**Time Period**	**SUNFLOWER** **average of means in mm**	**no. of pop. means averaged**
6	4.2 x 3.2 = 13	Terminal Archaic-Early Woodland	7.4 x 3.2 = 24	4
8	5.6 x 3.8 = 21	Middle and Early Late Woodland	7.8 x 4.0 = 31	3
		(without Boyd, MI)	(8.0 x 4.4 = 35)	(2)
3	7.2 x 4.9 = 35	"Mississippian"	11.4 x 6.1 = 70	4
		(without Wilford, MI)	(11.9 x 6.7 = 80)	(3)
		Ozark Bluff Shelters		
2	5.5 x 3.9 = 21	smaller achenes	10.1 x 5.4 = 55	2
		intermediate	10.8 x 6.3 = 68	2
4	7.3 x 4.9 = 36	larger achenes	11.6 x 7.7 = 89	2
no. of achenes	mean size		mean size	no. of achenes
300	5.5 x 3.9 = 21	Edens - 1706	9.7 x 5.2 = 50	12*
300	5.5 x 3.9 = 21	Craddock 66 - 380	10.3 x 5.9 = 61	17
		Craddock 66 - 186	10.7 x 6.3 = 67	32
		Craddock 66 - 384	10.9 x 6.3 = 69	150
		Craddock 67 - 548	11.3 x 7.2 = 82	14
		Brown Bluff - 78	11.9 x 8.1 = 96	56
56	7.1 x 5.0 = 36	Craddock - 552		
91	7.3 x 4.8 = 35	Alred - 103		
250	7.4 x 4.8 = 36	Alred (32-4-156)		
45	7.5 x 5.1 = 38	Edens - 980a		

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*This includes 3 achenes collected by Dellinger, measured by Heiser, and identified as "University of Michigan Lab. No. 276-12800'(15478H - Ark (E 1706)" (Heiser 1953).

in order to derive an average achene size for each of 3 broad prehistoric periods: Terminal Archaic and Early Woodland, Middle Woodland and early Late Woodland, and "Mississippian" (including Fort Ancient). The number of usable samples is minimal, but the results are generally supported by data from the smaller samples and by analyses of Asch and Asch (1979) and Andrea B. Shea. In addition, there are indications that the reconstruction factors for estimating original achene size from carbonized sumpweed seed and achene size tend to underestimate the mean size of larger achenes (Asch and Asch 1979; A.B. Shea, personal communication). It is suspected that the same is true for sunflower.

The product of length and width in mm is taken to be a reliable indication of achene size for purposes of comparison. For sumpweed these figures are 13, 21, and 35 for the 3 broad periods from earliest to latest. The comparable figures for sunflower samples are 24, 31, and 70. Two sunflower samples from the Yazoo Basin in western Mississippi are exceptionally small for their age. Achenes from the Boyd Site with an estimated date of A.D. 500 (John Connaway, personal communication) average the same size as sumpweed achenes from the same site (see Table 2), and achenes from the Mississippian period Willford Site have a mean length times width of only 41. It appears that these sunflowers, grown at the southern margin of the prehistoric sunflower belt, perhaps in damp soil, produced smaller achenes than those produced elsewhere at the same time. If we delete these 2 samples, the size progression for sunflower becomes 24, 35, and 80 through the 3 periods. This seems nearer to the reality of prehistoric evolution of sunflower achene size under domestication. It also is a better indication of the vast increase in sunflower achene size during Late Woodland and Mississippian times.

If we compare the sizes of sumpweed and sunflower achenes from Newt Kash Hollow (21 and 29; see Table 2) to the size progression portrayed in Table 1, they seem to fit best into Middle Woodland to early Late Woodland times; but they may have a mixed composition. This age seems about right for the Hooton Hollow sumpweed also, but the initial Cloudsplitter sumpweed collection fits well into the Early Woodland size category. The Mammoth Cave Vestibule sunflower, collected by Nelson and measured by Heiser, is much too large for an Early Woodland assignment but accords well with a Late Woodland designation.

On the basis of a limited series of measurements, I had assumed until recently that all of the sunflower and sumpweed from the Ozark Bluff shelters were Mississippian in age, probably not earlier than A.D. 1100 to 1200. Early in 1978 the University of Arkansas Museum graciously allowed access to collections there in order to select samples of Arkansas

TABLE 2.—*Sumpweed and sunflower from the same source.*

SUMPWEED			SUNFLOWER	
no. of achenes	mean size		mean size	no. of achenes
309	3.7 x 2.7 = 10	Salts Cave J IV: 4 - 11	7.4 x 3.3 = 24	57
40	4.0 x 3.1 = 12	Mammoth Cave cadaver	7.0 x 3.1 = 22	80
879	4.2 x 3.2 = 13	Salts Cave feces	7.4 x 3.2 = 24	1000
74	5.5 x 3.9 = 21	Newt Kash Hollow, KY	8.6 x 3.4 = 29	14
20	6.1 x 4.2 = 26	Boyd, MI	7.3 x 3.4 = 25	10
13	5.7 x 3.9 = 22	Hooton Hollow shelter, KY	9.0 x 4.0 = 36	4
74	6.0 x 4.2 = 25	Haystack shelter, KY	9.0 x 4.0 = 36	2
19	6.2 x 4.2 = 26	Rogers shelters, KY	8.6 x 4.1 = 35	11
300	5.5 x 3.9 = 21	Edens - 1706	9.7 x 5.2 = 50	12
300	5.5 x 3.9 = 21	Craddock 66 - 380	10.3 x 5.9 = 61	17
19	7.0 x 4.5 = 32	Paul McCulloch, MO	12.6 x 6.6 = 83	1000

Bluff Dweller sunflower and sumpweed achenes for study. With the generous assistance of museum personnel I was able to locate 6 collections of sunflower achenes and 6 of sumpweed, only 2 of which contained both species.

Measurement of the sumpweed achenes revealed that the samples fall distinctly into 2 size categories. Four samples from Craddock, Alred and Edens shelters average 7.3 x 4.9 mm = 36. This is approximately the size expected for all of the Ozark Bluff Dweller samples. However, 2 samples from Edens and Craddock 66, both of which have mean sizes of 5.5 x 3.9 mm = 21, are clearly outside of the expected Mississippian period size range. In fact, they are the same size as the Newt Kash Hollow sumpweed and fall between the Middle Woodland and early Late Woodland expected sizes. This suggests that they should date to around the fifth century A.D. Yet, data included in Tables 1 and 2 indicate that the mean sizes of sunflower achenes from these collections occupy intermediate positions between the early Late Woodland size, on the one hand, and the mean sizes of good Mississippian period collections and the other Ozark collections, on the other hand. Thus it would appear that the 2 Ozark samples with smaller sumpweed and sunflower achenes should date to approximately the seventh century A.D. This assumes that there was no contamination of the sample by larger sunflower achenes from a later deposition.

Two collections of sunflower achenes from Craddock 66 shelter which average 10.8 x 6.3 mm = 68 may be early Mississippian in age, whereas 2 more collections of still larger achenes from Craddock 67 and Brown Bluff shelters should date to well within the Mississippian period. In fact there is a radiocarbon date of A.D. 1110 + 110 (M-1711) on materials with the same collection number (BR - 78) as the Brown Bluff sunflower (Crane and Griffin 1968: 92). These achenes have a mean size of 11.9 x 8.1 mm = 96 which is the largest of any prehistoric collection on record. Mean thickness of achenes in the Ozark sunflower collections is consistent with mean size as determined by length and width.

There is one additional sample of 10 sumpweed achenes, measured by Richard I. Ford (personal communication), with a mean size of 7.0 x 5.2 mm = 36. This is from the Proether shelter in southern Missouri and clearly falls in the Mississippian period size category. Heiser (1953) has measured 2 samples of sunflower achenes from unidentified Ozark shelters. A sample of 9 achenes recovered by M.R. Harrington (Heye Museum No. 11/7265) has a mean size of 9.3 x 4.8 mm = 45 and thus falls near the early Late Woodland size. Another sample of 10 achenes (University of Michigan, Museum of Anthropology No. 13250) with a mean of 11.4 x 7.0 mm = 80 is Mississippian in size.

The chronological indications resulting from determination of sunflower and sumpweed achene size in the Ozark shelter collections are that early Late Woodland and Mississippian occupations are represented, possibly with an early Mississippian component as well, occuring within an inferred time range of the seventh century A.D. or earlier to the twelfth century A.D. or later. These estimates are based exclusively on sunflower and sumpweed achene sizes and are presented with somewhat limited confidence. They were derived independently of the available radiocarbon dates which can be interpreted as providing a chronology that differs in some respects from the chronology based on achene size.

Crane and Griffin (1968: 88-93) have reported 17 dates from 8 Ozark shelters ranging from 40 B.C. to A.D. 1950. Since there is no historic record of giant sumpweed achenes, the 3 latest dates of A.D. 1670, A.D. 1810, and A.D. 1950 should be of no concern, certainly not the last 2. Also it seems unlikely that the date of 40 B.C. (M-1694) from Red Rock shelter is relevant to the sunflower and sumpweed remains. Except for an Edens shelter date of A.D. 630, the remaining dates form 2 clusters. The earlier cluster includes dates of A.D. 200, A.D. 360, and A.D. 370 from Edens, Breckenridge, and Red Bluff shelters. The latter 2 dates might be seen to indicate the age of the collections of smaller sumpweed from Edens and Craddock shelters were it not for the size of the associated sunflower achenes. The later cluster includes 9 dates ranging from A.D. 935 to A.D. 1430 and presumably dates the Mississippian period occupations. Four of these dates range from A.D. 1080 to A.D. 1160, and 7 range from A.D. 1080 to A.D. 1350. It is likely that the collections with large sumpweed achenes and those with large sunflower achenes date from this period. In fact, as noted earlier, the Brown's Bluff collection containing large sunflower achenes has been dated to this period.

The single early Late Woodland date of A.D. 630 + 120 (M-1703 A) seems most likely to represent the age of the samples of smaller sumpweed achenes from Edens and Craddock shelters, but their actual age may be between this date and the date of A.D. 1080 + 110 (M-1702) which was determined on other materials from the same Edens provenience (Burial E-19). This would be approximately contemporaneous with the sumpweed of similar size from Stilwell and Newbridge in the lower Illinois Valley and some of the rockshelters in eastern Kentucky.

CONCLUSIONS

To summarize, conjecture, and conclude, I suggest that in general we can reasonably expect that the product of mean length times mean width in mm for sizeable collections of sumpweed and sunflower achenes to be approximately:

Sumpweed		Sunflower	
8 to 12	and	20 to 24	for Terminal Archaic samples
12 to 16	and	22 to 26	for Early Woodland samples
16 to 20	and	25 to 35	for Middle Woodland samples
20 to 26	and	35 to 60	for early Late Woodland samples, and
25 to 40	and	50 to 100	for Mississippian period samples.

These estimates are based on the available data and only minimally take into account the expectation that a certain amount of deviation from the norm will be encountered because of the operation of a variety of influencing factors. Currently the data indicate that greater deviation can be expected for sunflower, which might further indicate that greater varietal diversity had developed in sunflower. In any case, it appears that continuing increase in size of achenes took place more uniformly for sumpweed and that this species should be a better chronological indicator than sunflower.

The degree of accuracy of the estimated size ranges of achenes for each period will eventually be determined when we have an adequate set of measurements for additional collections of archaeological sumpweed and sunflower achenes which have been reliably dated.

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ON PREDICTING HUMAN DIETS

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ABSTRACT.—Optimal Foraging Theory (OFT) has helped animal ecologists understand the dietary preferences of animals. This paper addresses the question "Can OFT shed light on the food choices of humans?" In its simplest form, OFT predicts the diet which maximizes net energy gain to the forager. In the harshest of human environments, humans may be forced to maximize their energy intake; however, in most environments, humans are probably more concerned about a nutritionally balanced diet than about an energy-rich one, OFT theory can predict nutrient-contrained diets but the theory becomes more complicated and the required information on the nutrient contents of wild foods is usually lacking. Nonetheless, some evidence does suggest that humans often choose food so as to meet their nutrient requirements.

The area of OFT known as Central Place Foraging Theory may be directly applicable to stationary, hunter-gatherer societies. The theory predicts that people should be food generalist when hunting and gathering near home but should become progressively more specialized in foods they choose to bring home when they forage farther and farther afield. The evidence for and against this prediction is discussed.

Finally, the evolutionary mechanisms which might result in optimal human foraging behavior are discussed in some detail.

INTRODUCTION

In recent years, animal ecologists have become increasingly interested in the criteria which animals use to select their diets. Many ecologists believe that animals do not select food at random, but rather select food according to criteria that have evolved by natural selection (Pyke et al. 1977; Schoener 1971). More precisely, ecologists argue that the neural and sensorimotor mechanisms which, in large part, determine food choices, have evolved by natural selection to maximize Darwinian fitness. This viewpoint has led to a body of ideas known collectively as Optimal Foraging Theory. The purpose of this paper is to ask whether or not this theory might be useful to human ecologists studying human diets.

The usefulness of Optimal Foraging Theory to animal ecologists has largely been that it has allowed them to organize their thoughts and to ask new questions. Ecologists have long argued that food selection is, in some ill-defined way, adaptive. Optimal Foraging Theory has focused the adaptation picture by forcing investigators to state precisely what they mean by adaptive behavior. The result is that, for the first time, ecologists are formulating testable hypotheses about food selection. These hypotheses are being tested in laboratory and field experiments. As some hypotheses are accepted and others rejected, ecologists are coming closer to an understanding of the actual criteria of food selection.

In this paper, I address 2 questions. First, I ask "How might human food habits become adapted to local conditions?" This is fundamentally a question of evolutionary mechanisms and inevitably leads to the nature-nurture problem. Second, I ask "What patterns of human food selection are predicted by Optimal Foraging Theory?" As an animal ecologist with very little training in anthropology, I can only point out what the predictions are; fortunately, a number of qualified anthropologists are now attempting to test them (e.g., see Winterhalder 1977).

DISCUSSION

Mechanisms of Evolution

Even in the case of non-human behavior, ecologists have usually avoided the difficult questions of mechanisms. Ecologists have argued that adaptive foraging behavior results from natural selection working on heritable variation, but they have avoided the questions of how, in learning animals, behaviors are transmitted from generation to generation.

Pyke et al. (1977) state, without further elaboration, that "the selection that has so far been considered, either implicitly or explicitly, is Darwinian natural selection coupled with genetic inheritance, but the evolution could also be cultural and yet governed by selection." In the present paper, I consider 3 possible mechanisms of evolutionary change. These are:

1) Genetical evolution of learning mechanisms,
2) Cultural retention of individually adaptive behavior, and
3) Cognitive evaluation and retention of beneficial customs.

The first 2 mechanisms are variations on the old theme of natural selection. The third requires no differential fitness yet produces adaptive behavior. I shall present my personal view of the relative importance of each of these mechanisms to the evolution of human diets.

Genetical selection is the change in gene frequencies accompanying the differential survival and reproduction of individuals. A coherent viewpoint of the genetical evolution of behavior has been developed by ethologists and, more recently, by sociobiologists (see Wilson 1975 and Tinbergen 1951). This viewpoint, in my opinion, reveals little about the behavior of learning organisms, particularly humans. A basic tenet of sociobiology has been that genes may cause animals to behave in certain ways which propagate those genes in future generations. Human genes do not *cause* humans to behave; however, genes do influence how humans learn. No doubt, some ways of learning are more adaptive than others. The real problem is to specify *how genes influence learning* (see Pulliam and Dunford 1980).

The likelihood that an animal repeats a particular behavior depends, in part, on the reinforcement it experiences. The sensory and neural mechanisms of reinforcement may have evolved by genetical selection in 2 ways (Pulliam and Dunford 1980). First, genes specify certain *primary reinforcers* which guide early learning. Second, genes specify certain *learning programs* which control how experience with reinforcers is integrated.

For example, the taste of mother's milk is a *positive* primary reinforcer. That is, the genes specify certain connections between the sensory elements which detect this taste and the central nervous system mechanisms which evaluate experiences as positive. A child learns that certain behaviors increase its likelihood of access to this reinforcer, and that the other behaviors decrease this likelihood. Furthermore, the child's learning program specifies that stimuli consistently associated with the primary reinforcers shall become *secondary* reinforcers. Thus, the visual image of the child's mother become a secondary reinforcer by association with mother's milk. Once this association is perceived, the child will work for the *reward* of access to secondary reinforcers just as it will work for access to primary reinforcers.

The relevance of primary reinforcers to food selection is that primary reinforcers guide the learning of food habits. Certain tastes, such as from low concentrations of salt and intermediate concentrations of sugar, positively reinforce the eating of certain foods. Similarly, the taste of toxic compounds negatively reinforces eating other foods. Circumstantial evidence for the importance of primary reinforcers as adaptive guides to food selection comes from a variety of studies. For example, C.M. Davis (1928, 1939) found that human infants grew normally and maintained good health on a diet they selected for themselves. More carefully controlled experiments with naive rats have shown similar results. (For a review, see Nachman and Cole 1971).

If the mechanisms of reinforcement have evolved by natural selection to produce adaptive learning, then the reinforcing properties of food should change as the nutritive needs of the individuals change. The best evidence in favor of this view of the development of food habits comes from studies of *specific hunger* in laboratory animals. Numerous animal studies support the idea that animals with a particular nutritional need "learn to develop a preference or aversion to a particular food as a result of the beneficial or toxic consequences" (Nachman and Cole 1971: 340). For example, rats given a diet deficient in thyamine develop a preference for any food containing thyamine. Similarly, after several days of salt deprivation, sheep accept previously rejected, salt-rich foods.

The evidence for the role of specific hungers in humans is circumstantial. For example, a 3.5 year old boy with a severe adrenal deficiency maintained himself by eating salt by the handful (Nachman and Cole 1971). The child died shortly after his salt intake was restricted by physicians who thought that such high salt intake could not be good for the child. The specific cravings of pregnant women have also been interpreted as specific hungers for required nutrients. All in all, very little is known about the role of specific hungers in human food selection.

Although taste and specific hungers are surely important to human food selection, their importance is probably far outweighed by social learning. Parents not only can control what foods their children have available to eat, but they also use many forms of persuasion to influence their children's eating habits. Parents mold the food habits of their children by the selective presentation of reinforcers. This process of strong parental influence leads to a second mechanism of evolutionary change: selective retention of adaptive behavior.

Darwin recognized the importance of social learning to human behavior when he wrote that facial expressions "serve as the first means of communication between mother and her infant; she smiles approval and this encourages her child on the right path, or frowns disapproval" (Darwin 1896: 364). Darwin's viewpoint is echoed by the modern theory of social exchange. According to George Homans, an eminent sociologist, human values are "learned by being linked with an action that is successful in obtaining a more primordial value" (Homans 1974: 27). Homans (Ibid:27) goes on to say:

> Suppose a mother often hugs her child and getting hugged is probably an innate value - in circumstances in which the child has behaved differently from other children, and, as the mother says, 'better.' The 'behaving better' than others is a means to a rewarding end and is apt to become, as we say, 'rewarding in itself.' By such a processes of linking, men may learn and maintain long chains of behavior leading to some ultimate reward.

The important point that I wish to draw from Homans is that parents can control what their children learn by manipulating their social experience. Some of the 'values' acquired by social learning are what I call 'ideas' about behavior. An idea about behavior is what a person *perceives* as the relationship between behavior and access to rewards. Children learn ideas about behavior during the socialization process because adults, particularly their parents, control their access to positive and negative reinforcers.

What does social learning have to do with the *evolution* of behavior? Parents tend to teach their children the same ideas that they once learned from their own parents. Thus, acquired ideas may be passed from generation to generation. Since ideas are perceptions about the relationships between behavior and rewards, ideas *motivate* behaviors (Pulliam and Dunford 1980). Some behaviors affect individual fitness, i.e., they affect an individual's chances to survive and reproduce. Ideas that motivate behaviors which affect individual fitness also affect the likelihood that those same ideas will be acquired by the next generation.

As previously stated, a basic tenet of sociobiology has been that genes can cause people to behave in ways that increase or decrease the likelihood that those genes are replicated in future generations (Dawkins 1976). I argue that ideas can motivate people to behave in ways that affect the likelihood that those ideas are replicated in subsequent generations. Furthermore, I argue that such cultural selection of ideas has been far more important to the evolution of human behavior during the past million years than has genetic selection.

Humans have many ideas about what to eat and what not to eat. Decisions to avoid eating certain mushrooms or to eat beans with rice, or to eat insects when mammals are scarce are all decisions which potentially affect survivorship and reproduction. The ideas which motivate these behavioral decisions are perceptions of the relationship between feeding behavior and individual (or group) welfare. Some ideas about food selection have no doubt been "weeded out" of human cultures because they motivated maladaptive behavior. Other ideas have been selectively retained, i.e., replicated in subsequent generations, because they motivated adaptive behavior (see Durham 1976 and Ruyle 1973).

Interestingly enough, even though ideas which evolve by selective retention are perceptions of relationships between behavior and welfare, they may be *misconceptions* and yet lead to adaptive behavior. For example, an herb may have been added to the pot to appease the gods. The idea to do this may have been retained from generation to generation because the herb contained a rare vitamin which increased infant survivorship. Parents who defied the gods were unlikely to have children who survived long enough to learn their parents' non-orthodox beliefs. The point is that cultural retention of an adaptive behavior may be based on misconceptions about physical reality.

In the above example, selective retention was the result of selective deaths of the children of parents who had maladaptive ideas. Cultural evolution need not be such a blind process. If people correctly perceive the relationships between their behavior and their own welfare, adaptive behavior may evolve without any selective deaths. This is what I refer to as the cognitive evaluation and retention of beneficial customs.

Cognitive evaluation and retention of new ideas (i.e., of the relationships between new behaviors and welfare) depends on both individual perception of the welfare of others who have already evaluated the new ideas *and* individual perception of the consistency of new ideas with those already personally evaluated. The way in which these 2 factors influence food habits can be better understood by briefly considering the sociological theory of cognitive balance.

How does an individual decide to accept or reject a new kind of food? The evaluation of the new food can be analyzed using the P - O - X cycle of balance theory (Davis, C.M. 1939 and Heider 1958). *P* is the person making the evaluation and *X* is the new food being evaluated (more precisely, *X* is the idea that eating the new food is beneficial). *O* is a significant other used in making the evaluation. In this case, *O* is another person, institution or idea. The evaluation of the new food (*X*) depends on the person's previous evaluation of *O* and the person's perception of the relationship between *O* and *X*. For example, if a person's respected friend accepts a new food, then the person *P* is more likely to try it too. On the other hand, if a new food is sanctioned by the church *O*, then the person will try it if the person evaluates the church positively, and may reject it otherwise.

The purpose of bringing up a cognitive balance theory is that I think it sheds some new light on the question of when human behavior will be adaptive. I have argued that humans have genetically-inherited learning mechanisms which also play a role in the evaluation of new foods. If cognitive balance leads a person to try a new food, the food may be reevaluated according to its taste. A person will only accept a new food that "tastes bad" if the person's evaluation of the significant other (e.g., church or friend) outweighs the negative reinforcement of the taste. For example, the behavior of eating a noxious-tasting medicine when ill, because the doctor recommends it, will only persist if evaluations of doctors are very positive. Furthermore, the positive evaluation of "doing what the doctor says is best" will be culturally retained from generation to generation only if the idea leads, on average, to an increase in individual fitness, or, at least, to a perception of increased welfare.

I am proposing that the initial evaluation of new ideas depends on their own consistency with older, more established ideas, but that new ideas must also eventually pass the tests of individual reinforcement and cultural retention. Primary reinforcers are genetically-inherited guides to behavior that slow down the acceptance of potentially dangerous new ideas even if the new ideas are consistent with established ideas. Furthermore, ideas, even once totally accepted, may be selectively removed from societies if they motivate maladaptive behaviors. This is because individuals who have learned maladaptive ideas are less likely to pass their ideas on to children of the next generation. As a result, many more or less neutral ideas may be retained from generation to generation but those which truly lower the Darwinian fitness of the idea bearers will be gradually "weeded out" (Durham 1976).

The selective sieve of cultural retention can only be expected to operate efficiently over long periods of cultural and environmental stability, yet if a society's values become adapted to local conditions, cognitive evaluation of new ideas will be more and more likely to result in the rejection of those that motivate maladaptive behavior. A society whose ideology is well adapted can quickly adapt to minor changes in conditions. Nonetheless, if conditions change too rapidly, maladaptive ideas and behaviors are bound to accumulate. Furthermore, maladaptation breeds more maladaptation because previously accepted ideas are the basis of selecting yet other ideas. For these reasons, adaptive foraging behavior is only to be expected in stable cultures of people that have inhabited the same region for many generations. Optimal Foraging Theory may help human ecologists predict what foraging behavior is adaptive in a particular environment. The question of how well behavior is adapted to an environment can then be resolved empirically.

Optimal Foraging Theory

Optimal Foraging Theory consists of a set of reasonable propositions which can be made precise and which are, therefore, testable. For example, it seems reasonable that energy-stressed animals might make foraging decisions so as to maximize their net rate of energy intake while foraging. An optimization model turns this general supposition into a set of precise predictions which can be rejected or confirmed by comparison to real data.

Energy maximization does *not* mean that animals eat as much as they can, whenever they can. As applied to humans, the theory states that when energy-stressed,

1) people choose food so as to harvest as much energy as possible during the time they devote to hunting or gathering, or

2) people hunt and gather in such a manner as to minimize the time required to meet their energetic requirements.

Of course, minimizing foraging time also maximizes the time available for other activities (Smith 1979).

The theory makes both quantitative and qualitative predictions. I expect that, in general, the quantitative predictions will only be verified for human societies during periods of extreme food shortage. Nonetheless, the qualitative predictions of Optimal Foraging Theory are likely to predict trends in the foraging behavior of all hunters and gatherers.

No doubt, during some periods food is abundant and people are not so much energy-limited as they are nutrient-limited. During such periods, models of protein maximization or energy maximization with nutrient constraints (Pulliam 1975) might be more appropriate. Of course, the theory is only as good as its assumptions, and the assumptions for any particular study must be based on detailed field studies. Actually, most of the qualitative predictions are the same for energy maximization models and nutrient maximization models. It is these robust, qualitative predictions that are most likely to predict trends in human foraging behavior.

In the case of energy-maximization, the *value* to a forager of a particular prey item is defined as the ratio of its energy content to its handling time. Handling time is the average total time required to pursue and capture a food item after it has been encountered. In the case of human foragers, handling time would consist mostly of stalking and capturing time for a hunter, and digging and picking time for a gatherer.

A forager that maximizes net rate of energy intake, pursues prey with the highest value every time they are encountered. The decisions to pursue or ignore prey of lower value depend only on how frequently the higher-value prey are encountered. One of the most robust predictions of the theory is that when high-value prey are rare, the diet expands to include more low-value prey, and, conversely, when high-value prey are common the diet contracts.

A number of animal studies have tested qualitative and quantitative predictions of Optimal Foraging Theory. For example, Werner and Hall (1974) offered bluegill sunfish a choice of prey of 3 different sizes. They manipulated the abundance of the highest-value prey available in the aquarium and predicted when the fish should eat and when they should ignore the 2 kinds of lower-value prey. They found that not only did the fish diets expand when the highest-value prey were rare, but also that the fish began to eat the lower-value prey at the abundance of highest-value prey that was predicted by the theory.

Krebs et al. (1974) presented Great Tits with a choice between large and small mealworms. They varied the prey abundance by putting the mealworms on a conveyor belt which passed prey by the birds at different speeds. The found, as predicted, that the decision to eat or ignore the small mealworms was independent of the abundance of small prey and dependent *only* on the abundance of large prey. As expected, when mealworms were common, the tits ate only large ones, but when mealworms were rare, they ate both large and small ones. However, the theory predicted a specific abundance of large prey at which the tits should quite suddenly change their behavior and eat every mealworm presented. Instead, Krebs et al. (1974) found that the small prey were only gradually added to the diet. The results of this experiment support the qualitatiave predictions of the theory but not the quantitative predictions.

A few investigators have tried to test Optimal Foraging Theory under more or less natural conditions in the field. For example, Goss-Custard (1977) studied Redshanks foraging on invertebrates on a natural beach. He found that whether or not these birds accepted small prey depended only on the abundance of large prey and not on the abundance of the small prey themselves.

In a study of Chipping Sparrows in a natural oak woodland (Pulliam 1980), I found that these sparrows preferred seeds of high energy value and expanded their diets when high-energy prey were less abundant. However, I also found that the prey were not eaten in the same frequencies as predicted by theory. So again, the qualitative but not the quantitative predictions of the theory were supported.

How close animals come to matching the quantitative predictions of the theory seems to depend on how energy-stressed they are. This is shown dramatically by the experiments of Caraco et al. (1980) on *risk aversion* by Yellow-eyed Juncos. The theory of risk aversion is an extension of classical optimization problems to the situation where an animals must choose between food of high-value and high-risk and food of lower-value and lower-risk. The theory predicts that animals will be more likely to maximize energy intake even if a risk is involved when they are energetically stressed.

Caraco and his coworkers gave Yellow-eyed Juncos a choice of walking down one side of a Y-maze to receive 3 seeds or walking down the other side to receive 7 seeds half of the time, but no seeds the other half. The *expected* reward was then 3 seeds on the "low reward low value" side and 3.5 seeds on the "high reward, high risk" side. As predicted, the birds adopted high-risk strategies when energetically stressed and low-risk strategies when *not* energetically stressed. I expect this is a very robust prediction which will apply to many animals including humans.

A final robust prediction which may also apply to human food choices comes from what is known to ecologists as Central Place Foraging Theory. Many foragers start from a central place such as a nest, a den, or a village to which they return with food. The theory predicts how prey choices will vary as a function of prey abundance and how far the foragers will go from the central place.

Optimization models of central place foraging predict that as prey abundance declines and foragers go farther from the central place, they will be more selective about the prey they choose to bring back. This is because once the forager has travelled far from a central place, any extra time required to select a better prey may be small compared to transit time to and from the central place. This prediction holds regardless of whether the foragers are energy-maximizers or nutrient-maximizers.

CONCLUSION

During much of the history of mankind, people have survived by hunting and gathering. During periods of food shortage, individual survivorship has, no doubt, often depended critically on individual decisions about which foods to hunt and gather. These decisions have been made, in part, by reference to traditional knowledge about hunting and gathering techniques, favored hunting grounds, alternative foods, etc.

Traditional knowledge about hunting and gathering consists of culturally-inherited ideas about the relationship between foraging behavior and individual welfare. If ideas leading to adaptive behavior have been more likely to be culturally retained as part of traditional knowledge, then general trends of foraging behavior should be predictable by Optimal Foraging Theory.

Among the more robust qualitative predictions of Optimal Foraging Theory as applied to stationary human hunters and gatherers who have inhabited the same region for many generations are the following:

1) Human foragers should become more selective in their prey choices as the abundance of preferred prey increases;

2)Decisions to specialize or generalize the diet should be independent of the abundance of less preferred prey;

3) During times of food shortage, prey preferences should roughly be ordered according to the ratios of energy content to handling time;

4) Human foragers should be more willing to take risks for high energy gains during periods of food shortage;

5) People should be food generalists when hunting and gathering near home (a central place) and become progressively more selective about foods they choose to bring home when they forage farther afield.

Probably, human foragers never exactly maximize their rate of energy gain while foraging. Nonetheless, their behavior is probably much closer to this ideal than it is to random foraging. Optimal Foraging Theory should be a useful yardstick for measuring how well the behavior of hunters and gatherers is adpated to their energetic requirements. If the qualitative predictions listed above are supported, the quantitative predictions should also be tested.

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RESOURCE UTILIZATION AND FOOD TABOOS OF SONORAN DESERT PEOPLES

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ABSTRACT.—Resource utilization and food taboos of 8 Sonoran Desert cultures (Riverine Pima, Papago, Sand Papago, Pima Bajo, Seri, Colorado River Yumans, Maricopa and Western Apache) are compared. Taboo (or dietary prohibition) herein is used in *general* sense (species banned to the entire community) rather than *specific sense* (species banned to a particular age and/or sex class at specific times). The purpose is to compare nutritive resources (plant and animal species) available to 2 or more cultural groups exploiting the Sonoran desert. Western Apache, with the greatest number of taboos, had access to more ecotone resources and to more than one major life zone. Within the Pima-Papago cultural complex there is a probable underlying adaptive (ecological) basis for the fact that most restrictions were found with Riverine Pima (resource-rich ecotone habitat) and the fewest restrictions with Sand Papago (most harsh habitat of groups considered). There is a probable adaptive basis for Seri and Sand Papago having few dietary prohibitions (harsh environment and no agricultural resources). Speakers of mutally intelligible languages, even though disjunct geographically, tended to observe the same animal taboos if the resource base was not impoverished. Plant use was cross-cultural. Taboos functioned as symbols of group identity.

INTRODUCTION

A number of factors determine the dietary items any heterotrophic organism utilizes as food, including its own anatomical mechanism for obtaining the food, its physiological ability to assimilate the food, and the availability of the prey items themselves. All these factors play a major role in the dietary of man, an omnivorous animal. But we cannot stop there. Several factors radically alter the dietary categorization of man as an "omnivorous animal" and these are *culture* and *language*. It is almost an anthropological maxim that man's diet is not simply determined by his anatomical and physiological ability to handle prey items (both plant and animal) that happen to be available in the environment. All humans that we know live in a cultural context, speak at least one language, and practice dietary selectivity. (Our own culture provides examples of rigorously observed but unwritten, perhaps even unconscious, *rules* specifying dietary selectivity; see appendix.) In addition to culture and language, man, especially in "archaic" societies, differs from other animals in a dimension we might call a *sense of the sacred* (Eliade 1959; Rappaport 1971). All 3 modify diets.

Dietary selectivity has been discussed for a number of areas of the world, but to my knowledge there has been no intercultural comparison made of the aboriginal peoples living in the Sonoran Desert of the American Southwest (Fig. 1).

A number of questions came to mind when I decided to look at the variation in dietary resource utilization and taboos in desert peoples:

1) Did the utilization of plants as well as animals differ from one group to another?

2) Insofar as there were shared resources, were there dietary differences between groups speaking closely related (even mutually intelligible) languages, as between the Riverine Pima, Papago, Pima Bajo, and Sand Papago or between the Maricopa and the Colorado River Yumans?

3) Does agriculture modify the range of wild foods hunted and gathered?

4) Do dietary restrictions arise because of ecological determinism or do they arise and function as symbols of group identity?

A relatively greater amount of quantified subsistence data is available on Amerindians living in tropical areas (Carneiro 1968; Ross 1978; Chagnon and Hames 1979; others) even

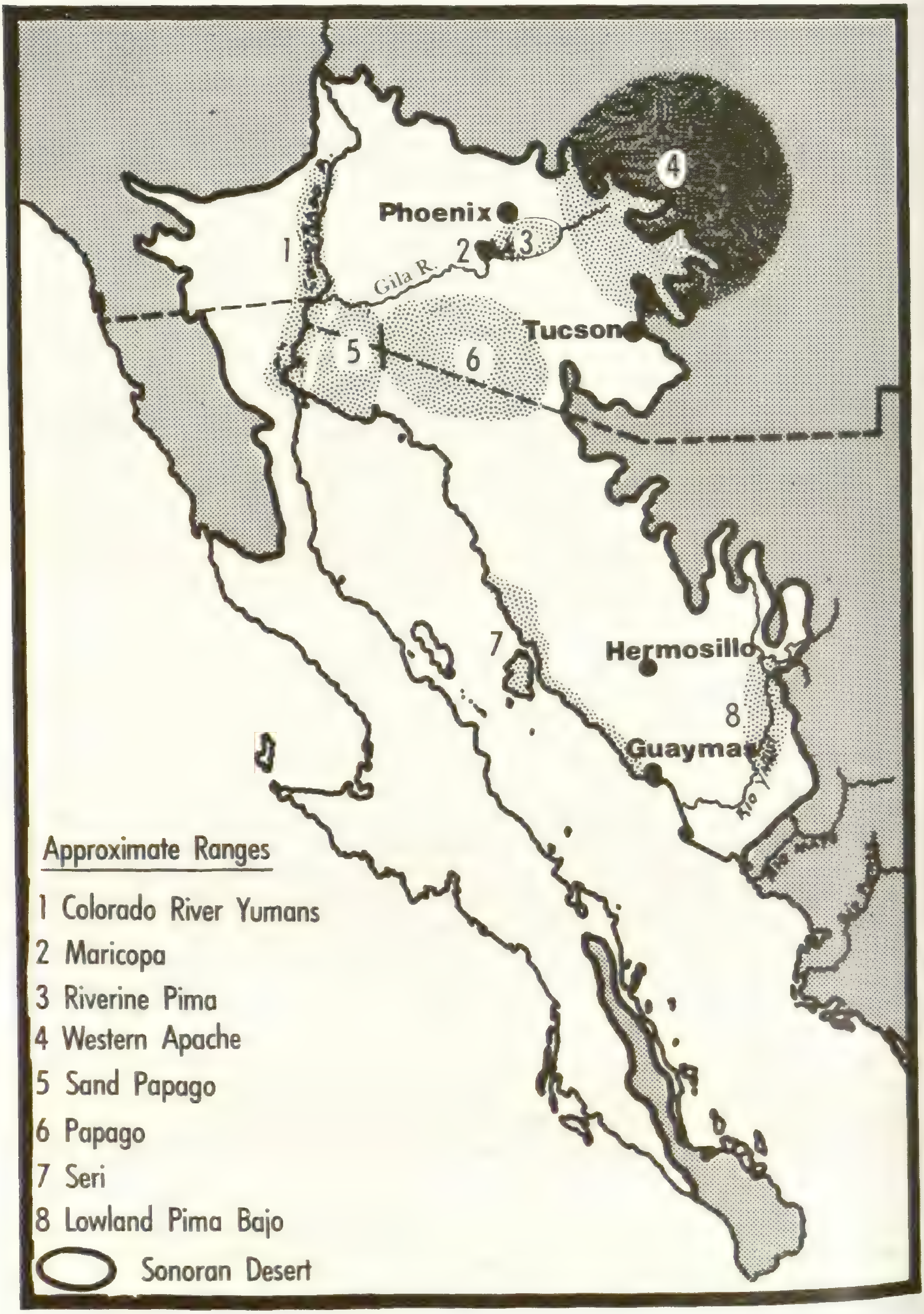

FIG. 1.—Localities (*ca.* 1850) of 8 groups discussed. (After Rea 1979a).

though considerable investigation remains (cf. respondents to Ross 1978). Tropical situations are characterized by high species diversity but low population numbers (i.e., there are more species but fewer individuals per species than in temporate forest communities). Relatively little is known of resource utilization in New World deserts where human cultures might be thought of as *marginal*. More is known of subsistence in Old World deserts (e.g., Kalahari, Australia). Even though absolute quantitative intercultural data from the American Southwest are now no longer retrievable, the comparative qualitative data presented here are probably largely valid and useful. (We must realize in *any* comtemporary study that the Sonoran Desert today is an artifact; community structure since the Pleistocence has been radically altered due to loss of megafauna and associated animals [e.g., Rancholabrean birds] and, more immediately, a century of disastrous overgrazing by Eurasian herbivores. No matter how hard we try to close our eyes to the facts, Southwestern deserts have been *radically altered* by the last century of abuse!)

Some philosophical debate surrounds the topic of the origin and function of food taboos. That taboos are cultural inventions is incontestable. But do they function as cosmological symbols in a culture, maintaining as orderliness and structural indentity? Are they understandable as daily, visible projections of *values* emanating from a common metaphysics? Or can they be reduced to some evolutionary fitness factor, fulfilling (unknown even to the adherents) a sanitary or hygenic function, or perhaps an ecological function of sustained yield or predator strategy theory? Can *why* man eats what he eats be understood in terms of nutrition and calories? Can *what* people hunt, gather, or grow be reduced to terms of cost-benefit? The dietary restricitons of Sonoran Desert cultures might suggest some answers.

METHODS

For comparative purposes only those plants or animals are considered here to which 2 or more cultural groups had access (see Table 1). Hence, Prairie Dogs (*Cynomys* spp.) of Western Apache are not taken into account here because no other group shared this resource. Comparisons are not to be taken in an absolute sense because (1) relative abundances of various prey items aboriginally are unknown, and there is good evidence that many species of plants or animals are now decimated or locally extirpated due to extensive degradation of the desert habitat (Hastings and Turner 1965; Rea 1977); (2) the relative importances of *specific taboos* are unknown; (3) the coverage of even absolute taboos is uneven, since some of the data (specifically for Westen Apache and Yumans) are from the literature and have not been verified. Literature citations are sometimes limited by the investigator's incomplete understanding of his own Linnaean taxonomy and the ethnotaxonomies of his native informants, and (far too often!) incomplete interrogation. Also, Sonoran Desert peoples have had varying, usually long periods of contact with Europeans. This contact with a technologically dominant culture has resulted in a general abandonment of aboriginal food ways. Of the groups considered here, only the Seri preserve a viable native subsistence pattern (though all the others preserve parts). Data for the Riverine Pima, Papago, and Pima Bajo are based on my own field work. Table 2 gives the life zones and ecotones that the 8 groups exploited.

DISCUSSION

Kinds of Taboos—Food taboos are equivalent to dietary prohibitions. Food taboos considered here are only *general* taboos, that is, those imposed on the entire ethnic group at all times. Excluded from discussion are *specific* taboos that restrict a particular food species for a specific age/sex class of the population at a particular time. Such prohibitions may affect, for instance, only men while hunting, or women while lactating, pregnant or menstruating. (A study of these taboos here now would take us too far afield; but this practical restriction is not to imply the lack of importance, either symbolically or ecologically, of specific or temporal taboos.)

TABLE 1.—*Resource utilization by desert tribes.*

	RIVERINE PIMA	PIMA BAJO	PAPAGO	SAND PAPAGO	SERI	MARICOPA	YUMAN SPEAKERS	WESTERN APACHE
Grasshoppers Acrididae	T	?	T	?	***	T	T	?
Cicadas *Cicadidae*	+	?	?	?	***	?	?	?
Caterpillars *Celerio lineata*	+	+	+	+	+	+	+	+
Mullusks Mullusca	0	0	0	+	+	0	+	0
Fish Teleostomi	+	+	0	+	+	+	+	T
Mud Turtle *Kinosternon*	+	T	T	+	***	?	T	?
Desert Tortoise *Gopherus agassizi*	+	+	+	+	+	+	T	+?
Gila Monster *Heloderma suspectum*	T	?	T	?	+	?	?	?
Desert Iguana *Dipsosaurus dorsalis*	T	0	T	+	0	?	+	0
Chuckwalla *Sauromalus obesus*	0	0	T	+	+	0	+	+?
Small lizards Iguanidae, Teidae	T	T	T	+	+	?	+	T
Snakes (all) Colubridae, Crotalidae	T	T	T	?	+/T*	T	T	T
Ducks & Geese Anseriformes	T	?	0	?	+	+	+	+
Hawks & Eagles Accipitridae	T	?	T	T	+	?	?	+
Vultures Cathartidae	T	T	T	T	T*	?	?	T
Turkey *Meleagris gallopavo*	0	+	T	0	0	+	0	+
Quail Odontophorinae	+	+	+	+	*	+	+	+
Herons & Egrets Ardeidae	T	?	0	?	+	?	?	T
Doves Columbidae	+	+	+	+	*	+	+	+
Roadrunner *Geococcyx californianus*	T	?	T	?	T	?	?	?
Great Horned Owl *Bubo virginianus*	T	T?	T	?	+	?	?	T
Other Owls Strigiformes	T	?	?	?	+	?	?	T
Raven *Corvus* spp.	?	?	T	?	T	?	?	T
Other Songbirds Passeriformes	+	?	?	?	+	+	+	+
Birds' eggs	+	+	T	?	+*	T*	+	+*
Cottontail & Jackrabbit *Sylvilagus, Lepus*	+	+	+	+	+	+	+	+
Ground Squirrel *Otosperma, Citellus,* *Ammospermophilus*	T	+	+	?	+	T	+	T
Pocket Gopher *Thomomys*	T	+	T	?	0	T	+	+
Small mice *Perognathus,* *Peromyscus*	T	+	T	+	***	?	+	+
Kangaroo Rat *Dipodomys*	T	0	T	?	0	?	+	0
Beaver *Castor canadensis*	+	+	0	0	0	+	+	+
Cotton Rat *Sigmodon*	+	+	+	?	0	+	+	0
Woodrat, Packrat *Neotoma*	+	+	+	+	+	+	+	+

TABLE 1 Continued

	RIVERINE PIMA	PIMA BAJO	PAPAGO	SAND PAPAGO	SERI	MARICOPA	YUMAN SPEAKERS	WESTERN APACHE
Muskrat *Ondatra zibethicus*	+	+	0	+	0	?	+	?
Porcupine *Erethizon dorsatum*	T	0	0	?	***	T	T	+
Coyote *Canis latrans*	T	T	T	?	T*	T	+?	T?
Dog *Canis familiaris*	T	T	T	?	T	T	T	T
Kit & Gray Fox *Vulpes macrotis,* *Urocyon cinereoargenteus*	T	?	T	?	+	T	+	T
Black Bear *Ursus americanus*	+	0	T	?	0	T	?	T
Raccoon *Procyon lotor*	+	+	0	0	+	+	+	+
Badger *Taxidea taxus*	+?	+	T	?	+	T	+	+ *
Skunk *Mephitis* spp.	T	+	T	?	T	T	T	+*
Puma *Felis concolor*	+	+	+	+	+	T	T	+
Bobcat *Lynx rufus*	+	+?	+	+	+	T	T	+
Peccary *Pecari tajacu*	+	+	+	?	+	+	T	T
Mule & White-tailed Deer *Odocoileius hemionus,* *O. virginianus*	+	+	+	+	+	+	+	+
Pronghorn *Antilocapra americana*	+	+	+	+	+	+	+	+
Desert Bighorn *Ovis canadensis*	+	0	+	+	+	+	+	+
Cattail *Typha* spp.	+	?	0?		0	***	+	+
Grasses	+	?	+		+	+	+	+
Palm Palmae	0	+	0		+	0	+	0
Yucca *Yucca baccata,* *Y. arizonica*	0	?	+		+	+	+	+
Century Plant *Agave* spp.	+	+	+		+	+	+	+
Oak *Quercus* spp.	+**	+	+		0	0	+**	+
Mistletoe *Phoradendron* *californicum*	+	?	+		+	+	?	?
Winter Greens *Monolepis, Atriplex* *wrightii,* etc.	+	+?	+		0	?	+	+
Pickleweed *Allenrolfea occidentalis*	+	?	?		+	+	+	0
Summer Greens *Amaranthus,* *Trianthema,* etc.	+	+	+		+	+	+	+
Velvet/Honey Mesquite *Prosopis velutina* *& P. juliflora*	+	+	+		+	+	+	+
Screwbean *Prosopis pubescens*	+	0	0		0	+	+	0
Palo Verdes *Cercidium* spp.	+	+	+		+	?	+	0
Hog-Potato *Hoffmanseggia* *densiflora*	+	0	+		0	+	+	?
Ironwood *Olneya tesota*	+	+	+		+	+	+	?

Table 1 Continued

	RIVERINE PIMA	PIMA BAJO	PAPAGO	SAND PAPAGO	SERI	MARICOPA	YUMAN SPEAKERS	WESTERN APACHE
Graythorn *Condalia lycioides*[1]	+	+	+		+	+	+	0
Saguaro *Carnegia gigantea*	+	+	+		+	+	+** *	+
Organpipe cactus *Lemaireocereus*	0	+	+		+	0	0	0
Barrel cactus *Ferocactus* spp.	+	+	+		+	+	?	0
Prickley Pear *Opuntia* spp.	+	+	+		+	+	+	+
Cholla buds *Opuntia* spp.	+	+	+		+	+	+	+
Sandfood *Ammobroma sonorae*	0	0/+	+		0	0	+	0
Wolfberry *Lycium* spp.	+	0	+		+	+	+	0
Chiltepin *Capsicum annuum*	+**	+	+		+**	?	0	+
Broom-Rape *Orobanche* spp.	+	0	+		+	+	?	0
Wild gourds *Curcurbita foetidissima* *& C. digitata*	+	T	+		0	+	+	T/+
Sunflower *Helianthus* spp.	***	0	***		0	?	+	+

KEY TO SYMBOLS:

0	organism doesn't occur	*	explained in text
?	no information	**	trade item
+	utilized	***	low aversion non-utilization
T	absolute taboo	ø	conflict in literature

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[1] Data from Bahr et al. 1974; Buskirk 1949; Castetter and Bell 1942; Curtin 1949; Felger, field notes; Fontana 1974; Hrdlička 1908; Moser and Moser, field notes; Rea MS, field notes; Russell 1908; Spier 1933; Underhill 1946.

Table 2.—*Ecotone resources.*

GROUP	ECOTONE
RIVERINE PIMA	riparian floodplains/Sonoran Desert
PAPAGO	none (Sonoran Desert)
SAND PAPAGO	none (Sonoran Desert)
PIMA BAJO (lowland)	riparian floodplains/Sinaloan thornforest (*monte*)
YUMAN SPEAKERS (Colorado River)	riparian floodplains/Sonoran Desert
MARICOPA (Gila River)	riparian floodplains/Sonoran Desert
SERI	Sonoran Desert/marine
WESTERN APACHE	*desert/coniferous forest (+riparian)

*Multiple ecotones: mobile people harvesting resources from Lower Sonoran, Upper Sonoran, Transition, and even Canadian Life Zones, with riparian ecotones running through much of these, plus raiding.

Food taboos differ in their "incidence of horror" (Thurton 1978), an emic factor that reflects the amount of aversion expressed or felt by a member of a culture at the prospect of violating a dietary restriction. Aversion ranges from disgust to mere indifference. For instance, with Riverine Pimans the incidence of horror is very high for snakes and lizards, but relatively mild for kangaroo rats and mice. As might be expected, in times of real nutritional stress (starvation), low aversion tabooed animals may be eaten (e.g., mice by the Papago; Castetter and Bell 1942). The usual reaction to the idea of consuming low aversion animals is simply "We don't eat them." I want to emphasize strongly that the emic decisions governing dietary rules in no way reflect the people's ideas of comestibility. A native consultant will often add, when discussing a tabooed animal, "Well, so-and-so (mentioning another tribe) eats them." I find no evidence in the Sonoran Desert for a clean vs. unclean categorization of foods, nor for an exclusion of animals based on their anomalous status in the native taxonomy (cf. Leviticus; Basso 1973).

A dietary restriction does not necessarily protect an animal from predation. The species may still be taken for its feathers, hide, or medicinal/religious value. Papago hunted Golden Eagles for feathers but never are the meat, and the entire procedure was surrounded by rigorous sanctions (taboos) requiring purification of the eagle-killer (Underhill 1946).

Sanctions on dietary restrictions vary. With Pimans, violations of certain "dangerous objects" produce "staying sickness." "People contract *ka:cim* [staying] sickness because they have behaved improperly toward a dangerous object which was endowed with dignity at the time of creation" (Bahr et al. 1974: 22). Improper behavior may mean molesting the creature, mishandling its bones, or even accidentally treading on its tracks. Staying sickness of northern Pimans may be caused by such species as the badger, bear, Turkey Vulture, coyote, Golden Eagle, Gila Monster, horned lizard, and gopher. A typical response to a question regarding a potential item in the Piman dietary may be: "We never bother that animal; it makes you sick." Jimson weed (*Datura*) is apparently the only recorded plant that figures directly in a staying sickness taboo. Perhaps among Pimans taboos were associated with all psychoactive plants; this hypothesis needs to be tested.

Some animals are specially protected by their symbolic function in the cultural cosmology. The coyote is one of the 3 principal figures in Piman creation stories. The 2 sibs of the Pima are coyotes and "buzzards," so these animals are never harmed. Other animals are immune because they are reincarnations of the deceased (e.g., Great Horned Owls with the Pima and dogs with the Seri). Rain is an essential factor in the lives of desert agriculturalists, particularly dry farmers. Various plants and animals are incorporated into a complex rain symbolism. For the Papago, eagle down feathers represent rain clouds; saguaro wine, the summer rain. The songs sung during the summer wine feast help "pull down the clouds" (Underhill 1946, 1976). The Hopi of northern Arizona preserve a complex ceremonial rain symbolism. Barton Wright (personal communication) states that the Hopi taboo any animal associated with rain: snakes (lighting symbols), Killdeer, frogs and tadpoles. White Mountain Apache also hold tabooed a number of birds that figure in rain symbolism.

The People

Riverine Pima—These Uto- Aztecan people live on the middle Gila, practicing irrigation agriculture and double (if not triple) cropping, at least since the introduction of wheat. Their area receives 25.5 - 38 cm annual rainfall. Aboriginally, much of their resources probably came from the desert/riparian ecotone, though there were low desert mountains nearby for exploitation. Although agriculture was an important aspect of their economic base, they relied heavily on hunting and gathering wild resources. Their hunting categories are complex (Rea 1979b), consisting of local garden hunting (cf. Linares 1976) and communal hunting as well as limited big game hunting.

Papago—These Uto-Aztecan people, living to the south of the Gila River and west of the Santa Cruz, were heavily dependent on gathering-hunting, with *ak chin* or *temporal* agriculture during the summer (monsoonal) rains. They lacked access to permanent streams or ecotones. Some Papago were symbiotic with the Riverine Pimans, working for them during harvest time in exchange for food (Russell 1908). The Papago occupied an area receiving 12.5 - 25.5 cm annual rainfall. They were 2-village people, living on the bajadas of desert ranges near water holes in winter, moving to their flood plains fields in summer and fall. Actually, the "Papago" are a collection of peoples speaking related dialects and sharing a similar subsistence economy. I will consider Sand Papago separately.

Sand Papago—The western-most Pimans, the Sand Papago or Sand People, lived nomadically in an area of 0-12.5 cm of annual rainfall where agriculture was virtually impossible. I am considering these separately from the agricultural (*temporal* or *ak chin*) Papago because their subsistence ecology and resource utilization was so radically different (Fontana 1974). Although speaking one of the Papago dialects, the Sand Papago had more in common ecologically with the Seri, and like them, utilized marine and other resources severly tabooed by the other northern Pimans. These are unforturnately the least known of the Pimans, linguistically and ecologically, and the few remnants today appear to be assimilated with other Papago or non-Indians.

Pima Bajo (lowland)—This category includes Pimans from south and east of the Papago and Riverine Pimans. At present, most Pima Bajo inhabit montane areas of the northern Sierra Madre Occidental. But at the time of contact and during early missionization they no doubt occupied most of the fertile floodplains of the lowlands. My investigations are entirely with the remnants of the lowland people living on the Rio Yaqui in the village of Onavas, Sonora. Lowland Pima Bajo hunt in the surrounding *monte* (Sinaloan thornforest; see Brown and Lowe 1978) and *temporal* (*ak chin*) farm the narrow floodplain of the Rio Yaqui. Many of their riparian resources are the same as those available to northern Pimans. Lowland Pima Bajo have had 3 centuries of contact with hispanic culture and have almost disappeared as an ethnic/linguistic entity.

Yuman speakers—I have lumped in this category 3 related Hokan-speaking groups (Cucupá or Cocopah, Yuma or Quechan, and Mohave) living along the lower Colorado River between Arizona and California. The subsistence biology of these peoples is described by Castetter and Bell (1951). They were floodwater agriculturalists (until the construction of dams) and had available to them perhaps one of the richest floodplains in North America. They were also hunter/gatherers, though most of their resources were probably obtained very locally, as with the Riverine Pimans. At the time of first contact they ranged also up the Gila, their villages interdigitating with these of the Riverine Pimans. I am considering the Yuman-speaking Maricopa (a collection of tribes) separately, even though originally they were Colorado River people.

Seri—On Tiburon and the adjacent Sonoran mainland live a hunting-gathering-seafaring people speaking a Hokan language. Their territory has a scanty rainfall and they were totally non-agricultural. In spite of the extreme harshness of the desert they (as well as the Sand Papago) occupied, they exploited the coastal ecotone, rich in protein resources. And as with the Sand Papago, their population limiting factor was probably available fresh water (from springs and *tinajas* or rock tanks). Both Seri and Sand Papago existed as nomadic bands of very low densities, and both were probably hostile to other humans. A considerable body of ethnobiological data exists on the Seri through the work of Moser and Moser, Felger, and others.

Western Apache—This group of Athabascan speakers includes the White Mountain, Cibicue, and Tonto Apache, all of which exploited desert resources for at least part of the year. I have lumped the ethnobiological data for the 3 groups assembled by Buskirk (1949). The Apache arrived in the Southwest fairly late, occupying territory vacated by Puebloan peoples around the fourteenth century.

Western Apache exploited a broad base of resources, ranging from the Lower Sonoran and Upper Sonoran desert, up through the coniferous forests of their mountain retreats. In addition to these Life Zones, they had available the riparian ecotone resources running from mountain to desert as well as other foodstuffs obtained by raiding sedentary agriculturalists (Pima, Papago, Pueblo). Of the 8 cultural entities considered here, the Western Apache had the richest economic base.

Maricopa—The so-called "Maricopa" Indians are in reality a collection of Hokan-speaking peoples who took refuge with the Riverine Pima some time early last century (Spier 1933). They were an agricultural-hunting-gathering people, farming the Gila floodplains near its confluence with the Santa Cruz and later near its confluence with the Salt. In spite of long contact with the Pima, they maintain their Yuman language. They are a poorly studied group as far as their ethnotaxonomies are concerned.

Major Taboos found in the Southwest

Below is a culture-by-culture list of dietary prohibitions from the 8 groups of southwestern desert peoples. Certainly these data are not complete, and there are bound to be errors, due primarily to incomplete investigation and faulty understanding of native ethnotaxonomies. Some of the literature has been difficult to interpret, particularly where it was contradictory or gave English glosses of animals that do not occur in the area (e.g., "prairie dogs" and moles in the lower Colorado River Yuman area).

Riverine Pima.—Tabooed animals include: skunk, dog, coyote, gopher, Round-tailed Ground Squirrel, kangaroo rat, *Peromyscus, Perognathus,* porcupine, herons and egrets, coots, ducks and geese (though these were hunted and eaten more recently, after the introduction of firearms, apparently as a result of Anglo influence), all hawks (including eagles), roadrunner, all owls (especially Great Horned Owl), all lizards and snakes without exception, and grasshoppers. Cicadas were widely eaten by children of a generation past, but older people say this was not an original food. The Pima ate a number of granivorous song birds (Passeriformes), especially Abert's Towhee, White-crowned Sparrow and Lark Bunting, species which proliferated, especially in winter, as a result of land-use practices (Rea 1979a,b). When a Pima dies, he or she becomes a Great Horned Owl, so that animal is never molested.

Pima Bajo (lowland).—The data are all from 2 native consultants, a man who hunts and dry farms, and a woman. Ethnotaxonomies are still being investigated, so this is not a definitive list. The positive utilization data are correct but incomplete. Food avoidances include Great Horned Owl, vultures, aquatic turtles, snakes, lizards, but not gophers, which both consultants said were eaten.

Both their ethnotaxonomies and their techniques of preparation of floodplain plants are very similar to those of the northern Pimans. Pima Bajo and Southern Tonto (Buskirk 1949) appear to be the only groups to eat skunk.

Papago.—Most aquatic resources available to the Riverine Pima and lowland (also riverine) Pima Bajo were unavailable to the desert Papago: waterbirds (Ardeiformes, Anseriformes), fish, mollusks, raccoon, beaver, muskrat, and aquatic plants. Taboos included bear, dog, coyote, mice, gopher, kangaroo rat, all hawks (including eagles), turkey (shot for feathers but not eaten), Great Horned Owl, roadrunner, all lizards and snakes, aquatic turtles, most insects, and bird eggs. The Papago made an annual pilgrimage to the Gulf of California to obtain salt. The entire endeavor was surrounded by the most stringent sanctions (Underhill 1946). All marine foods (fish, mollusks, marine mammals, crustaceans) were rigorously tabooed.

Sand Papago.—This westernmost dialectical branch of the Papago lived in the lowest, hottest, driest territory of any of the Pimans. They dispensed with many of the regular Pima-Papago animal taboos, even the high aversion ones: desert iguana, small lizards, snakes, and probably most small rodents. Marine resources were utilized: clams, oysters, sea turtles, fish, shrimp, and perhaps marine mammals (Fontana 1974). Unlike the Seri, the Sand Papago lacked boats or rafts for more efficient exploitation of marine resources, and some bands ranged far from the gulf coast. Unfortunately, no ethnotaxonomies have been recorded for Sand Papago. They shared with other Pimans taboos on vultures, hawks and eagles (Fontana 1974).

Colorado River Yuman Speakers (Quechan, Cocopah, Cucupá, Mohave).—Tabooed animals include: skunk, dog, bobcat, puma, porcupine, peccary, hawks, desert tortoise, mud turtles, perhaps coyote, and probably all snakes. Information on entomophagy is incomplete, but they avoided grasshoppers. Probably all utilized bird eggs except from tabooed birds. Hrdlička (1908:24) notes that the Mohave ate dogs and occasional badgers, a species of lizard (chuckwalla or desert iguana?), and "even coyotes" but tabooed beaver (utilized by Quechan). Eggs, particularly duck and quail, were an important resource.

Maricopa.—The Maricopa are a collection of about 5 Yuman tribes who have lived immediately west of the Gila River Pima since the early part of last century. Their animal avoidance pattern is interesting in that it follows closely that of the Yuman speakers from the Colorado River, rather than the Riverine Pima they have been intimately associated with for a century and a half. The taboos in common with the Colorado River people include: skunk, dog, coyote, bobcat, puma, and bird eggs. They share with the Pima (but not with their Yuman ancestors) taboos on Round-tailed Ground Squirrel and foxes (Kit and Gray). Also like the Riverine Pima (and unlike the rest of the Yumans) they ate peccary or javelina. Maricopa reportedly hunted turkey north of the Salt River (Spier 1933). There are unfortunately a great many holes in the data, particularly with regard to the smaller animals (birds, rodents, reptiles) and Maricopa ethnotaxonomies have never been satisfactorily investigated. Eggs were generally tabooed though one source says they ate quail eggs (Castetter and Bell 1951).

Seri.—The Seri ate the eggs of various aquatic birds including gulls, herons, and pelicans. The only birds completely tabooed were the roadrunner and the raven. Owls (even the Great Horned Owl) were occasionally taken. Vultures were eaten only at stress times. Quail and doves were not normally hunted, but might be taken by boys. Coyote meat was eaten during whooping cough epidemics (hence a medicine rather than a food as such?), but none ate domestic dogs, which were considered reincarnated Seri. Two small lizards, the Banded Gecko (*Coleonyx variegatus*) and the night lizard (*Xantusia* sp.) were considered toxic. The northern Pimans also consider the gecko a dangerous animal. The Seri ate 2 large species of rattlesnakes, but not sidewinders nor non-venemous snakes. Low aversion non-utilization categories include grasshoppers, cicadas, mud turtles, and mice. Much of the major protein supply of the Seri comes from marine resources (sea turtles, fish, shellfish, crustaceans).

Western Apache (White Mountain, Cibicue, and Tonto Apache).—Western Apache tabooed bear (generally), dog, coyote, fox, apparently gopher (except in stress times), peccary (as well as pork later), herons, all hawks and eagles, all owls, vultures, all *Corvus* spp., all small lizards and snakes, all fish, and apparently grasshoppers. Southern Tonto might take skunk. Western Apache still eat a great many song birds such as juncos and robins, but certain others are rigorously avoided. If a bird species were tabooed, so were its eggs. All other species were vulnerable to egg predation. My own field experiences of bird collecting with Western Apache indicate that they have more numerous and more rigorous avoidances than any other group in the desert. The absolute restriction of fish eliminated a potentially important food resource, for all the Western Apache country is well supplied with rivers and creeks. The Apache periodically went into the lowlands to harvest plants such as mesquite and saguaro that were unavailable at higher elevations. It would be interesting to know what animals they ate during their forays into the desert.

Observations and Discussion

No *major* game animal is tabooed by any desert culture: deer (both species), pronghorn, desert bighorn, jackrabbits, and cottontails. There are proscriptions, of course, on the manner in which certain game may be taken and how the meat, bones, antlers or horns may be handled and disposed of. With the Papago on certain occasions deer have to be strangled or suffocated and numerous restrictions prevent insult to the sacrificed animal (Underhill 1946).

The only animal that might be considered in the category of a major game species which some desert cultures completely taboo is the javelina or collared peccary. Its utilization is problematic. One might even wonder at its range fluctuations during the Holocene. Peccary bones occur in no Southwestern archaeological site, to my knowledge. It is tabooed by Western Apache and Colorado River Yumans but not by Gila River Yumans. But the species is truly marginal in both of these areas. Western Apache extended the peccary taboo to include the domestic pig (Buskirk 1949). Though an important resource in recent decades to both Desert and Riverine Pimans, it does not figure in their songs or myths (as other game animals do so prominently) and may even be a recent (post-contact) addition to the dietary, if not to the local fauna as well.

Some animals were not sought directly by hunters, but were shot and brought home as food when encountered on hunts. For the Riverine Pima these include: bear, puma, bobcat, jaguar. A similar explanation is given by most of the other desert cultures (cf. Buskirk 1949).

The dog was tabooed by all the desert tribes except apparently the Mohave (*fide* Hrdlička), though it was an important food resource with various other native North American tribes. It is not known whether the San Papago had dogs. The coyote was almost universally tabooed in the desert, the only exceptions being among the Mohave and Southern Tonto (Western Apache). Coyote is one of the most prominent characters in Piman legends. Though he is considered a mischievous trickster and the rest of the community suffers from his behavior, he is never molested. The Kit Fox and Gray Fox (which each have primary unanalyzable names in Pima-Papago) were also not molested, except by the Mohave.

Eurasian herbivores (horse, burro, cow, sheep) as far as I know, were adopted as food items by all the desert cultures, even though the first 2 (horse, burro) were generally tabooed by the cultures that introduced them to the Southwest.

The larvae of the White-lined Sphinx *(Celerio lineata)* were used by all the desert tribes. The host plants for this species are summer annuals that appear during the monsoonal season. This is a large caterpillar, several inches long. It was the only insect regularly taken by desert groups. Its importance might be judged by the facts that there were many preparation methods, the larvae were dried for storage, and the eating of these caterpillars has persisted to recent times, in spite of the aversion of the dominant English- and Spanish-speaking cultures.

Smaller animals (other than lagomorphs) were selectively tabooed or eaten by desert tribes. There appears no ecological imparative here. Let us look at the Riverine Pima for whom the ethnotaxonomies and utilizations are best worked out (Russell 1908; Rea MS). All species of fish, if of sufficient size, were eaten. The ethnotaxonomy of fish probably corresponds one-to-one with our Linnaean species concepts. All lizards and snakes are tabooed, regardless of size. Piman folk taxonomy of lizards, and probably also of snakes, corresponds to our Linnaean species. (I mention this as an aside to point out that ethnotaxonomies do not necessarily reflect utility, at least with Pimans.) Animals with strong totem, moiety or reincarnation symbolism are tabooed: coyote, vulture, owls.

Rodent utilization by the Riverine Pima is instructive and should caution against any simplistic deterministic approach to understanding their dietary restrictions. Round-tailed Ground Squirrels and Pocket Gophers are tabooed and the prohibitions are strong enough to have sanctions (staying sickness and birth defects) attached to them. This makes no sense from an ecological or practical point of view. Irrigation agriculturalists should have benefited by killing and eating the 2 most troublesome species in their ditches and fields. Heteromyid rodents (*Dipodomys* and *Perognathus*) as well as *Peromyscus* (and by extension, introduced *Mus musculus*) are tabooed. But 2 other rodents, the cotton rat, *Sigmodon*, and the woodrat, *Neotoma*, are the most prized of all the Pima animal foods. Metaphysical or symbolic selection of cultural foodways is shown here, not ecological or nutritional dictates.

An ecological factor is involved in what contributed the bulk of animal protein to the Riverine Pima diet. The most frequently taken game included: fish, jackrabbits (2 species), cottontails, cotton rats, woodrat, quail, doves (4 species), and sparrows (2 species). With the exception of the fish, these species have one thing in common: they proliferate as a result of the Pima agricultural and land use practices (Rea 1979a). The overall effect was to have the bulk of the animal hunting taking place close to settlements and fields, rather than in the mountains or bajadas. (There also may be a defensive factor involved here.)

Plant resources appear to be used transculturally by Sonoran Desert peoples. They serve no symbolic function for emic identity. Pan-cultural utilization was probably even more widespread in aboriginal times, but some plant resources (e.g., cattail pollen, ephemeral and wild grass seeds) probably dropped from the dietary because of tedious gathering or preparation methods or habit changes (Bohrer 1975). Among the Pima-Papago, Seri and Western Apache, many native plant foods are regularly prepared by at least the more traditional families, but other plant foods (e.g., *Orobanche, Phoradendron, Allenrolfea, Prosopis pubescens, Cercidium,* and *Olneya*) have completely fallen from the dietary.

Even though some of these plants, such as agave, mesquite, and cholla buds require a rather elaborate preparation technology to render them edible, they were important staples in desert diets.

The technology for the storage of seasonally available foodstuffs was probably a major key to survival in the desert.

Plants were undoubtedly an important protein source, at least to the agricultural peoples. Mesquite pods, corn, beans, teparies, and various other seeds appear to have been combined in the diet in such a manner as to supply many essential amino acids (Nabhan 1978).

At least 3 plant products (acorns, saguaro fruit and chiltepines) were traded to groups that did not have direct access to the plants themselves.

The idea of a 'hand-to-mouth' subsistence economy of nomadic gatherer-hunters (or hunter-gatherer-agriculturalists), maximizing their predation time (at the expense of other cultural elaborations) on marginal resources in tropical forests, deserts or savannas, is a *misconception* foisted on us by frenetic theoretical ecologists or by superficial observers. This concept is utterly false, as has been demonstrated by Lee (1968), Woodburn (1968), Chagnon and Hames (1979), and others who have studied real people living in marginal habitats. The work loads may be sexually disproportionate (as they assuredly are in western cultures!). Survival in harsh environments is not so much a matter of enormous input of *time* into the subsistence economy. Rather survival requires a thorough knowledge of the behavior of culturally selected "acceptable" animals and knowledge of the productivity of and preparation techniques for edible plants.

Taboos are a luxury. I think there are ecological limitations. The relatively rich riverine peoples with agriculture (Pima Bajo, Riverine Pima, Yumans, etc.) could afford to sacralize a good number of animal species, whereas those from the more harsh areas (Sand Papago and perhaps Seri) had to be more generalized in their dietary selections. For instance, the Sand Papago survived because they relaxed a strong reptile taboo of their ecologically richer eastern relatives. A strictly ecological approach (cost/benefits, optimum yield) fails to explain the function and maintainence of taboos, but I think does explain their limitations. Simoons (1967) has warned against the acceptance of facile "biological" explanations for the major meat taboos of the Old World. I would agree with Thurton (1978): "Food tabooes will show a certain minimum degree of fit with ecological and technical 'realities.' It is, of course, useful to have such an empirical demonstration, but it does not amount to an explanation of the taboos themselves."

Southwestern Amerindians are *not* the ecologists that some romantic writers would like to make them out to be. They have no qualms about exploiting a species to extinction and undoubtledly *have* in many instances in the past (cf. Paul Martin's Pleistocene overkill theory). The Zuni hunt flickers and orioles extensively to obtain feathers for ceremonial prayer sticks, I am sure with little regard to whether they are decimating the local population. I find it impossible to accept the idea (contra Ross 1978) that an Indian culture invents a taboo in order to protect a game species from extirpation. When the last sea turtle is harpooned in the Gulf of California, the Seri will enjoy the feast just as much as they have its predecessors for centuries.

On the other hand, the native Southwestern people have a strong sense of the sacred. Some animals are sacred, just as are some feathers, some shrines (spaces), some songs, and some ceremonies. This sense of sacred permeates the Southwestern cultures, as anyone who has had close contact with the still intact societies can hardly fail to notice. Hunting is a prayerful experience, and some animals are attributed powers so great that no person would want to abuse them. The Pima organizer of a rabbit drive will mention the sought after prey only obliquely, for to speak of jackrabbit or cottontail directly would be an insult to them. The Apache demands sexual continence before the hunt. While apparently all the desert peoples felt free to use all available plant resources, animal resources were a very different matter. Each culture (and even sub-culture) selected a repertoire of animals it considered too special for eating. In trying to understand desert food restrictions I am reminded of Eliade's (1959:13) observation:

> The *completely* profane world, the wholly desacralized cosmos, is a recent discovery in the history of the human spirit . . . desacralization pervades the entire experience of the nonreligious man of modern societies and, in consequence, he finds it increasingly difficult to rediscover the existential dimensions of religious man in the archaic societies.

CONCLUSIONS

With the presently available data, incomplete though they are for some Sonoran Desert groups, some tentative answers regarding dietary resource utilization can be given to the 4 questions asked at the beginning of this paper.

(1) Intercultural selectivity appears to be a matter of differential usage of *animal* species with few or no differences in *plant* usage. However, there appears to be a core group of game animals common to the diets of all desert groups.

(2) Generally, dietary selection follows linguistic lines. A Piman pattern is evident between the ecologically dissimilar Pima and Papago, the (unconscious?) rules arising from their shared concept of "staying sickness." The lowland Pima Bajo probably correspond, but the data are yet incomplete. The resource-poor Sand Papago show the greatest departure from the Piman pattern. The Maricopa show many parallels to the Cólorado River Yuman pattern, but there are a great many holes in the data preventing a rigid comparison. There appears to be some Piman influence on the Maricopa dietary.

(3) It appears that agriculturalists in the desert can afford more taboos than non-agriculturalists (Sand Papago and Seri), but it is not really possible to isolate the agricultural factor from the ecotone resource factor. Non-agriculturalists appear more opportunistic, maintaining a broader animal resource base. Sonoran Desert agriculturalists still maintained as many wild plant species in their food base as did the non-agriculturalists (though there undoubtedly were differences in importance values). Stated differently, agriculture is superimposed on gathering, rather than suplanting it as in Anglo-American culture.

(4) The origin of dietary restrictions is problematic, but I believe they function first as symbols of group identity and cosmology. (Note that non-Piman Amerinds cannot contract staying sickness!) Contra Ross's hypothesis for Amazonian groups (i.e., that perpetuation of animal taboos can be resolved in terms of cost-effective strategy of optimum yield), I believe there is no ecological determinism in the Sonoran Desert, but that there are ecologically imposed limits to dietary selectivity.

The most important biological question about any group of people is: How did they make a living within the constraints of the ecological environments? We have only just begun to study the cultural adaptations of these various desert peoples. Pioneer ethnobiologists such as Lyndon L. Hargrave and Alfred F. Whiting have pointed us in the right direction. But we must work fast to learn what we can about these precious remnants of native desert cultures before they are totally assimilated (linguistically and ecologically) into the mainstream of the maladaptive technological societies temporarily occupying (but not adapting to) the desert.

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Appendix: Animal Taboos in Anglo-American Culture

Some people seem unaware of their own rules of dietary selectivity. The bulk of Americans living in the United States follow a powerful (though perhaps unconscious) set of rules which in concert govern animal taboos. These may be formulated as follows:

1) *Vegetarian animals are acceptable; non-vegetarian species are tabooed.* (e.g., cows and chickens vs. coyotes and hawks.) Non-vegetarians include scavengers, predators, and carnivores.

2) *Vertebrates are acceptable; invertebrates are tabooed.* (e.g., fish, birds, mammals vs. insects, worms.) Marine crustaceans (which also violate rule 1) and marine shellfish are standard exceptions.

3) *Non-pets are acceptable; pets are tabooed.* (e.g., cow, chicken, perch vs. horse, pigeon, duck, goldfish.)

4) *Domestic animals are acceptable; wild animals are tabooed.* (e.g., cow vs. deer.) An arbitrarily defined category of "game" animals may be taken by some (but never sold), yet much wild game (bobcat, mountain lion, rodents, coyote, bear, doves) never reaches an American table.

5) *Muscle tissue is acceptable; organs are tabooed.* (e.g., roasts and other meat cuts vs. intestines, pancreas, gonads, brain.) Liver is the standard exception. Note that in the Anglo-American folk taxonomy "meat" when referring to food is synonymous with "muscle tissue."

As a result of these rules, strictly tabooed for the vast majority of U.S. Americans are: dog, cat, horse, burro, rodents, crayfish, bear, songbirds, insect larvae, snakes, lizards and many so-called game species. Rigorous legal sanctions prohibit commercial establishments (markets and restaurants) from violating these cultural taboos.

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DIETARY MINERAL ECOLOGY OF THE HOPI

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ABSTRACT.—The Hopi are considered one of America's oldest Native Indian groups who continue to live on traditional lands. In modern times, they have relinquished many of their earlier cultural practices, including those related to agriculture and diet. Foods consumed have changed from the earlier pattern of corn, beans, and squash, augmented with wild plants and animals to a contemporary diet which contains a variety of foods imported to the reservation. A survey of 420 Hopi women and children showed that less than 25% consume one item of indigenous food each day and that the variety of traditional foods consumed has decreased dramatically from that described in the early anthropological literature. The changing diet presupposed changes in nutritional status. Mineral analysis of traditional Hopi foods reveals high levels of all nutritionally essential elements. Additionally, Hopi cultural practices reinforced the use of unusual mineral-rich plant foods and salts which were of nutritional importance when the diet was limited to animal foods. Seventeenth century and contemporary Hopi deciduous teeth were analyzed for several minerals. While calcium and phosphorus were similar in both groups, the earlier group had significantly higher levels of strontium and the latter group had higher levels of zinc, copper and lead.

INTRODUCTION

The Hopi are considered one of America's oldest Native Indian groups who continue to live on traditional lands. Hopi villages on the mesas of northeastern Arizona (Fig. 1) have been continuously inhabited since A.D. 1150-1417, and although the Spanish and Anglo-American acquisition of Indian lands considerably reduced the Hopi food land base in the late nineteenth and twentieth centuries, cultivation of the corn-bean-squash foods continued to furnish the major components of the diet until recent times.

Previously, wild plants, animals and salt were gathered from areas as far away as the San Francisco Peaks (near present day Flagstaff) and the Grand Canyon. While the introduction of domestic livestock by the Spanish brought new protein resources, the eventual reduction of the fragile desert vegetative cover by grazing has resulted in erosion and exacerbation of moisture conditions for native and cultivated vegatation (Thornthwaite 1942).

Demographic influences on Hopi food culture and preparation include an increasing population per acre on the reservation and, at the same time, there is an increasing proportion of older people and others who are so engaged that they can no longer devote a major part of the working day to traditional agricultural or kitchen labor. The time consuming nature of food preparation in the traditional manner is emphasized in the practice of maize meal grinding by the Hopi women. Using stone *mano* and *metate*, corn grinding would take 3-4 h daily for the preparation of enough food for one day for the family which usually included 7-9 members. The preparation, cultivation and harvesting of fields using traditional agricultural methods is also recognized as a labor intensive occupation for the Hopi man from mid-April to October (Hack 1942; Forde 1931).

When all Hopi foods were supplied entirely by their native environment (except for the small amounts obtained by trading with neighboring tribes), Hack (1942) and Bradfield (1971) independently estimated the required farmland per capita to be 0.8 ha in corn and 0.2 ha in other vegetables. Thus, approximately 4.2 hl of corn were consumed per person per year (about 316 kg of cornmeal) and an equal amount was stored for lean years (Stephen 1936). In 1893 it was estimated that there were 1458 ha in corn, 810 ha in cultivated vegetables, primarily beans and squash, and 405 ha in peach trees for the total population of 2000 Hopi (Donaldson 1893). Peaches were introduced by the Spanish in the seventeenth century and were a popular food and trade item.

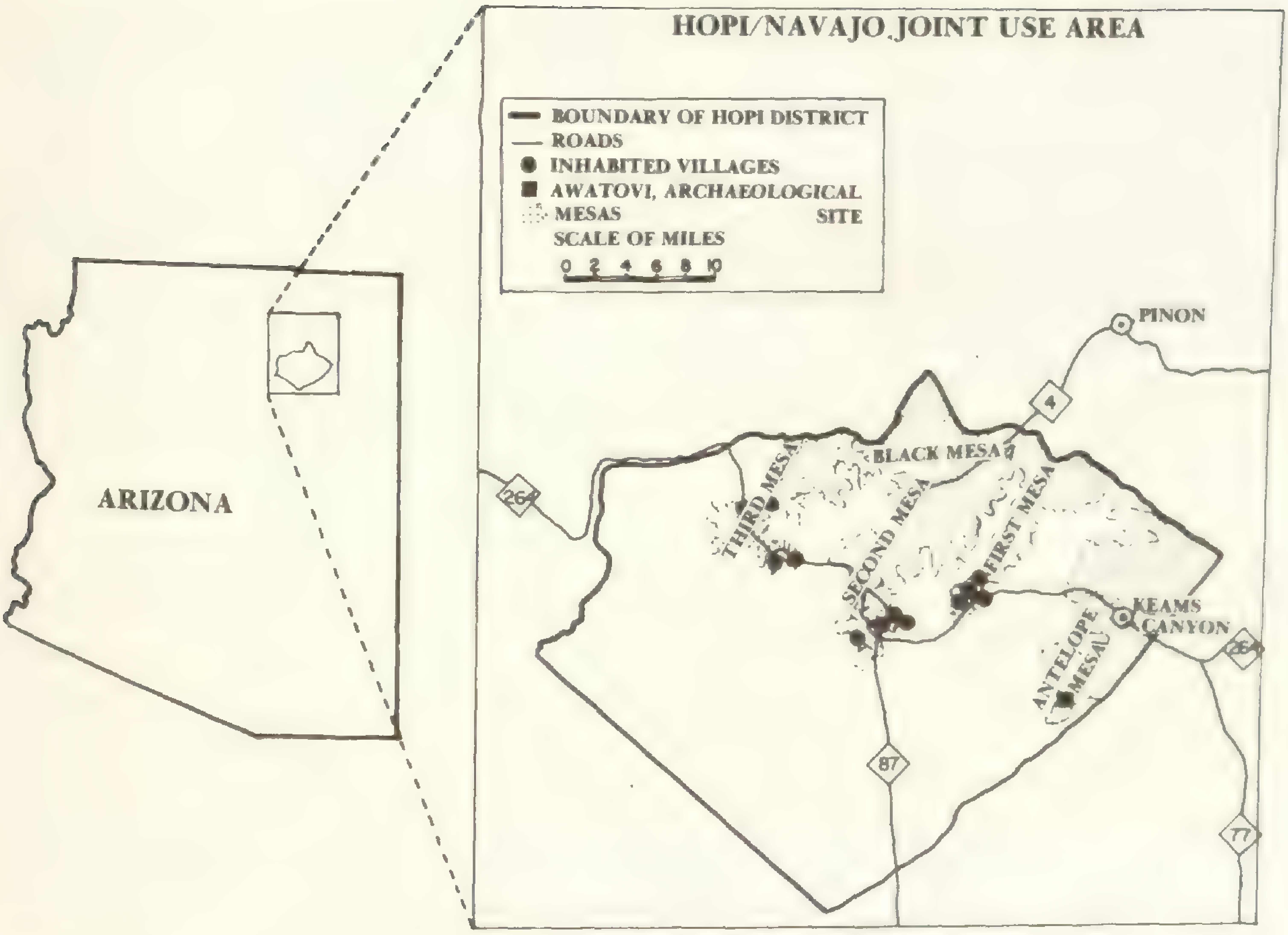

FIG. 1.—The Hopi area in Arizona (boundaries in the Joint Use Area are being negotiated).

For various social and geographical reasons, much of the traditional farmland has fallen out of use. As an example, the Oraibi (a Third Mesa village) Hopi cultivated about 972 ha in the 1890's; in the 1960's Bradfield (1971) recorded only 373 ha under cultivation by this village. In 1974, 2573 ha of "annually or intermittently" cultivated farmland were noted in the Hopi area (BIA 1974). For a population of 7500 Hopi, this averages about 0.3 ha per person. It appears, then, that the use of traditional agriculture and harvested foods has declined.

It is the intent of this report to describe the changing nutritional environment of the Hopi with regard to selected dietary minerals. A description of general dietary change is followed by data on selected minerals contributed to several indigenous Hopi foods, and comment on those minerals of particular interest. Finally, mineral data from seventeenth century and contemporary Hopi deciduous teeth permit comparison of human accumulation of certain minerals in preindustrial and current settings.

DISCUSSION

Dietary Change

A dietary study of 420 Hopi women and children in 1974-75 has confirmed the above geographical and social trends and shown an infrequent use of traditional Hopi food (Kuhnlein and Calloway 1977a). During the survey period, less than 25% of the individual daily records contained one item of traditionally prepared foods. The composition of the contemporary diet is primarily of items distributed in commercial food networks throughout America. The work of early anthropologists which was thoroughly compiled and expanded by Whiting (1939) in *Ethnobotany of the Hopi* permits a summary of foods used in pre-Spanish times. This is compared to the foods of the contemporary Hopi family in Table 1. The most prevalent items in terms of quantitative consumption are noted. It can be seen that the total variety of food plants was much greater in the earlier period, and that the composition of the diet in all food categories has dramatically changed.

While the diet was previously composed primarily of corn, beans, squash, seeds, wild greens, and fruits and water, today the diet is primarily beef, mutton, eggs, wheat, potatoes, some canned vegetables, fruits, and fruit jucies, lard and other fats, coffee, tea, milk, and several commercial pastries and sweets. Although the contemporary diet is not strikingly deficient in nutrients (including essential minerals) when compared to other American low-income populations (Kuhnlein and Calloway 1977a), there is a preponderance of refined cereals, animal fats, and sucrose-rich foods, all of which were not used previously. These items have been associated with dental caries, obesity and concommitant degenerative health problems which have been documented in contemporary Southwest Indians (Sievers 1966; Sievers and Cannon 1974).

TABLE 1.—*Indigenous and Contemporary Hopi Family Foods*[a]

Food Category	Indigenous[b]	Contemporary[c]
Fruit	agave, hedgehog cactus, juniper, tomatilla, cholla, prickley pear, squawbush, currant, rosehips, yucca (seasonal, some preservation)	melon, peach, apple, grapes (seasonal), orange, banana, commercially preserved fruits and juices*
High protein	beans*: tepary, lima, kidney, scarlet runner (ca. 20 var.), pinyon nuts, seeds* (many), wild game	Beef*, pork, mutton*, eggs*, poultry, fish, small amt. wild game, peanut butter, beans*, nuts
Vegetable	fresh sweet corn*, wild potatoes, pumpkin*, squash*, fresh beans, wild greens*; (ca. 39 sp.) (seasonal, some preservation)	sweet corn*, snap beans*, tomato, lettuce, chili*, squash, spinach, potatoes* (commercial and local grown, some preservation)
Grain	corn* (12-14 var., ca. 70 methods of preparation, often with culinary ash) Indian rice grass, millet	wheat*: yeast bread, fry bread, quick breads, tortilla, pasta, etc. (mostly commercial) corn: mush, grits, occasional old Hopi dishes (piki, nokquivi, etc.), rice, various breakfast cereals*
Separated fat		lard*, margarine*, oil*, butter
Dairy products		milk*, cocoa, cheese, preserved milk*
Other beverages	water*, herb tea	coffee*, tea*, pop*, sweetened juice drinks, powdered sweet drinks*
Sweets and snacks	sweet roots: 11 species (seasonal)	milk pudding*, candy*, jello*, chips* and other crisp and salted snacks, pastry*, jam

[a] Adapted from Kuhnlein and Calloway (1977a).

[b] Pre-Spanish

[c] Foods identified in a survey of 420 women's and children's diet records in 1974-1975.

TABLE 2.—*Approximate Percentage of Desired Daily Intake*[a] *Provided by 200 g Portions of U.S.D.A. Commodity and Hopi Cereals.*

Element (need)	Calcium (800 mg)	Magnesium (350 mg)	Manganese (7 mg)	Iron (15 mg)	Zinc (15 mg)
Cereal	(% of above contained in 200 g)[b]				
Commodity					
Corn Meal	1	23	7	36	8
White rice	1	15	34	41	16
White flour	5	15	17	35	7
Rolled Wheat	9	72	91	45	35
Hopi					
Corn meal	2	80	18	43	35
Piki bread	40	102	56	121	55
Bivilviki	142	159	57	224	49

[a] Desired intakes are arbitrary but reflect presumed upper needs levels of healthy adults or NRC allowances (1973).

[b] Products contained 88-92% dry solids, i.e. "as is" dry product basis.

From Calloway et al. (1974).

TABLE 3.—*Composition of Hopi Chamisa Ash*[a]

	g/kg		mg/kg
Na	1.57	Mn	710.00
K	174.00	Fe	3840.00
Ca	125.00	Cu	96.00
Mg	52.00	Zn	169.00
P	10.80	Se	8.00
		Br	98.00
		Rb	189.00
		Sr	1060.00
		Pb	11.00

[a] From Calloway et al. (1974).

Minerals in the Hopi Nutritional Environment

Culinary Ash.—A striking nutritional quality of traditional Hopi foods is the addition of essential elements in the preparation of blue cornmeal foods with a culinary ash. X-ray fluorescence analyses of samples reveals that sodium, potassium, calcium, magnesium, manganese, iron, copper, zinc, bromine, rubidium and strontium are all added with the ash (Calloway et al. 1974). It can be seen in Table 2 that the Hopi have a much better probability of meeting their mineral needs by consuming their own native foods than by using refined substitutes. Piki is a wafer thin bread prepared from blue cornmeal, ash and water. Bivilviki is from the same ingredients, but shaped into dumplings and boiled in water. Both are enriched with mineral nutrients because of the addition of ash.

Beaglehole (1937) and Nequatewa (1943) recorded that in addition to the usual midday and breakfast corn foods, piki and bivilviki, the Hopi commonly prepared at least 10 additional dishes of blue or pink cornmeal with a culinary ash. The preferred ash varies for different dishes, cooks and villages, but the most commonly used ashes are prepared by burning the green plant leaves and stems of *chamisa* (four-wing salt bush, *Atriplex canescens*) or dry bean pods and vines (*Phaseolus* sp.) The rich mineral content of Hopi chamisa ash is noted in Table 3. Culinary ash is also prepared from juniper branches, corn cobs or sheep dung. Today, some cooks substitute baking soda for ash, as the alkalinity produces a similar color change in the anthocyanin pigment within the cornmeal.

Salts.—Trace elements were also contributed to the earlier diet by the use of crude salts which were gathered by the Hopi from several geological deposits in the area. Sites in the Grand Canyon and Zuni Lake were most often frequented (Hunter 1940). Mineral levels in 11 salts from northeastern Arizona which are known to have been used by Native People are given in Table 4 with data from one commercial salt sample. The indigenous salts contained iron, arsenic, bromine, rubidium and strontium in substantial levels.

If the average Grand Canyon sample contained about 500 ppm iron, and 5 g of salt were consumed on a daily basis, this would provide 2.5 mg of iron, which is one-fourth to one-eighth the normal human requirement (Food and Nutrition Board 1974). Absorbability, however, is not known. The effects of these quantities of arsenic, bromine, rubidium and strontium are also not known. The small amounts of manganese, copper, zinc, nickle and selenium probably had only minor influence on improving mineral adequacy of the diet.

Sherds.—Ceramic sherds from the Hopi area were identified at the Harold F. Colton Research Center in Flagstaff and analyzed by x-ray fluorescence. The data given in Table 5 have been summarized in a recent report (Kuhnlein and Calloway 1979a). These fragments of ceramic vessels used in the Hopi area were found to contain considerable amounts of all the trace elements analyzed. It is possible that if these were used for food vessels, some of the minerals would leach out into foods, especially if the food pH was low. Today the Hopi rarely use ceramic containers for food.

Calcium.—This mineral is especially interesting for study in traditional Hopi foods because milk was not used in the culture except when infants were breast-fed. It was found that there were several excellent sources of calcium in Hopi foods which were clearly important in pregnancy and childhood when skeletal growth is rapid.

TABLE 4.—*Elements in Indigenous Salts From the Hopi Area Compared to Commerical Brand.*

	Cu	Zn	Mn	Fe	As	Br	Rb	Sr	Pb
	(ppm)								
Zuni Lake Domestic	<2	5±1	<9	13±5	2±1	34±2	<1	4±2	<4
Zuni Lake G3-411	3±2	2±1	<8	36±5	2±1	11±1	<1	4±2	<4
Grand Canyon G3-419[b]	3±2	3±1	<9	15±5	12±1	420±21	224±11	<2	<4
Grand Canyon E2345[c]	6±2	11±2	36±7	1530±70	414±20	1060±50	194±9	45±2	6±3
Grand Canyon E2346	3±1	5±1	<11	505±25	69±3	554±27	103±5	50±3	<4
Grand Canyon E2347[d]	3±1	6±1	10±6	360±18	127±6	372±18	130±6	15±2	<4
Grand Canyon G3.790	2±1	3±1	<8	57±5	22±1	288±14	85±4	5±2	<4
Camp Verde G3.230	8±2	3±1	<8	13±5	<1	18±1	<1	<2	<4
Camp Verde G3.69	2±1	<2	<8	18±5	<1	2±1	<2	2±1	<4
Medicine Cave NA863.1[e]	3±2	4±1	<8	436±21	<1	<1	<1	9±1	<4
Wupatki 405M.44	<3	2±1	10±7	265±13	<1	4±1	5±1	5±2	3±3
Co-Op Iodized	<3	2±1	<8	5±4	<1	67±3	<2	1±1	<4

[a] Except where noted, undetected elements were: Cr < 12 ppm; Ni < 3 ppm; Se < 2 ppm. Zuni Lake Domestic Salt was obtained from a Hopi kitchen and Co-Op Iodized was purchased in California. All other samples were generously provided by the Museum of Northern Arizona - museum catalog numbers are given.

[b] Se = 5±1

[c] Ni = 3±2

[d] Ni = 3±2

[e] Ni = 12±2

TABLE 5.—*Elements in Seven Pot Sherds from the Hopi Area.*

206	Fe	Mn	Cu	Zn	Hg	As	Sr	Pb
	(ppm)							
Tusayan corrugated	1.8%	83±30	45±2	49±2	6±3	7±2	195±8	32±7
Leupp black-on-white	1.7%	320±70	44±2	62±2	6±3	10±2	142±6	31±8
San Bernardo polychrome[a]	1.8%	180±50	35±2	90±4	6±3	13±2	95±4	22±8
Tusayan black-on-white	1.6%	110±30	32±2	50±2	5±3	< 5	215±9	35±8
Tusayan corrugated	2 %	130±40	95±2	68±3	7±3	5±2	179±8	46±8
Tusayan corrugated[b]	3 %	120±40	36±4	70±3	< 9	6±2	149±6	34±8
Contemporary First Mesa redware	6 %	50±20	24±3	209±8	15±4	9±3	43±5	32±11

[a] Typical style made in Awatovi.
[b] Found in Awatovi.

In Table 2 it can be seen that if only 200 g (dry weight) of cornmeal-ash foods were consumed, this would provide about 730 mg of calcium, which should be sufficient to meet nutritional needs, even if total availability were in question. Other good sources of calcium are water (Dutt and McCreary 1970) and seasonally collected green plants (Kuhnlein and Calloway 1979b) and probably other locally-grown plant foods as well.

Iron, zinc and phytate.—Iron is another nutritionally essential mineral of interest in Hopi foods. Geological formations in this area of Arizona are highly colored with iron-containing minerals, but iron is thought to be limited to the diets of most contemporary low-income women and children in North America (USPHS 1973; DNHW 1973). In addition, the appearance of porotic hyperostosis in skeletal remains of early Pueblo populations dependent upon a maize diet has prompted the speculation that the phytate content of whole-grain corn, by interfering with absorption, precipitated iron-deficiency anemia. This, in turn, may have caused the skeletal deformities (El-Najjar and Robertson 1976; El-Najjar et al. 1976). Zinc is also known to form insoluable complexes with phytate (Reinhold et al. 1976).

The content of iron, zinc and phytate in some traditional Hopi foods was investigated. In Table 2 it is seen that both piki and bivilviki (the most common traditional corn foods) contain ample iron and zinc in a 200 g portion. These samples were prepared from ash and cornmeal ground by modern Hopi with an electrical stone grinder. The amount of iron and 3 other minerals added to the cornmeal during the various stages of traditional *mano* and *metate* grinding and during mechanical grinding is shown in Table 6. Iron is accumulated in the meal prepared with *mano* and *metate* grinding in considerable quantity, probably as minute particles of rock. Manganese, calcium and phosphorus are also added in the traditional procedure. The electric grinder with stone rubbing surfaces did not make significant additions of any of the minerals analyzed, even though the resultant meal can also be classified as "stone ground." Zinc was not added in either procedure.

Phytate analysis was performed on modern Hopi corn for which mineral data were available, and these results are given in Table 7 (Kuhnlein and Calloway 1979b). The phytate ranged from a low value of 0.4% for lyophilized fresh sweet corn to 2.2% in mature yellow corn normally used for hominy. When chamisa ash was used to make the bivilviki, the levels of calcium, iron and zinc were increased and the molar ratios of phytate: mineral were reduced. Molar ratios of phytate: minerals were lower for the sweet corn than for the mature corn. The high level of calcium in the bivilviki might accentuate the formation of an insoluble phytate complex.

TABLE 6.—*Elements in Hopi Blue Maize Cornmeal Prepared with Mano and Metate vs Mechanical Stone Grinder*[a]

Sample Treatment	Fe (ppm)	Mn (ppm)	Ca (mg/g)	P (mg/g)
Mano and metate ground				
A1 After removing kernels from cob by hand	30±2	10±2	0.05	1.63
A2 After washing with stored water	33±2	10±2	0.06	1.52
A3 After coarse grinding	323±16	10±2	0.07	2.40
A4 After roasting in iron kettle	372±18	8±2	0.08	2.50
A5 After fine grinding	496±24	18±2	0.73	2.25
A6 After sifting with wire sifter	576±28	18±2	0.67	1.42
Mechanically stone ground[b]				
B1 After removing kernels from cob mechanically	31±2	9±2	0.04	1.83
B2 After washing	27±2	8±2	0.04	1.30
B3 After coarse grinding with "meat grinder"	47±2	9±2	0.05	2.43
B4 (No. B2) After fine grind by machine[b]	29±2	8±2	0.04	1.19
B5 (No. A2) After fine grind by machine[b]	26±1	9±2	0.05	1.44
Laboratory controls				
CA6 After microwave cooking and lyophilizing	502±25	20±2	n.a.[c]	n.a.
CB4 After microwave cooking and lyophilizing	29±2	8±2	n.a.	n.a.
CB5 After microwave cooking and lyophilizing	33±2	10±2	n.a.	n.a.

[a] From Kuhnlein and Calloway (1979a).

[b] "Little Jiffy" Electric Grinder, All Grain Co., Tremonton, UT S/N 1442

[c] Not analyzed

Also given are mineral values for corn excavated from Antelope House in Canyon de Chelly[1] (dated about A.D. 1200) where porotic hyperostosis was identified in skeletal remains. The iron and zinc values are similar to the contemporary Hopi corn, but calcium is substantially higher. Unfortunately, enough sample for phytate analysis was not obtained.

Questions regarding the quantitative binding of minerals to phytate in foods, the various complexes formed between the many different minerals and phytate, and ultimate availability in the gut have still to be elucidated (Oberleas et al. 1966). However, it is tempting to speculate that the use of culinary plant ash emerged as an experiential response to limited amounts of animal foods with high content of absorbable essential mineral nutrients (particularly iron, zinc and calcium) and consequent dependence on a largely cereal-legume diet.

Strontium.—High levels of strontium in the Colorado River and in northern Arizona soils and plants indicate that this area of Arizona is rich in natural strontium (Kopp and Broner 1967). This is shown in elevated levels in some native salts reported here, and also in water, water-extracts of soils, native leafy green plants and other Hopi foods (Kuhnlein and Calloway 1979a). The culinary ash used by the Hopi in blue cornmeal foods contains large amounts of strontium as well as calcium and was very likely a major contributor of both elements in the indigenous diet. Strontium and calcium are closely interrelated, biologically, and it is thought that strontium can substitute for calcium in the apatite complex of skeletal tissue (Likens et al. 1961).

Analyses of Hopi harvested foods reveal 10-30 Mg Sr/g Ca and these ratios are considerably higher than the ratios of the contemporary Hopi diets (about 5 mg/g Ca) (Kuhnlein 1976). This is not unusual considering that relatively small amounts of cornmeal-ash foods are included in modern Hopi diets.

TABLE 7.—*Phytate and Minerals in Hopi Corn*[a]

			Phytate/mineral ratio			
	Phytate gm/kg	Ca gm/kg	Fe mg/kg	Zn mg/kg	Fe mole/mole	Zn mole/mole
Blue Cornmeal	18.7	0.09	32	26	50	71
Bivilviki (from the above cornmeal)	14.8	5.67	168	37	8	37
Hominy Corn	21.9	0.07	31	38	59	55
Roasted Sweet Corn	6.5	0.12	64	60	9	11
Antelope House Corn (yellow kernels)	n.a.[b]	0.43	23	26	n.a.	n.a.

[a] From Kuhnlein and Calloway (1979b).
[b] Not analyzed.

TABLE 8.—*Minerals in Deciduous Tooth Dentin*[a]

Element	17th Century Hopi n=10 (1)	Contemporary Hopi n=16 (2)	Contemporary Californian n=12 (3)	"P" Value Column 1 vs 2	"P" Value Column 2 vs 3
		µg/g dentin			
Pb	7.0±3.8[b]	27.6±15.2	16.6±5.4	<.001	.015
Sr	478.0±86.4	97.7±23.3	87.3±13.7	<.001	.260
Zn	134.0±31.1	178.0±52.9	151.0±30.5	.013	.099
Cu	10.1±2.0	22.9±24.4	15.8±16.5	.055	.371
Hg	4.0±1.7	5.6±4.7	5.3±5.4	.237	.908
		g/100 g dentin			
Ca	26.8±1.0	29.4±3.1	25.1±1.5	.005	.001
P	11.6±1.5	10.5±3.0	11.3±0.6	.244	.304
g P/g Ca	0.42±0.05	0.36±0.11	0.45±0.01	.026	.004
mg Sr/g Ca	1.78±0.29	0.34±0.09	0.35±0.09	<.001	.780

[a] From Kuhnlein and Calloway (1977b).
[b] Mean ± S.D.

Lead.—Lead is naturally present in lead and uranium deposits in this area of Arizona, but was not abundant in the indigenous diet because geological conditions, especially that of high soil pH, render lead insoluble and plant physiology excludes lead. Although it has been determined that lead does not enter locally-grown Hopi foods in the agricultural setting (Kuhnlein and Calloway 1979a), some Hopi corn foods were found to contain lead in levels high enough for concern if those foods were to comprise the major part of the diet (Calloway et al. 1974). Lead was not present in large amounts in the native salts reported here, but it was found in chamisa ash[2], and ceramic sherds from the Hopi area (Kuhnlein and Calloway 1979a).

Lead is one mineral element generally thought to have increased in the modern environment due to combustion of fossil fuels which release lead into the atmosphere and to the use of many lead-containing products of technology. For instance, lead in canned milk and canned infant formulas (which have become the preferred substitutes of human breast milk in this area) was greater than 0.5 ppm during the late 1960's (Lamm et al. 1973). Paint, plumbing, cooking equipment and processed foods might all contribute to increased lead in the Hopi environment.

Minerals in Seventeenth Century and Contemporary Deciduous Teeth

Comparison of the composition of seventeenth century and contemporary Hopi deciduous tooth dentin was made to assess the change in the human burden of several elements resulting from the change in diet and general environment since the preindustrial period (Kuhnlein and Calloway 1977b).

Deciduous teeth from 10 individual skeletons dated from the seventeenth century were obtained from the Hopi collection of the Peabody Museum of Harvard University[3]. The excavations were made in the late 1930s from the Franciscan compound in the pueblo of Awatovi, which is located on the eastern section of the current reservation (Fig. 1). The burials were placed within the church after the Pueblo Revolt in A.D. 1680 when the monks were expelled, and presumably before the abandonment of the pueblo around A.D. 1700 (Brew 1949). Naturally exfoliated contemporary Hopi tooth samples were randomly obtained in 1974 directly from reservation-resident children living in several villages. A third group of samples, also naturally exfoliated, were donated through 2 dental offices in 1974-75. These were from healthy, geographically stable children in the same age range living in relatively industrialized, suburban section of northern California. Dentin was removed from the teeth and analyzed for lead, strontium, zinc, copper, and mercury by x-ray fluorescence and for calcium by atomic absorption. Phosphorus was measured with the Fiske-Subbarow method (Kuhnlein and Calloway 1977b).

Strontium and lead were of especial interest since both are potential toxins and are known to accumulate in dentin. Zinc and copper also accumulate in hard tissues in response to diet and are detectable with the same method. Calcium and phosphorus are major elements in teeth and have been used as indicators of skeletal integrity.

The results in Table 8 show significant differences between the seventeenth century and contemporary Hopi teeth. Lead, zinc and copper are higher in present-day teeth, reflecting an increase in environmental levels of these elements. It is unlikely that this increase is due to changing natural background levels in the Hopi area; rather, it reflects the introduction of many technological products in the last 50 years. Mercury was present in similar concentrations in all groups, indicating that the amount deposited in hard tissues has not changed; however, it is not known how well dentin reflects dietary content of mercury.

Recently, lead and zinc have been shown to increase with urbanization and industrialization in Norwegian populations. Deciduous teeth from Medieval Bergen and modern urban and rural communities were analyzed and results gave the same trends as those reported for the Hopi (Fosse and Justesen 1978a, 1978b).

Strontium is more than 4-fold higher in the seventeenth century teeth when compared to the 2 contemporary groups. The Ca/Sr ratio in the seventeenth century teeth is higher than any here-to-fore reported, although Steadman et al. (1958) noted similarly high levels from Tonga and Texas. Since this element is not considered a product of modern technology, its presence in tooth structures can be viewed as a natural consequence of the local geological contribution to the nutritional environment.

Calcium and phosphorus levels in all groups are within accepted limits, but it is interesting that the contemporary Hopi levels differ from the other groups. This is reflected in their higher Ca/P ratios.

It appears, then, that the Hopi have become increasingly exposed to lead, zinc, and copper since the preindustrial period, and that their exposure to strontium has decreased. In fact, it seems that uptake of these minerals from the Hopi nutritional environment today is similar to that of northern California where there is obviously greater industrial development./

CONCLUSION

These data can offer only a few perspectives on dietary mineral ecology of the Hopi. It is clear that the exposure to many minerals has changed since the diet was composed entirely of native grown and prepared foods. It naturally follows that exposure to other nutrients has changed as well, with declining use of cornmeal ash foods, native salts, and other uniquely Hopi food practices, in favor of refined commercial foods, there has been a concommitant decline in intakes of calcium, strontium, iron, zinc, other minerals and also phytate. On the other hand, the deciduous tooth analysis strongly indicates an overall increase has occurred in intakes of zinc, copper, and lead since the preindustrial period. Within the same time, these data confirm a decrease in strontium exposure.

Given the variety of minerals which are important in human physiology, the complexity of assessing mineral availability in foods and the difficulties in estimating human mineral utilization, there is all likelihood that the total picture of change in Hopi dietary minerals from early to contemporary times will never be completely understood. However, these studies do give some understanding of the modern historical change in diet and mineral status. It is also very clear that many traditional Hopi foods were important sources of minerals, and that these are no longer being used to full advantage.

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NOTES

[1] Courteously provided by Dr. Christry Turner III, Arizona State University.

[2] The 11 ppm reported in Table 3 is not unusually high. If the fresh weight plant contained a typical level for plant foods, ca. 1 ppm, it would concentrate about 10-fold upon ashing.

[3] These were kindly supplied by Mr. Al Santaluca

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THE PERCEPTUAL BASES OF ETHNOBIOLOGICAL CLASSIFICATION: EVIDENCE FROM AGUARUNA JÍVARO ORNITHOLOGY

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ABSTRACT.—Preliminary experiments conducted to explore the principles of Aguaruna Jívaro bird classification of 164 commonly occurring species reveal that classification is primarily determined by the perceptual salience of each species. Those species of birds rated independently by a western ornithologist as perceptually highly salient are shown to have stable, codable Aguaruna names. Birds of low perceptual salience have low codability. Birds of all levels of perceptual salience are consistently more codable for males than for females, indicating a marked division of ornithological knowledge by sex. Methodological and theoretical implications of these findings for further work in microethnobiological research are discussed.

INTRODUCTION

Ethnobiology is moving slowly toward an understanding of the principles underlying native systems of biological classification. Work over the last several years has explored the formal structural features of ethnobiological taxonomies. A major conclusion of this work is that native systems of biological classification are structurally quite similar. (Berlin 1972; Berlin et al. 1973; Bulmer 1974; Hays 1974; Hunn 1977).

Considerably less research has been devoted to determining the substantive nature of ethnobiological classification. Ethnobiologists are not yet able to predict which groups of plants and animals will be given conceptual recognition by the local society nor predict how the recognized groups will be perceived to be related. This is perhaps the most serious weakness in our understanding of how ethnobiological systems of classification actually work.

In this paper, we will explore some of the substantive features of ethnobiological classification by describing a portion of our research on Aguaruna Jívaro ornithology[1]. We will address 2 primary questions about Aguaruna bird classification. First, we will try to explain why the Aguaruna find certain species of birds easier to name than others. Second, we will examine why some named species are perceived to be more similar to one another than to other species. Answers to these questions require an understanding of the correspondence of native names to individual biological species. Our analysis of this correspondence employs 2 methods, each leading to complementary conclusions. The first part of this paper focuses on *individual biological species*. Here we determine which species are likely to be given stable linguistic recognition by a large numbers of informants and which are likely to receive more variable labeling. This line of investigation helps answer our first question, why certain species are easier to name than others.

The second part of this paper focuses on the *individual* native name. Here we attempt to discover the patterns in which particular names are applied to biological species. These patterns, we believe, help reveal the internal structure of ethnobiological categories and contribute to an answer of our second question, why certain biological species are perceived to be similar to one another. We believe that our findings will contribute to a better understanding of the structure and function of ethnobiological systems of classification.

DISCUSSION

Part I: The Psychological Salience of Ethnobiological Categories

The fundamental plant and animal taxa in ethnobiological systems of classification have been called folk generic categories (Berlin et al. 1973, 1974; Berlin 1972, 1976, 1977). While folk generic categories have been defined in differing ways by several authors (Bartlett 1940; Bulmer 1970; Cain 1956; Conklin 1954; Rosch et al. 1976), we believe that underlying these various formulations is a recognition of essentially the same conceptual and biological unit[2].

Work in ethnobiological classification has up until now made the assumption that folk generic categories of plants and animals differ little from one another in their perceptual distinctiveness, however this might be measured. This assumption is probably wrong. Several years of field work in ethnobiology have led us to the belief that biological species differ considerably in their overall distinctiveness from one another, and that this differential distinctiveness leads to the formation of folk generic categories of differing degrees of perceptual importance. Following traditional psychological terminology, we will use the term salience to refer to the relative perceptual importance or distinctiveness of any specified species of bird. As will be seen below, perceptual salience can be measured indirectly.

The Linguistic Codability of Ethnobiological Categories.—An examination of the ways local populations apply names to species of plants and animals reveals that people agree closely on the appropriate name of some species and disagree markedly on the name of other species. Following the usage of Brown and Lenneberg (1954) in their classic study of color naming, we will use the term *codability* to refer to the degree of variability in naming responses for any specified stimulus, in this case, for any particular species. The greater the variability in naming, the less codable the species.

One should expect species with high salience ratings to be highly codable while species of lower salience ratings should be less codable. If such a relationship could be shown to hold true, it would suggest that a society's linguistic codification of the biological universe is constrained by the character of the natural discontinuities in a particular habitat.

The Naming Experiments.—In order to collect information to test the relationship of salience and codability, we undertook a series of naming experiments in a small village of Aguaruna Jívaro in the Upper Maranon River Valley of northern Peru. Specimens of 157 species of birds were collected and prepared for use as stimuli in 3 naming experiments. The species used in our experiments did not constitute a complete inventory of the total avifauna found in the region inhabited by the Aguaruna, an avifauna that is believed to include some 500 species. We are confident, however, that they represented the most common and regularly occurring birds in the immediate locality of our field site. As far as possible, sexually dimorphic species were represented by specimens of both sexes in the naming experiments. A total of 260 specimens were ultimately employed as stimuli in our experiments.

Because of the large number of specimens, 3 separate naming experiments were conducted. Specimens were placed on long, cane work tables against backgrounds of tancolored botanical corrugates. The placement of specimens along tables was arbitrary, with the exception that specimens of the same species never appeared directly adjacent to one another.

In carrying out the naming tasks, informants were asked of each specimen "*wajim paiya,*" "What is it called?" and the response was recorded in a notebook. Each subject required approximately 15-20 minutes to complete each experiment. All participants were paid a nominal sum at the completion of each task.

Twenty-eight informants (18 male, 10 female) participated in the first experiment, 25 (21 males, 4 females) in the second, and 27 informants (21 males, 6 females) in the third experiment. Practical considerations made it impossible for all informants to participate in each of the 3 experiments. Furthermore, women were hesitant to participate as subjects in the study, leading to a sample biased toward male informants.

The Measurement of Perceptual Salience.—There are no established criteria for measuring perceptual salience of plants or animals. For purposes of this preliminary research, perceptual salience was determined by the subjective judgments of one of us (JPO) who has specialized in the study of the systematics and ecology of Peruvian birds for the last 20 years. The entire series of bird specimens was examined and ranked into 4 major salience categories — from very high (116 specimens), high (94 specimens), moderate (32 specimens) to low (18 specimens). Male and female birds of the same species showing strong sexual dimorphism were usually given separate salience ratings. All of the saliency judgments were, of course, carried out independently of any information for the linguistic codability of the individual species. The criteria used in establishing perceptual salience will be discussed below.

Measurement of Codability.—A codability measure was needed that would characterize the degree of agreement among subjects for each specimen. A number of possibilities were considered. The most obvious was the size of the mode, the number of people offering the most common name for the specimen. Another would be the number of distinct names offered; comparable to the use of the number of different species in an area as a measure of species diversity. The Brown and Lenneberg (1954) codability score used a combination of the above measures. While all of the measures considered gave similar orderings of specimens by their codability, we decided to determine codability with a variant of the Shannon measure of uncertainty (Clifford and Stephanson 1975; Garner 1962), namely:

$$1 - \frac{N(\log_2 N) - \sum_{i=1}^{s} n_i(\log_2 n_i)}{N(\log_2 N)}$$

where N is the number of naming responses (i.e., subjects), s is the total number of names, and n_i is the frequency with which the ith name was given as a response.

This measure ranges from one, in the case of total agreement, to zero, in the case of total disagreement. We chose this measure because it is computed on the basis of the frequencies of all of the names applied to a given specimen rather than just the most common name or names.

Findings.—Table 1 shows the relationship found between linguistic codability and perceptual salience. Whether measured with Peason's or Spearman's r, the correlation between salience and codability is statistically significant at the .001 level. Interestingly, most of this effect seems attributable to the contrast of the 'very high' group with the lower salience levels since the correlation coefficients remain very nearly the same when the lower 3 levels are collapsed into a single group, see Table 2.

Currently, efforts are underway to codify the ornithological criteria used as the basis for salience ratings. This is difficult because multiple criteria are involved and each may have differing weights in any particular case. The features most often mentioned by the ornithologist were size of bird, opportunity for observation, distinctiveness of plumage, and distinctiveness of the bird's vocalizations. Only one of these characters, size, is easily quantifiable[3]. As predicted by Hunn for ethnobiological classification in general (Hunn 1977:74), size is quite strongly correlated with the codability of a bird, as shown in Table 3.

TABLE 1.—*Correlation of Salience with Codability*

Pearson R	Prob	Spearman R	Prob	N
.478	.001	.492	.001	252

TABLE 2.—*Correlation of Collapsed Salience with Codability*

Pearson R	Prob	Spearman R	Prob	N
.467	.001	.472	.001	260

TABLE 3.—*Correlation of Size with Codability.*

	Pearson R	Prob	Spearman R	Prob	N
Codability with Size	.396	.001	.369	.001	274
Salience with Size	.203	.001	.117	.033	248

TABLE 4.—*Multiple Regression of Codability on Salience and Size.*

Variable	F to Enter	Prob	Multiple R	R Square	R Square Change	Simple R	N
Salience	69.4	.001	.469	.220	.220	.469	248
Size	34.2	.001	.562	.315	.095	.397	248

TABLE 5.—*Comparison of Men with Women by Codability.*

	Mean	Standard Deviation	N
Men	.700	.244	289
Women	.408	.350	289
Difference	.292	.272	289

$T = 9.49$ $p << .001$

The correlation of codability and size is significant at the .001 level. However, since salience ratings were in part based on size, there is also a weak but statistically significant correlation of size with salience ratings. To show the effect of size differences controlling for level of salience, the results of a multiple regression of codability on salience and size are presented in Table 4. It can be seen that while salience is the better of the 2 predictors of codability, both are highly significant and explain substantially independent portions of the variability in codability. The apparent independence of size and salience may be partially attributable to the many small birds which were highly salient and codable due to their striking plumage color.

Linguistic codability not only varies according to the characteristics of what is perceived but also according to the characteristics of the human perceiver. One would expect that ornithological knowledge will increase with age, and our initial studies support this intuition. Earlier work on inter-informant variation in Aguaruna plant identification

(Boster 1977) suggested that we might also expect differences by sex of subject. Table 5 indicates that the birds in our naming tasks were significantly more codable for men than for women. A T test was performed treating the men and women's codabilities of each token as matched samples. The T value was 9.49 with 288 degrees of freedom, $p \ll 001$.

An individual's skill in the classification of birds is the outcome of life experience, role expectation and some component of natural talent. The first 2 factors differ according to the sexual division of labor. The third does not. In spite of the fact that women have ample opportunity to observe birds on a casual basis, their roles do not train them to become "bird watchers." Aguaruna males, on the other hand, become adept folk ornithologists at an early age while hunting birds with the blowgun. When hunting, they have many opportunities to see the birds just as they appear in our bird naming tasks: dead, close at hand, with feathers intact. Even when a woman has an opportunity to observe birds in food preparation, she is at a disadvantage due to the male practice of removing all plumage before giving the bird to the woman for cooking. On the other hand, in the classification of manioc varieties, it is the mature women who are the experts, reflecting their role and experience as manioc cultivators. These findings suggest that the Aguaruna division of intellectual labor mirrors the division of physical labor.

Part II: The Internal Structure of Ethnobiological Categories

Our focus to this point has been to examine the relationships of the *biological species* to the various linguistic expression(s) used to refer to that species.

We now take the *name* as a starting point, and ask in what ways a single name maps onto biological species. Just as one can measure degree of agreement on the name of a given species, it is also possible to measure the range of species referred to by a particular name. The examination of the biological range of a term affords an understanding of the internal structure of ethnobiological categories.

As mentioned in the discussion on the naming experiments, there may be more than 500 species of birds in the immediate region of tropical rainforest inhabited by the Aguaruna. It is an area of ornithological diversity exceeded by few other regions of the world. There is little reason to expect that the human population in the area will develop a system of classification that provides a separate name for each of these 500 or more species. It is notable, nonetheless, that we have elicited, independent of the naming experiments, more than 300 distinct Aguaruna generic names for birds. Our ultimate goal is to specify the biological ranges of each of these terms, and to outline the ways in which these categories are conceptually organized into a coherent system of classification. Before discussing the experimental results that bear on the internal structure of ethnobiological categories, it is essential to present an overview of our current understanding of Aguaruna bird taxonomy.

Aguaruna Bird Taxonomy.—The most general terms in Aguaruna ornithological systematics are *chigki* and *pishak*. The former term is best glossed 'large game bird' and may not be appropriately applied to any bird that is not edible.

The term *pishak* is polysemous. Its primary meaning seems to be 'small bird.' Its secondary meaning is 'bird' and may, in certain contexts, be applied to species also labelled as *chigki*. We are uncertain of the extent to which this meaning is held by the population as a whole.

Our understanding of the organization of the 300 basic generic categories is far from complete. However, it seems clear that the Aguaruna do not mentally store these 300 categories in some arbitrary list structure. On the contrary, systematic elicitation and informed observation reveal that subjects form "horizontal groupings" (Hunn 1977:62) of species of birds that are perceived to be closely related to one another on the basis of overall similarity.

Such groupings were first described for ethnobotanical systematics as "covert categories"

(D'Andrade MS; Berlin et al. 1968) and later as "covert complexes" (Berlin et al. 1974). Covert complexes have been discovered in several other ethnobotanical systems of plant classification (Berlin 1977; Hays 1974, 1976). For ethnozoology, these mid-level categories are described in detail by Hunn (1977), as well as by Bulmer (1974), Dwyer (1977) and Majnep and Bulmer (1977). While not all folk generic categories are members of one of these groupings, complexes include the vast majority of all Aguaruna birds. Finally, Aguaruna complexes are remarkably similar in content to well recognized ornithological taxa at the family and sub-family levels of classification.

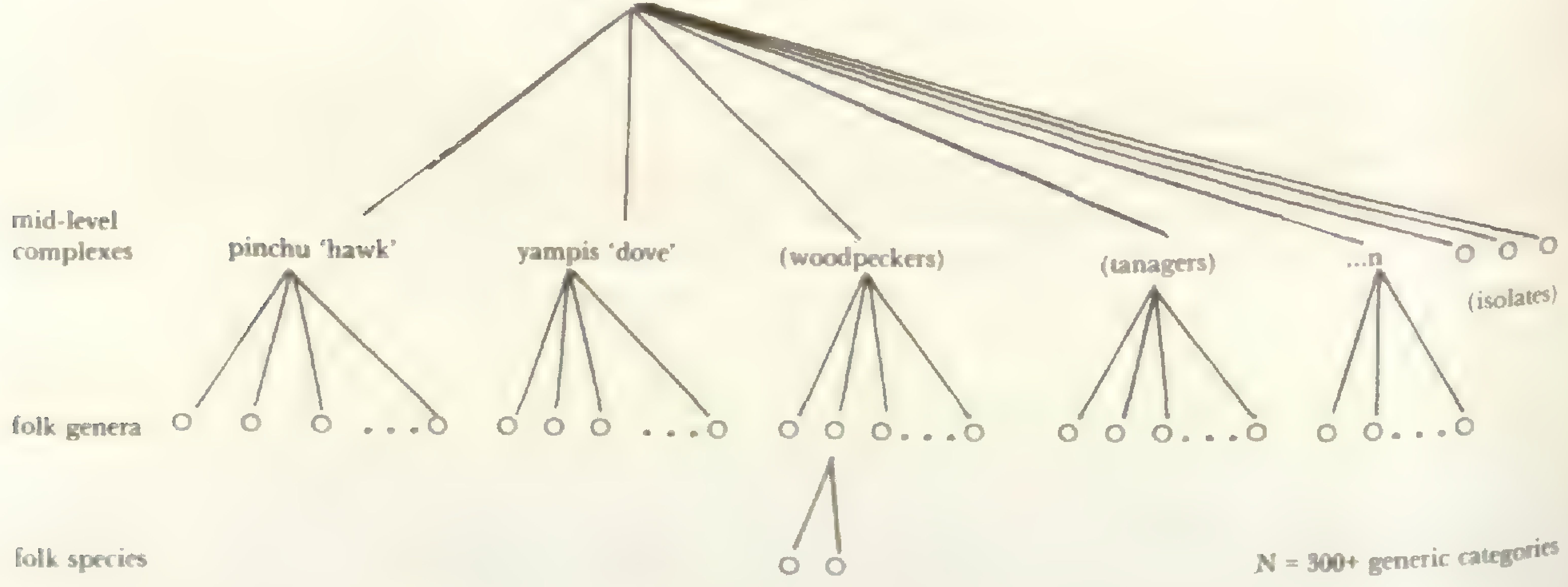
The Aguaruna system is distinct from most other systems described in the literature in that at least some of these mid-level complexes are named (e.g., *pinchu* 'hawk,' *yampis* 'dove,' *shiik* 'puff bird').

The taxonomic structure for Aguaraun bird classification seems to be a shallow one comprised of approximately 300 basic generic classes, most of which are members of mid-level complexes. Most of these complexes are unnamed. Finally, some small number of generic taxa are sub-divided into what we have called "folk species." Typically, a generic category will be segmented into 2 or 3 folk species, though we do have a few examples of 5 or more. This taxonomic structure is illustrated in Figure 1.

The Naming Experiments, Part II.—Our sample of 157 species of birds elicited 275 distinct naming expressions in our experiments. Some of these names were applied by all informants to one or more specimens in the naming tasks but others were used much less frequently. Of the 275 expressions, less than half were judged to be "good names," either by observing the frequency of their application to a given specimen or by the restriction of their application to a narrow biological range.

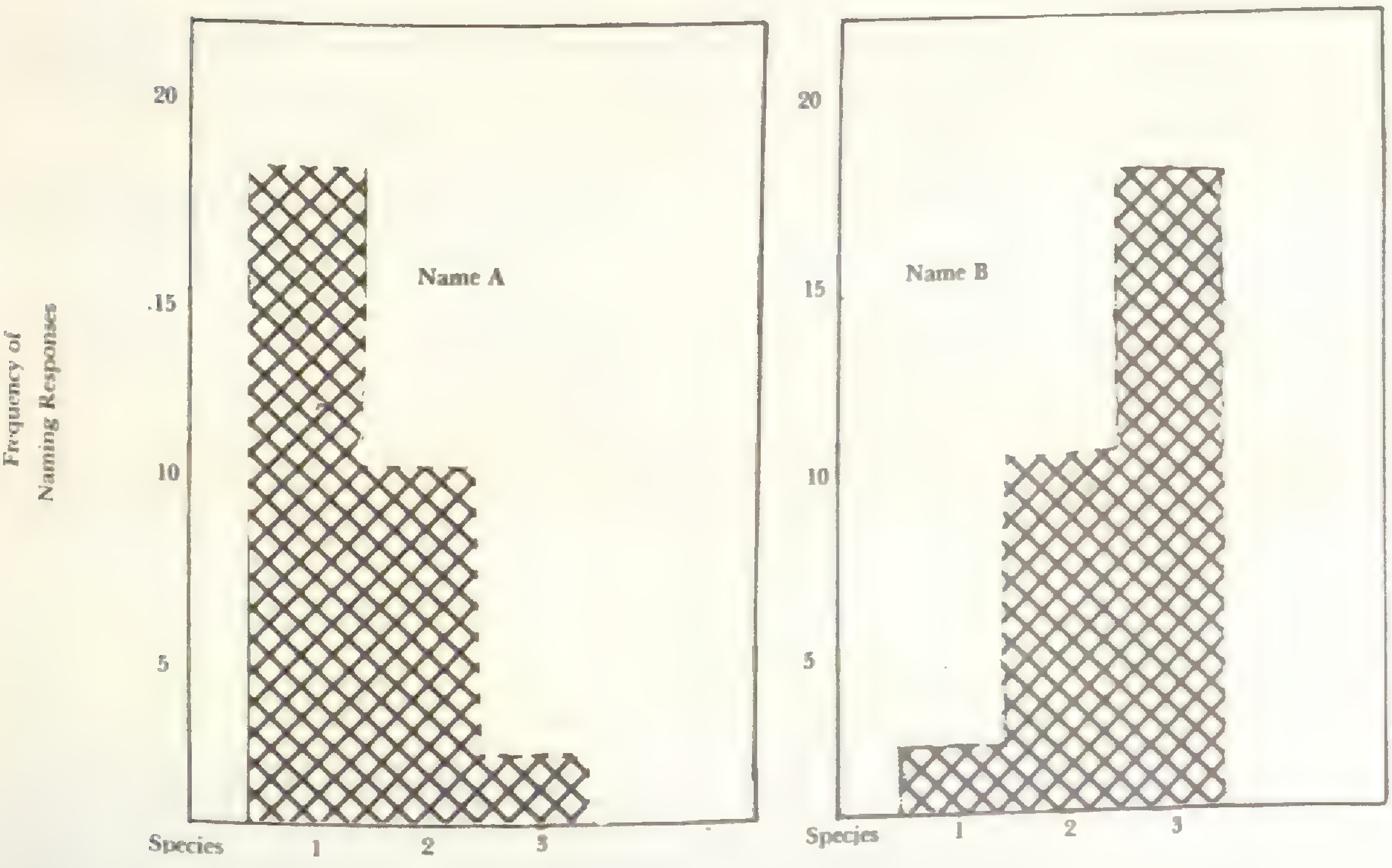
The relationship of stable generic names to the species in our sample provides a tentative picture of Aguaruna bird classification. Some 140 of the 157 species are found to be members of one of the mid-level complexes described above. Another 10 are seen as isolates, not participating as a member of any complex, and another 7 are not systematically paired with any Aguaruna name. Because only 157 of the approximately 500 birds in the area were examined in our experiments, none of the complexes is represented by their total membership. Nonetheless, the basic outlines of the structure of each are apparent.

The Complexes.—Methods of establishing the membership of covert complexes in ethnobiological classification have been outlined in Berlin et al. (1968), Hays (1974, 1976), and Hunn (1977). The complexes we describe here were established on the basis of 2 primary



types of evidence. First, we systematically interviewed 3 knowledgeable Aguaruna males. The subjects were asked to form groups of all those generic bird names that they considered to be *pataji* 'in the same family,' or *kumpaji*, 'closely similar.' The third subject, quite knowledgeable but nonliterate, was interviewed over several days in lengthy, tape-recorded sessions. The ethnographer, working through an alphabetically arranged dictionary of all the potential bird names that had been collected from earlier interviews, asked the subject, "Brother, does such and such a bird have any relative?", recording the names of the birds on cards. Because of the number of bird names involved, the ethnographer found it impossible to remember which names had already been listed as the relative of some particular category. The subject, however, would emphatically state, "We have already named that one." The stability of his groupings became evident when, on beginning analysis of these materials, we discovered that he had provided mutually exclusive complexes of bird names with the exception of 2 generic names which had been assigned to more than a single group!

A second kind of evidence used for the recognition of ethnobiological complexes comes from observing the actual distribution of naming responses. Often, the biological ranges of Aguaruna names will systematically overlap in such a way as to suggest close perceptual similarity of the categories involved. As an illustrative example consider 2 Aguaruna bird names, A and B. These expressions refer to at least 3 species — 1, 2, and 3 — in the following fashion. Species 1 predominately receives name A, species 3 predominately receives name B, and species 2 receives name A by half of the subjects and name B by the other half. If 20 individuals are involved in the naming task, we can diagrammatically indicate these facts as shown in Figure 2. The distribution of naming responses allows one to infer that categories A and B are conceptually related in that their biological ranges overlap. When the generic categories of a covert complex elicited from knowledgeable subjects correspond with those generic categories tied together on distributional grounds such as those just described, we have good reason to believe that we have discovered a stable, salient, grouping of birds.



Of the 27 mid-level complexes attested in our data, 4 are named and 23 are covert. Some examples of complexes with their English common-name glosses, are as follows:

Named

1) pinchu 'hawks and falcons'
2) yampis 'doves'
3) pagka 'ant shrikes'
4) shiik 'puff birds'

Covert

5) 'woodpeckers'
6) 'wrens'
7) 'spotted antbirds'
8) 'ant wrens'
9) 'oropendolas and relatives'
10) 'cotingas'
11) 'aracaris and toucans'
12) 'barbets'
13) 'manakins'
14) 'tanagers and relative'
15) 'Folliage gleaners and relatives'
16) 'hummingbirds'
17) 'large solitary fly catchers'
18) 'small flycatchers'
19) 'thrushes'
20) 'rails and crakes'
21) 'quails and partridges'
22) 'curassows, guans and chachalacas'
23) 'cuckoos'
24) 'trogons'
25) 'vultures'
26) 'umbrella birds'
27) 'parrots'

While a description of each of these complexes is prohibited by limitations of space, one, the woodpeckers, is described in detail as illustrative.

The Woodpeckers.—When asked to provide the names of the relatives of *tatasham*, the most distinctive woodpecker in the area, informants respond with 7 or 8 of the following categories:

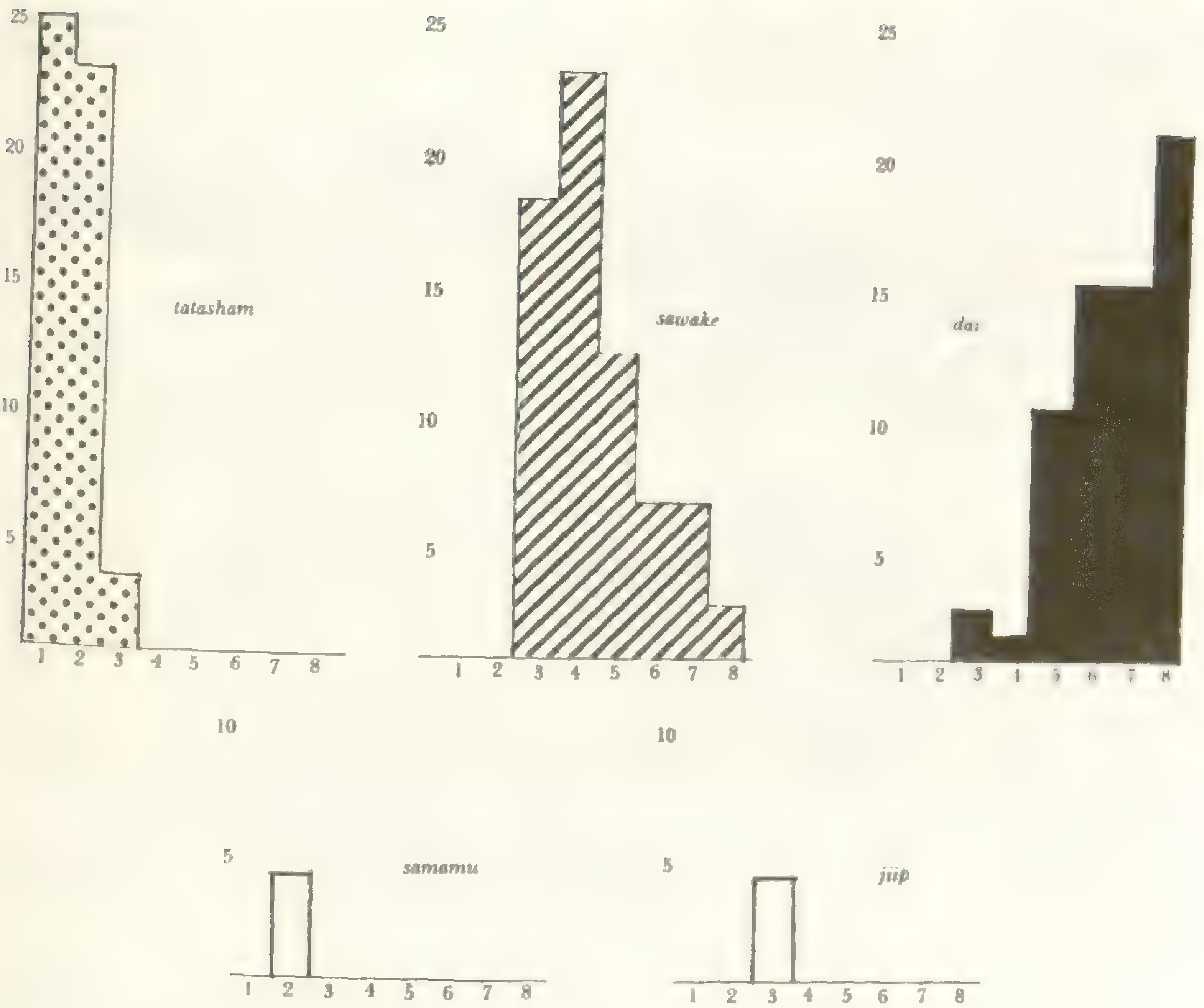
1) tatasham
2) samamu
3) sawake
4) jiip
5) dai
6) tejesha
7) shiapu
8) yaakit

At the time we conducted our naming experiments, 8 species of woodpeckers had been collected and, of the 8 elicited names, terms 1-5 were employed by our Aguaruna subjects. The distribution of naming responses over the 8 species can be seen in Table 6. Table 6 reveals the internal structure of the 6 categories employed by the Aguaruna in classifying these 8 species, a structure diagrammatically represented in Figure 3.

TABLE 6.—*Distribution of naming responses for 8 species of woodpeckers in naming experiment**.

	AGUARUNA NAMES FOR WOODPECKERS					
SPECIES OF WOODPECKERS	(SHIG) TATASHAM	SAMAMU (TATASHAM)	JIIP	SAWAKE	DAI	TEJESHA
1) *Phloeceastas melanoleucos*	25, 25					
2) *P. rubricollis*	23	4				
3) *Celeus spectabilis*	4, 3		4, 1	16, 23	2, 1	
4) *C. elegans*				23	1	
5) *C. grammicus*				12	10	
6) *Chrysoptilus punctigula*				6	15	1
7) *Veniliornis affinis*				2	21	
8) *V. passerinus*				6	15	

*Numbers indicate number of subjects on a single naming experiment responding with specified name. Two numbers in a cell indicate 2



Note: Highest number of possible responses for single species = 25.

WOODPECKER SPECIES

1. *Phloeceastas melanoleucos*
2. *P. rubricollis*
3. *Celeus spectabilis*
4. *C. elegans*
5. *C. grammicus*
6. *Chrysoptilus punctigula*
7. *Veniliornis passerinus*
8. *V. affinis*

FIG. 3.—Distribution of naming responses for 8 woodpecker species in naming experiment.

A careful consideration of Table 6 and Figure 3 will, we believe, lead to the following inferences.

1) For most informants, just 3 folk *generic* categories are sufficient to classify the 8 species of birds. These categories are *tatasham, sawake,* and *dai.*

2) For speakers using only these 3 terms, each of the categories formed by them is biologically polytypic, i.e., each named category includes 2 or more species.

3) Nonetheless, for these polytypic categories, a single biological species can be discerned which might be interpreted as focal, or most typical of the category. For *tatasham,* the focal species is *Phloeceastas melanoleucos;* for *sawake, Celeus elegans,* and for the *dai, Veniliornis affinis.*

4) Some informants, all knowledgeable males, distinguish *P. rubriocollis* with the name *samamu,* separating it from *tatasham,* with its focus on *P. melanoleucos.*

5) Some few informants, again males, recognize *Celeus spectabilis* with a separate generic name, *jiip.*

6) Finally, 3 species — *V. passerinus, Chrysoptilus punctigula,* and *C. grammicus* are ambiguously assigned to either *sawake* or *dai.*

These distributional facts are in large part interpretable in terms of the morphological and behavior characteristics of the biological referents. Of the 4 genera present, *Phloeceastas* is the largest and most vividly marked. It should not be confused with members of the other woodpecker genera and is, in fact, linked with *Celeus* only 3 times (2 of the 3 subjects are women). *Celeus, Veniliornis,* and *Chrysoptilus* are much less distinctively marked and our naming data show that they are likely to be confused with one another.

Of the 3 polytypic genera (*Phloeceastas, Celeus,* and *Veniliornis*), a single species in each emerges as the most striking perceptually, and each of these represents the focal member of the named Aguaruna category. *P. melanoleucos,* the focal *tatasham,* is strikingly black and white in contrast to *P. rubricollis,* which is more evenly black and brown.

Furthermore, *P. melanoleucos* is more likely to be observed, frequenting clearings, the forest edge, and tree falls. *P. rubricollis* is found in more dense forests, often in the upper canopy and is not easily seen.

Celeus is a polytypic genus of 3 species (Fig. 4). The naming data suggest that *C. elegans* is the prototypical *sawake. C. spectabilis* is singled out by a few males as *jiip,* and *C. grammicus* is often confused with the smaller genus *Veniliornis.* It is difficult to explain this pattern of naming responses solely on the basis of morphological features. The pattern of naming responses, we believe, is best explained in terms of the frequency of observation of these species by the Aguaruna themselves. *C. elegans* and *C. grammicus* are much more common than *C. spectabilis.* It is apparent that the majority of the people have formed their category of *sawake* around the more common *C. elegans* and have merged the more striking but rare *C. spectabilis* into the already formed category.

The 2 species of *Veniliornis* are quite similar in appearance, though *V. affinis,* which frequents the forest edge and clearings, is seen more often than *V. passerinus,* a bird of the deep forest. We believe *V. affinis* is selected as focal due to these facts (Fig. 4).

Chrysoptilus punctigula is ambiguous and is likely to be merged with *sawake* (the *Celeus* spp.) or with *dai* (the *Veniliornis* spp.) (Fig. 4). We believe that this merger is also perceptually based. Infrequently observed, *Chrysoptilus* is about the same size as the typical *Celeus,* but its drab olive green colors make it similar to *Veniliornis.* The 2 conflicting characters cause it to be confused with the 2 named folk categories which it most closely resembles, *dai* and *sawake.*

It is important to note that the relationships of the species to one another than can be inferred from the distribution of naming responses for this set of birds should be similar for both Aguaruna and modern western ornithology since modern ornithological classification is also based on overall morphological and behavioral similarities of species. Figure 5 provides a diagrammatic representation of the degree of relatedness of the species involved as determined by Aguaruna naming responses as it compares with the classification of biological affinity as determined by ornithological practice. Both systems are clearly similar in overall structure.

Common and Expert Knowledge: Lumpers vs. Splitters.—As mentioned earlier, our data on the internal structure of Aguaruna bird categories come from 2 major sources: interviews with knowledgeable subjects and naming tasks with segments of the local community. The kinds of data obtainable from these 2 sources differ markedly. Through interviews, an ethnographer can gain an insight into an individual's use of a large range of categories. Through naming tasks, the ethnographer can determine to what extent the community as a whole is in agreement on the good examples of the named categories. The naming task data represent an aggregation of all of the individual categorizations into a single collective representation. The collection of both kinds of data provides the opportunity to investigate the ways in which individual categorizations are coordinated in collective naming. Using information from both sources, the patterns of disagreement on the best name for species can often be explained as the outcome of 2 different individual strategies of categorization Among modern biologists, these strategies are called 'lumping' and 'splitting.' Given [illegible] closely related biological species, the splitters will make a greater number of [illegible] distinctions in the set than the lumpers. As a result, the lumper's name refers to a wide biological range while the splitter's name is more narrowly focused. Even in [illegible]

FIG. 4.—Eight woodpecker species used in naming experiments reported upon in this paper. From top to bottom: *Phloeoceastas melanoleucos, P. rubricollis, Celeus spectabilis, C. elegans, C. grammicus, Chrysoptilus punctigula, Veniliornis affinis, V. passerinus.*

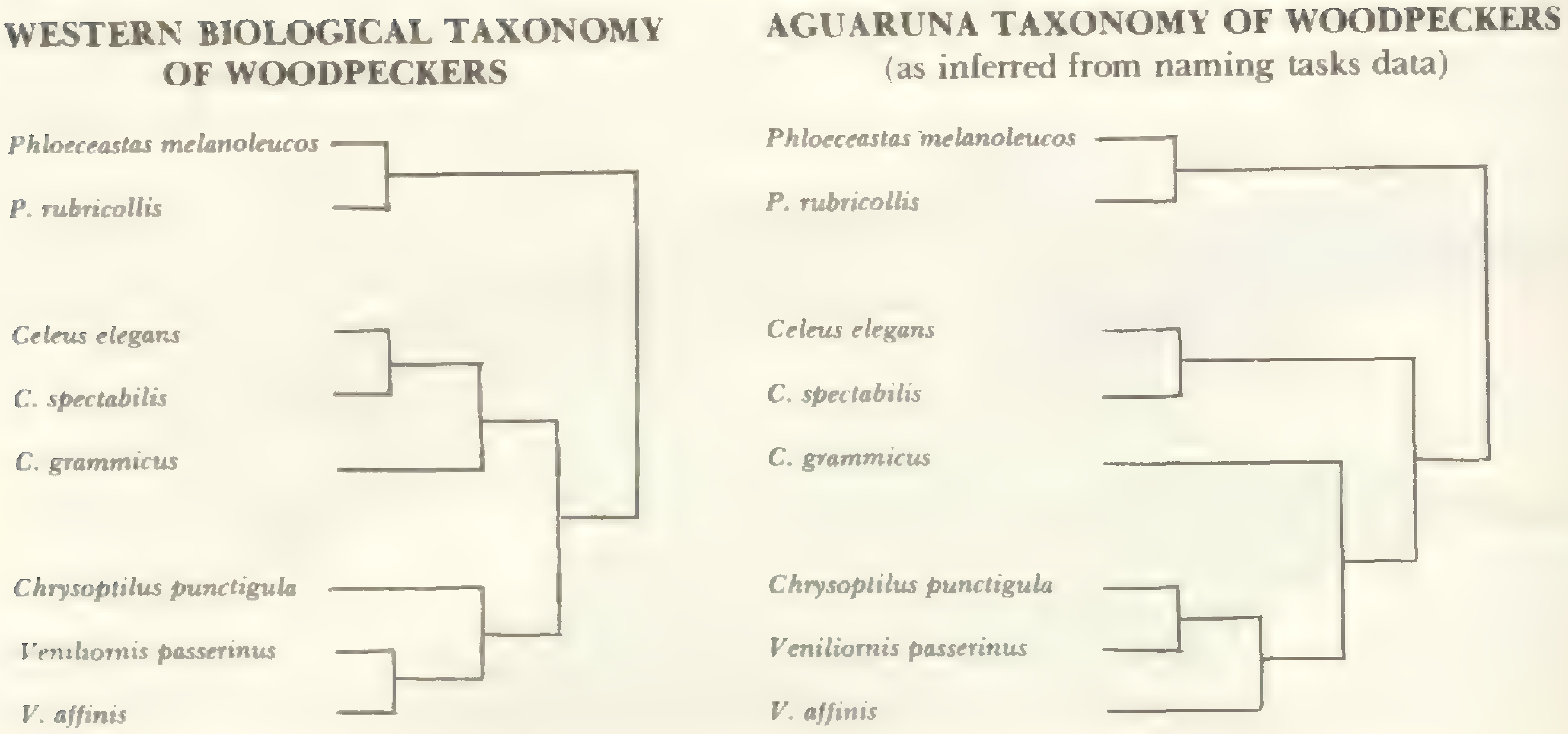


FIG. 5.—Comparison of western and Aguaruna classification of woodpeckers.

which lumpers outnumber the splitters, the splitter's names can be recognized as those consistently applied to a narrow biological range and rarely used outside of that range.

Our hearts belong with the splitters. These subjects provide the most intricate and internally consistent categorizations. Lumpers' categories are not only broader but sometimes almost random. For these reasons, among others, we equate splitting with expertise. In our study, splitters tend to be older men though a few of the younger men also showed considerable skill at fine discrimination of birds. However, it should be understood that the lumpers and splitters were not absolutely fixed groups for sometimes even the most expert made 'mistakes.'

The typical lumping strategy is to classify 2 or more closely related biological species by the same name while the typical strategy in splitting is to separate the species. Furthermore, the lumper's name for the category will generally be that used by the splitter to refer only to the most salient of the related species. This can be illustrated in Figure 8. In the case of the woodpecker genus *Phloeceastas* discussed earlier, lumpers refer to both *P. melanoleucos* and *P. rubricollis*, *tatasham* while splitters reserve *tatasham* for *P. melanoleucos* alone, calling the less salient *P. rubricollis*, *samamu*. In the treatment of the genus *Celeus*, lumpers refer to all species as *sawake* (with some confusion on *C. grammicus*), while splitters call only *C. elegans* and *C. grammicus*, *sawake*, distinguishing *C. spectabilis* with the name *jiip*. In sum, lumpers and splitters agree on the name of the most salient species and differ only in their designation of the least salient. This amplifies the correlation of salience with codability.

CONCLUSIONS

In this paper, we have examined the patterns of correspondences between Aguaruna names for birds and the biological species to which these names refer. The patterns of inter-informant variation that can be observed has allowed us to make several inferences about the components of the structure and process of ethnobiological classification. First, we found that highly perceptually salient species are more codable than are less salient species. Salience was demonstrated to be determined in part by size of bird, though we believe that distinctiveness of plumage coloration, frequency of observation, and distinctiveness of vocalization, also contribute to overall salience. We found that female subjects disagreed more often on the names of birds than do males, and we suggested that this could be explained as an outcome of the sexual division of labor in Aguaruna society.

Second, an examination of the distributional patterns of bird names over multiple biological species has allowed for a better understanding of the internal structure of ethnobiological categories. A detailed analysis of one covert grouping of birds, the woodpeckers, revealed that the prototypical members of the complex were perceptually

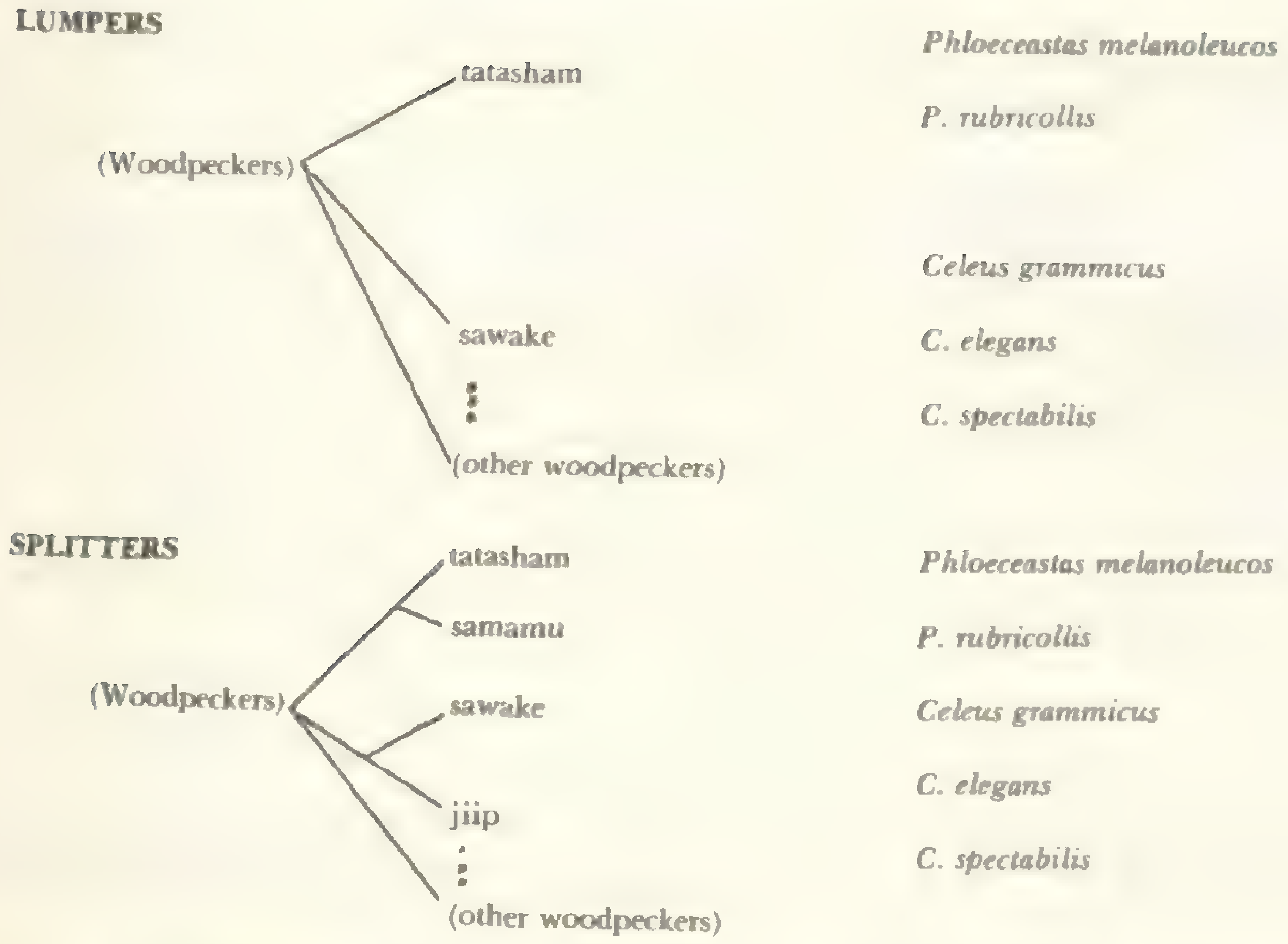


FIG. 6.—Aguaruna lumping and splitting strategies for the classification of woodpecker species.

more salient, on the basis of numerous characters, than other species in the complex. Furthermore, species that are closely related ornithologically were shown to be also closely related perceptually in the folk system. Both the western scientific and folk systems were thus seen to be quite similar in overall structure. Finally, we noted that the patterns of disagreement in naming within the complex reflected individual strategies of classification based on expertise which we called lumping and splitting. When lumpers and splitters agree on the name for a species, it is generally on the most perceptually salient, a pattern which increases the correlation of codability and perceptual importance.

Several years ago, Hunn (1977) proposed what to many seemed an impossible task for ethnobiological theory. There he stated that the "... ultimate test (of a theory of ethnobiological classification) involves the prediction of the scientific denotata of all folk-biological categories nomenclaturally recognized for a particular culture ... and the subsequent and independent verification of the predictions by field investigations" (Hunn 1977:72). Our findings suggest that such a test may one day be feasable. Not only should we eventually be able to specify which species are likely to be named in some particular habitat, but we should be able to specify those species that are seen to be related, those which are likely to be focal and peripheral to some category as well as those species that are likely to be totally unknown. The most logical place to make such a series of predictions would be in a society residing in a habitat similar to that of the Aguaruna with a comparable tropical forest avifauna. While we are aware that the number of factors involved make such an exercise difficult, the outcome of the experiment should bring us closer to an understanding of precisely what constraints govern the formation of ethnobiological categories in general.

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Notes

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2. The ethnobotanist H.H. Bartlett, the first modern writer to refer to these classes as generic categories, defined them as those categories which are "more or less consciously thought of as the smallest grouping requiring a distinctive name" (1940:341). For the zoological systematist A.J. Cain, these categories refer to the smallest perceptual discontinuities in the biological world that can be recognized "... without close study" (1956:97). For the ethnozoologist, Ralph N.H. Bulmer, these fundamental units (in his terminology, "speciemes") are readily perceived on the basis of numerous characters of form and behavior (Bulmer 1968, 1970; Bulmer and Tyler 1968). Rosch et al. (1976) use the term "basic level objects" to refer to these fundamental categories. For us, generic categories are definable in terms of a series of linguistic, taxonomic, psychological, and biological criteria, (c.f., Berlin 1977). Generic categories in ethnobiological systems of classification cryout to be named.
3. Size measurements were taken from *The Birds of South America* (Schauensee 1970). Since we were unable to obtain size measurements for some of the birds and salience ratings were unavailable for certain others, the number of items involved in each comparison may vary between 248 and 274. Effect of this fluctuation on the correlation coefficients seems to have been minimal.
4. Comparably named suprageneric groupings have recently been described by Steven Feld for the Kaluli of New Guinea (Feld 1979).

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QUELITES — ETHNOECOLOGY OF EDIBLE GREENS — PAST, PRESENT, AND FUTURE

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ABSTRACT.—Quelites are edible greens usually derived from young, tender annual herbs but they may also include flowers, inflorescences, and stem tips of perennials. Because these plant parts are available only seasonally and they do not leave recognizable macrofossils, this food resource has been difficult to detect in archaeological context. Historical references have been vague and most recent ethnographic reports contain incomplete references due to seasonality and derogatory connotations attributed to quelite consumption. Recent studies among the Tarahumara of Chihauhau, Mexico, and experimental studies in Mexico and Africa suggest that: 1) a great richness of plants is exploited, 2) human disturbance is necessary for maintenance of this resource, 3) greens form a nutritionally important component of annual diets, 4) quelites represent products of ecologically sound agricultural practices and yields are based upon the multiple cropping model, 5) encouragement of this resource may have led to the domestication of such plants as *Amaranthus*, *Brassica*, and *Chenopodium*, and 6) these plants may be a valuable resource in future food production systems.

INTRODUCTION

Until recently, the significance of uncultivated edible greens in the traditional native American diet has not been appreciated. As the intensity and depth of botanical, ethnological and archaeological investigations increase, practical and theoretical concepts are being applied to the elucidation of the principles of resource exploitation by man. The employment of undomesticated greens — referred to as "quelites" in Mexico — as food provides an opportunity to investigate the ethnoecology[1] of this poorly understood food resource.

The ideas expressed and part of the data presented in this paper are based upon ongoing ethnoecological-ethnobotanical studies among the Tarahumara Indians (Bye 1976). This group of southern Uto-Aztecan speakers number about 50,000 and live in the sierras and barrancas of southwestern Chihuahua. They are considered subsistence agriculturalists (maize, bean, cucurbit, and chile) who supplement a significant portion of their diet with plants procured through hunting and gathering. The statements regarding the Tarahumara are restricted to data obtained in the pine-oak forest of the sierras (2000-3000 msm) although general comments include observations in the sub-tropical barrancas (500-2000 msm) as well.

Uncultivated edible greens are generally herbaceous plants whose young leaves and tender tips are consumed. In some cases, especially in the barrancas, these "greens" may include underdeveloped inflorescences and tender, thickened stems. The Tarahumara refer to these greens as "guiribá" to which the Spanish term, "quelite," is generally applicable. These plants are usually immature when consumed and are eaten raw (in a few cases) or lightly cooked in warm water and are consumed fresh in season or dried for use during the dry season.

DISCUSSION

From the ethnoecological viewpoint, I would like to discuss 6 aspects which are being considered in formulating the general ecological principles of human exploitation of vegetal resources. These points include: 1) diversity[2] of resources, 2) importance of human disturbances, 3) measurements of productivity, 4) ecological importance of plants in agricultural systems, 5) the importance of these resources in the future.

TABLE 1.—*Some common edible greens or quelites of the Tarahumara. All of these species are commonly found in and along cultivated fields.*

Scientific Name (Arranged by Family)	Tarahumara Name Mexican Name	Season of Procurement
AMARANTHACEAE		
Amaranthus retroflexus L.	basorí, wasorí quelite del agua	spring/summer
CHENOPODIACEAE		
Chenopodium ambrosioides L.	chu'á' epazote	summer/fall
Chenopodium berlandieri Moq.	chu'á quelite de cenizo	spring/summer
COMPOSITAE		
Bidens odorata Cav.	sepé	spring/summer
Cosmos paraviflorus (Jacq.) HBK.	hu've	spring/summer
CRUCIFERAE		
Brassica campestris L.	mekuásare coles	spring/summer fall-cultivated
Lepidium virginicum L.	rochíwari	winter/spring fall-cultivated
MALVACEAE		
Anoda cristata (L.) Schlecht.	rewé	spring/summer
PORTULACACEAE		
Portulaca oleracea L.	chamó verdulaga	summer/fall
URTICACEAE		
Urtica dioica L.	ra'urí, ra'oke	spring/summer

Species Richness

Richness in the number of species and in the phenological types is an important parameter in evaluating the ecological potential of any resource system. The Tarahumara are known to employ over 120 species of quelites. Most of these plants are ingested in the form of immature leaves and stems of herbaceous dicots although a few plants have the edible portion represented by bulbous leaf bases (e.g., *Pitcarnia palmeri*), pseudobulbs (e.g., *Gongora* sp.), succulent stems (e.g., *Opuntia* spp.), and immature inflorescences (e.g., *Jacobinia candicans*). Of these 120 plus edible species, only 10 are consistently consumed today in the sierras (Table 1) and all are found in anthropogenic communities (Fig. 1).

These common species have been erroneously referred to as "wild greens" although a few researchers recognized their relationship to human disturbance (Messer 1972; Wilken 1970). Biologically, these plants are weeds which are evolutionary and ecological products adapted to survival in habitats disturbed by human activity. Without constant human interaction over thousands of years, these forms would not be present or in sufficient density to be an adequate food resource. These common quelites are annual and represent 3 major life forms which are important in the availability of culturally acceptable and seasonally distributed resources: 1) winter annuals (e.g., *Lepidium*), 2) spring-summer annuals (e.g., *Amaranthus*,

FIG. 1.—Some edible weeds form an anthropogenic community (maize fields and margins; May 1978; Cusárare, Chihuahua). Top row (left to right): *Amaranthus retroflexus**, *Chenopodium berlandieri**, *Brassica campestris**, *Lepidium virginicum**. Bottom row (left to right): *Galinsoga semicalva, Simsia eurylepis, Bidens ordorata**, *Cosmos parviflorus**, *Ipomoea hirsutula, Dalea* sp., *Anoda cristata, Urtica dioica*. An asterisk (*) denotes the preferred species. Scale equals 5 cm.

Bidens), and 3) summer-fall annuals (e.g., *Portulaca*).

It should be noted that there are only a few perennials and that the ecologically wild species play a relatively minor role in the total diet. One notable exception to this statement would include certain species of prickly-pear cacti, *Opuntia* spp., found wild in the barrancas (although it is known to be a tolerated weed, encouraged weed, or even cultivated wild plant in some regions).

Human Disturbance

Human disturbance is an important factor in determining the presence and density of these common edible weeds. They are members of various anthropogenic communities[3] which are maintained by the Tarahumara and include cultivated fields, field-fence margins, dwelling sites, corrals and trailsides. A general ethnoecological principle to be documented in the future states that the existence of large human populations depends on the net productivity of the ecosystem which is available only in the early developmental stages of succession. Based on Odum's (1969) Ecosystem Development Model (Fig. 2), net productivity[4] in an ecosystem is available for harvest, storage and consumption in the developmental stages but not in the mature stages or climax. Consequently, human activities tend to push succession back to the early stages and to maintain those stages. In these early stages, certain resources can be manipulated directly (e.g., cultivated fields) or indirectly (e.g., weed communities) so as to concentrate those exploitable resources in time and space. Recently, this principle has been illustrated in a restricted sense by the development of the "garden hunting" concept using a tropical ecosystem and animal resources (Linares 1976). The exploitation of quelites represents an analogous situation with plant resources. Interestingly, Bohrer's (1977) speculations on the food habits in

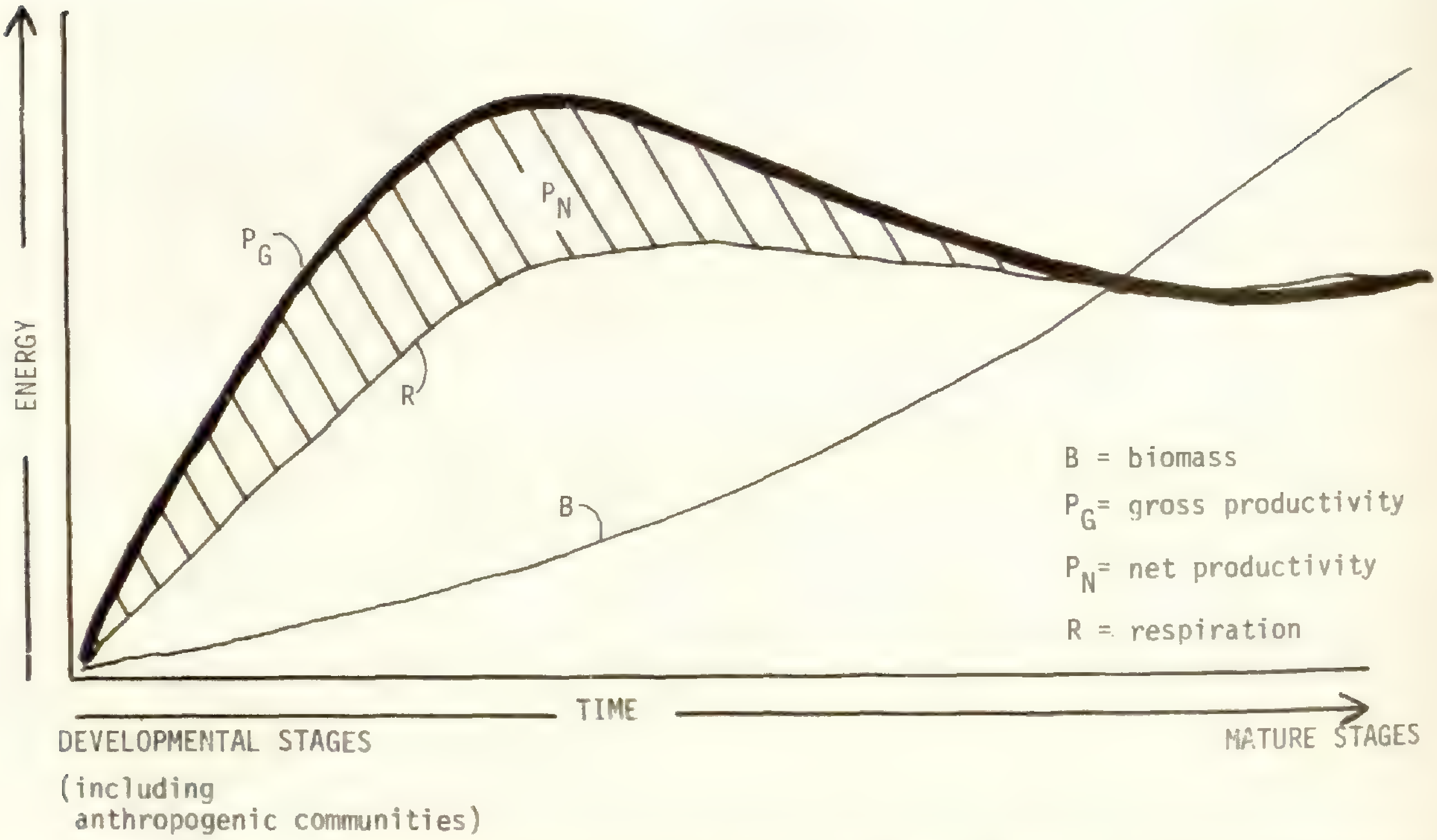

FIG. 2.—Generalized Ecosystem Development Model (after Odum 1969). Note that Net Productivity is available in the development stages and not in the mature stages.

hominid evolution suggest that plants of the early successional communities were exploited as food rather than members of the more mature communities.

Many of the characteristics of the developmental stages of Ecosystem Development (Odum 1969) are beneficial to human exploitation of concentrated resources. These characteristics include: 1) low species diversity, 2) low biomass, 3) linear food chains, 4) grazing food chains, and 5) short lived organisms with simple life cycles (e.g., annual plants). The attributes of low species diversity and low biomass may seem contradictory until one assesses the quality of the species and the biomass. In general, species richness and diversity increases with ecosystem development but the relative importance of herbs to woody plants is greater in the early stages (Fig. 3) (Beckwith 1954). The biomass is relatively low due to the nature of herbaceous annual plants which do not accumulate tissue as do inedible, woody perennials of later stages.

The presence and density of edible greens depend on several factors which are only poorly known today. Many weed seeds have evolved mechanisms for long distance dispersal (in order to colonize distant habitats when available) and for short distance dispersal (in order to increase the seed bank for maintenance of local population) (Baker 1974; Harper 1977). Disturbance (by digging, plowing, etc.) of the upper layer of the soil is critical to the germination of weed seeds so that seeds near the surface and light germinate and emerge faster than if they were deeper in the soil (Fig. 4) (e.g., Dawson and Burns 1962; Wiese and Davis 1967). The ecological importance of disturbance to light flash and seed germination has been discussed by Sauer and Struik (1964). Density of certain species in early stages of succession tends to be related to the surface area of the disturbance. Davis and Cantlon (1969) found that *Amaranthus retroflexus* tends to increase in density as the open area increases during the first year of experimental secondary successional studies in New Jersey. It is possible that agricultural practices originated, in part, in response to human preference for genetically altered plants in ecologically altered habitats. Partially domesticated plants (i.e., genetically altered from undomesticated progenitors) may have been encouraged, sown and subsequently selected in the manipulated habitats which developed into agricultural and garden habitats rather than wild progenitors of domesticated plants transferred from refuse mounds to manipulated fields and subsequently selected.

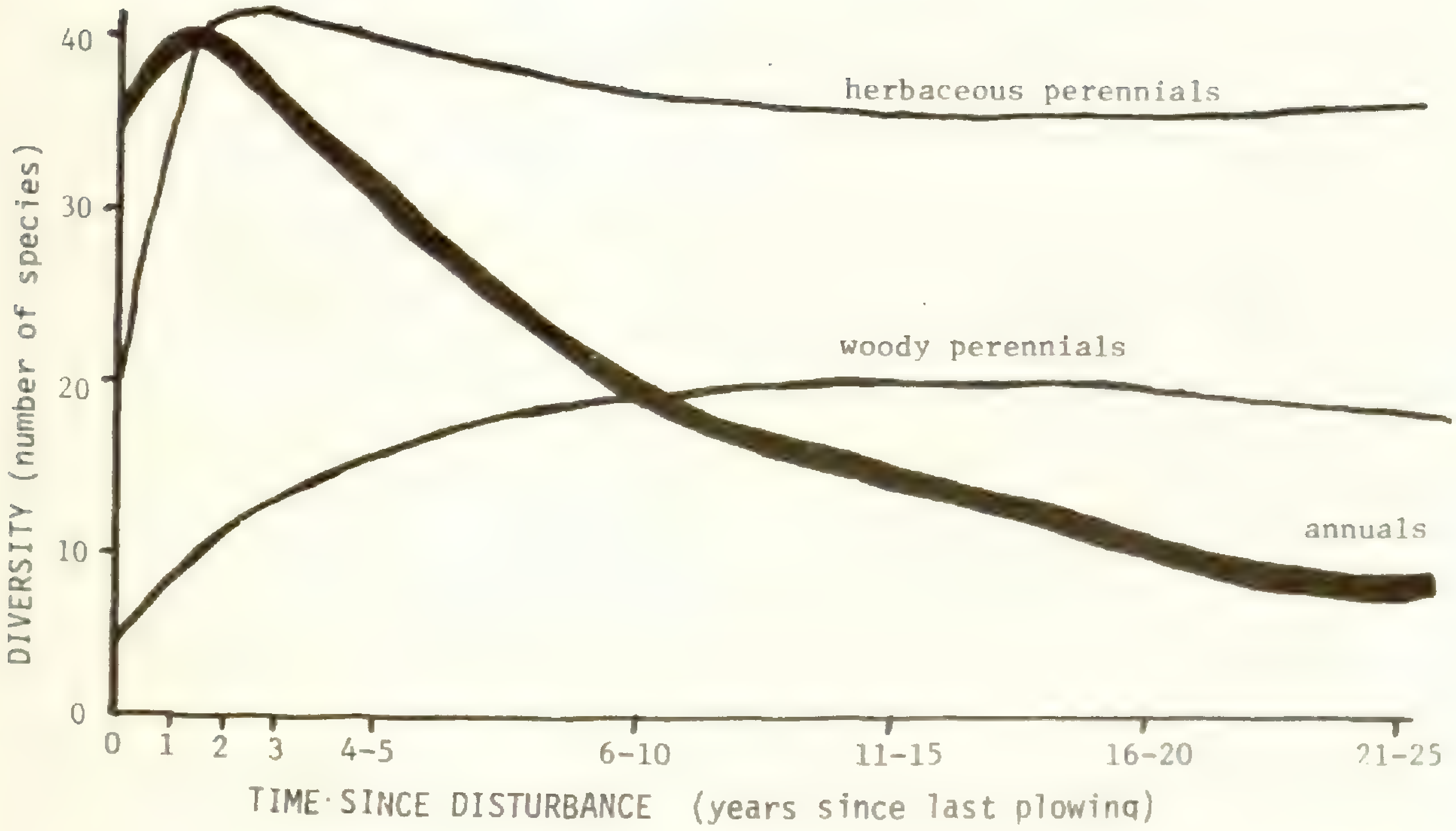

FIG. 3.—Generalized model of relative change of annuals, herbaceous perennials and woody perennials in the early stages of succession in abandoned agricultural fields (after Beckwith 1954).

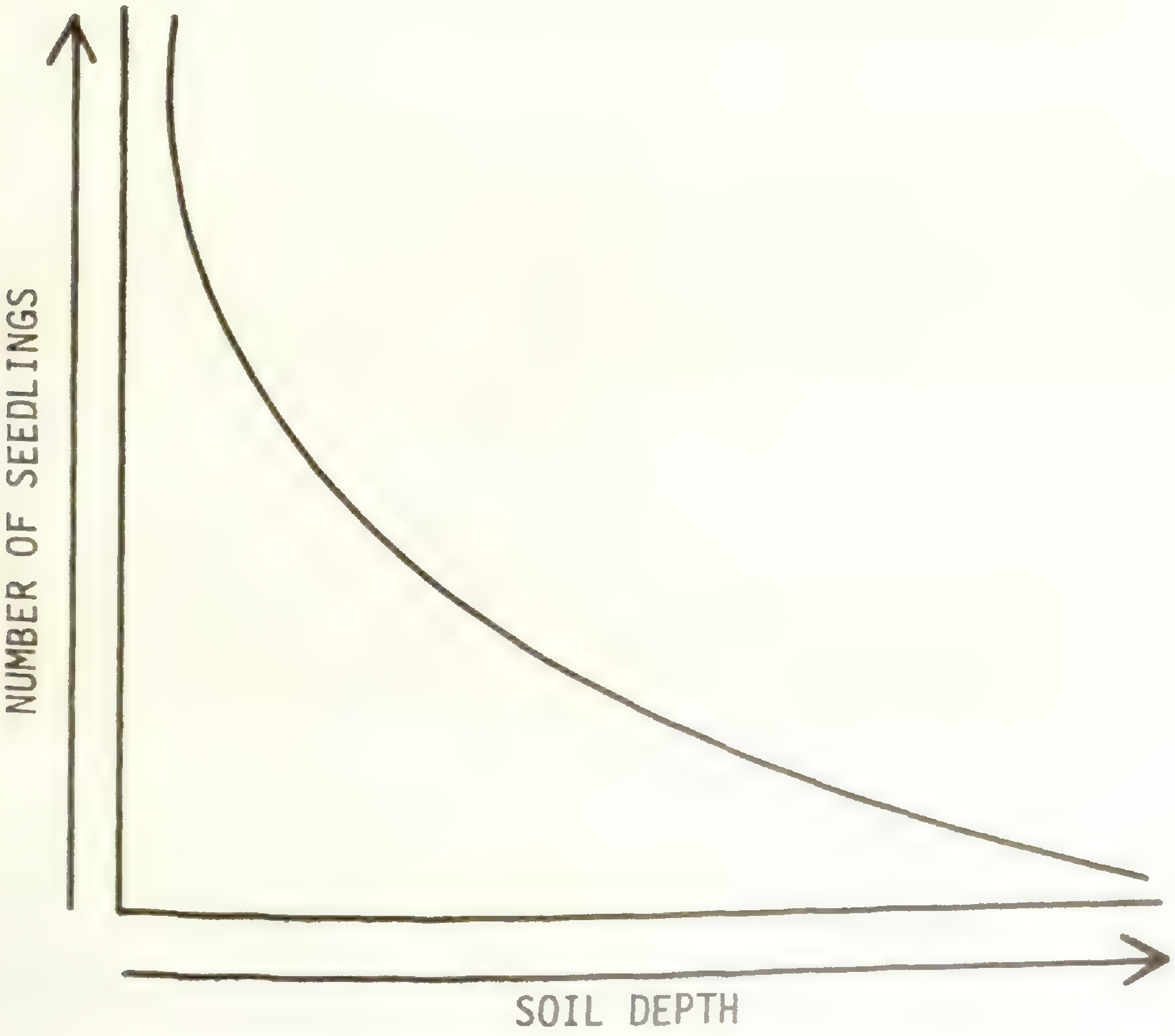

FIG. 4.—Generalized relationship of seed germination to seed depth in the soil.

Productivity

Quelites are an important primary producer of the manipulated ecosystem exploited by the Tarahumara. The significance of this productivity to these subsistence agriculturists can be measured in several ways. A few considerations are outlined below.

Being subsistence agriculturists, the Tarahumara depend on an annual diet cycle based upon maize, bean, cucurbit and chile which are consumed from fresh plants in August through October and from stored, dried forms in October through May. Often times the stored cultivated food supplies are limiting from April through July. During this latter period, the diet is augmented by hunted and gathered resources such as fish, wild greens, roots, bulbs, and "hearts" of maguey (*Agave* spp.). It is during this period that quelites from the cultivated fields dominate the diet. May-June period also marks the end of the dry season and the beginning of the rainy period and the start of the annual growing season. The seeds of weeds as well as planted maize emerge in the fields in mid to late May in response to the increased temperature and moisture. The coincidence of the marked change to warm moist regime with the germination and emergence of edible weed seedlings with the depleted food reserves is critical to the survival of the Tarahumara populations in the sierras.

The weeds can also provide food after the initial growing period. July and August may be frequented by severe hail storms which destroy the young maize plants. Also, animal pests such as crows and insects can destroy portions of the maize crop at different stages. The tender apices of the older weed plants as well as the late emerging seedlings can be collected and consumed. The quelites represent a living emerging food reserve.

When considering primary productivity in ethnobotanical terms, one must account for not only quantity in time but also quality. Although studies are in progress, preliminary data indicate that in the sierran cultivated maize fields, 100 g of edible seedlings of *Amaranthus retroflexus* (Fig. 5) can be harvested in May and early June from a plot varying from 1-4 m². Regeneration of another 100 g of edible weed seedlings can occur during this period in about a week. A daily serving of *A. retroflexus* consists of about 100 g per adult individual and is prepared by slightly cooking it in warm water and rinsing it in cold water 2 or 3 times and then eating it with a little salt along with tortillas or pinole.

FIG. 5a.—Tarahumara woman collecting *Amaranthus retroflexus* (Bye 8532; 30 May 1978; San Ignacio Arareco, Chihuahua).

FIG. 5b—Seedlings of *A. retroflexus* at the early developmental stage when they are consumed as quelites (Bye 8510; 28 May 1978; Cusarare, Chihuahua).

The quality of quelites can be measured in several ways. One system involves cultural preference based upon beliefs and cross-cultural comparisons. For example, some Mexicanized Tarahumara no longer eat certain quelites because the dominating Mexican culture looks down upon such practices. Older Tarahumara do not eat certain species because "only the Apaches" or "only the pigs" eat those particular weeds. Another system considers the biological components such as nutritive quality, toxicity, palatability, pharmacology and flavoring.

The nutritional requirements of the Tarahumara and the value of their present diets are not known at this time. A preliminary evaluation of the Tarahumara maize-bean-cucurbit diet indicates that the following items are deficient: protein, calcium, vitamin A, thiamine, riboflavin, and vitamin C. The first 3 components are only present at about a quarter of the minimum Recommended Dietary Allowance (RDA) for an adult (National Academy of Sciences 1974) while the latter 3 components are marginally dificient. An addition of 100 g of quelites (e.g., *Amaranthus, Brassica,* and *Chenopodium*; see Table 2) has only a slight impact on the protein yet provides sufficient calcium, vitamin A, thiamine, riboflavin and vitamin C to meet the RDA standard for the United States. It should be noted that nutritional loss by traditional Tarahumara preparation techniques using warm (not boiling) water is probably minimal based upon knowledge of loss of ascorbic acid through various cooking methods (Caldwell and Gim-Sai 1973). Other preparation techniques such as sun wilting and mineral additions may enrich the value of quelites as well.

Toxic materials may be removed from food plants through selective breeding and genetic manipulation of domesticated plants or through gathering and preparation techniques applied to non-domesticated plants. The Tarahumara collect only the young, tender leaves which tend to accumulate in the older, senescent leaves which are not gathered. Aqueous cooking and leaching (rinsing) practices can also reduce the amount of these substances.

TABLE 2.—*Nutritional value of some weedy greens (per 100 g edible portion) (Leung 1961).*

Plants	Ca (mg)	Vit. A (IU)	Thiamine (mg)	Riboflavin (mg)	Ascorbic Acid (mg)
Amaranthus spp.	313	1600	0.05	0.24	65
Brassica campestris	252	1335	0.12	0.29	118
Chenopodium berlandieri	156	2765	0.17	0.47	109
Average	240	1907	0.11	0.33	97

Palatability is another factor which affects the edibility of quelites. In general, only the young leaves and stem tips are consumed. These tender structures are relatively unlignified compared to mature tissue.

Chemical constituents of certain edible weeds may provide additional values due to flavoring and pharmacological activity. *Chenopodium ambrosioides*, a common weed along margins of fields and fences, is often added to beans and meat dishes. It imparts a distinctive flavor to the food. Also, the leaves contain ascoridole as part of the Oil of Chenopodium which is known to be an effective anthelminthic medicine (Guenther 1948-1952; Santos 1925).

The Tarahumara often collect edible weed seedlings from week 2 to week 6 after germination. After this time the plants are often too large and lignified for consumption (although the stem apices and terminal leaves can be consumed in times of emergency or famine). Recent study on the nutritional value of leaf protein in Africa included species of *Amaranthus, Solanum*, and groundnuts (Oke 1973). The extractable protein nitrogen, a measure of leaf protein, was found to peak during week 5 to 6 and was followed by rapid decline in nutritional value in later weeks (Fig. 6). It appears that the Tarahumara gathering of palatable leaves occurs when the potential extractable nutrient value reaches its peak.

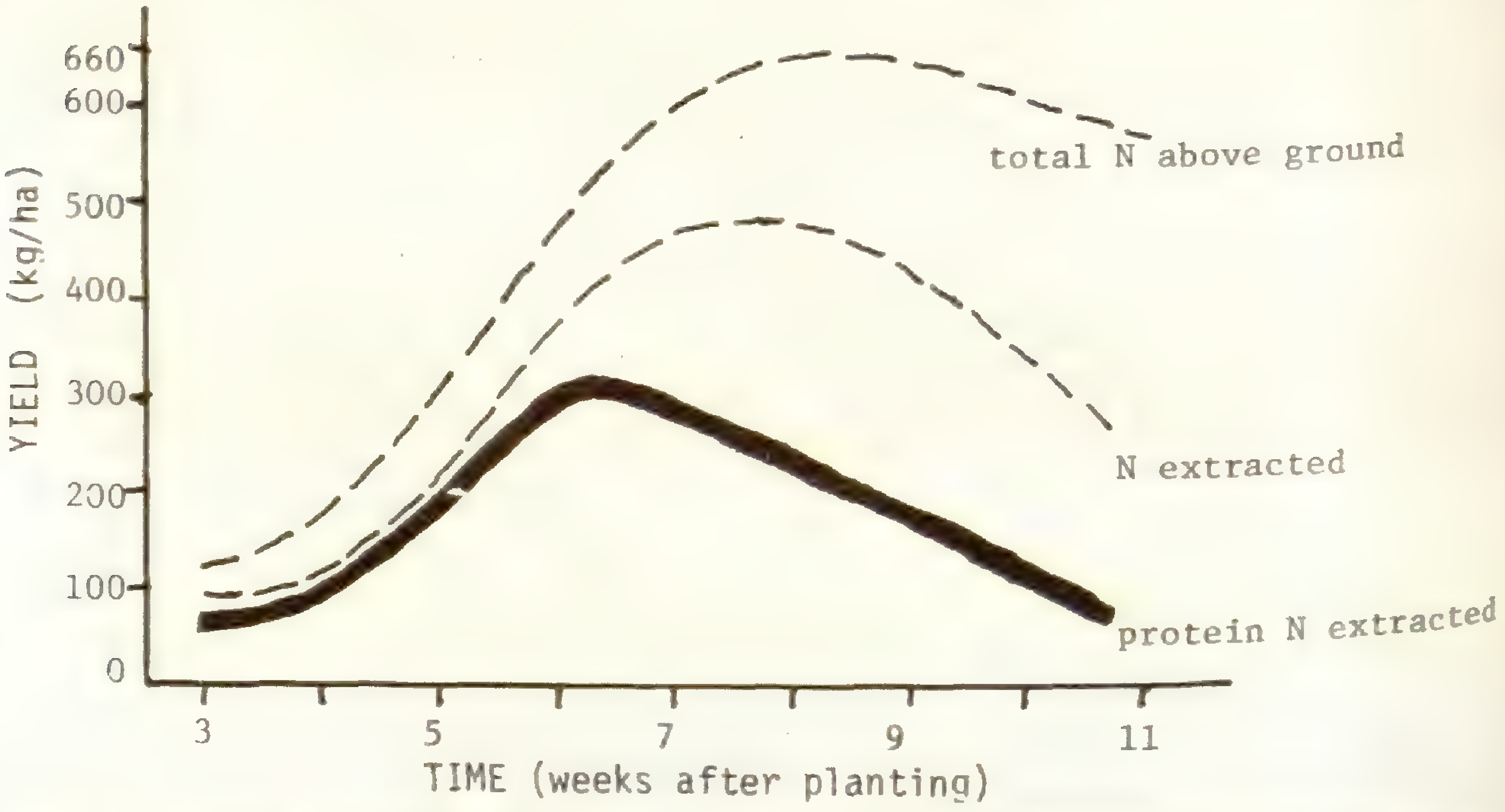

FIG. 6.—Change of nitrogen and protein content in leaves over time (based upon harvested groundnut leaves; from Oke 1973).

Ecological Benefits

Although the Tarahumara practice of leaving the weeds in the field for extended periods (Fig. 7) may appear uneconomical, this strategy may be ecologically sound. Unconscious dispersal of weed seeds by Tarahumara movements while harvesting maize during the previous year and turning over the soil for planting enables the weed seed bank to build up in the soil and to be closer to the surface to insure high rate of germination. When the weeds emerge, they are not weeded out until 6-8 weeks later. Subsequent weeding of cultivated fields at similar intervals allows for the establishment of new weed populations which provide emergency food reserves. This system allows weeds to be the first crop with the second crop, maize, being available later. This double crop system allows for the harvest of reliable yields of one type of net productivity in an environment where maximum yields of one crop systems are not possible due to poor soil fertility, limited moisture and unpredictable pests and weather.

Only recently have the practical aspects of multiple cropping systems been considered in applied techniques and theoretical terms (Papendick et al. 1976). The essence of the multiple cropping is the complementary use of growth resources by different components of the system. The rate of exploitation of each resource by each component is separated by space and or in time. Hence, the shallow rooted amaranth weeds should be extracting water and nutrients in the upper soil surface above the deeper planted maize seeds. After a certain period of growth the roots of both species would be competing for the same resources in the same space and time, to the detriment of each species. Future research will investigate the hypothesis that the Tarahumara remove weeds when they begin to compete with maize for the same resources. Before that time (6-8 weeks) the weeds do not compete with maize and therefore should not negatively affect the maize yield. Net productivity of reliable yield therefore has 2 temporal peaks — early in the growing season with weed seedlings or quelites and late in the growing season with the harvested maize.

Tentative support for this reasoning can be seen in experimental work carried out at Chapingo, Mexico (Alcalde Blanco and Hernandez X. 1972). Plots of maize were treated with

FIG. 7.—A field consisting of two crops: 1) edible weeds (*Amaranthus*, *Chenopodium*, *Bidens* and *Cosmos*) and 2) maize. (June 1973; San Ignacio Arareco, Chihuahua).

different weeding practices. It was found that the weeds left in the fields for days 1 to 30 and for days 1 to 62 after planting had no effect on the maize yield compared to the control (weed-free plots). Maize yield decreased if weeds were left in the fields after these periods (Fig. 8). The 2 weeds used in this experiment were *Amaranthus* and *Simsia*, 2 Tarahumara quelites.

The Tarahumara concept of multiple, reliable yields appears to illustrate multiple cropping ecological theory. Weeds may also provide other ecologocial benefits such as soil protectors, dispersion of food resources for various predators, and other factors which merit further investigation.

Domestication

The exploitation of weeds may represent one pathway to domestication and subsequent agriculture. Weeds and domesticates represent end products of genetic and ecological alterations mediated by human activities (Fig. 9). Domesticates appear to be the result of human directed evolutionary changes in plants in order to increase and stabilize genetically the valued plant parts. These plants produce valued yields in a manipulated environment. Weeds, on the other hand, are not directed by conscious human selection but are evolutionary responses to human disturbed habitats which vary in time and space. As we know more about domestication, the more important weeds become in understanding this evolutionary process (De Wet and Harlan 1975).

This domestication process recognizes weeds as one type of progenitor which was suggested by Vavilov (1951) with respect to secondary centers of origin of crop plants (e.g., rye, originally a weed in wheat fields, became the domesticated grain when wheat did poorly in cultivation in northern Europe). People's response to edible resources found in human disturbed environments could trigger conscious sowing and selection of weed seeds. Domesticated amaranths and chenopods are derived from weed progenitors (Fig. 10) (Sauer 1967; Wilson and Heiser 1979) in both the northern and southern continents of the Western Hemisphere. This North-South pattern may also be present with peppergrass, *Lepidium*. Cultivated *Lepidium meyenii* is a restricted domesticate of high altitudes of South American

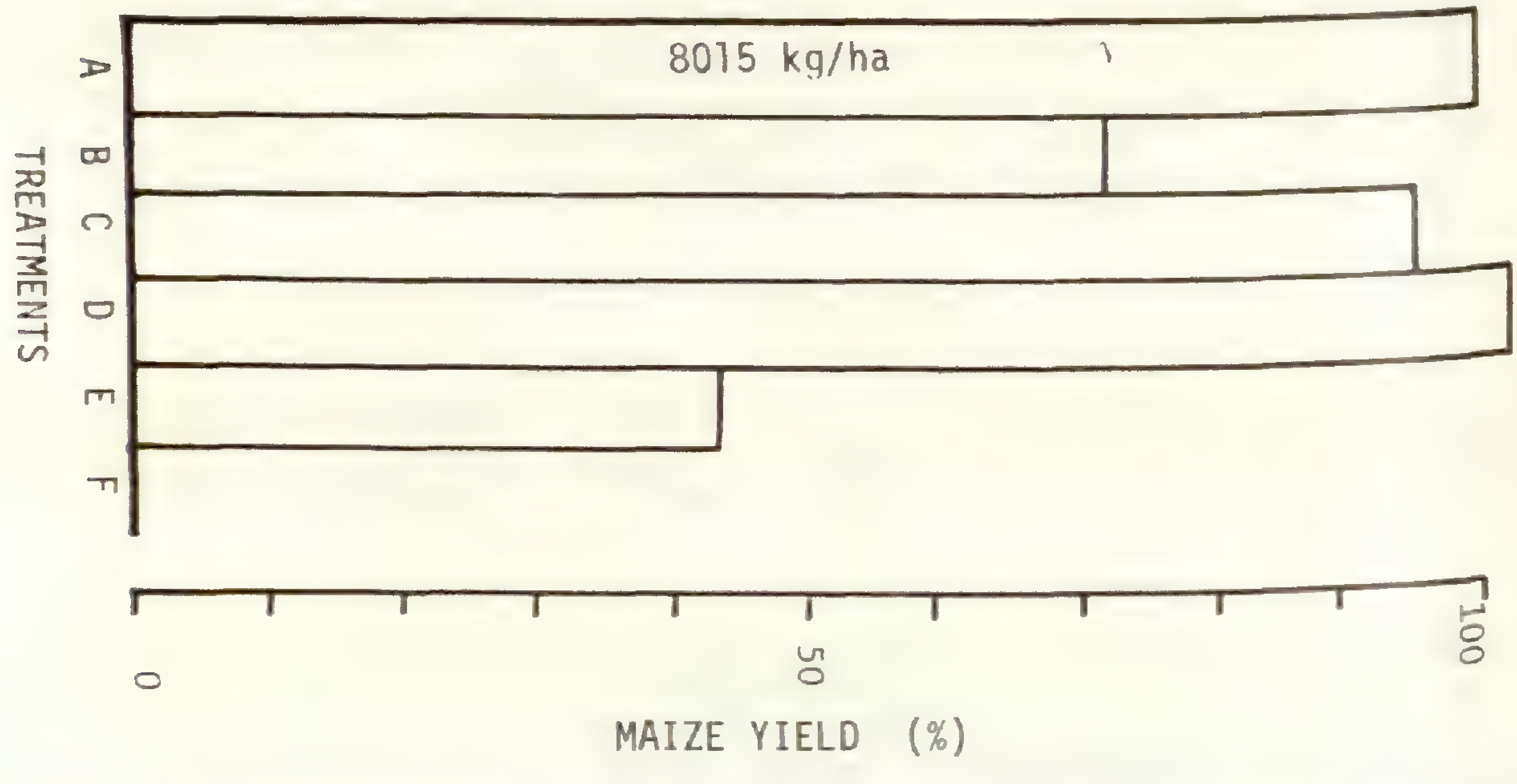

FIG. 8.—Competition study of maize and weeds (*Amaranthus* and *Simsia*) (based upon data from Blanco and Hernandez X. 1972). A, maize free from weeds at all times (control); B, maize free from weeds days 1-30 (after planting); C, maize free from weeds days 31-62; D, maize free from weeds days 63-94; E, maize and weeds together during total growing season; F, weeds alone.

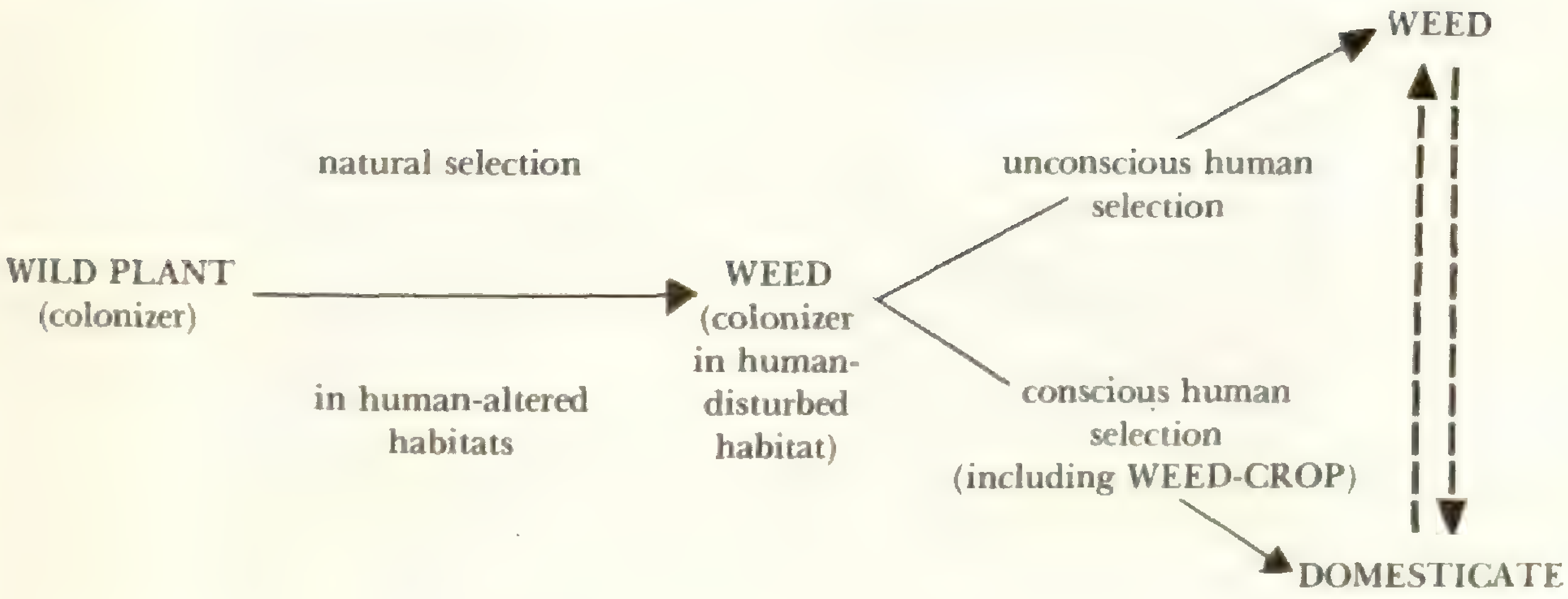

FIG. 9.—A generalized pathway of domestication involving weeds and domesticates.

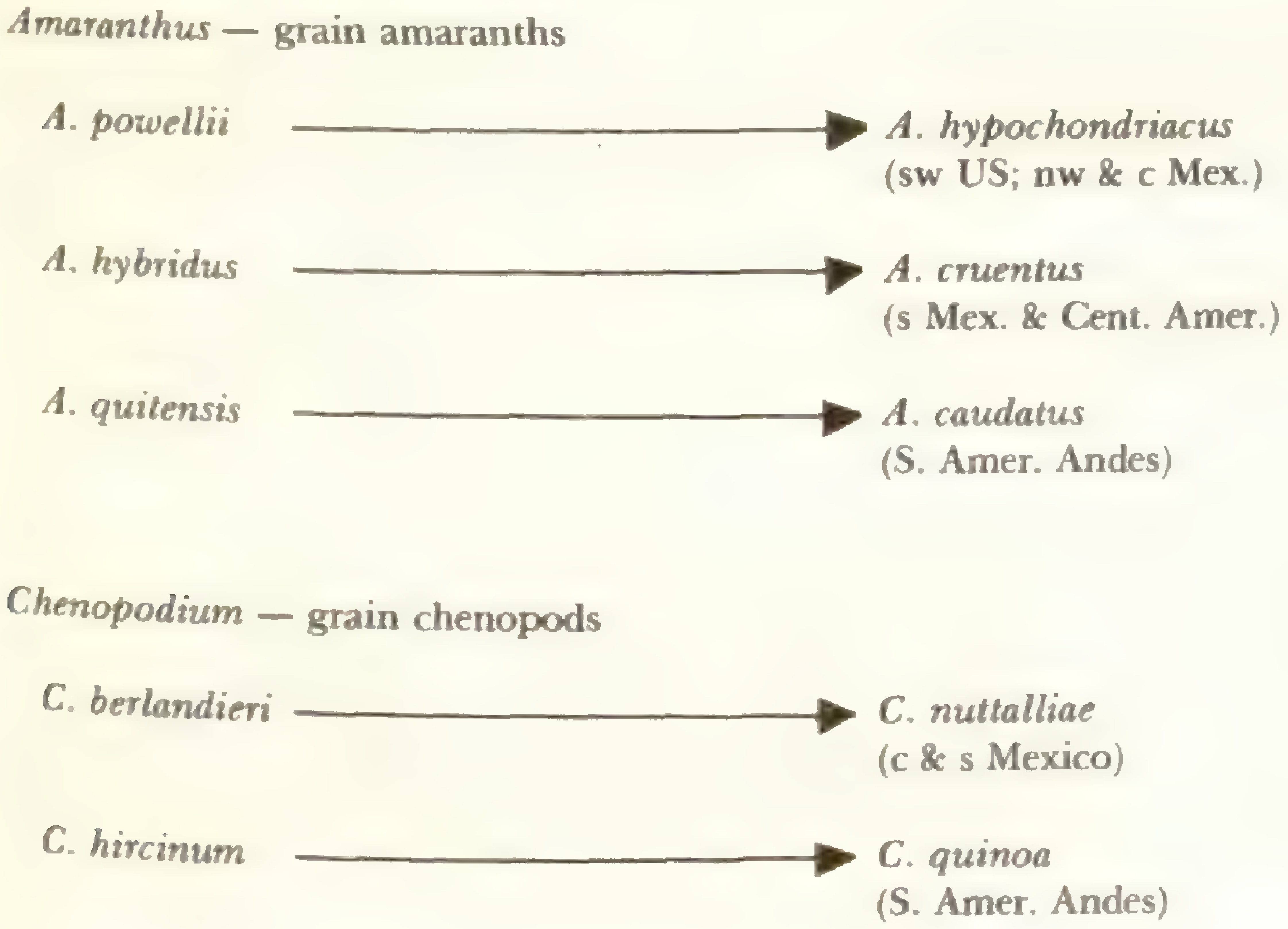

FIG. 10.—Weed progenitors of domesticated food plants.

Bolivia and Peru (Gade 1976; Leon 1964). Although no native *Lepidium* is known to be domesticated in North America, the Tarahumara plant seeds of *Lepidium virginicum* as a weedcrop in cultivated fields (Fig. 11). Perhaps the domestication of *Lepidium* in the northern latitudes is proceeding slower. An "experiment" to examine this domestication hypothesis started nearly 300 years ago and is still in progress. *Brassica campestris*, a weedy mustard introduced by the Spaniards, has been considered a potential candidate for domestication in South America although there has been no conscious sowing and selection of this weed (Gade 1972). In North America, the Tarahumara presently have *Brassica* as a weed-crop (Bye 1979).

Future Resources

As we begin to understand the evolution, ecology and nutritional values of edible weeds, these plants can become more beneficial in the future. Strategies of germplasm conservation of economically important plants should incorporate sampling surveys of weedy relatives as

FIG. 11a.—Cultivated plot of *Lepidium virginicum*, a weed-crop.

FIG. 11b.—Plants of cultivated weed-crop, *L. virginicum*, from plot in Fig. 11a. (Bye 7040; 7119; 10, 15 Oct. 1975; east of Cusarare, Chihuahua).

well as wild progenitors. Domesticates, weeds progenitors and weed byproducts result from ongoing plant-man interactions and represent a process and not an event. These interactions involve degrees of symbiosis as well as synergism between plants and man with changes in response to various biological, ecological and cultural factors.

For our agroeconomic societies, quelites should provide new stimuli for evaluating productivity, cultural perception and value systems. A few grams of certain edible weedy greens grown in low energy input ecosystems may be more nutritious and cheaper than cultivated vegetables from high energy input industrialized ecosystems. Despite negative cultural pressure, some edible weeds (e.g., *Portulaca, Chenopodium*) are still available in Mexican open air markets and supermarkets (Fig. 12). Perhaps our young, modern civilization has a lot to learn about subsistence and productivity from older civilizations which have survived thousands of years by eating weeds as one component of their subsistence.

CONCLUSIONS

Survival of the agricultural Tarahumara populations is dependent upon edible weedy greens from cultivated fields. The diversity of plants and the ecological and evolutionary bases of their exploitation of quelites suggest that certain generalities could be drawn and

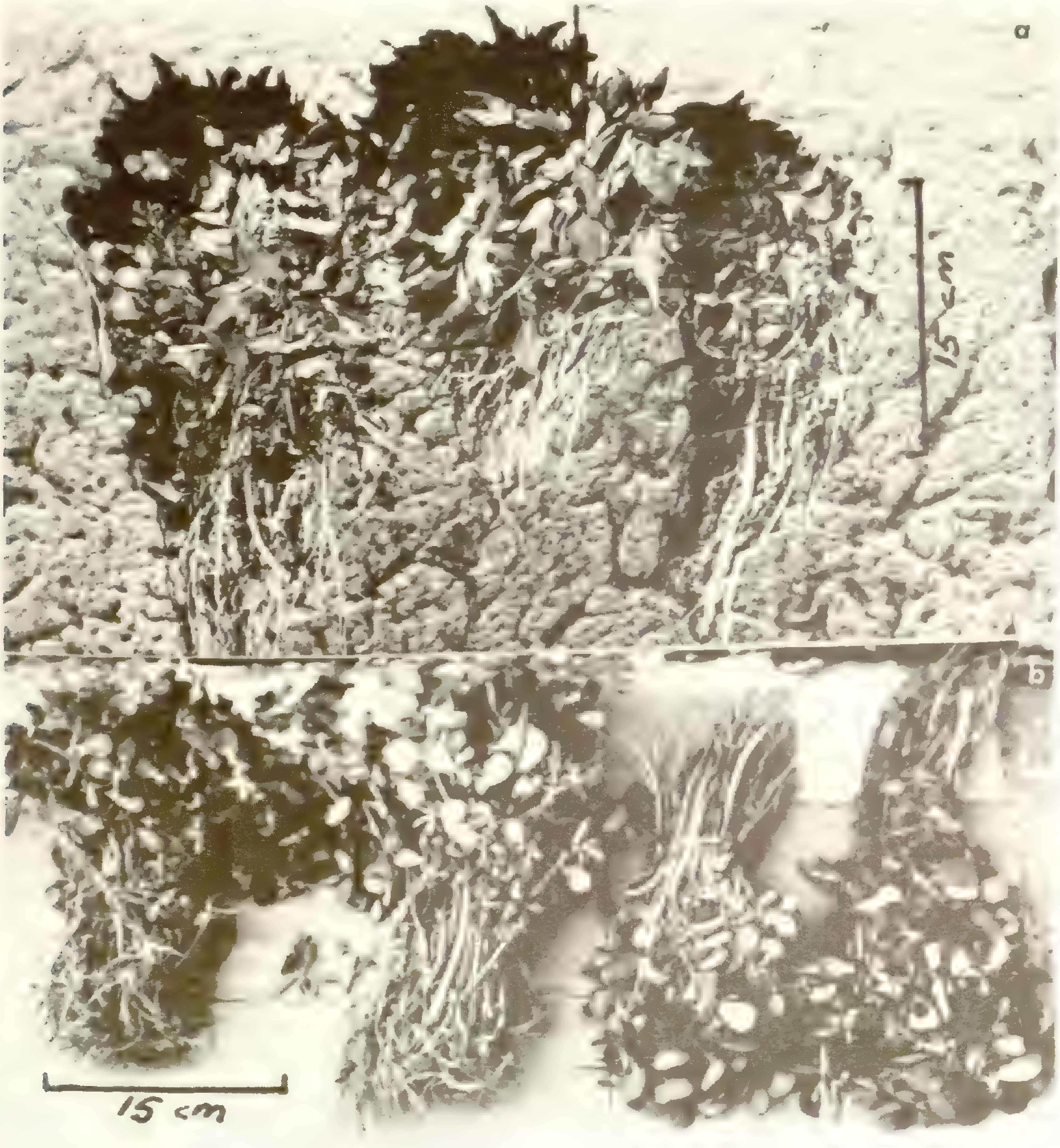

FIG. 12a and b.—Weeds sold as quelites in Chihuahua market. a, *Chenopodium berlandieri* (Bye 9322: 30 March 1979); b, *Portulaca oleracea* (Bye 9100, 9101, 9102; 2 September 1978).

applied to the development of ethnoecological principles. One principle appears to be that disturbance of the ecosystem in order to push the ecosystem back to the early developmental stages and to maintain the communities at these stages is important to the biological existence of human populations. Net productivity is available for exploitation in the early stages of succession and is subjected to variation in quantity and quality depending on human activities.

We are able to study the processes of plant-man interactions today in order to elucidate ethnoecological principles. Edible weeds are consumed by the Tarahumara. This plant-man interaction appears to be based upon biological and ecological theory. The principle of this resource exploitation should apply to other present-day cultures as well. Because these processes are evolutionary in nature, we should expect evidence of weed food resource exploitation from archaeological studies in the forms of phytoliths and epidermal tissues from coprolites, field soils, and preparation implements. This principle should also apply to the future. Once it is understood and applied, we should expect a more realistic basis for developing relationships between human populations and their ambient vegetal environment.

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NOTES

[1] Ethnoecology is the area of study which examines the ecological bases of human interactions with and relationships to the ambient environment.

[2] Ecological diversity is generally considered to consist of 2 components: richness and evenness. For the purpose of this paper, the emphasis is upon richness, which can be defined as the variety of species present in a given community. given community.

[3] Anthropogenic community is a plant community initiated and maintained by human activities and represents an early secondary successional community.

[4] Net productivity represents the amount of energy which accumulates in the ecosystem over a period of time (usually on an annual basis). It can be defined by the difference between Gross Productivity and Respiration in a given community or ecosystem.

J. Ethnobiol. 1 (1): 124-134 May 1981

ON THE RELATIVE CONTRIBUTION OF MEN AND WOMEN TO SUBSISTENCE AMONG HUNTER-GATHERERS OF THE COLUMBIA PLATEAU: A COMPARISON WITH *ETHNOGRAPHIC ATLAS* SUMMARIES

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ABSTRACT.—The subsistence dependence codes in Murdock's *Ethnographic Atlas* have been used to evaluate hypotheses as to the relative contribution of men versus women to hunter-gatherer subsistence. The *Atlas* codes are based in most cases on impressionistic ethnographic summaries of the role of gathering, hunting, and fishing in the societies of the sample. The validity of these coded data is evaluated for representative North American Indian cases by comparison with estimates of the caloric and protein contributions of the major subsistence resource types based on ethnohistorical and ethnobiological research. The *Atlas* data are shown to be systematically biased in favor of hunting and fishing resources at the expense of gathering resources.

INTRODUCTION

Lee's data on the relative caloric contribution of the products of hunting and gathering among !Kung Bushmen (Lee 1968:39) clearly demonstrate that the pervasive stereotype of men as providers, women as economically dependent childrearing specialists, does not apply to all foraging societies. In fact, comparable figures reported for other Bushman groups (Tanaka 1976) and for Australian Aborigines (Gould 1977) suggest that the female economic contribution as gatherer (measured as percent of caloric requirement provided) ranges between 60% and 80% generally among foragers in the arid tropics. Lee's cross-cultural sample drawn from the *Ethnographic Atlas* (Murdock 1967) indicates that only above ca. 40° latitude does the male economic contribution through fishing and hunting meet the bulk of subsistence requirements (Lee 1968:43).

However, the case is apparently not yet considered conclusive. Ember has recently argued to the contrary that among the 181 *Atlas* hunter-gatherer societies—those rated zero on Murdock's "subsistence dependence" code for animal husbandry and agriculture—"men, not women, . . .typically contribute substantially more to primary subsistence" (1978:441). If we accept the *Atlas* data at face value and sample as representative, Ember is correct, since 77% of the *Atlas* cases rate hunting and fishing (in which males are nearly always the primary producers) of greater value than gathering to subsistence. However, Ember chose to ignore the significance of the geographical bias in the *Atlas*. Fifty-seven percent of the hunter-gatherer cases in the *Atlas* are from at or above 42° latitude compared to only 17% of the total cases at or above that latitude. Eighty-four percent of the hunter-gatherer cases in the *Atlas* are from North America, while only 25% of the total cases are from that continent (see Table 1). The statistics from North America do not differ significantly from worldwide figures, however the correlation of latitude with the importance of gathering shows up clearly. Hunting and fishing are rated as exceeding the contribution of gathering among only 49% of societies below 42° but among 98% of those at or above that latitude.

There remains the questions of the face value of the *Atlas* subsistence ratings. Ember equates Murdock's scale with percentage of caloric requirements met (1978:441, 445). Murdock made no such claim. Rather, his 5 major subsistence factors—gathering, hunting, fishing, animal husbandry, and agriculture—are rated 0 to 9 with respect to "the relative dependence of the society" on the factor in question (Murdock 1967:46). There is no mention of calories, nor is any operational definition of "subsistence dependence" offered. To interpret Murdock's subsistence scale in terms of calories is to impute a spurious objectivity to the *Atlas* data. I hope to show here that in at least one major culture area, the Columbia-Fraser Plateau—which represents 13 of the 181 hunter-gatherer cases in the *Atlas*—Murdock's subsistence codes are seriously and systematically biased in favor of the hunting-fishing contribution if interpreted in caloric terms.

These 13 societies represent an area of 750,000 sq km drained by the Fraser and Columbia Rivers in what is now British Columbia, Washington, Idaho, and Oregon (see Fig. 1). The northern or British Columbia portion of the Plateau area is largely forested, while the southern portion is an arid sagebrush steppe and grassland surrounded by pine parkland and mountain forest. A diverse subsistence economy based on gathering, fishing, and hunting has supported continuous aboriginal populations for 10,000+ years (Cressman 1977). In no Plateau case does Murdock rate gathering as contributing more than 35% to "subsistence dependence."

FIG. 1.—Map of the Columbia-Fraser Plateau Region of the Pacific Northwest indicating approximate locations of 13 *Ethnographic Atlas* societies.

TABLE 1.—*The correlation of latitude and the importance of gathering to subsistence among North American hunting-gathering societies (data from the* Ethnographic Atlas *[Murdock 1967]).*

	Number of Societies with Gathering Rated ≥ r on Murdock's Subsistence Scale		/ Total number of Societies
SUBREGION	**≥ 52° N**	**≥ 42° N**	**Total**
Arctic/Subarctic	0/37	--	0/37
Northwest Coast	0/27	0/ 5	0/32
California	0/ 1	18/29	18/30
Plateau/Great Basin	2/20	9/13	11/33
Plains	0/11	0/ 5	0/16
Southwest	--	2/ 2	2/ 2
Northern Mexico	--	1/ 2	1/ 2
TOTAL: NORTH AMERICA	2/96	30/56	32/152
PERCENT WITH GATHERING ≥ 5	2.1	53.6	21.1
TOTAL: WORLDWIDE	2/103	40/78	42/181
PERCENT WITH GATHERING ≥ 5	1.9	51.3	23.2

*Murdock (1967) rates each society's subsistence economy on 5 major types of subsistence activity, gathering, hunting, fishing, animal husbandry, and agriculture, on the following scale: (0) zero to 5%, (1) 6% to 15%, (2) 16% to 25%, (3) 26% to 35%, (4) 36% to 45%, (5) 46% to 55%, (6) 56% to 65%, (7) 66% to 75%, (8) 76% to 85%, (9) 86% to 100% dependence on the subsistence type in question. The factors must add to equal 10.

DISCUSSION

The Data Base for Estimating Subsistence Contributions

Lee was able to measure actual consumption over a period of several months among a group of hunter-gatherers little affected by contact with modern civilization. The Columbia-Fraser Plateau situation, however, is quite different. European influences date to ca. 1730 when horses reached the area indirectly from Spanish sources in the Southwest (Haines 1938). Epidemics of smallpox dating to before 1780 (Boyd MS*a*) spread from early coastal or Great Plains contacts. Fur traders, missionaries, settlers, treaties and consequent Indian wars followed close on the overland explorations of Mackenzie and Lewis and Clark, leading to the restriction of most of the native population to reservations by the end of the nineteenth century. Hydroelectric dam construction on the Columbia begun in 1931 has now all but eliminated any semblance of traditional subsistence fishing patterns (Pacific Northwest Regional Commission 1976). Thus estimates of the relative contribution of gathering, hunting, and fishing to the caloric requirements rest on limited ethnohistorical documentation by early explorers and missionaries and the statements of elderly informants recorded by twentieth century ethnographers. These ethnobiological data—often quite detailed and extensive as to species recognized and used and the time and place of harvest—must now be interpreted in the light of scientific knowledge of the natural history and biochemistry of resource species.

Previous attempts to characterize the ecological parameters of Plateau subsistence have focused almost exclusively on salmon (Hewes 1947, 1973; Kew MS; Palmer 1975a; Sneed 1971). No attempt has yet been made to quantify the vegetable input. This one-sided emphasis on the economic value of the native fisheries seems to reflect a misunderstanding of the potential nutritional contribution of native plant foods. For example, Hewes (1973:134) assumed that "the satisfaction of this demand [for calories] must have been largely up to the fisheries. . . , since other natural foods available in the area in quantity are notoriously low in fuel value," among which he specifically includes bitterroot and camas (Ibid.:151), 2 Plateau staples. Hewes's estimation of the fuel values of native plants is simply wrong (e.g., for camas see Konlande and Robson 1972). Furthermore, recent ethnobiological and cultural ecological research in the area[1] clearly indicates a much more important role for vegetable products as sources of food energy than Hewes recognized.

For example, French and I have documented a folk classification system of extraordinary detail applied to a single taxonomically difficult genus, *Lomatium*, of the Umbelliferae. Fourteen basic folk taxa are named in Sahaptin, the language of the middle Columbia, at or below the scientific species level. Most of these species are important native foods including the staples, *Lomatium canbyi* Coult. & Rose and *L. cous* (S. Wats.) Coult. & Rose. These along with bitterroot (*Lewisia rediviva* Pursh), camas (*Camassia quamash* [Pursh] Greene), and huckleberries (especially *Vaccinium membranaceum* Dougl. ex Hook.) account for the bulk of vegetable foods gathered in the southern half of the Plateau region. Preliminary studies of densities and harvest rates of these species suggest the feasibility of reliance on vegetable resources in this area for the bulk of the calorie requirement (Hunn and French MS).

Estimates of Salmon Consumption

Hewes's estimates of salmon consumption are the most comprehensive attempted to date for the region. However, his interpretation of the nutritional factors is misleading. He does not allow for the fact that the edible fraction of whole salmon is generally considered to be approximately 80% of the total weight (Martinsen, pers. comm.). Furthermore his caloric calculations are based on commercial samples. These are biased in 2 respects. They selectively represent the fattest species, Chinook (*Oncorhynchus tschawytscha*) and Sockeye (*O. nerka*), and they represent individuals taken at the beginning of the spawning migration. Yet Idler and Clemens (1959) have shown that migrating salmon (Fraser River Sockeye) lose on average 75% of their caloric potential during this migration, as do Amur River Chum Salmon (*O. keta*) (Pentegov et al. 1928).

Table 2 cites salmon samples on which the present argument rests. The 20 samples represent 6 species (including Steelhead Trout, *Salmo gairdneri*) and average 170 kcal/100 g. Table 3 lists Hewes's salmon consumption estimates for the 13 *Atlas* societies of the Plateau with kcal/person/day equivalents based on 80% edibility and the present 170 kcal/100 g standard energy value. These equivalents are then reduced by a variable migration calorie loss factor, which for Fraser River groups is as calculated by Kew (MS).[2] For Columbia River groups I determine the calorie loss factor by taking the ratio of the total length of the river (1936 km) to the distance up the main stem of the Columbia to the mid-range of the group cited. For groups resident on tributary streams only, I calculated the ratio as that of the distance from the Columbia River mouth to the mid-range of the group to the total distance to the limit of salmon migration on that tributary.[3] This ratio is then multiplied by 0.75, the average caloric value lost by salmon in migration, and the result subtracted from one. I use Hewes's value of 2000 kcal/person/day as the minimal daily requirement (MDR), in the absence of reliable estimates of body weight or population structure for pre-contact populations of the region.

The tabulated calculations clearly show that estimates of salmon consumption fall consistently well short of the percentages of subsistence dependence cited by Murdock, with the exception of Thompson. The caloric contribution of salmon throughout the Plateau based on Hewes's consumption figures averages 26% compared to the 44% average dependence on fishing cited by the *Ethnographic Atlas*. While other fish contributed to the total dependence on fishing (Hunn 1979), waste, loss to scavengers, and the use of salmon as fuel (Thwaites 1959:124) should tend to offset any increment from non-salmon fishing sources, except among groups such as the Flathead with restricted access to salmon.

TABLE 2.—*Salmon proximal analyses used, per 100 g.*

	G WATER	G PROTEIN	G FAT	KCAL*
Rivera 1949: canned				
11 samples, 6 species	66.95	22.17	8.61	172
Rivera 1949: fresh				
2 samples, sockeye & steelhead	67.7	22.0	9.13	176
Watt and Merrill 1963: fresh				
1 sample, Chinook	64.2	19.1	15.6	222
1 sample, pink	76.0	20.0	3.7	119
Watt and Merrill 1963: canned				
1 sample, Chinook	64.4	19.6	14.0	210
1 sample, chum	70.8	21.5	5.2	139
1 sample, Coho	69.3	20.8	7.1	153
1 sample, pink	70.8	20.5	5.9	141
1 sample, sockeye	67.2	20.3	9.3	171
AVERAGES	67.7	21.5	8.7	170

*kcal for fish is calculated on the basis of 4.27 kcal/g of protein and 9.02 kcal/g of fat (Watt and Merrill 1963).

TABLE 3.—*Estimates of salmon consumption (pounds/person/year), caloric yields (kcal/person day), and percents of estimated MDR (2000 kcal/person/day).*

SOCIETY	Annual Consumption	Gross Caloric Yield	Calorie Loss Factor	Net Caloric Yield	% of MDR	*Atlas* Rating	Percent Difference
WISHRAM	400	676	.88	594	30	50	-20
TENINO	500	845	.87	735	37	50	-13
UMATILLA	500	845	.81	684	34	40	- 6
NEZ PERCE	300	507	.52	264	13	40	-27
	582	983	.52	511	26	40	-14
SINKAIETK	500	845	.67	566	28	40	-12
SANPOIL	500	845	.62	524	26	50	-24
COEUR D'ALENE	100	169	.25	42	2	30	-28
FLATHEAD	100	169	.25	42	2	40	-38
KUTENAI	300	507	.25	127	5	40	-35
CHILCOTIN	600	1014	.64	649	32	50	-18
SHUSWAP	500	845	.675	570	28	40	-12
LILLOOET	600	1014	.80	811	41	50	- 9
THOMPSON	900	1521	.81	1232	62	50	+12

Annual consumption figures are from Hewes (1973) except for the larger Nez Perce figure which is from Walker (1967). Calorie loss factors for the Fraser River groups, chilcotin, Shuswap, Lillooet, and Thompson, are from Kew (MS).[2] Gross caloric yields are derived from annual consumption figures by converting to kg/day and multiplying by 0.8, the edible portion. The calorie loss factor is calculated as the distance from the mouth of the Columbia River to the center of the particular group's range divided by the length of the main stem of the Columbia or, if the group occupied a tributary, by the distance to the limit of salmon migration on that tributary.[3] The resultant ratio is multiplied by 0.75, the fraction of caloric value lost by salmon in migration, and subtracted from 1.0. The net caloric yield is simply the gross caloric yield times the caloric loss factor.

The Contribution of Vegetable Staples

If no more than 30% of the calories come from fish, what might have supplied the rest? For the southern half of the Plateau there is solid evidence that the bulk of the remainder, and certainly in excess of 50% of the MDR, came from vegetable staples. The evidence is of 2 sorts. First, the following ethnohistorical and ethnographic observations may be used to estimate per capita consumption rates as they cite daily harvest rates, annual harvest totals, lengths of harvest season, and indicate elements of native procedure relevant to the estimation of harvest rates, such as the fact that roots are peeled before packaging.

> I saw a young woman at the Skitsoe village [Coeur D'Alene], who had collected and prepared sixty sacks of good Gamas [*Camassia quamash*], each sack containing 1-1/5 bushel; she was spoken of in the best terms throughout the village (Geyer 1845-1846, quoted in Hart [1976:16]).
>
> The digging of Gamass takes place as soon as the lower half of the flowers on the raceme begin to fade, or better, when the time of flowering has already passed (Ibid.).
>
> Gathering bitterroot was a tedious, although not difficult task. Women often worked three or four days to fill a fifty-pound sack. Each woman gathered at least two sacks, enough to sustain two people through the winter. A sack of bitterroot was worth . . . a horse, . . . (speaking of the Kutenai [Hart 1976:49]).
>
> The Sanpoil root digging grounds consisted of the entire portion of their territory lying south of the Columbia river, an area of over a million acres. . . . . the entire Sanpoil population moved from its winter home on the river and set up temporary quarters at various spots on this prairie early in April of each year. Here they remained for thirty to forty days, during which time the entire energies of the women were devoted to digging roots, for in this short period it was necessary to accumulate a sufficient supply to last the entire year. . . . Each woman dug over about one-half acre in one day. . . . The several varieties of camas [local vernacular for *Lomatium* spp., as well as the true camas, which does not occur in the region under discussion] were gathered in greatest quantity. Bitter root was second in importance. . .A good day of camas digging often netted as high as a bushel of roots. . . The skins of roots. . . were slipped off as they were dug, or more commonly at camp in the evening (Ray 1933:97-98).
>
> May and early June is the main collection season, . . . This root [*Lomatium cous*], along with camas, formed the bulk of the plant foods stored for winter use. A good digger gathered 50-75 pounds of /qamsit/ [*L. cous*] in a single day (speaking of the Nez Perce [Marshall 1977:52]). These different locations had camas marshes which matured at different times; the lowest, warmest ones were exploited in early to mid-June; the highest, collest [sic.] could be worked until September. . . Harbinger (1966) said that a good digger could gather 80-90 pounds per day of hard labor, while less intensive work would yield 40-50 pounds easily. . . My informants estimate that women gathered camas for two to three weeks (speaking of the Nez Perce, [Marshall 1977:55, 57]).
>
> People moving to the mountains for berries. They obtain at this season the large mountain huckleberry [*Vaccinium membranaceum*]. . .They are usually absent on these excursions [away form their village at the Dalles on the Columbia River], from four to six weeks; during which, each family lays in, for winter use, four or five pecks of nice dried berries (speaking of a Tenino-Wishram group, diary entry for August 19, 1843, of the missionary H. K. W. Perkins [Boyd MS*b*]).

The second source of consumption rates for vegetable staples is from my preliminary time-and-motion studies of contemporary Indian root-digging. One Umatilla woman, working at a normal pace and using the contemporary steel version of the traditional digging stick, dug 33 *L. cous* tubers/h, or 3.79 kg/h of peeled roots. I find that I can dig and "pocket" a *L. canbyi* tuber in 7 s. Allowing 3 s to find the next plant, we have 6/min or 360/h, which at 11.0 g/tuber (N=52) gives 3.96 kg/h. These estimates tend closely about a figure of 4 kg/h or a bushel (ca. 30 kg) in 7.5 h, not an unreasonable day's work. The close accord between the ethnohistorical/ethnographic estimates and my experimental figures is encouraging. These estimates are summarized in Table 4. The low value for the Kutenai bitterroot harvest cited is perhaps due to the fact that the Kutenai are on the northern fringe of that species' range (Daubenmire 1975), and the high value for the Flathead camas harvest is noted as a remarkable achievement (Geyer, in Hart 1976:16).

Per capita caloric consumption is based on a producer/consumer ratio of 1:4 with kcal/100 g standards as in Table 5. The harvest periods of tubers in spring, camas in summer, and huckleberries in fall were largely distinct. Thus we may add the estimates for spring tubers, camas, and the berry harvest to arrive at a rough but conservative annual per capita consumption figure:

SPRING (*Lomatium* spp. and bitterroot)	900 kcal
EARLY SUMMER (camas)	400 kcal
LATE SUMMER/FALL (huckleberries)	50 kcal
ESTIMATED ANNUAL PER CAPITA CONSUMPTION	1350 kcal

This figure is more than double the estimated contribution from salmon for this area and 67.5% of the estimated MDR. Compare this to the 30% "subsistence dependence" attributed by Murdock to the Wishram, Tenino, Umatilla, Nez Perce, Sinkaietk, Sanpoil, Coeur D'Alene, and Flathead, all known to have harvested several of these species in quantity.

It might be argued that harvests were not continuous during the periods of resource maturity. It is certainly true that women were called upon to preserve both fish and game harvested by the men. However, length of harvest figures cited in Table 4 are generally conservative.[4] Transport of the harvest to the winter villages might also pose problems, given the quantities involved, especially in prehorse times. However, spring roots and huckleberries were dried before transport reducing their weight by over 50%. In addition, there were many other fruits, berries, tubers, bulbs, and greens eaten on the spot which have not been included in this estimate. Thus 1350 kcal/person/day from gathering seems reasonably applicable throughout the southern Plateau. The more northerly groups generally lacked these staples, relying instead on a variety of liliaceous bulbs other than

TABLE 4.—*Estimates of plant food harvest rates (kg/woman/day), total harvests (kg/women/year), and caloric yields (kcal/person/day).*

SPECIES	Estimated Daily Harvest	Harvest Period/ Days	Total Annual Harvest	kcal Yield	Locale
SPRING:					
Lomatium canbyi	30	30-40	1050	800	Sanpoil[1]
Lomatium cous	22.7-34.1	ca. 40	1136	988	Nez Perce[2]
	33.3*	ca. 30	999	869	Umatilla[3]
Lewisia rediviva	30.3*	ca. 60	1818	1121	Umatilla[3]
	6.5	7	45	28	Kutenai[4]
EARLY SUMMER:					
Camassia quamash	36.4-40.9	14.21	677	524	Nez Perce[2]
	18.2-22.7	14-21	358	277	Nez Perce[2]
			2160	1672	Flathead[5]
LATE SUMMER/FALL:					
Vaccinium spp.		28-42	63.9-80.2	31	Tenino-Wishram[6]
			98	42	Umatilla[3]

Sources: (1) Ray 1933, (2) Marshall 1977, (3) Hunn and French MS, (4) Hart 1976, (5) Geyer 1845-46, Boyd MS*b*.
Note: Ranges of values are averaged for subsequent calculations.
*Based on 8-hour days.

camas, such as *Fritillaria* spp., *Erythronium grandiflorum* Pursh, and *Lilium columbianum* Hanson in Baker, and to a more considerable extent upon hunting (Palmer 1975a).

On Measuring Subsistence Dependence

The data compiled here do not demonstrate that the *Atlas* subsistence scale is incorrect, only that those scales cannot be reliably interpreted in caloric terms. Murdock's figures are based on ethnographic reports that are almost without exception mere impressions. For example, his rating of the Sanpoil as "32500" (i.e., 26-35% gathering, 16-25% hunting, 46-55% fishing, 0-5% animal husbandry and agriculture) is clearly in accord with Verne Ray's characterization of Sanpoil subsistence emphases. Gathering, says Ray, the Sanpoil ethnographer of record, is but "a valuable supplement to the meat and fish that hold first place in the diet of the Sanpoil (1933:97)." Ray devotes 20 pages each to fishing and hunting among the Sanpoil and but 9 to fruits and vegetable products. Yet Ray's own statements on the spring root harvest (quoted above) proves the contrary. Clearly the *Ethnographic Atlas* reflects both the bias of the ethnographer and of *his* informants for the less predictably available foods (cf. Lee 1968:40, for a similar informant bias among the Bushmen), which seem most always to be the special task of men to pursue.

In the final analysis, subsistence dependence cannot be reduced to calories. Though calories are the body's first and largest requirement, survival obviously requires an adequate balance of nutrients over the long run. Salmon provided protein in more than adequate amounts, a nutrient the region's starchy staples largely lack. And salmon is rich in Vitamins, especially A and D (Rivera 1949). Game might be relied upon when other foods were in short supply. Fruits and berries, even lichens (Turner 1977), contributed other vitamins and a variety of mineral nutrients, while "Indian celeries," eagerly sought in late winter and early spring after a winter on a diet of dried stores, are rich sources of Vitamin C.[5]

To single out one resource, one nutritional requirement, or one sex as the key to understanding the success of hunting-gathering adaptations is to miss the point entirely. Human foragers survived to colonize nearly the entire land surface of the earth by virtue of judicious selection of an ample and varied diet from an extensive, empirically sound folk biological inventory of the flora and fauna. To argue that either men or women were of paramount importance in the evolutionary history of the human species is to ignore the most human ecological characteristic, familial economic cooperation.

TABLE 5.—*Plant food proximal analysis used, per 100 g.*

SPECIES	G Water	G Protein	G Fat	G Carbohydrate	kcal
Lomatium canbyi					
av. 6 dried root samples[1]	11.68	2.58	1.48	82.41	352
same, adjusted for water content	71.9	0.9	0.47	26.22	112
1 sample, fresh[2]	71.9	0.8	0.12	25.9	108
Lomatium cous					
1 sample, fresh[2]	67.9	1.0	0.4	30.0	127
Lewisia rediviva					
1 sample, fresh[2]	76.6	0.7	0.1	21.6	90
Camassia quamash					
1 sample, fresh[2]	70.0	0.7	0.23	27.1	113
Vaccinium sp.					
blueberries, raw[3]	83.2	0.7	0.5	15.3	62

Sources: (1) Washington MS, (2) Benson et al. 1973, (3) Watt and Merrill 1963.

CONCLUSIONS

I have summarized evidence which demonstrates that the importance of vegetable resources gathered by women as sources of food energy is not confined to Bushmen or Australian Aborigines. Nor do plant foods play an insignificant role everywhere above 40° latitude. Murdock's *Ethnographic Atlas* "subsistence dependence" code summaries to the contrary, the food-collecting societies of the southern half of the Columbia-Fraser Plateau of northwestern North America (at ca. 45° - 48° N latitude) obtained in the neighborhood of 70% of their food energy needs from plant foods harvested by women. The wide divergence between the *Atlas* summaries and comparable figures based on the best available evidence for this region, raise serious doubts about the general validity of the *Atlas* subsistence codes.

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Notes

1. These studies include research with Wishram and Tenino by D. and K. French, Umatilla and Yakima by E. Hunn, Nez Perce by A. Marshall, Wanapum and Sinkaietk by N. Washington, Thompson, Lillooet, and Okanagan Colville by N. Turner and the British Columbia Indian Language Project, Kutenai and Flathead by J. Hart, and Shuswap by G. Palmer (Hart 1974; Hunn and French MS, Marshall 1977; Palmer 1975a, 1975b; Turner 1973, MS; Turner, Bouchard, and Kennedy 1980; Washington MS).
2. Kew's calorie loss ratios are almost certainly overestimates since he states that, "Total caloric value of a sockeye measured at the river mouth will be reduced to nearly one half when it reaches the Upper Stuart spawning grounds ..." (MS:6). Idler and Clemens cite losses of 69.1% for males and 79.8% for females at the time of death on the Stuart Lake migration path (1959:18).

3. For the groups cited here, the Wishram mid-range is taken as the Dalles (Columbia River mile 190), the Tenino at the Deschutes River mouth (Columbia River mile 202), the Umatilla at the mouth of the river of that name (Columbia River mile 300), the Nez Perce at the confluence of the Clearwater and the Snake Rivers (Columbia River mile 324 + Snake River mile 140), the Sinkaietk at the mouth of the Okanogan River (Columbia River mile 534), the Sanpoil at the Sanpoil River mouth (approximately Columbia River mile 615), the Coeur D'Alene at Spokane Falls, limit of salmon migration on the Spokane River, the Flathead at Metaline Falls, limit of salmon migration on the Clark Fork-Pend O'Reille River, and the Kutenai at the head of migration on either the Columbia River (Columbia Lake) or the Kootenai River (below Kootenay Lake). Limit of migration on the Snake River is at Upper Salmon Falls (approximate Snake River mile 400). Mileage figures abstracted from Fagot (1970:111-124) and United States House of Representatives (1952).
4. In 1978 *L. canbyi* was exceptionally early and could have been harvested as early as February. In 1979 *L. canbyi* and *Lewisia rediviva* were commonly available up to ca. 600 m elevation by April 1. In 1977 *L. cous* and *Lewisia rediviva* were still being harvested by Umatilla Indians at 1400 m in the Blue Mountains of Oregon on June 22. Since camas may be harvested into September (Marshall 1977:57), a root harvest period of 100+ days is possible.
5. Benson et al. cite 66 mg/100 g ascorbic acid for the young growth of *Lomatium nudicaule* (Pursh) Coult. & Rose (1973:145), an important "Indian celery" of the region.

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DEVIL'S CLAW DOMESTICATION: EVIDENCE FROM SOUTHWESTERN INDIAN FIELDS

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ABSTRACT.—Devil's claw (*Proboscidea*; family Martyniaceae), herbaceous plants of deserts and grasslands, have been utilized for food and fiber by numerous Indian groups in southwestern North America. A white seeded devil's claw, with longer fruit providing more useful basketry fiber, has been cultivated by basketmakers in California, Nevada, Utah, Arizona and Sonora. Historically, this devil's claw taxa has been poorly understood, and has often not been recognized as being genetically distinct from wild *Proboscidea* spp. in the region.

Through morphological, ecological and chemical comparison with other *Proboscidea*, in the wild and under cultivation, certain distinguishing characteristics become apparent. The white seeded race appears to be most closely related to typical *Proboscidea parviflora* (Woot.) Woot. & Sandl., and their differences are in those characteristics most often altered via domestication. It is suggested that cultural selection by basket-making native farmers in the Southwest, and natural selection in their field environments can account for the distinctiveness of the white seeded devil's claw.

Additionally, ethnographic and linguistic information elucidate the white seeded race's affinity with *P. parviflora*, yet also its distinction as a native cultivated crop. After evaluating these various data, it is concluded that *P. parviflora* has undergone the evolutionary process of domestication, increasing its usefulness as a basketry fiber producer. It does not merit the status of a cultigen—or fully domesticated plant—since its survival from year to year is not entirely dependent on man's intentional planting. Yet, white seeded devil's claw is today highly associated with cultivation in a few Indian *rancherias* in Arizona.

INTRODUCTION

To *domesticate* a plant literally means to bring it into the human household. The process of domestication involves cultural selection for economic characters, as well as natural selection in the man-altered environment where the plants are grown. The intensity of these selective pressures is not constant through time nor through space. It varies with the demand for the economic product, the kind of horticulture or agriculture practiced by the people involved, and the degree of geographical or phenological isolation between the cultivated plants and their wild relatives.

Often, an incipient domesticate has not been recognized as such. This is because the cultivated plant may still have the appearance of its wild relatives. Additionally, the early stages of cultural adoption may not involve formal husbandry so much as simple seed selection, sowing and protection in an otherwise unmanaged environment, which looks "wild" to observers from another culture.

Given these conditions, it is not surprising that it took Europeans more than 2 centuries in southwestern North America before they questioned whether certain plants the Indians utilized were more than merely wild crops. In the case of devil's claw (*Proboscidea*), the use of the plant for food and fiber was recognized decades before its outright cultivation was noted (Fig. 1). Additional time passed before scientists first suggested the plant as a possible domesticate.

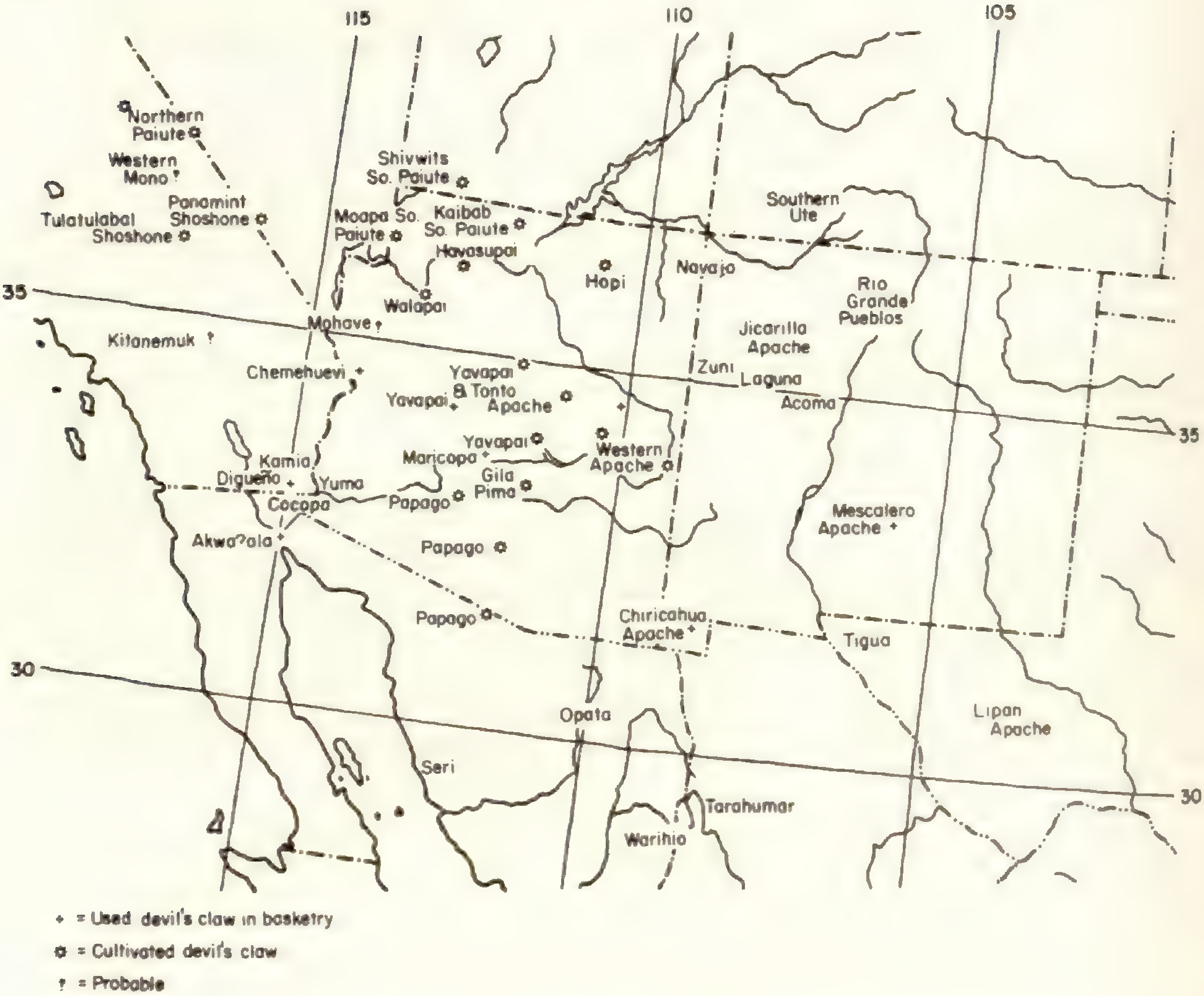

FIG. 1. Locations of tribes growing or using devil's claw (cartography by Alison Habel).

Early researchers suggested the presence of "introduced" kinds of devil's claw among the Indians. However, Castetter and Bell (1942:113, 202) were the first to realize that one kind was almost completely dependent upon cultivation. They noted that a second kind of annual devil's claw among the Pima and Papago was different from the wild kind in Arizona in respect to several characteristics. They claimed that this longer clawed, white seeded kind was found *only* under intentional cultivation or as a volunteer in agricultural fields.

Hevly has indicated (in Correll and Johnston 1970:1448) that strains of *Proboscidea parviflora* (Woot.) Woot. and Standl. semi-cultivated by Southwestern aboriginal groups are anomalous for *Proboscidea* in that they have white seeds. Recently, Yarnell (1977), without further data or analysis, concluded that *Proboscidea parviflora* was one of only 3 species definitely domesticated north of Mexico.

If one goes to the reservations of the Papago and Pima Indians today, one finds a somewhat more complicated situation than that described by Castetter and Bell (1942). Both black and white seeded devil's claw are cultivated in fields and gardens; additionally white seeded devil's claw can be found on roadsides and in arroyos within Papago *rancherias*, growing nearby the more common black seeded *Proboscidea parviflora* (Nabhan and Fritz 1977). Given this information alone, we feel that the data in Castetter and Bell's work do not place devil's claw in enough of a cultural and botanical context to convince the scientific community that domestication has actually occurred.

The proposed status of domesticate for *Proboscidea parviflora* has thus been largely unrecognized and untested. We will use the devil's claw example as a case study in how anthropologists and botanists methodologically determine when a plant has undergone cultural selection and domestication, over and above mere cultivation. Additionally, we discuss problems in the interpretation of historic specimens and ethnographic data, and suggest some testable indicators of domestication.

In presenting hypotheses regarding how and where the domestication process might have occurred for *Proboscidea*, we wish to emphasize how much has yet to be learned. We hope to encourage further research of devil's claw as well as of other little-known crops. Such research is urgently needed, since many minor crops have been abandoned within this century as modern monocultural agriculture has usurped the land and water formerly allotted to smaller scale mixed crops.

Devil's claw cultivation is a case in point. Today it is practiced in only a few "islands" within its former range. Due to the demise of traditional basketry and agriculture among several Southwestern cultures, considerable native knowledge and *Proboscidea* germ plasm have eroded within the last half century.

DISCUSSION

Botanical Background and Historical Recognition

Within the New World family Martyniaceae, the genus *Proboscidea* is divided into 2 subgenera: *Dissolphia*, including 3 yellow-flowered perennial species; and *Proboscidea*, including 10 species, most of which are annual, with flowers of cream, pink or purplish hues (Van Eseltine 1929; Hevly in Correll and Johnston 1970; Hevly 1969a; 1970). We will be concerned with 3 annual species of the southwestern United States and adjacent Mexico: *Proboscidea fragrans* (Lindl.) Decne.; *P. louisianica* Miller (Thell.), and *P. parviflora* (Woot.) Woot. and Standl.

Partially overlapping in range, (eg., in Texas), these species are nevertheless phenetically distinct and macroscopically distinguishable (Table 1). However, the 3 species have been found to be experimentally cross-compatible. First generation (F^1) flowering and fruiting hybrids can easily be obtained, although F^1 fruits contain few seed (Anderson 1922: 141; Perry 1942; Hevly, unpubl. data). A more thorough treatment of the genetic and biogeographic relationships of these species is currently being prepared by Peter Bretting at Indiana University, in a taxonomic revision of the genus *Proboscidea*.

In the 1870s, Dr. Edward Palmer published 2 of the first specific notes on the use of Southwestern devil's claw. Palmer (1871:422) noted that the Apache Indians cooked the immature fruit of *Martynia violacea* for food, and utilized part of the ripened fruit as ornamentation in basketry. Additionally, Palmer (1875:112) described the preparation of fruit of *Martenia proboscides* as a black basketry ornamentation, as it is used "by all the tribes of Arizona." At the time that Palmer made these comments, only 2 annual species of devil's claw were recognized in North America, both with large calyces; *M. fragrans*, for which *M. violacea* is a synonym—with purple flowers; and *M. louisianica*, for which *Martenia proboscides* is a misspelled synonym—with white to pink flowers.

Neither article acknowledges if Palmer collected voucher specimens to substantiate these identifications; thus there is no way of checking the suggestion that 2 species were then utilized. The paucity of voucher specimens, as we shall see, has persisted into recent decades; it is still not clear if more than one devil's claw species has been utilized in Southwestern basketry.

During the decades that followed Palmer's articles, it became apparent that the most common kind of devil's claw in Arizona, New Mexico and adjacent Mexico is distinct from the above 2 species due to its smaller calyces, and differently colored flowers. This species was named *Martynia parviflora* Wooton in 1898, but was transferred along with *M. louisianica* and *M. frangrans* to the genus *Proboscidea* because their flower and fruit characteristics were incompatible with *Martynia* (Hevly 1969b).

TABLE 1.—*Comparison of* Proboscidea *in the Southwest.*

CHARACTER	(SUGGESTED DOMESTICATE) WHITE-SEEDED RACE	UNDER CULTIVATION: P. PARVIFLORA	IN THE WILD P. PARVIFLORA	P. LOUISIANICA	P. FRAGRANS
Geographic distribution	Southern Nevada, southern Utah, southeast California, Arizona, & northeast Sonora	Arizona (a few tribes) & experimentally in Arizona & New Mexico	Arizona, south and west New Mexico, & Trans-Pecos Texas. North Mexico west of Sierra Madre. Rare in Californias; extremely rare in Nevada.	Southern U.S. to Colorado, eastern New Mexico & central Texas. Adventive in California, elsewhere.	Tran-Pecos Texas & northeastern Mexico east of the Sierra Madre.
Plant size	To 1.4m tall x 3m wide	To .9m tall x 1.8m wide	To .5m tall x 1.5m wide	To 17m tall x 1.2m wide	To .6m tall x 2m wide
Leaves	Sub-orbicular-ovate, sometimes deltoid-ovate; entire to 3-10 lobed; sinuses obtuse, denticultate; width up to 35cm; cordate to inequilateral at base.	Sub-orbiular-ovate to deltoid-ovate to deltoid-ovate; entire to 3-10 lobed; sinuses obtuse, denticulate; width up to 25 cm; cordate to inequilateral at base.	Bus-orbicular-ovate to deltoid-ovate; entire to 3-7 lobed; sinuses obtuse, denticulate; width up to 25 cm; cordate to inequilateral at base.	Orbicular-reniform to broadly ovate; entire to sinuate; width up to 30 cm; cordate at base.	Deltoid to broadly ovate; nearly entire to 5-7 lobed; sinuses acute; width up to 25cm; cordate to equalateral at base
Inflorescence	Surpassed by, or rarely equalling the foliage	Equalling or surpassed by the foliage	Equalling or surpassed by the foliage	Surpassing the foliage.	Surpassing the foliage.
FLOWERS:					
Calyx length	15-27mm; bracts 8-17mm	13-20mm; bracts 4-11mm	10-15mm; bracts 5-8mm	15-20mm; bracts 7-10mm	25mm; bracts 12mm
Corolla length	34-54mm	34-44mm	25-40mm	35-55mm	35-65mm
Corolla color	Dull white to pink; rarely reddish purple; limb often with faint purple blotches on upper lobes	Reddish-purple, pink to nearly white; limb often with purple on upper lobes	Reddish-purple, pink to nearly white; limb often with purple on upper lobes	Dull white to somewhat pinkish purple; purple blotches absent or blotches on upper lobes	Violet purple to reddish purple, rarely white; limb often with purple blotches
Corolla internal ornamentation	Bright yellow guidelines, & small red dots associated with them in lower half of tube; dark blotches absent	Bright yellow guidelines; & small red dots associated with them in lower tube; blotches usually lacking	Bright yellow guidelines; & small red dots associated with them in lower tube; blotches usually lacking	Yellow-orange guidelines, violet blotches, orange or red-purple dots around the entire tube.	Bright yellow guidelines; violet blotches & dark red-purple dots the entire tube length.
Filament pubescens	Gladular at or below their point of attachment but glabrous above the arcuately curved portion.	Glandular at or below their point of attachment but glabrous above the arcuately curved portion.	Glandular at or below their point of attachment but glabrous above the arcuately curved portion.	Glabrous, sparsely villous or tomentose below attachment point, glandular on arcuately curved portion.	Glabrous, sparsely villous or romentose below attachment point, glandular on arcuately curved portion
FRUIT:					
Number per plant	75-200	60-100	40-80	40-80	40-80
Claw-body ratio	2.5-3	2-2.5	2-2.5	1.5-3	ca. 1.6
Claw length	25.3±4.3cm	17.0±2.7cm	15.7±4.8cm	9-30cm	to 20cm
Pliability	Soft-pliable	Hard-brittle	Hard-brittle	Hard-brittle	Hard-brittle
Color	Darker black	Brown-black	Brown-black	Brown-black	Brown-black
SEED:					
Number per fruit	49.5±12	53.2±9	40-55?	15-67	
Size	.953-.039x.516.040mm	.984-.070x.527.055mm	8-10x4.5-6mm	7-10x5-6mm	6.5-8x4-5.5cm
Color	White-gray	Black-gray	Black-gray	Black-brown	Black-brown
Germination	More immediate, even	Delayed, uneven	Delayed, uneven	Delayed, uneven	Delayed, uneven
Per cent oil	39.2-40.3%	35-38.3%	35-40%	35-43.5%	39%
Per cent protein	23.9-25.5%	20-25%	20-30%	20-25%	
Pollination: (& compatibility)	Crossing by bees (Some selfing?)	Crossing by bees (Selfing 15% effective)	Crossing by bees (Selfing?)	Crossing by bees (Selfing rare or ineffective)	Crossing by bees
Insect visitors (*pollinator)	*Perdita hurdi*, *Bombus sonorus*, *Apis melifera*, *Xenoglossa angustior*, *Melissodes sp.**, *Xylocopa brasilionorum*, *Xylocopa orpifex androlenca*	*Xylocopa orpifex androlenca*		*Melissodes communis**, *Anthophora occidentalis**, *Augochlorella striata**, *Bombus fervidus**, *Lasioglassum spp.*, *Bombus americanorum**, *Melissodes obliqua**, (Phillippi, personal communication 1976)	*Xylocopa spp.*, *Bombus sonorus*

Over the hundred years since Palmer's introductory notes, the use of devil's claw has been recorded for more than 30 native culture groups in southwestern North America (Table 2). In addition to basketmakers' use of fiber splints from the dried fruit, devil's claw fruit and seed have been eaten, and used medicinally; the fruit have been made into tools and ornaments, and have been given supernatural significance. Again, because written references have seldom been accompanied by voucher specimens, and because obsolete nomenclature has often been utilized, we can only guess which devil's claw species various ethnographers have seen.

After the turn of the century, ethnographers began to comment on the planting and protection of devil's claw (Table 3). Russell (1908:133), Spier (1928:134), and Roberts (1929:141) imply that cultivation or lack of it was directly related to the abundance of wild

TABLE 2.—*Devil's claw use in southwestern North America: Early ethnographic references.*

Culture Group	Basketry Use	Other Use	Early References	Early Identifications	Other References
Santa Clara Pueblo		X	Robbins et al, 1916:57	*Martynia*	
Jemez Pueblo		X	Castetter, 1939:notes	*Martynia*	
Cochiti Pueblo		X	Lange, 1959:150		
Zuni Pueblo		X	Stevenson, 1909:46	*M. louisiana*	this report
Hopi Pueblo	X	X	Hough, 1897:33-44	*M. louisiana*	Whiting, 1939:92
Hano Pueblo			Robbins, et al, 1916:57	*Martynia*	
Apache (general)	X	X	Palmer, 1871:422	*M. violacea*	Palmer, 1875:112
Warm Springs Apache	X		Gifford, 1940:45	*Martynia*	
Mescalero Apache	X		Gifford, 1940:45	*Martynia*	
Chiricahua Apache		X	Gifford, 1940:45	*M. louisiana*	Castetter and Opler, 1936:45
Huachuca Apache	X		Gifford 1940:45	*Martynia*	
			Gifford, 1940:45	*Martynia*	
Cibeque Western Apache	X		Gifford, 1940:45	*Martynia*	Buskirk, 1949:164
White Mountain Western Apache	X		Mason, 1904:512	*M. louisiana*	Rea, 1977: notes
San Carlos Western Apache	X		Hrdlicka, 1905:404	cat's claw	Roberts, 1929:141
Western Yavapai	X	X	Corbusier, 1886:324	cat's claw	Gifford, 1936:281
Northeastern Yavapai	X		Gifford, 1936:281	*Martynia*	
Walapai	X		Mason, 1904:517	*Martynia*	McKennan, 1935:80
Havasupai	X		Voth, 1890s:11	*M. louisiana*	Spier, 1928:134
Southern Paiute (general)	X	X	Palmer, 1870s, noted in Bye, 1972:98		
Virgin River and Moapa So. Paiute	X	X	this report		
Shivwits So. Paiute	X		Stewart, 1942:340	*M. proboscidea*	Drucker, 1941:110
Kaibab So. Paiute	X		Stewart, 1942:340	*M. proboscidea*	Kelly, 1964:78, 80
Chemehuevi	X		Mason, 1904:519	*Martynia*	Stoffle and Evans, 1976:4
Kawaiisu	X		Merrill, 1923:7	*M. proboscidea*	Zigmond, 1978:202
Panamint Shoshone (Koso)	X		Coville, 1892:358	*M. proboscidea*	Merriam 1903:826
Death Valley Shoshone	X		Steward, 1941:338	*M. proboscidea*	Jaeger, 1941:248
Northern Paiute	X		Steward, 1941:338	*M. proboscidea*	
Western Mono	X		Merrill, 1923:7	*M. proboscidea*	
Kern River Tubatulabal	X		Merrill, 1923:7	*M. proboscidea*	Voegelin, 1938:30
Kitanemuk	X		Merrill, 1923:7	*M. proboscidea*	
Akwa?ala (Pai Pai)	X?		Drucker, 1941:110	*Martynia*	
Maricopa	X	X	Forde, 1931:124	*Martynia*	Spier, 1946:129
Gila Pima & Papago	X	X	Mason, 1904:519	*Martynia*	Russell, 1908:133
Yaqui		X	Watson, 1898:66	*M. palmeri*	
Seri		X	Felger & Moser, 1976:23	*P. altheaefolia*	
Warihio		X	Gentry, 1963:92	*M. annua, M. fragrans*	
Pima Bajo (Lowland Onovas)		X	Pennington, 1980	*P. arenaria* *P. sinaloensis*	Rea, 1978:notes

TABLE 3.—*Ethnographic references to devil's claw cultivation.*

Culture Group	**Citation**	**Quotation**
Pima	Hrdlicka 1906:43	The cat's claw is cultivated by the Pima in their melon patches.
Pima	Russell 1908:133	The pods of the devil's claw, *Martynia fragrans* Lindl., furnish the third material necessary for the ordinary basket. The supply of wild plants is not large enough, and a few martynia seeds are planted each year by the basketmakers.
Papago & Pima	Kissell 1916:202	Although martynia grows wild, most of the Indians seed it in their fields, since they find the cultivated plant yields pods with hooks of greater length, finer grain and a better black.
Pima	Breazeale 1923:42	The martynia, or devil's claw grows wild ... but I have never seen it growing out upon the desert away from any cultivated field or wash. The Indians often plant a few stalks around their houses, as the wild varieties often have horns not suitable for basketry.;
Papago	Castetter & Underhill 1935:57	The black was ihu'k, the unicorn plant or devil's claw (*Martynia fragrans*) ... Now many sow the seed and raise a regular crop.
Pima & Papago	Castetter & Bell 1942:202	Only the white seeded form was grown, as its pods had longer, finer grained and deeper black black strips of epidermal tissue, and therefore more suitable for use in basketry. They were planted in hills ...
Pima	Curtin 1949:107	Ihuk is cultivated by the Pima for use in basket-making, although it grows wild on plains and mesas.
Papago	Dobyns 1952:211	Papagos domesticated *eohuk* (*Martynia louisiana*), the pod bark being their black material for basket designs.
Havasupai	Spier 1928:134-135	The second variety, with hooks 25 to 30 cm long, was introduced by Pagadjahuda, a Walapai. Although the wild plants are also used, it is customary to plant martynia at the same time as corn.
Havasupai	Whiting 1942:378	[Pagadjahuda planted a whole field of the introduced variety, selling a superior product. Another Havasupai woman, however, claimed she had herself introduced the plant from the Mohaves. Another thought the seeds had been obtained from the Hopi long ago, while still another suggested the Yavapai as a source.]
Havasupai	McKee, McKee & Herold 1975:13	... and an introduced variety with hooks about four inches longer is commonly cultivated. The latter yields adequate crops of the black claws for local use, so few basketmakers gather the smaller wild form.
Apache	Roberts 1929:141	... the San Carlos do not cultivate the plant as do some other tribes, for it is plentiful in their country in its wild state.
Tubatulabal Shoshone	Voegelin 1938:30	Coiled basketed decorated in ... black material from ... antennae of pods of devil's horn, *Martynia proboscidea* Glox ... which is classified as weed, grown occasionally in gardens now, pods sometimes saved.
Shoshone & Northern Paiute	Steward 1941:338	NP-Fsp [Northern Paiute, Fish Springs, California, near Bishop]: procured it from Saline V., through TS said his father had planted it at Fish Springs ... S-Lida [Shonshoni of Lida, Nevada, north of Death Valley]: planted devil's claw in gardens.
Shoshone	Jaeger 1941:248	... *M. parviflora* ... was introduced into Death Valley eighty years ago by a brother of Hungry Bill, a Shoshone Indian, who visited Fort Mohave and found the Indians there making black patterns in their baskets from fiber of the fruits. He procured seeds and planted them in Johnson Canyon; the plant still flourishes there.
Shivwits & Kaibab Southern Paiute	Stewart 1942:340	Devil's claw (*Martynia proboscidea*) SK [Southern Paiute, Kaibab]: Use learned from SS [Southern Paiute, Shivwits] and material still purchased from them. (Kelly, ms, states seeds seeds have been planted near Mocassin, Arizona).
Kaibab Southern Paiute	Kelly 1964:80	With the development of decorated ware, seeds of *Martynia* (tuusupi *Martynia proboscidea*) obtained from St. George, Utah, planted locally.
Panamint-Death Valley Shoshone now near Bishop	Smith and Simpson 1964:46	Mamie Button's basket is woven of willow, Joshua tree roots and fibers from the fruit of devil's claw ... The dark brown designs are woven of *Martynia parviflora* which Mamie called devil's claw. The Hunters and Buttons cultivate this black-seeded annual in their garden for use in basket-making.

devil's claw in their area at the time. It is usually stated that devil's claw is grown for its fiber used in basketry, although in certain cultures (e.g. the Papago), seeds were no doubt eaten also.

Although split devil's claw fiber splints have been found in cave deposits dating roughly A.D. 1150 in Arizona (Exhausted Cave - Hevly and Hudgens, MS) and New Mexico Tularosa Cave - Kaplan 1963), the antiquity of devil's claw cultivation is an open question: Did cultivation for basketry fiber occur in previous centuries, unrecognized or ignored by chroniclers, or did it begin this last century to keep pace with basketry sales?

Beginning with Spier (1928:134-135), there are statements that a longer clawed cultivated variety is introduced rather than being indigenous to the localities where it is grown. Kissell (1916:202) implies that the wild devil's claw in Papago country is seeded in their fields, and that cultivation produces longer clawed fruit with better qualities for basketry.

From the 1930s onward, specimens accompanied by limited ethnographic data were deposited in museums and herbaria (Table 4). Associated field notes are often unfortunately ambiguous. For instance, Percy Train's note that at Moapa, Nevada, devil's claw is "In Indian field," does not clarify whether or not he collected an intentionally planted crop, a self-seeded feral plant, or a wild "weedy" volunteer. Particularly in terms of fruit size, we don't know if collectors chose an atypically large fruit, a representative individual, or a conveniently small fruit that could be "pressed and mounted" easily. Botanists continued to label their specimens with obsolete nomenclature, and of course anthropologists were no more aware that finer taxonomic distinctions wete possible. Fig. 2 maps the sites of cultivation.

Castetter and his colleagues, during their studies of Pima and Papago ethnobotany, amassed considerable information regarding devil's claw cultivation. Yet even their information is ambiguous on some major points, and at times it is contradictory. Castetter and Underhill (1935:57) note that *Martynia fragrans* grows wild in Papago country (sic), but long ago, women began to protect fertile patches of it; later they began to sow its seeds. Castetter and Bell (1942:113) identify as *M. louisianica* both the wild black seeded variety, and the white seeded, longer clawed kind that "never grew wild," but is propagated by planting in holes. They doubted that Pimans who asserted that devil's claw has been cultivated for a long time, and suggested that only wild *Martynia* was utilized before a commercial stimulus increased basketry production.

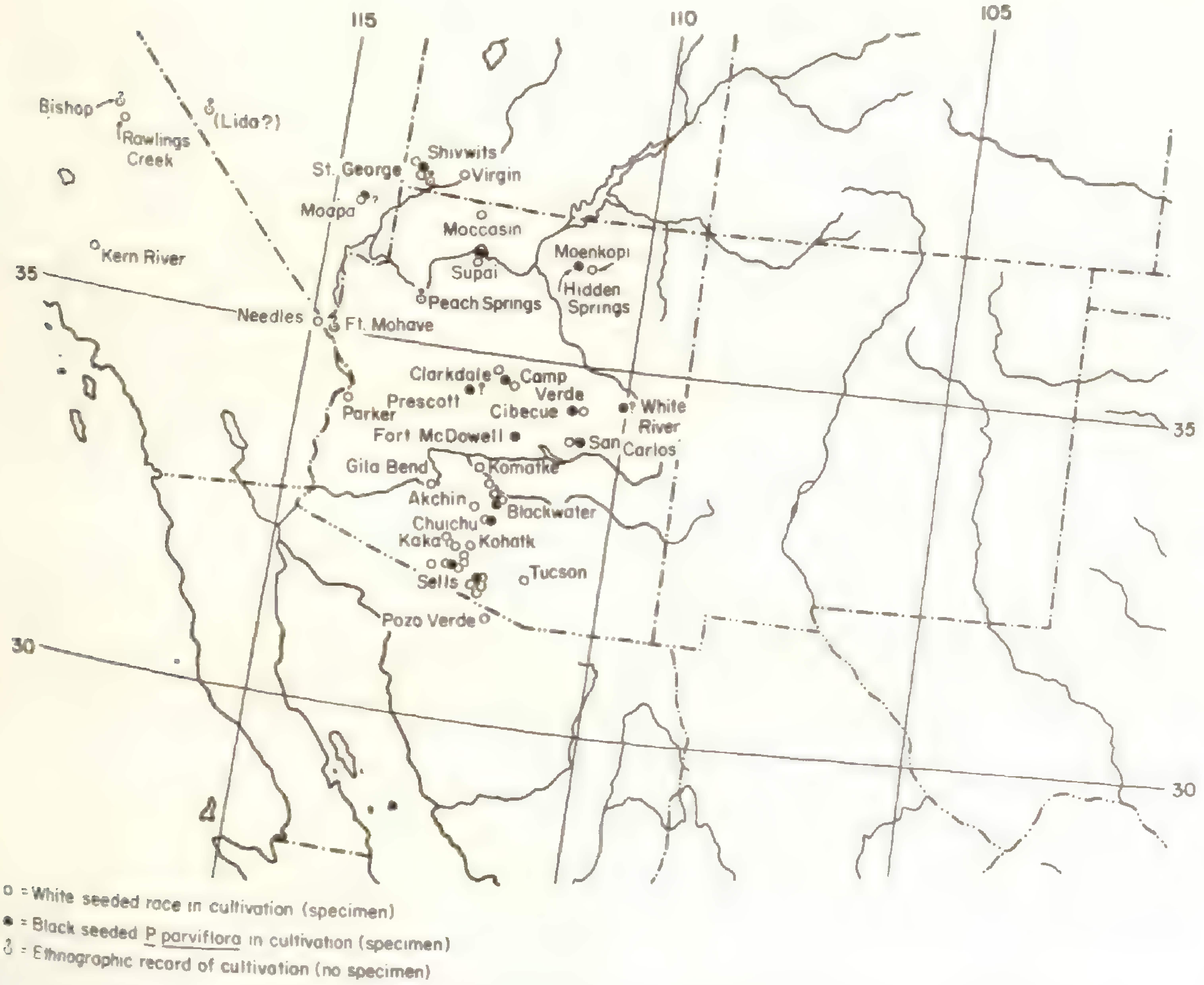

FIG. 2. Locations of devil's claw cultivation by Native Americans (cartography by Alison Habel).

TABLE 4a.—*Possible records of the suggested domesticate in museums and herbaria.*

Original ID	Locality	Culture	Collector & #	Date	Museum or Herbaria	Suggestive Characteristics
M. probosidea	Weldon, Kern Co., Calif.	Tubatulabal Shoshone	E.W. Voegelin #13	7/7/32	UC	"used for black basketry material...
M. louisianica?	Monolith, Paiute Mts. Kern Co., Calif.	Kawaiisu	Zigmond 57/2	7/22/37	F	(no notes on specimen, but Zigmond (1978) suggests it was introduced from Needles, with claw length of 20 cm)
P. louisianica?	Keene, Kern Co., Calif.	Shoshone?	J.D. Woolsey	9/04	UC	"Escaped" (No other notes: inference same as above)
M. louisianica	Moapa Indian Reservation, Clark Co., Nevada	Moapa Southern Paiute	Percy Train #1917	6/6/38	NY, ARIZ	"In Indian field." (Light flower color. Leaves surpassing inflorescence. Rare in wild in Nevada)
M. louisianica	Moapa Indian Agency, Clark Co., Nevada	Moapa Southern Paiute	Eva Murphey #675	9/27/37	RENO, UC	"Garden...Rich soil." (Claws 21 & 24.3 cm; white seed; leaves surpassing inflorescence)
M. louisianica	Virgin, Washington Co., Utah	Virgin River Southern Paiute?	Marcus Jones #6086	9/27/1894	UC, NY, US, MBG	(Rare in Utah. Claws 28, 27, 26, 22.2 cm; leaves large, up to 19 x 17 cm)
M. proboscidea	Havasupai Canyon, Coconino Co., Ariz.	Havasupai	Elzada Clover #5179	7/17/40	ARIZ	"In fields. Used by Indians in basket weaving." (Fruit immature; possibly the wild race, but too young to tell).
P. parviflora	Havasu Canyon, Coconino Co., Ariz.	Havasupai	A.F. Whiting #1047/B4504	10/18-25/40	MNA	Long claw (32.3 cm); white seed. Planted in fields. *halaa' kakiyula* (hooked long). Used in basketry
P. parviflora?	Havasupai Canyon, near Navajo Falls, Coconino Co., Ariz.	Havasupai	C.F. Deaver #4454	10/3/53	NAU	White seed, claws up to 17 cm on immature fruit. Not clear if in fields or beyond.
M. parviflora	Wilkerson Ranch, Rawson Creek, 6 mi so. of Bishop, Inyo Co., Calif.	Panamint Death Valley, Shonshone	R. Enfield for G. Smith	3/14/64	San Bernadino Co. Museum	White seed, claws 25.5 cm. "The Hunters & Buttons cultivated this black-seeded (sic) annual in their gardens."
P. parviflora	Seed from Kitt Peak, Papago Indian Reservation, Pima Co., Ariz.	Papago	Vorsila Bohrer #1257, 1258	10/27/67	ARIZ	"White seed; flowers white with purple spot." (Claws 15.5-25.5 cm.)
Proboscidea	Little Tucson, Papago Indian Reservation, Pima Co., Ariz.	Papago E-74	Wetmore Dodge	to 12/38	ASM	"Cultivated e'hook. The soft variety is white. A white seed is called s-moik..." (claw 27 cm; white seeds).
P. parviflora	Fresnal, Papago Indian Reservation, Pima Co., Ariz.	Papago #7916	R.H. Peebles		ARIZ	"Flowers light purple...Papago name 'Ee' kuk.' Used in basketry." (White seed, claw 21 cm).
Proboscidea	Pozo Verde, Sonora, Mexico	Papago	Edmund Faubert #54-30, 31	11/19-28/74	CRN, INAH	(White seed, claw 18 cm.)

?=Some doubt as to identification due to lack of field notes, or poor quality of specimen.

TABLE 4b.—*Our collections of culturally utilized devil's claw in herbaria.*

Proposed Status	Locality	Culture	Collector & #	Date	Herb	Suggestive Characteristics
Wild	Oraibi, Navajo Co., Ariz. 5,675 ft.	Hopi	Whiting 854 B2851	9/14/37	MNA	Immature. Roadside. Tolerated weed when in fields. Used in kachinas, for awls; associated with lightning and rain bringing. *tumo ala.*
Domesticate	Supai Village, Coconino Co., Ariz 5,600 ft.	Havasupai	Whiting 1047 B4504	10/18-25/40	MNA	Long claws, white seed. Planted in fields. halaa kakiyula-(hooked long). Used in basketry.
Wild	Supai Village, Coconino Co., Ariz. 5,600 ft.	Havasupai	Whiting 1047 B4505	10/18-25/40	MNA	Short claw, black seed. Wild in fields and waste places near the village. Tolerated when self-seeded in fields. Used in basketry.
Domesticate	Clarksdale, Yavapai Co., Ariz. 3,400 ft. Seed grown in Cornville	Apache	Whiting 3099 B24, 344 and 3099 B24, 311	6/19/76, 6/21/76	MNA	Seedlings cultivated from white-gray seed. Cultivated in Clarkdale for basketry fiber.
Domesticate	Supai Village, Coconino Co., Ariz. 5,600 ft. Seed grown in Cornville	Havasupai	Whiting 3099 B24, 343 from R.C. Euler	7/23/76	MNA	White seed, low claws. Cultivated in Supai for basketry fiber.
Domesticate	Topowa, Pima Co., Ariz. 2,474 ft.	Papago	Bretting and Nabhan x465	8/14/76	ARIZ	Volunteer in garden with squash, being watered to produce fiber for basketry. Pale flower. Large leaves.
Domesticate	Anegam, Pima Co., Ariz. 2,400-3,000 ft.	Papago	Bretting and Nabhan x467	8/14/76	ARIZ	White seed, long claws, pale flowers. Planted and irrigated in dooryard garden; also volunteers watered and tolerated in watermelon patch. Grown to sell to basketmakers.
Domesticate	Chiawuli Tak, Pima Co., Ariz ca 2,500 ft	Papago	Nabhan x526B	10/1/76	ARIZ	Cultivated annual up to .8 cm tall x 1.5 m diam. White seeds, claws 24 cm. Corolla color variable in population. Grown in 15 x 15 m patches in rainwater-fed field. *I-hug.*
Domesticate	Coolidge-Gila River Reservation area, Pinal Co., Ariz. Seed grown in Tucson	Pima	Nabhan 585	7/26/76	ARIZ	Corolla white, with purple on lobes, seed white, leaf 22 x 16 cm. Cultivated for basketry fiber by Gila Pima.
Domesticate	Komatke, Maricopa Co., Ariz. 1,040 ft. Seed grown in Tucson	Pima	Nabhan 584	8/1/76	ARIZ	Corolla white, with purple on lobes, claws 24 cm, seed white, leaf 16 x 16 cm. Cultivar grown for basketry in "old fields."
Domesticate & cultivated wild	San Simon, near Tracy, Pima Co., Ariz.	Papago	Nabhan x534	10/76	ARIZ	Both long clawed (18 cm) white seeded race and black seeded "wild type" (13.5) cultivated in garden behind house. Irrigated. Grown to sell as basketry fiber.
Wild	Santa Rosa, Pima Co., Ariz.	Papago	Nabhan x535	10/76	ARIZ	Wild plant .4 m tall, claws 14 cm avg., black seed. In Santa Rosa wash.
Feral Domesticate?	Santa Rosa, Pima Co., Ariz.	Papago	Nabhan x569	10/76	ARIZ	White and gray seed in claws 12.5 cm avg. On semi-erect plant in roadside disturbance area with *Cucurbitas* and *Amaranthus*. Presumed to be feral or genetically influenced by domesticates grown nearby.
Wild	Santa Rosa, Pima Co., Ariz.	Papago	Nabhan x570	11/76	ARIZ	Dark seed, claws 27 cm. avg., wild plant 100 m from closest houseyard (where domesticate is grown). In depression on side of dirt road.
Wild	Supai Village, Coconino Co., Ariz., 5,600 ft. Seed grown in Tucson	Havasupai	Nabhan 584-II from R.C. Euler	8/1/76	ARIZ	Corolla white, claw 17 cm., black seed. Wild around village.

TABLE 4b. continued.

Proposed Status	Locality	Culture	Collector & #	Date	Herb	Suggestive Characteristics
Domesticate	Ak-chin near Maricopa, Pinal Co., Ariz. Seed grown in Tucson	Papago	Nabhan 662 from Fritz & Nabhan 617a	8/5/77	ARIZ	Corolla, pale cream; infl. surpassed to equalling foliage, white seed. Grown in backyard, with watering, for basketry fiber. *E hook.*
Wild?	Blackwater area, Pinal Co., Ariz. 1,400 ft. Seed grown in Tucson	Papago?	Nabhan 663 from 610d	8/5/77	ARIZ	Black seed, 4 carpelled fruit, claws short. Leaves smaller than domesticate, flowers pale, infl. equalling or surpassed by foliage. Produces fruit with 2, 3, and 4 carpels. Obtained from Blackwater Trading Post.
Domesticate	Chuichu, Pinal Co., Ariz. 1,400-1,500 ft.	Papago	Nabhan 664 from 568b	8/5/77	ARIZ	Corollas pale cream, infl. surpassed by or equalling foliage, white seed. Grown in yard for basketry fiber. *E hook.*
Black seeded incipient domesticate	Cibecue, Navajo Co., Ariz. 4,940 ft.	Cibecue Apache	Nabhan 665	8/9/77	ARIZ	Corollas pale, claws extremely long, seeds black. Apaches report white seeds in population too. Apparently some grown, some weeds. In field with maize, beans, sunflowers. Used in basketry.
Wild	Below Old Oraibi, Navajo Co., Ariz. 5,400 ft.	Hopi	Nabhan 1035	8/15/78	ARIZ	Apparent agrestal volunteer in sandy plowed field of cucurbits, below mesa. Short claws, black seeds.
Wild?	5 mi. east of Cibecue, Navajo Co., Ariz. 6.600 ft.	Apache	Nabhan 1032	8/12/78	ARIZ	Apparent volunteer in dry farmed cornfield; not seen in surrounding wild lands. Immature seedlings; synaptospermous from old fruit.
Domesticate	San Carlos, Gila Co., Ariz. 5,300 ft.	Apache	Nabhan 1031, 1007 Nabhan 1007	8/12/78; 7/16/78 7/16/78	ARIZ ARIZ	Dooryard garden, intentionally cultivated. Plants .7 m tall, large leaves, pale flowers, prolific. Used in basketry.
Domesticate	Little Tucson, Pima Co., Ariz. 2,400 ft.	Papago	Nabhan 863b	8/4/78	ARIZ	Dooryard garden. Pale flowers, large fruit. Plants .5 m tall. *I-hug.*
Wild	Whiteriver, Navajo Co., Ariz. 5,300 ft.	Apache	Nabhan 1013	7/17/78	ARIZ	Apparent volunteers in maize and beanfield, 312 plants in 50 m. Black seeds, short claws. Harvested for fiber.
Wild	San Carlos, Gila Co., Ariz. 5,300 ft.	Apache	Nabhan 1005	7/16/78	ARIZ	Roadside by field, volunteer weed. 30 cm tall, 1.3 m across. 1mm fruit, pale flowers.
Wild	San Carlos, Gila Co., Ariz. 5,300 ft.	Apache	Nabhan 1006	7/16/78	ARIZ	Volunteer, thick, weedy patch in maize field. Pale flowers, black seed.
Wild	Fresnal Village (Chiwuli Tak) Pima Co., Ariz. 2,500 ft.	Papago	Nabhan 705	9/11/78	ARIZ	Volunteer in fallow field. Red-purple to cream flowers, black seeds. 15-45 cm tall.
Domesticate	Supai Village, Coconino Co., Ariz. 5,600 ft.	Havasupai	Nabhan 899	8/22/78	ARIZ	In plowed field. Flowers unusually pale. Fruit immature. Used in basketry. Plant 1.5 m tall x tall x 2 m across *Halak(a)*
Wild	Supai Village, Coconino Co., Ariz. 5,600 ft.	Havasupai	Nabhan 889	8/19/78	ARIZ	Diversion-irrigated field. Plants 1m tall, black seeds, smaller fruit than domesticate, in mixed patch of both races.
Domesticate	Supai Village, Coconino Co., Ariz. 5,600	Havasupai	Nabhan 890	8/19/78	ARIZ	Diversion irrigated field. Plants 1-1.5 m tall, white seeds, claws as much as 30 cm. In mixed patch of both races.

TABLE 4b. continued.

Proposed Status	Locality	Culture	Collector & #	Date	Herb	Suggestive Characteristics
Wild?	Supai Village, Coconino Co., Ariz. 5,600 ft.	Havasupai	Nabhan 900	8/20/78	ARIZ	In plowed field. White corolla with purple and yellow. Fruit immature. Plant 1.5 m tall x 2 m across. Apparently feral and protected. Used in basketry. *Halak(a)*
Feral Domesticate?	Peach Springs, Mohave Co., 4,800 ft.	Havasupai, Walapai	Nabhan 904	8/21/78	ARIZ	Immature seedling feral in yard of Sarah Cook, Havasupai basketmaker among the Walapai. Probably volunteer from fruit brought up from Supai.
Feral Domesticate?	Lower Moenkopi, Coconino Co., Ariz. 4,777 ft.	Hopi	Nabhan 884	8/15/78	ARIZ	River diversion bean and melon field. Agrestal or protected plant, apparently not intentionally sown. Plants 1.5 m across, large fruit, white seeds, leaves 25 x 23 cm. Used by Hopi woman making Paiute baskets. *Tumoala.*
Feral Domesticate?	Lower Moenkopi, Navajo Co., Ariz. 4,777 ft.	Hopi	Nabhan 1102	8/23/79	ARIZ	Not intentionally planted. Scattered in tepary plot. Plants 4 m tall, 1.7 m across. White seed,; claw 36 cm, body 11 cm.
Feral Domesticate	Kaibab, Mohave Co., Ariz. ca. 4,600 ft.	Kaibab So. Paiute	Nabhan 1106	8/24/79	ARIZ	Volunteering plants in partially cultivated, irrigated field. Plants .35 m tall. White seed, claw 20.8 cm, body 9.9 cm.
Feral Domesticate or wild?	Shivwits to Irving Rd., Washington Co., Utah, ca 4,000 ft.	Paiute? or none	Nabhan 1113	8/25/79	ARIZ	Volunteering plants in meadow/field, scattered. Plants 1 m tall, 2.2 m across. White seed, claw 36 cm long.
Wild under Cultivation	Shivwits, Washington Co., Utah ca. 4,000 ft.	Shivwits So. Paiute	Nabhan 1114	8/25/79	ARIZ	Apparently intentionally cultivated. Plants up to .7 m tall. Black seed, claw 18 cm long.
Domesticate	Shivwits, Washington Co., Utah ca. 4,000 ft.	Shivwits So. Paiute	Nebhan 1115	8/25/79	ARIZ	Cultivated and tended, in tomato field. Plants .5 m tall, 2 m across. White seed, claw 23 cm long
Wild	Fort McDowell, Maricopa Co., Ariz. 1,400 ft.	Yavapai (& Apache?)	Nabhan 1021	7/24/78	ARIZ	Roadside near field. Black seeds, claw 20 cm. Plants 30 cm tall. *Helagah.*
Wild	2 mi. west of Casa Blanca, Pinal Co., Ariz. ca. 1,200 ft.	Pima	Nabhan 1018	7/24/78	ARIZ	Ruderal weed between road and cottonfield. Plants .5 m tall, 1 m across. Black seeds.
Wild	Middle Verde, Yavapai Co., Ariz., ca 3,200 ft.	Yavapai-Apache	Nabhan 1025	7/25/78	ARIZ	Tolerated agrestal weed in irrigated, mixed crop field. Flowers dark pink and purple Fruit moderately long with black seeds.
Domesticate	Queen's Well, Pima Co. Ariz. ca. 2,500 ft.	Papago	Nabhan 1029	8/1/79	ARIZ	Hand irrigated dooryard garden. Pale flowers, immature plants. White seed obtained from owners. Fruit used as basketry fiber. *I-hug.*

Castetter and Bell's conclusions were based primarily upon several interviews between 1938-40; we have not come across any voucher specimens collected by them, or notes on the plants themselves. In the interviews, only the white seeded variety is noted as being cultivated, and only the black seeded variety is mentioned as growing away from fields. For one interview, notes imply that a Pima farmer responded negatively to the question of whether his people cultivated wild plants, but later acknowledged that devil's claw is cultivated (Castetter 1939:44). Dobyns (1952:211) concluded that the Papago had domesticated devil's claw based on similar (unpublished) observations.

Yarnell (1977) has concluded that the distinctive characteristics of the cultivated form described by Castetter and Bell—white vs. black seeds, longer "pods," plus finer grained and deeper black pod-epidermis—justify its status as a cultigen. He suggests that several centuries of artificial selection is a reasonable estimate for the duration of the domestication process in devil's claw. Yarnell also hypothesizes that the original motivation for cultivation was possibly the food-value of the pods and seeds, and that more recently, cultivation has emphasized basketry material production. He does not mention the presence of the domesticate in culture groups other than the Pima-Papago.

We feel that with the limited data which Yarnell had available, it would be difficult to refute 2 arguments against his conclusion: 1) How do we know that the white seeded variety is not another "wild" species of devil's claw imported into the area, which is cultivated while the other indigenous species are not? 2) How do we know that cultivation practices alone do not result in the longer, finer claws? Could the white seed color be due to the early harvesting of cultivated fruits, which would keep the seed from ripening to a black color? Thus, is it the treatment of the plants rather than distinct genetic material due to domestication which account for the apparent differences?

TABLE 5.—*A comparison of relative association with man-made habitats of two races of* Proboscidea parviflora.

HABITAT	WILD RACE BLACK SEEDS	DOMESTICATES WHITE SEEDS
A. Undisturbed or protected range	N=23	N=18
B. Minimally-managed & grazed range or deserts	+	
C. Overgrazed & manipulated range	+	
D. Floodplains	13%	+
E. Riverbeds & arroyo channels	17.3%	5.5%
F. Managed meadows & corrals	4.3%	
G. Roadsides, paths & cleared areas	30.1%	11%
H. Abandoned fields	4.3%	5.5%
I. Dumps, houseyards (uncultivated) & plant-processing areas	4.3%	11%
J. Cultivated *temporal* (runoff) fields	13%	5.5%
K. Cultivated irrigated fields	+	5.5%
L. Cultivated (kitchen) gardens	13%	55%

(Documentation from specimens collected in Pimeria Alta: southern Arizona and northern Sonora. Method based on index for comparing weediness in related plant taxa (Hart 1976). "+" indicates lack of specimen, but valid observation.)

Additionally, we have discovered that Castetter and Bell's "clean" correlation of white seeds with agricultural fields, and black seeds with "wild" environments does not hold true in Pima-Papago country today (Table 5). We have located several fields and gardens where Indians are propagating black seeds, and have also found white seeded fruit on plants growing away from fields, although always within Papago *rancherias*.

We therefore doubt that Yarnell's inductive reasoning that *Proboscidea parviflora* must be domesticated has really settled the matter. His contribution is, on the other hand, that he has brought the suggestion of domestication of a native arid land plant to the attention of a wider audience. We would like to answer his challenge, by providing a methodology for evaluating whether devil's claw, or any other plant, has been domesticated.

Domestication: Definitions and Testable Principles

In using the term *cultivated plant*, people often confuse the process of cultivation (i.e., planting, and tending plants and their environment) with the status of the plant itself. By the plant's status, we mean whether or not its genotype is different from the genotype of plants growing in the wild. A propagated plant may have the same genotype as untended plants in the wild, even though the conditions in a garden environment may influence its phenotype so that it appears different. When the genotype is different due to direct human influences, the plant is often termed a cultivated (or better), domesticated plant.

In order for us to consider the status of devil's claw, it is necessary to be more specific about our use of the term *domesticate*. Indeed, there are numerous definitions and descriptions of what a domesticated plant is (Table 6). Utilizing different definitions, one might actually come to conflicting conclusions regarding which of the world's plants are domesticated.

As a foundation for our study, we will use the explanation offered by Harlan (1975:63-64): "In the case of domesticated plants and animals, we mean that they have been altered genetically from their wild state and have come to be at home with man. Since domestication is an evolutionary process, there will be found all degrees of plant and animal association with man and a range of morphological differentiation from forms identical to wild races to fully domesticated races. A fully domesticated plant or animal is completely dependent upon man for survival. Therefore, domestication implies a change in ecological adaptation, and this is usually associated with morphological differentiation."

To this basic explanation, it must be added that the intended human influences such as selection of desirable characteristics are joined by "accidental" or indirect selective pressures (Baker 1972:32). The most significant indirect human influence is the modification of environments, particularly the maintenance of agricultural environments, where plants then undergo "natural" selection.

This process of natural selection in and adaptation to agricultural environments may begin before the plants are actually cultivated. Whitaker and Bemis (1975:367-368) point out that plants adapted to disturbed soils may rapidly increase their geographic ranges by following man and his edaphic disturbance; this in turn affects their genetic variabilities. They hypothesize that certain cultigens evolved a high degree of dependence upon manmade conditions, as well as numerous protentially useful characteristics, before humans began to cultivate and directly select these characteristics.

Because so many economic characteristics of domesticated plants can develop without direct human selection, and are in fact common in agricultural weeds, we must be cautious in utilizing these characteristics as indicators of domestication. Thus the presence of any subset of indicative features in a plant cannot "prove" in itself that domestication has occurred. The data must be viewed within the context of plant's natural history and use, known instances of selection, and other factors. Otherwise, we may be contrasting a weedy race of a species with a less opportunistic race in a manner in which the weedy race appears to be a domesticate.

TABLE 6.—*Domestication: Alternative definitions and explanations.*

Quotation	**Citation**
"domestication ... complete and regular reproduction of the species through more or less controlled and selective breeding in the company of man.	Meggitt 1965:23
... the crucial feature of domestication is man's control over the breeding of his domesticates. He improves his crops by sowing only selected seeds ...	Watson and Watson 1971:5
Domestication implies that the plants or animals have been manipulated to such an extent that genetic changes have occurred resulting in new races or species ... Cultivation, with the attendant element of human selectivity, conscious or unconscious, frequently results in genetic changes. Even so, there will be an intermediate stage where plants are sown and harvested but show no morphological changes. Helbaek ... has therefore distinguished between 'cultivated' plants that have been sown and harvested but show no morphological alternations, and 'domesticated' plants where morphological change has occurred.	Bender 1975:1.52
... domesticates show both intended and accidental results from human actions, including selection.	Baker 1972:32
The stages of domestication are as follows: a) loose contacts, with free breeding. b) confinement to human environment, with breeding in captivity. c) selective breeding organized by man, to obtain certain characteristics, and occasional crossing with wild forms. d) economic considerations of man leading to the planned 'development' of breeds with certain desirable properties. e) wild ancestors persecuted or exterminated.	Zeuner 1963:63
The cultivated plant never originates directly from the wild species, in perfect form, but evolves step by step over a long period of time. The farther it has come along, that is, the earlier it was taken under cultivation or the more intensely bred and selected, the fewer wild characters will be found in it ... Their occurrence [wild-plant characters] in cultivated plants must thus be taken as a sign that a plant has not yet completed its evolution from a wild species to a cultivated plant.	Schwanitz 1966:63
The most immediately apparent change under domestication is in morphological characters such as size, shape and color, particularly of the part of the plant used by man ... Up until now, crop plants have not evolved by any processes different from those operating in wild plants. The ultimate source of variability is mutation ... The new forms produced are then subject to selection, but in crop plants new variants have to pass the test of human selection as well as, or sometimes instead of, natural selection.	Pickersgill and Heiser 1976:55

Nevertheless, we have gleaned from the literature a number of morphological and ecological characteristics which commonly change through the process of domesticating a plant (Table 7). Hypothesizing that these changes would occur in any *Proboscidea* if domesticated, we can use these indicators to examine the "real life situation." Individual characteristics which may be found in any useful plant, wild or cultivated, or in weeds, will be interpreted in light of these other possibilities.

We have made 2 major assumptions in applying these indicators to the problem of possible *Proboscidea* domestication. We have assumed that if devil's claw has been domesticated, the process increased the quantity or quality of the products which have been most pervasively and intensively utilized—the fiber in the dried fruit, and the seed. Thus we

TABLE 7.—*General trends in plant domestication, in reference to devil's claw.*

	Apparent difference in white seeded race	Should change if domesticated		Change possibly due to deliberate human selection	Change possibly to selective pressures associated with harvest	Change possibly due to selective pressures in cultivated environment	General trend in domestication process discussed in
		for seed	for fiber				
Feature							
Disproportionate enlargement of desired plant produce	X	?	X	X		X	Schwanitz 1966:30; Baker 1972:32; Harlan 1975:137
Increase in leaf size	X	X	X			X	Schwanitz 1966:14, 21
Increase in size of other parts	X	X	X			X	Schwanitz 1966:14, 28
More determinate growth habit				X	X	X	Harlan 1975:137; Baker 1972:33
Change in color of product	X	X	X	X			Harlan 1975:138; Yarnell 1977
Change in texture of product	X						Harlan 1975: 138
Change in protein/carbohydrate ratio (usually a decrease)	?	X		X		X	Harlan 1975:127, 131
Reduced toxicity of edible parts							Baker 1972:33; Schwanitz 1966:28-42
Loss of differential dormancy (or of germination-delaying mechanisms)	X	X	X			X	Baker 1972:34; Harlan 1975:132; Schwanitz 1966:43
More uniform maturation, more simultaneity in ripening					X		Schwanitz 1966:44; Harlan 1975:127
Difference in life span	?				X	X	Schwanitz 1966:44-44
Greater yield of desired produce	X	X	X	X		X	Schwanitz 1966:29; Baker 1972:34
Loss of natural seed dispersal mechanisms, or of synaptospermy		X		X	X	X	Schwanitz 1966:32; Baker 1972:34; Pickersgill and Heiser 1976:60
Greater frequency of unusual variants surviving	?	X	X	X		X	Harlan 1975:138; Pickersgill and Heiser 1976:60
"Bottleneck effect" in overall genetic variability	X	X	X			X	Pickersgill and Heiser 1976:60-61

hypothesize that devil's claw was domesticated either for basketry material, for a food product, or for both, and not for other reasons: its value as an ornamental or religious item, the use of the young fruit as a vegetable, etc.

Secondly, we have decided to compare the white seeded, supposedly longer clawed devil's claw cultivated by Southwest Indians with the 3 most common annual *Proboscidea* in the Southwest. In particular, most of our quantitative comparisons are with wild *Probosicidea parviflora*, as it occurs in Arizona spontaneously, and when brought into cultivation.

In doing so, we have ruled out that the annual white seeded devil's claw 1) belongs in another genus; 2) is more closely related to *Proboscidea* perennials in either subgenus; 3) is more closely related to other annual *Proboscidea* in the Southwest, or elsewhere.

Our emphasis on comparison with Arizona populations of *Proboscidea parviflora* is in part due to logistics, since that material is more readily available to us. However, Table 1 makes evident that the white seeded devil's claw is more phenetically similar to wild *P. parviflora* than to *P. fragrans* or *P. louisianica*, as we understand these taxa today. Furthermore, Yarnell's suggestion that the white seeded devil's claw is a *Proboscidea parviflora* cultigen warrants our most critical attention. We will nevertheless note similarities to *P. louisianica* and *P. fragrans* whenever possible, and allow as an alternative hypothesis the development of the white seeded devil's claw from interspecific hybridization or introgression (Fig. 3).

Finally, following Harlan and DeWet (1971:509-517), we will avoid using the terms variety, cultivar, line, strain, type, or kind for the rest of the discussion, due to their indiscriminate use in the past. Temporarily, we will refer to the suggested domesticate simply as the "white seeded race" of *Proboscidea*, without assuming that it is a domesticated, weedy or spontaneous race of any particular species. Also, for the purposes of brevity, we will refer to all black seeded *P. parviflora* as the *P. parviflora* spontaneous race, even though there may conceivably be domesticated or weedy black seeded races which we are ignorantly lumping into this one category. We will also refer to the spontaneous race as wild or typical black seeded *P. parviflora*, depending upon the context.

Skewed Distributional Range

The geographic range and ecological niche which the white seeded race occupy should be regarded in light of the distribution of wild *Proboscidea* in general. Yet it is somewhat difficult to determine the "natural" distributional range of annual *Proboscidea* spp. in the Southwest. Whereas there are "core geographical areas" where each species is commonly found (Table 1), the intrinsic dispersibility of their fruit has allowed them to be transported by animals (including man) to many isolated localities far away from these cores.

Large native herbivores undoubtedly participated in the long distance dispersal of devil's claw to disjunct localities even before man and his domesticated animals became involved in this process. Natural historians have described the shape of devil's claw fruit as one ideally adapted to catching and persisting in the fetlocks of ungulates. They have hypothesized that this mechanism was responsible for the dispersal of *P. louisianica* to South Africa, and to a locality in Great Britain (Bancroft 1932:62-64).

The habitats which annual devil's claw frequent are often corridors which allow further geographical extension of their range by animal, water or wind transport. The habitat preferences of the 3 species of annual *Proboscidea* indicate adaptation to sporadically disturbed soils, particularly the sandy loams of floodplains and gravels of roadsides. Historic human modification of Southwestern floodplain environments, particularly through agriculture and road-building may have dramatically altered distributions from prehistoric times. Additionally, such modification maintains niches with disturbed soil where deliberately transported plants such as *P. louisianica* in the Palm Springs area, can establish themselves after escaping from cultivation (Robbins 1940: 86)

Although the distribution of the *P. fragrans, P. louisianica* and *P. parviflora* remain

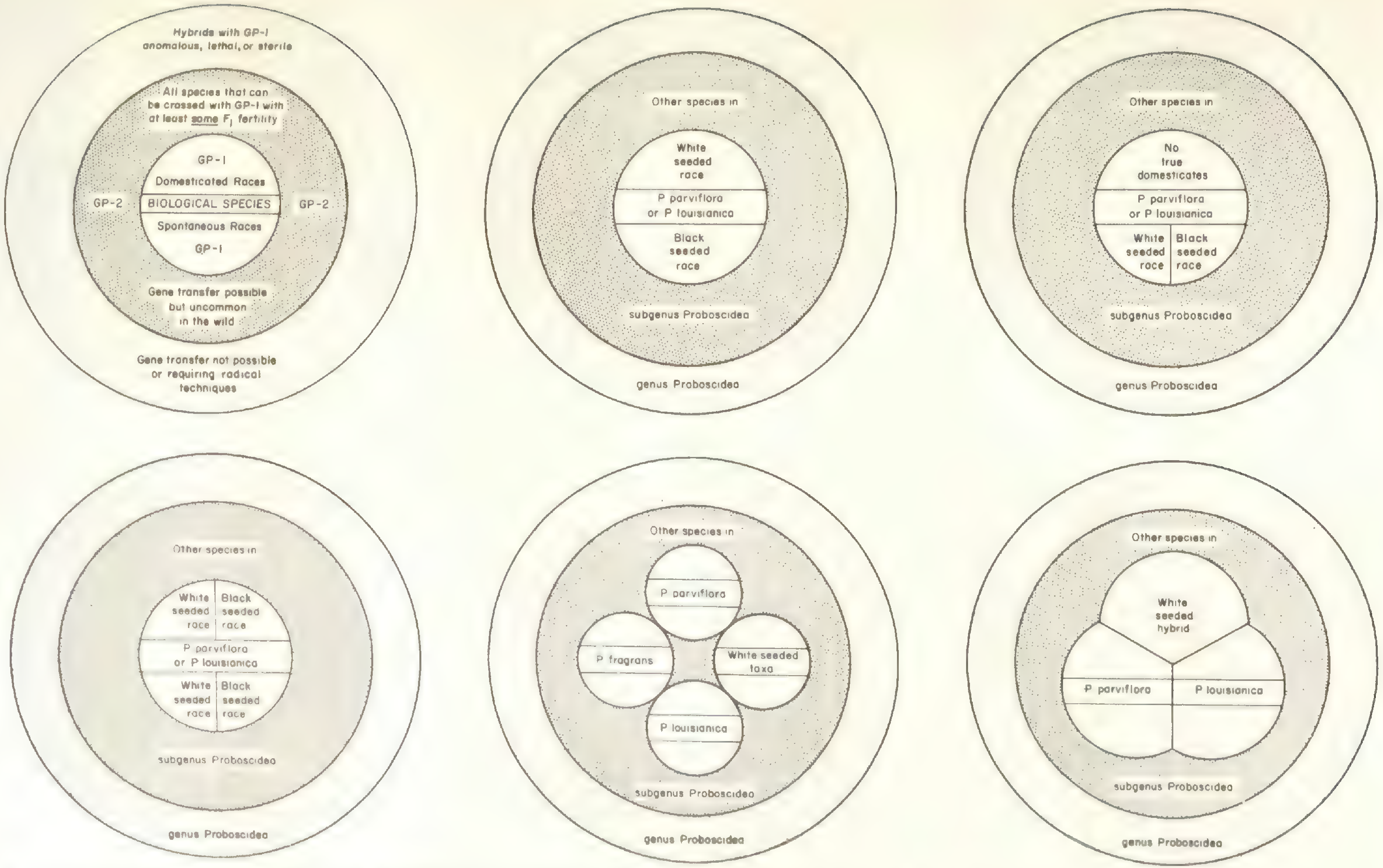

FIG. 3. Alternative hypotheses for gene pools relationships to the domesticate. Legend in upper left follows Harlan (1975).

problematic, the range of the white seeded race is nevertheless peculiarly skewed in relation to them: 1) it is highly specific to the *rancherias* of native peoples of the Southwest's true deserts and nearby uplands. 2) It appears to extend northwest beyond where annual *Proboscidea* is commonly found in the wild in northern Arizona, southeastern California, and southern Nevada. 3) Its range overlaps to the greatest extent with the range of *P. parviflora*.

Today, the black seeded annual *Proboscidea* are strongly associated with man-disturbed environments, yet the degree of association is even higher for the white seeded race. A survey of annual *Proboscidea* specimens collected in one particular area—the aboriginal territory of Northern Piman groups in Arizona and Sonora—illustrates this point (Table 5). All available seed or herbaria specimens with detailed habitat notes were utilized to compare the location of the white seeded race and spontaneous *P. parviflora*, regardless of whether or not they were cultivated in those locations.

Although the presence of *P. parviflora* in fields and on pathways around human settlements indicates weediness and dependence on human disturbance, it ranges beyond these habitats to a greater extent that the white seeded race does. Beyond cultivated fields and yards, the white seeded race has only been collected within disturbance habitats in *rancherias*.

Although it is not possible to prove that all these plants are recent "escapes" from cultivation, subjective information suggests that the plants are feral cultivates. Papago informants have volunteered that white seeded plants growing in their yards "planted themselves" from seed that blew over from nearby devil's claw processing areas (see Table 8, for processing site explanations). In both cases, large stands of the white seeded race were cultivated within the *rancheria*.

If the white seeded race were domesticated from *P. parviflora*, it is possible that the status of black seeded races as agricultural weeds played an intermediate role in this process. Since black seeded *P. parviflora* is considered a tolerated weed in fields beyond the range of devil's claw cultivation today—among the Hopi and Apache in Arizona (Whiting 1939:92 and Anonymous 1976), and among mestizos in eastern Sonora—it is doubtful that in this case a weed race evolved as a result of introgression betwen domesticated and spontaneous races (see Harlan 1965:173-176).

Finally, the white seeded race, because it can grow without intentional planting by man, is not an obligatory cultivate or cultigen. According to Harlan's definition, it can not be a fully domesticated plant in the strict sense, since it can survive to some extent without direct dependence on man.

Seed Characteristics

If domesticated for the food value of its seed, devil's claw should have undergone changes in several of a number of characteristics, including a) number of seed per fruit; b) seed size; c) change in the nutritive value of the seed; d) change in seed coat color or texture; e) change in seed dispersal pattern; and f) loss of germination-delaying mechanisms. Several of these characteristics might also be affected if devil's claw was domesticated for the fiber in its fruit, particularly c, e and f.

We compared the number of seed per fruit in the white seeded race (n=69, from 4 populations), with the number in black seeded *P. parviflora* (n=50, from 3 populations), there is no statistical difference at the .05 level for the 53.0 + 9.8 seed per fruit of the white seeded race, and the 53.9 + 8.3 seed per fruit of the black seeded race.

These sample sizes are relatively small, and the populations analyzed do not allow considerations of variation within the region. From these data alone, however, it is apparent that there are no major differences in the seed number of the 2 kinds of fruit. We will therefore assume that the number of seed per fruit in the white seeded race has probably not been determined by deliberate human selection, or modified by selective pressures associated with cultivation and harvest.

TABLE 8.—*Behavioral chain for Pima and Papago use of devil's claw.*

Purpose	Activities		Material Correlates	Time/Frequency	Location	Wastes
To insure supply of fruit for processing	Broadcast or plant seed in holes 5 cm; clear weeds in 1 m circle around hole.	Find wild population nearby on floodplain & protect	Hoe or dibble stick; brush	May or later	Floodplain or garden	Weeds
To acquire fruit when still pliant & prior to weathering	Harvest green fruit when claw tips become sharp			Before first frost	In field or in wild	Unusable fruit (too small or deformed)
To keep fruit pliant	Pile green fruit in sun, cover with ash, let dry (Papago)	Soak in pottery bowl (Pima)	Ashes, or water and containers	Usually fall, for a week	Fieldside or by house	Ashes
To straighten & keep usable fruit for future use	Husk fruit of remnant epidermis; hook dried fruit into hoop			After drying	Same	Husked epidermis, & broken fruit
To preserve for later use	Hang or cover hoop		Twine or cover	Fall & after	Under ramada	
To soften & ready dried fruit for splint-making	Unhook desired number of claws; soak in bowl	Unhook small number of claws; bury in sand & drench	Bowl or bucket; water	As needed, overnight or 2 days	Near house	
To strip splints of fibers from fruit	Slit claw tip with awl, & run awl under fiber. Peel 2 fiber splints off with teeth, from tip to claw/body transition		Awl or knife, teeth	After soaking	Ramada work area	Imperfect, torn splints
To store splints for future use	Bind splints into a bundle		Twine	While stripping	Same	
To thresh seeds from splinted fruit		Beat with stick & pry open	Stick, fingers	Anytime	Near house	Splinted, deseeded fruit
To eat seeds (snack)		Crack seedcoat	Teeth	Anytime	Same	Seedcoats
To ready splints for immediate use	soak in bowl		Bowl & water	As needed	House or ramada	
To tape splint for use	Pull splint through hole in can (after 1918)	Scrape with knife and/or rock tool	Tin can or rock, & knife	Just prior to use in basket	House or ramada work area	Splint scrapings, rock tool
To work splints into basket design	Cross under previous splint, wrap around rod, snip off or tuck under where design ends		Awl, pick or knife	As needed	Same	Snipped splint remains

In terms of seed size, the 3 annual species of *Proboscidea* with which we are concerned, all fall within the general range of 7-11 mm long x 4-6 mm wide x 2-4 mm thick. Size of a particular seed is affected by its place in the ovary, as well as by maturity of the fruit and other factors. Size variation within a fruit is considerable.

We measured seed sizes of all seed in only 2 average-sized fruit of the white seed race, and 2 averaged sized fruit of black seeded *P. parviflora*, grown in the same irrigated field. Mean sizes and ranges at one standard deviation are given in Table 1. These data suggest a slightly greater volume of the white seeds, but without a substantial sample, we will refrain from further speculation. A severalfold difference in seed volume, such as that between domesticated beans and their wild progenitors, is nevertheless not evident with these devil's claw.

In terms of nutritive value, *Proboscidea* seed are non-toxic with high oil and protein content. Because of interest in the 1950s in developing devil's claw into a commercial oil seed, numerous chemurgic analyses of Southwestern *Proboscidea* were undertaken. After compiling protein and oil values in the literature (Earle and Jones 1962: 245; Ghosh and Beal 1979:748), we see that the seed of Southwest annuals normally range between 35-43% oil, and 20-35% protein.

Two acquisitions of the white seeded race and one of the black seeded *P. parviflora*, grown in the same irrigated field in 1976, have been analyzed by nutritional biochemist Dr. James Berry. The white seeds cultivated by the Pima contained 40.3% oil and 25.5% protein, values remarkably high for *Proboscidea*. The white seeded race cultivated by the Havasupai, and the black seeded race originally growing wild in their area yielded 39.2% and 38.3% oil, plus 23.9% and 23.2% protein respectively (Barry et al. in press). Thus the white seeds apparently have a slightly higher nutritional content that black seeded *P. parviflora*, or at least they are at the high end of the range for *Proboscidea*. It is possible that selective pressures in the cultivated environment, or deliberate human selection for the fruit or seed have resulted in relatively more energy being funnelled into these reproductive parts of the plant.

We mentioned earlier that the white-gray seed coat of the commonly cultivated race is atypical for the genus *Proboscidea*. In analogy, Yarnell (1977) has pointed out that lighter colored seed distinguishes domesticated *Amaranthus* from its wild progenitors. In devil's claw, it can either be hypothesized that 1) natives found this character in the wild, and brought it into cultivation; 2) it was expressed after selective pressures associated with harvesting were initiated, or 3) it is a function of the greater frequency of variants, including recessives, which survive in cultivated environments.

It is probable that the lighter color is determined by one or a few major genes, i.e., it is a quantitative character. A crossing program to determine the inheritance of characters such as this is now in progress (Peter Bretting, personal communication). Seed coat morphology study by electron microscope has not yet identified any differences between races.

In terms of seed dispersal, Sappenfield (1954:1) has calculated that approximately 10% of wild *Proboscidea* seed "shatter," or drop as the fruit dry and the claws split and curl. From our simple observations, we estimate that roughly 4-12% of the fruit's total seed are released as the white seeded fruit begins to dehisce. In spite of these crude estimates, we doubt that there are major differences in the seed dispersal of the various races and species. Certainly, there is not a dramatic difference in fruit dehiscence as there is between wild and domesticated legumes (Harlan 1975:138-139).

Germination delaying mechanisms in wild *Proboscidea* include 1) germination inhibitors of the seed and 2) the leathery-textured ovary walls behind which the seed are trapped unless the fruit is physically torn apart. Through differential dormacy wild *Proboscidea* spp. avoid "putting all their eggs in one basket;" the proverbial basket here being the unpredictable moisture conditions of the Southwest.

Anderson (1968:171) has determined that the germination inhibitors in wild *Proboscidea* include a) seed coat thickness; b) a water soluble chemical inhibitor in the seed coat; and c) a dark requirement, or light sensitivity factor in the embryo. Because of these inhibitors, agronomists have had difficulties getting good field germination with wild *Proboscidea* brought into cultivation (Quinones, personal communication).

Our attempts at utilizing a standard laboratory test to determine possible differences in rate and per cent of germination were somewhat unsatisfactory. At 85° and then at 90°F, we obtained 40% germination in one sample of the white seeded race, but there was no germination of one other sample of white seeds, and 2 samples of black seeded *P. parviflora* (n=25, at each temperature).

Our field plot observations indicate some difference in per cent emergence under irrigated conditions. In 1977, one month after an April 21 planting, 65% of the white seed had emerged (n=55, from 9 acquisitions) and 16% of the black seed of 2 *P. parviflora* had emerged (N#25, from 4 acquisitions).

We suspect that the white-seeded race may have lost at least one of its germination inhibitors, possibly due to long term selective pressures associated with planting seed, and utilizing seed from plants in surviving cultivated populations. Further paired tests are needed to determine a) if field emergence differences are significant for larger sample sizes and b) if an inhibitor which the black seeds have that is possibly absent in the white seeds can be isolated. We doubt whether other germination delaying mechanisms, such as the persistance of seed behind the placentae walls, are different for the white seeded race.

Floral Morphology and Ecology

Flower size, shape and color are characters which are sometimes altered indirectly through human selection for the economic products of a plant. If a plant, through domestication, comes to produce fruit much larger than that of its wild progenitors, the calyx size may be increased too in order to accommodate the fruit. Or often, linkages affect several characters at once, so that a flower color may increase in frequency in a population, due to its genic association with a selected character. On the other hand, overall floral design is fairly conservative, and within a species is little affected by short term selective pressures.

In addition, floral ecology is certainly affected by cultivation and domestication. For instance, in South America, where wild and domesticated tomatoes originate, they are predominately cross-pollinated by insects; when taken beyond the range of their pollination agents, they have evolved into a self pollinating plant (Rick 1976).

Such ecological factors may eventually work as selective pressures influencing floral characters. A species variable for flower color, dependent upon cross pollination by bees, may swamp bee populations in number when cultivated in large stands. Particularly bright flowers might have a selective advantage over less intense flowers by attracting a greater percentage of the available bees. Depending on the inheritance of flower color, this may influence the frequency of allelles affecting color over time.

In terms of flower size, our data indicate that while cultivation increases the lengths of the corolla, calyx and bracts of black seeded *P. parviflora*, these characters are still considerably longer in the white seeded race. In fact, the white seeded race overlaps in these characters as much or more with *P. fragrans* and *P. louisianica* as with *P. parviflora*.

Several hypotheses can be proposed to explain this situation: 1) In the white seeded race, floral part sizes reflect a closer affinity with *P. louisianica* or *P. fragrans*. 2) A larger flower size has developed in the white seeded race while being domesticated from *P. parviflora*; the larger size accommodates the larger fruit. 3) It reflects introgression between 2 of the species.

Flower shape in the white seeded race is generally the same as that in *P. parviflora*. Among the largest flowers of the white seeded race, there is a tendency to be slightly more ventricose, though not as much as typical *P. louisianica* and *P. fragrans*. It is noteworthy that a wild, long clawed (32 cm), black seeded specimen collected on the Gila River Indian Reservation at the Pima village of Sacaton had a similar ventricose flower shape (Peebles, Kearney and Harrison #75, ARIZ). In addition, its flowers were mostly purple; because of these characters, Kearney and Peebles (1960:795) suggested its affinity with *P. fragrans* even though that species is nowhere else in Arizona. Again, does this reflect hybridization between different races or species, or simple introduction? Abberrant flower shapes, including ones with an extra lobe and a wider tube, have been found in low frequencies on plants within cultivated plots of the white seeded race.

Flower color determination in wild annual *Proboscidea* is not well understood. Perry (1942:43-47) reported that reciprocal crosses between *P. fragrans* and *P. louisianica,* and subsequent backcrosses, indicate that purple flower color dominates white flower color. Perry suggested that color inheritance was due to a single gene.

However, reciprocal crosses between 4 annual *Proboscidea* by Hevly (unpubl. notes) do not substantiate that purple flower color is dominate over white, since F^1 plants were intermediate. F^2 plants tended to have darker flower colors, but the F^2 population size was not large enough to suggest genotypic frequencies.

Most flowers of the white seeded race have similar color patterning and internal ornamentation as wild *P. parviflora*; however, all colors are usually less intense. Often, corolla color is pale cream or white, but we have also seen pink and reddish-purple flowers on white seeded plants on the Papago Reservation. However, these darker flowers were in a population within 50 m of where black seeded *P. parviflora* is cultivated. Does the variability in flower color in this white seeded population reflect the introgression of typical *P. parviflora* in the white seeded race?

We should note that white or pale cream flower color is not specific to the white seeded race; it also occurs in *P. louisianica,* and infrequently in wild *P. parviflora.* It has been suggested that different fruit types—of distinct lengths and shapes—are associated with different flower color types in *P. parviflora* (Paur 1952:1), but we have noticed no such clear cut relationships. Finally, it is noteworthy that in other floral characters (e.g. corolla ornamentation, filament pubescens, and inflorescence position) the white seeded race is most similar to *P. parviflora.*

The pollination ecology of devil's claw has received an increasing amount of attention in recent years, but the picture is far from complete. Hurd and Linsley (1963:249-250) reported the apparent cross-pollination of perrenial *Proboscidea altheifolia* by the corolla-cutting bee *Perdita hurdi.* However, their repeated examinations of wild *P. parviflora* flowers failed to show bee visitation for pollen, or a relationship with this bee. Dr. P.H. Timberlake (personal communication) has subsequently become aware of one example of *Perdita hurdi* visitation to annual *Proboscidea* in Mexico. To our knowledge, there are yet no reports of this bee pollinating wild *P. parviflora* in the United States.

Thieret (1976:175-176) reports the insect visitors, including pollinators, to *P. louisianica* flowers on wild plants in Oklahoma and in his garden in Utah (see Table 1). Preliminary experiments with pollinator exlusion, plus self and cross-pollination, suggest that *P. louisianica* fruits do not develop if pollinators are excluded of if artificially selfed (Thieret 1976:177). However, other investigators report that hand pollination of *P. louisianica* yields about 50% fruit set regardless of whether plants are self- or cross-pollinated (Moegenson, personal communication; Phillippii, personal communication).

Self-pollination, though still probably not the key pattern in wild populations, may also be effective in black seeded *P. parviflora.* In an experimental cultivated plot in New Mexico, of *P. parviflora* (and other species?), 15% of the 500 inflorescences bagged for self-pollination produced some seed (Anonymous 1953:16).

Dr. Floyd Werner has identified for us a few of the fairly frequent bee visitors to cultivated plots of the white seeded race (Table 1), but we do not have concrete confirmation of actual pollination by any of these hymenopterids. Most noteworthy is our discovery of *Perdita hurdi* in the flowers of a large, annually planted houseyard plot of the white seeded race at the Papago village of Santa Rosa.

Exclusion experiments and detailed field observations on both Indian-cultivated plots of the white seeded race and black seeded *P. parviflora,* and in spontaneously occurring stands of *P. parviflora,* are needed to determine: 1) Will selfing occur in these populations, and have the selective pressures of cultivation in large stands increased the frequency of selfing in the white seeded race? 2) Is the frequency of visitations by various bee species different in cultivated plots as opposed to spontaneously occurring populations? 3) If *P. hurdi* is in fact pollinating the cultivated white seeded race, but not small stands of *P. parviflora* in the wild, is this due to greater reliability or abundance of reward for the bee, akin to that provided by perennial *Proboscidea*?

Fruit Size and Morphology

Among the features which might be modified, if *Proboscidea* were domesticated for their fruit's fiber, are: a) a disproportionate increase in the fibrous "claw" part of the fruit; b) changes in texture, color and quality of the fiber; c) a greater yield of fruit per plant d) an altered frequency of unusual fruit shapes surviving. If large seed were selected in the domestication process, changes might include a) a disproportionate increase in the seed-holding "body" part of the fruit, where the ovaries are; b) reduction in fruit dehiscence (see seed dispersal discussion); and possibly c and d as above. Additionally, because mean fruit lengths of populations vary within wild *Proboscidea* species ranges, a bottleneck effect might occur, where the wild populations would be more variable than the domesticated populations. The "bottleneck" in variability would be the original selection of germ plasm undergoing domestication from only a small portion of the "available" genetic variability within compatible races of species.

Table 9 indicates that there is significant differences in the claw/body ratios of the fruit of the white seeded race, and typical *P. parviflora,* in the wild and under cultivation. We defined the "claw" and "body" of the fruit in a somewhat arbitrary way, but were consistent in how these features were measured. The claw, as we defined it, is the appendage of the dried fruit from which the Indians derive their fiber splints (Fig. 4).

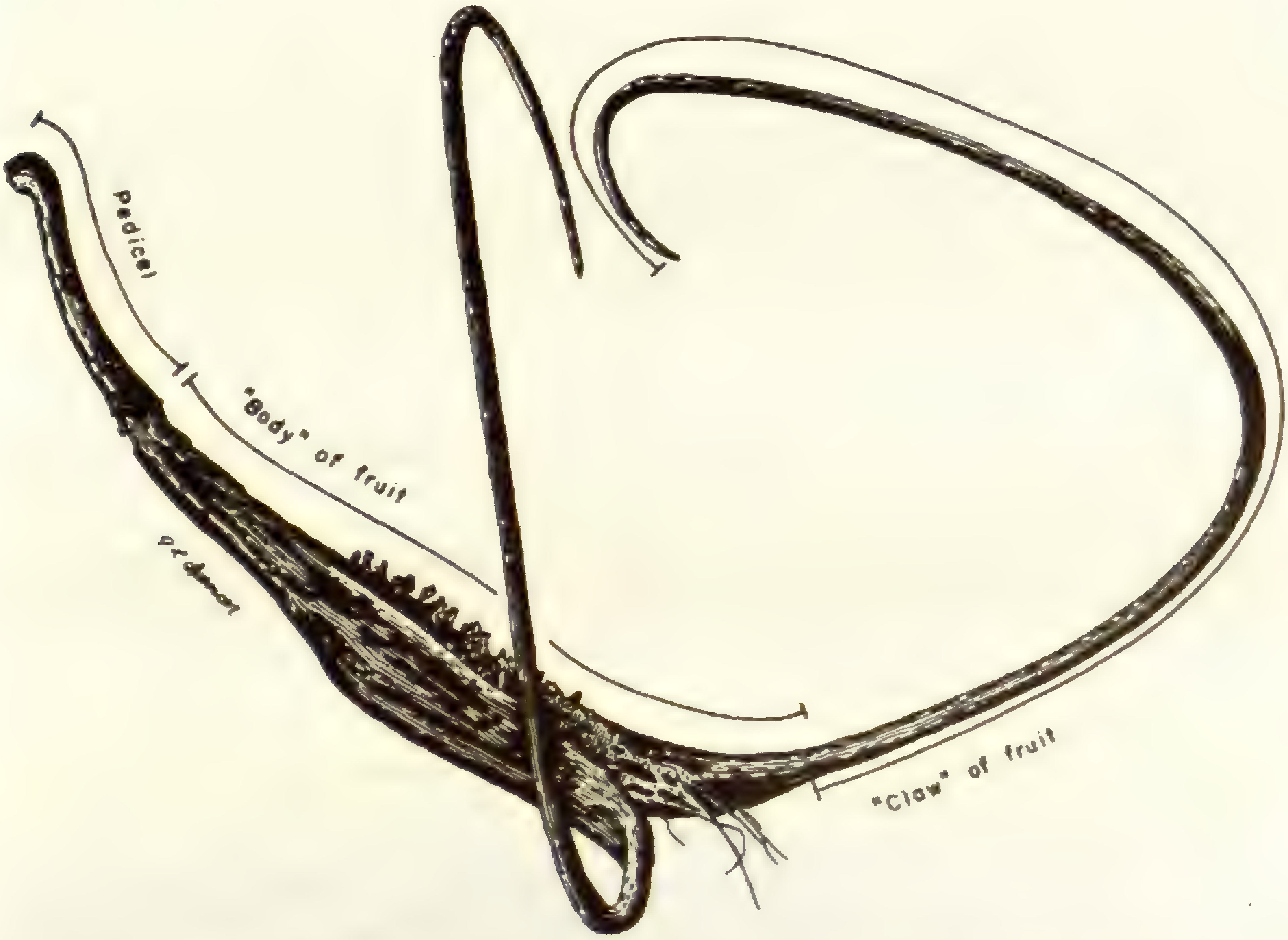

FIG. 4. Claw and body measurements of fruit of devil's claw (drawing by Judy Spencer).

TABLE 9.—*Claw/Body ratios for the white seeded race and the black seeded* P. parviflora.

Seed Source	**Locality Grown**	**X claw/X body**	**Sample**
White seeded race, cultivated:			
Havasupai Indian	Cornville	2.99	36
Apache Indian	Cornville	2.59	37
Pima Indian	Tucson	2.59	28
Papago Indian	Topowa	2.84	35
Black seeded race, cultivated by Indians:			
Papago Indian	Chiawuli Tak	2.32	31
Black seeded race, spontaneously; or cultivated#:*			
Navajo Indian*	Wupatki	2.34	10
Havasupai Indian#	Tucson	2.21	21
Mestizo, for Papago*	Nogales	2.29	26
Botanists*	Tecoripa	2.21	15

The 2.5+ claw/body ratio of the white seeded race may not necessarily indicate that a disproportionate increase in the usable part has occurred via domestication. Hevly has noted that in *P. louisianica* fruit, the ratio may vary from 1.5-3 (in Correll and Johnston 1969:1449), and it is possible that populations of *P. parviflora* and *P. fragrans* unavailable to us may have fruit which have a ratio greater than 2.5. The white-seeded race could have simply been chosen from such wild material, without selective pressures for longer claws being active within the cultivated environment. It is noteworthy that Gila River Pima remember wild populations of *P. parviflora* with exceptionally long claws that are located as much as 150 km away from their present homes. If the white seeded race has had part of its fruit disproportionately enlarged via cultural selection, it appears that selection was for fiber and not for seed-holding capacity.

We have measured the claw lengths of populations of the white seeded race, as well as those of typical *P. parviflora*, when a) harvested from the wild and b) grown in irrigated and *temporal* fields (Table 10). Statistical analyses of our data are summarized in Table 11. In the analysis of variance in and between populations of localities with 5 or more fruit of the cultivated white seeded race and wild and cultivated black seeded *P. parviflora*, one or more populations are distinct at the .01 level of significance. Utilizing all localities with one or more fruit, including those of presumably "feral" white seeds, the distinction between populations is still significant. This is due primarily to the extremely high values for the white seeded race under cultivation.

The greatest apparent difference in claw lengths is between the white seeded race when under cultivation, and all the other material measured, cultivated or uncultivated. The cultivated white seed claws measure 25.3 cm ± 4.3 cm, whereas all other means fall below 20 cm, and the ranges at one standard deviation do not extend above 23 cm.

To better illustrate the relationships between different germ plasm under different treatments, pooled variances were utilized to contrast combinations of these populations. When considered together, the white seeded race is significantly different from each of the black seeded *P. parviflora* treatments at the .01 level of confidence.

TABLE 10.—*Samples of claw length listed by source and locality.*

Locality and Source	**Mean (X)**	**Range (σ)**	**Population (n)**
A- White seeded race cultivated and/or irrigated	25.3 cm	±4.3 cm	249
A-1 Cataract Canyon #(Havasupai)	26.1	3.9	62
A-2 Cataract Canyon (Havasupai)	25.0	0.7	2
A-3 Cataract Canyon *(Havasupai)	34.0	0.0	1
A-4 Camp Verde *(Apache)	26.9	4.1	36
A-5 Moapa, Nevada (Southern Paiute)	24.3	0.0	1
A-6 Kern Co., California (Tubatulabal)	32.7	0.0	1
A-7 Komatke #(Gila River Pima)	23.2	3.3	52
A-8 Casa Blanca #(Gila River Pima)	22.6	1.6	8
A-9 Blackwater (Gila River Pima)	22.6	2.9	17
A-10 Chuichu (Papago)	25.8	1.8	2
A-11 Santa Rosa (Papago)	22.5	3.7	3
A-12 Covered Wells (Papago)	25.8	0.0	1
A-13 Kitt Peak (Papago)	20.5	3.0	10
A-14 Ali Chukson (Papago)	27.0	0.0	1
A-15 San Simon (Papago)	25.6	3.8	7
A-16 Chiawuli Tak (Papago)	21.0	0.0	1
A-17 Topowa (Papago)	28.2	4.7	40
A-18 Ahegam (Papago)	23.2	0.0	1
A-19 Sells (Papago)	24.1	5.5	3
B- White seeded race cultivated (feral?)	18.5	3.9	6
B-1 Kaka (Papago)	12.4	0.0	1
B-2 Santa Rosa (Papago)	20.0	1.2	2
B-3 Covered Wells (Papago)	19.4	3.9	3
C- Black seeded *P. parviflora*, spontaneous	15.7	4.8	127
C-1 Cataract Canyon (Havasupai)	25.5	0.0	1
C-2 Wupatki (Navajo)	17.4	2.1	10
C-3 Sacaton	32.0	0.0	1
C-4 Sacaton	27.5	0.0	1
C-5 Ventana	14.5	3.3	37
C-6 Ventana	9.0	1.5	7
C-7 Wilcox	18.5	0.0	1
C-8 Rosemont	11.7	4.6	15
C-9 Hereford	13.5	1.6	12
C-10 Agua Prieta, Sonora	17.4	0.0	1
C-11 Nogales (Mestizo for Papago)	20.2	3.3	26
C-12 Tecoripa, Sonora	15.7	3.0	15
D- Blackseed, cultivated by Indians	19.6	3.1	31
D-1 Chiawuli Tak (Papago)	19.6	3.1	31
E- Black seed cultivated and/or irrigated	16.5	2.6	148
E-1 Cornville*	17.1	1.6	19
E-2 Sacaton	22.8	1.0	2
E-3 Cataract Canyon #	15.8	2.5	78
E-4 Tucson #	15.1	1.5	16
E-5 Tucson #	18.3	2.8	17
E-6 Southern Arizona #	17.9	2.6	16

*grown in 1976 in Cornville, Arizona. #grown in 1976 in Tucson, Arizona.

TABLE 11.—*Statistical evaluation of claw measurements (see Table 10 for identifications of populatons A-E).*

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1. **Analysis of variance within and between populations for localities with 5 or more measurements (B is exluded): observed $F_{3,17} = 25.25$; greater than tabular $F_{3,17} = 5.18$. Therefore at least one population is significantly different at the .01 level of confidence.**
2. **Analysis of variance within and between populations for all localities (B is included): observed $F_{4,36} = 30.12$; greater than tabular $F_{4,36} = 3.58$. Therefore at least one population is different at the .01 level of confidence.**
3. **Contrast of pooled variance of combined populations via contrast coefficient matrix:**
   (A + B) vs (D + E) - Pooled variance T value = -1.195
   Therefore pooled populations not significantly distinct at .01 level of confidence.
4. **Contrast of Indian cultivated (d) black seed vs experimentally cultivated (e) black seeded *P. parviflora* (see conclusions...):**
   D = 19.55 ± 1.14 (SE x T) vs E = 516.49 ± 0.41 (SE x T)
   Therefore populations significantly distinct at .05 level of confidence.

The comparison of spontaneously-growing black seeded *P. parviflora* with the black seeds in cultivated treatments is most revealing. The pooled variance analysis shows no significant difference between the uncultivated and cultivated *P. parviflora*. One variable interpretation of this analysis is that cultivation does not dramatically affect claw length of *P. parviflora*.

In general, these data suggest that claw lengths are more genetically than environmentally determined. The noticable exception to this general rule is the small size of feral white seeded claws. Yet because of our extremely limited sample of uncultivated white seeded fruit, we hesitate in considering this a major contradiction of the general trend. Until additional data indicate otherwise, we conclude that the white seeded race is genetically different from *P. parviflora* in this economic characteristic, even if there is still gene flow between these taxa.

Table I indicates that there are some relative differences in the color, texture and quality of the claws and their fiber. These differences have been pointed out to us by native basketmakers, and will be discussed later. It is possible that these presumably quantitative characters have been gradually modified through cultural selection.

Our data on fruit yield are relatively subjective; we do not yet have good records for all taxa grown under the same conditions. However, we have counted at least 150 ripening fruit on a single plant in a Papago garden at Sells, and project that its yield could easily surpass 200 fruit over the entire growing season. None of the wild seed which we have brought into cultivation have approached this productivity, although several of our white seeded plants yielded at least 80-120 fruit.

There are also little data on the frequency of fruit variants, or mutants, surviving in wild and cultivated populations of *Proboscidea*. However, 3- and 4-clawed fruit are a curiosity readily collected by Pima and Papago basketmakers. They have provided us with a multiple clawed fruit with white seeds, and 2 informants have recalled 3-clawed germ plasm that was supposedly maintained for several generations. We have only come across one 3-clawed black seeded fruit, brought into a Blackwater, Arizona trading post by an Indian. Because of the difference in the relative number of cultivated versus wild fruit we have examined, we cannot yet hypothesize whether the statistical frequency of surviving variants is actually higher among cultivated white seeded fruit.

Finally, it is notable that a number of Papago basketmakers volunteer that they "plant only the seeds of the longest ones, because when the plants come up, they make more big devil's claw." In other words, conscious selection for long claws is continuing. The majority of the Papago and Pima who note this selection also associate white seeds with intrinsically larger fruit.

CONCLUSIONS

In evaluating the available biological data in light of the alternative hypotheses presented (Fig. 3), we will attempt to answer the following questions: With which established *Proboscidea* taxa does the white seeded race show the greatest affinity? How does it differ from this taxa? Are the differences similar to those between wild species, are they the effects of cultivation, or do they indicate true domestication? If so, what drove the domestication process: selective pressures for food or fiber?

Although the white seeded race has a geographic range which does not fall completely within the range of any of the recognized annual species, it has a great deal of overlap with *P. parviflora*, and little with *P. louisianica* or *P. fragrans*. The area where it may extend beyond the range of the recognized wild annual *Proboscidea* is in Nevada, where but one truly wild *P. parviflora* occurrence has been recorded (Dr. Wesley Niles, personal communication) and parts of eastern California. However, given the ease of dispersibility of devil's claw, we conclude that geographic range is in itself a poor indicator of affinities within the *Probosicidea* genus.

There is little doubt, however, that in regard to floral morphology, color and ornamentation, the white seeded devil's claw is most similar to *P. parviflora*, rather than *P. fragrans* or *P. louisianica*. Additionally, the feature of the foliage surpassing the inflorescence is shared with *P. parviflora* but not with *P. louisianica* or *P. fragrans*.

These features are not always clear on pressed herbaria specimens, so that collections noting white flower color, with relatively large flowers, have often been referred to as *P. louisianica* on these latter features alone. We are confident, however, that the flowers of the white seeded devil's claw show much more affinity with *P. parviflora* than with typical *P. louisianica*, except in terms of flower size, a trait easily influenced by both cultivation and selection.

Other diagnostic characters, such as leaf shape and filament pubescens bear out an affinity with *P. parviflora*. Less diagnostic features such as seed size and number of seed per fruit, oil and protein content also illustrate that the white seeded race and black seeded *P. parviflora* are within the same general range.

The characteristics in which the white seeded race diverges the most from typical *P. parviflora* are *not* those which distinguish wild species from one another, but those most commonly influenced by domestication. These include disproportionate enlargement of an economic product (the claw), increase in quality of the product (darker and more pliable), seed color change, and loss of delayed germination.

Other slight differences in characters, such as yield, leaf size, calyx and corolla size, and oil content are in features easily accounted for by indirect cultural selection. We conclude that the white seeded race does appear to have been domesticated from wild *P. parviflora*, since the spontaneous race of *P. parviflora* does not "take on" these characteristics when simply brought into cultivation.

Because the claw has been enlarged to a greater extent than the seed-holding body of the fruit, we feel that selection for fiber rather than food has been the driving force of domestication. Fiber quality has been considerably modified, whereas seed characteristics such as size, number per fruit, dispersibility, and protein have remained relatively the same. These characteristics are usually altered significantly when a plant is domesticated for the food value of its seed. The seed features, e.g.s., loss of delayed germination, white seed color, which have developed in the domesticate could evolve under pressures from cultivation and deliberate human selection for fiber as easily for food.

Thus we recognize numerous features which suggest disruptive selection of *P. parviflora* in cultivated environments and deliberate human selection, resulting in the evolution of a distinct white seeded race. This process is continuing, but to our knowledge has not yet developed a fully domesticated, obligatory cultigen. The presence of presumably feral white seeded devil's claw in Papago *rancherias* indicates that the domesticate is highly associated but not entirely dependent on humans and their intentional planting of seeds. It is possible, however, that in the Kern County, California and southern Nevada, beyond the range where wild annual *Proboscidea* are commonly found, that the survival of the white seeded race was more dependent on cultivation than it is in the Papago *rancherias*.

Finally, it is worth emphasizing that the situation is much more complex than simply having wild black seed and domesticated white seed. Characteristics such as slightly smaller floral parts, and more grayish hues in the white seeds suggest that "the domesticated qualities" of Camp Verde Apache devil's claw are not as pronounced as those of the Papago and Havasupai. The black seed which the Papago cultivate have claws 19.6 ± 3.1 cm, significantly longer than the black seeded claws which we brought into cultivation (Tables 10 and 11). Does this indicate incipient domestication, or merely that the Papago selected seed from longer claws in the wild to begin with? The frequent association of wild devil's claw with the gardens of Apache basketmakers on the Fort Apache Indian Reservation (Anonymous 1976), may well illustrate the "self-domestication" process discussed by Whitaker and Bemis (1975:325-368).

Bretting (personal communication) is undertaking a systematic crossing program of various acquistions of white seeded and black seeded *P. parviflora*, including some of our collections. Presently, variation within the white seeded domesticate's gene pool, as well as within *P. parviflora* in general, is poorly understood. We encourage others to investigate this variation, eliciting information from native basketmakers on less obvious characters that they recognize. To clarify the selective pressures driving devil's claw domestication, we urge scientists to actively work in the settings where this process took place - the agricultural fields and gardens of Southwestern *rancheria* people.

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WASPS, WARRIORS AND FEARLESS MEN: ETHNOENTOMOLOGY OF THE KAYAPÓ INDIANS OF CENTRAL BRAZIL

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ABSTRACT.—This paper is an attempt to briefly summarize the taxonomic features of the folk entomological classification system of the Kayapó Indians of Central Brazil. The folk system shows a correlation with scientific taxonomies, especially at levels of Class, Order and Family. Several morphological continua or "sequences" are evident and within these are found additional sub-groupings called "complexes." Of particular interest in this paper is the sequence labeled "ñy," which is analogous to the scientific Orders of Isoptera and Hymenoptera. Patterns for these groupings reflect important social and cultural values and are indicative of the significance of bees, ants, wasps and termites in the Kayapó belief system.

INTRODUCTION

The Kayapó Indians are one of the largest remaining tribes in Brazil's Amazonian Basin. Their well-earned reputation for belligerance and violence (cf. Wagley 1977:31) kept them insulated from encroaching western society until 1937. In that year the first missionaries established permanent contact with the Gorotire Kayapó. The Gorotire represented only one of several schismatic groups, all of which had once been united in a powerful and populous ancestral village, *Pyka-to-ti*[1] (Posey 1979b). Once the Gorotire had been "pacified" with Western trade items and medicines, other Kayapó groups ceased their warfare and established contact with Brazilian Indian Foundation (FUNAI) officials. The last group to be pacified was the Mekrãngoti Kayapó, who have now had less than 15 years of sporatic contact with the outside world (Verswijver 1978).

Most of the data analyzed in this paper were collected in Gorotire, the largest of the northern Kayapó villages. Gorotire was the base camp for this 14-month project because of its accessibility and the presence of some bilingual (Kayapó and Portuguese) Indians. Gorotire was originally established as an "attraction" village that was well-stocked with medicines and trade items to "attract" unpacified Kayapó groups. As a result, the Gorotire population is a heterogenous group. Nearly 20% of the village are Xikrin (a related Northern Kayapó group), 1% are non-Kayapó (originally children captured during raids and raised as Kayapó), and 10% have immigrated to Gorotire from other Kayapó groups within the past 5 years. This lends to Gorotire a "syncretic" air: the tribal elders are often heard arguing over whose version of a story or ceremony is the "proper" one. Thus it should not be assumed that Gorotire is a village that agrees even upon its own lore and mythology. Certain aspects of Kayapó culture, however, are more rigidly defined, or, if variation does occur, it is in a highly predictable manner. This paper deals with cultural phenomena that conform to this pattern: the principles underlying the Kayapó entomological classification system.

Ecological Profile

The Kayapó have traditionally been considered "marginal" peoples poorly adapted to their environment (Steward and Faron 1959). They have been pictured as exiles from savannas and inadequately adjusted to the region of Central Brazil (Levi-Strauss 1958). Bamberger (1967) refuted this misconception by pointing out that sociological factors, not ecological limitations, were responsible for the size of Kayapó villages. The Kayapó are abundantly adapted to the diversity of the campo-mato ecosystems in which they are found and dietary essentials are obtained with minimal effort and time (Posey 1979a). There is evidence that aboriginally the Gorotire population was 8-10 times larger than today (Posey

1979b). The great amount of time spent in the presentation of intricate and time-consuming artifact production, plus frequent performances of elaborate rituals and ceremonials, hardly seem to reflect a group pushed to the brink of marginal survival.

The village of Gorotire is located on the broad, flat campo next to the Rio Fresco (7°48'S, 51°7'W). To the east are vast expanses of "campo cerrado" and "cerradão"; in other directions, deciduous forest called "mato de segunda classe." Along the Rio Fresco is found "gallery forest" (See Cole 1960, and Hueck 1966, for a discussion of these ecological types).

Classification of soils, climates and vegetative types has been drastically generalized to the point of obscuring any variations in the area. Basic research is still lacking on these subjects.

Kayapó villages have traditionally been located near both campo and mato. This allows exploitation of various ecosystem types and maximizes the potential for utilization of natural products and game. This diversity has given the Kayapó a greatly varied diet that requires minimal effort.

Elevation at Gorotire is approximately 1000 m. There is a marked dry season (May to August), with hot, windy days and cool nights. The peak of the rainy season is in February, when the Rio Fresco reaches its maximum. Annual rainfall is approximately 1700 mm.

Gorotire is one of 7 northern Kayapo villages located in the *reserva indigena* Kayapó (see map). The total Kayapó population is now over 2500; the area of the *reserva* is over 1,900,000 ha.

METHODS

Research was at first limited to work with the 6 men and 3 women who spoke Portuguese. Although an attempt to learn and utilize Kayapó was made from the onset of the project, it was 7 months before eliciting could be carried out in the indigenous language. The type of data gathered reflects these stages of the project.

One of the first tasks begun was to establish an insect collection. Frequent field trips were taken for the sole purpose of collecting as many different organisms as possible in categories the Indians loosely grouped together.

Four to 5 Indians accompanied the researcher on collecting forays. The researcher began the process by capturing a large grasshopper. The Indian assistants responded by capturing dozens and dozens of other grasshoppers. The researcher attempted to widen the selective process by capturing a dragonfly. The Kayapó assistants responded with dozens upon dozens of captured dragonflies. The researcher continued to try to widen the parameters of "acceptable" things by pointing out butterflies, then beetles, and finally cicadas. "Are these relatives?" the researcher asked, pointing to the insects already collected and those still uncaptured in an effort to determine if a notion of relatedness existed. "Yes," responded the Kayapó assistants. "Then capture all of the relatives of these (pointing to insects already collected) you can!" The results was hundreds and hundreds of the same insects, depending upon the frequency of certain insects at the time. It was impossible to explain to the assistants why 300 of the same thing was unnecessary. But eventually the range of "relatives of insects" (consistently called "*maja*") expanded in what was assumed to be a reflection of native ideas of relatedness.

After 3 months of this type of collecting, it appeared the lateral expansion of the category was completed. The category included all insects, scorpions, spiders, ticks, centipedes, millipedes, crayfish, and pseudoscorpions. The category *maja* has a one-to-one correspondence with the scientific category of Phylum Arthropoda.

As the collection progressed, it became apparent that most organisms were grouped into very generalized categories. If there were no consistent sub-groupings (i.e., no named or unnamed differentiations), the specimens in that group were boxed and sent to the Museu Goeldi for classification and storage in the Museu collections.[2]. If any evidence of subdivisions did exist, however, the specimens were retained in the village for further study.

In the village, informants were asked to a) name each specimen, and b) group those specimens that were the same (*abenkot*) or simliar (*ombiqua*). In this manner, it was determined that covert (unnamed) grouping 5 exist that correspond in a one-to-one fashion with the scientific Class Arthropoda (Table 1). Further sub-groupings were few, except for the covert category corresponding to the scientific Class Insecta. Eighteen sub-classes ("forms") were found in this category (Table 2).

Each specimen was numbered and each number was recorded in a master notebook. This notebook contained essential field data on the specimen, plus a sketch or field identification notation if possible. If appropriate, entries were also made regarding the cultural use of the

TABLE 1.—*Arthropod groups.*

CLASS/ORDER	COMMON NAME	KAPAPO NAME		CORRELATION
Arachnoidea	————	————		————
(a) Scorpionida	scorpion	makre	> mak	1:1
(b) Pseudoscorpionida	pseudoscorpion	makkryre		1:1
(c) Phalangida	harvesters	hehpati	> heh	1:1
(d) Aranea	spiders	heh		1:1
(e) Acarina	mites/ticks	ten		1:1
Crustacea	crawfish	maj		1:1
Diploda	milipede	morokreruti		1:1
Chilopoda	centipede	kekek		1:1
Insecta	insects	(covert)		1:1

TABLE 2.—*Levels of correspondence for insects.*

B.O.L. CATEGORIES*		COMMON NAME	CORRESPONDENCE LEVELS	CORRELATION #
Focal Forms:				
(1) mara		beetle	Order (Coleoptera)	1:1
(2) ipoi		true bug	Order (Hemiptera)	1:1
(3) kapo		roach	(Family: Blattidae)	#
(4) krytkanet		grasshopper, cricket	Order (Orthoptera)	1:1
(5) wewe		butterfly, moth	(Various Orders)	-
(6) kanenet		dragonfly	Order (Odonata)	1:1
(7) kokot		leafhopper, cicada	Order (Homoptera)	1:1
(8) pure	>	fly	Order (Diptera)	1:1
(9) kopre				
(10) rorot		termite	Order (Isoptera)	1:1
(11) mrum		ant	(Family: Formicidae)	#
(12) amuh		social wasp	(Family: Various)	#
(13) mehn		bee	(Family: Apidae)	#
Collective Forms:				
(14) ngoire		minute insects	(Various)	
Aberrant Forms:				
(15) karere		earwig	Order (Dermaptera)	1:1
Transititional Forms:				
(16) kapoti		giant roach, mantid	Order (Dictyoptera)	#
(17) kungont		solitary bee & wasp	(Various)	#
(18) mehnkamamuh		honey wasp	(Genus: Brachygastera)	#

*B.O.L. (Basic Object Level Categories)

#Correlations stated in relation to correspondences at the scientific level of *Order* (# indicates an over-differentiation; - is under-differentiation).

insect or any peculiar circumstances under which the specimen was collected. (Often Indians would bring a specimen to be examined because they thought it interesting, unusual or particularly significant).

Groupings of insects were tabulated initially for 6 men and 3 women; the maximal number of insects utilized in these sorting experiments was 635. Informants conducted the grouping activities on 3 different occasions, each time with actual insect specimens. The identification number of each specimen grouped was recorded for each category.

"Informant error" was treated as problematic since patterns in "error" were soon evident and eventually predictable. Based on these data, 4 types of "forms" were identified (Table 2):

1) *Focal forms,* those consistently labeled and grouped in the same way and considered "typical" of the category. These forms are best illustrated as "fuzzy sets" (cf. Gardner 1976; Kempton 1978) with certain members being more focal and others being more peripheral.

2) *Transitional forms,* those consistently "mislabeled" between 2 categories. These forms are viewed as being "like" 2 groups that are contiguous categories in a morphological sequence.

3) *Aberrant forms,* those consistently labeled in one category, but given a special name because of unusual morphological characteristics.

4) *Collective forms,* those consistently given the same name and grouped together, although informants point out members of a collective class may not "really" be the same. In the one collective form discussed in the paper, small flies (*ngôire*), members of the category were considered too small to have significant morphological features and were illustrated with small dots.

Utilizing tabulated responses and informant sorting responses, it was possible to link into a more generalized pattern 18 named groupings. These groupings seem to best coincide with the criteria of "basic object level" categories (cf. Dougherty 1978; Rosch et al. 1976). Informant drawings and statements showed that the underlying patterns of these subordinate groupings were based on recognition of gross morphological features.

DISCUSSION

Patterns in Folk Entomological Classification

For the Kayapó all things are divided into 4 categories: 1) things that move and grow, 2) things that grow but do not move, 3) things that neither move nor grow, and 4) man, a creature that is akin to all animals, yet unique and more powerful than most animals because of his social organization.

It is the covert (unnamed) category of "animal" with which this paper is particularly concerned. All animals are sub-divided into 2 named groups: those with "flesh" (called by the name "*mry*"), and those with "shells" and no flesh (called "*maja*"). This latter group, animals with shells and no flesh, coincides with the scientific Phylum Arthropoda. Further folk subdivisions correlate with the 5 scientific classes of Arthropoda (Table 1).

Although the folk grouping that corresponds with "insects" is covert, there is a 1:1 relationship with the scientific Class Insecta. There are 4 morphological "sequences" within this grouping (Fig. 1). The term "morphological sequence" refers to a continuum of traits that unite a series of basic object level categories. The sequence may be an uninterrupted continuum with overlapping members between contiguous categories along the continuum; or there may be interruptions in the continuum. To bridge this gap, named transitional forms may occur to produce intermediate categories (Table 2).

Sequence 1: Let us look at *Sequence 1* (Fig. 1) as an example. There is a continuum of gross morphological form from the OVATE "polar form" to the OBLONG "polar form." Within this sequence can be found 2 distinct complexes:

Complex A. This includes that part of the overall Sequence from beetles (*mara*) to hemipterans (*ipoi*) to roaches (*kapo*). All forms in this complex have leathery outer wings or protective wing covers; their general form ranges from ovate to oblong. Considerable

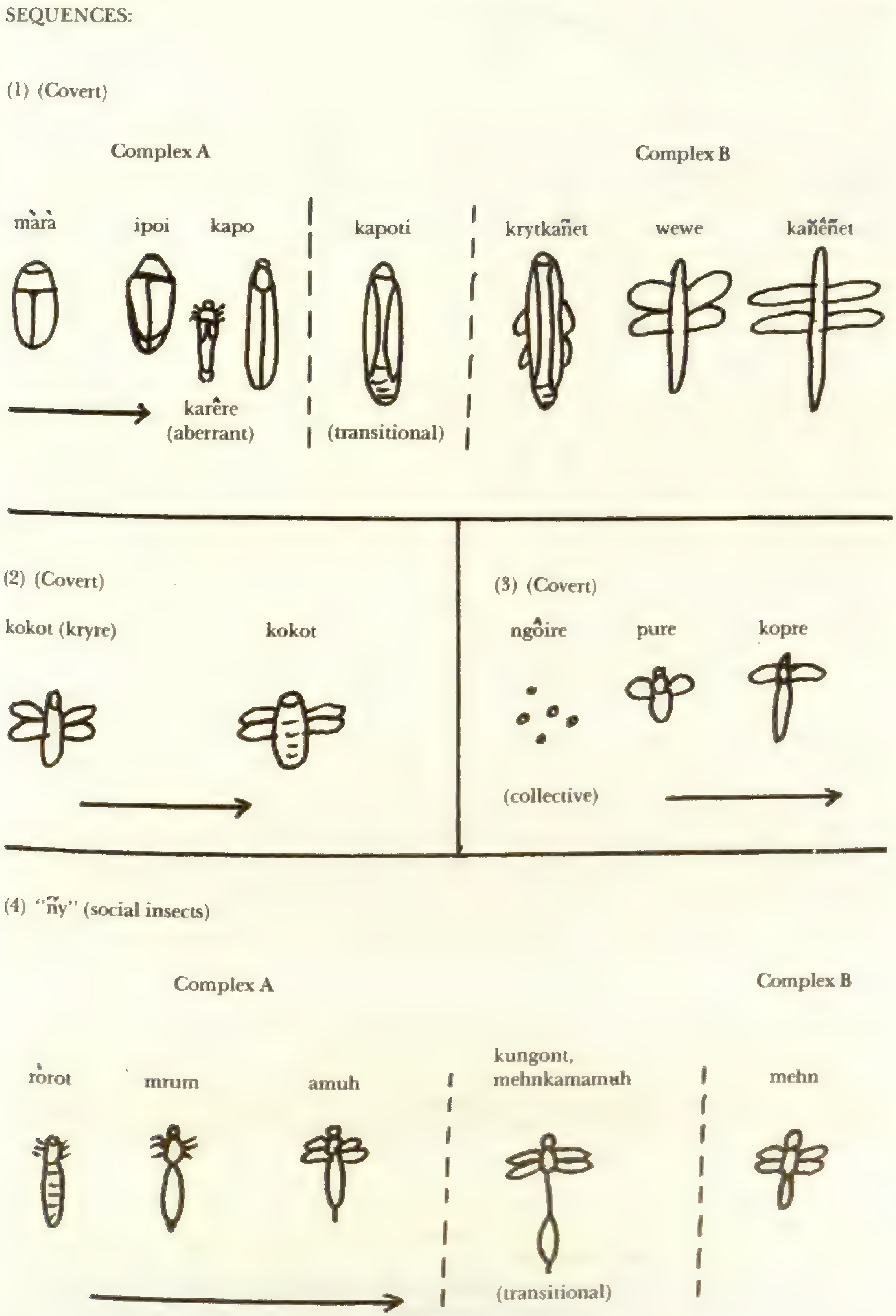

FIG. 1.—Insect sequences and complexes (based on drawings by Irã Kayapó).

FIG. 2.—A drawing by Irã Kayapó of the wasp nest (*amuh ũrũkwa*).

ambiguity occurs between these 3 forms — that is, certain beetles are consistently classified as *mara* and *ipoi*, but never is there overlap between *mara* and *kapo*. Likewise many *ipoi* are classified as *mara*, but also as *kapo*. No *kapo*, therefore, are co-classified with *mara*. The earwig *karere* is an aberrant form. It is consistently classified as a type of *kapo*, but is singled out because of its morpohological distinctiveness (mainly because it has rudimentary wings and "pincers" on its abdomen) and given a special monomial label.

The overall sequence is interrupted with the transition from *kapo* to *krytkanet*, i.e., from cockroaches to grasshoppers, although the morphological form continues toward elongation. This break is clearly due to the presence of large wings that become sufficiently conspicuous to define the perimeters of the animal's shape.

There is a transitional group, *kapoti* or giant cockroaches, that bridges this gap. The large wings and elongated bodies of this group cause them to be co-classified with *kapo* and *krytkanet*. This transitional form has a distinctive name and coincides with the scientific Family Blattidae.

Complex B. The Sequence (Sequence 1) continues the second Complex (Complex B). In Complex B we have 3 overlapping genera: grasshoppers (*krytkanet*), butterflies (*wewe*), and dragonflies (*kañenet*). The polar form is the dragonfly, whose form is distinctive because of its extremely elongated abdomen and 4 wings.

Sequence 2: This sequence consists of a single complex called *kokot*. The continuum within the complex is one of smallness to largeness — the leafhoppers being considered the "children" of the larger cicadas. There is something of a form sequence from the slightly rounded leafhoppers to the ovate cicadas, but this is insignificant to most informants.

Sequence 3: This sequence consists of a single complex of flies. It includes 2 object level categories: tiny flies (*kopre*), and mosquitoes (*pure*), biting flies and pium. There is, as is expected, overlapping between contiguous categories and minor morphological form gradation from *ngoire* (tiny flies, which are drawn as small dots) and more slender mosquitoes.

Sequence 4: This sequence is composed of 3 distinct object level categories in Complex A: termites (*rorot*), ants (*mrum*), and wasps (*amuh*). Complex B is composed of the single category honey bees (*mehn*). The break in the morphological sequence comes between wasps and bees. This is attributable to the anomalous nature of bees, for they are the only shelled animal *maja* with major economic benefit. There are intermediate forms to bridge this functional gap. These intermediate forms are bees that make no honey and are solitary *kungont*, and social wasps that do produce wax and honey (*mehnkamamuh*).

This is the only named Sequence, being called "ñy." This name refers to the social nature of these insects; the name is also used to label the immature forms (larvae and pupae) that the Indians say are carried about like children in the insects' "villages" (or *urukwa*). The "ñy" or social insects are seen to be in a special relationship to man because of their communal nature. All "ñy" colonies (*urukwa*) are thought to have a chief (*õ-benadjyra*) and be organized into family units just like the Kayapó. They are known to have warriors and the sounds of their movements are likened to Kayapó movements and singing.

The Kayapó are aware that some "ñy" really live alone — that is, there are solitary forms. But they see these as socially aberrant types that used to live in a "village" but for some reason now live alone. Solitary bees and wasps are like certain Kayapó who go off alone maybe for years on spirit quests, or are like shamans, who are solitary by nature. These insects are associated with the manipulation of spirits and are important ingredients in the concoctions of shamans. In short, their anomalous nature in relation to other social Hymenoptera and Isoptera make them important tools in the manipulation of natural powers by shamens. These aberrant forms are labeled with primary lexemes, although they are consistently classified as a sub-group of the category *amuh*, social wasps.

Except for Sequence 4 (termites, ants, bees and wasps), specific taxa are few for insects; subspecies are even fewer. Affixes denoting color, texture, size (or age), or some other general feature are frequently attached to the primary (1°) lexemic label of the generic category. An informant may choose any of a number to describe a specimen. Thus, (*màrà-tyk-ti*) means big, black beetle and the label may apply to any one of many beetles that are big and black. But the same beetle might also be called (*màrà-krã-ti*), big-headed beetle, if it were black and also had a big head. Occasionally a descriptive (or secondary lexeme) label may be reserved for a particular, limited set of insects. Within the beetle category is such an example, (*màràtire*) or dung beetles (Scarabidae). Each insect group (basic object level category) has a "father" (*bam*). The "father" is usually the largest member of the group. The "father" of the (*màràtire*) is the impressive Rhinocerous Beetle (*Strataegus*, Scarabaeidae). It is called the (*krã-kam-djware*) and is also considered the "chief" (*õ-benadjware*) of all insects (really all *maja*).

There are, however, only a few examples of this specific naming in Kayapó insect classification — except, as I have said, within the Sequence (4) of "ñy," the social insects. There are 32 sub-groupings of (*mrum*) ants; 48 sub-groupings of wasps (*amuh*); and 57 sub-groupings of bees (*mehn*). These specific and sub-specific groups are generally labeled with secondary (2°) lexemes. But why does this specialized classification occur within the Sequence "ñy?"

The importance of bees is obvious: they are sources of honey and wax. But of what significance are wasps and ants? Already we know these animals are like man because they live in societies like the Kayapó: they have villages, chiefs, and warriors. But so do termites, yet there are only 4 sub-divisions of termites (*rorot*). This is certainly not due to a paucity of termite types in the Kayapó area.

To understand this situation, we must understand one of the most significant of Kayapó myths: the story of the ancient fight with the giant rhinocerous beetle, the *krã-kam-djware*.

In ancient times the Kayapó lived in the sky with other animals. The Kayapó were then like other animals and Indians could understand animal languages. But in these ancient days, the Kayapó were weak and did not live in villages or have societies. Indians were not more powerful than other animals and certain animals, especially the beetles (*màrà*) under the leadership of their "chief," the *krã-kam-djware*, waged war against men. In the ancient days, in the sky, the Kayapó learned to organize themselves into groups and live in villages like the "ñy" (wasps and ants). Then in a great battle in those ancient times, the valiant and fearless warriors of the Kayapó defeated the *krã-kam-djware*. That defeat established man as a creature more powerful than other animals because of 2 things: 1) the power came from the social organization, and 2) the great strength and valiance of the Indian warriors that had also come from the wasps. The Kayapó had learned the wasps' secrets by carefully observing the behavior of wasps and had learned of their "power" that could be gotten through their potent stings. The venom of the wasps had been the secret; the aggressive, fearless attacks of the wasps had been the model for Indian warriors.

Today, on regular occasions the Kayapó commemorate the acquistion of these secrets and their victory over the *krã-kam-djware*. They are constantly searching for the nest of the most powerful and aggressive wasp (the *amuh-dja-ken: Polistes testacolor*). When a nest is found that is sufficiently large (usually 1.5 m long, 0.5 m in diameter), scaffolding is erected (by night when the wasps are inactive) to prepare for a re-enactment of the ancient event.

In the numbing cold of a gray pre-dawn haze, the entire village goes solemnly to the site. The warriors dance at the foot of the scaffolding and sing of the secret strength they received from the wasps to defeat the giant beetle. The women wail ceremonially in high-pitched, emotional gasps as the warriors, two-by-two, ascend the platform to strike with their bare hands the massive hive. Over and over again they strike the hive to receive the stings of the wasps until they are semi-conscious from the venomous pain.

This ceremony is one of the most important to the Kayapo: it is a re-affirmation of their humanity, a statement of their place in the universe, and a communion with the past. Time and space collapses to provide the unity of being — the continuity of life, history, identity and knowledge.

The wasp's nest itself is a symbolic statement of this unity. Its three-dimensional shape illustrates the relationships between the polar forms of the classification morphology — the ovate and elongate forms (Fig. 2). A cross-sectional view — or view from above or below — shows the circular form; a lateral view shows the elongate form. The nest is a graphic study of the relationship between these shapes.

Even more importantly, the general structure of the hive itself serves as a model of the universe. The hive is divided into parallel "plates" that seem to float just like the layers of the universe. The Kayapó say that today they live on one of the middle plates. But in ancient days, they believe they lived on another plate above the sky. Some Kayapó still live on an upper plate the tribal elders say, and their campfires are the stars in the sky (Fig. 3).

And below? From lower plates comes the "worthless men" (non-Kayapó, *kuben-kakrit*). Many *kuben-kakrit* still live below, though most have already ascended to "this earth layer" through a termite mound.

Termites are in alliance with "worthless people" and termites themselves are worthless. They are weak (*rêrêkre*) and cowardly (*wajobore*) and, although they appear to live like Indians and social insects, they are neither brave (*akrê*) nor strong (*tytx*) like wasps or Kayapó warriors. No Indian would, therefore, find value in studying termites (*rorot*). They are sub-grouped only according to whether they are white, red, or black — the skin colors of non-Kayapó "worthless people." (A fourth subgrouping labels the termite that lives in the mound through which came the *kuben-kakrit*).

And what of ants? They are more like men than even wasps because they walk and hunt on the ground. The Kayapó believe that ants too have special powers because of their stings. But the power received from ants is more useful on man's hunting ally — the dog. Ants are used in many concoctions to make a hunting dog unafraid to keep his nose to the ground and to

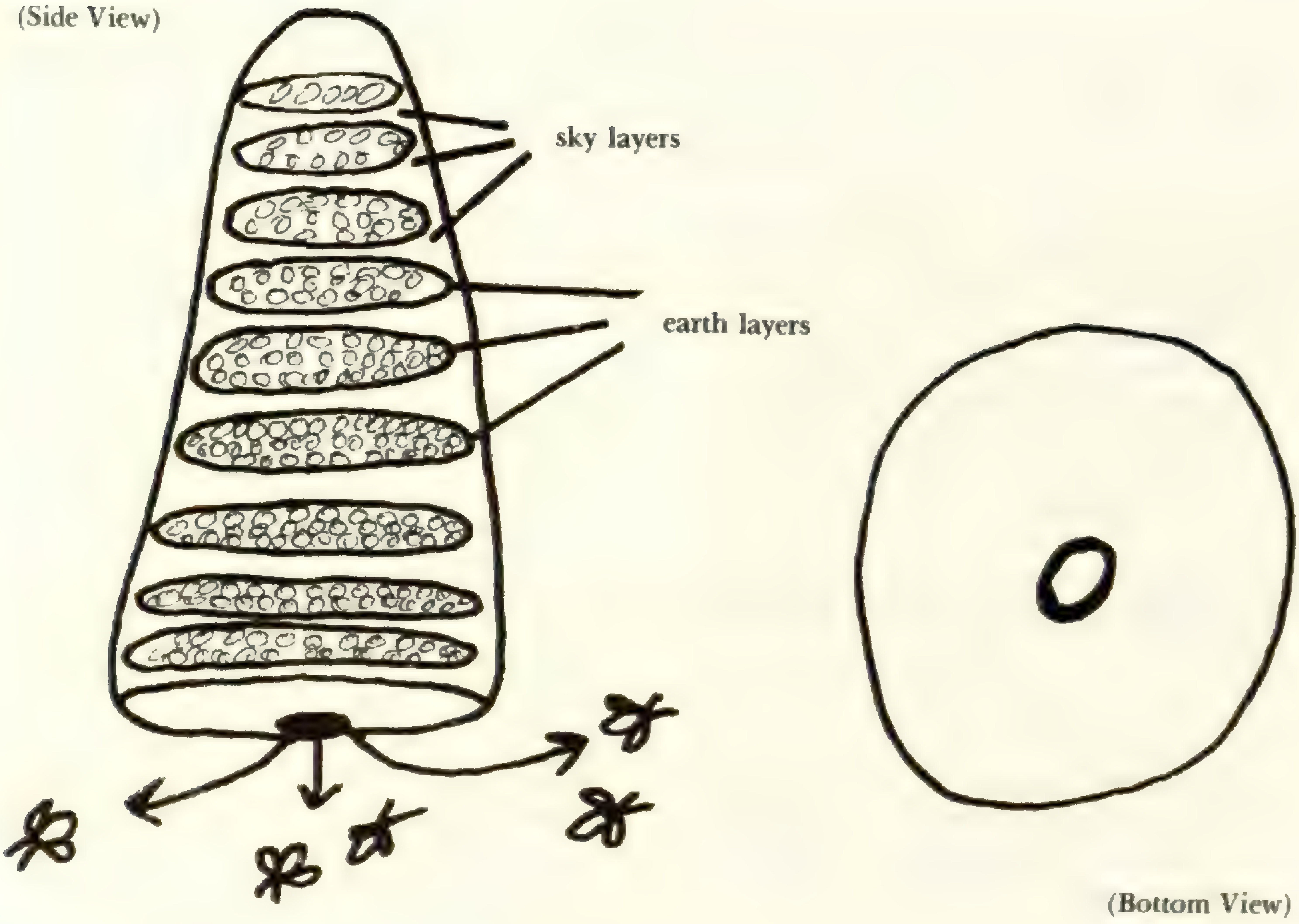

FIG. 3.—Cross-section of a wasp nest (drawing by Irã Kayapó).

make him aggressive. Some ants are seen as excellent hunters, so often man and dog are adorned for the hunt with the sacred red urucu paint mixed with ant parts. To be good hunters, therefore, the Kayapó must know ants, just as they must know wasps to be brave and fearless warriors.

CONCLUSION

In conclusion, I believe ethnomethodology can lead the ethnographer into fields of investigation along natural (*emic*) paths. Folk taxonomies are in and of themselves cultural statements, but it appears that these taxonomies may reflect deeper cultural patterns.

This analysis indicates that insects are encoded at a "basic object level" with the predominating characteristic being gross morphology (shape) that grades from the ovate form to the elongate form. These 2 "polar forms," and the relationships between these forms, become an underlying principle for Kayapó folk entomological classification as well as a spatial and structural theme in the belief system. It is therefore suggested that the correlations between a) basic shapes and forms, b) belief system patterns, and c) classification principles may be more closely integrated than previously expected. It appears that belief systems can play an important role in classification patterns and that such patterns can, in turn, offer an emic guide to cultural realities of perception.

ACKNOWLEDGMENTS

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NOTES

[1] The orthographic system used throughout this paper for Kayapó words is the official Brazilian government version developed in 1974 in conjunction with the Summer Institute of Linguistics (SIL).

For further information on the Kayapó language, see Stout and Thompson (1971, 1974).

[2] A collection of nearly 6,000 insect specimens was deposited with the Museu Paraense 'Emílio Goeldi' (Belém-Pará), under the supervision of Dr. William L. Overal, head of the invertebrate zoology section. I am indebted to Dr. Overal for his limitless assistance in identification of both collections.

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USE OF OPAL PHYTOLITHS IN PALEOENVIRONMENTAL RECONSTRUCTION

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ABSTRACT.—Soil and climatic conditions in the Wyoming-Nebraska-Colorado area of the High Plains are not conducive to pollen preservation. Opal phytoliths, which are present in many achaeological sites in sufficient quantities to provide information concerning both natural and introduced vegetation, are proving to be a viable alternative to pollen in paleoenvironmental reconstruction. The results of phytolith studies can amplify the archaeological data in regard to environmental, cultural, and geological processes.

Examination of soil samples from archaeological sites on the High Plains is on-going research by the Department of Anthropology and the Wyoming Recreation Commission, University of Wyoming. This paper deals with past and current research being conducted and the results of these studies.

INTRODUCTION

One of the goals in recent archaeological excavations has been to obtain data useful for reconstructing paleoenvironments. Palynology has been the best and most widely used method for this purpose. However, soil and climatic conditions in the Wyoming-Nebraska-Colorado area of the High Plains are often not conducive to pollen preservation. To find a viable alternative to pollen studies in paleoenvironmental reconstruction, the Department of Anthropology, University of Wyoming, has been conducting opal phytolith research. Opal phytoliths are present in many archaeological sites in sufficient quantities to provide information on vegetation, both natural and introduced. The results of phytolith studies can amplify the archaeological data in regard to environmental, cultural, and geological processes.

Phytolith studies can provide data about types of grasses growing on the site area and on nearby grazing areas, changes in vegetational types, and changes in moisture levels. It may be able to determine use of buffalo chips for fuel, primary butchering areas of game animals, sleeping areas with grass pads, and types of grasses ground on metates. Humid grass phytoliths may indicate a previous water source, and phytoliths in fill materials can provide information about vegetation from areas draining into the site.

Rovner (1971:343-344) states:

> For any fossil system to be useful to the archaeologist at least three criteria must be met. The material must withstand decomposition, exhibit sufficient morphological differences to be of taxonomic significance, and provide sufficient quantities to reflect the nature of the entire assemblage from which it is derived.

Although phytoliths may not meet all 3 criteria in all situations, they can provide valuable insight and their contribution to the archaeological record must be considered.

Opal phytoliths form as plants take up soluble silica. The soluble silica forms around and in plant cells producing distinctive shapes (Yeck and Gray 1972:639). However, the shape of the silicon bodies may not be the same as its cell, making phytoliths difficult to classify. Pollen is produced in a single repetitive form by each plant, phytoliths are produced in a wide range of sizes and shapes within any specific plant and parts of plants.

When the plants decay, the resistant silicon forms are deposited in the soil. Twiss et al. (1969:111-112) produced a morphological classification of grass phytoliths of 4 classes: Chloridoid (short grass), Panicoid (tall grass), Festucoid (humid grass), and Elongate which appear in all grasses (Fig. 1). Amounts of opal phytoliths available in samples differ from site to site depending on the variables present. A percentage count of phytolith types

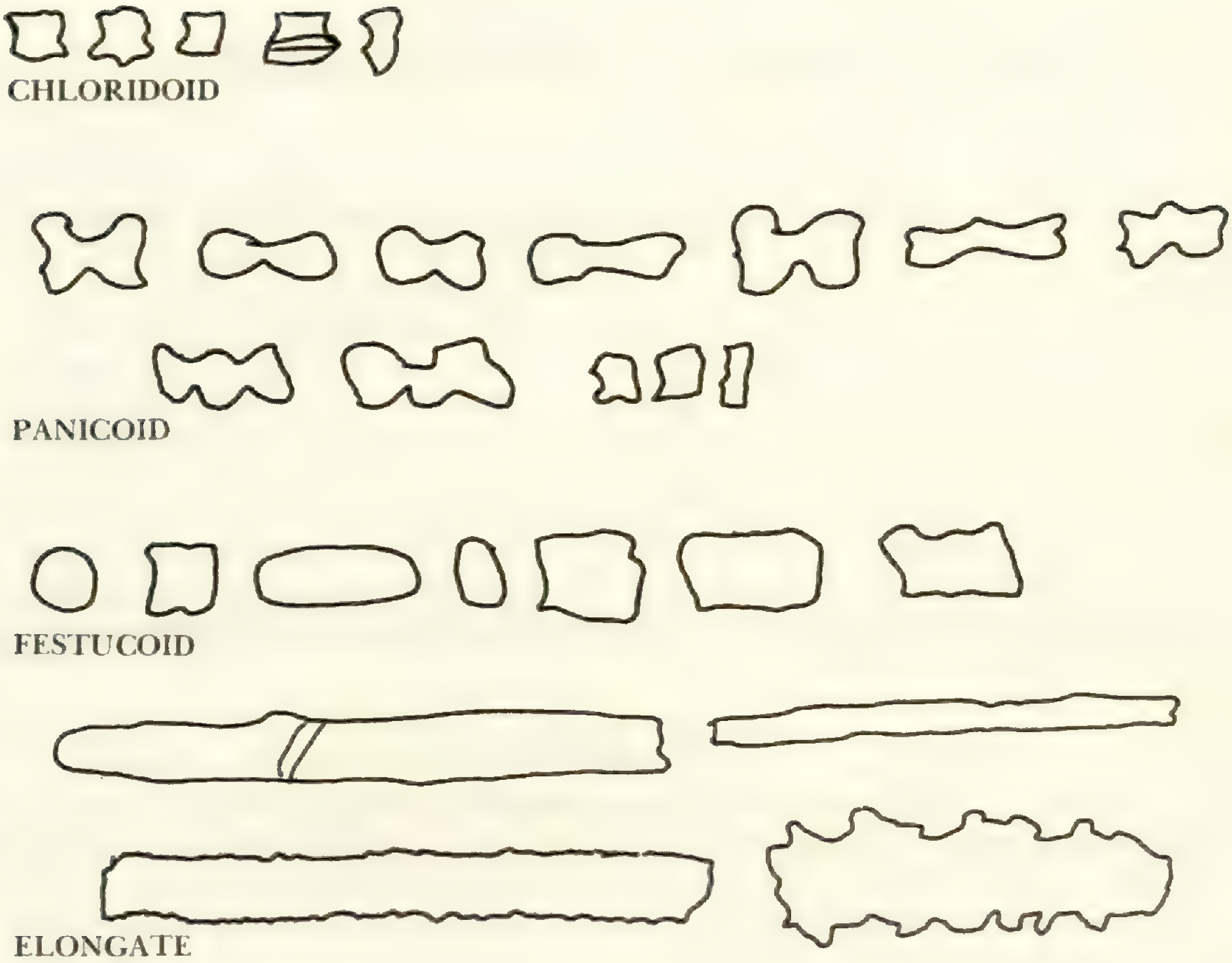

FIG. 1.—Morphological classification of grass phytoliths.

appearing in each slide ascertains with some degree of reliability the grasses predominent in the site area.

Opal phytolith studies can provide information concerning not only the climate of an area during the time a site was occupied, but can also show changes that have occurred in an area over a period of time. Changes in vegetation are shown by changes in class type of phytoliths. Phytolith size is also indicative of changes in moisture (Yeck and Gray 1972:639). Phytoliths are not indestructible; they can be fused by fires, eroded by soil action, and are susceptable to destruction by the soil chemistry.

DISCUSSION

In the past 4 years, samples from a variety of sites in this High Plains region have been examined for phytoliths. The sites range in age from Folsom to Late Prehistoric, spatially cover most of Wyoming and parts of northwestern Nebraska and northeastern Colorado, and represent various functions as campsites, kill sites, and rockshelters. Some sites have produced excellent phytolith evidence, others have been totally void. This paper presents a broad overview of phytolith studies that have been conducted (Fig. 2).

The Hanson site, located in the northern Big Horn Basin on the west side of the Big Horn Mountains near Shell, Wyoming, is a prehistoric campsite. The site has been dated 10,700+670 B.P. (RL-374) (Frison 1978:23) and is culturally affiliated with the Folsom complex. Phytolith evidence from Hanson was very poor. Samples from a soil column in Hanson I yielded nothing. However, a sample taken in the occupation level from the organic fill below a *Bison* humerus in Hanson II produced representative samples of tall grass and humid grass phytoliths.

Another site which produced extremely poor phytoliths was the Agate Basin site located in eastern Wyoming in the Cheyenne River drainage close to the southern Black Hills of South Dakota. Agate Basin dates 10,430+570 B.P. (RL-557) (Frison 1978:23) and is the type

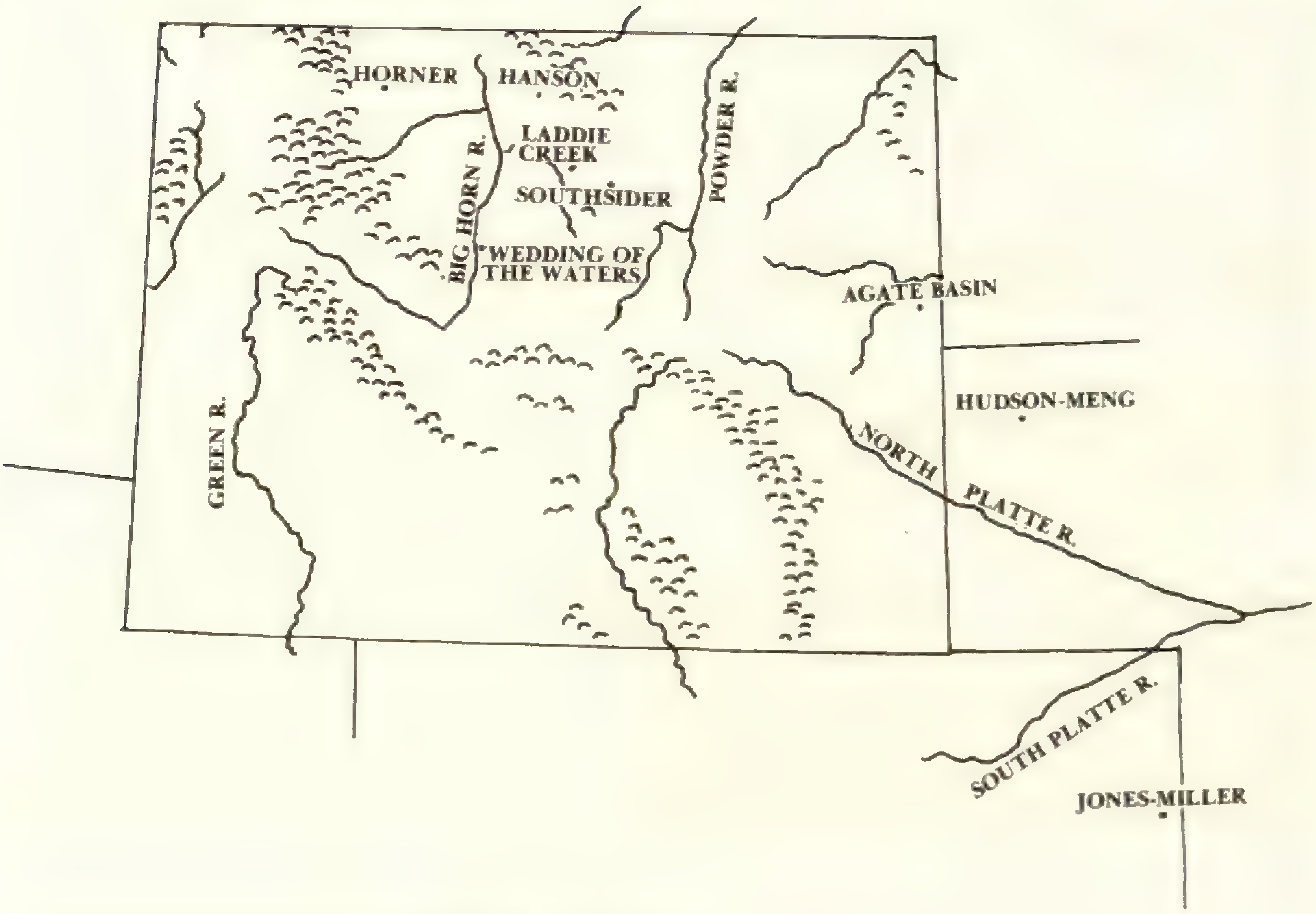

FIG. 2.—Location of sites discussed in this study.

site for the Agate Basin point. It is a bison kill and processing site. Samples from soil profiles and within the bone bed produced rod-shaped phytoliths but none that could be classified. One exception is a sample from Unit 4 in a soil profile. This sample is within the Agate Basin level in the site and contained short grass prairie phytoliths.

Hudson-Meng, a bison kill and processing site, is located a few km to the south and east of Agate Basin in northwestern Nebraska near Crawford on the northern slope of the Pine Ridge Escarpment in the Hat Creek drainage (Agenbroad 1978). The site dates 9820+160 B.P. (SMU-224) (Frison 1978:23) and is associated with the Alberta cultural complex. Soil samples were taken from Hudson-Meng during the 1975 field season. Samples from a trench at the west edge of the site (Fig. 3), in the bone bed, and from a hearth within the bone bed produced the following results. A high percentage of Festucoid class phytoliths were in all the productive trench samples indicating the constant presence of humid grass, possibly a microenvironment caused by a spring or stream. Trench samples 1, 3, and 4 imply a period of increased moisture when tall grass prairies would be present. Trench samples 6 (the Alberta bone bed level) and 7 show reversal of this trend with short grass phytoliths being more common. Samples 2 and 5 were essentially void of phytoliths which may indicate an extremely dry period. These interpretations are supported by the pollen analysis at the site (Agenbroad 1978:117).

Extrapolated figures from the bone bed, hearth area, and sample 6 are compared in Fig. 4. Sample 6 was taken outside the butchering area; the high percentage of Festucoid phytoliths indicates a nearby water source. The phytolith counts of Festucoid and Panicoid classes in the bone bed sample are consistent with sample 6. The contents of the bison viscera deposited during butchering account for the significant increase in Chloridoid class phytoliths. The evidence in the bone bed sample implies that the bison had been grazing on short grass prairie prior to the kill. Increased phytolith counts from the hearth area, high percentages of Chloridoid class phytoliths, and lack of charcoal at the site strongly suggest the use of buffalo chips for fuel.

FIG. 3.—Hudson-Meng soil profile from the north wall of the west trench.

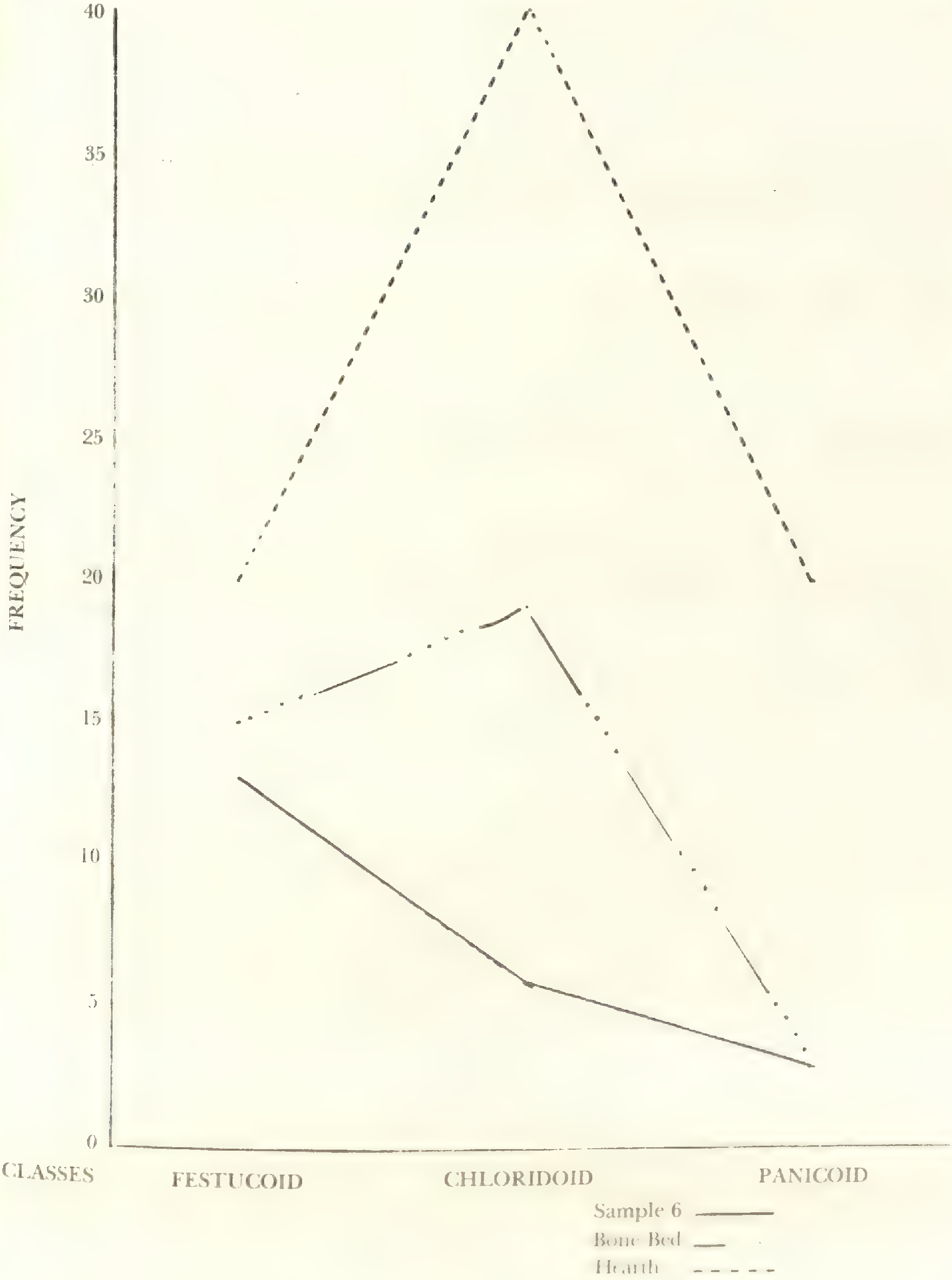

FIG. 1.—Comparisons of phytolith count from trench sample 6 and extrapolated figures from the bone bed and hearth areas.

Jones-Miller, a Hell Gap site, was also tested for phytoliths. Jones-Miller is a bison butchering site in northeastern Colorado near Wray located at the head of a draw draining into a tributary of the Arikaree River (Stanford 1974:29). Soil samples were taken from Jones-Miller in 1974. The occupation level at Jones-Miller produced multiple rod-shaped phytoliths as well as tall and short grass prairie phytoliths. The ratio of short grass to tall is 2:1. No samples were taken out of the bone bed so no explanation can be made for having 2 types of phytoliths in the occupation level. Samples taken from above the occupation level showed a marked reduction of any identifiable phytolith.

The Horner site is located on a terrace near the confluence of Sage Creek and the Shoshone River near Cody, Wyoming. Type site for the Cody Complex, Horner dates 8950+220 B.P. (RL-574) (Frison 1978:23) and is a bison kill and processing site. Samples taken during the 1977 field season produced short grass phytoliths from the bone bed. Samples above the bone level had an abundance of rod-shaped phytoliths which are non-diagnostic, and no others that could be identified. Samples from a profile from the top of the bone bed to the surface contained no phytoliths that could be classified. In 1978, a soil sample produced only rod-shaped phytoliths. These results appear to compare favorably with those obtained from Hudson-Meng.

The paucity of phytoliths from 2 stratified rockshelters, Wedding of the Waters Cave in the Wind River Canyon near Thermopolis and Southsider Shelter in the Big Horns near Medicine Lodge Creek is to be expected. Grass would not occur naturally in the shelters and remains would have to have been introduced by men and animals. The chances of locating bedding grasses or grass carried in as food are slight. Unidentifiable abraded phytoliths on a grinding stone found in a storage pit from Southsider indicate the cultural use of grasses at this site during the Early Plains Archaic.

The Laddie Creek site is located on the west flank of the Big Horn Mountains near the Medicine Lodge Creek site. This stratified site exhibits evidence of human occupation dating from the Cody Complex through Prehistoric or Protohistoric Crow with at least 7 levels of Altithermal occupation (Karlstrom 1977:11). The modern level containing Crow pottery, the Late Archaic level, and the Paleo level produced a predominance of Panicoid or tall grass prairie grasses. The altithermal levels produced a limited number of rod-shaped phytoliths, but no phytoliths that could be classified.

CONCLUSION

The study of opal phytoliths is not new. The technique has been used by botanists and range management people to trace forest migrations. However, its use with archaeological sites as an alternative and/or compliment to palynology has been a recent development. Phytoliths are an alternative to pollen as they appear to be preserved in some sites with little or no pollen preservation. Phytolith samples were obtained from Jones-Miller, a site with no pollen preservation, and Hudson-Meng, where pollen remains were limited. Phytolith studies can compliment palynology because grasses appear to be the greatest producers of phytoliths. Production of phytoliths is relatively weak in trees. Pollen production is the opposite and pollen is either wind or insect distributed. Phytoliths, if not found where the plant grew, died, or decayed are transported primarily by animal consumption, man's gathering of plants, or by soil erosion by wind or water.

Why phytoliths are preserved in one site and not in another is a problem facing the researcher. Rovner (1971) states that heavily alkaline soils most severely affect opal phytolith preservation. The pH for samples from Hudson-Meng, Jones-Miller, Agate Basin, and Horner appear to negate this statement. The highest pH readings (8.2 to 9) were from Hudson-Meng, the site producing best phytolith results. In his soil analysis of the Laddie Creek site, Karlstrom (1977) found pH values ranging from 6.9 at the surface (the Crow complex) to 8.2 at 261.6 cm below the surface (the Cody complex). The Late Archaic and Altithermal levels have values ranging from 7.4 to 7.7. Only the Altithermal level failed to produce phytoliths. Joel Norgren (personal communication) has suggested that stability of phytoliths in this area may be due to a water source. Moisture in this area is primarily from spring showers which suddenly cause the prairies to green. This instant water source may produce highly unstable phytoliths as opposed to those formed in grasses growing near a constant water supply.

The publications concerning archaeological work with phytoliths are scarce. Numerous problems are encountered in phytolith studies and methodology varies from researcher to researcher. Publications of modern comparative specimens are poor and in many cases lacking in necessary detail. Laboratory equipment and chemicals are expensive and facilities are not always available.

Phytoliths cannot be considered the definitive answer in paleoenvironmental reconstruction; instead, they must become a part of the whole — one discipline among many whose contributions aid in reconstructing paleoenvironments. Phytoliths have been shown to be a valuable tool to the archaeologist in paleoenvironmental reconstruction despite problems encountered in interpreting the data. They have proven to be a viable alternative to pollen in numerous sites in the High Plains and will continue to be investigated at the University of Wyoming.

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ASPECTS OF DETERIORATION OF PLANT REMAINS IN ARCHAEOLOGICAL SITES: THE WALPI ARCHAEOLOGICAL PROJECT

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ABSTRACT.—Walpi is a Hopi village which has been occupied continually since the 1690s. Accurate dating of proveniences has been attained through tree-ring data, ceramic seriation, early maps of the village, Euro-American remains, photographs, and informant data. In addition to building, fill, and abandonment dates, the number of years a deposit has been exposed to the natural elements is frequently known. With a data base ranging from the present to 3 centuries in the past, one can evaluate the factors causing the deterioration and disturbance of archaeological data; a complex set of processes which are as yet poorly understood.

In order to partially rectify this situation, experiments were set up in controlled environments to determine the effects of differential exposure to the elements on deterioration of plant species. These experiments over a period of one year have revealed a noticeable reduction in mass of seeds within 5 different genera. In addition, over 35,000 plant remains from Walpi were analyzed in relation to 26 attributes describing the condition of the specimens in an attempt to diachronically qualify differential preservation of archaeobotanical remains. Emphasis here is placed on the effects of carbonization and rodent and insect activity. The data indicate that vast quantities of plant remains may be lost to foraging rodents and insects. The paucity of carbonized remains at Walpi suggests that what is preserved in carbonized form in most open sites can give a skewed picture of plant use.

INTRODUCTION

Archaeologists and other specialists have been concerned with the representativeness of the archaeological record and processes of deterioration for almost 2 decades. Most attempts to evaluate deterioration have concentrated on inorganic remains in archaeological sites (Ascher 1962, 1968; Kleindienst and Watson 1956; Lee 1968; Schiffer 1976). Those who have addressed the process of deterioration of organic remains have thus far restricted themselves to the study of bone loss and preservation (e.g., Behrensmeyer 1975; Gifford 1978; Issac 1967). This paper considers deterioration of plant remains in archaeological sites and partially evaluates loss by 2 experimental studies, and by an examination of the conditions, and kinds, of plant remains at Walpi, a Hopi pueblo continuously occupied since A.D. 1690. The processes of deterioration are complex and multi-faceted. Here, some preliminary findings are presented which should aid in our overall understanding of deterioration of plant remains in archaeological sites.

The Walpi data are excellent, in that preservation of uncharred plant remains is generally good. Many colors are retained on the remains, and soft parts such as corn husks 250 years old look no different from those which are about 25 years old. In addition, the proveniences of these remains are well dated by tree-ring analysis, ceramic seriation, early maps, Euro-American manufactured remains, photographs, and informant data. Given the ability to date proveniences, some within 20 year spans, and the wide range of plant remains (over 37,000 were analyzed in relation to 26 attributes describing their condition), we are in a position to evaluate some factors causing the deterioration and disturbance of archaeobotanical data. These factors are some of the components of a complex set of processes which are as yet poorly understood.

METHODS

Two independent experiments were made under laboratory conditions to: 1) examine the effects of differential exposure to the elements on the seeds of 5 plant genera commonly found at Walpi, and 2) examine preferential eating habits of mice on 5 of the more common seed genera at Walpi. Analysis of the Walpi archaeobotanical record suggested that rodent and insect activity had a profound effect on the plant remains. In this report, some of that effect is measured in a qualitative and quantitative manner.

An initial concern was to measure the differences in plant remains which had been exposed to the elements for varying amounts of time. In this case, seed count and species condition information in 3 rooms at Walpi was viewed in relation to exposure to the open air for 10, 35, and 65 year intervals. The second look at the Walpi plant data concentrated on a synchronic assessment of the state of preservation of some of the analyzed plant remains at the pueblo.

DISCUSSION

Some effects of differential exposure to the elements.—Experiments on deterioration of Hopi corn, pumpkin seeds, pinyon nuts, red, white, and kidney beans, and sunflower seeds were initiated in December, 1977, and completed in November, 1978. The purpose of these experiments was to test the effects of moisture, temperature, moisture and temperature periodicity, and acidity on seed preservation. To study these effects 10 50-seed samples were selected, weighed, and placed in clear jars. One sample was sealed and kept as a control. The other samples were effected by one or more variables. Some were kept inside and either saturated with moisture at regular intervals; alternately saturated for 3 months and then kept dry for 3 months; or saturated with a slight (pH ca. 5.5) acid solution. These same variables (plus a constantly dry sample) were also placed outdoors to test the effects of temperature variation. These variables are listed for each sample in Table 1.

The loss of mass for each sample is listed in Table 2. The average loss was 7.8%. If this rate of the original mass were lost each year, the entire seed assemblage would be lost in only 13 years. This accelerated loss of mass is not often the case and probably was not occurring at Walpi. Within the experimental seed samples, however, there is considerable variation in loss of mass both between samples and between seed types.

Looking at the seeds individually, one notes that the 3 bean types have lost an average of almost 12% of their mass, while the other 4 seeds have lost only 4.8% of their mass.

The implications of the archaeological record are apparent. Given any environmental condition tested here, beans will be lost more rapidly. Beans have a thin, fragile seed coat which breaks rapidly leaving the interior immediately susceptible to external factors. When

TABLE 1.—*Variable states for each numbered sample.*

SAMPLE	VARIABLE STATES
3	Control sample. Sealed with lid.
4	No water added, placed outside.
5	Saturated with water monthly, placed outside.
6	One half water necessary for saturation is added monthly, placed outside.
7	Water added monthly 3 months, dry 3 months, kept inside.
8	Water less than saturation is added, kept inside.
9	Acidic water less than saturation is added, kept inside.
10	Water added monthly for 3 months, dry 3 months, placed outside.
11	Water less than saturation is added, kept outside.
12	Saturated with water monthly, kept inside.

TABLE 2.—*Per cent weight loss for each seed.*

SAMPLE NO.	CORN	PUMPKIN	PINYON NUT SHELLS	KIDNEY	RED	WHITE	SUNFLOWER	MEAN SAMPLE
3	0	0	0	0	0	0	0	0
4	*2.2	2.6	2.4	1.3	0	0	0	1.4
5	*2.1	*1.3	2.3	15.1	21.3	19.8	4.3	9.5
6	*0	*0	2.3	4.1	8.7	9.0	5.0	†5.8
7	5.8	3.8	5.1	7.0	8.6	13.5	5.1	7.0
8	5.8	5.3	2.3	9.3	10.5	15.2	1.2	6.9
9	3.7	1.3	4.8	8.5	11.8	12.4	1.3	6.3
10	5.6	11.4	6.5	9.6	7.9	9.0	2.8	7.5
11	3.9	2.6	6.7	6.6	8.9	9.3	2.5	5.8
12	16.3	5.7	11.4	18.5	40.7	35.2	13.2	20.1
‡MEAN SEED	5.7	4.7	4.9	8.9	13.3	13.7	3.9	7.8

*Eaten by mice 5 months into project.
†Excluding corn and pumpkin.
‡Excluding control sample.

the seed coat breaks, the bean splits into its 2 cotyledons also making deterioration easier. This process can be accelerated by seed germination, with the seedlings soon dying. Beans are also prone to attack by microbial organisms (e.g., Jansen 1979). All 3 bean types supported thriving bacteria and mold communities within 2 months after the experiment began. These communities were most active in moist conditions where the temperature was stable or where water was available to saturation. Dr. Jack States, a mycologist at Northern Arizona University, identified the microbs and noted that there was significant variation in kind and amount of destruction between the bean types. The white beans kept in a stable environment (sample 8) were intact, but had some cracking and disintergration on the seed coat. Oozes of bacteria and some crystal formations were causing the destruction. The kidney and red beans which were kept outside in a fluctuating environment (sample 11; Fig. 1) were often split open with both the cotyledons and seed coats partially decayed. There was a moderate amount of bacteria on these beans, but they were mostly covered with the mold *Paecilomyces* and small amounts of *Fusarium*. States further commented that *Paecilomyces* is common in Arizona and flourishes on habitats that are alternately wet and dry. Given time, the molds would probably destroy the beans in their entirity.

Microbial deterioration of plant remains is commonplace (Jansen 1979). In essence, microbs survive because they "spoil" food that would otherwise be used by man or other animals. Bacteria and molds are most effective on soft or fleshy foods. The tough seed coats or cases or the other seeds used in the experiment evidently provided more protection from attacks by mold and bacteria. It is evident that beans are susceptible to complete microbial destruction. This may explain why beans are relatively rare at Walpi (Gasser 1980) and why they are also rare in most Anasazi sites (Gasser 1981). Beans, however, are not the only foods which would be destroyed by microbs. Corn kernels, squash meat, greens, tubers, and fleshy fruits are also very susceptible to similar destruction.

FIG. 1.—Red beans from Sample 11 with *Paecilomyces* mold.

FIG. 2.—Rodent gnawed watermelon, bottle-gourd, and juniper seeds from Walpi.

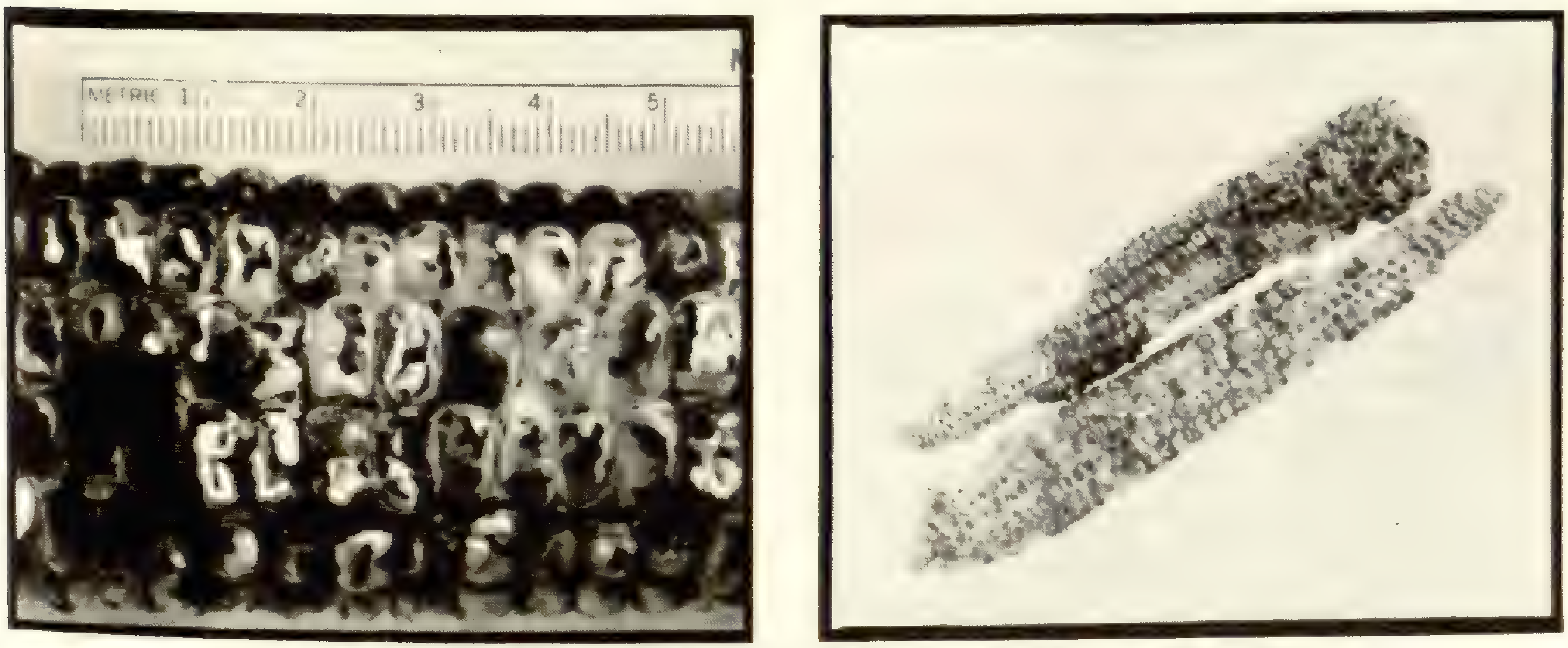

FIG. 3a, b.—Corn from Walpi damaged by larva of Dermestid beetles.

Analysis of the experimental data by sample also reveals systematic differences. The sample (#2) kept dry but subjected to temperature change varied only minutely. Samples 6 and 11 were the next least subject to loss of mass. Both were characterized by having less water added than the other specimens and by being outside and subject to temperature fluctuation. The outside sample most susceptible to loss of mass was the one saturated each month. Saturation is defined as the seeds being immersed in water for 8 hours and the excess water poured off. Thus, the seeds absorbed as much water as they could contain.

Weight loss of samples maintained at a constant temperature with only moderate water added was very slight. However, for the saturated sample the effects were dramatic. The combination of stable temperature and abundant water promoted healthy colonies of mold (Fig. 1) in all seeds and resulted in an average 20% loss in mass(Table 2). Even excluding the beans, the loss of mass was 11.6%.

A comparison of samples 8 and 9 reveals the effects of acid on deterioration. Overall, the seeds with slight acid solution lost 0.6% less mass than those without acid. Apparently, the acid slightly inhibited the growth of mold and bacteria. However, a marked change in color was noted in the corn kernels subjected to acid. The blue corn kernel turned a bright red color which penetrated the seed coat to the interior of the seed.

In summary, assuming an abundance of oxygen at all times, moisture is the most important factor causing deterioration of seeds. If moisture is abundant, a stable

TABLE 3.—*Species condition breakdown in 3 rooms at Walpi.*

	ROOM 168 **piki house** **fill date 1920-1965**		**ROOM 83** **storage room** **fill date 1930-1950**		**ROOM 187** **storage room** **fill date 1880-1920**	
CONDITION	**#**	**%**	**#**	**%**	**#**	**%**
unaltered, whole	38	18	133	31	74	10
rodent-insect gnawed	104	48	70	16	65	9
slightly degraded	17	8	50	12	150	21
fragments > 50%	22	10	60	14	204	28
fragments < 50%	10	5	51	12	38	5
split at suture	25	12	65	15	125	17
charred or partially charred	1	+	1	+	62	9
Total	217	101%	430	100%	718	99%

temperature also promotes deterioration. However, if moisture is present, but not abundant, the effect of temperature appears to be minimal. Over the course of a year a fluctuating temperature may impede deterioration during the winter by slowing the growth of mold and bacteria. The amount of loss during stable mid year temperatures with alternate periods of wetting from summer rains and drying might cause rapid disintegration. If the soil is slightly acidic, this will slow deterioration by impeding the growth of bacteria and mold.

The second examination of deterioration brought about by exposure to the elements was drawn from the Walpi archaeobotanical record. The time differences in species counts and their conditions in 3 rooms at the pueblo were measured. These rooms are, 1) Room 168, a piki house whose fill was deposited between 1920-1965, and has been exposed to the elements for 10 years, 2) Room 83, a storage room whose fill was deposited between 1930-1950, and has been exposed 25-35 years, and 3) Room 187, also a storage room whose fill was deposited much earlier, between 1880-1920. The fill in room 187 has been exposed for approximately 65 years.

The first test of this data base involved comparing plant counts by genera in each of the 3 rooms. Hypothetically, one would expect that the room exposed for the longest duration would contain the least plant remains. Such was not the case. This study produced results (Table 3) which indicated an inverse relationship, where more plant remains were in the room exposed for 65 years. This does not seem plausible, and an alternative needs to be examined. For instance, actual counts may be misleading as numbers may reflect the cultural bias of differential discard. Thus, more trash may have been discarded in Room 187 than in the other 2 rooms.

A more viable test of these data was to examine the condition of the specimens in each of the 3 rooms. A plant artifact's condition of preservation is more independent of the cultural experience than its numerical frequency. We are interested here in many of the non-cultural effects such as rodent and insect gnawing and other degradation of plant remains in sites.

Table 3 details the results of this examination of the state of preservation of the remains in each of the 3 rooms. These data indicate only a few relationships one would expect of remains which had differing lengths of exposure to the elements. For example, an assemblage of plant remains should continue to degrade with length of exposure. Seeds and other plant parts which were slightly degraded, fragmented less than 50%, split at suture, or charred or partially charred, occurred with greater frequencies as the length of exposure increased. This implies a steady and rather constant rate of degradation. In some examples this was not always the case. Unaltered remains and fragments greater than 50% were less common in the rooms exposed for 10 and 65 years than they were in the room exposed for 25-35 years. This might be the result of sampling error or the effect of unaccounted factors, but it does indicate that there is not a direct relationship, where organic remains throughout a pueblo disintegrate at an even rate.

Rodent and Insect Activity.—Another significant fact that appeared as a result of this study was that rodent and insect gnawing apparently decreased as the length of exposure increased. Rodent and insect gnawing occured on 48% of all the seeds in the room exposed for only 10 years, on 16% in the room exposed for 25-35 years, and 9% in the room exposed for 65 years. These data suggest that rodents initially gnaw and consume large amounts of plants soon after they are discarded, and may continue to do so until there is a more desirable nearby food supply. Rodents bias the record extensively. The data on Table 3 indicate that as much as 50% of some discarded organic trash is partially consumed by rodents.

Some seeds are probably consumed in their entirety by rodents and insects; others seem to be gnawed or cracked only enough to gain access to the soft portion of the seed encased in its shell. Figure 2 illustrates watermelon seeds from Walpi and reveals partial gnawing. A laboratory produced example of rodent gnawing on watermelon seeds was obtained at the beginning of the Walpi botanical analysis and enabled identification of some rodent gnawing on archaeological seeds. For this study, rodent gnawing was determined by the presence of incisor-sized impressions on a beveled surface of the seed or seed coat, such as that illustrated with the watermelon, bottle-gourd, and juniper seeds in Fig. 2. When some of this seed damage might be attributed to insects as well, the combined category of rodent-insect gnawing was used.

Insect gnawing was only reported when corn was damaged as illustrated in Figure 3 which shows corn kernels on cobs which have been infested with the larva of dermestid beetles. The cobs with dermestid infested kernels shown here was unaltered when Adams excavated them from Room 121 2 years ago. Dermestid larva accompanied the remains back to the Museum, and did this amount of damage in the intervening period. The larva of this beetle enter the kernel at its anterior end and consume the soft starchy interior, often leaving only the pericarp behind. The thin pericarp would probably disintegrate leaving no remains of the kernels.

Rodents and insects seem to prefer different foods, each taking its toll in differentially degrading and destroying plants in sites. The next analysis examined the presence of rodent and insect damage on all seeds in all of the sampled proveniences at Walpi (Table 4). Table 4 indicates those species affected by rodent and insect activity, the species total seed count in the sample, and the number and percent of which were either rodent or insect gnawed. In some cases it was impossible to identify the gnawer, hence the category rodent-insect gnawed. Table 4 indicates that 42% of all of the corn at Walpi, excepting shucked cobs, husks, and other non-kernel parts, were damaged by insect activity. Insects or rodents damaged over half of the bottle-gourd seeds, and often did much damage to other seeds of the Cucurbitaceae. Rodents damaged over half of the more than 24,000 watermelon seeds investigated by this analysis. Rodents (or insects) also damaged 75% of the juniper seeds. Rodent gnawing was also evident on many stones of fruits such as cherries, plums, and apricots. Peach pits, which were abundant at Walpi, seem to have been avoided by the rodent predators.

An analysis of 11 rodent nests and one rodent cache (Table 5) is helpful in determining preferred rodent foods. Table 5 indicates that 75% of these rodent contexts contained watermelon seeds and half or more contained sunflower, unidentifiable squash, and melon seeds. Corn was found in only 2 of the 12 contexts, beans in only one. In general, the nest contained few seeds, and the small seed counts in them may not be good indicators of a plac to find preferred foods. A rodent cache (e.g., Lockard and Lockard 1971:221) in Room 112 a Walpi was much more revealing of the species preferred by rodents. The cache was in a smal subfloor depression. It contained 1468 seeds of 15 genera, many of which were roden gnawed, and a large amount of rodent feces. Almost half of the seeds in this cache wer

TABLE 4.—*Tablulation of rodent and insect gnawed plant parts at Walpi.*

SPECIES	TOTAL COUNT	# INSECT GNAWED	% INSECT GNAWED	# RODENT GNAWED	% RODENT GNAWED	# RODENT-INSECT GNAWED	% RODENT-INSECT GNAWED
Bottle-Gourd seeds	462					240	52
Watermelon seeds	24,746			13,738	56		
Melon seeds	1,155					25	2
Maxima squash, banana type seeds	138					96	70
Maxima squash, S. American type seeds	23					6	26
Maxima squash seeds	9						
Pepo squash seeds	55					3	5
Mixta squash seeds	926					59	6
Unknown type A squash seed	9			1	11		
Not identifiable squash seeds	22					3	11
Beans	509					3	+
Corn cobs with kernels	46	41	89				
Cob fragments with kernels	10	3	30				
Corn kernels	1,692	642	38				
Peach pits	2,960			1	+		
Plum pits	23			2	9		
Apricot pits	43			11	26		
Cherry pits	9			5	56		
Almond hull	4			1	25		
Juniper seeds	700			523	75		
Pinyon testa	1,954			93	5		

watermelon, almost a third were corn kernels. The only other significant species were melon and striped cushaw squash seeds.

The data in Tables 4 and 5 are indicators of foods which rodents prefer when foraging on Hopi trash deposits. The last experiment undertaken involved a more direct test of rodent seed preference. Live mice were fed some seeds which were commonly found at Walpi to determine which were preferred over others. Four domesticated mice were purchased from the pet store and 2 domestic house mice (*Mus musculus*), a species which occurs at Walpi, were trapped and separated into 3 cages and fed 25 g each of various seeds. The results of this experiment are portrayed in Table 6. It is clear from this evidence that given a choice of 5 species which included blue flour corn, honeydew melon seeds, Mammoth Russian sunflower achenes, Halloween field pumpkin seeds, or white, common, kidney, or tepary beans, the "average" mouse preferred the corn. In the 2 experiments with the domesticated mice, they consumed over 40% of the available corn within 2 days, practically ignoring other species, and ate all of the 25 g of corn within 5 days. Once the corn started to diminish significantly, the mice turned to sunflower and melon seeds. They chewed the seeds from the margin, never splitting them along the suture to extract the soft interior as might be expected. The white beans and pumpkin seeds suffered no significant weight loss. After 3 days a few of the beans and pumpkin seeds were slighty chewed by the mice, resulting in nothing beyond slight damage to the seed. The experiment with the house mice also showed that after 3 days they, too, avoided the beans and selected the melon, corn, and sunflower seeds in nearly equal amounts.

TABLE 5.—*Breakdown of seed counts in one rodent cache and 11 nests at Walpi.*

	NESTS													
SPECIES	**FS107**	**FS207**	**FS59**	**FS289**	**FS113**	**FS164**	**FS154**	**FS139**	**FS182**	**FS223**	**FS216**	**FS204**	# of occurrence	% of occurrence
CUCURBITACEAE:														
Watermelon	665	1	1	1	4	35	1	4	no seeds	1			9	75
Melon	159		1	6		12	4				3	3	7	58
Bottle-Gourd	1					1							2	17
Mixta Squash	135						1						2	17
Pepo Squash	19											1	2	17
Squash				10	3	18		1		1	1		6	50
CORN	432										123		2	17
BEANS				1									1	8
OTHER DOMESTICATES:														
Cotton	5		1			1				13			4	33
Wheat	1												1	8
Peach	1			1									2	17
Sunflower	15		1	1	2	1					1		6	50
WILD SPECIES:														
Skunk Bush	1				1								2	17
Rice Grass	19			2	4	1	3						5	42
Prickly Pear	10												1	8
Pinyon	4			1		1				1	1		5	42
Ground Cherry					3								1	8
Amaranth											1		1	8
Goosefoot							1	1		2			3	25
Sunflower					1								1	8
Unknown	1												1	8
TOTALS	1468	1	4	23	18	73	10	6	0	18	130	4		

TABLE 6.—*Seed weight loss due to consumption by mice at 48, 72, and 120 hour intervals.*

EXPERIMENT #1	**at 48 hours seed weight**	**% loss**	**at 120 hours seed weight**	**% loss**
2 domestic mice with free water				
25 g flour corn	11	56	0	100
25 g melon	23	8	18	28
25 g sunflower	24	4	20	20
25 g pepo squash	25	0	25	0
25 g white beans	25	0	25	0
EXPERIMENT #2				
2 domestic mice with free water				
25 g flour corn	15	40	0	100
25 g melon	22	12	16	36
25 g sunflower	24	4	24	4
25 g pepo squash	25	0	24	4
25 g white beans	25	0	25	0
EXPERIMENT #3	**at 72 hours seed weight**	**% loss**		
2 house mice without free water				
25 g flour corn	23	6		
25 g melon	22	12		
25 g sunflower	23	6		
25 g kidney bean	25	0		
25 g tepary bean	25	0		

Other researchers have experimented with feeding native rodent species (*Perognathus* spp. and *Dipodomys* spp.) domesticated seeds, but did so for entirely different purposes than pursued here (Mares and Williams 1977; Lockard and Lockard 1971; Rosenzweig and Sterner 1970). These studies found that native rodents would accept all types of seeds presented, but might specialize in small or medium-sized varieties if resources were especially abundant (Mares and Williams 1977:1188; Rosenzweig and Sterner 1970:223). Lockard and Lockard (1971:219) found, in addition, that if specialization occurred, it generally favored seeds high in carbohydrates, oils, proteins, and species with a thin seed coat. Human trash deposits provide abundant nearby resources, and might encourage specialization in rodent foraging behavior. It is worth noting, too, that even in areas of abundant seed resources, there is not enough seed selection involved to prevent a number of rodent species from coexisting in the same environment (Rosenzweig and Sterner 1970: 222-223). Hence, an abundant habitat such as a trash midden could support a number of species of rodents.

These ecological studies recorded some information that appears to contradict findings reached here. For instance, Lockard and Lockard (1971:220) found that *Dipodomys deserti*, a kangaroo rat, preferred pinto beans and most other available species to sunflower seeds. Here, *Mus musculus* and its domesticated white relative, avoided beans entirely when other foods were available. Both Lockard and Lockard (1971:222) and Mares and Williams (1977:1188) found that *Perognathus* and *Dipodomys* preferred wheat over most species including sunflowers and corn. Rosenzweig and Sterner (1970:219) also found that pumpkin and squash seeds were preferred over sunflowers. Seed type preferences vary, undoubtedly, by rodent species and plant species availability. The critical factor is not really what species are preferred by foraging rodents, but that rodents might consume any type of seed in a trash deposit, and that consumption will favor some species over others.

CONCLUSION

Despite the fact that many of these Old World plants are not found in many Southwestern archaeological sites, these data on the condition of the Walpi plant remains, some of the effects of differential exposure, and preferred rodent foods, should be useful in assessing plant remains in other sites regardless of their location on the globe. Elements affecting differential exposure, and foraging rodents are universals that can be projected into the past and across spatial boundaries with some accuracy. The concept is, of course, uniformitarianism. We have performed a few experiments, have studied the condition of almost 40,000 plant remains, and can conclude that what is recovered by the archaeologist is a skewed picture of actual plant use. Corn kernels are quickly destroyed by insects and rodents, and most probably do not survive over 10 years in an unprotected room or midden. Beans are often destroyed by mold and bacteria during fluctuating moist and dry conditions, but do not seem to be affected by most rodents or insects. Some of the Cucurbitaceae are heavily foraged upon by rodents, others to a lesser extent. What is found in most archaeological sites is almost certainly a distorted image of past use. The present status of our knowledge can be refined, however. Hopefully, these experiments have pointed out the need for more experimental work. Only when this is done, will we proceed to a level of interpretation of archeobotanical data which is beyond guess work.

As a postscript, it is important to note that less than one percent of the plant remains from Walpi were carbonized, and what was charred did not accurately represent the entire assemblage. Archaeobotanists frequently have to rely on carbonized remains as indicators of plant use in the past (Minnis 1978: 362; 1981; Gasser 1981: 18-26) and it is evident that most carbonized remains represent a very skewed picture. Unfortunately, in most open sites all that remains to be excavated are charred plant macrofossils and pollen.

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EARLY ACCEPTANCE OF WATERMELON BY INDIANS OF THE UNITED STATES

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ABSTRACT.–Modern authorities agree that watermelon ***(Citrullus lanatus)*** is an Old World plant that probably originated in Africa. Watermelons were grown by the Spanish in the Southeastern United States before 1576 and their presence was noted 50 leagues inland and in the Southwest before the end of the sixteenth century. Over the next 100 years there is increasing historical evidence of their use by Indians over a wide area. Some early accounts indicate that more than one kind of watermelon was grown. It is suggested that there may have been multiple introductions and that the plant was readily accepted by the Indians because it could be successfully cultivated by the same methods used for the native squash ***(Cucurbita*** spp.)

Pioneer ethnobotanist Melvin Gilmore, writing in 1914 (1977:68-77), was so impressed by accounts of his Omaha Indian informants that they had known watermelon "from time immemorial" that he suggested it might have been present in America before the coming of Europeans. This possibility was reinforced for him by reading early historic accounts of the use of watermelons by Indians over a wide area in the United States and by documented instances of the plant's ability to volunteer.

Lyman Carrier (1923:67-78), an agronomist with the United States Department of Agriculture, was greatly impressed by the early historical evidence of watermelon in America, particularly by LaHontan's account of the late seventeenth century that this tropical plant had been adapted for cultivation as far north as Canada by the Hurons. Although he mentioned the possibility that seeds of watermelon may have been distributed from a Spanish introduction in the West Indies, he concluded that "At present the evidence favors the American Indian as the discoverer and domesticator of the edible watermelon".

Carrier was also of the opinion that the descriptions in the early herbals of "anguria" or "citrull", which are often claimed to be watermelon, really are those of the colocynth or bitter melon. He further claimed that the description of "Virginia Watermelons" in the revised edition of Gerard's Herbal, published in 1636, but written in 1621, "is unquestionably the true watermelon" (Carrier 1923:65-68). Carrier's argument was to help support his contention that the watermelon originated in America. It is mentioned here, without passing judgment, because it does give an indication of the approximate time when the watermelon became generally known and grown in Northern Europe.

Gilmore's and Carrier's historical research on the use of watermelons by the Indians is extensive and useful, but we have been unable to find publications by other botanists that agree with their conclusions. No direct relatives of the watermelon *(C. lanatus)* are known to be native to the Americas and, to our knowledge, there is no archaeological evidence of its presence there before Europeans reached the New World.

Modern botanical writers generally agree that the watermelon *(C. lanatus)* originated in Africa and that its use is of considerable antiquity. It has not yet been possible, however, to pin down a specific time and place of domestication (Harlan et al. 1976:14; David 1976:254; Purseglove 1976:294). Whitaker and Davis (1962:2) suggest that there appears to have been a strong secondary center of diversification in India. It may be no coincidence that *sandia*, the Spanish name for watermelon taken from the Arabic, refers to an origin in India. (Dozy and Englemann 1915:339).

At the risk of belaboring the point that watermelon is of Old World origin, it may be pointed out that seeds identified as *C. vulgaris* (now *lanatus)* were recovered in archaeological excavations from the Inyanga ruins in Africa which date from the eighth century or earlier (Shaw 1976:114).

In addition, the Moor D'Ibn-Al-Awam of Seville, Spain, in his *Book of Agriculture* written in 1158, describes six kinds of melons, one of which appears to fit two varieties of watermelon:

> 6. The melon in the ***shape of a jar***, because it resembles this sort of vessel; the ***melon of Palestine***, which is the melon of Constantinople, the melon of India or the Scinde, includes two varieties; the one has a black seed and the rind of this one is very dark green passing to black; the other one has a pure red seed and the green color of it's rind passes to yellow (Clément-Mullet, tr. 1864, Vol. I:17, 1866, Vol. II, Part 1:216). (Clément-Mullet's French translation from the Arabic will be found in Appendix I.)

Historical references in this paper are ones in which the English word "watermelon" or the Spanish *sandia* was used directly or in reliable translation. They also include cases where watermelon was clearly indicated by descriptive terms or statements such as "it is nothing but water". References in which there appears to be some doubt whether watermelon or some other cucurbit was intended have been omitted.

In 1576, a farmer named Juan Serrana testified in a Law court that the soil of Santa Elena Island was good for growing maize, pumpkins and watermelons *(sandias)* (Connor 1925:159).

In 1597, de Salas, a Spanish soldier, traveled 50 leagues inland to the Indian town of Cute and there found Indians growing watermelons (Serrano y Sans 1912:144). This was in the province of Ocute located on the lower reaches of the Ocmulgee River, a tributary of the Altamaha, which had been visited by de Soto (Swanton 1946:138). This indicates that the aboriginal cultivation of watermelon had already begun to move inland.

To the west, in Mexico near the border of the present state of Texas, Espejo in 1582, reported watermelons among the Indians of the Conchos nation (Bolton 1963:170). Sixteen years later in 1598, Oñate declared that watermelons were generally grown by Indians of the Pueblo area in the Southwest (Ibid. 1963:217). There is archaeological confirmation of the watermelon in the Southwest, sometime between 1626 and 1675, by Volney Jones's identification of two kinds of watermelon seeds recovered from the turkey pens excavated by Toulouse at Abo Mission, southeast of Albuquerque (Jones 1949:30).

It has been pointed out above that the watermelon began to be generally known in northern Europe in the first quarter of the seventeenth century. The earliest reference that we have been able to find for watermelons in the Northeast is the 1629 statement of Master Graves (1968:124) that in New England "we abound with . . . sundries sorts of fruits as musk-millions, water-millions . . . ".

A 1634 report by Father Andrew White on his way to Maryland shows that ships from Europe enroute to the colonies sometimes stopped in the West Indies where watermelons had been previously introduced (Hall 1959:38). In the same year, it was reported in a *Relation of Maryland* that settlers had made trial of "Musk-mellons, Water-mellons, Cow-cumbers . . ." (Hall 1959:82). In a 1649 account of New Netherland, the writers remarked that watermelons could be grown in the fields, but in the Netherlands, they require particular attention in gardens (Brodhead 1856:277). By the period of 1665-1670 watermelons had reached the Great Lakes, for Perrot (1911:113) noted their use among the Heron at that time and, shortly after in 1673, they were reported among the Illinois by Marquette (1966:129).

From the seventeenth century and later there are historical references to the cultivation of watermelons by Indians from the lower Mississippi Valley north into Canada and from the east coast west to California. Kino, the explorer priest, reported in October

1700 that he saw watermelons growing "at the foot of a hill, from the top of which, California is plainly visible", while he was in the country of the Yuma Indians (Bolton 1919, Vol. 1:249). The watermelon appears to have been in use among the Natchez some time before the early part of the eighteenth century, when the French had regular contact with these Indians, for they called June "the watermelon moon" (LePage duPratz 1975: 338). (See also Appendix II for additional early historic references to watermelon in the United States.)

We have been unable to find any reliable mention of watermelon in the North and Northeast before the accounts given above of about 1629-1649, hence transmission to the Huron and the Illinois appears to have taken a relatively short time. The spread to the north was probably hastened by the method in use among the Huron described by Sagarde. Seeds of squash were sprouted by placing them in a box filled with rotted wood, which was moistened and suspended over the smoke of a fire (Kinietz 1965:19). A similar method was described by G. L. Wilson's Hidatsa informant as late as 1914 (Wilson 1977:68). Charlevoix (1763:237) observed that this method was also used for watermelons. He said, "Sun-Flowers, Water-Melons, and Pomkins are set by themselves; and before they sow the Seed, they make it shoot in Smoke, in light and black Earth".

Accounts of the seventeenth and early eighteenth century sometimes indicate that more than one kind of watermelon was grown. It will be recalled that Jones (1949:30) recovered two kinds of watermelon seeds at Abo Mission. Marquette (1966:129) said of the Illinois in 1673, "They also sow beans and melons, which are excellent, especially those that have red seeds". Some watermelon seeds are "reddish black" and some are "white, yellow, brown, green, black". (Whitaker and Davis 1962:38). Marquette's statement appears to indicate that more than one kind was grown by the Illinois. John Banister (1678-1692) spoke of "watermelons red, yellow and white meated" (Ewan and Ewan 1970:350). LePage duPratz (1975) described several kinds of watermelons grown in Louisiana that varied in shape from round to long and in size from 10 to 30 pounds. The seeds of "Some are black and others red" (1975:230, 231). There is, of course, no certainty that more than one variety reached all Indians or, if they did, that they continued to be grown.

Watermelon seeds could have reached the Indians by diffusion from Spanish settlements in Florida, Mexico or the Southwest, or possibly from traders or missionaries in the North or East. The priest Kino did distribute seeds, including those of the watermelon, while in the country of the Pima and the Papago (Castetter and Bell 1942:74), but we know of no documented instances of this practice by early missionaries or traders in the North. Incidently, Kino found that the Indians already had watermelons, even those near the present day Cocklebur, Arizona, "although never in that village had there entered another white face or Spaniard" (Bolton 1936:398).

Among collections of plant remains recovered from archaeological sites sent to the Missouri Botanical Garden for identification were five that contained seeds of watermelon *(C. lanatus)* (Cutler and Blake 1976:13, 14, 45, 46). These are listed with measurements of seeds, cultural affiliation and dates in Table 1. A brief additional statement on each may be in order, however.

Zimmerman, located on the Illinois River opposite Starved Rock, was possibly the village visited by Marquette in 1673 (Brown 1975:2).

King Hill is located on the Missouri River bluffs in a residential area of St. Joseph, Missouri (Ruppert 1974:2-11).

Utz is on the south bank of the Missouri River north of Sedalia, Missouri. It was the home of the historic Missouri Indians until about 1714 (Berry and Chapman 1942; Bray 1978).

Rhoads is on a tributary of the Sangamon River north of Springfield, Illinois. It was occupied by Kickapoo Indians in close touch with the British (Klippel 1973).

Coal Pit, a village of the Little Osage near the western border of Missouri was probably the one visited by Pike's Lieutenant Wilkinson (Chapman 1974:120). While there on

TABLE 1. – *Watermelon seeds from five Midwestern historic and protohistoric archaeological sites (Carbonized, unless otherwise noted.)*

Site name	Zimmerman	King Hill	Utz	Rhoads	Coal Pit
Site number	11Ls3	23Bn1	23Sa2	11Lo8	23Ve4
Approx. period of occupation	A.D. 1673-1691	Ca.A.D. 1700	Ca.A.D. 1600-1714	A.D. 1760-1820	A.D. 1790-1820
Culture or tribe	Historic Kaskaskia	Late Oneota Kansa (?)	Late Oneota Hist. Missouri	Historic Kickapoo	Historic Little Osage
No. of seeds	52	2	2	7	5
Sizes of seeds (mm)	7.8 by 4.9 9.0 by 5.6 9.4 by 5.2 9.9 by 5.0 9.9 by 5.2	8.8 by 5.1 9.4 by 5.3	10.0 by 5.6	9.4 by 5.0 9.5 by 4.7 9.5 by 5.0 12.3 by 8.2 (*)	11.0 by 5.6

(*) Not carbonized.

18 August 1806, Wilkinson was given "watermelons about the size of a twenty-four pound shot, which though small, were highly flavored" (Jackson 1966, Vol. II:5). Since a 24 pound shot is only about 14 cm in diameter, these were quite small watermelons.

A small, round variety of watermelon has survived up to recent times among some Indian tribes. Gilmore (1977:68) described the old watermelon of the Omaha as "small, round and green, having a thin rind and red flesh, with small, black, shining seeds". Bohrer (1960:200) described a similar variety grown by the Zuni, which was 17.1 cm in diameter. Castetter and Bell (1942:119) also spoke of a small, spherical melon with pink flesh, 20.3 cm in diameter, which was grown by the Pima.

Reasons for rapid acceptance of the watermelon by Indians over a wide area, often with different cultures, appears to lie in the fact that methods of successful cultivation are similar to those of the native squashes *(Cucurbita* spp.) with which they were familiar. Also, the long, hot continental summers over much of the United States favored its growth. Contributing factors were the sweet and refreshing taste, which was probably particularly relished where the diet was monotonous, and the excellent keeping qualities of some varieties. Whiting (1939:92) mentioned an old Hopi type that kept until mid-February. Storage for winter use was noted by Robbins et al. (1916:112) among the Tewa and by Bohrer (1960:200) among the Zuni. Peter Kalm described methods used by the settlers in Pennsylvania to keep watermelons "during a great part of the winter" (Benson 1966:516).

Since watermelons appear to have been adopted by the Indians for use fairly early, and since they could be grown locally and did not have to be imported as did the usual trade goods, there would seem to be a good chance that watermelon seeds may turn up on sites where no trade goods are recovered. The increasing use of flotation techniques enhances this possibility. In any event, they should be of particular interest to archaeologists for they are as good an indication of the effect of European presence as glass beads and articles of brass or iron. Also, with a greater recovery of seeds, it may be possible to distinguish archaeologically a number of places where more than one variety was grown.

APPENDIX I

Clément-Mullet's French translation from the Arabic

6. le melon en *forme de jarre*, parce Qu'il reasemble à cette sorte de vase: ***le melon de Palestine***, qui est le melon de Constantinople, le melon de l'Inde ou du Scinde, comprenant deux variétés; l'une a la graine noire et (l'écorce) d'un vert très-foncé passant au noir; l'autre a la graine d'un rouge pur, et la couleur verte de son écorce passe au jaune (Clement-Mullet 1866, Tome II, Pt. 1:216).

APPENDIX II

Additional early historic references to watermelon in the United States

Date	Reference
1663	John Josselyn noted watermelons in New England in the account of his second voyage (1865:60,101).
1679	John Banister wrote a letter in this year telling about watermelons in Virginia, (Ewan and Ewan 1970:41).
1687	Joutel was given watermelon to eat by the Arkansas and later by the Kaskaskia Indians (1962:143,146,156,163).
1690	De Leon saw watermelons near the present day town of Crocket in Houston County, Texas (Bolton 1963:415).
1691	Casanas noted watermelon among the Tejas and Asinai Indians of Texas (Swanton 1942: 128,243).
1691	Espinosa mentioned that watermelons were grown in the province of Texas (Swanton 1942:243).
1697	Mange said that watermelons were grown at San Agustin de Oiar, which is near present day Tucson, Arizona (Burris 1971:215).
1697	Cadillac said that the harvest of the northern Indians included watermelons (1962:12).
1699	Penicaut was given watermelon to eat at the village of the Pascagoulas (McWilliams 1953: 18).
1705	Liette said that the Illinois harvested "a great many fine watermelons . . . many of them as big as a water bucket" (1962:126).
1705	Beverley spoke of several varieties of watermelon in Virginia (1947:141).
1748-1749	Peter Kalm mentioned watermelons a number of times in noting their presence in Canada, eastern North America and in the Illinois Country (Benson 1966:59,508,509,515,516,617).

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A "LOST" VIKING CEREAL GRAIN

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ABSTRACT.–Lyme grass ***(Elymus arenarius)***, a coastal wild grass of the artic and sub-artic of the northern hemisphere, occurs in carbonized form in Viking archaeological sites, especially in Iceland and Greenland. There is also an increase in elymus pollen contemporary with the Viking homesteads at L'Anse-aux-Meadows, Newfoundland. In Iceland, lyme grass grain was the main source of bread flour until the eighteenth century, when imports from Europe of wheat flour replaced it. Folk tradition in Iceland held that lyme grass bread was both more tasty and nutritious than wheat bread. Comparison of some basic nutritional values of lyme grass grain with some other standard foodstuffs, including amaranth, shows that lyme grass has considerable nutritional value for human beings. The most remarkable aspect of the restoration of lyme grass as a foodstuff in the future would be that it would form a cereal crop which can be grown in the artic regions where no other suitable agricultural crop is forthcoming. If the world food shortage becomes more acute in the next few decades, the cultivation of lyme grass would open up millions of acres of food production.

INTRODUCTION

Several peoples of the world have been recorded as having used lyme grass *(Elymus arenarius* L.) as a flour. While this grass (Fig. 1) normally grows in circumpolar contexts, primarily near marine environments, Newberry (1857) cites its collection by Pacific coast "Digger" Indians as far south as northern California. It has also been collected by peoples of the northern Soviet Union (Komarov 1963). The greatest users of lyme grass, however, were the Vikings, especially those Norsemen who came to Iceland, Greenland, and Newfoundland. Different folk names are "strand oats" and "strand wheat" in English, *Strandhvede* (Strand wheat), *Sandhavre* (Sand Oats), *Vild Hvede* (wild wheat), *Melur* and *Sand Melgras* (Sand Meal-grass) in Norwegian and Icelandic. These folk-names (Fernald 1910) reveal a notion of lyme grass bearing an edible grain.

The evidence for lyme grass from mainland North America comes from two sources. The first source is the reference to "self-sown wheat" in the Vinland discovery sagas (Magnusson and Palsson 1965:52). The second source of evidence is from the excavations at L'Anse-aux-Meadows, Newfoundland, where there is a distinct jump in easily recognizable *Elymus* pollen in several zones at the site, although the genus was in Newfoundland thousands of years before the Norse settlements (Henningmoen 1977).

In the pollen at L'Anse-aux-Meadows pond *Elymus* pollen is present at the deep 160-170 cm levels with a C_{14} date of 3,890 ±110 B.P., but it rapidly drops out of the record at two loci. It picks up again later, at the 60-80 cm levels, roughly at the position of the Norse occupation, judging from the date cited, and another date at 2,000 B.P. obtained from the column. A third sample has *Elymus* only at the 60-70 cm zone where the radiocarbon date falls between 1,130 to 1,450 B.P. at a 95% confidence level.

FIG. 1–Glume-covered and bare grains of lyme grass *(Elymus arenarius)*.

Even clearer indications come from the Palsa Bog on terraces immediately behind the Norse houses. *Elymus* is lacking here at the deep 170 cm level with a date of 5,320 ± 60 B.P., but is plentiful at the 40 cm level and up; a sample from the 35 cm level has a date of 460 ± 80 B.P. It appears again at the 65-80 cm level, which should be the zone representing the Norse settlement according to Henningmoen (1977:314-315). Thirty cm east of House F, *Elymus* occurs only at the 50 cm level where there is a corresponding C14 date of 1,280-1,680 B.P. in the levels below.

From the archaeological features themselves, at House A, North wall, *Elymus* first appears at the 40 cm level, where the wall is about 4 cm above the old land surface. It occurs sporadically inside the wall turves, reaching a maximum abundance at the 18 cm level on top of the surviving wall, reducing to a minimum presence at the 13 cm level in the soil overlying the top of the turf wall of the house. This suggests the pollen is concentrated on the ledge of the standing wall. Also occuring outside the houses is the European weed *Rumex*, known only in modern or very recent pollen deposits (Henningsmoen 1977:328-333). Location of pollen in the southern wall of this house is less clear, although the 3 cm deep occurrence of *Elymus* in the diagram is coded "top of the wall" despite the shallow depth. Similarly, the pollen diagram for House F, northern wall, is difficult to equate with a published section, but the sole occurrence of *Elymus* here in the 20-30 cm level of the wall has an unambiguous accompany C14 date of 1,050 to 850 B.P., making it clear that the *Elymus*, like the *Rumex*, associates with the Viking homestead on Newfoundland.

The most intensive use of lyme grass seems to have been in Iceland and Greenland. Historic records imply that at about A.D. 1000 lyme grass was collected from thick wild stands to supplement the crops of wheat and barley which sometimes failed this far north. Apparently, as the climate of the northern hemisphere deteriorated by the late Middle Ages and eventually led to abandment of the Greenland settlements and increased hardship in Iceland, lyme grass replaced the more normal cereals of Western Civilization in cultivation. Archaeological excavations of Norse settlements in Greenland were done mostly before World War II, so the lack of a fine chronology prevents any glimpses of changing incidences of lyme grass use. As late as 1783 the English botanist Sir William Johnson Hooker (quoted in Fernald 1910) spoke of "Fields used to produce the Sea-lyme grass" and noted that devastation by volcanic eruption would have dire consequences for the food supply since very little "corn" (undoubtedly normal wheat grain) was imported into the cities and those isolated regions.

The somewhat vague evidence from the sagas concerning lyme grain in Greenland finds support in the distribution of wild stands of *Elymus* in Greenland. Lyme grass in the narrowest sense *(Elymus arenarius* L. [2n=42] variety *villosus)* grows primarily on the ruins of old Norse and ancient Eskimo settlements. Other lyme grass *(Elymus arenarius mollis* [2n=28]), the Neoarctic variety, is found from Greenland to northwest Asia (Pedersen 1972:76-77; Fredskild 1973) and occurs with less density but more widespread coastal distribution.

It is still uncertain as to whether or not lyme grass was ever domesticated in the Viking homeland. Certainly it is notably lacking in the bizarre gruels which were concocted from cultivated grains, some questionable domestics such as *Chenopodium*, and weeds. These gruels were consumed as last meals by the time-of-Christ bog bodies such as Graubelle, Tollund and Borremose men (Helbaek 1958; Brandt 1950), who clearly antedate the Vikings by nearly a millennium. Olsson (1974:30-32) notes that lyme grass has spread anthropogenously from the coasts all over southern Sweden, exhibiting both a normal littoral as well as xerophytic varieties. He considers the key ecosystem elements in the *Elymus* communities to be human agency and nitrophilia.

Decline in the consumption of lyme grass began with the rise in commercialism in the sixteenth century. After 1800 with the blossoming international trading system and the greatly enhanced food production in Europe and North America, lyme grass grain was slowly replaced by imports of wheat, rye and barley. This process was encouraged by trading regulations from the kingdoms of Norway and Denmark (Nørlund 1936), which successfully exercised sovereignty over Iceland. Lyme grass flour was not abandoned completely, however, until early this century (Sigurbjornsson 1960:52).

At first consideration, it seems only normal for the Icelanders to prefer wheat flour and the like over lyme grass meal for bread and other bakery products. Despite the factors mentioned above, the replacement of lyme grass by imported flour remains something of a mystery. According to some Icelanders, the *melur* flour from lyme grass was more tasty than wheat flour and more nutritious as well. Hooker, the botanist (in Fernald 1910:27-28), shared this opinion concerning the relative taste and the Icelanders had not yet perfected the technique of "drying and preparing the grain."

Is this folkloric insistence on the superior gustatory and nutritional qualities of lyme grass the mere grumbling of some conservative diehards? Hooker's assertions were strongly put and folklore often contains a grain of truth hidden therein. Rather than dismiss these traditions, we have tested the lyme grass grain for some aspects of its nutritional value. Our motives were not merely to vindicate Vikings, who seldom needed help from anyone, but also included the evaluation of lyme grass as a possible agriculture crop for the arctic, a climatic zone which hitherto has been only seldom utilized for food production.

METHODS

With funding at our disposal, we tested the content of lyme grass seeds for iron, seven fatty acids and 17 amino acids (Table 1) at the Experiment Station Chemical Laboratories of the College of Agriculture, University of Missouri-Columbia. A comparison was made between dry, uncooked lyme grass grain and several other prominent foodstuffs including the top four crops (wheat, rice, maize, and potatoes) which produce more tonnage for the world's food then do the next most prominent 26 crops combined (Harlan 1976).

The amino acid assays were made on hulled, twice-ground samples and were saponified and analyzed by liquid chromatography (Benson and Patterson 1971). Heptacecanoic acid (C17:0) comprised the internal standard used to quantify fatty acids. No indigenous heptodecanoic acid had been found in a trial sample. A computer interfaced with the GLC set was used for identification and quantification of the fatty acids. The iron content was assayed by a nitric perchloric acid wet-ash digestion follows by an atomic absorption determination.

TABLE 1.–*Amino Acids, Iron and Fatty Content of Lyme Grass* (Elymus arenarius).

	Sample 1	Sample 2	Sample 3		Sample 1	Sample 2	Sample 3
AMINO ACID				Phenylalanine	.98	.85	1.17
(protein per 100 g)				Histidine	.44	.47	.51
Aspartic Acid	.94	1.34	1.06	Lysine	.51	.75	.59
Serine	.87	.81	.88	TOTAL			
Glutamic Acid	5.84	4.78	6.62	PROTEIN	18.23	17.38	20.76
Proline	2.38	1.70	2.71	FATTY ACID			
Glycine	.87	.88	.94	(mg per 100 g)			
Alanine	.70	.88	.76	Palmitic	2.13	1.78	2.04
Cystine	.18	.12	.16	Palmitoleic	.08	–	.08
Tyrosine	.36	.32	.36	Stearic	.13	.09	.14
Ammonia	–	–	–	Oleic	2.83	2.14	2.74
Arginine	.82	1.00	1.01	Linoleic	10.10	5.20	10.90
Threonine	.61	.64	.65	Linolenic	4.85	6.30	4.14
Valine	.73	.84	.94	Arachidonic	–	–	–
Methionine	.24	.23	.26	TOTAL	20.12	15.51	20.04
Isoleucine	.55	.61	.71	IRON			
Leucine	1.21	1.16	1.43	(mg per 100 g)	5.50	5.40	5.80

DISCUSSION

Comparison of the characteristics of the dry, uncooked lyme grass grain with that of some other foodstuffs (Table 2) shows that among the cereals, its iron content exceeds that of wheat *(Triticum aestivum)* and oats, while its protein content surpassed that of some touted sources such as oats, high-protein corn, Soviet *Triticum-Elymus* hybrids, and amaranth. Wild wheat *(I. monoccum)* does have a higher crude protein rating (22.8%) (Harlan 1967:198; Harlan et al. 1973:318). Red beans have a slightly higher protein value but lyme grass total protein content challenges even salmon. Among the essential amino acids amaranth may have twice as much leucine and lysine as *Elymus,* although *Amaranthus edulis* with a high lysine content which provided protein for Aztecs (Ortiz 1978), has a leucine content somewhat inferior to that of *Elymus* (Downton 1973) even though the absolute content is only slightly higher.

Amaranth's leaves, of course, provide a human and animal foodstuff which though less storable, is even more nutritious. The leaves and glumes of lyme grass would not be suitable for human consumption, but make an excellent hay for livestock. According to data compiled by Sigurbjornsson (1960), sheep, beef cattle, and horses thrive on the

TABLE 2.–*Comparison of Lyme Grass With Other Foodstuffs.*

	Lyme Grass	Amaranth	Soviet Hybrid *Elym.-Trit.*	Soviet Wheat	Wheat	Hybrid Corn High-Protein	Maize	Rice	Potatoes	Oats	Red Beans	Salmon	Beef
AMINO ACID (protein per 100 g)													
Aspartic Acid	1.20					1.38	.60						
Serine	.85					.72	.46						
Glutamic Acid	5.95					2.92	2.33						
Proline	2.26					1.15	.98						
Glycine	.90					.96	.34						
Alanine	.84					.97	.72						
Cystine	.15	.25				.30	.21						
Ammonia	–												
Arginine	.94	1.39				.93	.31						
Threonine	.64	.99				.71	.34						
Valine	.84	1.39				.90	.48						
Methionine	.25	.30				.31	.27						
Isoleucine	.64	1.35				.53	.37						
Leucine	1.27	2.41				1.01	1.35						
Phenylalanine	1.00	1.28				.67	.60						
Histidine	.48	.66				.46	.31						
Lysine	.62	1.26				.68	.20						
Other	–												
TOTAL PROTEIN	18.80	14.5	14.6	14.4	9.3	12.9	8.5		2.1	14.2	22.2	20.2	28.6
FATTY ACIDS (mg per 100 g)	1.866	.5	X	X	4.3	X	2.6	.49	.0	7.4	1.5	12.2	15.4
IRON (mg per 100 g)	5.6	5.9	X	X	2.3	X	1.8	2.9	.6	4.5	2.5	.9	8.2

(Most non-*Elymus* values are taken from Watt et al. 1975 Tables 1, 3. Soviet hybrids and wheat are from Ivanovskaya 1960:89; high-protein maize-corn amino acids are from Misra et al. 1972:1426; Amaranth amino acid means are from Olivera and Carvalho 1975:258.)

cut body of the plant, the food value of which far exceeds that of the straw of wheat and other familiar Eurasiatic cereals. Lyme grass does not endure close grazing by livestock and would not be suitable for a pasture grass, even though it makes excellent fodder as the by-product of grain production.

Lyme grass seems to compare with several other crops as poorest in terms of yield (Table 3). One must bear in mind, however, that high yielding crops such as rice, maize, and wheat have been domesticated for nearly 8000 years, whereas lyme grass has scarcely been selected for productivity during only a few centuries as a cultivar. Lyme grass's yield range actually overlaps with the much tested and promoted amaranth, so it appears to have some potential as to productivity as well as nutritional value. As Sigurbjornsson (1960: 51) points out, the low yield is relatively unimportant, since the crop can be

TABLE 3.—*Yield per hectare of Lyme grass and other crops (world averages).*

Crop	Yield, kg per hectare	Crop	Yield, kg per hectare	Crop	Yield, kg per hectare
Rice	2,300	Wheat	1,560	Amaranth	683-983
Maize-corn	2,400	Oats	1,660	Lyme grass	600-800
Barley	1,910	Soybean	1,740		

(Sources: Amaranth, *Organic Gardening and Farming Research Center* and Downton 1973. Tsitsin and Petrova 1952 quoted in Sigurbjornsson 1960:50; others, U.S. Department of Agriculture, modern world averages.)

grown on land otherwise useless for agriculture. Jack Harlan (personal communications) assures us, moreover, that this yield is identical to that of domesticated cereals, such as rice, maize, and wheat, under conditions of subsistence agriculture with no soil inputs.

In any case, lyme grass has potential as a cultivar in the high artic, north of the Artic circle, in a region hardly utilized for food production and certainly not grain farming. Thus, in any future grain shortage the extension of agriculture into these regions would add immensely to the world land acreage available for food production at a time when some feel (Brink et al. 1977) that there is hardly any more new land for farming. This would include vast areas of the Soviet Union, a region notorious for inadequate grain supplies, as well as millions of acres in North America. In Alaska alone there are an estimated 16 million acres useable for agriculture (Wooding et al. 1974). Figure 2 shows the region of prime potential for lyme grass farming in North America, since stands of wild lyme grass grow there now.

Our conclusion then is that the Icelandic folklore and tradition is correct, that it was a highly nutritious cereal and therefore it must have made a considerable contribution to Norse and Viking diets of the North Atlantic region. Also, the potential of lyme grass to ameliorate the shortage of world food supplies emerged from this study, perhaps the most significant conclusion we can draw. Its ability to thrive in marginal climates and its high nutritional values should bring lyme grass to the attention of both botanists and agricultural economists.

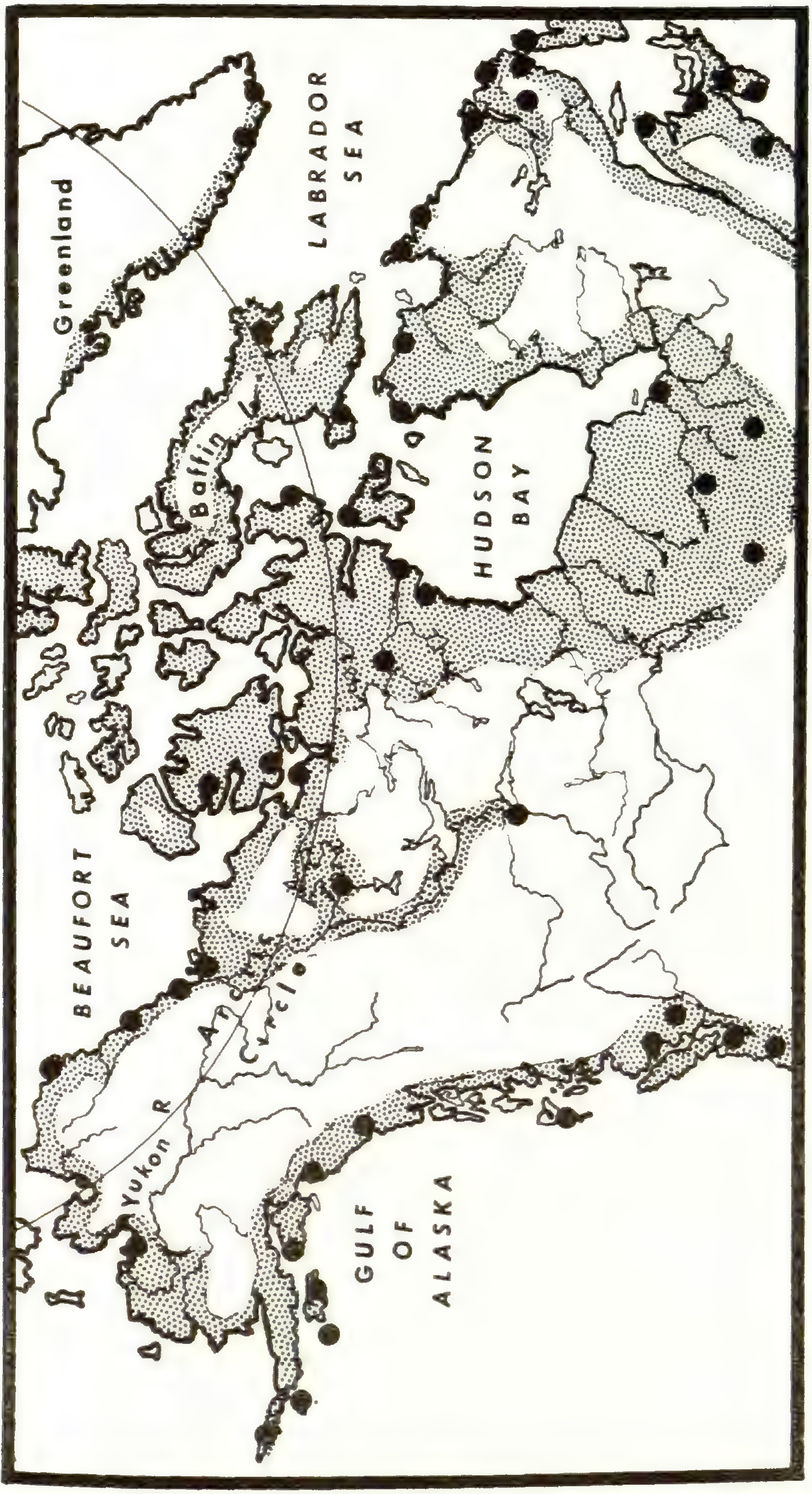

FIG. 2—Map of present distribution of lyme grass (*Elymus*) in North America. Stripped area indicates habitats suitable for lyme grass, dots show locations of lyme grass identified under controlled conditions. (After Raup with modifications for Greenland and Newfoundland.)

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THE AÑU AND THE MACA

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ABSTRACT.–***Tropaeolum tuberosum*, *añu*,** and ***Lepidium meyenii*, *maca*,** are cultivated in the Andes mountains for their edible underground parts. Cultural and medicinal associations between the plants are supported by their similarity in secondary chemistry, and by the pharmacological properties of the isothiocyanates released upon hydrolysis of the glucosinolates present. ***T. tuberosum*** has been reported to contain p-methoxybenzyl glucosinolate; ***L. meyenii*** is reported here to contain benzyl and p-methoxybenzyl glucosinolates. The likelihood that human selection for specific flavor and medicinal properties has altered the secondary chemistry of, at least, the ***añu*** raises questions concerned with both human taste perception and plant domestication.

INTRODUCTION

The relationship between the use of plants for food and medicine and the chemical constituents of these plants involves a combination of biological and cultural factors. The choice of particular plants in many cases reflects their obvious and well studied nutritional and pharmacological properties (Arnason et al. 1981). Where plants are used in ways which have no apparent western scientific basis, their use is thought to be principally of symbolic and cultural significance (Ford 1981). Needless to say effective medicinal agents have considerable cultural significance as well; plants may possess properties which are not yet defined by western scientific methods.

The question of the initial discovery of empirically used plants is intriguing (Ford 1981). The means by which humans (and animals) perceive beneficial or harmful constituents in relation to physiological homeostasis is interesting but not well understood. Plants of solely ritual and mythological importance must be considered in the broader context of human spiritual and social values. However the association of the western empirical and the cultural values of plants with their chemical constituents are both likely. Physiological perception primarily through taste and smell provides the basis for such association.

Lévi-Strauss (1966) discusses briefly the systematization of such sensory data. Although his chemical treatment is rudimentary, he provides insight into the processes by which primitive man might form structures that are ultimately uncovered by science. The differentiation of plants on the basis of organoleptically detectable physical properties and the translation of perceptional differences into culturally important categories can be difficult to appreciate. For the observer who is accustomed to orient his/her universe visually, the taxonomy of taste is a difficult folk taxonomy to come to terms with (Berlin et al. 1974). Analytical techniques which allow the detection of subtle differences in chemical composition and properties are a starting place from which to tackle problems of this type.

Tropaeolum tuberosum Ruiz and Pavon, the *añu, isaño* or *mashua*, and *Lepidium meyenii* Walp., the *maca*, together represent an interesting case of association of chemical properties with deep rooted cultural beliefs and concepts. This association seems to be a combination of both empirically definable and cultural concepts. Both plants contain similar constituents which are readily detectable by taste and which have a physical basis of action in many cases.

The *añu* and the *maca*, in the Tropaeolaceae and Brassicaceae respectively, are two species of plants from Andean South America cultivated for their edible underground parts and for their medicinal uses. The *añu* is presently known from southern Venezuela to northern Argentina although use of the tuber as food is relatively localized in comparison to other tuber crops such as potato (Montaldo 1977). The *añu* grows best between 2500 and 3700 meters above sea level. The varied medicinal uses of the plant have been summarized recently and their efficacy in many cases has been substantiated (Johns et al. 1981). The *maca* is more restricted in distribution. Although it may have been more widespread at the time of the Spanish conquest, it is presently cultivated for its edible root in the Departments of Pasco and Junin, Central Peru, between 3500 and 4000 meters above sea level (Leon 1964). Historically the plants probably grew sympatrically over a much wider geographical range than at present.

These two plants correspond strikingly in terms of the historical and modern folk beliefs associated with their putative effects on human reproductive potential. These beliefs correspond in turn with the similarities in phytochemistry. Although the two families, Tropaeolaceae and Brassicaceae, are usually classified quite separately by systematists, they are both typified by having glucosinolates, the mustard oil glucosides, as their major secondary metabolites.

The numerous reports on the supposed effects of *añu* in enhancing female fertility and as an anti-aphrodisiac and anti-reproductive agent in males have been summarized (Johns et al. 1981). References to the *maca* are more scarce; Leon (1964) provides the most accessible and recent overview of its biology and ethnobotany. It is reported by the chroniquilists in the time of the Spanish conquest that the Indians recommended feeding *maca* to domestic animals to combat low reproductive rates at high altitudes, and that the Spanish noticed the positive effects. Leon (1964) reports that *maca* is now eaten by Indian and white women who want to have children. It is sold in the market for this purpose. More recent visitors to the area around Lake Junin (Michael F. Brown, Jefferey Parsons, Kent V. Flannery, personal communications) report that belief in the fertility effects are widespread. However the fact that the belief applies particularly to male fertility seems to contradict the beliefs listed previously.

Maca may be eaten fresh at the time of harvest, but is more commonly dried for long term preservation. It is prepared similarly for both food and medicine. Dried roots are cooked in milk and/or water and are served either in the cooking liquid with perhaps a little sugar, or in a cocktail with aguardiente. *Añu* is usually boiled before use and retains much of its characteristic flavor. It is occasionally preserved in a drying process similar to the production of *chuño* from potatoes; in Bolivia this product is known as *taiacha* (Fernandez 1973). The effects of preparation on medicinal properties or chemical constituents are unknown, but in the case of *maca* and boiled *añu* they appear insignificant.

The glucosinolates characteristic of both of these plants undergo enzyme hydrolysis upon damage of the tissue and release the volatile and distinct tasting isothiocyanates, or mustard oils (Fig. 1). These are the compounds responsible for taste in cruciferous vegetables (MacLeod 1976); they are, as well, biologically active (Benn 1977). A variety of naturally occurring isothiocyanates (and parent glucosinolates) are known. These can be distinguished chemically on the basis of side-chains. Although they all have the sharp taste of mustard, they are also distinguishable by taste to some extent.

Tropaeolum tuberosum has been differentiated into a wild and a cultivated subspecies. This classification is supported chemotaxonomically (Johns and Towers 1981). The obligate cultigen, subsp. *tuberosum* contains only p-methoxybenzyl isothiocyanate (Fig. 2). The wild subsp. *silvestre* is characterized by benzyl, 2-propyl, and 2-butyl ixothiocyanates (Fig. 2) (Kjaer et al. 1978; Johns and Towers 1981).

The literature contains no reports of phytochemical studies of *Lepidium meyenii*. *Lepidium* species, as members of the family Brassicaceae, are known to contain glucosinolates. Species from other parts of the world have been studied and found to contain a

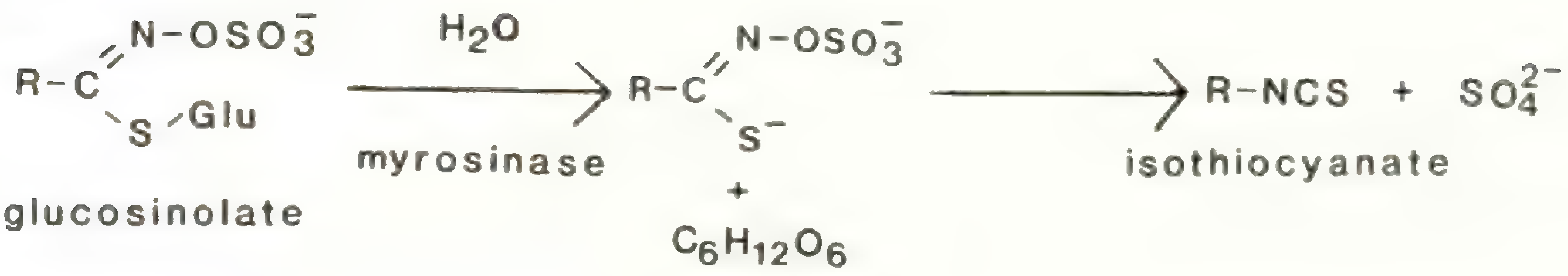

FIG. 1–Formation of isothiocyanates by enzymatic breakdown.

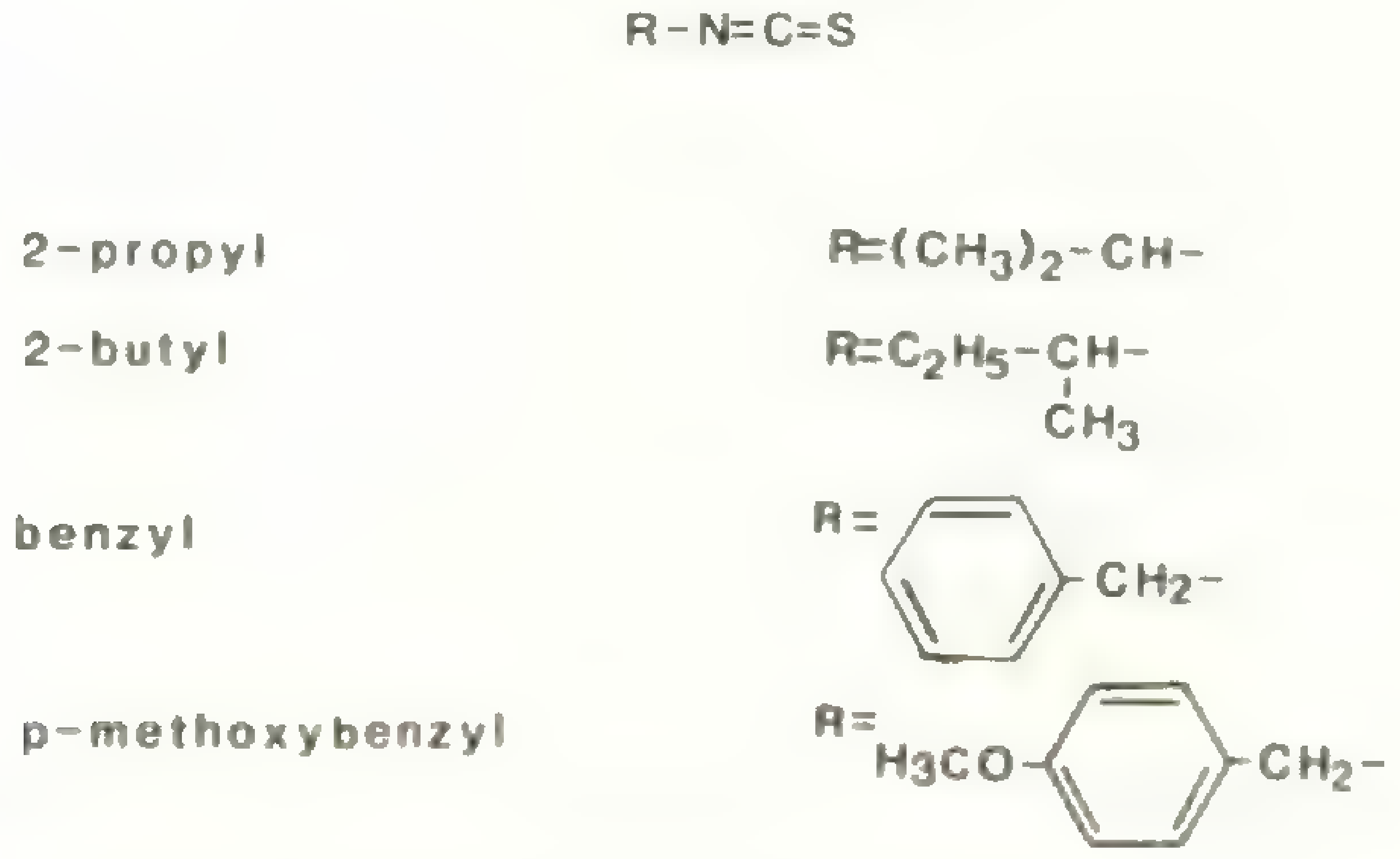

FIG. 2–Isothiocyanates of ***Tropaeolum tuberosum*** and ***Lepidium meyenii.***

variety of glucosinolates including benzyl glucosinolate reported above from *T. tuberosum*. Variation comprising alkyl and alkenyl derivatives occur within the genus although aromatic glucosinolates, with or without hydroxy and methoxy substitutions in m- and p-positions, prevail (Kjaer and Wagniere 1971). 3,4,5-Trimethoxybenzyl glucosinolate occurs in *L. sordida* A. Gray (Kjaer and Wagniere 1971) and *L. hyssopifolium* Desv. (Kjaer et al. 1971). The only species studied from South America, *L. bonariense* L. from Argentina, is reported to contain p-hydroxy and p-methoxybenzyl isothiocyanates.

MATERIALS AND METHODS

Roots of *L. meyenii* collected in Wayri, Department of Junin, Peru on July 15, 1973 by Michael F. Brown and subsequently preserved in p-dichlorobenzene and deposited at room temperature in the Museum of Anthropology, University of Michigan were examined in 1980. Isothiocyanates liberated enzymatically from ground root material (7 g) were studied using the methods described previously for *T. tuberosum* (Johns and Towers 1981). Extracts were examined for isothiocyanates, thiocyanate ions and cyclic oxazolidinethiones (Ettlinger and Thompson 1962).

RESULTS

Lepidium meyenii gave a negative test for thiocyanates and cyclic oxazolidinethiones. Therefore the plant does not contain p-hydroxybenzyl isothiocyanate. Paper chromatography (PC) of thiourea derivatives using a solvent system of benzene-ethanol-water (5:1:2) (Ettlinger et al. 1966) showed only one spot corresponding to benzyl isothiocyanate.

Reverse phase High Performance Liquid Chromatography (HPLC) showed one large peak corresponding to benzyl or p-methoxybenzyl isothiocyanates, and one smaller unidentified peak. By normal phase HPLC this sample was resolved into four peaks. The largest of these corresponded to benzyl isothiocyanate and a smaller one to p-methoxybenzyl isothiocyanate. The area of the 'benzyl' peak in reverse phase was 63%, while the area of the combined benzyl and p-methoxybenzyl peaks in normal phase was 65%. This rough measure supports the supposition that the two peaks were resolved from the major peak in the reverse phase system. The identity of the two other peaks remains unknown.

PC and HPLC data combined indicate that *L. meyenii* contains benzyl isothiocyanate as its principal isothiocyanate and p-methoxybenzyl isothiocyanate in relatively smaller amounts. Because only one thiourea spot was seen by PC the unidentified spots on HPLC are likely not isothiocyanates. Until more samples are examined and other methods of analysis can be used to confirm the identity of the compounds present, these results must be viewed as preliminary.

DISCUSSION

The parallels between the *añu* and the *maca* as agents affecting fertility appear more than coincidental. Reproductive rates are indeed lower and a concern at high altitudes (Sobrevilla et al. 1968; Buck et al. 1968) and folk beliefs associated with fertility are to be expected. However, the association of two glucosinolate-containing 'root' crops with this concern is highly suggestive. Chemical analysis shows that both plants are characterized by aromatic glucosinolates. They appear to both produce p-methoxybenzyl isothiocyanate while the *maca* also produces benzyl isothiocyanate. At least in the conception of Andean peoples there is a relationship between aromatic isothiocyanates and human reproductive processes. The overlap of constituents between the two plants suggests that association may be as specific as between p-methoxybenzyl isothiocyanate and human reproduction.

The use of *T. tuberosum* subsp. *tuberosum,* and *añu,* to negatively affect male reproductive processes was supported by pharmacological studies with rats (Johns et al. 1981). The mechanism for this activity, while apparently indirect, supports the empirical use of the plant by Andean peoples. The proposed mechanism is likely to account for similar effects for the *maca,* as well as for any isothiocyanate containing plants, whether they be aromatic or not.

Therefore, although the use of isothiocyanates in general has a western scientific basis, the specific emphasis on aromatic isothiocyanates seems culturally determined. It may be strictly coincidental that both 'root' crops contained these compounds, and that associations were easily drawn by people familiar with both plants. However, studies on the botanical origin of the cultigen, *T. tuberosum* subsp. *tuberosum,* indicates that the situation is not so straight forward (Johns and Towers 1981). Although a hybrid origin of the cultigen from the wild taxon is likely, this process has resulted in the replacement of the three constituents of subsp. *silvestre* with p-methoxybenzyl isothiocyanate. Although this is conceivable without human intervention, in light of the selection that has gone on in producing the *añu,* a plant cultural artifact (Ford 1980), it seems likely that human selection for the particular chemistry of the cultigen has played a role. Such selection with regards to cultural concerns of flavor and medicinal use underlines the association of the *añu* and the *maca.* The origin of *Lepidium meyenii* is not known, and whether it has as well been chemically selected by humans is an intriguing question.

CONCLUSION

Considerable work remains to explore fully the exciting implications of this association between the *maca* and the *añu.* Ethnobotany has traditionally linked the interests of botanists and anthropologists. Problems of this sort require the collaborative efforts of phytochemists and anthropologists as well as of physiological psychologists. Basic investigations are necessary to understand the biological aspects of human perception and recognition of chemical stimuli, the cultural categories into which stimuli are differentiated and the process by which perceived chemicals are interpreted in relation to human chemical taxonomies.

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NUTRITIONAL CONTENT OF SELECTED ABORIGINAL FOODS IN NORTHEASTERN COLORADO: BUFFALO *(BISON BISON)* AND WILD ONIONS *(ALLIUM SPP.)*

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ABSTRACT.—An examination of the nutritional content of wild onions and of bison meat is an outgrowth of archaeological research conducted by Colorado State University. Archaeological studies in north-central Colorado indicate more than 10,000 years of occupation by hunting and gathering nomadic American Indians. The sites are located at elevations ranging from over 12,000 ft. to less than 4,000 ft. in the Rocky Mountains and in the western edge of the Great Plains. Typically they consist of complexes of stone tools in association with fireplaces, and sometimes ceramics, stone rings and bone debris. The prehistoric occupants are interpreted to be nomads harvesting wild foods according to their seasonal availability. Ethnographic examples include the Ute and Arapahoe tribes. Efforts to examine the nutritional content of wild plant and animal foods have yielded interesting results. Wild onion *(Allium)*, and buffalo meat *(Bison)* data are presented with comments on their availability and prehistoric utilization. The amounts per unit volume of water, protein, and ash are presented. Mineral, trace element and caloric content are indicated where available. Conditions and the effects of preservation are discussed. These foods are evaluated in terms of human minimal daily requirements. Data collection strategy and directions for further research are indicated.

INTRODUCTION

For more than ten years faculty and students at Colorado State University, Fort Collins, have been engaged in archaeological research in north-central Colorado under the direction of Elizabeth Ann Morris. The geographic area involved is the ecotone between the front range of the Rocky Mountains and the high Great Plains of the eastern portion of the state. During the early years of our research our concern was locating and selectively excavating prehistoric sites in this region. We are developing a chronology utilizing radiocarbon dates, stratigraphic depositional occurrence of taxonomically distinct artifact types, and the rare occurrence of historic trade goods. We also are accumulating settlement pattern data, and learning to recognize functionally different site types. Additionally, we hypothesize aspects of the prehistoric life style based on "hard" evidence of the material culture and "soft" inferences from observations on ethnographic peoples. To this end, we have surveyed hundreds of sites and excavated several that promised to be informative with regard to the previously mentioned research goals. Our data consist largely of locational data for the sites, artifacts of stone and rarely other materials, and diverse midden debris including bones of the animals that were eaten.

The reconstructed life style of the people hypothesizes at least 11,000 years of semi-nomadic wandering by nuclear or extended families and probably bands. These groups moved about an area familiar to them, camping by streams and springs, and harvesting seasonally available plant and animal foods. In the warm summer months they would move to the forests and tundra of the mountains to fish and hunt and collect the berries and greens of high altitudes. In the fall they would return to lower elevations and some of them would participate in one or more buffalo hunts. Whether the animals were driven over a cliff or into a man-made or natural trap, large numbers would be eaten on the spot or, importantly, preserved for the cold, lean winter months in the form of jerky or pemmican. The winter months would be spent, by a least many groups, in the dry foothills-plains border in the rain shadow of the Rocky Mountains where snow fell less often than on the western slope or the high plains, and where the warm dry "Chinnok" winds would ameliorate the cold temperatures. The coming of warmer temperatures and the longer days of spring caused greening of the countryside, to the relief of the man and animals alike, and the beginning of a new year's food supply.

In recent years our interest in the details of their subsistence economy has intensified. The animal bones in the trash deposits at archaeological sites are a factual indication of which species were eaten. Bones have not been preserved in all of the sites that we have excavated but where they have been, they have been predominately buffalo *(Bison)* (Kainer 1976; Metcalf 1974; Morris and Kainer 1975; Morris et al. 1979; Ohr et al. 1979; Witkind 1971). There is one notable exception, the Owl Canyon rock shelter where the people ate rabbits almost exclusively (Burgess 1981). Some rabbit bones occur in most sites, as well as other animals such as deer, antelope, and canid. However, deer is second most numerous after buffalo in the bone producing sites. Additionally, the bones in most sites do not represent many diverse animals, but are of these few species suggesting a cultural preference. Apparently, there was often no desire or need to eat other available meat such as porcupine, badger, prairie dog, bear, lion, bobcat or birds. The Packrat Rockshelter (5LR170) is an interesting exception with a very diverse fauna represented (Emslie 1981; Morris et al. 1981). Interestingly, evidence for the cannibalisation of *Homo sapiens* is also absent (Garn and Block 1970; Wurf 1976).

Research on the nutritional content of bison meat has been presented elsewhere (Witkind and Morris In Prep.) and we will present only a brief summary here. Witkind (1971) describes the Roberts buffalo jump and presents the original form of the nutritional content data. Bones in the site represented both adult and immature animals. After a considerable search, a freshly deceased bison was located that had not been fed a supplementary diet. Meat samples from five different muscles of a range-fed 500 lb. bull calf were analyzed for their caloric, protein, and moisture content and for the amount of eight nutritionally important trace elements. These were calcium, phosphorus, sodium, potassium, magnesium, zinc, copper and cobalt.

The samples tested contained 67% to 73% moisture. Drying the meat to make jerky would not only keep it from spoiling but it would reduce its weight by two-thirds to three-quarters. This would be an important consideration for people who carried their supplies or depended on dog travois to move all of the belongings that they did not cache. Only moisture is eliminated in drying; the fat, protein, minerals and trace elements remain. In the five muscles tests, 4-9% of the fresh weight was fat. The fatness of an animal would vary a good deal with season of the year and the richness of its pasture. From 25-29% of the fresh bison meat samples was protein. Clearly, buffalo meat is mostly water and protein. The total caloric content of the samples varied from 83 cal/g in shank meat to 2.14 cal/g in loin meat. The great range reflects the variation in the amount of fat (with its high caloric content) in the individual samples.

DISCUSSION

Almost all of the eight trace elements (calcium, phosphorus, sodium, potassium, magnesium, zinc, copper and cobalt) were present in greater quantities in buffalo hump meat than in the other muscles tested. It is interesting to note that hump meat was so prized by Indians and early white settlers alike on the plains. It not only tasted better, but it was better for them. Additionally, buffalo meat contained much more per unit volume of two trace elements that were tested in common in the onion sample that is discussed below. They are phosphorus and sodium. Copper, zinc, calcium, magnesium and cobalt are apparently present in onions in greater quantities per unit volume than in buffalo meat (Table 2). This may be a sampling error, in which dirt adhering to the plants was included in the analysis.

In summary, if we consider the nutritional content of jerky made from buffalo hump meat, less than one-tenth of a pound of jerky would supply the minimum daily requirements of phosphorus, sodium, potassium, magnesium, zinc and copper. From five- to seven-tenths of a pound would supply enough calcium and 1.2 lbs. would supply enough calories.

In view of the fact that bison bones are so often prevalent in local archaeological sites, it is interesting to compare the amount of meat available from a bison compared to the amount available from other animals. A selected sample indicates that the total weight of buffalo bulls ranges between 1,600-1,800 lbs., and buffalo cows range between 800-900 lbs. A whole bull elk weighed by the Wyoming Game and Fish measured 529 lbs., approximately half the weight of a buffalo cow and a third of the weight of a buffalo bull. Deer and antelope are even smaller.

Wild onions (*Allium* spp.) were selected as an example of a vegetable food available in the mountain-prairie ecotone. Samples were arbitrarily picked because they grew commonly in the site area during the summer of 1980, and because they were easily recognized by the non-botanists on the crew. Ralph Dix, Professor of Botany, designed the sampling procedure and trained Judy Jacobson, historic preservation major, to do the field observations and laboratory analysis. We have no concrete evidence that any of the specific cultures whose remains we recovered ate onions but it seems possible if not likely. In central Wyoming, Frison (1975:396) reports the outside husks of onions covering a rock shelter floor that had a Middle Archaic occupation. Our site, Pack Rat rock shelter, also contains Middle Archaic remains, but we have no perishable items preserved (Morris et al. 1981). Harrington (1967:345) describes onions being used to flavor soups, stews and meats. Eight species of *Allium* are mentioned by Rogers (1980). The bulbs and sometimes leaves of all can be eaten fresh or cooked, and they store well. The juice boiled down to a syrup is good for coughs and colds. *Allium* spp. were collected in spring and early summer by the Gosiute Indians of Utah, but they were not saved for winter use (Chamberlin 1911). Weiner (1972:74) also mentions that the Dakotas and Winnebagos applied crushed onions to insect bites to ease the pain and additionally for a scalp massage, to strengthen the heart and restore sexual potency!

Three species of *Allium* were observed in our study area; *A. textile*, *A. geyeri* and *A. cermuum*. They did not differ in size or the vegetational area where they grew. The nutritional analysis included whole plants of all three species. A plant superficially resembling *Allium* in its flower form and its bulbous root also occurs in the area. This is *Zygadenus*, or Death Camus, containing a deadly poison for which there is no antidote. Students and staff alike became extremely sensitive to the differences between Death Camus and wild onions as the Indians must have been in their time.

The study area was divided into four parts, because preliminary inspection indicated that the differing vegetational cover might effect the frequency of occurrence of onions in each. These areas were grassland (short grass prairie), shrubland, gully, and rocky slope. All four vegetational areas contained some plants in common. Sandy soils varied only slightly from area to area. Differing density of plants, moisture availability and slope varied between the areas and are thought to be major factors affecting the varying dominant vegetation and the onion occurrence.

Thirty 1 m squares were sampled in each of two areas, the shrubland and the grassland. The location of each was determined by throwing a 1 m stick and measuring off a 1x1 m square where it landed. Twenty-five squares on the slope were sampled and 15 squares on the gully floor. The frequency of *Allium* plants per square ranged from a minimum of .26 bulbs in the grassland, to 1.76 plants per square in the shrubland. Total number, partly affected by the differing sample size, ranged from eight in the gully to 214 onions in the shrubland. In summary, *Allium* bulbs were numerous within a few hundred meters of the site, and tended to concentrate in shrubland and slope areas where they were not crowded out by the grasses. Other nonsystematic counts of onion frequency were also made and all observations confirm the high frequency of onions in the area in June 1980.

Onions were removed from five quadrants in each vegetational zone. The bulbs were measured and weighed, with slight differences per zone observed. The average weight of each whole plant was 1.00 g. The average weight per bulb was .39 g. Shrubland and slope areas not only produced many more *Allium* plants, but they were slightly larger bulbs than those in the grassland and gully areas.

In an effort to determine the nutritional content of *Allium* a sample of whole onion plants was sent to the Raltech Scientific Service in Madison, Wisconsin. The results were presented in terms of g/100 g or, they can be thought of as percentages of any volume or amount.

Moisture	67.9 g/100 g (or %)
Protein	2.2 g or %
Fat	0.4 g or %
Ash	2.6 g or %
Crude fiber	6.1 g or %
Carbohydrates	20.8 g or %

There were 95.6 cal/100 g of onions, or remembering that the average weight per fresh onion plant was 1 g—each plant would have .956 cal, as well as minute amounts of fat, protein and ash. Any size of fresh onion sample would be just over two-thirds water.

The ash was analyzed for its content of the following important nutritional elements: Calcium, Phosphorus, Potassium, Magnesium, Sodium, Aluminum, Barium, Iron, Strontium, Boron, Copper, Zinc, Manganese and Chromium. The results were:

	Mg per onion (Average wt. = 1 g)	Mg/100 g onions
Calcium	4.3770	437.70
Phosphorus	0.3096	30.96
Potassium	2.7200	272.00
Magnesium	0.4423	44.23
Sodium	<0.1500	<15.00
Aluminum	0.1259	12.59
Barium	0.0246	2.46
Iron	0.0850	8.50
Strontium	0.0030	0.30
Baron	0.0035	0.35
Copper	0.0872	8.72
Zinc	0.0523	5.23
Manganese	0.0114	1.14
Chromium	0.0014	0.14

In the interests of learning what wild onions would contribute to the Minimum Daily Nutritional Requirement for humans, Table 1 was compiled. The MDR figures are for both sexes and for individuals at least one year old. It must be remembered that the MDR figures were computed in the United States. Other nations, including even Canada, have computed different figures for some of these and other nutritional components. Furthermore, it has been widely suggested that peoples of different ethnic backgrounds

Table 1.–*Minimum Daily Requirement of calories and selected elements and minerals required by humans of at least one year of age. Average computed weight of one onion equals one gram. MDR figures are for the U.S.*

Element	Minimum Daily Requirement	Amount in 1 g	Amount in 100 g
Calcium	800-1200 mg	4.3770 mg	437.70 mg
Phosphorus	800-1200 mg	.3096 mg	30.96 mg
Potassium	550-5625 mg	2.7200 mg	272.00 mg
Magnesium	150-450 mg	.4423 mg	44.23 mg
Sodium	325-3300 mg	<.1500 mg	15.00 mg
Aluminum	No figures	.1259 mg	12.59 mg
Barium	No figures	.0246 mg	2.46 mg
Iron	10-18 mg	.0850 mg	8.50 mg
Strontium	No figures	.0030 mg	.30 mg
Boron	No figures	.0035 mg	.35 mg
Copper	1.0-2.5 mg	.0872 mg	8.72 mg
Manganese	1.3 mg	.0114 mg	1.14 mg
Zinc	10-25 mg	.0523 mg	5.23 mg
Chromium	.02-.20 mg	.0014 mg	.14 mg
Calories	2400	.9560	95.6

may have different minimum daily nutritional requirements. The daily total energy requirement would be greater in any case. However, keeping these possibilities in mind, the figures are presented in Table 1 as a point of reference.

It may seem that even if 100 g of fresh wild onions consisting of an average of 100 onion plants, only the MDR of copper and for some people chromium and manganese would be met. However, substantial amounts of the MDR for calcium, zinc, potassium, and iron would be consumed and useful amounts of magnesium as well. Useful amounts of the minimum daily caloric requirement would be taken. Onions contain so little phosphorus and sodium that they provide negligible contributions of these nutrients. Onions would be good for people who needed a low sodium diet. In summary, collectable amounts of wild onions contain significant portions of eight important dietary elements but very small portions of phosphorus, sodium, protein, fat, and calories. An aboriginal group dependent upon eating wild onions alone would have a mostly deficient diet. Eaten in large quantities the nutritive intake would improve slightly but the resource would quickly be exhausted in any given area.

Analysis of vitamin C content in wild onions is not included in our analysis at this time. However, the U.S. Bureau of Agriculture Handbook 8 lists the ascorbic acid content of commercially grown raw onions and whole raw onion plants as ranging from 42 to 138 mg/100 g (Watt and Merrill 1975). Meats generally contain no Vitamin C and this no doubt would have given added appeal for onions to an aboriginal tribal diet in the spring.

If we compare the nutritional value of wild onions to that of buffalo meat, interesting and not entirely unexpected results emerge (Table 2).

TABLE 2.— *Comparison of the nutritive value per 100 g sample of fresh wild onion and buffalo hump meat. With the exception of the calories, figures may be read as g/100 g, or %.*

Ingredient	Wild Onions	Buffalo Hump Meat
Calories	95.60	138.00
Moisture	67.90 g	67.00 g
Protein	2.20 g	25.00 g
Fat	.40 g	5.00 g
Calcium	437.70 mg	2.60 mg
Phosphorus	30.96 mg	399.00 mg
Potassium	272.00 mg	33.50 mg
Magnesium	44.23 mg	17.00 mg
Sodium	15.00 mg	76.50 mg
Aluminum	12.59 mg	— — —
Barium	2.46 mg	— — —
Iron	8.50 mg	— — —
Strontium	.30 mg	— — —
Boron	.35 mg	— — —
Copper	8.72 mg	.60 mg
Manganese	1.14 mg	— — —
Zinc	5.23 mg	2.50 mg
Chromium	.14 mg	— — —
Cobalt	— — —	1.20 mg

Buffalo hump meat compared to an equivalent weight of wild onions has about the same amount of moisture, much more protein and fat and half again as many calories. Considering comparable measurements of the minerals and trace elements, bison meat contains more phosphorus and sodium than does wild onion, and less calcium, potassium, magnesium, copper and zinc. A diet featuring buffalo meat flavored with onions would supply a high proportion of basic nutritional requirements.

Table 3 is a selected list of wild foods with their nutritive values as published by the U.S. Bureau of Agriculture (Adams 1975; Watt and Merrill 1975). The items were selected by us for being in the natural undomesticated, unfertilized state but we cannot be positive of this. Some of the results are interesting indeed and offer useful suggestions for direction for future research.

We are interested in pursuing these aboriginal nutritional studies. Some floral data is available already such as the nutritive value of prickly pear cactus, pinyon nuts, yucca plants and numerous wild fruits (Watt and Merrill 1975). Certain other wild animals besides bison have been measured, at least once. Examples are muskrat, beaver, rabbit and caribou. Obvious directions for future research are to assess the quantities available and nutritive value of local plants that appear frequently in the ethnographic if not the archaeological record. Ponderosa Pine *(Pinus ponderosa)* tree products, Prairie morning glory root *(Ipomea* spp.), Indian rice grass *(Oryzopsis hymenoides)* seed, Skunkbush sumac *(Rhus trilobata)* and wild plums *(Prunus americana)* are easily available. Using buffalo meat and wild onions as initial studies we expect an interesting, and rewarding class of information to emerge in the future.

TABLE 3.–*Nutritive values of selected foods. Data is presumed to represent native foods without modern soil or fertilizer enrichment, but this was not controlled in the sampling (Adams 1975; Watt and Merrill 1975).*

Food, approximate measures, units and weight		Values for edible part of foods									
		Water	Food energy	Protein	Fat	Carbohydrate	(Ca)	(P)	(Fe)	(Na)	(K)
	Grams	%	Calories	g	g	mg	mg	mg	mg	mg	mg
Amaranth, raw leaves - 1 lb.	454	86.9	163	15.9	2.3	29.5	1211	304	17.7	—	1864
Bamboo shoots, raw, cut into pieces of 1-in. length - 1 lb.	454	91.0	122	11.8	1.4	23.6	59	268	2.3	—	2418
Beaver, cooked (roasted) - 1 lb.	454	56.2	1125	132.5	62.1	0.0	—	—	—	—	—
Beechnuts-shelled - 1 lb.	454	6.6	2576	88.0	226.8	92.1	—	—	—	—	—
Crayfish, freshwater	100	82.5	72	14.6	.5	1.2	77	201	1.5	—	—
Duck, flesh only	100	70.8	138	21.3	5.2	0.0	—	—	—	—	—
Groundcherries (poha or cape-gooseberries), raw, without husks - 1 lb.	454	85.4	240	8.6	3.2	50.8	41	181	4.5	—	—
Mushrooms, raw - 1 lb.	454	89.1	159	8.6	2.7	29.5	59	440	6.4	45	1701
Muskrat, cooked, roasted	100	67.3	153	27.2	4.1	0.0	—	—	—	—	—
Pinenuts: Pinon, shelled - 1 oz.	28	3.1	180	3.7	17.2	5.8	3	171	1.5	—	—
Pricklypears, raw	100	88.0	42	.5	.1	10.9	20	28	.3	2	166
Quail, raw, giblets	100	63.0	176	21.8	6.2	6.7	—	—	—	—	—
Rabbit, wild: flesh only, raw	100	73.0	135	21.0	5.0	0.0	—	—	—	—	—
Raccoon, cooked, roasted	100	54.8	255	29.2	14.5	0.0	—	—	—	—	—
Snail, raw	100	79.2	90	16.1	1.4	2.0	—	—	3.5	—	—
Trout, brook, raw	100	77.7	101	19.2	2.1	0.0	—	266	—	—	—
Trout, rainbow or steelhead, raw	100	66.3	195	21.5	11.4	0.0	—	—	—	—	—
Turtle, green, raw	100	78.5	89	19.8	.5	0.0	—	—	—	—	—
Venison, lean meat only, raw	100	74.0	126	21.0	4.0	0.0	10	249	—	—	—

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FACTORS INFLUENCING BOTANICAL RESOURCE PERCEPTION AMONG THE HUASTEC: SUGGESTIONS FOR FUTURE ETHNOBOTANICAL INQUIRY

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ABSTRACT.– Patterns abstracted from interview sessions, discussions, and observed behavior during 13 months of fieldwork among the Huastec in northeastern Mexico suggest some of the factors shaping Huastec botanical resource perception. The recognition of a plant as a particular sort of resource depends on the interaction of a number of factors. Among the many factors discussed here are the biological, physical, and chemical properties of the available plants, human biological and cultural needs, Huastec perception of their natural and social environment, the subsistence system, household demography, economic strategies, politico-economic standing, historical trends, and illness and curing beliefs. Factors influencing the resource status of a subset of plants used by the Huastec for firewood, construction, and medicinal purposes are discussed. An understanding of plant use context is necessary to interpret Huastec plant use data, to study Huastec plant management systems, to investigate the impact of human activities on plants and plant communities and to evaluate the adaptive functions of ethnobiological knowledge. It is suggested that inquiry into the reasons for species' inclusion in useful plant lists can bring to ethnobotany a much needed focus for organizing systematic, multidisciplinary research yielding integrable data.

INTRODUCTION

This paper focuses on the botanical resource perception of individual human actors who sustain themselves in a moist tropical northeastern Mexican environment emicly understood on Huastec terms. The questions to be addressed are: What makes a given plant a particular kind of resource? What kinds of needs do resources fill? What factors influence the perception and choice of resources to fulfill these needs? In order to answer the questions I have raised, my discussion will develop the meaning of "resource" and "need" in the context of action-related decisions made by individual Huastec actors. Before the discussion is begun, however, I will briefly delimit the term "resource perception". As it is used here, "resource perception" refers to the process of assigning a particular resource role, or "use" to a plant by evaluating that plant's possible utility and the consequences of using it.

By elucidating the factors influencing resource perception, I hope to accomplish two things. First I hope to provide a new perspective for interpreting the data in useful plant lists, and secondly, I hope to contribute to the development of appropriate methods for evaluating the adaptive functions of ethnobotanical knowledge. Useful plant lists collected from indigenous people are often touted as the empirically valuable results of millenia of native experimentation designed to fine-tune the human to his environment. It is generally felt that, unless a "supersititious" basis for a plant's use is clear, the plants are listed as specific kinds of resources because they have the physical properties which answer standard human needs and would very likely serve these purposes well in any context where they are available. In most cases, no further criteria beyond the folklore vs. functional distinction are applied for understanding the value or meaning of a plant's use. The Huastec data suggest that the value of the information in these useful plant lists, so long associated with the term ethnobotany, has been both under and over estimated.

In addition to containing "uses", ethnobotanical lists usually include native plant names. During the past few decades cognitive and linguistic anthropologists have focused on the plant names in these lists to the *de facto* exclusion of their accompanying uses. Investigators (Berlin et al. 1973; D'Andrade 1976; Hunn 1977; Randall 1976), however, have debated the value, structure and functioning of classification systems generated using ethnoscientific methods. Randall (1976) has stressed that the motive for classification must be examined in the context of real-life situations if classification behavior and the underlying mental organization of the information relevant to the classification are to be understood; i.e., plant names and plant uses need to be tied back together and studied within real contexts where plant names are signs for information about more than just the plant's morphology. Hays (1981) has called for testing of assumptions that folk biological classification systems are adaptive. If "uses" are to be interpreted as "behavioral responses" as Hays (1974; 1981) suggests, then we must learn to recognize and understand these responses by developing a deeper understanding of the real-life contexts in which the responses occur. The following consideration of Huastec resource perception suggests the complexity pursuant to developing appropriate methods for evaluating the adaptive functions of ethnobiological knowledge and folk biological classification systems.

RESEARCH SETTING AND METHODS

The Huastec are Mayan language speakers who in pre-Conquest times controlled a large ecologically diverse area including most of San Luis Potosi and large areas of Hidalgo, Tamaulipas, Queretaro, and Veracruz states (Laughlin 1969). Today approximately 60,000 Huastec speakers live southwest of Tampico in the Sierra Madre Oriental foothills of southeastern San Luis Potosi and northern Veracruz, primarily a climax vegetation zone of tropical rainforest, Bosque Tropical Perrenifolio (Rzedowski 1966). The vegetation today, however, consists almost entirely of successional communities that reflect human management (henceforth referred to as anthropogenic vegetation zones).

Huastec resources labeling decisions occur within the context of the natural and social ecosystems in which they participate. The Huastec live as Indians within the mestizo (i.e., national cultural identity) dominated politico-economic setting of Mexico. Families generally live in dispersed household units within corporate communities and receive their subsistence from the products of their land, cash cropping and wage labor. Anthropogenic vegetation zones usually maintained by a Huastec family include cash producing sugarcane, managed forest plots, and cornfield-fallow cycling fields managed as *milpa* by slash and burn methods. The details of Huastec botanical resource management within these anthropogenic zones have been discussed elsewhere (Alcorn 1981). Land use patterns are affected by individual and community concerns, local interpretation of government regulations about using available land, and locally administered government loan policies. Cash cropping centers around sugarcane which is processed into raw sugar by individual family operations and sold at low prices into a mestizo controlled market. Henequen and coffee are also important cash crops in some areas.

Research was designed to identify Huastec botanical resources, to investigate the methods and impact of Huastec resource management, and to construct and integrate cognized and operational models of the Huastec natural and social environment in order to generate hypotheses about the impact of Huastec world view on ethnobotanical processes influencing elements of the Huastec vegetational environment. Methods used during 13 months of fieldwork included structured and informal discussions, the administration of interview schedules, the drawing of land use maps in consultation with Huastec land holders, and participant observation. Interviews were conducted in Spanish and Huastec. Extensive data about plant uses, plant names, and plant management were provided by 50 informants from 20 communities. Eighty-four individuals were formally interviewed but many more people provided valuable insights. One Huastec collaborated with me throughout the entire project and participated in most interview sessions.

To date, 2000 plant specimens have been collected in scientifically identifiable condition (i.e., flowering or fruiting specimens). I have identified the majority by using pertinent floras, monographs, and the University of Texas herbarium. Specimens that were difficult to identify were sent to appropriate specialists for determination. Different botanical taxa collected and identified from the Huastec habitat during this project now total 910. Vouchers will be deposited in the following herbaria: CHAPA, INIF, MEXU, TEX, and the Instituto Nacional de Investigaciones sobre Recursos Bioticos in Jalapa, Veracruz.

RESULTS

The Huastec depend on the plant world for many raw materials. Men, women and children quickly discriminate between plant resources and nonresources every hour of the day. Specific uses have been recorded for 65% of the botanical taxa I collected. Plant utility is reflected in three of the four Huastec botanical life-form cover terms. The word for tree, *te'*[1], also means a branch, a pole, or a piece of wood, be it a loom, a housepost, or a quickly fashioned hook for retrieving a desired fruit. *Ts'a:h,* the cover term for vine, also refers to any lashing material, be it vine or rope. *Ts'oho:l,* the cover term for herbaceous plant, is also used to mean medicine derived from any plant source (tree, vine, bark, root, etc.). Today *to:m* only refers to grass. Grass is rarely used for thatch in the Huasteca today but in Tzeltal, a related Maya language, *tom* refers to the grass bundles prepared for thatching a house. A term for grass thatch bundles was not elicited in Huastec.

When presented with a fresh vegetative shoot, Huastec informants attempted to recognize and identify the specimen by evaluating characteristics which would make it useful. Leaves were usually crushed and smelled (chemical evaluation). Questions were asked about the fruit, habit and habitat. Knowledge of all these characteristics has potential value for resource assessment as well as for identification. Unless they were large and showy, edible, or otherwise useful, flowers were rarely discussed. Once identification was made, the informant usually volunteered uses for the plant and added qualifying statements about preparation, value, and problems involved in its use. The resource value of a particular plant for a particular use often hinged upon the context of the use and the user. Although "resource" means something which is used to satisfy social, biological, and physical needs, the Huastec acknowledge that trade-offs are inherent in the use of any resource.

Plants are clearly resources for the Huastec. But what kinds of resources are necessary and what makes "plant X" a specific kind of resource? When a Huastec informant was asked, for example, "Is 'plant X' a resource for 'use Y', a wide range of responses were given. "Yes" and "no" answers were rare. Characteristic answers included:

"My ancestors needed it, I don't."
"Only other people know."
"I can't use it, people are too invidious."
"I've heard that it can be used, but I've never tried it so I don't know."
"I don't know. Maybe that's why mestizo merchants buy it from us in the market."
"No, well yes. It could be used, but I use 'plant Z' because I have it here by the house."

The range of answers to this question gives us some clues about the Huastec resource labeling process. The utility of a resource is assessed by the individual from a shared Huastec bias and a personal idiosyncratic bias. Respondents' replies indicate a personal consideration of actions implicit in the choice, the appropriateness of the action, and the constraints limiting the action. Nonetheless, a given respondent's answer is not necessarily optimally adaptive. His decision obtains from his calculation of the interplay effects of factors which also shape that context.

Patterns abstracted from conversation, interview sessions, and observed behavior suggest some of the factors shaping the context of Huastec resource perception. Based on the investigative focus necessary to study them in further detail, I have chosen to lump the factors into four general catagories: biological and physical; cultural; economic; and personal and social.

Basic to the Huastec resource evaluation process are the empirically measurable physical or chemical qualities which qualify or disqualify a plant from the use in question. Huastec, however, not only assess the physical and chemical attributes of "plant X" but also consider its spatial and temporal position in their vegetational environment. The plant's ecological requirements, its membership in a particular community, its life cycle, its reproductive biology, its speed of growth as well as other aspects of the plant's biology are considered, as far as they are known to the individual, within the context of the existing time and space investment patterns which characterize his land management system. Because his existing land management system is designed to meet many other needs apart from the one under question, the consideration of the changes necessary for the integration of "plant X" into that system is critical to his decision. Ecological changes potentially caused by the integration of "plant X", the scarcity of "plant X", and the scarcity of resources necessary to maintain "plant X" are also considered and compared to similar criteria for available substitutes. Other empirically measurable variables considered include the biological needs of the individual, his household, and his domestic animals.

There are also, however, less easily measurable factors that are important in the resource perception process. Culturally generated needs create the requirement for certain resources (e.g., specific ritual items). The perceived context for plant use is shaped by Huastec world view. Native inquiries into a plant's properties and the interpretation of the results are shaped by native epistemological biases. Cultural sanctions against the use of "plant X" in a given way may remove it from the resource category of "use Y". In some cases a use or a plant may be identified with a particular cultural identity and thus appropriate or inappropriate for the person being questioned. For example, some plants are identified with mestizo as opposed to Indian identity. Other plants/uses are identified with a particular role within Huastec society. For example, the use of short, hollow lengths of carrizo [*Arundo donax* L., *Pennisetum bambusiforme* (Fourn.) Hemsl. *(paka:b)*] is associated with curers.

Other considerations are economic. Allocation of time and space necessary for the maintenance, acquisition and/or use of the possible resource is considered within the context of the individual's present life strategy and against the value assigned free time. The known "opportunity costs" of opting for a "new" resource are evaluated against the probable gains. The risks and uncertainties that surround the maintenance of "plant X" were it to be acknowledged as a resource are considered within the context of the land management system presently in operation. Risks are also evaluated in a social context. Some resources are more easily appropriated by other people, and the individual must assess the ease of appropriation as well as the losses and benefits which might attend such a transaction. Limitations on the individual's land management system may leave particular needs unfilled and transactional resources become necessary to fulfill these needs. The cash generating potential of a resource, the labor investment necessary, and the stability of the market for "plant X" may also be considered in this context.

A final category of considerations are those peculiar to each individual. The individuals's household demography affects the household's needs and resources, and, of course, changes over time. The individual's personal knowledge of "plant X" and alternatives, as well as his knowledge of particular resource categories, clearly affects his answer to our question. His knowledge depends upon the form of existing information networks and the person's participation in them in order to gain other's knowledge. It also depends on the individual's own investigations of the plant. Age, personality, experience, and status affect the individual's knowledge as these factors change with time. The individual's particular management skills and his personality also affect the decision to perceive "plant X" to be a resource. For example, an individual's definition of plant resources is affected by his personal response to the traditional wealth leveling pressures of the community, his personal desire for power, and the paths he chooses to achieve it. The individual may rely on others for certain services/products and have no need to know about resources necessary to them. The factors considered by the individual in resource labeling decisions reflect the fact that the Huastec derive their plant resources from two sources: directly from the natural environment to which they have access, or indirectly through transactions with other people. Resources maintenance activities include the management and cultivation of social relationships as well as the management and cultivation of vegetation. Methods open to the individual for attaining goods indirectly through other people influence his resource perception and vegetation management.

The factors which I have listed here clearly do not exist in isolation. My isolation and classification of them can only be heuristic because these and other interrelated factors interact in shaping resource perception. The individual's answer will vary over time as any of the factors mentioned above, and thus the interrelationship between factors, is altered. In addition, past interactions have created historical trends of resource definition and "use" that shape the possible present-day choices. Huastec plant resource "needs" and "uses" are restricted to those that are part of particular present-day Huastec strategies (including existing technological patterns such as raw sugar production practices, the "invisible technology" of Huastec agroeco system management, etc.) designed to operate in today's Huastec habitat and within Huastec social organization. At the same time, however, "needs" and "uses" bear marks of the historical strategies out of which they developed.

Conflicts and constraints limit the use of available resources. Needs and the choices of certain resources may conflict with the choice of others. Such conflict imposes constraints on the use of particular plants. Other constraints are generated by peculiar intracommunal resource access regulation. For example, while each family has a specific, often inadequate, land holding, other people may request loan of the land without payment of rent, or demand part of a harvest in exchange for volunteered labor. Thus, individuals are forced to juggle their household operations both to avoid being taken advantage of by others while at the same time attempting to get as much as possible from others. Finally, the politico-economic environment of the individual as an Indian within the Mexican sector of the world economic system limits and shapes his decisions. His choices can only be made within the context created by the decisions of those of higher authority.

The ethnobotanical list of Huastec plants and their uses generated by my research reflects the interaction of factors influencing Huastec resource perception. A brief treatment of a few selected species in each of three "use" categories important for survival (firewood, construction materials, and medicine[2]) will illustrate this interaction.

The species commonly recognized as firewood include: *Acacia angustissima* (Mill.) Kuntze *(shi:shit)*, *Acacia cornigera* (L.) Willd. *(thobem)*, *Adelia barbinervis* Schlecht. & Cham. *(ata')*, *Calliandra houstoniana* (Mill.) Standl. *(wi:t'ot')*, *Callicarpa acuminata* H.B.K. *(et te')*, *Conostegia xalapensis* (Bonpl.) D. Don. *(chikab te')*, *Croton reflexifolius* H.B.K. *(olih)*, *Cupania dentata* DC. *(ts'aw')*, *Guazuma ulmifolia* Iam. *(akich)*, *Leucaena pulverulenta* (Schlecht.) Benth. *(thuk')*, *Lippia myriocephala* Schlecht. & Cham. *(anam te')*, *Nectandra loeseneri* Mez. *(oh te')*, and *Sapindus saponaria* L. *(walul)*. Although one might expect the firewood designation to be awarded to heavy wood which burns slowly to produce long lasting, hot coals, some of these species produce firewood of a very poor quality. What these species do share in common is their membership in the fast growing successional community of fallow cornfields. Depending on its age and structure, the vegetation which covers the fallow can be a resource to be burned, grazed, or kept for future use. If the decision is made to slash and burn the vegetation, then the option is where to burn it and for the production of what. It can either be burned in the field to provide ash for fertilizing the corn to be planted or it can be collected and burned in the hearth to provide heat for cooking. My preliminary data suggest that the amount of land devoted to the cornfield-fallow cycled fields depends more on the amount of firewood needed than on the amount of corn needed.[3] Management practices often emphasize firewood production over corn production. Deliberate light burning of fields and removal of wood before buring increase the firewood yields but cut the yield of corn (Fig. 1). Pollarding of firewood-producing trees and opting not to carry out the traditional one-time weeding of the milpa speed up firewood production. Thus, factors influencing agricultural patterns, the availability of alternate firewood resources, species' response to the agriculture regime, and species' representation in the successional fallow vegetation are reflected in the labeling of these species as firewood resources.

The species commonly used for the main houseposts in house construction include: *Cordia alliodora* (R. & P.) Oken *(wish te'), Diphysa robinoides* Benth. *(chichath), Harpalyce arborescens* A. Gray *(k'an te'), Nectandra loeseneri* Mez. *(oh te'),* and *Piscidia piscipula* L. Sarg. *(tsi:hoi).* The physical requirements for houseposts strictly limits the species that could potentially fulfill this resource role. The species listed share strong wood, a straight bole, and decay resistance. They also share the ability to grow well on agriculturally poor ridgetop soils or as isolated individuals spared in the sugarcane or milpa-fallow cycle fields.

The species used for roofing materials are: *Imperata brasiliensis* Trin. *(ata: to:m), Licaria capitata* (Schlecht. & Cham.) Kosterm. *(sholim te'), Sabal mexicana* Martius *(oto:mal, apats')* and *Saccharum officinarum* L. *(pakab).* The superior material is the thatch of *Licaria capitata* leaves. *A Licaria* leaf roof is said to last for 30 or more years, keep the house cool, and be impervious to rain. Today, however, few people recognize

FIG. 1–Planting milpa after firewood harvest. Stacked between the new milpa and the stand of flowing corn in the background is the firewood collected before burning the slash. Light burning left more firewood to be gathered later. Also visible are spared palms for thatch production and developing housepost trees that were pollarded for firewood during preparations for planting corn.

or use *Licaria capitata* as a roofing resource ostensibly because increasingly intensive land use has caused *Licaria capitata* to become a scarce forest tree in many places. Palm thatch from *Sabal mexicana* has largely displaced *Licaria* and *Imperata brasiliense* thatch. *Sabal mexicana* is a multipurpose species that has been purposefully introduced into many local areas in the past 50 years. Palms neatly fit into existing patterns of land use because, once established, they can be spared during milpa clearing or integrated into sugarcane fields. People who are really pressed for land and can't afford to devote space in their fields to palms or those who can't afford to get palm leaves from others choose to use the inferior thatch of sugarcane leaves, instead of using the sugarcane leaves as a resource to mulch and fertilize their cane fields. Thus, the list of thatch resources is not a list of four functionally equivalent species but rather a list that reflects a trade-off between land use and utilitarian considerations.

The list of Huastec medicinals can not simply be viewed as a list of drug plants used to treat biomedical diseases. Medicines, as a Huastec category, have the innate power to transform, or to be empowered by a curer or witch to transform a person's state of being. They may be used to poison or to sicken someone as well as to cure a person of an illness, or to prevent illness from striking. An illness, moreover, is not just a biomedical malfunction but also an event within a social field, and both of these aspects of illness are treated by curative medicines. Medicines may do their work by direct application, by ingestion, by merely being swept over a person, or by burning at midnight in the pathway to a person's home. Huastec illness etiologies include such agencies as embedded foreign objects sent by witches, interference by dead spirits, the action of stars, and soul loss by fright.

While knowledge of the same construction and firewood resources is shared by most adult Huastec, the knowledge of many medicinal plants is not. Over half of the 900 plants I collected had medicinal uses but agreement on the use and the means of application varied widely. There are many reasons for this. A person may learn about medicines from treatments applied by relatives, neighbors, and curers. Visible signs of use (e.g., seeing scars on a tree's trunk) might lead the individual to ask someone what kind of resouce the tree is. At the same time, however, a person may also have a plant's use revealed to him or her in a dream. Some people also experiment with plants to determine their effects on the body, and the information derived is then processed according to Huastec beliefs. Such individually derived information is not freely shared. Another factor influencing medicinal plant resource recognition is the increasing availability of manufactured medicines which substitute for some herbal remedies. People may know that a given plant has a given medicinal use but not perceive it to be resource for themselves because they prefer some other plant or because they prefer to get injections or take pills instead.

In order to illustrate briefly the complexity of evaluating Huastec medicinal plants, I will discuss one commonly used species. *Cissampelos pareira* L. *(k'on k'ach)*, a pantropical vine found in a variety of habitats, is used to treat *ichich* in the Huasteca. *Ichich* is similar to the concept of "evil eye", but rather than referring to eyes, it refers to hearts. The heart of an older, more serious person, for example, naturally saps energy from the heart of a younger, more lighthearted person, causing *ichich*. Chidren are especially vulnerable to this malady, but adults and even pigs also suffer from it. *Ichich* is often the initial diagnosis made when someone feels ill, especially from gastro-intestinal problems. The patient who is suspected to be suffering from *ichich* may be swept with the leaves of *k'on k'ach* or a number of other plants. In the case of *k'on k'ach*, the leaves are then crushed in a small amount of water by rubbing between the hands. If the liquid gels, as it invariably does, it is seen as a positive diagnosis of *ichich* detected and removed by the sage, omniscient plant. Of the 34 people questioned about *k'on k'ach*, only three stated that this diagnostic procedure could be followed by the ingestion of a root decoction made from the same plant. *K'on k'ach* is a relative of the South American plant *Chondrodendron tomentosum* Ruiz & Pav. from which tubocurarine and other alkaloids that paralyze voluntary muscles are extracted for biomedical use. The roots of *k'on k'ach* contain some of the same alkaloids and have been exported as substitutes for *Chondrodendron tomentosum* (Morton 1977). In other parts of the world, native people have taken advantage of the muscle relaxant properties of *k'on k'ach* for a number of purposes including the expulsion of intestinal worms (Uphof 1968). But, although the root is pharmacologically active, the Huastec primarily perceive the plant to be a medicinal resource because of its predictable, diagnostically valuable (as culturally defined) gelling properties. Huastec who have chosen to identify themselves as mestizos assert their new identity by denying the existence of *ichich* and the resource value of *ichich* treatment plants like *k'on k'ach.*

Change in the resource status of a plant can alter its management and thereby the ethnobotanical process to which it is subjected. Huastec informants assign resource value to plants not only while acting to use particular plants but also while making plant management decisions. Twenty-five percent of native non-corn plants available to the Huastec are currently "managed for" by some individuals, and resource status is an important determinant of how a particular plant is managed (Alcorn 1981). Resource designation, then, potentially affects at least two types of "behavioral responses": the usage of a plant and the management of a plant.

DISCUSSION

The Huastec data fulfill the expectation that indigenous people know a great deal about their environment. But the Huastec data also demonstrate that the specific "uses" to which plants are put at any given time derive from a complex plant resource evaluation process operating from a well developed knowledge base that includes contextually related/dependent data. Resource evaluation is not an objective consideration of a plant's material qualities abstract from context, and resource perception is influenced not only by the individual's context but also by his understanding of that context.

The "needs" whose fulfillment is being sought include biological needs of the individual and household, as well as cultural needs, both of which vary over time. The use of one particular resource, be it plant or human, may in turn create the need for other specific resources. Consideration of "costs" of recognizing a particular resource include the assessment of the energy expenditure to fulfill the "need" and the possibility of losing this investment to others with or without compensation. The interpretation of what "fulfills" a need also depends on biological and cultural factors. Because of culturally determined preferences, a particular food, a particular style of house, or a particular kind of medical treatment may "fulfill" needs better than other available items of equal or better functional value.

Useful plants lists isolated from their context may be of limited value to economic botanists seeking empirically valuable data about the useful characteristics of particular species. On the other hand, these lists provide an indispensable vocabulary for studying the grammar of human ecological relations. For example, once resources are known, studies of the management of these plant resources can contribute to the evaluation of human impact on plant evolution and the structure of plant communities (Alcorn 1981; Bye 1979). Furthermore, investigation into the context of plant use not only contributes to the interpretation of plant uses, but also, in turn contributes to the understanding of humans' adaptation to their environment. Plant "use" is an integral part of the mental and physical life of people who live in direct contact with their natural resources. Any attempt to understand the adaptive value of the structure and functioning of human cognition as evidenced in ethnobiological classification systems must come to grips with the fact that the "uses" or "behavioral responses" to plants are not so simple as they have been understood by many investigators. Assigning "functional equivalence" (Hays 1974; 1981) to plants is problematic when "use" and appropriateness of use may vary depending on specific contexts.

CONCLUSION

Ethnobiology is a rich, relatively unexploited domain that could yield important information on human ecology. But if the adaptive value of ethnobotanical knowledge is to be tested in any meaningful way, plant "use" must be analyzed as a text that derives part of its meaning from the cultural, natural and social context in which it occurs and serves its function. The complex of factors influencing resource perception described here forces us to recognize that meaningful investigation into the adaptive value of botanical resource use requires not only the collaborative efforts of botanical, ecological, biomedical, pharmacological, economic, and nutritional approaches, but also anthropological study of potentially adaptive functions of resources used in the social and politico-economic aspects of the human's ecosystem.

Despite recent redefinitions of ethnobotany to include linguistic, epistemological, and evolutionary approaches to plant-human interrelationships, ethnobotany quixotically remains an ill-defined discourse without a unifying theme (Ford 1978). More workers are bringing the techniques of their particular disciplines to bear on different aspects of plant-human interrelationships, but their fragmentary contributions are not being synthesized in a way that makes their results useful or meaningful to workers in other disciplines. A renewed focus on the useful plant lists that traditionally defined ethnobotany may provide the important and necessary starting point for the systematic, multidisciplinary inquiry that is the unrealized potential of ethnobotany. Understanding the dynamic process leading to the inclusion of plants in useful palnt lists provides the blueprint for work to flesh out the bare bones of these lists so that their potential contribution to human ecology can be fulfilled. Knowledge of the factors important to individuals' resource perception and the interrelationships between those factors structures a juncture about which multidisciplinary inquiry can articulate by coordinating the collection, interpretation, and integration of data gathered by workers using the approaches of their diverse disciplines. Such a multidisciplinary approach would mutually enrich the participating disciplines and add new depth for archaeological and linguistic interpretation of plant-related data.

On the applied level, the integration of such ethnobotanical inquiry with current efforts in peasant agricultural decision-making research (e.g., Barlett 1980) could make a significant contribution to the development of locally adapted sustained yield agroecosystems that provide appropriate resources to meet the needs generated by the physical, biological, social and politico-economic realities of the local ecosystem.

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NOTES

[1] For the general reader, Huastec words are spelled here as they would be in English. Vowel sounds are approximately those of Spanish. In addition, the colon (:) indicates an extended or lengthened vowel, and glottal stops after vowels and glottalized consonants are signified by the vertical apostrophe ('). Spelling relects pronunciation in the Potosino dialect of Huastec. Plant names given are those in most common usage.

[2] The category of food resource was not chosen because food resource evaluation is very complex. Accurate measurements of food consumption by a representative sample of all age and sex groups of the population, reliable nutrient analysis of the food as it is prepared and served, and knowledge of the nutrient requirements of all sectors of the population would be necessary to make any meaningful statements about the empirical food value of particular species and species combinations. Furthermore food classification, dietary rules defining culturally appropriate meals, and the symbolic values of foods would require extensive investigation.

[3] Quantitive evaluation of the amount of firewood available and the amount of firewood used is difficult, however. The amount of firewood used varies according to the size of the family and the food being prepared. In addition, non-cooking usage of firewood (raw sugar production, pottery firing, charcoal making, heat, etc.) also varies widely. Because people can collect firewood from land not their own, it is difficult to circumscribe the area producing firewood to meet the needs of a given set of firewood users. In addition, firewood production per hectare varies according to the stand's age and management.

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ELEMENTS OF THE PUREPECHA MYCOLOGICAL CLASSIFICATION

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ABSTRACT.– During two years of field work the authors studied the knowledge and uses of the mushrooms among the Purépecha (Tarascan)[1] Indians of Lake Pátzcuaro in Michoacán (Mexico). A folk mycological classification was obtained through interviews and samples collected in the field with the aid of local informants and the use of photographs of the mushroom species from the region.

The mushrooms are divided in 11 main groups or taxa arranged in three general classes. The overall classification is made on the basis of the properties and attributes of the mushrooms that the Purepecha recognized.

The Purepecha mycological classification demonstrates principles analogous to those which govern folk taxonomies. Nevertheless there are some differences with other biological classifications found among other indigenous groups. These differences are discussed in the present paper.

INTRODUCTION

Traditional knowledge of indigenous groups regarding mushrooms is an aspect of ethnobotany which is little studied. Ethnomycological interests have focused mainly upon the use of hallucinogenic or edible mushrooms. It is only recently that other aspects such as traditional classification have been dealt with. One might think, as some authors state, that algae and mushrooms are omitted from the classification systems of illiterate peoples since they are species of organisms that may be identified solely on the basis of characteristics too small to be seen without the use of a 10x hand lens. Nevertheless, this does not always occur. Among the Purépecha Indians of Lake Pátzcuaro in Michoacán, Mexico, there is ample knowledge of the mushrooms that grow in the region. This knowledge comprehends their mycological characteristics as well as their attributes and properties, which are used in the classification of these organisms. In this paper some elements of this system are presented and commented on. This study together with that regarding the ways in which mushrooms are used, forms part of a larger research project of Purépecha ethnobiology. Some results of this project have already been published (Toledo et al. 1980; Mapes et al. 1981).

THE STUDY AREA

The Lake Pátzcuaro region is located in the state of Michoacán on the transversal neo-volcanic axis. Physiographically speaking, it is an endorreic basin that is part of a lacustrine basin system. The surface area is approximately 1000 square km, 10% of which is the lake itself. The basin is delimited by several mountain systems with altitudes ranging from 2000 m (the altitude of the lake) to 3200 m. The climate is temperate with a rainy season extending from June to September.

The ecosystems of the region are represented mainly by pine and broadleaf forests in varying degrees of association, as well as by fir forests on the highest peaks. There are also many secondary associations.

There are nearly 80,000 inhabitants distributed throughout some 100 towns and villages in the basin. The indigenous population constitutes about 25% of the total, living in 23 communities. At least 90% of the indigenous population is bilingual.

The Purépecha from the lacustrine basin of Pátzcuaro are mainly dedicated to agricultural and fishing activities which are combined with some other activities such as hunting, gathering, and the manufacture of handicrafts. These activities are the basis of subsistence (Toledo et al. 1980).

It is important to point out that the Purépecha, since the Prehispanic times have developed a great knowledge about the plants present in the region. Nowadays this knowledge has persisted and more than 50% of the species present in the region are still known. On the other hand plants are used to satisfy the basic needs of health, energy, housing and feeding (Toledo et al. 1980).

MATERIALS AND METHODS

The ethnomycological information was obtained through interviews and samples collected in the field with the aid of bilingual men and women of different communities. It is important to point out that both sexes have a very similar degree of knowledge about the properties and uses of mushrooms in general. Nevertheless some differences were detected in the ethnomycological knowledge among different communities such as Ichupio, Ucasanástacua, Janitzio, etc., places in which mushrooms are practically unknown. This contrasts with the great tradition of knowledge and use of mushrooms present in the communities of San Francisco Pichátaro and Cuanajo.

When we were in the field collecting specimens many mushrooms were photographed *in situ*. The majority of the photographs (12.5 x 8.5 cm prints) were taken in color; these were the main tools used in searching for traditional classification systems of mushrooms.

The people were asked to group or to separate all the "kinds" of mushrooms shown in the photographs according to their similarities or differences, and to name them in their own tongue. The criteria used to identify the mushrooms were also asked. This gave the necessary basis to construct a preliminary model of Purépecha classification.

RESULTS

Generally the Purépecha consider mushrooms as something apart from plants and animals, saying 'mushrooms are not plants'. They are the 'flowers of the ground'. Mushrooms as a whole are categorized as *terekuicha*, which means 'all the mushrooms that are found on earth'. The singular form of *terekuicha* is *terekua* although in some cases the latter is changed to *tereko* or *teko*, especially in combination with other words to form a single term such as *pantereko* or *panateko*.

Interestingly, the use of a single term to denote mushrooms as a whole is something not exclusively Purépecha. Other researchers have also found this with other indigenous groups in Mexico. For example Brown (1972) reports the use of the word *cikinte*, meaning mushroom, among the Huastecos. According to Laughlin (1975) the Totzile Indians identify mushrooms in general by the name *canul te tik*. Escalante (1973) found *ccho* to be used by the Matlazinca Indians. Wasson and Wasson (1957) mention that the Mazateco Indians of Huatla, Oaxaca say *tai*, and *nanacatl* or *nanacate* are employed by the Nahuas.

The *terekuicha* are divided into three classes. Mushrooms described as fleshy, with ribs or gills under the cap belong to the first. This corresponds to the Order Agaricales. The second class are those mushrooms which are fleshy, and have pores under the cap. These correspond to the Family Boletaceae; the third class of mushrooms are fleshy, hard or gelatin-like, but having neither gills nor pores when fleshy. This is a heterogenous group.

These three classes are sub-divided in turn into a total of 11 groups. The criteria used as a basis for identifying the members of these groups are shape, color, consistency while fresh, as well as habitat. As is known, this is precisely the criteria uses in occidental mycological classification to identify different species of mushrooms (Guzman 1977, 1978).

The different groups that the Purépecha recognized are *kutserekua* or *kux tereko*, which means, 'pig-mushroom', a species known in Spanish as *trompas* 'pig snouts' or simply 'snouts', 'all that raises itself are snouts'. In the *tepajkua* group, which means 'pasture mushroom', are those which grow in the pastures, hence the Spanish name of *llaneritos* or *llaneros;* they have little brown ribs and are round. The *tzupata* group, which means 'flower' is known in Spanish as *flor de durazno*, 'peach flower', because if they are damaged or crushed they smell like a peach.

The group *tiripiti terekua* which means 'golden mushrooms', are known in Spanish as amarillos, 'the yellow ones'; and are enclosed by a universal veil, 'a little cloth surrounds them like an egg'.

The group *ts'apk'i*, which means 'sparrow hawk', are those which have dark brown markings on the cap like the markings of the sparrow hawk, 'They have a long leg'. These mushrooms are also known as 'little umbrellas' because they grow in bunches but are united at the base.

The *pantereko* group or *cemitas* includes the mushrooms shaped like large pieces of bread. They are also known as *panzas de buey*, 'ox's belly'.

The *sirat angants terekua*, literally meaning in Purépecha 'smoke cap', are 'those which give off something like smoke'; they are also known by the names of *charamusquitas* or *orejas ration*, 'rat's ears', due to their peculiar shape.

The *k'uin antsir terekua* or *patitas de pájaro*, 'little bird's feet', in Spanish are those which have the shape of the feet of birds. They have many branches.

The *tetaras* are those which have little or no leg (stem). The *tamanda*, which means 'rotten trunk', are those which grow in the trunks of trees. They are the wooden mushrooms.

In each one of the previously mentioned groups one or more species of mushrooms are found. Generally the genuine species (Berlin et al. 1974) is referred to, the representative one that everybody knows. In this model the Purépecha make various groupings with genuine species and with others that are similar. It is important to know that in forming these groups the mushrooms that are included by comparison have to share certain characteristics with the main mushroom. Within each one of these groups the Purépecha are able to identify the edible (the good ones) and inedible (the bad ones) mushrooms and the mushrooms that 'make you drunk'.

Thus we have in the *kux terekua* group the following species: *Hypomyces lactifluorum* that is the *kutsereko* genuine mushroom and *Gomphus floccosus* and *Hygrophoropis aurantiaca.* The 'bad mushrooms' of this group are *Lactarius deliciosus, Lactarius salmonicolor, Lactarius vellereus* and *Lactarius piperatus.* It is necessary to emphasize that the first two species are edible (Guzman 1978); nevertheless, these are recognized by the Purépecha as 'bad species'. All of these mushrooms are orange in color and have the shape of a snout.

The main mushroom of the *tepajkua terekua* group is *Agaricus campestris* which is edible and the 'bad' mushroom is *Agaricus xanthodermus* which is toxic. 'It is a relative of the *llanero* mushroom' *(A. campestris)*, the Purépecha say.

In the *ts'upata* group the Tarascans identify *Hygrophoropsis auriantiaca* which does not smell like a peach, but looks very much like *Cantharellus cibarius,* a mushroom which we have not collected yet from the Pátzcuaro region and which reportedly does have a peach-like odor. The 'bad' mushroom of the *ts'upata* is not known.

In the *tiripiti* group the principal mushroom is *A. caesarea* which is edible and has a covering called a volva. It also has a veil under the cap which covers the gills and forms a ring around the foot of the mushroom when it matures.

The 'bad' mushrooms of the *tiripiti* group are the equivalent to the following species of *Amanita: A. gemmata, A. muscaria* subsp. *flavivolvata.*

The *ts'apk'i* group includes only *Macrolepiota procera* which is a complex of at least two species; other Spanish names for *M. procera* translated literally from the Purépecha are 'little eagle', 'sparrow hawk mushroom', 'quail mushroom' and 'little umbrella'.

The principal or genuine mushroom of the *paxakuas* group appears to be *Lyophyllum decastes,* other examples are *Armillariella polymyces* and *A. tabescens,* all of which are edible. Nevertheless, some people separate the species of *Armillariella* into different classes of *paxakuas* and they are given the name of *uachitas,* 'little clusters'. There are also 'bad' *paxakuas* which have been identified as *Naematoloma fasciculare* and other species of *Naematoloma* that have not yet been studied but are toxic.

The *pantereko* group includes three genera and six species in the family Boletaceae: *Boletus edulis, B. frostii* and *B. aestivalis, Suillus lutens, S. granulatus,* and *Xerocomus spadiceus.*

Different classes are included in the *sirat angants terekua:* the *sirat angants urapiti* which corresponds to *Helvella crispa* and known in Spanish as *orejas de ratón blanca,* 'white rat's ears', and the *sirat angants turipiti* or *orejas de raton negras,* 'black rat's ears', which have been identified as *Helvella lacunosa.* Both species are edible and their bad form is *kauicha sirat angants* which is *oreja de ratón borracha,* 'drunk rat's ear'.

The *k'uin ants'ir terekua* includes mushrooms belonging to the Family Clavariaceae and especially the genus *Ramaria* which is the most important. These mushrooms constitute a taxonomic complex of various unstudied species.

The mushrooms of the *tataras* group are roundish, 'with little or no leg' (stem) as the informants say. They are white when young. The main or genuine mushroom is *Lycoperdon* with three species *L. umbrinum, L. perlatum, L. pyriforme* also known as *trompitas de venado,* 'deers muzzle'. All of these grow in pine broadleaf forests. Other edible *tataras* which grow only in pastures are *Vascellum intermedium* and *Arachnion album* identified in Purépecha as *burkuatsita. Calvatia cyathiformes* known as *patarata* is edible when young and used for medicinal purposes when adult.

The *tamanda* group includes all mushrooms that grow in tree trunks such as *Fuligo septica* called *tamanda kuatsita* in Purépecha which is the genuine or good mushroom. Species of the family Polyporaceae include *Polyporus azureus, P. versicolor* and *Lenzites betulina. Tremella lutescens* which is not edible and known as *flor de palo* is also in this group. Lichens or *t'sakapu ts'ipata,* meaning *flores de piedra,* 'rock flowers', or *anatapu ts'ipata* meaning *flores de árbol,* 'tree flowers', fall into this group as well. Thus the *tamanda* group is taxonomically the most complex since it includes at the same time myxomycetes *(Fuligo),* mushrooms from the Families Polyporaceae, Tremellaceae and Lichens.

It is important to note that the Purépecha can refer to each of the mushroom groups recognized by their respective names without having to say the word *terekua.* Thus they speak simply of the *tiripiti,* the *tataras,* the *tamanda,* the *k'uin ants'ir,* etc.

A schematic representation of the general Purépecha mycological classification is shown in Figure 1.

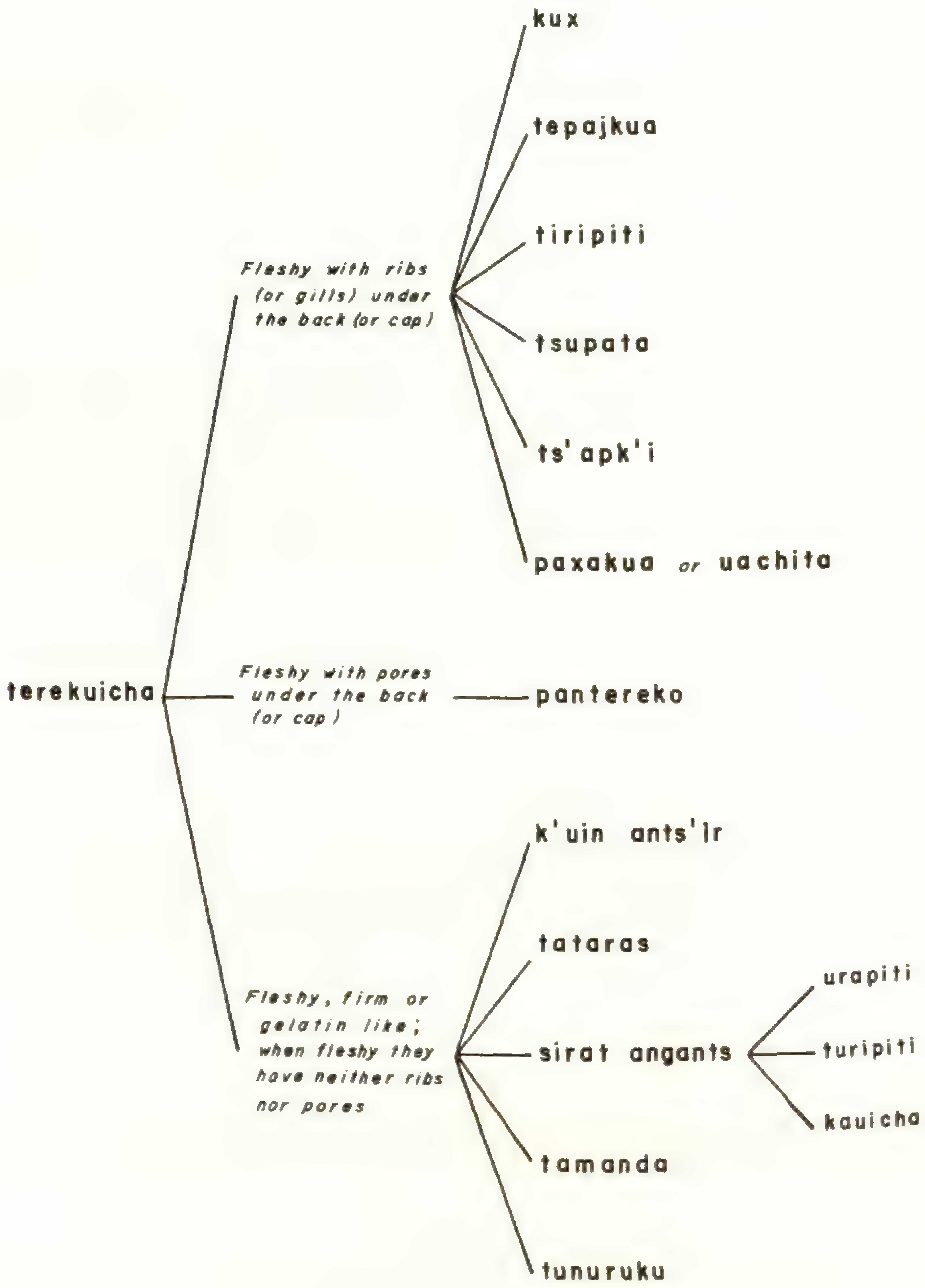

FIG. 1. Schematic representation of the Purépecha mycological classification.

DISCUSSION

The Purépecha classification system for mushrooms described above appears to be similar to biological classification systems found among other indigenous groups in Mexico (Berlin et al. 1974; Berlin 1977) and in other countries (Diamond 1966 in New Guinea and Berlin 1976 in Brasil and Peru).

The Purépecha mycological classification system may be considered atypical since it does not fully demonstrate all the general principles which govern the folk classifications. Nevertheless it fulfills to a large degree these principles.

The mushroom groups: 1) *kux tereko;* 2) *tepajkua;* 3) *tsupata;* 4) *tiripiti;* 5) *ts'apki;* 6) *paxakua;* 7) *pantereko;* 8) *sirat angants;* 9) *k'uin ants'ir;* 10) *tataras* and 11) *tamanda* seem to correspond to the generic taxa. These taxa are those which the majority of the people can recognize easily as 'the different classes of mushroom that exist'. In addition, taxa are always named with primary lexemes which can be analyzed linguistically. For example *kux terekua,* which means 'pig snout' mushroom, or *tepejkua terekua,* which means 'pasture'.

As Jacobson affirms (according to Escalante 1973) these terms, as with all the generic taxa of classification, may designate two things: contiguity or similarity as indicated by the *tepajkua* or 'pasture mushrooms', because they are found in pastures, or the case of the *kuxtereko* or 'pig snout' mushroom because they look somewhat like a pig snout. And in this way the names are easier to remember and can be applied regularly to the mushrooms.

The three classes to which these 11 groups belong based on the presence or absence of gills, and pores under the cap seem to correspond to the taxa life-forms. The Purépecha names of each one of these taxa were not recorded.

Under the generic taxa some mushroom groups seem to correspond to specific taxa. Such is the case of the *sirat angants.* These correspond to three different species of the *Helvella* genus. This is the case of a close relation of correspondence between occidental taxonomy and folk taxonomy. It may be observed in Purépecha classification that the mushrooms belonging to classes one and two (fleshy with ribs or gills under the cap and fleshy with pores under the cap) correspond to the Order Agaricales (for the first) and to the Family Boletaceae (previously Order Boletales) (for the second) respectively, according to the modern mycology. The *tataras* correspond to the Order Gasteromycetes.

The specific taxa in the folk taxonomies are designated with secondary lexemes wherein one of its members indicates the category subordinate to form in question (example *sirat angants* or 'smoke cap'). And the other member functions as a classifier (*urapiti* or white). In other cases such as *paxakua, tepajkua,* or *kutserekua,* specific taxa are not clearly defined. In a generic taxon such as *kux tereko* one or many species of mushrooms are found. One of these species is the main or genuine species and the other species included have to share certain characteristics with the main mushroom.

It can be compared with the type-specific plant nomenclature in Tzeltal described by Berlin et al. (1974); "In nearly all Tzeltal specific contrast sets one of the members of the set is considered as the focal or most dominant member". In Purépecha however the members of these specific sets are not named with secondary lexemes. At least they were not detected during the field research.

In regards to the corn fungi *Ustilago maydis* commonly known as *cuitlacoche,* which parasites the ears of corn, it is identified among the Purépecha of the Pátzcuaro basin as *tukuru, puax, tecolote, viejito, hongo de milpa.* Interestingly enough the Purépecha (at least those from Pátzcuaro) do not consider *Ustilago maydis* a mushroom. The photographs of these fungi were always put aside with the explanation that it was part of the corn. This mushroom is an edible one and is sold at the market in the town of Pátzcuaro.

The mycological classification presented here is a primary interpretation of the field data. Probably other interpretations can be made.

There are certain aspects of this classification system which are particularly interesting. For example, the unique beginner is named and is polysemic; names have not been recorded for the taxa in the life-form category, and various specific taxa are not clearly defined.

It should be noted that this classification system shares similar aspects with other non-biological ones, especially those referring to soils. These classification systems are considered atypical as well because the unique beginner is well defined, named and is polysemic. The taxa at the level two (life form) are undefined and not named. These classifications have been studied among the Purépecha by Barrera (1981) and Williams and Ortiz-Solorio (1980) among several peasant groups.

All of the foregoing draws attention to the need to study the folk classifications of lowly organisms such as mushrooms, mosses, and other non-biological entities. Doubtless this will enrich the discussion concerning the universality and validity of the general principles of folk taxonomies which has been developing over recent years.

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NOTES

[1] The Indians of Lake Pátzcuaro have named themselves Purépecha which means 'the common people'. Tarascans has been the most frequently used word to name them. Originally this word was used by the Spaniards during the conquest and it has a different meaning.

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THE PERVASIVENESS OF ONOMATOPOEIA IN AGUARUNA AND HUAMBISA BIRD NAMES

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ABSTRACT.—As part of our continuing research on the nature of ethnobiological knowledge among the Aguaruna and Huasbisa, two Jivaroan populations of the rain forests of northcentral Peru, we have discovered that a major portion of the vocabulary for birds is onomatopoetic in origin. The purpose of this report is to provide evidence for the pervasiveness of onomatopoeia in these languages and to offer some initial speculations as to the significance of this pattern of naming. A rapid perusal of the literature suggests that onomatopoeia of this type is not uncommon in languages spoken by peoples of small-scale, technolgially simple, non-literate societies. The study of ethnobiological onomatopoeia might enlighten us on issues concerning the relation of vocabulary and cultural complexity.

INTRODUCTION

The Jivaroan Languages

The Jívaro language family comprises four closely related groups: Aguaruna, Huambisa, Shuar, and Achuar (McQuown 1955; Loukotka 1968; Greenberg 1960). The approximately 20,000 speakers of Aguaruna (Uriarte 1977) are found along the upper Marañón River of northcentral Peru, beginning around the Pongo de Retema and extending below the Pongo de Manseriche, as well as along the Marañón's major tributaries in this area, the Cenepa, Comainas, Numpatkaim, Nieva, lower Santiago, Apaga, and Potro. Some Aguaruna are to be found on the upper Mayo River, a tributary of the Huallaga (Brown 1980). Huambisa is spoken by approximately 5,000 speakers (Chirif and Mora 1977). Huambisa villages begin at the community of Galilea on the lower Santiago River and extend northward along the upper reaches of the Santiago and its tributaries to the Ecuadorian border. Shuar, with about 10,000 speakers (Grimes 1978), is primarily restricted to the upper Santiago, upper Morona, and upper Pastaza drainages of Ecuador's Oriente, though some Shuar speakers are found in Peru along the upper Corrientes River (Shell and Wise 1971). Speakers of Achuar, approximately 3000 in number (Grimes 1978), are found in both Ecuador and Peru along the Pastaza, Bobonaza, Corrientes, and Tigre Rivers, often passing freely across the international border that separates the two countries.

The Jivaroan languages are quite closely related, and our unsystematic observations indicate that they are, in the main, mutually intelligible with one another (see also Larson 1957; Shell and Wise 1971). Aguaruna and Huambisa apparently have little difficulty in interpreting Shuar language radio broadcasts of the Ecuadorian Shuar Federation. Of the four ethnolinguistic groups, however, Aguaruna appears to be the most distinctive phonologically and lexically.

Taxonomic Phonemes of Aguaruna and Huambisa

The most comprehensive work on Aguaruna descriptive linguistics is that of Larson, Fast, Payne, and Pike (Larson 1963, 1966, 1978; Fast and Larson 1974; Payne 1974; Pike and Larson 1964). Descriptive linguistic research on Huambisa has been carried out by Beasley and Pike (1957). Published comparative analyses relating to the two ethnolinguistic groups can be found in Larson (1957) and Shell and Wise (1971). An unpuslished comparative treatment is seen in Turner (1962, cited in Payne 1974).

Reference to the above work, as well as that of the present authors, lead us to state that the taxonomic phonemic inventories of Aguaruna and Huambisa are identical, with the exception of the presence of voiced bilabial and alveolar stops (b, d) in Aguaruna which are absent in Huambisa. Segmental consonants are: p, t, k, ʔ, (b, d), ¢, č, s, š, m, n, ɔ , w, y, h, r. Vowels are: i, ɨ, a, u. Vowel nasalization (indicated by underlining the affected vowel, e.g., i̲, ɨ̲, a̲, u̲) is phonemic, as is stress. A detailed analysis of Aguaruna phonology, with special reference to nasalization, can be found in Payne (1974).

Types of Onomatopoeia in Jivaroan Vocabulary

Stereotypic conventions for vocalizing natural sounds represent an active phonological process in the Jivaroan languages. It is most apparent in certain areas of the extensive ethnobiological lexicon, notably in native speakers' characterizations of the sounds of the calls of animals, especially birds, frogs, mammals and certain insects. The calling and signaling behavior of animals may be rendered in one of two ways in Aguaruna and Huambisa. (1) The calls may be *literally mimicked* or *imitated* by resorting to whistling, humming, grunts, hissing, smacking or clicking (cf. the whistled rendition of the song of the Bobwhite quail, *Colinus virginianus).* Efforts to literally mimic a call may be accomplished at times with the aid of double-cupped hands, appropriately held leaves, or by animal bone whistles. The regular speech sounds of the language are not employed in literal imitation. (2) The calls of an animal may be *phonologically vocalized,* employing the resources of the regular speech sounds of the language in combination with such paralinguistic processes as *stress, intonation, tempo,* and *vocalic quality.* In both Aguaruna and Huambisa ornithology, we have found that all birds that *call* can be literally mimicked. In addition, and of more linguistic interest, a large majority of the birds that can be mimicked also have conventionalized *onomatopoetic vocalizations.*

An *onomatopoetic phonological vocalization* of a particular animal's call and the *name* of that animal may be related in at least one of two ways: (1) the vocalization may bear no resemblance to the name (cf. the stereotypic calls of certain domesticated animals—cat: meow-meow, pig: oink-oink). (2) the vocalization may be similar to the name in that some or all of the speech sounds of the name comprise a fragment of the vocalization (cf. the British English name *cock* (synonym *rooster)* and the call, *cockadoodledoo;* or the name *Bobwhite,* which is a complete phonological replication of the call of *Colinus virginianus).*

These expressions are phonologically onomatopoetic in the strict sense in that, to use the terminology of Otto Jespersen, " . . . the echoic word designates the being that produces the sound" (1921:399). We will restrict our description in this paper to only those terms which are onomatopoetic in this strict sense.

Data base

We have earlier pointed out that ornithological knowledge is not uniformly shared by all members of Aguaruna society (Berlin et al. 1981). This knowledge is closely related to an Aguaruna's age and sex, and the same findings hold true for the Huambisa. If one is a male in either of these societies, one will know more bird names and be able to name reliably and identify a wider variety of bird species than if one is an adult female.

In general, even adolescent males know more than do adult females. These patterns of knowledge directly reflect the different social roles of men and women.

At the present time, it is difficult to provide an exact number for the total inventory of bird species known to mature, knowledgeable males, but on the basis of extensive interviewing with five principal informants, in addition to detailed survey work, we now calculate that at least 250 distinct species of birds are recognized linguistically in both Aguaruna and Huambisa. We were able to obtain taped recordings of 224 bird names and their vocalizations in Aguaruna and 206 names and accompanying vocalizations in Huambisa. Of the 224 recorded names in Aguaruna, 86 (38%) were onomatopoetic in character. In Huambisa, 71 (34%) of the 206 recorded names were onomatopoetic. The proportions would probably be a bit higher had the complete inventory been examined.

METHODS

The Aguaruna data reported here were drawn from tape recordings made in 1978 on the Cenepa River. The interviews were carried out with a monolingual male, approximately 50 years of age. Earlier sessions with this informant had been conducted to determine the perceived genetic relationships among known bird species in the area. Utilizing an alphabetical list of Aguaruna bird names (elicited from other informants as well as written sources [Larson 1966; Guallart 1964]), the informant was first read a name and then asked, "X̲, does it have any relatives?" [X̲, kumpahí̲ aȼáwak]. Names of the perceived "relatives" of the named bird were then written on 5x8 inch cards. Following the establishment of groups of related species, we worked systematically through each group, querying of every bird, "X̲, how does it talk?" [X̲, wahí̲tu čičáwak]. (The question frame "X̲, wahí̲tu uhímawak" 'how does it whistle?' elicits a whistled or hummed imitation of the call.) The response was recorded on Ampex tape (Plus Series) using a Sankyo ST-60 cassette recorder. Biological referents of the bird names were obtained in subsequent naming and sorting experiments with the same informant utilizing prepared specimens as stimuli.

The Huambisa data were taken from taped interviews made in 1979 on the Santiago River. Three Huambisa males, all in their mid-forties, particpated in the interviews. One informant was monolingual, the other two spoke minimal Spanish. In these sessions, informants systematically sorted prepared bird specimens into groups considered to be related to one another. The names of each bird in the groups, as well as missing "relatives," were recorded on 3x5 inch paper slips. Of each specimen, we asked, "X̲, how does it talk?" [X̲, warí̲tu čičáwak]. (To elicit a whistled or hummed indicator, the appropriate question form is, "X̲, urúk uhímawak"). Recordings were made on Memorex MRX$_3$ Oxide tape using a Superscope C-10 cassette recorder.[1]

DATA

Birds and Their Calls

For ease of reference and to facilitate future comparisons, we have presented individual bird species according to their biosystematic order as given in Meyer de Schauensee (1966). As will be seen, some species of birds are given onomatopoetic names in both Aguaruna and Huambisa. Other species, however, will show an onomatopoetic name in just one of the two languages. We will, nonetheless, present the vocalizations of the species involved in both languages if these data are available. Data on the names and vocalizations of 118 species of birds are transcribed.

Most of the bird vocalizations are repeated several times. In order to make the relationship between the bird name and the call more explicit, the first onomatopoetic segment of the call appears in bold print.

Our conventions for the transcription of bird vocalizations are broadly phonetic. We have attempted to employ standardized American linguistic phonetic notation throughout. We believe that the transcriptions, in conjunction with comments such as "staccato," "falsetto," "irregular tempo," etc., are easily replicated by the interested reader with minimal effort. (A more detailed phonological representation of these onomatapoetic vocalizations is in preparation.) For the non-linguistic specialist, the following key may be of use:

Key to special symbols

ʔ = glottal stop
R = uvular trill
u = w
i = y
C̥ = voiceless consonant
V̥ = voiceless vowel
V̥̭ = h
r̃ = trilled r
ř = flap r
ŋ = velar nasal
ɣ = velar spirant
Ṽ = nasalized vowel
_⌐‾‾¬_ = intonation contour
V̍ = stressed vowel
V͒ = sustained vowel
• = syllable division
C̩ = syllabic consonant
C˺ = unreleased consonant
= pause
C̱ = fortis onset
b̃ = bilabial trill

SCREAMERS, Anhimidae

Anhima cornuta 'Horned Screamer'

Ag: amúntai [ɨ̥u.i̥ik. ɨãũ. ɨãũ. ɨ̥u.i̥ik. ɨãũ.ɨãũ.ɨãũ.]
Hu: amúntai [a.mu̍n.tai. ɨ̥.au. a.mu̍n.tai. ɨ̥.au
[a.mu̍n.tai. ɨ̥.au.]

falsetto, lilting, overloud

HAWKS, Accipitridae

Ictinia plumbea 'Plumbeous Kite'

Ag: (no data)
Hu: isíp [i.si͒. i.si͒. i.si͒.]

falsetto

Spizaetus tyrannus 'Black Hawk-eagle'

Ag: ukukúi [u.ku.ku.ku.ku.ku̍i. u.ku.ku.ku.ku.ku̍i]
Hu: ukukúi [u.ku.ku̍i͒. u.ku.ku̍i͒. ku.ku.ku.u.ku.ku̍i͒]

falsetto

FALCONS AND CARACARAS, Falconidae

Daptrius ater 'Black Caracara'

Ag: šanášna [ša. ša. ša.] slight falsetto
Hu: šanásňa [ša. ša. ša.]

Falco rufigularis 'Bat Falcon'

Ag: tiú tiú (not recorded)
Hu: ȼiártik [tsɨ.tsɨ.tsɨ.tsɨ.tsɨ.tsɨ] falsetto

CHACHALACAS, GUANS, and CURASSOWS, Cracidae

Ortalis guttata 'Speckled Chachalaca'

Ag: wakáȼ [sa.sa.sa.sa.sa.sa.sa.sa.sa.
uɤ.ta.řa.ka. ua.ta.řa.ka. ua.ta.ra.ka]
Hu: wakáȼ [ua.ta.řak.a. ua.ta.rak.a. ua.ta.rak.a. kau]

Penelope jaquacu 'Spix's Guan'

Ag: aúnȼ [a.u̯ui. a.u̯ui. a.u̯ui. auR̥.u̯aR̥. u̯aR̥.u̯aR̥.]
falsetto, first phrases lilting
Hu: aúnȼ [au.u̯ui. au.u̯ui. au.u̯ui. auR̥.auR̥.auR̥]
falsetto, first phrases

Aburria pipile 'Blue-throated Piping-Guan'

Ag: kúyu [kun.tšu.i̯ĩ. kun.tšu.i̯ĩ. kũ.i̯u.u̯i. kũ.i̯u.u̯i.
kũ.i̯u.u̯i. kun.tšu.i̯ĩ.]
Hu: kúyu [ku.iu.ku.iu.ku.iu.kun.tsai. ku.ku.ku.kun.tsai]

Aburria aburri 'Wattled Guan'

Ag: uwačáu [u.u̯ai.u̯a. u.uai.u̯a.] gentle rising to 2nd syllable,
gently falling, vowels heavily sustained
Hu: awačá [tša.řai.u̯a. tša.rai.u̯a. tša.rai.u̯a]

Crax globulosa 'Wattled Curassow'

Ag: pí̲i̲wi [pɨs.pi. pɨs.pi. pɨs.pi pa̯a.u̯u.u̯u.u̯u.]
Hu: pi̲i̲ (bird name known, but no knowledge of its vocalization)

HOATZIN, Opsthocomidae

Opisthomcomus hoazin

Ag: saasá (not recorded)

Hu: saasá [sa.sã̍.sã̍.sã̍.sã̍.sã̍.sã̍.sã̍]

RAIL, Rallidae

Aramides cajanea 'Gray-necked Wood-Rail'

Ag: kuá̌cau (not recorded)

Hu: kunčár [kun.tsa̍ř.kun.tša̍r.kũ̍.kũ̍.kũ̍.kũ̍.kũ̍.

[kun.tša̍ř.kun.tša̍ř.kũ̍.kũ̍.kũ̍.kũ̍.kũ̍.]

lilting tempo

Anurolimnas castaneiceps 'Chestnut-headed Crake'

Ag: pílhuak (not recorded)

Hu: pítur číŋki [pi̍.tu.ř̌u. pi̍.tu.ř̌u. pi̍.tu.ř̌u.

pi̍.tu.ř̌u] lilting tempo, falsetto

SUNBITTERN, Eurypygidae

Eurypyga helias

Ag: tíinkin [ti̍n.ti̍n.ti̍n. ti̍n.ti̍n.ti̍n. ti̍n.ti̍n.ti̍n.]

regular tempo

Hu: tiŋkía (not recorded)

PLOVERS, Charadriidae

Hoploxypterus cayanus 'Pied Lapwing'

Ag: tɨ́utɨu [tɨ̍u.tɨ̍u.tɨ̍u.tɨ̍u.tɨ̍u. tɨ̍u.tɨ̍u.tɨ̍u.tɨ̍u.tɨ̍u.]

Hu: tuɨ́ntui (no knowledge of call)

SANDPIPERS, Scolopacidae

Actitis macularia 'Spotted Sandpiper'

Ag: piámpia ~ tíŋkin [pi̍.am.pi̍a.pi̍a.pi̍a.

pi̍.am.pi̍a.pi̍a.pi̍a.] rapid tempo

Hu: piampía [sui̍.sui̍.sui̍.sui̍.sui̍.sui̍.sui̍.]

DOVES AND PIGEONS, Columbidae

Geotrygon saphirina 'Sapphire Quail-dove'

Ag: pukuí [pu.kui. pu.kui. pu.kui.]

Hu: pupui (hummed imitation)

PARROTS, Psittacidae

Ara manilata 'Red bellied Macaw'

Ag: kayák [kia.ku.ka.ia.ku. ki.ia.ku.ki.ia.ku.]

lilting falsetto

Hu: kayák [kã.iãk. kã.iãk. kã.iãk.]

falsetto, irregular

Aratinga leucophthalmus 'White-eyed Parakeet'

Ag: čípi [kĩ.kĩ.kĩ.kĩ.kĩ.kĩ.kĩ.] falsetto

Hu: kíiki [kĩ.kĩ.kĩ.kĩ.kĩ.kĩ.kĩ.] rapidly, falsetto

Aratinga weddellii 'Dusky-headed Parakeet'

Ag: (not in Cenepa area?)

Hu: šiši ∿ pɨrtunyɨ́s ∿ šántanta [ši.ši.ši. ši.ši.ši.

ši.ši.ši.] falsetto

Pyrrhura picta 'Painted Parakeet'

Ag: man¢ɨ́ɨt [tsɨt.tsɨt. tsɨt.tsɨt. tsɨt. tsɨt.]

irregular

Hu: ¢ɨ́ɨp [tsɨt.tsɨt. tsɨt.tsɨt. tsɨt.tsɨt. tsɨt.]

irregular falsetto

Forpus xanthopterygius 'Blue-winged Parrotlet'

Ag: šiwím [ši.ui. ši.ui. ši.ui] irregular tempo

Hu: nuínui [sic] [nui.nui.nui. nui.nui.nui. nui.nui.nui]

cf. Ag *Touit huetii* falsetto

Brotogeris cyanoptera 'Cobalt-winged Parakeet'

Ag: kihus [ki.ii.ki.ki. ki.ii.kik. tšim. tšim. tšim]

Hu: čiímp [tši.rim. tši.rim. tši.rim]

first syllable in each phrase clipped

(Note: the last segment of the vocalization of this species in Aguaruna is cognate with the name of the bird in Huambisa.)

Touit huetii 'Scarlet-shouldered Parrotlet'

Ag: nuinuí [šik.šik.šik.šik. šai.o̥ok.šai.o̥ok.šai.o̥ok.
[ša.ka̍š.ka̍š.ka̍š.ka̍š.]

Hu: šái [ša̍ĩ.ša̍ĩ.ša̍ĩ. ša̍ĩ.ša̍ĩ.ša̍ĩ.]

(Note: Huambisa name is identical to part of the vocalization in Aguaruna.)

Pionites melanocephalus 'Black-headed Parrot'

Ag: čirikás [tši.ři̍k. tši.ři̍k. tši.ři̍k]

irregular falsetto

Hu: čirikás (vocal information not recorded)

Pionopsitta barrabandi 'Orange-cheeked Parrot'

Ag: (bird not known)

Hu: muí [mui.mui̍. mui.mui̍. mui.mui̍. mui.mui̍.]

Pionus menstruss 'Blue-headed Parrot'

Ag: tuíš [tui̍š.tui̍š.tui̍š.tui̍š.tui̍š.tui̍š.]
[kũ̍.i͡a.tšik. kũ̍.i͡a.tšik.]

Hu: tuíš [tui̍š. tui̍š.tui̍š.tui̍š.tui̍š.tui̍š.]

vowels clipped

Amazona ochrocephala 'Yellow-headed Parrot'

Ag: kawáu [tsa̍.tsa̍.tsa̍.tsa̍.i̥͡i .ka.řa.řa.řa.řa]

Hu: awarmás [au.řa.au.řa.au.řa.au.řa] falsetto

Amazona festiva 'Festive Parrot'

Ag: čawít (not recorded)

Hu: čawít [tša.u͡i̍.ta.tša.u͡i̍.ta.tša.u͡i̍.ta. ka.ra̍ŋ.
[ka.ra̍ŋ.ka.ra̍ŋ.ka.ra̍ŋ.] falsetto

Amazona amazonica 'Orange-winged Parrot'

Ag: paháí [pa̍i.pa̍i.pa̍i. pa̍i. pa̍i.pa̍i. pa̍i.]

irregular tempo

Hu: parái [šá.ta. šá.ta. šá.ta. šá.ta.]

falsetto, lilting

CUCKOOS, Cuculidae

Crotophaga major 'Greater Ani'

Ag: kuákua [qxR̥̍.qxR̥̍.qxR̥̍.qxR̥̍.ša.řâ]

Hu: kuákua [sak. aȗ. .kuȒ̥]

Crotophaga ani 'Smooth-billed Ani'

Ag: báit [mai.mai.mai.mai.] falsetto

Hu: mawái [ma.u̯a̍i.ma.u̯a̍i.ma.u̯a̍i] falsetto

OWLS, Strigidae

Glaucidium brasilianum 'Ferruginous Pygmy-Owl'

Ag: takɨ́nt [tã̍ŋ.tã̍ŋ.tã̍ŋ. ta.kɨ̍n.ta. ta.kɨ̍n.ta] repeated

Hu: (not recorded)

POTOOS, Nyctibiidae

Nyctibius 'Great Potoo'

Ag: káu [qxḁ̍u̥R̥.qxḁ̍u̥R̥.qxḁ̍u̥R̥.qxḁ̍u̥R̥]

Hu: káu [qxḁ̍u̥R̥. i̯a.tsu.řu. i̯a.tsu.řu. i̯a.tsu.řu. qxḁ̍u̥R̥] falsetto

Nyctibius aethereus 'Long-tailed Potoo'

Ag: autám [auȗ. auȗ. auȗ.] note distinct vocoids,

falsetto

Hu: (not recorded)

Nyctibius griseus 'Common Potoo'

Ag: aúhu [ã̑. aiš.u̯a.šuã.šuã. ã̑. aiš.u̯ã.šuã.šuã] falsetto

Hu: aúhu [aȗ. ȗ̥u.ȗ̥u.ȗ̥u.ȗ̥u. aȗ. ȗ̥u.ȗ̥u.ȗ̥u.ȗ̥u.] falsetto

NIGHTJARS, Caprimulgidae

Hydrosalis climacocerca 'Ladder-tailed Nightjar'

Ag: papáhu [uũ̥̯̍.uũ̥̯̍.uũ̥̯̍.uũ̥̯̍. uũ̥̯̍. uũ̥̯̍. uũ̥̯̍.] irregular

Hu: papár (not recorded)

SWIFTS, Apodidae

Reinarda squamata 'Fork-tailed Palm-Swift'

Ag: (not in, or very rare in, Cenepa area)

Hu: ačúnmaya šúrpip [ᵐbi̍s. ᵐbi̍s. ᵐbi̍s. ᵐbi̍s. šú.rǔ.rǔ.]

HUMMINGBIRDS, Trochilidae

Eutoxeres aquila, E. condamini 'Sicklebilled Hummingbirds'

Ag: jɨmpɨ́čau [ɨɨm.pɨ̍.wɨs.wɨs.wɨs.wɨs. ɨɨm.pɨ.tšau.wɨs.wɨs.

[ɨɨm.pɨ.wɨs.wɨs.wɨs.] melodic

Hu: uhúh jɨ́mpɨ (no known call)

TROGONS, Trogonidae

Trogon viridis 'White-tailed Trogon'

Ag: táwai [ta̍u.ta̍u.ta̍u.ta̍u.ta̍u.ta̍u.] staccato falsetto

Hu: táwai [ta̍.ta̍.ta̍.ta̍.ta̍.ta̍.ta̍.ta̍.] rapid tempo falsetto

Trogon collaris 'Red-bellied Trogon' (perhaps other red-bellied species as well)

Ag: čákua [tša.kũã̍.kũã̍.kũã̍.kũã̍. tša.kũã̍.kũã̍.kũã̍.kũã̍.]

falsetto, some whisper

Hu: (no information)

KINGFISHERS, Alcedinidae

Ceryle torquata 'Ringed Kingfisher'

Ag: mun čáhi̱ (not recorded)

Hu: taráš [ta.ra̍š. ta.ra̍š. ta.ra̍š.]

Chloroceryle amazona 'Amazon Kingfisher'

Ag: čáhi (not recorded)

Hu: čáhi [tša̍.ĩĩ̥̯.tša̍.ĩĩ̥̯.tša̍.ĩĩ̥̯.tša̍.ĩĩ̥̯]

rapid regular tempo, falsetto

MOTMOTS, Momotidae

Baryphthengus ruficapillus (martii) 'Rufous Motmot'

Ag: yukúhu [uu.r̃u. uu.r̃u. uu.r̃u. uu.r̃u. uur̃u]
Hu: yukúru [uu.řu. u.řu. u.řu. tr̃u] falsetto

PUFFBIRDS, Bucconidae

Bucco capensis 'Collared Puffbird'

Ag: bukɨ́tau [bu.kɨa.tau. bu.kɨa.tau. bu.kɨa.tau]
lilting
Hu: maukátarar [mo.ka.ta.řǎř. mo.ka.ta.řǎř.
mo.ka.ta.řǎř]

Monasa morphoeus 'White-fronted Nunbird'

Ag: tawíkuru ~ tíhu [iiu.iiu.iiu.iiu.iiu.iiu.ta.ui.kruk.
[tauik.ta.uik.ta.uik.ta.uik. ta.ui.
kuřu.]
[ta.ui.ku.řu.]
Hu: tawikuru [ta.uik.ta.uik.ta.ui.ku.řur̃.
ta.ui.ku.řur̃]

BARBETS, Capitonidae

Capito aurovirens 'Scarlet-crowned Barbet'

Ag: (not present in Cenepa area; inhabits flooded forest lacking there)
Hu: apú púr [pur̃.pur̃.pur̃.pur̃.pur̃.] falsetto

Eubucco richardsonii 'Lemon-throated Barbet'

Ag: púuŋ [b̃u.b̃u.b̃u.b̃u]
Hu: wincǔ púr [b̃r.b̃r.b̃r.b̃r.b̃r.b̃r.] falsetto

Eubucco bourcierii 'Red-headed Barbet'

Ag: tíwa [tiu. tiu. tiu. tiu]
Hu: tíwa [ti.ua. ti.ua. ti.ua.] falsetto

TOUCANS, Ramphastidae

Aulacorhynchus derbyanus 'Chestnut-tipped Toucanet'

Ag: ikáuk ~ wa̱a̱k [ũa̍k ũa̍k ũa̍k ũa̍k]

continuous breathy

Hu: ikiák [ũa̍k ũa̍k ũa̍k ũa̍k]

continuous

Pteroglossus castanotis 'Chestnut-eared Aracari'

Ag: piristan pininč [prȋ̌s. prȋ̌s. prȋ̌s. prȋ̌s. prȋ̌s]

Hu: pirístin [pi.řȋs. pi.řȋs. pi.řȋs. pi.řȋs]

Pteroglossus flavirostris 'Ivory-billed Aracari'

Ag; sáitam pinínč [ka̍.ka.ka̍.ka̧.ka̍.ka.ka̍.ka.ka̍.ka̍.ka̍.yã̑.

[ka.ka.ka.yã̑. ka̍.ka.ka̍.ka.ka̍.ka]

Hu: kakarpa¢ [kař.ka̍t.kař.ka̍t. kař.ka̍t. kař.ka̍t.

kař.ka̍t.] vowels slightly whispered

Selenidera reinwardtii 'Golden-collared Toucanet'

Ag: kahún¢am [ka̍u.ka̍u.ka̍u.ka̍u.] rasping

Hu: karún¢am [ka̍u.ka̍u.ka̍u.ka̍u] rasping

Ramphastos culminatus 'Yellow-ridged Toucan'

Ag: kɨ́hua [kɨ̍au. kɨ̍au. kɨ̍au. kɨ̍au. kɨ̍au.]

falsetto, breathy

Hu: kɨ́rua [kɨ̍.řua. kɨ̍.řua. kɨ̍.řua]

R. ambiguus 'Black-mandibled Toucan'

Ag: šá̱a̱tak [šã̑.ta.řa̍k.ta.řa̍k.ta.řa̍k. šã̑.ta.řa̍k.ta.řa̍k.

[ta.řa̍k. šã̑.ta.řa̍k. šã̑.ta.řa̍k.ta.řa̍k.]

falsetto

Hu: šá̱rtik [šã̍r.tik.tik.tik. šã̍r.tik.tik.tik.

[šã̍r.tik.tik.tik.] falsetto

Ramphastos cuvieri 'Cuvier's Toucan'

Ag: yaríka ¢ukaŋ ká ∿ apú ¢ukaŋ ká

[i̯a.ři̍.ka.ka̍.ka̍.ka̍. ɨ̯u.ka̍.ka̍.

i̯a.ři̍.ka.i̯a.ři̍.ka. ɨ̥ɨu.ka̍.ka̍.ka̍. i̯a.ři̍.ka]

Hu: apú ¢ukaŋ ká [i̯a.kuɨ̍ŋ.kuɨ̍ŋ.kuɨ̍ŋ. i̯a.kuɨ̍ŋ.kuɨ̍ŋ.]

continuous

WOODPECKERS, Picidae

Celeus elegans 'Chestnut Woodpecker'

Ag: yawá̲ sawákɨ [i̯a.u̯ã.u̯ã.u̯ã.u̯ã.u̯ã.] breathy falsetto

Hu: apú sawákɨa [sâ.u̯â.kɨa. sâ.u̯â.kɨa]

rapid fall on final syllable

Melanerpes cruentatus 'Yellow-tufted Woodpecker'

Ag: tɨhašá (no vocalization, whistled only)

Hu: tɨrakšá [tɨ.řak.sɨ.šâ. tɨ.řak.sɨ.šâ. ti.řak.sɨ.šâ.]

falsetto

WOODCREEPERS, Dendrocolaptidae

Campylorhamphus trochilirostris 'Red-billed Scythebill'

Ag: bikuaḿkuas [bi.kua̍m.kua̍m.kua̍m. bi.kua̍m.kua̍m.kua̍m.

[bi.kua̍m.kua̍m.kua̍m. tši.tši.tši.

[bi.kua̍m.kua̍m.kua̍m.]

Hu: ša̲a̲wiá [tšia.tšiau.tšik.tšik.]

ANTBIRDS, Formicariidae

Thamnophilus schistaceus 'Black-capped Antshrike'

Ag: či̲híkiu ~ či̲kiu [tšĩ.kĩãũ. tšĩ.kĩãũ. tšĩ.kĩãũ.

[tši̍.tši̍.tši̍. tši̍.tši̍.tši̍. tšĩ.kĩãũ]

falsetto throughout

Hu: čičikia [tši̥.tši̥.kia. tši̥k. tši̥k.

tšik.tšik. tši̥.kiḁ]

vowels strongly clipped

Thamnomanes ardesiacus 'Dusky-throated Antshrike'

Ag: kunčačám [kun.tša.tša̍t. kun.tša.tša̍t.

[šui.šui.šui.i̥̯ui.i̥̯ui.i̥̯ui.u̯i.u̯i] falling tone

Hu: (no information)

Myrmotherula (striped species, ie *brachyura* or *obscura)*

Ag: čunčuíkit [tšun.tšui̍.ki̍.ki̍.ki̍.ki̍.
tšun. tšui̍.ki̍.ki̍.ki̍.ki̍]

Hu: čunčuikit (not recorded)

Mymotherula axillaris 'White-flanked Antwren'

Ag: či̲a̲tas [tši̍̃ã.tas. tši̍̃ã.tas. tši̍̃ã.tas]

Hu: kí̲a̲tsa [ki̍̃ã.tsã. ki̍̃ã.tsa.tsa. ki̍̃ã.tsã.tsã.]

Myrmotherula schisticolor 'Slaty Antwren'

Ag: čúčup [u̯is.u̯is.u̯is.u̯is.u̯is. tšu̥.tšu̥̍.pi̥.
[tšu̥.tšu̥̍.pi̥. tšu̥.tšu̥̍.pi̥]

rapid, short syllables

Hu: čúčup [tši̍k.tšu. tši̍k.tšu] vowels whispered

Myrmoborus myotherinus 'Black-faced Antbird'

Ag: uhi̲kíaš [u.i̥̯i.kĩ.kĩ.kĩ.kĩ. u.i̥̯i.kĩ.kĩ.kĩ.kĩ.]

falsetto

Hu: píšak [pi.ša̍k. pi.ša̍k. pi.ša̍k] falsetto

[pi̍.si.ri. pi̍.si.ri] danger call

Hylophalax naevia 'Spot-backed Antbird'

Ag: wiimpíš [u̯im.piš. u̯im.piš.u̯im.piš.u̯im.piš]

staccato

Hu: pisípiš [pi̥̍s.pi̥̍s.pi̥̍s.pi̥̍s.pi̥̍šu̥]

Chamaeza sp. 'Antthrush species'

Ag: (no data)

Hu: tuáš [tua̍.tua̍.tua̍.tua̍.tua̍.tu̍.tu̍.tu̍. tu̍k.tu̍k.tu̍k.]

falsetto, dropping pitch on last three syllables

Formi carius analis ‘Black-faced Antthrush’

Ag: takínč [tin.ki.*aa̍*. tin.ki.*aa̍*. tsu.ki̍p. tsu.ki̍p]
Hu: tukímp [tɨ.ki̍mp. tɨ.ki̍mp. tɨ.ki̍mp. tɨ.ki̍mp]

Myrmothera campanisona ‘Thrush-like Antpitta’

Ag: puámpua [pua̍m.pua̍m.pua̍m.pua̍m.pua̍m]
Hu: puámpua [pu.a̍m.pu.a̍m.pam.pam.pam.]

rapid tempo, pitch gradually falling

COTINGAS, MOURNERS AND PIHAS, Cotingidae

Rhytipterna simplex(?) ‘Grayish Mourner’

Ag: ukúntuč [u.ku.ku.ku.tu.tšia̍.tšia̍.tšia̍.
u.ku.ku.ku.tu.tšia.tšia.tšia]
Hu: ukúrpip [ku.řu.ku.pi.pi.pip. ɨ.ka̍n.tšam.ka̍n.tšam]

repeated

Lipaugus cinerascens ‘Screaming Piha’

Ag: pápainč [pa̍i.pain.tša. tu.uɨa̍.tu.uɨa̍. pa̍i.pain.tša.]
[tu.uia.tu.uia]
Hu: pápainč [pa.pain.tša. pa.pain.tša.] falsetto
[tu.uɨa.tu.uɨa. tu.uɨa̍.]

Querula purpurata ‘Purple-throated Fruit-crow’

Ag: pauwái [pa̍u.uai. pa̍u.uai. pa̍u.uai.
[ĩĩ.iã. ĩĩ.iã. pa̍u.uai] irregular tempo
Hu: paučíŋki (no data)

Phoenicircus nigricollis ‘Black-necked Red Cotinga’

Ag: píǥa [tsĩã. tsĩã. tsĩã. tsĩã.] regular tempo
Hu: ¢aánč [tsa̍ntš. tsi̍ř.tsi̍ř.tsi̍ř.tsi̍ř.tsa̍ntš
[tsa̍ntš. tsi̍ř.tsi̍ř.tsi̍ř.tsi̍ř.tsa̍ntš] rapid tempo

Rupicola peruviana 'Andean Cock-of-the-Rock'

Ag: ɨŋátin ∿ [ɨɣâ.ɨɣâ.ɨɣâ.ɨɣa.]
súŋka
Hu: iátinu ∿ [ɨ̍a.ɨ̍a.ɨ̍a.ɨ̍a] falsetto, overloud,
súŋka yell-like

MANAKINS, Pipridae

Pipra pipra 'White-crowned Manakin'

Ag: k<u>aa</u>wiá [kã̂.u̯i̍aʔ.kâ.u̯i̍aʔ.p̃.p̃.p̃.
kã.ui̍aʔ.kã.u̯iaʔ.p̃.p̃.p̃.]
Hu: k<u>aa</u>wiá (not recorded)

Tyranneutes stolzmanni 'Dwarf Tyrant-Manakin'

Ag: čúup [tšuu.pi̍ʔ. tšuu.pi̍ʔ. tšuu.pi̍ʔ] slight whisper
Hu: čúup (not recorded)

FLYCATCHERS, Tyrannidae

Contopus virens 'Eastern Wood Pewee'

Ag: (no data)
Hu: tíwi [ti.u̯î. ti.u̯î. ti.u̯î.] falsetto

SWALLOWS, Hirundinidae

Stelgidopteryx ruficollis 'Rough-winged Swallow'

Ag: činím [tši̍.tši̍.tši̍.tši̍.tši̍]
Hu: činím [ši̍.ši̍.ši̍.ši̍.ši̍.ši̍.ši̍.]

Atticora fasciata 'White-banded Swallow'

Ag: šuímpip [šišiš. šišišiš. šišišiš.]

Hu: namakáya šúrpip [šu.ři̍p.šu.ři̍p.šu.ři̍p.šu.ři̍p] slight whisper

slight falsetto, lilting

JAYS, Corvidae

Cyanocorax violaceus 'Violaceous Jay'

Ag: kíhuančam [ki̍au.ki̍au.ki̍au.ki̍au.] some falsetto
Hu: kírhuančam [kḭ̍a.kḭ̍a.kḭ̍a.kḭ̍a.kḭ̍a.]

WRENS, Troglodytidae

Troglodytes aedon 'House Wren'

Ag: čuíčuiŋ [tšũĩ.tšũĩ.tšũĩ. tšui̍.tšui̍.tšui̍. kua̍ŋ .
[kuaŋ .kuaŋ .kuaŋ .] rapid tempo
Hu: čuíčuiŋ (not recorded)

Microcerculus marginatus 'Nightingale Wren'

Ag: tiŋkís [ti̍.ti̍.ti̍.ti̍.ti̍.ti̍. sɨ.sɨ.sɨ.sɨ.sɨ.sɨ.]
repeated
Hu: tiŋkís [ti̍.ti̍.ti̍.ti̍.ti̍.ti̍.] pitch falls and tempo slows
toward end of call

AMERICAN ORIOLES AND BLACKBIRDS, Icteridae

Scaphidura oryzivora 'Giant Cowbird'

Ag: ¢an¢in¢ɨ́ (not recorded)
Hu: ¢in¢an¢ɨ [tsin.tsan.tsɨ.tsɨ.tsi.tsɨ.tsɨ.
tšın.tšan.tsɨ] falsetto

Clypicterus oseryi 'Casqued Oropendola'

Ag: wáuk [u̯a.ḁ̑. u̯ȃk. o̥̯o̍.o̥̯o̍.o̥̯o̍.tšu̥̍.ku̥.tšu̥̍.ku̥.tšu̥̍.ku̥.
u̯a.ḁ̯a.ḁ̯a.ḁ̯a. tšu̥̍.ku̥.tšu̥̍.ku̥.tšu̥̍.ku̥.tšu̥̍.ku̥.
i̥̯u̍i.i̥̯u̍i.i̥̯u̍i.i̥̯u̍i.i̥̯u̍i.] falsetto
Hu: wáuk [u̯au.ki̍k. u̯au.ki̍k. u̯au.ki̍k. tša.řa.ka̍k.
tša.řa.ka̍k.tša.řa.ka̍k.] falsetto

Psarocolius decumanus 'Crested Oropendola'

Ag: suák čúwi [tšua̍k.tšua̍k.tšua̍k. tšua̍. tua.ta.ua̍i.
[tua.ta.u̯a̍i. sȃx. sȃx. sȃx.]

Hu: ¢áŋ kɨ [tsáŋ. tsáŋ. tsáŋ. tsáŋ. tsɨ́.řik.

[tsɨ́.rik. tsɨ́.rik.] fortis onset

(*P. decumanus* is referred to by non-cognate forms here, though each term is onomatopoeic for their respective languages.)

Cacicus cela 'Yellow-rumped Cacique'

Ag: tɨ́ɨs [tɨ̌s.tɨ̌s.tɨ̌s. tɨ̌s. tɨ̌s.tɨ̌s. tɨ̌s.] irregular

Hu: čuwíkit [sa.sa. sã.sã. sa.sã. sã.sã.] irregular

Icterus icterus 'Troupial'

Ag: (no data)

Hu: huítam [uui.uui. uui.uui. uui.uui.] repeated

TANAGERS, Thraupidae

Euphonia rufiventris 'Rufous-bellied Euphonia'

Ag: táma uúšap [ǔs.pa.kía.kía.kía.šui.šui.šui.kía.kía.
kía.]
[ǔs.pa.kía.kía.kía.šui.šui.šui.kía.kía.
kía]

Hu: túma úšap [sic] (no knowledge of call)

Tangara chilensis 'Paradise Tanager'

Ag: sɨmančúk [sɨ.tšík. sɨ.tšík. sɨ.tšík.] staccato

Hu: síča (not recorded)

Wetmorethraupis sterrhopteron 'Orange-throated Tanager'

Ag: inčítuč [in.tší.tu.tšia. in.tší.tu.tšia.] melodic
(sustained ingression of air, then call repeated)

Hu: sančípu (not recorded)

Thraupis episcopus 'Blue-gray Tanager'

Ag: suwi̱č [sũĩ.sui.sũĩ.sũĩ.sũĩ.sũĩ.] irregular

Hu: suwɨ́č [su.ui. su.ui. su.ui] final syllable falsetto

Ramphocelus nigrogularis 'Masked Crimson Tanager'

Ag: čǎ́ŋkɨ [tsa̍ŋ. tsa̍ŋ.tsa̍ŋ. tsa̍ŋ. tsa̍ŋ.tsa̍ŋ]

irregular, staccato

Hu: čáŋkɨ [sɨ.tša̍ŋ. sɨ.tša̍ŋ. tša̍ŋ.kɨ.sɨ.tša̍ŋ. tša̍ŋ.kɨ]

vowels strongly clipped

Piranga rubra, P. olivaceus 'Summer and Scarlet Tanagers'

Ag: (no data)

Hu: pič́urkik [pi̍.tšur̃.kik. pi̍.tšur̃.ki.ki̥. pi̍.tšur̃.

[pi̍.tsur̃.ki̍.ki̍.ki̍]

Tachyphonus surinamus 'Fulvous-crested Tanager'

Ag: wampaŋkít [tsɨ̥t.tsɨ̥.tsɨ̥.tsɨ̥.tsɨ̥.] irregular tempo

Hu: čančím [tša̍n.tsɨ.tsɨ.tsɨ.] ~

[tsa̍n.tsɨn.tsɨn.tsɨ̥.tsɨ̥.tsɨ̥.]

Cissopis laveriana 'Magpie Tanager'

Ag: pišɨ́ [pɨ̥̍št. pi̥̍št. pi̥̍št.] rapid, irregular

Hu: píši [piš. sɨ̂. piš. sî.] last syllable falsetto

Unidentified onomatopoeic bird species, Aguaruna

kuŋki. (probably an antbird)

[kuŋ.ki̍. ĩ̥ĩ̥.ĩ̥ĩ̥.ĩ̥ĩ̥.ĩ̥ĩ̥. kuŋ.ki̍. šã.šã.šã šã.šã. ii̥.

kuŋ.ki̍.. šã.šã.šã.šã.šã.]

wíňčuňču (probably an antbird)

[na.ya.tu.wɨ.tat.mɨ. uin.tšun.tšu.]

repeated, melodic quality

táŋtaŋ (probably an antbird)

[ta̍ŋ. ta̍ŋ. ta̍ŋ. ta̍ŋ. ta̍ŋ. ta̍ŋ.]

tuátua (probably an antbird)

[tua̍t. tua̍t. tua̍t. tua̍t. tu̍. tu̍. tu̍.]

~~ɨɨ~~á wisuí (a cotinga?)

[u̯i̍s. u̯i̍s. u̯i̍s. u̯i̍s. u̯i̍s. u̯i̍s.]

pi̲ú̲n̲čik (a flycatcher?)

[pĩũñ.tši̍k. pĩũñ.tši̍k. pĩũñ.tši̍k.]

[tšik] syllable strongly staccato

kíhim (a flycatcher)

[kȋ.ki.ki.ki.ki.ki. kȋ.ki.ki.ki.ki.ki.]

slightly falsetto, slightly nasalized

kistonkái (yellow breasted flycatcher)

[ti̍p.ti̍p.ti̍p. ti̍p.ti̍p.ti̍p. kis.ton.ka̍i. ti̍p.ti̍p.ti̍p.
ki̍s.ton.ka̍i] short, irregular tempo

wíswiswis (yellow breasted flycatcher)

[u̯i̍s.u̯i̍s.u̯i̍s.u̯i̍s. u̯i̍s.u̯i̍s.u̯i̍s.u̯i̍s. u̯i̍s.u̯i̍s.u̯i̍s.u̯i̍s.]

máakua (a hawk, probably *Herpetotheres cachinnans* 'Laughing Falcon'

[mã̍.kũã̑. mã̍.kũã. ma̍.kũã. u̯ã̍. u̯ã̑. u̯ã̍.]

soft, whispered quality

kaúta (a hawk, probably *Micrastur* sp.)

[ãũ̍. ãũ̍. ãũ̍.] breathy quality

š̲íi̲k̲i̲ (a parrot)

[ki̥̍.ki̥̍.ki̥̍.ki̥̍.ki̥̍.ki̥̍.ki̥̍.ki̥̍. tši̥̍.tši̥̍.tši̥̍.] rapid tempo

wawík~ apu šíi̲k *Notharchus macrorhynchus* 'White-necked Puffbird'

[u̯a.u̯i̍k. u̯a.u̯i̍k. u̯a.u̯i̍k. u̯a.u̯i̍k.u̯a.u̯i̍k.]

breathy, increasing in tempo toward end of call

wiú (a puffbird)

call begins with a whistle– [u̯i̍u.u̯i̍u.u̯i̍u.u̯i̍u.]

ča̲i̲s (a tanager?)

[tšãĩs̃. tšãĩs̃. tšãĩs̃. tšãĩs̃. tšãĩs̃.] irregular tempo

ćičákaim (a tanager?)

[tši̥.tši̥. tši̥.tši̥. tši̥.tši̥. tši̥.] irregular tempo

dáhun (a trogon?)

[da̍.u̥̯ũ. da̍.u̥̯ũ. da̍.u̥̯ũ. da̍.u̥̯ũ. da̍.u̥̯ũ.] staccato

yámakiu (a trogon?)

[y̍a.mak. kĩãũ. kĩãũ. kĩãũ. y̍a.mak. kĩãũ.kĩãũ.kĩãũ.]

kúp (a thrush)

[ku.pȋ ku.pi̍. u̯i̍.ki.pu.u̥̯us.ai.ši. ku.pi̍̑.]

wiúm (a flycatcher)

[u̯iu̍.u̯iu̍.u̯iu̍.u̯iu̍.u̯iu̍.u̯iu̍.u̯iu̍.] rapid tempo

piúsa (a flycatcher)

[piu̍š. piu̍š. piu̍š.piu̍š.] irregular tempo

Unidentified onomatopoeic bird species, Huambisa

paráiparái (a flycatcher?)

[pa.ř̍ai.pa.ř̍ai.pa.ř̍ai.

pa.řai.pa.řai.pa.řai.

[pa.řai.pa.řai.pa.řai.] falsetto

ɨčɨ́rtukaip (a flycatcher?)

[ɨtsir.tu.kai̍p.tsɨr.tkai̍p.tsɨr.tkai̍p]

CONCLUSION

The foregoing data demonstrate that onomatopoeia in Aguaruna and Huambisa ornithological vocabulary is pervasive. More than a third of the terms of both languages for bird species are onomatopoetic in origin. These figures are comparable to those obtained for several other languages spoken by peoples of comparable socio-technological level of development. The Tzeltal Maya show 49% onomatopoetic bird names (Hunn 1977:84, Berlin n.d.). In Kaluli, a language of Highland Papua New Guinea, Feld reports that 49 of the 125 bird names (39%) are onomatopoetic (Feld 1979:149). These species as a group are recognized in Kaluli as those that "say their names" (ibid.:156). In Selepet, another Papua New Guinea language, McElhanon (1977) describes 131 of 355 bird names to be onomatopoetic (37%). Speck reports that 23 of the 63 bird names he recorded in Canadian Delaware (some 37%) were derived from the perceived sounds of the birds' calls (Speck 1946).

While onomatopoeia is most obvious in ornithological vocabulary, it is also highly productive in the naming of frogs, toads, some mammals, and some insects in both Aguaruna and Huambisa. Hunn has suggested for Tzeltal ethnobiological vocabulary that "The distribution of [onomatopoetic] terms closely parallels the distributions of highly developed auditory signaling behavior among animal forms" (1977:83-84).

We believe that onomatopoetic naming plays a productive mnemonic role in naming certain animals. Our evidence is anecdotal but suggestive. During the process of our investigations (Berlin et al. 1981; in preparation), large numbers of Aguaruna and Huambisa subjects participated in experiments where they were asked to name specimens of animals sequentially arranged along long work tables. Many subjects, when confronted with a specimen whose name they had temporarily forgotten, be it a bird or a frog, would (unconsciously?) begin to vocalize the animal's call, then, with a flash of recognition, proudly pronounce the appropriate name. It appeared to us that the process of phonological vocalization aided these subjects in recall. Jespersen, noting the tendency of children to use stereotypic vocalizations for certain animals as their first names for the creature itself appears to be talking about a similar process. "These words [such as *quack quack*] are an imperfect representation of the birds' natural cry, but from their likeness to it they are easier for the child to seize than an entirely arbitrary name such as duck" (1921:150).

In languages spoken by peoples of small-scale, technologically simple, non-literate societies, one might expect to find that the natural sound signaling habits of many creatures are replicated in the actual names people assign to these animals, thus forming a direct link between the linguistic designation of the organism and an important aspect of their behavior. We speculate that such non-arbitrary names are easier to remember, and probably less difficult to learn. Naming animals after their calls would appear to be an efficient way of reducing the cognitive effort required of peoples of non-literate traditions who must learn, retain, and actively employ rather sizable ethnobiological vocabularies. Conversely, we further argue that the functional load carried by ethnobiological onomatopoeia will lessen and ultimately be lost altogether as societies move to higher and higher levels of socio-technological complexity and individuals become less and less aware of their biological environment. Ethnobiological onomatopoeia might serve, then, as a useful index of cultural evolution, the process being highly elaborated in the languages of non-literate peoples and gradually diminishing with the growth and development of complex literate traditions. It is our hope that future ethnobiological research will be conducted to test the validity of such speculations.

ACKNOWLEDGEMENTS

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NOTES

[1] We have not addressed the problem of informant variation in this paper. We do not know to what extent the onomatopoetic bird vocalizations recorded from the four Aguaruna and Huambisa informants who participated in this study are shared for the population as a whole. This could, of course, be tested in several ways, one of which would be to play the tape recorded vocalizations to a sample of subjects and ask that they identify the bird represented. We have reason to believe, however, that the vocalizations represent rather entrenched features in Huambisa and Aguaruna ethno-ornithology by virtue of the striking similarities in the overall patterning of calls in both languages. Furthermore, a comparison of the Aguaruna and Huambisa vocalizations with those entered in a dictionary of Shuar of Ecuador (Bolla n.d.) show striking parallels, suggesting that these precise patterns of onomatopoeia are wide-spread through the family as a whole, probably characteristic of proto-Jivaroan.

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NEWS AND COMMENTS

This section of the *Journal of Ethnobiology* is intended as a "bulletin board" for upcoming conferences, brief reports of research in progress, recent publications of interest, and requests for exchange of information or opinion. You all are encouraged to make use of this space. Bear in mind a probable delay of several months or more between receipt of material by the "News and Comments" editor and its appearance in print. Contributions for the next issue, Vol. 2 No. 1, should be received by the "News and Comments" editor no later than 1 March 1982. This issue will be released in May 1982. Contributions for Vol. 2 No. 2 should be received no later than 1 September 1982. This issue will be released in December 1982. Refer to the inside back cover of this issue for the mailing address for the "News and Comments" editor. *Comments* are solicited also, critical of or supplementary to previous *Journal of Ethnobiology* articles or furthering debate on other issues relevant to the readership. In the instance of a critical rejoinder to a *Journal of Ethnobiology* article, the original author(s) will be invited to respond before publication. The relevance of materials submitted will be evaluated by this editor with the assistance of knowledgeable editorial board members.

NEWS

Harold C. Conklin's *Folk Classification: A Topically Arranged Bibliography of Contemporary and Background References Through 1971* has been reprinted (1980) with corrections and the addition of an author index. It is available from the Department of Anthropology, Yale University, New Haven, CT 06520.

ARCHAEOZOOLOGICAL CONFERENCE

The fourth International Archaeozoological Conference is to be held at the Institute of Archaeology, University of London, April 18-23, 1982. The theme of the conference is "The Contribution of Faunal Analysis to the Study of Man"; it is expected that the proceedings will be published in three volumes dealing with hunters and their prey, shell middens and the exploitation of the sea and sea shore, and the use of domesticated animals.

Abstracted from *the Newsletter of the International Council of Archaeozoology* (1981) by Donald K. Grayson, Department of Anthropology, University of Washington, Seattle, WA 98195.

FIFTH ETHNOBIOLOGY CONFERENCE

The Fifth Annual Ethnobiology Conference will be held in Balboa Park, San Diego, California, co-sponsored by the San Diego Natural History Museum and the Museum of Man. A call for papers will be issued in January 1982. Registration will be Wednesday evening 21 April. Paper sessions will be Thursday and Friday, 22-23 April. An ethnic banquet featuring native Japanese plant and animal foods will be served Friday evening. Saturday is reserved for field trips into surrounding vegetational communities.

Notice received from Amadeo M. Rea, Curator of Birds and Mammals, Museum of Natural History, P.O. Box 1390, San Diego, CA 92112.

SOCIETY OF ETHNOBIOLOGY

We are currently filing papers to establish the Society of Ethnobiology, Inc., a nonprofit corporation which will oversee publication of the *Journal of Ethnobiology* and organization of the annual ethnobiology conferences. Once this corporation is established, all subscribers to the journal will automatically become members of the society. Membership dues are equivalent to subscription rates for the journal.

COMMENTS

When the *Journal of Ethnobiology* was first proposed three of the present editorial board members, B. Berlin, T. Hays, and E. Hunn, were editing an occasional newsletter dubbed the *Folk Classification Bulletin.* Publishing the *Folk Classification Bulletin* proved to be a struggle dependent entirely on begged and borrowed time and money. The *Folk Classification Bulletin* content had been largely ethnobiological—reasonable given the predilections of its editors—and it seemed logical for the *Folk Classification Bulletin* to join forces with the *Journal of Ethnobiology.* Thus the *Folk Classification Bulletin* ceased publication after four issues, Volume 1, number 1 (Fall 1977), and number 2 (Spring 1978), Volume 2, number 1 (Fall 1978), and Volume 3, number 1 (Fall 1979), the last under the editorial guidance of James Boster.

The last two issues of the *Folk Classification Bulletin* highlighted a debate on the relevance of "Fuzzy Set Theory" (Lofti A. Zadeh, "Fuzzy Sets," *Information and Control* 8:338-353, 1965) for constructing formal models of folk biological classification. Hunn touched off the debate with a discussion entitled "Fuzzy Sets and Folk Biology" (*FCB* 2[1]:1-3, 1978) in which he evaluated the utility of an extension of the notion of "fuzzy subset" proposed by Willett Kempton to account for certain anomalous results he encountered in attempting to apply the original notion of fuzzy subset (Zadeh 1965:340) to the classification of cups and mugs ("Category Grading and Taxonomic Relations: A Mug is a Sort of a Cup," *American Ethnologist* 5:44-65, 1978).

Hunn concluded that neither Zadeh's nor Kempton's notion of "fuzzy set inclusion" was appropriate for modeling the structure of folk biological taxonomies. In the next issue (*FCB* 3[1]: 7-13) Kempton replied to the effect that Hunn's analysis of fuzzy set membership confounded the distinct notions of probability and degree of set membership, that his analysis of membership in terms of weighted features was faulty, and that what is needed is less formal manipulation and more empirical research. In the same issue, Boster defended Hunn's analysis (*FCB* 3[1]:13-15) by presenting a more explicit interpretation of the graphic heuristic Hunn had devised. Subsequently David Reason of the University of Kent at Canterbury has brought one philosopher's perspective to this debate in an extended reply to Hunn entitled "On the Essential Futility of the Formal Representation of Folk Classification." By way of preview, I will briefly summarize Reason's reasons (sic) here, with the understanding that the full text of this debate with additional commentary will be published in a subsequent issue of the *Journal of Ethnobiology.*

Reason and Hunn agree that the fact that the notion of a set (e.g., a basic folk biological taxon) is logically primitive contributes to the inadequacy of set theoretic models of folk biological classification. A basic folk biological taxon, as for example "raccoon," is taken as given. Our various attempts to formally analyze the structure of taxonomies address only the logic whereby these sets might be related to one another to construct a taxonomic hierarchy of such sets. Hunn has argued that ethnobiologists must account not only for the taxonomic structure, but also for the existence of the basic taxa in the first place ("Toward a Perceptual Model of Folk Biological Classification," *American Ethnologist* 3:508-524, 1976). Why "raccoon"? Why not "ringed-tailed quadruped" (a concept both more or less inclusive than "raccoon")? According to Hunn, neither fuzzy set theory nor classical set theory provides an adequate framework for understanding how basic sets are constructed. Rather, Hunn has suggested, one should take the perception of similarity and difference as primitive (1976:515-520). Then formally construct sets from those primitive relations.

Reason disagrees, arguing that these basic sets of which folk biological classifications are built are derivative instead of social and historical conditions governing their appearance. Thus to understand the true *meaning* of a folk system of concepts is a task "intrinsically antithetical to the exercize of formal representation."

If you are interested in contributing to this debate, copies of the relevant pieces may be obtained from the "News and Comments" editor. A contribution of $1 will be welcome to cover duplication and mailing expenses.

NOTICE TO AUTHORS

The *Journal of Ethnobiology* accepts papers on original research in ethnotaxonomy and folk classification, ethnobotany, ethnozoology, cultural ecology, plant domestication, zooarchaeology, archaeobotany, palynology, dendrochronology and ethnomedicine. Authors should follow the format for article organization and bibliographies from articles in this issue. All papers should be typed double-spaced with pica or elite type on 8½ x 11 inch paper with at least one inch margins on all sides. The ratio of tables and figures to text pages should not exceed 1: 2-3. Tables should not duplicate material in either the text or graphs. All illustrations are considered figures and should be submitted reduced to a size which can be published within a journal page without further reduction. Photographs should be glossy prints of good contrast and sharpness with metric scales included when appropriate. All illustrations should have the author(s) name(s) written on the back with the figure number and a designation for the top of the figure. Legends for figures should be typed on a separate page at the end of the manuscript. Place all tables and figures in consecutive order at the end of the manuscript. Do not place footnotes at the bottom of text pages; list these in order on a separate sheet at the end of the manuscript. Metric units should be used in all measurements. Type author(s) name(s) at the top left corner of each manuscript page; designate by handwritten notes in the left margin of manuscript pages where tables and graphs should appear. Submit 2 copies of the manuscript plus the original copy and original figures to:

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Individuals with information for the "News and Comments" section of the journal should submit all appropriate material to Eugene Hunn, Department of Anthropology, DH-05, University of Washington, Seattle, Washington 98195. Please note that the former *Folk Classification Bulletin* has been incorporated into this section.

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ANIMAL DOMESTICATION AND OSCILLATING CLIMATES

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ABSTRACT.—Two case studies, one set in western Iran, the other in northern Chile, are described in an effort to reintroduce climate as a factor in the prehistoric adoption of goat and llama herding. This paper focuses on the likelihood of short-term variability in precipitation in these arid regions dramatically affecting game availability in a non-density dependent fashion. The effect is the adoption of domestic stock, a technology of risk reduction, in a context of re-orientation of social values from those associated with hunters to those associated with pastoralists.

INTRODUCTION

This paper presents an argument that irregular short oscillations in climate can be isolated as key variables in two widely separated episodes in the record of animal domestication—one in the Zagros Mountains of western Iran, and the other on the western slopes of the Andes in northern Chile. While climate has often been suggested as an agent in the origins of pastoralism and agriculture, the causative links binding environment and human behavior have been insufficiently specified (Harris 1977:184). Either the link is too diffused, that is, able to predict the onset of herding/farming within a broad regional frame, but incapable of dealing with specific sequences at specific sites, or too straight forward, emphasizing the technological and economic aspects of change at the expense of the social and ideological contexts in which it is imbedded. The existence of these flaws has deflected interest from climate as a primary causative element and in the direction of population pressure models (Cohen 1977). Alternatively, the differences between domesticating and non-domesticating societies have been downplayed (Higgs and Jarman 1972), recasting the Neolithic revolution more as a step than a threshold in human history.

This discussion is aimed at revitalizing climate as an element in the origins of animal domestication. Climate is viewed as a sort of boundary mechanism, a frame that describes the limits within which social and technological options are played. The key to the linkage between climate and domestication is oscillation—the occurrence of erratic short-term environmental variability. I try to show how changes in the distribution and availability of game, that can be hypothesized given our knowledge of the climatic history of each region, discouraged the social and technical institutions associated with hunting and encouraged those associated with pastoralism.

DOMESTICATION

There are two basic approaches to defining the term domestication as a cultural process. The first views domestication as a temporally elongated sequence of technological innovations in the methods of extracting resources from animals (Bray 1976: 90). Each innovation has effects on the selective factors conditioning animal reproduction with the result that domestic stock gradually diverge morphologically and behaviorally from their wild ancestors. Hunting and herding, in this view, are distinct sets of ecological relations. Domestication, or the process of moving from one to the other, is modelled by schemes that view culture primarily as an adaptive system designed to wrest resources from the environment. Commonly these schemes include resource stress as a motivating variable, since domestication is seen as a response involving extra work to solve an economic problem.

The continuum of development in doemstication is usually broken into segments which are labeled with such terms as 'selective predation', 'husbanding', 'semi-domestication', and 'full domestication' among many others (Higgs and Jarman 1972, Zeuner 1963). Many of the segments are associated with expectations, concerning alterations in animal morphology, or the equipment required to manage animals in a particular way, that can be recognized in the archaeological record. Further, each segment or form of man/animal relationship is arranged along another continuum of productive potential with each historical innovation—taming, secondary products, selective breeding—linked to larger yields of animal products.

However, a case can be made that some of the initial steps in the development of pastoralism did not necessarily produce increased yields of animal products. This perhaps surprising statement is based on the behavior of many modern pastoralists. The management goal of these herdsmen is not to maximize production of such commodities as meat, milk, and wool. It is rather to maximize the size of the herd. Any production directed activity such as slaughter, milking, and castration potentially reduces to one degree or another the herd growth rate. Said another way, pastoralists try to avoid taking products from their herds preferring instead to have the maximum possible unharvested resource on hand.

Texts on animal management emphasize the point that the technological features associated with husbandry, most of which serve to minimize the impact on herds of mortality factors other than man, disturb the system of checks and balances within an environment by reducing its diversity and so its resilience. Herdsmen eliminate competing predators such as the large canids and felids and tend to the health and security of their animals. The result is that the pastoral herd can have a population structure that has even more mature animals than a wild herd. In that case a greater proportion of forage is going toward animal maintenance than growth in the domestic flocks compared to the wild herd. Productive potential is actually reduced. The desire of pastoralists to increase their herd sizes also places regional systems at risk through the destructive effect on pasturage of over grazing. Despite this well recognized risk herders tend to continue to expand their flocks in competition with each other, particularly in societies with fragmented, 'family' based, forms of pastoral production (Bates 1973:143). This tendency is at least part of the reason large areas of the Near East have been deforested through over-grazing. It is therefore more accurate to say that pastoralism is potentially more productive. Whether that potential is realized is a separate issue. The question is largely one of whether pastoralists can be induced to cull their herds in such a way as to maximize the number of young growing animals.

The answer depends on the pastoralists' perception of risk. Another primary benefit of pastoralism is the freedom to schedule the extraction of animal products with a certainty not available to hunters. Meat, for example, is available year-round if the herdsman is willing to slaughter one of his animals. However, that willingness is tempered by the realization that, in contrast to the exploitation of plants, harvesting animals does not lead to resource renewal (Ingold 1980). Therefore, in the absence of an institution capable of transforming animal products into a form of wealth or credit, later redeemable for food or other animals, even in times of stress, herdsmen will continue to enlarge their herds to provide insurance for themselves and their dependents. Allen (1977), following Jacobs (1969), suggests that the institution which can serve this function best is the village, a nexus where a wide range of resources may be exchanged. Under these circumstances the productive potential of animal management can be released.

The economic benefit of herding is thus two-fold. The immediate gain is stability, insurance against times of stress. In those cases where a reliable institution of exchange is available, management can lead to greater productive levels. The process of domestication in economic terms, however, is initially one of risk redirection. The hunter's gamble on the availability of game is replaced with the herdsman's worries over disease, predators and stock loss.

The second approach to defining domestication emphasizes the social component of the association between human and animal populations. For example Ducos (1978:54) offers: "domestication can be said to exist when living animals are integrated as objects into the socio-economic organization of the human group, in the sense that, when living, those animals are objects for ownership, inheritance, exchange, trade, etc., as are the other objects (or persons) with which human groups have something to do." Domestication in these terms is a social process, a transformation of the rules that structure not just animal populations, but human groups as well. For animals the transformation is primarily one of taming (Hediger 1968:108). When more than one animal is included, it also involves the restructuring of the age and sex distributions of their groups with resultant alterations in social behavior. For human groups the social transformation moves along two paths. The first path establishes specific bonds between individual domesticators and individual domesticated animals—a process that encompasses petkeeping, the use of animals for labor, and milk production. Alternatively, the transformation establishes bonds between populations of domestic animals and populations of domesticators with a blurring of the ties that bind any two individuals together. This second path is associated with what Ingold (1980) has called carnivorous pastoralism, or, on a more elaborate scale, ranching. Neither axis necessarily presupposes the other, and the order of appearance is probably due to the migratory habits of the animal involved—the more migratory, the more likely the first will precede the second, the less migratory, the second may precede the first.

Each of the paths is associated with different human emotional relationships to animals. For instance, Bennett (1964) examined the attitudes of farmers and ranchers on the Great Plains who were raising cattle for meat. He observed that "when animals are herded in fairly large numbers . . . utilitarian attitudes toward the animals tend to become dominant" (p. 37) and "attitudes toward cattle contain almost no element of sympathy or compassion, and very little tendency toward the establishment of relationships between single men and single animals" (p. 42). This attitude contrasts strongly with the affectionate or sentimental relationship that describes the bonds of these ranchers with their horses and dogs, or milkers with their dairy animals.

A difference in attitudes along the two paths also exists in the realm of social structure. Domestication that forms individual bonds is associated with the use of animals for cementing social ties. The cattle of African pastoral systems, which are used for milk and blood production, bear the load of establishing complex intersocietal links, where goats, which are raised primarily for meat, do not (Ingold 1980:186).

The social and ideological factors associated with domestication can also be contrasted with those of hunting groups in a broad way. Ingold (1974, 1980) and Paine (1971) have isolated several important contrasts. First, hunting groups tend to have undivided access to the animals they hunt. The hunting territory and the animals it contains, in other words, are viewed as shared resources though buffer zones between hunting groups may be present (Hickerson 1965). Second, hunting groups tend to have complex redistributional rules that extend outside the family and insure the maximum dispersal of food. These rules for game need not extend to gathered resources. Third, for hunters, expertise in the chase is the important source of prestige. Prestige is not generated by possession of the kill, but by the right to distribute it (Paine 1971: 158). The unit of production is corporate.

Herders, on the other hand, divide access to the resources. The production unit and the circle of redistribution is subsocietal. Prestige is generated through the number of animals held. Successful herders are disinclined to gather dependents around them (as hunters often do), since it would ultimately require division of the source of prestige (and insurance against hard times), the flock. Pastoralist groups are, therefore, more rigid as the individual entrepreneurs balance stock levels with staff to maximize their positions. Explaining the origins of domestication on the social level may therefore be characterized as offering a plausible solution to the problem of why the concept of value is shifted from a focus on a hunter's skill rather than his property, to a focus on a herdsman's property rather than his skill in accumulating it.

Modeling the Process of Animal Domestication

The process of domestication thus operates in two spheres—productive systems and social institutions. A successful model must explain the transformation in each that is brought on by the shift from hunting to pastoralism. Here I will consider one possible pathway.

Climate change can affect the structure of productive systems by altering in a non-density dependent way the availability of various plant and animal resources. As such, climate has been included among the considerations involved in resources stress explanations for the origins of plant and animal domestication (Binford 1968). Resource stress acts to cause the evolution by creating an imbalance between residents and food supply. Climate change is an efficient factor in this regard because it is non density dependent and does not allow productive systems to adjust their demand requirements in response to the stress. Population pressure is less efficient since predator-prey (or hunter-hunted) relationships are density dependent. That is, the rate of the hunter's kill is proportional to the availability of game. Most predator-prey interactions tend toward either equilibrium points of population abundance or stable limit cycles where the population levels of predator and prey traverse a loop of positions. In either case the density dependent nature of the relationship tends to buffer any population pressure unless an intrinsic rate of population increase for the predator can be hypothesized.

Resolution of the stress can take three forms—abandonment of the region, shifting to alternate resources that are unaffected by the climatic change or changing the mode of production to more efficient forms, or, at least, ones resistant to the particular form of stress. Since we are interested here with the third of these options, it is useful to speculate on what conditions would work against selection of either of the first two. The second option, turning to new resources, would be foreclosed in an environment where all the resource options were being restricted by the climate change. This would be particularly likely in arid or semi-arid ecosystems where the number of herbivore game alternatives is much restricted. The first option, abandonment, would be less attractive when the stress factor was of short or intermediate duration: that is, when experience had taught the residents that bad times tend to be brief, and that game levels will rebound in a relatively brief time. This would be true especially when the game species involved have high natural herd growth rates and when their mortality is not primarily conditioned by density-dependent factors like predators. To summarize, under conditions of short range resource stress in a simplified ecosystem, the option of husbandry or pastoralism appears to be an attractive way to buffer food supplies.

The other side of the problem, how resource stress can act on social institutions to bring about the change in values outlined previously, has been discussed by Ingold (1974:527) with respect to Lappish reindeer specialists:

> Traditionally, Lappish reindeer hunting and fishing groups were organized on a territorial *(siida)* basis. The territory, together with its resources, was viewed as the joint property of the group. As long as these resources were perceived to be quite sufficient to maintain the traditional hunting economy, they "should be regarded as capital in an emic and extra-economic context" (Paine 1971:169). Heuristically we may suppose that increasing scarcity of wild deer would assign to the deer a strictly economic value over and above that of the territory itself.

Placed in the context of resource stress, once climatic variation had reduced game levels to point below which even the greatest hunter could not count on success, value and prestige would come to be attached to the possession of game itself. This shift is also a root of the different perception that hunters and herders have of their resources. Hunting groups share access to the animals they rely on for food, herding groups divide access to them. During periods of stress those hunters who also possessed tame animals would be in a strong position. Reliance on the offspring of these culturally controlled animals during periods of resource stress would establish the pattern of numerous independent pastoral units within the society, since the axis of taming binds individual animals to individual herders rather than populations to populations.

To return to climate, insofar as people would expect that game levels were likely to continue to oscillate due to unpredictable environmental changes, they would be encouraged to establish insurance herds against this certainty. Groups caught in this pattern of resource oscillation would experience conflicts both between alternative views of property and prestige, and between modes of production based, on the one hand, on shared access to the resources, and on the other, divided access. These tensions would be likely to persist until the disruptive effect on uncontrolled pastoral herd growth effectively eliminated wild game as a resource alternative. Because of the tension, transitional occupations are likely to be rare in the archaeological record, and pastoral management systems will seem to emerge suddenly from hunting societies.

The Mahidasht Region (Fig. 1)

The Mahidasht or the valley regions near Kermanshah, Iran (Levine 1976:487) has been the scene of investigations into the origins of domestication and settled village life since the 1950's. It is part of the Zagros mountain system, a northwest-southwest trending band of rugged terrain in Iraq, Iran and Turkey that is crosscut by a complex drainage system. The joint effect of these physiographic factors has been to produce a topography characterized by independent valley systems connected by narrow and precipitous defiles (Oberlander 1965). The valley floor of the Mahidasht is located at an altitude of approximately 1350 m. The region overlaps two important vegetational zones -the oak forest and the almond/pistacio savannah. The area was occupied during the Pleistocene with samples reported from such sites as Warwasi (Turnbull 1975), Bisitun Cave (Coon 1951), and Ghar-i-Khar (Young and Smith 1966). Until recently the only known early Holocene sites were Sarab, Asiab (Braidwood et al. 1961) and Tepe Ganj Dareh (Smith 1978). However, a recent survey by Smith and Mortenson (n.d.) suggests that condition is an

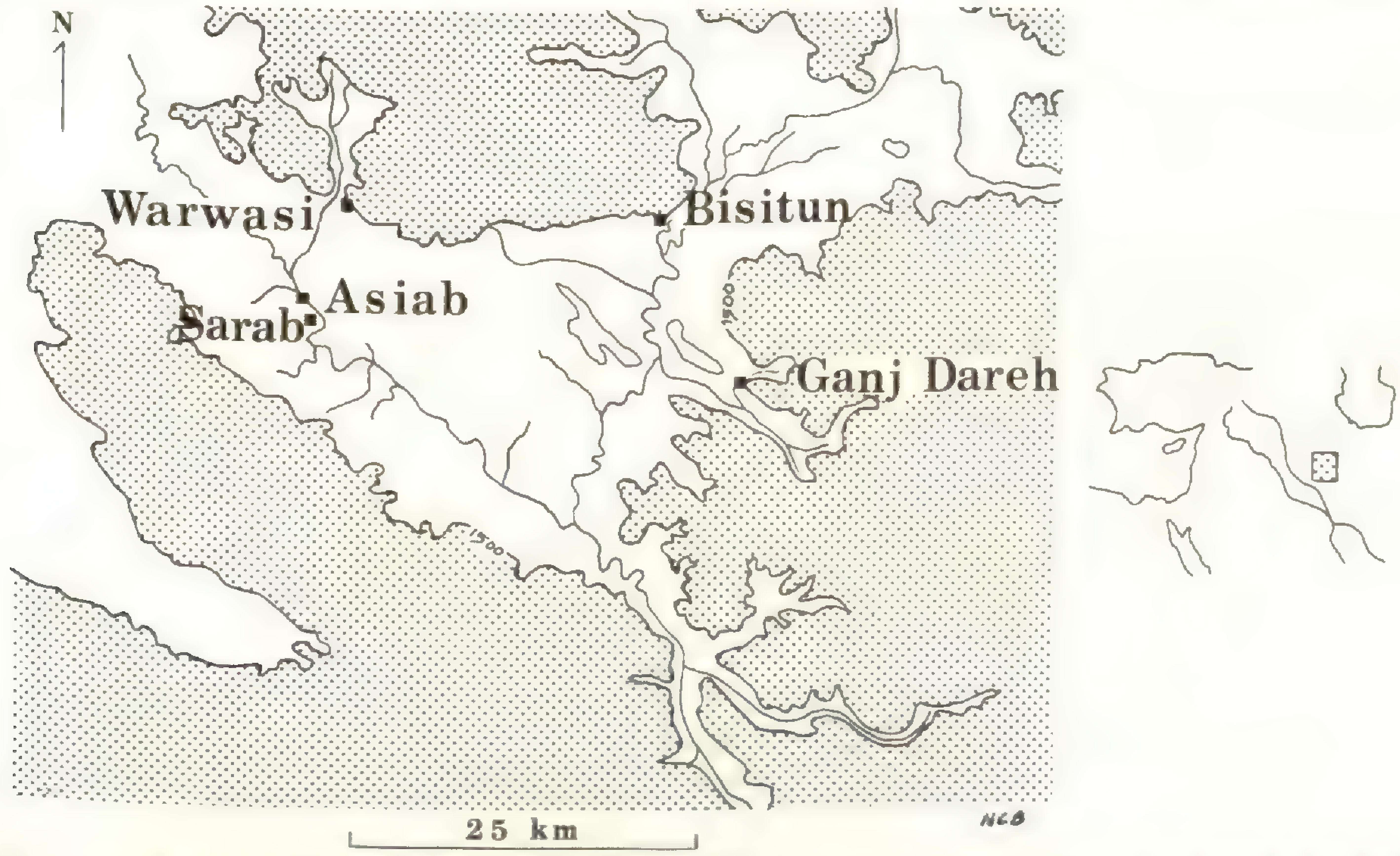

FIG. 1–Location of late paleolithic and early neolithic sites in the Mahidasht region of west-central Iran.

artifact of concentrating the search for sites primarily on the alluvial plain. In their survey, three new sites of early Neolithic character were discovered, all located in narrow "nearly inaccessible valleys" within two or three hours walk of Tepe Ganj Dareh. On the basis of this discovery, they suggest that the initial steps toward sedentary life, pastoralism and agriculture, took place in the small, ecologically diverse valleys surrounding the Kermanshah Valley.

The earliest evidence of animal husbandry comes from the site of Tepe Ganj Dareh, excavated over five seasons by Philip E. L. Smith of the University of Montreal. On the basis of radiocarbon determinations, the site was occupied in the eighth and perhaps ninth millenium B.C. The site contains five superposed occupations. The earliest, labeled Level E, is characterized by a series of basins excavated into culturally sterile soil, no evidence of permanent architecture, and some indication that the site was occupied seasonally, probably in the spring (Hesse 1979). The upper four levels, D - A, contain mud-brick architecture, ceramic storage facilities, and stone mortars and a few fragments of pottery. Evidence for animal husbandry is of two sorts (Hesse 1978). What seem to be goat footprints in some of the bricks from Level D argue that tame animals must have roamed the village. The harvest profiles, estimates of the age and sex of the slaughtered animals, and, therefore, evidence of the system of production, calculated for Levels E and D - A contrast. On the basis of mandibular tooth wear (Payne 1973), the proportion of young sheep and goats (12-24 months) slaughtered during the architectural phases of the occupation increased compared to the earlier material (see Fig. 2). Considering the two species *(Ovis orientalis* and *Capra aegagrus)* separately, on the basis of the relative frequency of fused long bone epiphyses, it appears that only the harvest pattern for the goats changed. Using the fact that goat sexual dimorphism is reflected in the dimensions of many of the bones of the skeleton, it was possible to create individual harvest profiles for both bucks and does (Hesse 1982a, following the suggestions of Higham 1968). The harvest profile for Level E compares favorably with the age and sex proportions found in a wild goat nursery herd—an almost total absence of mature males in a sample dominated by male and female kids and mature females. Tepe Ganj Dareh Level E is roughly contemporaneous with Asiab (Bökönyi 1978) where mature males dominate the samples. When compared, the samples produce a picture of seasonal hunters exploiting sub-populations of goats, taking those age and sex categories that would be expected to be nearby each of the sites based on the seasonal topographic preferences of the species. Tepe Ganj Dareh Level D, on the other hand, has a harvest profile for goats that agrees with the slaughtering patterns of pastoralists—a reduction in infant mortality and elimination of does which fail to kid (Bates 1973:147).

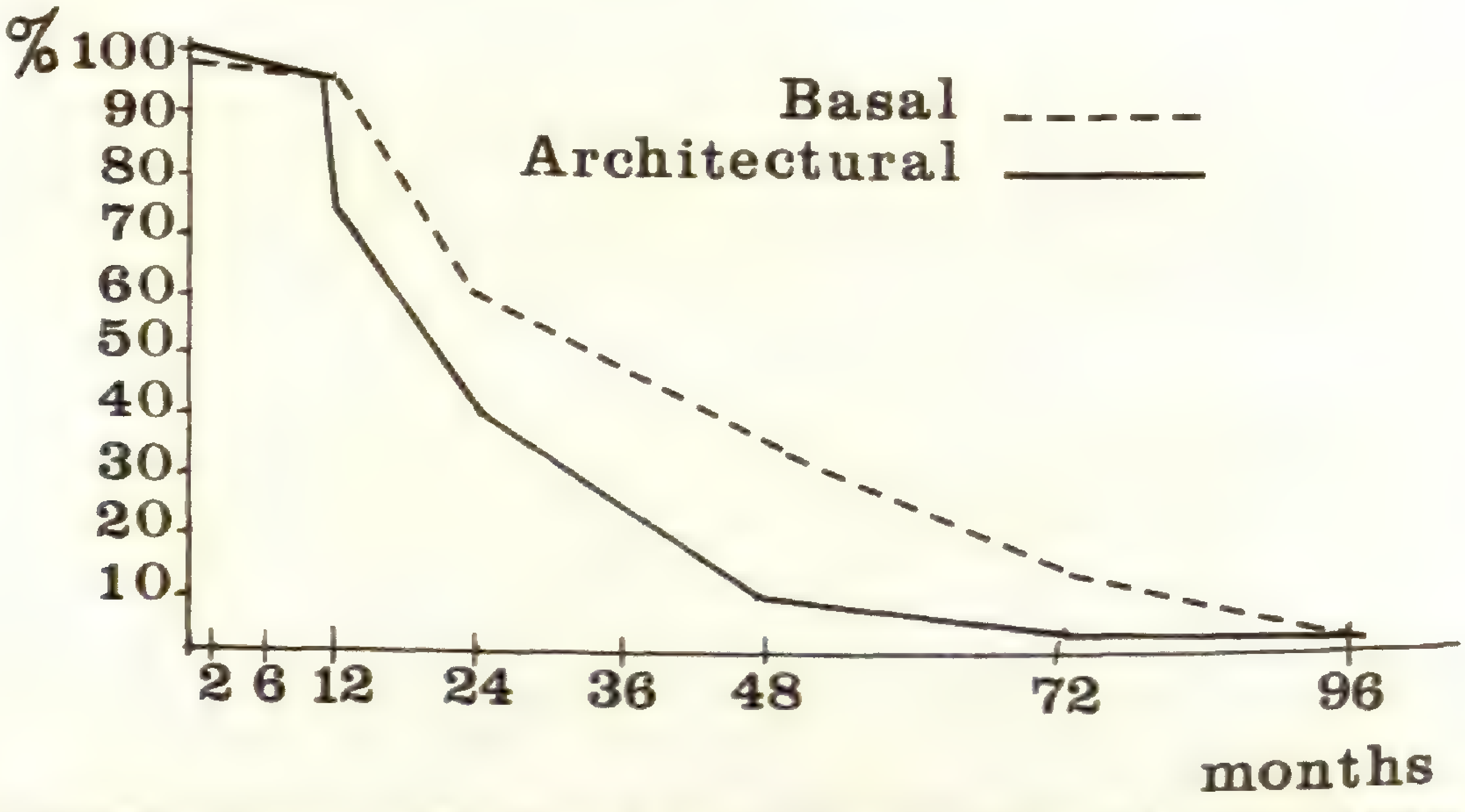

FIG. 2—Goat/Sheep harvest profiles from the basal(—) and architectural (————) levels at Tepe Ganj Dareh. The curves represent estimated percentage survivorship at the ages indicated and are based on tooth wear (Payne 1973).

To draw climate into the discussion about this episode of animal domestication, two observations about the early Holocene environment of the Mahidasht need to be made. First, the evidence suggests that the diversity of the herbivore fauna was reduced from Pleistocene conditions. The faunal samples from Warwasi and Bisitun indicate that Pleistocene subsistence was based on a mix of equids, red deer, gazelle, sheep and goats. In the Holocene, however, equids are absent from Tepe Ganj Dareh, as well as the three new sites discovered by Smith and Mortensen, and present in only very small quantities at Asiab (Bökönyi 1978:6). It is not unlikely that the growth of an oak/pistacio forest on the western slopes of the Zagrow may have been partially responsible for this. Onagers, gazelles, sheep and goats are not well adapted to wooded conditions. Some forms of sheep and goats, in fact, show a marked reluctance to enter forested regions (Geist 1971). In fact, the development of this vegetational pattern may have been an important determinant in creating the distribution of sheep phenotypes in modern Iran (Valdez et al. 1978). However, sheep and goats are vertical rather than horizontal migrators (Formozov 1969). As such they can adapt to seasonable variations in climate by utilizing steep gradients in relatively small areas, rather than moving across extensive tracts of open country. Equids are not so adapted. They tend to migrate significant distances in regions where rainfall is seasonal (Klingel 1974:130). Male equids maintain large territories which they dominate through their visual presence (Ibid.:127). Of all the equid species the least known is the Asiatic wild ass or onager likely to be represented in the Mahidasht samples. However, Clabby (1976:34) notes, "all races of the Asiatic Wild ass prefer the unrestricted views and wide expanses of the open country where their alertness and speed give them maximum protection."

Equids, of course, did not disappear from southwest Asia. What I suggest is that by interfering with migratory routes, the vegetational changes that accompanied the early Holocene caused a rearrangement of faunal communities. The new faunal distributions were zoned, with the foothills on either side of the Zagros mountains supporting the open country herbivores (equids and probably the gazelles), while the mountainous regions were occupied by sheep and goats, species that could successfully exploit islands of rugged terrain in a growing forest. This trend would have forced the occupants of the Mahidasht to specialize more and more on caprines as modern climatic conditions emerged.

Our knowledge of post-Pleistocene climate suggests factors that could induce variations in the remaining game biomass. Biomass is linked to variations in annual precipitation. If the regression equation published by Coe et al. (1976:348) based on twelve African ecosystems is taken as an estimate of the trend of change (not an estimate of actual biomass) expectable in the dry conditions of the Zagros, the modern range of annual rainfall for the Mahidasht (378-490 mm) translates into a 25-30% variation in biomass.

Van Zeist (1969) indicates that early Holocene rainfall was greater than Pleistocene levels, but was concentrated more seasonally, while mean temperature was lower in the period than today. A study of the alluvial deposits in the Mahidasht suggests that the precipitation that did occur in the early Holocene would have been stormier than today (Vita-Finzi 1969). Bobek's (1963) study of Zagros snowlines reports that they oscillated several times during the Holocene. From these observations I tentatively conclude that Holocene conditions in the Mahidasht were characterized by irregular and violent weather. The cooler temperatures implies that much of the precipitation fell as snow.

The serious effects that snowfall can have on sheep or goat populations has been discussed by Formozov (1969). Both snow depth and *nast*–a hard icy layer formed by conditions of repeated melting and refreezing–prevent animals from getting at forage. The most disastrous effects occur when the heavy snowfalls come late in winter. Then it compounds the problems of already exhausted animals and is particularly devastating to the new born. The picture is clear in the following passage, which describes conditions in a region to the north of the Mahidasht.

> In the previous hard winters, many of these animals perished from lack of food, and those remaining alive were greatly exhausted by hunger, and they became the prey of wolves. Radde (1862-1863) showed that the snowy winter of 1831 destroyed the remaining Trans-Baikal mountain sheep . . . which had previously suffered persecution by man. "The destruction of such large and strong animals as argali by this winter proves that nowadays, because of various conditions in which man is completely innocent, even species of large animals can become extinct at least locally." (Formozov 1969:63).

The fact that snowfall can seriously affect sheep populations was emphasized by Murie (1944:65-67, 87-88). Murphy and Whitten (1976) have been able to plot the relationship between snowfall and population levels for the Mt. McKinley Dall Sheep. They conclude that every major population decline is associated with an episode of heavy snow. The ability of these animals to revive from near extermination lies in their high natural herd growth rates, and their relative invulnerability to predators. In fact, the sheep populations studied by Murphy and Whitten experienced several cycles of population growth and decline in the fifty years their data covers. Local oscillations in density are unlikely to be overcome by migrations since sheep and goats are vertical migrants, exploiting botanical successions in precipitous habitats. They show a considerable attachment to home ranges and population exchange between habitats is slow. While these reports have dealt specifically with sheep, it is reasonable to assume that similar patterns would characterize the Near Eastern wild goat, since it seems to be a behavioral analog of New World sheep. Also, the descriptions for Alpine Ibex (Nievergelt 1966) and Bezoars (Schaller 1977) suggest broad similarity between the species.

While the evidence is circumstantial, I believe that it is a reasonable conclusion that the Holocene occupants exploiting the goat habitats fringing the Mahidasht experienced recurrent oscillations in game availability. These oscillations probably took place within the lifetimes of single individuals. This led to two related changes—a need to adapt the mode of production to include the provision of an insurance herd, and a shift in the way resources, prestige, property and the social unit of production were defined.

What could have been the origin of the insurance herd? One explanation (Bökönyi 1973) is that hunters would have simply captured herds, tamed them, then herded and husbanded them. The difficulty with this sort of model is that it is hard to see how the captured herd could be divided among the households of the community as individual properties to form the basis of competing rather than cooperating productive units. In Ingold's (1980) discussion of the origins of pastoralism, the argument is presented that the insurance herd is not bred directly from hunted animals, but are the offspring of tame animals already incorporated into the households. As the property of households, when the insurance herd was used as food during periods of resource stress, it would fall under different redistributive rules than hunted animals in which all members of the band had a stake. In the case of reindeer pastoralism, which is the subject of Ingold's treatment, the source of the tame household animals was the need for transport stock to move the camp along the nomadic round.

Whether a parallel existence of tame household goats in preneolithic Zagros communities can be demonstrated is problematic though some morphologically domestic goats are present at Asiab (Bökönyi 1973). However, the bulk of the slaughtered animals do not seem to have been herded (Hesse 1982a). Three speculations might be offered. First, the footprints found in the Level D bricks suggest that some adult Caprini were highly socialized in the Tepe Ganj Dareh community during the development of pastoralism. Two tentative functional explanations for their presence can be offered—as ritual animals as suggested by the use of horn cores *(Ovis orientalis)* as decorative devices, or as producers of dung for fuel, the nature of their droppings being such that it can only be effectively collected when the animals are penned together. Either, admittedly unsupported, suggestion would place an insurance herd in the Tepe Ganj Dareh community under different conditions than hunted animals.

Rapid increase in the insurance herd, and goats can increase at a rate of 33% per year (Dahl and Hjort 1976:231), would lead to ecological destabilization, reorientation of social priorities, and the establishment of the pastoral way of life.

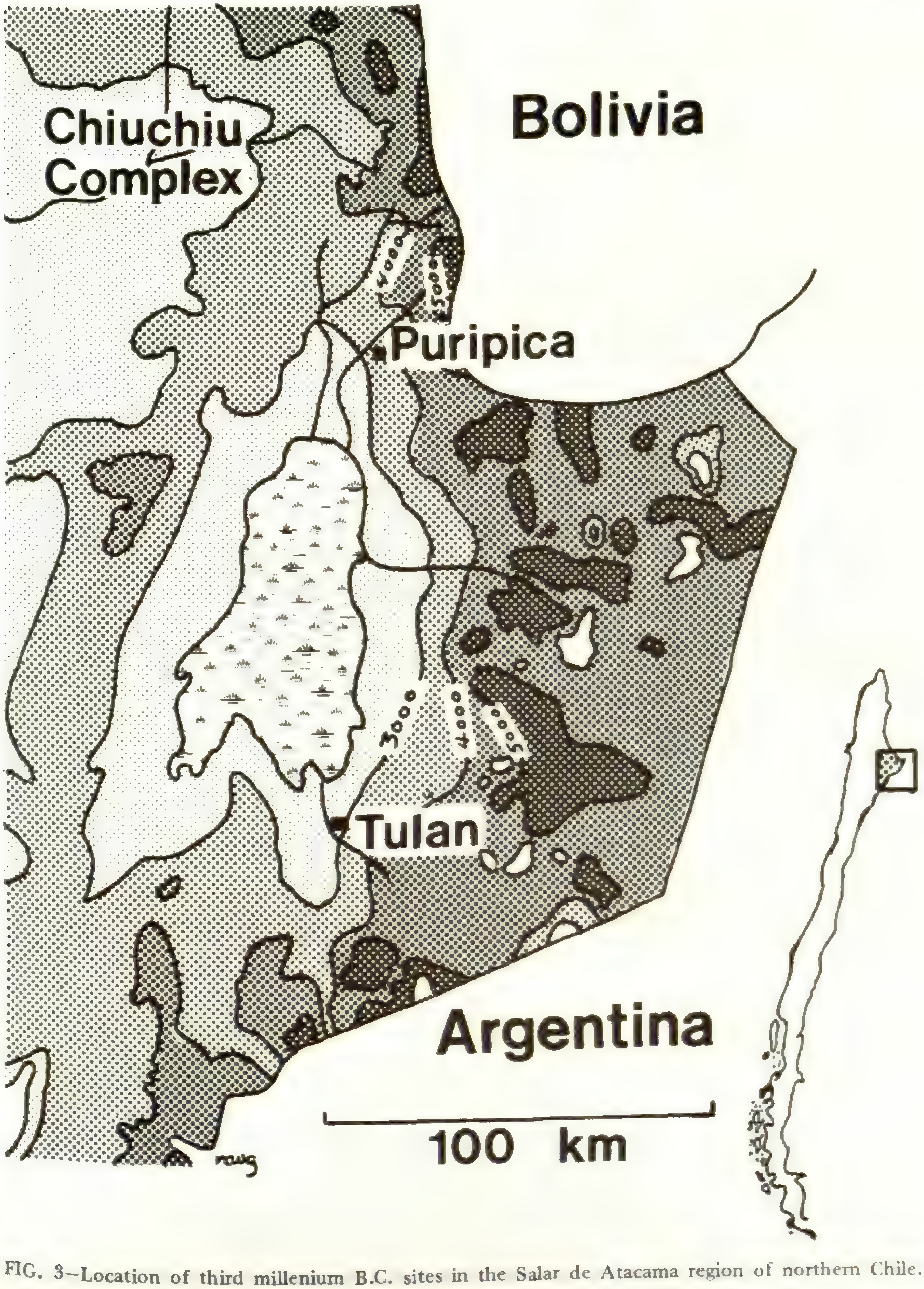

FIG. 3–Location of third millenium B.C. sites in the Salar de Atacama region of northern Chile.

The Salar de Atacama Region

The second case study concerns the arid mountainous regions bordering the Salar de Atacama in northern Chile. The study region, which is centered around the town of San Pedro de Atacama contains three broadly defined habitats. The first of these is the Salar, a basin with a floor located at an elevation of approximately 2500 m. Above 4000 m is the Puna de Atacama, a rugged area dotted with lakes that are the habitat of several varieties of flamingo. According the Núñez and Dillehay (1979:39-40), this region should not be considered similar to puna regions to the north in Peru. They emphasize the harsher nature of the more southerly climate, the more dissected nature of the terrain, which is dotted with volcanoes, though both areas share general climatic instability (Winterhalder and Thomas 1978). Between the puna and the salar is a sloping region cut by a series of small canyons through which water flows year round. Between these canyons the slopes are extremely desertic at the lower elevations, though they do contain important resources including raw material for stone tools.

The earliest occupation of the region that is known from excavations is represented by the sites of Tuina, located to the north and west of the Salar, and San Lorenzo, located to the east, both of which have radiocarbon determinations indicating habitation in the eighth and ninth millenium B.C. Following the occupation of these sites there is a hiatus, possibly brought on by volcanic activity (L. Núñez, personal communication), until approximately 3000 B.C.

The herbivore resources of the Atacama region are more restricted than what is found in the more watered regions to the north. None of the fourteen sites in the region which I have studied have any deer remains. Only one fragmentary metopodial is known from the Chiúchiú complex located just to the north (M. Druss, personal communication). Meat supplies were procured through the exploitation of camelids with supplements obtained from rodents like the viscacha, chinchilla, and tuco-tuco, and birds including the flamingo, the Andean goose and the tinamou. The relative frequency distribution of the remains of these species in the various quebrada and salar sites indicate clearly that the hunting techniques of their occupants were finely tuned to the biological subtleties of the region.

The study of the origins of pastoralism in the Andes has been stymied to some degree by the difficulty of separating the archaeological remains of the various species of camelid. The two basic wild forms (ignoring for the moment, the complexities of that paleontological issue), apparently diverge somewhat in habitat preference, diet, and social behavior (Koford 1957; Raedeke 1977; Rick 1980). The vicuña tends to higher altitudes, has a more rigidly defined territorial system, and prefers grasses, whereas the guanaco is a browser with a looser social structure that occupies somewhat lower elevations. In terms of the Atacama region, vicuña would be common in the puna, guanaco in the quebradas. Because of these behavioral divergences, it is reasonable to assume that hunters would employ somewhat different strategies in killing them. The unfortunate result of this line of reasoning is that unsegregated archaeological samples will tend to mix the evidence of different human behaviors. Wing (1972, 1977), however, has shown that the size difference between the two species can be used to separate archaeological remains. In the samples from the Atacama considered here, that fact was utilized to interpret the bimodal tendency in the distributions of measurements of foot bones (Hesse 1982b). With the faunal collections separated in this way it was possible to detect a contrast in harvest profiles that indicates pastoralism involving only the larger form (Fig. 4).

The sites of interest are Tulan-52, one of a cluster of Archaic sites located just below 3000 m along a quebrada leading to the south and east of of the salar, and Puripica-1, located at about 3200 m above a canyon that leads to the north and east (Núñez 1981).

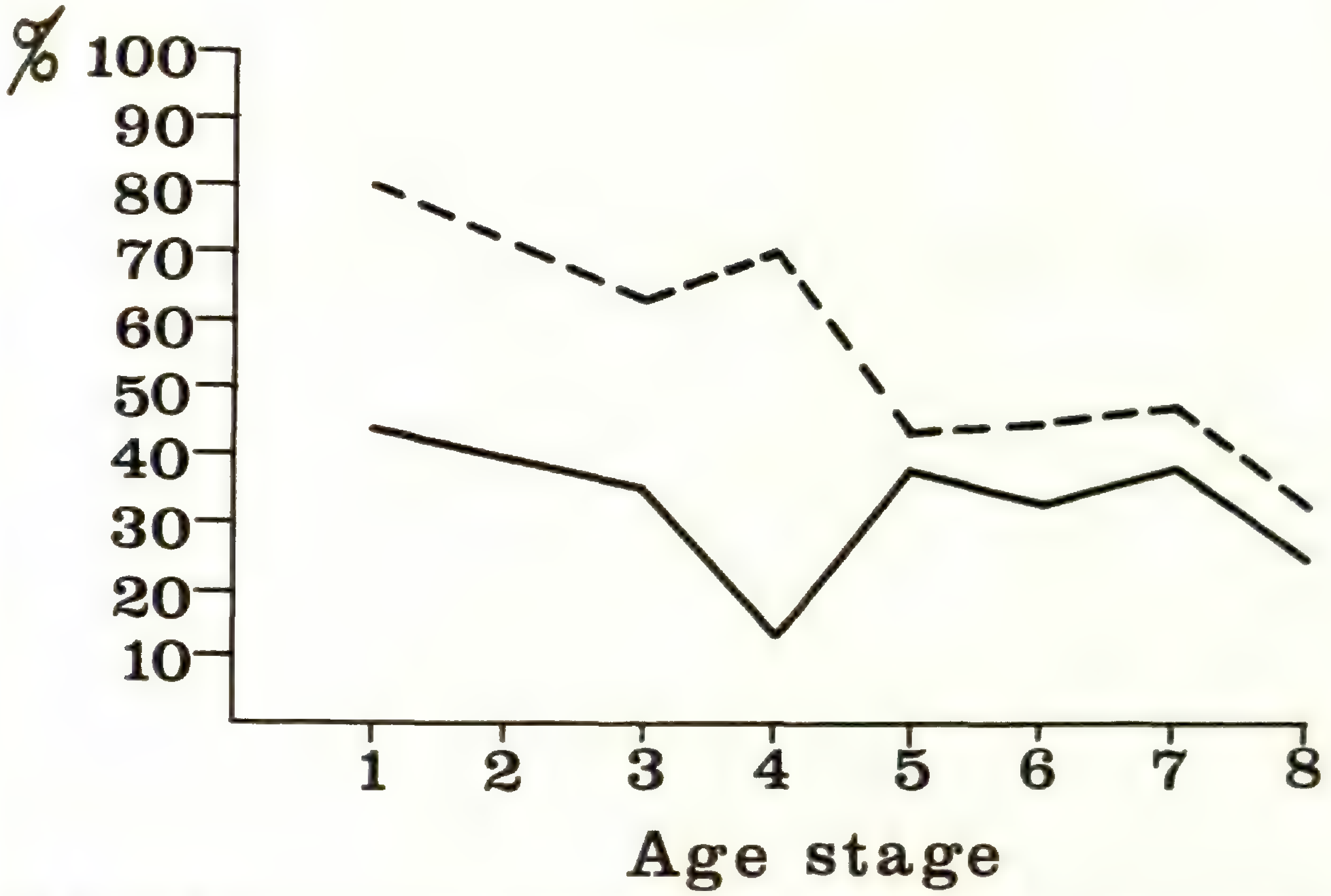

FIG. 4–Camelid harvest profiles from Tulan-52 (---) and Puripica-1 (————). The percentage survivorship is plotted against a series of relative age stages following the suggestions of Wing (1972).

Radiocarbon dates for each site suggest occupation during the mid to late third millenium B.C. The assemblages from both sides include simple stone shelters and mortars. In the case of Tulan-52, it is estimated that there were about 30 semi-subterranean dwellings; in the case of Puripica-1, 40-50. The lithic assemblage from Tulan-52, however, has a higher proportion of projectile points. The excavations at Puripica-1 produced a series of petroglyphs depicting camelids. Both sites contained a mixture of large and small camelids (presumably guanacos and vicuñas). The vicuñas, however, were represented almost exclusively by toe bones. I would suggest that this represents butchering of these small camelids at some distance from the sites, probably reflective of the facts that vicuña territory would have been located at some distance above the sites and only the skins were being imported. A similar interpretation has been drawn by Rick (1980:273) and Simons (1980) for samples that probably contain a mixture of large and small camelids. The majority of these animals were mature at death, at least based on the percentage of fused phalanges, a harvest profile in keeping with wild herd demographics (Hesse 1982b). The harvest profiles for the guanacos, on the other hand, contrast between the two sites, with a much greater proportion of the Puripica guanacos being taken young. More specifically, the shift to this emphasis on young large camelids occurs between levels III and II in the occupation. If young kill is accepted as evidence for domestication (Wing 1972, 1977), I suggest that this shift implies the transformation to pastoralism. It cannot be determined with the evidence at hand whether this adoption represents indigenous taming and domestication of Atacama camelids or import of stock from regions to the north where pastoralism is much earlier documented. Nothing in the archaeological record for the site, however, argues for extensive extra-regional contact.

How is climate involved in this? Two factors stand out. Snowfall on the puna has been identified as a significant cause of camelid mortality. Koford (1957:164) alludes to the effects of snow and hail which is particularly frequent during the birth season on the puna. Alternatively (Jane Wheeler, personal communication), oscillating periods of extreme drought which are recorded in the puna of southern Peru have been identified as primary causes of camelid mortality. Browman (1974:191) notes the effects of both conditions on puna herds of domestic camelids:

> Loss by freezes and snows and through drought and consequent pasture failure also runs high in some years. Several of Diez de San Miguel's 16th century informants reported losses of animals killed by freezes and heavy snows; the Lurinsaya of Acora claim the loss of the entire communal herd of 1,000 in a freeze in 1565. Even though the wet season is the summer season, at the high elevations (4000 m and above) the rain turns to snow, which prevents the flocks from finding forage and causes high losses among the weaker newborn animals.

Further, in the classic ethnography of Andean pastoralism, Flores-Ochoa (1979:95) emphasizes the danger of droughts which are characterized as a main hazard for the llama and alpaca herders he describes.

Bowman (1924:30) reports the history of 19th century precipitation for the Atacama region. Heavy downpours of snowfalls occurred in 1819, 1823, 1952, 1859, 1878, 1885, 1903, and 1911 (from Druss 1978:116). Such precipitation would have created short-lived explosions in the desert vegetation at elevations below the puna, but would have had a devastating effect on the high altitude camelids. If Núñez and Dillehay (1979) are right in their assessment of the inhospitable nature of the Puna de Atacama for year-round habitation, then we can expect that the hunters moving up and down the quebradas to the east of the salar would experience irregular periods of lack of game during their visits to the highlands. The best evidence that the occupants of the Atacama region were experiencing oscillations in moisture availability has been published by Druss (1977, 1978). His study of the Chiúchiú complex produced correlations linking settlement type, location and duration with climatic regimes inferred from artifactual and ecofactual remains (1977:Table 4). He concluded that third and second millenium B.C. settlement patterns were controlled by oscillations in moisture.

Again, while the case is circumstantial in that direct evidence of resource stress cannot be archaeologically documented, I believe that it is a reasonable conclusion that the ancient inhabitants of the Atacama region experienced serious fluctuations in game availability brought on by expectable but not predictable climatic variation. In the case of Puripica this economic uncertainty was buffered at some point midway in the occupation through the incorporation of domestic stock into the way of life. In the case of the Tulan region the adoption of pastoralism seems to have occurred at approximately 1700 B.C. based on evidence from a site adjacent to Tulan-52 (Núñez 1981). The source of the insurance herd, following Ingold's model, would likely have been pack animals, necessary if part of the reason for habitation in the region was the exploitation of the locally abundant mineral resources and trade in vicuña skins.

CONCLUSION

The two case studies just presented have a number of features in common. Both episodes of pastoral development took place in arid or semi-arid ecosystems where the large herbivore population was dominated by a minimum number of species, one basically a browser, the other a grazer. The sites which contain the evidence for pastoralism are located in complex topographies adjacent to larger open spaces. Each environment was probably afflicted by irregular climatic conditions capable of catastrophically affecting game availability.

Domestication has both a technological aspect, the methods of taming and breeding, and a social/ideological one, the intersection of animals with a web of values and interpersonal organization. The explanation of its onset must account in some manner for both of these aspects. Oscillating game availability can be linked to cultural systems both in terms of an effect on productive technologies and on social institutions. The potential result of these effects is carnivorous pastoralism, a predatory adaptation capable of insuring its success by destroying the potential for other systems.

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TRADITIONAL USE OF DEVIL'S-CLUB *(OPLOPANAX HORRIDUS;* ARALIACEAE) BY NATIVE PEOPLES IN WESTERN NORTH AMERICA

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ABSTRACT.—Devil's-club *(Oplopanax horridus;* Araliaceae) is a deciduous, spiny shrub which was and still is an important medicinal plant for many Indian peoples in western North America. Its traditional uses involve both physical and spiritual realms of medicine. The inner bark and roots were used to treat rheumatism and arthritis, stomach and digestive ailments, tuberculosis, colds, skin disorders, diabetes, and many other ailments. Extracts from it have marked hypoglycemic properties, but little else is known of its pharmacological attributes. It was taken by shamans, initiates, and others wishing to attain supernatural powers. Special protective powers were attributed to it, presumably because of its prickliness. Its wood was used for fishing lures and the charcoal as a pigment in a protective face paint for ceremonial dancers. Devil's-club was named in almost every Native language used within its geographic range. There are some 13 to 15 known separate etymons for it in more than 25 different languages. In most languages, the derivation of the name is presently unknown. More pharmacological research on this plant is needed.

" . . . Behold! there was a devil's-club tree larger than any other tree in the whole world. He [the son of Devil's-club] took his stone ax and felled the great devil's-club tree; and after it was down, he took all the sap and bark; and . . . he carried it down to his town . . . Then he started to wash his body with the bark of the devil's-club and its sap, and he ate some to purify himself. He did so for forty days . . . " (from a Tsimshian myth—Boas 1916:175).

INTRODUCTION

Devil's-club *(Oplopanax horridus* [J.E. Smith] Miq.; Araliaceae) is a well-known shrub of western North American forests. The stems and foliage are densely armed with stiff spines that " . . . break off at once on entering the skin or clothing and make life a burden to the prospector, explorer, or mountain-climber . . . " (Gorman 1896:73). Nevertheless, despite its sharp, menacing spines—or perhaps in part because of them—it was respected as a protective agent and important medicinal plant by many indigenous peoples in western North America. Few medicinal plants were more widely and consistently used within their geographic range. Devil's-club wood was also used in traditional fishing technology along the Northwest Coast and the charcoal was used as a decorative and protective pigment.

This paper summarizes the many uses of this plant in Native cultures, and stresses the medicinal properties implied by its widespread usage. It is potentially valuable to modern medicine because preliminary research (Justice 1966) indicates that at least some of the traditional remedies involving devil's-club may have a sound biochemical basis.

DISCUSSION

Botanical description of Devil's-Club

Oplopanax horridus is sometimes cited in botanical and ethnographic literature under the synonyms: *Fatsia horrida* Benth. & Hook., *Panax horridum* J.E. Smith, and *Echinopanax horridum* Decne. & Planch. It is in the ginseng family, only one other member of which is indigenous to western North America, namely *Aralia nudicaulis* L., wild sarsaparilla. Both plants are related to the true ginseng, *Panax quinquefolius* L. (syn. *Aralia* *quinquefolia* Gray), well known in folk medicine and native to eastern North America. The Oriental ginseng, *P. genseng* C.A. Mey, is even more prized in Chinese folk medicine (Li Shih-Chen 1973; National Academy of Sciences 1975:102).

Devil's-club is a deciduous shrub of 1-3 m (or more), with long, thick, ascending or decumbent stems and large, palmately lobed leaves with blades up to 40 cm or more wide, irregularly serrate margins, and long petioles (Fig. 1). They superficially resemble large maple leaves. The stems, petioles and leaf veins are densely armed with thin, sharp spines 5-10 mm long (Fig. 2) that are highly irritating and can fester when imbedded in the skin. Some individuals experience a severe allergic reaction to them. The small, greenish-white flowers bloom from May to July, depending on elevation and latitude. They are subsessile in compact umbels borne in elongate racemes or panicles up to 25 cm long. The fruits are bright red, fleshy berries, somewhat compressed, ellipsoid, and often spiny (Hitchcock et al. 1961 (Pt. 3):506).

FIG. 1–Devil's-club *(Oplopanax horridus).* Approximately 1/6 natural size.

This shrub often grows in dense, nearly impenetrable thickets in moist, rich soil in coniferous woods. It is especially common near streams and occurs from near sea level to subalpine elevations in the mountains. Its range extends from Alaska southwards along the coast and on the west side of the Cascade range to southern Oregon, and eastwards to the Rocky Mountains including parts of Idaho, Montana, and Alberta. It also occurs in a small enclave in northern Michigan and the Thunder Bay district of Ontario.

Another species of *Oplopanax*, *O. japonicus* (Nakai) Nakai (sometimes considered a subspecies of *O. horridus)*, occurs in Japan. Hultén (1968:696) provides a distribution map for *O. horridus*. The somatic chromosome number for the species is 2n=48 (Taylor and MacBryde 1977:53).

Devil's-club in Folk Medicine

In Native cultures of northwestern North America, health and the maintenance of well-being seem to assume two general aspects: 1) physical, i.e., the use of various medicinal preparations, usually herbs, which are administered by herbal specialists within a family or village group; and 2) spiritual, i.e., the "magical" or supernatural practices of shamans, or "Indian doctors," who deal more with the evil spirits associated with illness than with its physical manifestations (Turner et al. 1980:150; Turner and Efrat In Press; Turner et al. In Press). Devil's-club played, and still plays, an important role in both of these types of medicine, although in some instances the two are so closely intermingled that separating them completely would be unrealistic. Nevertheless, for the purposes of this paper, it is a useful dichotomy and examples of the use of devil's-club in these two aspects of medicine are given in Tables 1 and 2 respectively.

FIG.2– Devil's-club stem, showing thin, sharp spines. Approximately 1/5 natural size.

"Physical" Attributes of Devil's-Club Medicine

The chemical properties of devil's-club, as they might relate to the uses in Table 1, have not been thoroughly investigated. Japanese researchers have isolated a sesquiterpene, a sesquiterpene alcohol, and a sesquiterpene ketone from the closely related *O. japonicus* ("haribuki"). These are, respectively, echinopanacen (C_{15} H_{24}), echinopanacol (C_{15} H_{25} OH), and oplopanone (C_{15} H_{26} O_2) (Takeda et al. 1966:219). A derivative of oplopanone is used commercially in Japan as an antipyretic and antitussive drug for coughs and colds. Undoubtedly these compounds are also present in *O. horridus,* but further details of the chemical composition of this plant are apparently not known.

Extracts of *Oplopanax,* like those of its relative, ginseng, have marked hypoglycemic properties (Lewis and Elvin-Lewis 1977:218; Justice 1966;37). The hypoglycemic attributes undoubtedly contribute to the use of devil's-club to treat diabetes:

> "Our attention was brought to this material through the examination by one of us of a surgical patient who on hospitalization, developed marked symptoms of diabetes. This person, it was learned, had kept in apparent good health for several years by oral doses of an infusion of this root bark, and is in fact still leading a normal life with the aid of this infustion" (Brocklesby and Large 1938:32).

TABLE 1.–*Medicinal Uses of Devil's-Club (Physical Aspects)**

Native Group	Details of Use	Reference
Tanaina (Kenai)	dec of st drunk for fever	Kari 1977:62
Tanaina (Upper Inlet)	dec of inner bk drunk for tuberculosis, stomach trouble, coughs, colds, and fever	Kari 1977:62
Tanaina (Upper Inlet)	inner bk of rt baked, powdered, used as poultice on swollen glands, boils, sores, other infections	Kari 1977:62
Eyak	dec (?) drunk as emetic, purgative	Smith 1973:330
Tlingit	warm dec of seal oil and inner bk drunk as emetic, cathartic	Smith 1973:330
Tlingit	inner bk chewed, tied onto wounds to relieve pain, prevent blood poisoning	Smith 1973:330
Tlingit	ashes used for sores	Krause 1956:284
Tlingit Kaigani Haida	inf of bk, rt drunk for general strength, colds, chest pains, arthritis, black eyes, gall stones, ulcers, constipation, tuberculosis	Justice 1966:36
Tlingit or Kaigani Haida	inf of inner bk drunk for cancer	Justice 1966:36
Tlingit or Kaigani Haida	inner bk chewed, spit on wounds as emergency analgesic	Justice 1966:36
Tlingit or Kaigani Haida	inner bk laid on skin over fracture to reduce pain, swelling	Justice 1966:36
Tlingit or Kaigani Haida	inner bk or rt dried, pulverized with pitch, applied to skin abrasions	Justice 1966:36
Tlingit, Haida or Tsimshian	dried inner bk laid into tooth cavity for pain relief	Justice 1966:36
Tlingit, Haida or Tsimshian	inner bk pulverized, mixed with oil, eaten for pain relief	Justice 1966:38
Haida	dec of inner bk in sea water solution drunk for 9 days for rheumatism, arthritis; laxative	Turner 1970:66

*The following abbreviations are used: dec - decoction; inf - infusion; st - stem(s); rt - root(s); and bk - bark.

TABLE 1.—Continued

Native Group	Details of Use	Reference
Haida	dec of inner bk drunk for "tuberculosis of the bone"	Turner 1970:66-68
Haida	bk chewed, juice swallowed for bad cold or general sickness	Turner 1970:66-68
Haida	berries rubbed on hair and scalp of children against lice, dandruff	Turner 1970:66-68
Haida	st used to beat rheumatic limbs as counter-irritant	Turner 1970:66-68
Tsimshian	dec drunk for unspecified illness	Smith 1973:330
Gitksan	dec of st taken as purgative in treating gonorrhoea	Smith 1928:62
Gitksan	dec of st taken to knit broken bones	Smith 1928:62
Gitksan	dec of st, with *Viburnum,* taken as diuretic, purgative for "strangury," rupture, or any sickness	Smith 1928:62
Gitksan	bk mashed with fern rt, *Abies* bk, *Pinus* or *Picea* gum, *Lysichitum* rt, and applied warm to boils, ulcers, for rheumatism, lung haemorrhage	Smith 1928:62
Southern Carrier	dec of bk drunk as purgative before and after childbirth	Smith 1928:62
Northern Carrier	inner bk swallowed for stomach and intestinal cramps, esp. after taking a purgative; itself a purgative	Smith 1928:62
Central Carrier	inner bk swallowed for general sickness	Carrier Linguistic Committee 1973:82
Central Carrier	bk scraped, plastered over sore area	Carrier Linguistic Committee 1973:82
Carrier	bk used by women after childbirth; mashed, swallowed immediately after to help expell afterbirth	Morice 1893:132
Carrier	bk mashed, swallowed as purgative	Morice 1893:132
Bella Coola	inner bk, esp. of rt chewed as emetic; taken with water	Smith 1928:62

TABLE 1.–(Continued)

Native Group	Details of Use	Reference
Bella Coola	inf of st in sea water drunk as emetic	Smith 1928:62
Bella Coola	dec of st used in steambath for stomach trouble, rheumatism	Smith 1928:62
Bella Coola	dec of bk of rt and st drunk as purgative, and for rheumatism	Smith 1928:62
Bella Coola	dec of st with *Ribes* rt drunk as general tonic	Bouchard 1975-77:B., 5
Bella Coola	dec of inner bk or rt with *Sorbus* bk, *Ribes* st used for steambathing, e.g. for lameness	Bouchard 1975-77:B., 5a
Bella Coola	inf or dec of rt or st drunk or used in steambath for many illnesses	Bouchard 1975-77: B, 5a
Heiltsuq (Bella Bella)	inf of rt drunk for diabetes	MacDermott 1949:181
Heiltsuq (Bella Bella)	inf of inner bk drunk as laxative, used for bathing	B. Rigsby, pers. comm. 1981
Heiltsuq (Bella Bella)	inner bk chewed, then salt water drunk, as laxative	B. Rigsby, pers. comm. 1981
Southern Kwakiutl	4 pieces of rt held in mouth, juice swallowed, for stomach pains, constipation	Turner and Bell 1973:278
Southern Kwakiutl	inf of bk drunk for tuberculosis, other ailments	Turner and Bell 1973:278
Southern Kwakiutl	ashes mixed with oil, rubbed on swellings	Boas 1966:382
Southern Kwakiutl	dec of despined bk, with *Lomatium* seeds, or with sea water, urine, used in steambath for body pains	Turner and Bell 1973:278
Ohiat Nootka	dec used in bath for arthritis, rheumatism	Rollins 1972:25b
Nitinaht	inf of despined st drunk for arthritis	Turner et al. In Press
Nitinaht	inf of bk taken for rheumatism; with *Alnus*, *Abies* bk for tuberculosis	Rollins 1972:25b
Mainland Comox	bk, rt inf in bath as skin tonic	Bouchard 1973:7
Mainland Comox	inf of bk drunk to stop internal haemorrhaging, sometimes taken with *Ledum* tea	Bouchard 1973:7

TABLE 1.–(Continued)

Native Group	Details of Use	Reference
Sechelt	inf of inner bk used in steambath for lameness, arthritis, rheumatism	Bouchard 1977:9; Rollins 1972:25a
Sechelt	weak dec of inner bk, rt drunk for diabetes	Bouchard 1978:8
Sechelt	dec of bk, rt used as wash for skin disease	Rollins 1972:25a
Sechelt	inf of inner bk drunk as "tonic"	Bouchard 1977:8
Sechelt	charcoal, with oil, poultice for burns	Bouchard 1977:8
Sechelt	dec of bk, rt taken for rheumatism, other ailments	Turner and Timmers 1972:8
Sechelt	dec of bk, rt applied externally for skin disease	Turner and Timmers 1972:8
Squamish	dec of inner bk, with *Abies,* taken for diabetes	Bouchard and Turner 1976:71-72
Squamish	inner bk used in steambath for rheumatism	Rollins 1972:25a
Squamish	inner bk chewed to clear throat	Bouchard and Turner 1976:71-72
Cowichan Halkomelem	used in sweatbath to drive away sickness, for colds, conditioning	Rollins 1972:3
Cowichan Halkomelem	dec of bk drunk for measles, esp. in children	Rollins 1972:10
Upriver Halkomelem	st taken for arthritis	Galloway 1979:7
Lummi	inner bk laid on women's breasts to stop excessive lactation	Gunther 1973:41
Skagit	dec of bk, with *Chimaphila, Rhamnus,* drunk for tuberculosis, and to start post-partum menstrual flow	Gunther 1973:41
Cowlitz	dec of bk drunk for colds; used to wash rheumatic limbs	Gunther 1973:41
Quileute	plant as unspecified medicine	Reagan 1934:65
Lillooet	dec of despined st drunk for arthritis	Turner 1972:13
Thompson	inf of st drunk for indigestion, stomach troubles; dec as tonic, blood purifier	Turner et al. In Press

TABLE 1.–(Continued)

Native Group	Details of Use	Reference
Thompson	charcoal mixed with grease, as salve for swellings, sores	Steedman 1930:459
Thompson	inf of despined st drunk for flu, weight loss, and other ailments	Annie York, pers. comm. 1981
Okanagan-Colville	inf of rt or despined st drunk for tuberculosis, dry cough	Turner et al. 1980: 73
Shuswap	dec drunk by some women for several days after childbirth	Teit 1909:584
Kootenay	dec taken as medicine for any illness	Hart et al. 1981:54
Crow, Cheyenne	? rt smoked with tobacco for headache (ident. uncertain in orig. source - Blankinship, 1905:12)	Johnston 1970:316
Sahaptin	dec of wood, inner bk drunk for "tuberculosis" (splitting blood)	D. French, pers. comm. 1981

TABLE 2.–*Uses of Devil's-Club in "Spiritual" Medicine**

Native Group	Details of Use	Reference
Eyak	important in magic	Smith 1973:330
Tlingit	rt eaten by novice shamans for purification	Krause 1956:195
Tlingit	st used to whip suspected witches	Krause 1956:203
? Tlingit	dried bk mixed with red ochre as love charm	Justice 1966:36
Tlingit	rt chewed by shamans to augment hypnotic powers	Gorman 1896:73
Haida	st hung over doorways to protect against witchcraft	Turner 1970:67
Haida	st eaten, with *Moneses* to gain supernatural powers	Swanton 1905:212
Haida	st, bk eaten to bring luck in gambling	Newcombe, unpbl., ca. 1901
Haida	st, bk chewed for ritual purification of gamblers, hunters, sick people	Newcombe, unpubl., ca. 1901

*For abbreviations used, see Table 1 footnote

TABLE 2.–(Continued)

Native Group	Details of Use	Reference
Tsimshian	inf of inner bk for removing odours (see also Table 4)	M. Seguin, pers. comm. 1981
Tsimshian	dec drunk, used in bath to gain supernatural power	Barbeau 1961:73
Tsimshian	inner bk chewed, rubbed on body to bring luck in hunting	Boas 1916:172
Bella Coola	st charm against supernatural power	Turner 1973:201
Bella Coola	st hung in house, used as fumigant, to ward off "strong sickness"	Bouchard 1975-77:B., 5
Southern Kwakiutl	st attributed magical powers	Turner and Bell 1973:278
Southern Kwakiutl	st hung with *Veratrum* rt around child's neck to ward off sickness	Turner and Bell 1973:274
Central Nootka	ashes mixed with water drunk for strength	Fenn et al. 1979:35
Nitinaht	charcoal used in protective face paint for ceremonial dancers	Turner et al. In Press
Upriver Halkomelem	charred st, mixed with grease, used as protective face paint	Galloway 1979
Lummi	charcoal used, often with red ochre, as ceremonial face paint; associated with death	J. Thomas, pers. comm. 1981
Okanagan-Colville	medicine (see Table 1) must be made in secret; would lose effectiveness if even another person's shadow passed over it	Turner et al. 1980:73
Crow, Cheyenne, Blackfoot	? used by medicine-men in their incantations (ident. undertain - see Table 1)	Johnston 1970:316

A similar observation was made by another doctor, G.E. Darby, at Bella Bella, who reported that the local Indians and at least one non-Indian were using an infusion of the roots for diabetes (MacDermot 1949). Margaret Siwallace, a Kimsquit woman living at Bella Coola, also knew of a local Caucasian woman who took devil's-club (probably as an infusion) for diabetes (Turner 1973:201).

Another study (Graham and Noble 1955), reported by Justice (1966:37), found that the dried roots and stalks of devil's-club contained a drug that substantially inhibited the effects of a pregnant mare's serum upon the growth of a rat's ovaries; this property may well relate to the use of devil's-club as a post-partum treatment for women (Table 1).

MacDermot (1949:181) noted that the plant has " . . . apparently a hygroscopic and detumescent effect on swellings," but did not elaborate. His comment may be based on personal observation, or may simply be his conclusions from knowledge of how it was used.

The fresh plant and extracts made from it have a characteristic sweetish odour. The late George Young, a Haida man from Skidegate who had taken the "devil's-club treatment" for arthritis, apparently with remarkable success, recalled that shortly after one had drunk the decoction of devil's-club, he could smell it from his joints (Turner 1970).

Annie York, a Thompson woman from Spuzzum in the Fraser Canyon, keeps a supply of de-spined, dried devil's-club sticks on hand to use when required (Fig. 3). She makes an infusion by steeping four short (2-3 cm) pieces in about a liter of boiling water. This is taken in doses of about 125 ml (i.e., half a cupful) before meals, to relieve weight loss, flu, and other ailments. She warns that it can cause too much weight gain. She had heard that the roots could be taken for diabetes (A. York, personal communication 1981).

FIG. 3–Dried, de-spined devil's-club sticks, kept for use as medicine for flu, excess weight loss, and other ailments, by Annie York, a Thompson woman from Spuzzum, B.C. Approximately 1/4 natural size.

Aside from Young's and York's, there have been many testimonies as to the efficacy of devil's-club as a medicine. Justice (1966:38) notes several. One was a Chief of one of the Alaskan villages who took it for a red, painfully swollen finger that was unreleived by the prescribed treatment of aspirin, raising the hand, and heat. He took one glass of devil's-club extract, which relieved the symptoms completely in eight hours. Another was a case of four teenagers who used the dried inner bark laid directly into a tooth cavity and experienced prompt pain relief. Adult males reported that they had applied the stalk strips to axe wounds received in the bush, sufficiently relieving the pain to enable them to continue on until they came to medical attention. Yet another case is described by Justice (1966:38) where a male patient with metastatic adenocarcinoma [secondary malignant tumour] was discharged from the hospital with a few month's prognosis and a terminal supply of morphine. Three years later, he had regained his health and strength after extensive treatment with devil's-club extract.

However, Justice (1966:38) also notes instances where devil's-club had no noticeable effect as a medicine. A patient with advanced rheumatoid arthritis and ankylosis of most of her small joints reported no benefit from the extract. A 54-year-old woman with Hodgkins disease was taking the extract regularly and was also receiving more conventional medical treatment at the hospital but no mention was made of the status of her condition, with the implication that the treatments were having no apparent effect.

Although devil's-club extract is not known to be toxic to humans or animals, people who drink it regularly report that upon beginning the treatment one may have diarrhea and feel very weak, and that greater weakness is experienced if alcoholic beverages are taken concurrently (Justice 1966:37). Furthermore, hares given the devil's-club extract in the tests by Brocklesby and Large (1938) had more fatty degeneration of the liver than control animals. No increased tolerance was observed after repeated tests. Effects on the liver of humans are presently unknown.

"Spiritual" Aspects of Devil's-club Medicine

The various protective and purifying properties attributed to devil's-club, as shown in Table 2, seem closely related to its laxative and emetic properties, and to its most striking physical feature—its prickliness.

External and internal cleansing was of paramount importance in Native cultures in the quest for guardian spirit power (to bring success in hunting, gambling and other activities), in the acquisition of shamanistic powers, and for living in general. For example, ritual scrubbing and bathing, fasting, and the drinking of cathartic tonics often accompanied the adulthood training of young men and women reaching puberty (Turner et al. In Press).

Hence, it is difficult to distinguish between the use of the cathartic qualities of devil's-club as a physical treatment for sickness and their use as a psychological aid to obtain supernatural powers. As Justice (1966:37) points out, the hypoglycemic properties of the plant may well have promoted the abilities of shamans (and initiates) to enter a trance-like state, conducive to having visions of supernatural spirits. He further notes that, "The legend [see later discussion] of the shaman's increased strength after one week of only the extract [of devil's-club] for food may be related to increasing tolerance to the hypoglycemic effects."

The prickly, or "sharp" quality of devil's-club seems closely associated with the plant's ability to provide immunity against "witchcraft", evil spirits, or people with malicious intent and to bring luck and "power" to the user of the plant (Table 2). A similar protective role is assumed by other species of thorny or prickly plants in western Native cultures. These include: wild roses *(Rosa* spp.), Rocky Mountain juniper *(Juniperus scopulorum* Sarg.), Oregon-grape *(Berberis aquifolium* Pursh), black hawthorn *(Crateagus douglasii* Lindl.), swamp gooseberry *(Ribes lacustre* Poir.), thistles *(Cirsium* spp.), and trailing wild blackberry *(Rubus ursinus* Cham. & Schlecht.) [Rollins 1972; Turner and Bell 1971; Turner 1973; Turner et al. 1980, In Press). With all of these plants, including devil's-club, it is not the prickles or spines per se that give protection; rather it is some innate quality that is manifested in an infusion or decoction of the plant (Turner et al. 1981:131), or even in smoke from burning it (Turner 1973:206).

The close relationship of the protective powers of devil's-club with its prickliness is alluded to by John Thomas, a Nitinaht speaker from the west coast of Vancouver Island:

> "The reason they use this kind of wood [as charcoal face paint for ceremonial dancers – see Table 2] is because it's sharp. When you see somebody with that kind of paint, you couldn't look them in the eye, their power is so strong . . . " (Turner et al. In Press).

John Thomas (personal communication, 1981) also explained that within his own group (Nitinaht), and among neighbouring Coast Salish groups, devil's-club is considered "sacred." Along with red ochre paint, it is considered to be a link between the ordinary, or profane world, and the supernatural, or the spirit world. He pointed out that in a recent reburial ceremony at Lummi, Washington (Coast Salish territory), which was filmed and shown on local television, devil's-club charcoal and red ochre were used both as face paint and sprinkled over the graves.

Similarly, a Cowichan (Halkomelem Coast Salish) man described a sweat-bath for purification of a "sick" person who had been made ill by a malicious Indian doctor from another area. First, a canoe was filled with "sharp things," including thistle, devil's-club, black hawthorn, and other thorny plants. Water was poured onto these plants, a bulrush mat laid down to protect the patient, and the sick person laid down in the water on the mat. Then hot rocks were placed in the water-filled canoe until the heat was unbearable. The thorns in the plants were thought to prickle and drive sickness out of the bather (Rollins 1972:25a).

The protective or supernatural powers attributed to devil's-club are also reflected in Northwest Coast mythology and oral tradition, particularly among the Haida, Tsimshian, and Tlingit. A good example of this is in a story told by the late Willie Matthews, a Haida speaker and Hereditary Chief of Masset on the Queen Charlotte Islands: One of his ancestors had been fasting out in the forest for several days. Eventually, he came across a giant devil's-club plant with a trunk about 0.5 m (1½ ft.) in diameter and leaves almost 2 m (5 ft.) across. He ate the inner bark from it, and immediately lost consciousness. Upon awakening, he saw a supernatural being, similar to a "fairy," who was thenceforth his guardian spirit. Ever since then, Willie Matthews' family had many names alluding to "fairies". A Tsimshian myth, quoted in part at the beginning of this paper, provides a similar episode (Boas 1916:172), as does a Tlingit myth recounted by Swanton (1909: 136).

There are many other mythological references to hunters and others seeking purification or supernatural help by eating devil's-club or drinking or bathing in an infusion of the plant (Barbeau 1953:414, 1961:73; Boas 1912:166-7; Krause 1956:188; Swanton 1905:212, 1909:308). In a Tlingit myth, devil's-club and red [ochre ?] paint were found at the entrance to a supernatural house (Swanton 1909:95), and later, a woman being pursued threw a devil's-club stick behind her and it immediately grew into a dense thicket of devil's-club (Swanton 1909:95). In another, similar account, a devil's-club comb was dropped to become a thicket, thus obstructing pursuers (Swanton 1909:383).

Summary of Medicinal Uses

There is a remarkable consistency in the various medicinal uses of devil's-club, even among cultural groups that are totally distinct linguistically and geographically. In Table 3, medicinal uses are summarized by cultural groups, with the most widespread applications shown first. It can be seen that the use of devil's-club in treating arthritis and (or) rheumatism is, or was, almost universal along the Northwest coast. It is likely that its use was even more widespread than indicated, since several coastal groups, including Coast Tsimshian, Haisla, and Heiltsuq (Bella Bella), have been little studied ethnobotanically. The use of devil's-club as a dermatological aid is also widespread, as is its use in treating ailments of the respiratory and digestive systems.

TABLE 3.–*Summary of Medicinal Uses of Devil's-Club**

Type of Ailment	Native Groups using Devil's-Club as Treatment
Arthritis and (or) rheumatism	Tlingit and (or) Kaigani Haida; Haida; Gitksan; Bella Coola; Southern Kwakiutl; Nootka; Nitinaht; Squamish; Sechelt; Halkomelem (Upper Stalo); Cowlitz; Lillooet
Protection and (or) Purification	Tsetsaut; Eyak; Tlingit; Haida; Tsimshian; Bella Coola; Heiltsuq; Southern Kwakiutl; Nootka; Nitinaht; Halkomelem; Lummi (and probably other Salish groups - cf. Table 4)
General tonic or unspecified illness	Tlingit; Haida; Gitksan; Bella Coola; Southern Kwakiutl; Sechelt; Halkomelem (Cowichan); Thompson; Central Carrier; Kootenay
Dermatological aid (wounds, burns, infections, etc.)	Tanaina; Tlingit and (or) Kaigani Haida; Gitksan; Comox (Mainland); Sechelt; Thompson; Central Carrier; (? Sahaptin)

*References for individual groups given in Tables 1 and 2

TABLE 3.–(Continued)

Type of Ailment	Native Groups using Devil's-Club as Treatment
Stomach and Digestive tract	Tanaina; Tlingit and (or) Kaigani Haida; Bella Coola; Heiltsuq; Southern Kwakiutl; Thompson; Northern Carrier
Tuberculosis	Tanaina; Tlingit and (or) Kaigani Haida; Haida; Kwakiutl; Nitinaht; Skagit; Okanagan-Colville
Cold or cough	Tanaina; Tlingit and (or) Kaigani Haida; Haida; Squamish; Halkomelem (Cowichan); Cowlitz; Okanagan-Colville
Purgative or emetic	Eyak; Tlingit and (or) Kaigani Haida; Haida; Gitksan; Bella Coola; Carrier
Childbirth (Post-partum)	Carrier (Central and Southern); Skagit; Lummi; Shuswap
Diabetes	Heiltsuq (Bella Bella); Sechelt; Squamish; (Bella Coola–knew from use by non-Indians); Thompson
Internal haemorrhaging	Gitksan; Mainland Comox
Broken bones	Tlingit and (or) Kaigani Haida; Gitksan
Analgesic	Tlingit and (or) Kaigani Haida
Measles	Halkomelem (Cowichan)
Gonorrhoea	Gitksan
Fever	Tanaina
Dandruff, lice	Haida
Headache	? Crow, Cheyenne (probably mistaken identification)

Other Uses of Devil's-Club in Native Cultures

In Table 4, various non-medicinal uses of devil's-club are summarized. The wood, which is soft and lightweight, was often used to make various kinds of fishing lures. Devil's-club lures are said to have the property of spinning through the water as if they were alive, and were apparently very effective. The Nitinaht people used it for at least two types of lures, one of which–the cod-fish lure–was actually named after devil's-club (Turner et al., In Press). It consisted of a streamlined piece of cedar with a flat strip of devil's-club lashed around it endwise, forming two rounded wings which gave a propeller-like motion to the lure (Fig. 4). The lure was thrust down into the water from a canoe with the aid of a long pole. It was then dislodged and allowed to spin to the surface. Cod-fish, hungry or curious, would follow it up, and were then speared by the waiting fisherman. The second type of lure consisted of a small, fish-shaped piece of devil's-club wood to which a hook was fixed and a line attached. This was drawn through the water and functioned in the same way as a modern fish-shaped lure. It was especially good for catching "sea-bass" (Turner et al. In Press).

TABLE 4.—*Other (Non-medicinal) Uses of Devil's-Club*

Native Group	Part of Plant	Details of Use	Reference
Haida	wood	used to make black-cod lures	Turner 1970:67
Tsimshian	inner bark	infusion used for removing odours, e.g., for washing fishing nets that were not catching any fish, and were suspected of having been carelessly or maliciously urinated or defecated on.	M. Seguin, pers. comm. 1981
Heiltsuq and/ or Tsimshian	leaves, with spines singed off	used in bunches, like steel wool, in water, to remove human scent from hunters	B. Rigsby, pers. comm. 1981
Nootka (Hesquiat)	wood	used to make fish lures and octopus spears	Turner & Efrat In Press
Nootka (Hesquiat)	bark	shavings boiled in water with various kinds of berries to make stain for basket materials and other objects	Turner & Efrat In Press
Nootka (Manhousat)	wood	used for fish lures for greenlings and rockfish	Ellis & Turner 1976:7
Nitinaht	wood	used for cod and "sea-bass" lures	Turner et al. In Press
Nitinaht	charcoal	ceremonial face paint (see Table 2)	Turner et al. In Press
Makah	wood	used for fishing lures, e.g., for "bass"	S. Gill, pers. comm. 1981
Clallam	wood	used for fish lures for bass and other fish	Fleischer 1980:197; Gunther 1973:41
Lummi	charcoal	ceremonial face paint (see Table 2)	Gunther 1973:41; John Thomas, pers. comm. 1982
Straits Salish	charcoal	ceremonial face paint (black) or bluish coloured tattoo pigment	Turner & Bell 1971:78
Upper Cowlitz (Taitnapam dialect, Yakima)	bark	dried, pulverized for baby talc or perfume	Gunther 1973:41

TABLE 4.–(Continued)

Native Group	Part of Plant	Details of Use	Reference
Green River	bark	dried, pulverized as deodorant	Gunther 1973:41
Squamish	charcoal	used recently as black face paint (mixed with bear grease)	Bouchard & Turner 1976:72
Halkomelem (Upper Stalo)	charcoal	ceremonial face paint	John Thomas, pers. comm. 1981

The uses as face paint, perfume, baby talc, deodorant, and even in preparing a stain for basket materials and other objects (Table 4) may actually relate to the "protective" powers attributed to the plant (Table 2), although the protective aspect was not alluded to in the references cited in the former table. John Thomas (personal communication 1981) confirmed that the Lummi and other Coast Salish peoples who used the face paint in ceremonial dances were, and are, well aware of the underlying, protective purpose of its use (see also previous discussion).

Devil's-club, in at least two Northwest coast cultures, was associated with bears. The Tlingit apparently based their original use of the plant as medicine on the observation of two bears attempting to soothe battle wounds by chewing devil's-club roots (Justice 1966:36). The Bella Coola people called the fruits "grizzly's high-bush cranberries (*Viburnum edule* Raf.)", or simply "grizzly's fruit or berries" (Turner 1973:201), and believed that grizzlies ate the berries and used the branches for bedding. Additionally, at least one Sahaptin person believed that devil's-club is eaten by bears (D. French, personal communication 1981).

Among the Haida, "Devil's-Club" was both a place name (a village on the Queen Charlotte Islands) and the name of a Chief (C.F. Newcombe unpubl., ca. 1903). The importance of devil's-club is reflected by the fact that throughout its range it had a name in almost every Native language spoken. The distribution of nomenclatural recognition and use of devil's-club in Native cultures in western North America is shown in Figure 5. The various Native names are listed in Table 5. From a preliminary inspection, one can distinguish some 13 to 15 separate etymons (i.e., names with a single, unique source). Several of the Salishan languages (e.g., Lillooet, Thompson, Comox, Sechelt, and Squamish; Halkomelem and Straits Salish; Green River, Skagit, and Swinomish; and probably Shuswap and Okanagan), and the three Tsimshian languages (Coast Tsimshian, Nisgha, and Gitksan), have names of the same etymon (i.e., of common origin), but no such relationships can be seen in the names from languages of different families. Even Nitinaht and Nootka, closely related languages of the Wakashan Family that share many words of common origin, have distinct, unrelated names for devil's-club.

Many of the names for devil's-club have a "plant" suffix incorporated [e.g., -mapt (Nootka); -apt (Nitinaht); -ay (Comox and Sechelt); -eɬp (Halkomelem); -az̓ (Lillooet); and -wuʔk "wood, bush" (Kootenay)]. But for the majority of names the stem of the word has no obvious meaning; its derivation has been forgotten or obscured with time. Exceptions are the Bella Coola, Tanaina, Nitinaht, Sahaptin, and Shuswap names, whose meanings are given in Table 5. This situation seems to indicate a long-standing association of the plant within the various languages and cultures, particularly those such as Haida, Southern Kwakiutl, and Nootka, where the name is unrelated to that in any other language.

FIG. 4–Cod-fish lure used by Nitinaht and Nootka peoples. The elongated piece of wood is western red cedar *(Thuja plicata)*, and the lashing of Sitka spruce root *(Picea sitchensis)*. The two propeller-like appendages, which extend around the cedar wood, are almost certainly of devil's-club wood, although the material is not identified in the cataloguing material. (Lure collected ca. 1911 at Dodge's Cove, Vancouver Island, by C. F. Newcombe; photo by R. Bethell, Catalogue No. 2224, Ethnology Division, British Columbia Provincial Museum.) Approximately 2/3 natural size.

TABLE 5.–*Names for Devil's-Club in Western North American Indian Languages**

Language Family	Language	Name	Reference
Athapaskan	Tanaina	heshke̲ghka'a ("thorn big big"), or heshkegh ("thorn big") (also refers to wild rose in Outer and Upper Inlet dialects)	Kari 1977:62
Athapaskan	Tlingit	s!Axt! âchta	Swanton 1909:383 Krause 1956:254
Athapaskan	Carrier	hwu 1rə1	Morice 1892-3:132
Haida	Haida (Skidegate and Masset)	c'íłənǰaw (xII)	Turner & Levine 1972a:9 and 1972b:11
Tsimshian	Coast Tsimshian	wooms	Boas 1912:260; M. Seguin, pers. comm. 1981; Dunn 1978:110

*Orthography of original reference source has been retained

TABLE 5.–(Continued)

Language Family	Language	Name	Reference
Tsimshian	Nisgha	wuʔums, or waʔums	B. Rigsby, pers. comm. 1981
Tsimshian	Gitksan	huʔums, or wuʔums	Hindle and Rigsby 1973:18; B. Rigsby, pers. comm. 1981
Wakashan	Heiltsuq, or Bella Bella	wiq̓ás	B. Rigsby, pers. comm. 1981
Wakashan	Southern Kwakiutl	ix̱wm̓ī́	Turner and Bell 1973:278
Wakashan	Nootka (Hesquiat, Manhousat)	n̓a · p̓a · łmapt	Turner and Efrat In Press; Ellis and Turner 1976:7
Wakashan	Nitinaht	ʕayx^{w}q^{w}apt ("cod-fish lure plant")	Turner et al. In Press
Wakashan	Makah	ʔa · ʔałbap	S. Gill, pers. comm. 1981
Salish	Bella Coola	tsk'alhkw (cf. stsk' Douglas-fir bark slivers), or sk'alhk	Turner 1973:201
Salish (Coast)	Comox (Mainland)	ch'ī́7t'ay	R. Bouchard Unpubl. field notes 1973-76
Salish (Coast)	Sechelt	ch'ḗ7at'ay (or ch'ā́7at'ay)	Turner and Timmers 1972:8; Bouchard 1977-78
Salish (Coast)	Squamish	ch'ā́tiyay̓	Bouchard and Turner 1976:71-72
Salish (Interior)	Lillooet	k'ā́tlaz̓	Turner 1972:13
Salish (Interior)	Thompson	k'ḗtyeʔ	Turner et al. In Prep.
Salish (Coast)	Halkomelem (Cowichan)	q^{w}ā ʔpəłp	Turner and Bell 1971:78

TABLE 5–(Continued)

Language Family	Language	Name	Reference
Salish (Coast)	Halkomelem (Upriver)	qwő:pelhp	Galloway 1979:7
Salish (Coast)	Straits	qwáʔpʌɬp	Turner and Bell 1971:78
Salish (Coast)	Lummi	qwu′n’numpɬ	Gunther 1973:41
Salish (Coast)	Clallam	puqɬč	Fleischer 1980:207
Salish (Coast)	Green River	xaxadī′a’ts	Gunther 1973:41
Salish (Coast)	Skagit	xadī′ats	Gunther 1973:41
Salish (Coast)	Swinomish	xadī′ats	Gunther 1973:41
Salish (Coast)	Upper Cowlitz (Taitnapam dialect of Yakima)	sqaipqa′ipas	Gunther 1973:41
Salish (Coast)	Snuqualmi	tcitca′tc lu′’i	Gunther 1973:41
Chimakuan	Quileute	che-chah-pulth	Reagan 1934:55
Salish (Interior)	Shuswap	xwuxwaleḵw (refers to the clean smell of branch; cf. xw7uxw “any smell”)	Palmer 1975:58
Salish (Interior)	Okanagan-Colville	x̱ax̱ag̱áy̓lhp (sometimes also refers to *Ribes, lacustre),* or x̱wux̱wug̱way̓lhp	Turner et al. 1980:73
Kootenay	Kootenay	naɬiy¢axawuʔk	Hart et al. 1981:53
Sahaptin	Sahaptin (Warm Springs)	x′našwaakuɬ (‘currant [prob. *R. lacustre]* -like’)	D. French, pers. comm. 1981
Sahaptin	Sahaptin (Columbia River)	shḵapḵápnuwash	Hunn 1979:12

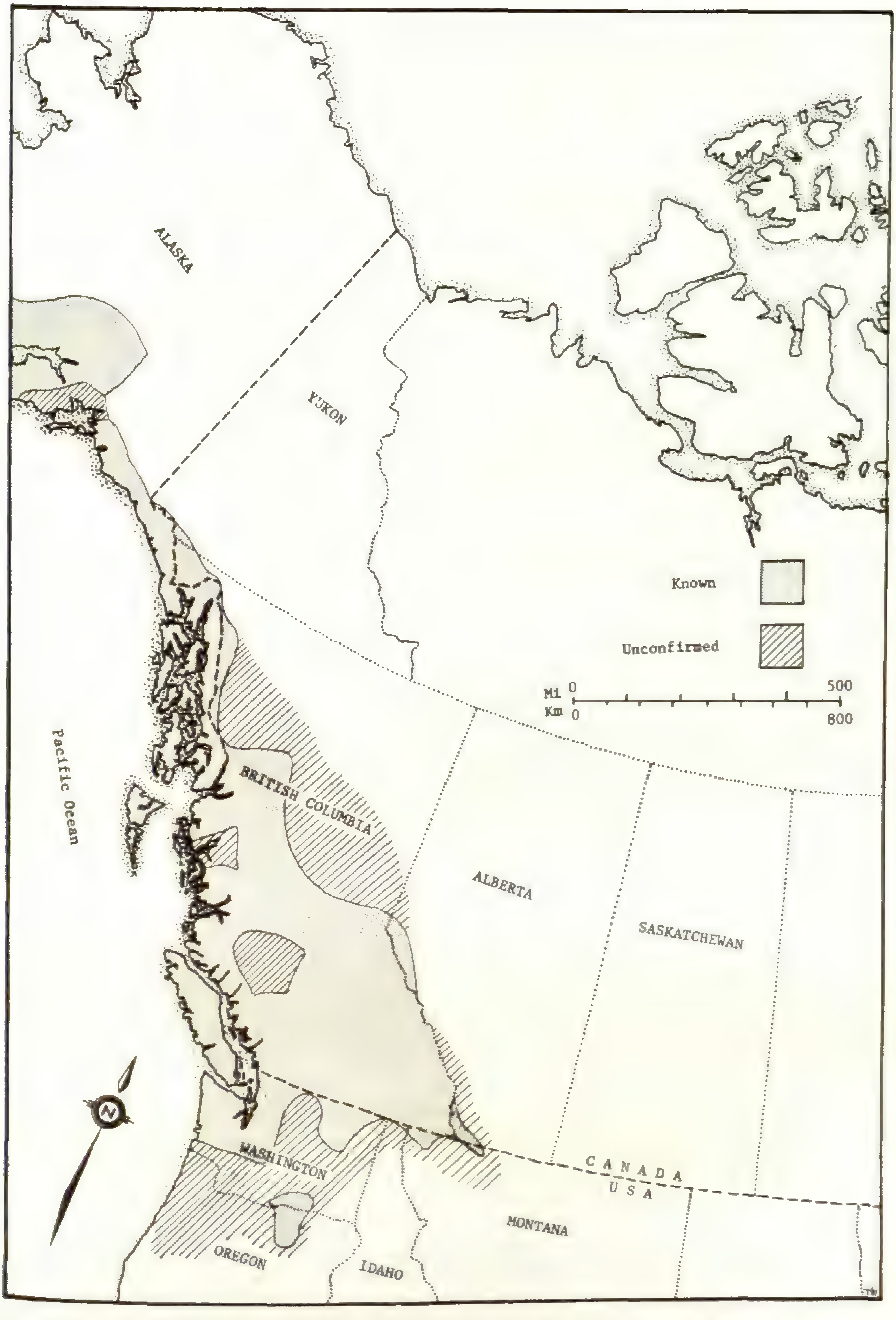

FIG. 5–The distribution of nomenclatural recognition and use of devil's-club in Native cultures in western North America.

CONCLUSION

The many medicinal uses of devil's-club may have originated from the protective qualities attributed to it because of its spines, and also from its cathartic properties. Its unusual odour may also have invited medicinal experimentation. It is also possible that its use by animals, such as the fighting bears observed by the Tlingit (Justice 1966: 36) prompted its use by people. Other herbal medicines, such as fern fronds used by the Hesquiat on the west coast of Vancouver Island, were also said to have originated from use by animals (Turner and Efrat In Press).

Although the medicinal use of devil's-club is widespread in western North America, the peoples of the northern Northwest Coast, particularly the Haida and Tlingit, seem to have had the greatest number of medicinal uses for it, and among these groups and the Tsimshian, it played a prominent role in mythology. This could be an indication that at least some of its medicinal uses diffused from north to south and from the coast to the interior. But the fact that many other languages have specific, unique names for the plant indicates that knowledge of it must have been long-standing in many areas. The use of the charcoal as face paint, both protective and decorative, for ceremonial dancers seems centered in the territories of the central Coast Salish and Nitinaht peoples, as does the use of the wood in making fishing lures.

In those language groups having a common eytmon for devil's-club, it is difficult to determine whether the names evolved independently during the course of natural differentiation of the languages, or whether the name was borrowed after the languages had already diffused. The latter would be obvious in languages from different families, but for this species, related names are found only in related languages within the same family. It is likely that the origins of both its names and uses have been permanently obscured and are thus untraceable.

The use of devil's-club among Native peoples has continued, and in some areas may actually be on the increase as interest in cultural heritage among younger generations is revived (Justice 1966:38). Sometimes the elders who formerly used it are unable to go out and collect it anymore, but do use it whenever they can get it from others.

Devil's-club charcoal is still being used as a protective face paint for ceremonial dancers (John Thomas, personal communication 1981). Sometimes vaseline is substituted for the animal fat traditionally used as a base for it (Gunther 1973:41). In the early 1970's, some Haida people still kept a stick of devil's-club under their mattresses or across the top of their doorways to protect the household against evil influences.

The effectiveness of devil's-club as a medicine for arthritis, skin ailments, malignant tumours, and other types of afflictions requires further investigation. It is remarkable, considering the widespread and continuing usage of devil's-club among Native and even non-Native peoples, that its chemical composition and pharmacological properties have not been more thoroughly studied to date.

There is always a danger in placing too much trust or faith in a medicine such as devil's-club. Justice (1966:38) cites an example at Yakutat in Alaska, where a female cancer control program was rejected, presumably because of the belief in the efficacy of devil's-club as a cancer treatment. Nevertheless, assuming that attitude and positive feeling about a medical treatment are important to its success, consideration should be given to the incorporation of well-tried traditional remedies, such as devil's-club, with modern scientific treatments in medical programs involving North American Native Peoples.

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The photograph in Figure 4 is reproduced with the permission of the Ethnology Division, British Columbia Provincial Museum. The other photographs and the map are by Robert D. Turner.

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VERTEBRATE FAUNA FROM FOUR COASTAL MISSISSIPPIAN SITES

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ABSTRACT.–Samples of vertebrate fauna recovered from three archaeological sites on barrier islands off the Georgia coast and one on the mainland coast indicate a specialized economy emphasizing marine resources. Faunal evidence suggests a use of fishes from the immediate estuarine-salt marsh system. The few highly seasonal resources of the region were not exploited. Vertebrate evidence indicates that occupation was either intermittant or continuous at these coastal sites. The collections total 17 bird, 213 mammal, 941 fish, 114 reptile, and 40 amphibian individuals.

INTRODUCTION

Along the Atlantic coast between North Island, South Carolina, and Anastasia Island, Florida, lies a series of barrier or sea islands (Fig. 1). Behind these islands is found a rich estuarine-salt marsh system. For many years scholars of diverse interests have examined this unique environment because of its importance to the American fisheries industry. Archaeologists have also been attracted to the coastal islands, and have excavated and tested sites of all temporal phases. Although questions on chronology and settlement patterns have been and continue to be the major focus by archaeologists in this region, questions pertaining to subsistence have been considered by coastal archaeologists for a number of years with indications that estuarine fishes have been important food items throughout human occupation on the coast (Larson 1980). In spite of this interest in human use of the estuaries, until recently an adequate vertebrate data base had not been assembled for studies of aboriginal use of marine resources. As of 1979, some 17 sites have been excavated between Sapelo Island and Anastasia Island, but only five of the faunal assemblages passed the test of adequacy, that is, had over 200 individuals and 1400 total bones (Reitz 1979a; Wing and Brown 1979). Of the five adequate samples, only two were aboriginal: the Archaic St. Simons Shell Ring excavated by Rochelle Marrinan (1975) and the Savannah Kenan Field excavated by Ray Crook (1978). Since 1979 three additional sites have produced large samples. As a result there are now four adequate late Mississippian vertebrate faunal assemblages available for analysis from the Georgia sea islands.

These four collections indicate a prehistoric/historic subsistence strategy based on fishing, supplemented by deer hunting. Deer *(Odocoileus virginianus)*, sea catfishes (Ariidae), and drums (Sciaenidae) were the major resources to the exclusion of most other species. Species utilization was not the same at the four sites, suggesting that even in a small geographical area where resources are basically similar throughout, there were sufficient subsistence variations to be reflected in the faunal record. Of further interest was the minor importance of highly seasonal resources such as migratory waterfowl, bluefishes *(Pomatomus saltatrix)*, and herrings (Clupeidae). Based on the faunal evidence it appears that occupation of the coastal islands was not confined to a single season, but may have been sporadic throughout the year, or even continuous.

SITE DESCRIPTIONS

The sites all date primarily to Savannah or Irene Phases. The Savannah phase is the late Mississippian phase on the Georgia coast, beginning around AD 1000 (Crook 1982) or AD 1150 (Pearson 1979). The Savannah Phase is followed by the Irene Phase, but the time span is subject to debate. Charles Pearson initiates the Irene Phase at AD 1350,

FIG. 1—Sea Islands of the Atlantic Coastal Plain.

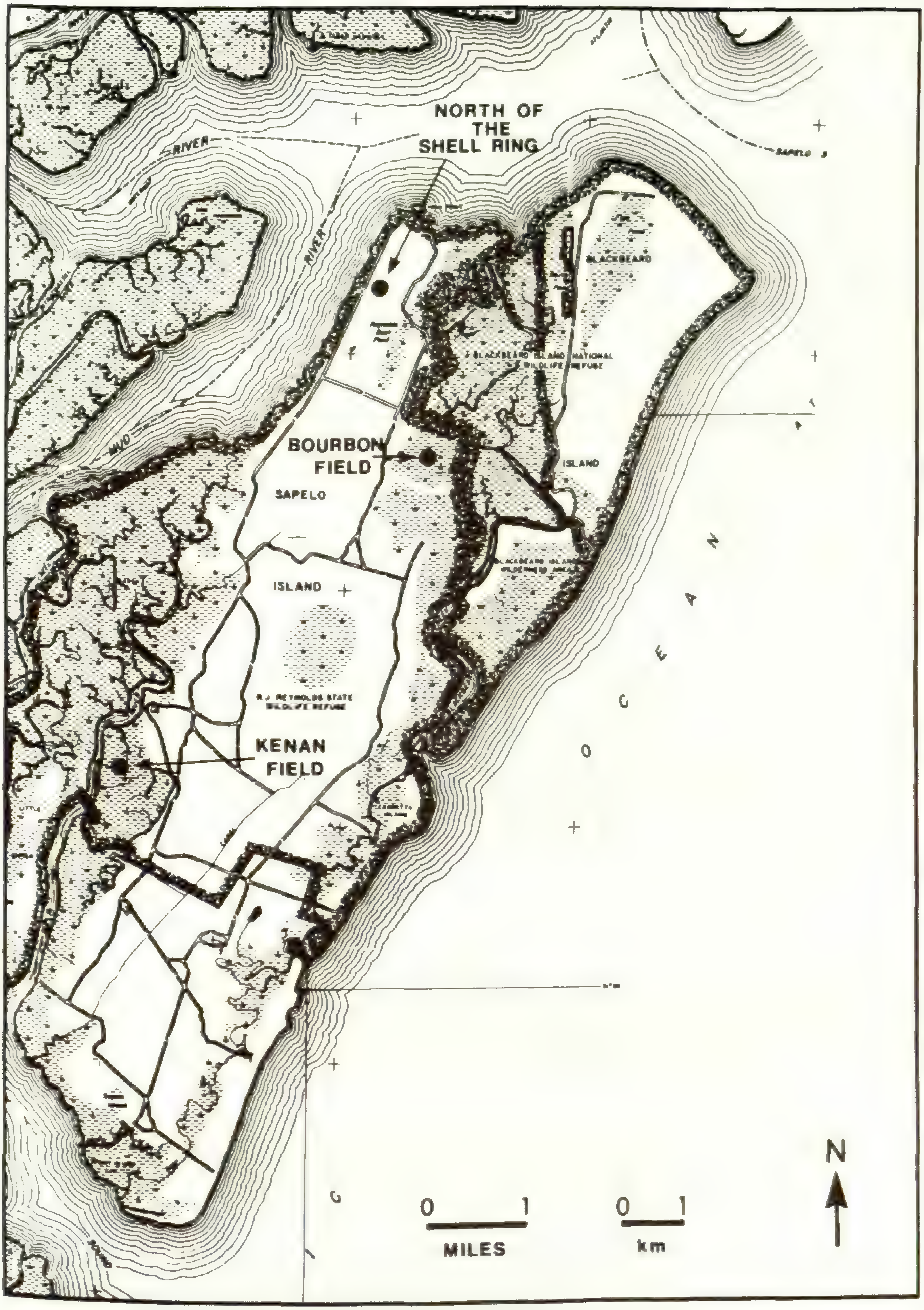

FIG. 2—Sapelo Island, Georgia (Anonymous 1968).

while Lewis Larson, Ray Crook, and Robin Smith interpret this phase as an early historic aboriginal phase beginning about 1540 (Crook 1982) or 1526 (Milanich 1977). The Irene Phase may have ended as early as 1550 (Pearson 1979), but the excavators of the sites terminate it with the end of the Mission Period at 1680 (Milanich 1977). A C_{14} date from Irene-San Marcos Phase context at Bourbon Field indicates an occupation within the 1540-1680 period (Crook 1982). Pine Harbor Phase is the Irene Phase equivalent on the Altamaha River and Smith's San Marcos Phase corresponds with Crook's Sutherland Bluff Phase. Irene and San Marcos Phases may be contemporaneous (Crook 1982). The temporal designations used below are those provided by the excavators. At contact, Spanish administrators identified the residents of the Kings Bay area as Timucuans and the Sapelo area as Guales (Larson 1978).

Three of the four sites discussed here are on Sapelo Island, Georgia (Fig. 2). Kenan Field was excavated by Dr. Ray Crook in 1976-1977 (Crook 1978). It is a multicomponent aggregate village covering 60 ha. The site is composed of 589 discrete shell middens measuring 5-10 m in diameter, two mounds, and several structures. Pine trees currently are grown on the site. The site is located on the west side of Sapelo Island, bordered on the northwest by Duplin River and on the south by Barn Creek, near a salt marsh. Six structures, one mound, and 11 shell middens were excavated. Quarter-inch screens were used at each non-feature until except for portions of three test pits in shell middens. A 11 soil sample was taken from columns from each shell midden but not analyzed. Soil from two portions of each shell midden and from features was screened through 1/16 in mesh and chemically floated. Although a Sutherland Bluff component was found at Kenan Field, the occupation was primarily Savannah and Irene Phases.

Bourbon Field is a similar multi-component aggregate village approximately seven km northwest of Kenan Field, on the east side of Sapelo Island. It is located behind Blackbeard Island facing Blackbeard Creek and a salt marsh (Crook 1982) and was excavated in 1979-1980 by Crook. Bourbon Field covers 14 ha and is composed of 119 discrete shell middens and a small earthern mound. It is currently an open field used by the Georgia Department of Natural Resources as a migratory bird feeding station. During excavations, 63 tests were conducted in the off-midden areas and ten shell middens were studied. A ¼ in screen was used at all excavations features and shell-midden volumetric samples. Volume samples of 20 l each were taken from each natural level and screened through a graduated series of meshes. Faunal samples collected in ¼ in portion were lumped with ¼ in fraction from the rest of the shell midden, therefore "column sample" refers only to fine-screened fractions of bone with the ¼ in fraction removed. Features were also screened in this manner. While the Bourbon Field site contains materials dating from the Sapelo through San Marcos Periods, the Savannah/Irene Phase occupation is primarily represented (Crook 1982).

The third Sapelo site is located on the west side of the island, about 2 km west of Bourbon Field and 5 km north of Kenan Field, and by the Mud River and a salt marsh. The excavations were placed 45 m north of a drainage ditch north of the Sapelo Shell Ring, hence the site is known as North of the Shell Ring Drain. The excavations were conducted in 1979 by Dr. Lewis Larson. The faunal sample comes from four contiguous 2 x 2 m units, placed on one undisturbed shell midden. At present, magnolia trees and live oaks primarily grow at this site. During excavations, ¼ in screens were used except for a 50 cm^2 column sample from the shell matrix which was screened through 1/16 in mesh. The ceramic assemblage contained Irene Burnished Plain, Irene Filfot Stamped, and Savannah Check-Stamped, and an occasional Spanish Olive Jar fragment. It is thought this represents an Irene occupation somewhat later in time than the main occupation at either Kenan or Bourbon Field (Crook, personal communication).

The fourth site, the Kings Bay Site (9Cam171), is located on the mainland behind Cumberland Island (Fig. 3) approximately 81 km south of Sapelo Island and was excavated by Robin Smith in 1978-1979 (Smith et al. 1981). The site is a multicomponent discontinuous shell midden covering 91.5 ha and stretching 4.5 km along the western

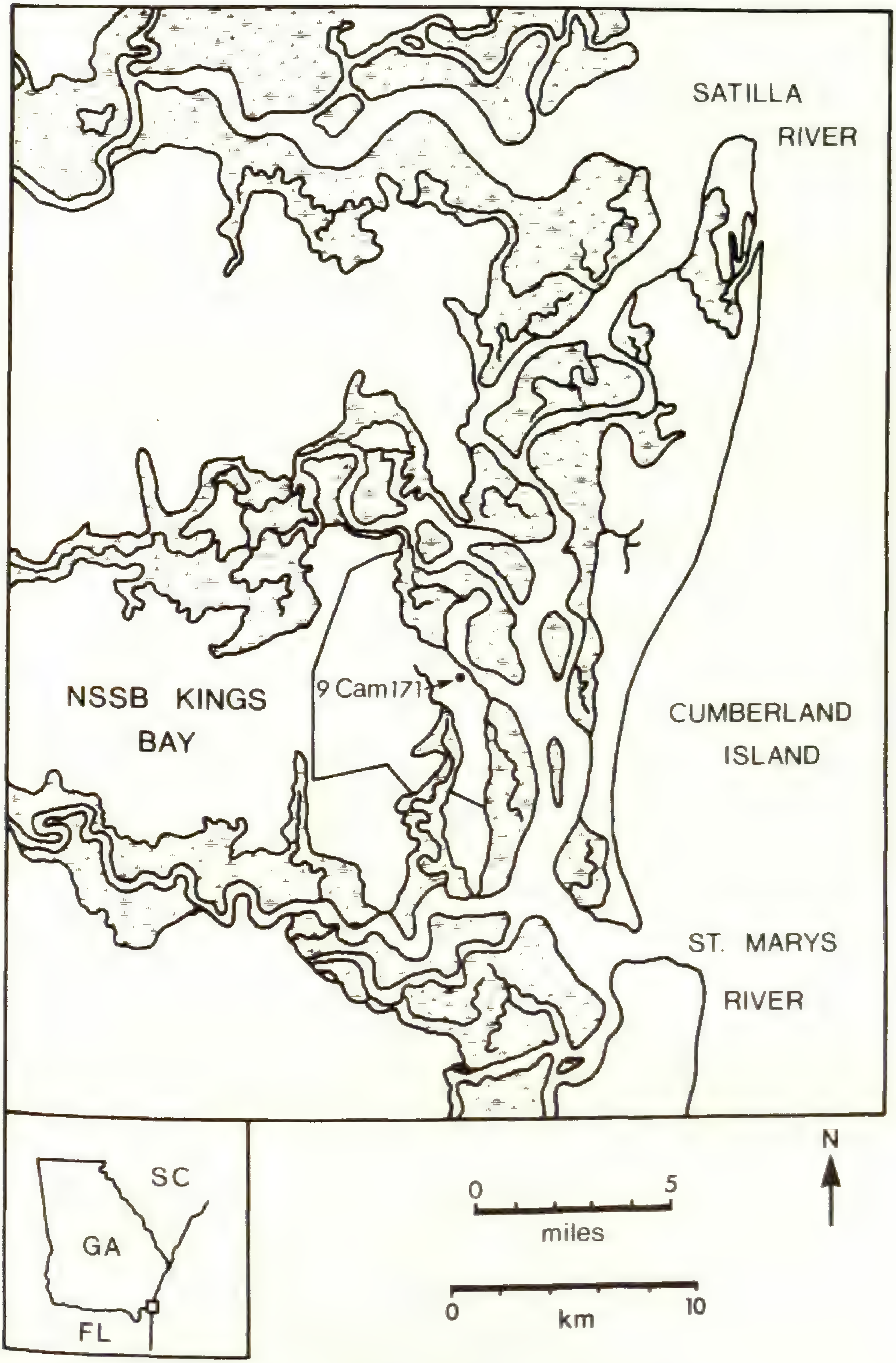

FIG. 3—Kings Bay (9Cam171), Georgia

edge of Kings Bay, bordered by a salt marsh. The Kings Bay Site is covered by pine plantation and Southern Mixed Hardwoods and is currently being impacted by construction of the Naval Submarine Support Base. During excavations, a series of sheet deposits and features were uncovered, but reference here is primarily to the Savannah Phase features. Soil from the Savannah Phase features was screened with 1/8 in mesh. Column samples also screened with 1/8 in mesh, were taken from zone deposits, but only two [San Marcos period column samples] were studied. Zone material was screened using 1/4 in mesh.

In most respects the environments of the Sapelo Island sites and the Kings Bay site are similar (Johnson et al. 1974). All are bordered by salt marshes and estuaries connected by large sounds leading to the ocean. Tidal creeks of various sizes twist through the marshes. Freshwater biotopes are available within .5 km of all sites but beaches are more distant. Dominant vegetation aboriginally was probably Maritime Oak Forests in all cases (Johnson et al. 1974). This is a region of moderate mean annual temperatures of 22 degrees C and average rainfall of 110 cm. Mean tide level at Sapelo Island and at Crooked River, just north of Kings Bay site, is 1.036 m, with a spring tide range of 2.438 m. Mean tidal ranges are 2.072 m (Tide Tables 1981). Sapelo and Cumberland Islands are in the Carolina Region with water temperatures of 15-20 degrees C (Ekman 1953; Briggs 1974) and where wide turbidity, salinity, and temperature fluctuations place unusual stresses on the estuarine fauna (Hoese 1967; Stickney and Miller 1973). Among the species best adapted to these conditions are herrings (Clupeidae), sea catfishes (Ariidae), and drums (Sciaenidae) (Mahood et al. 1974; DEIS 1978).

Seasonal variations in species availability are less pronounced in this region than elsewhere. None of the mammals hibernate (Golley 1962). While sea turtles are strictly warm weather visitors, other turtles are inactive only on very cold days (Carr 1952). Birds increase in density and diversity during the winter, representing one of the most seasonally variable resources, however coastal Georgia is not a major area for migratory flocks (Robertson and Kushlan 1974). Sharks are primarily present during warm weather conditions, but the bony fishes (Osteichthyes) present a variable dispersal pattern depending on individual age and species. Many species are represented in the estuaries by adults, juveniles, or both throughout the year (DEIS 1978). Some species remain inside the estuary throughout the year, but occupy different habitats within the estuary in response to water temperatures or salinity levels. Other species visit the estuaries only in the winter either as adults or juveniles, but more species visit estuaries in the summer. The young of most fishes live in the estuary for the first year or two of life and can be found there throughout the year. Adults are less able to tolerate estuarine extremes. Diversity, measured as an index of the number of species and the number of individuals, does not change seasonally as much as relative abundance (Dahlberg and Odum 1970); however, the total number of species is higher in the summer and fall (Dahlberg 1972). Variations in species occurrence are also found between years depending upon rainfall and temperatures. Seasonal behavior of fishes in the estuarine setting is complex based upon several variables which may not be known to the archaeologist. The species list itself provides only a general guide. Ideally it should be possible to determine seasonal patterns of exploitation of bony fishes by examining growth rings of otoliths, vertebrae, or scales (Casteel 1976).

METHODS

The faunal remains were identified and analyzed using standard zooarchaeological procedures (Wing and Brown 1979). Kenan Field and Kings Bay materials were identified using the comparative skeletal collections at the Zooarchaeology Laboratory, Florida State Museum. Bourbon Field and North of the Shell Ring Drain samples were identified at the University of Georgia's Zooarchaeology Laboratory, Department of Anthropology. Minimum Numbers of Individuals (MNI) were determined by paired elements and age, and aggregated as MNI (strata) for each non-contiguous unit following Grayson (1973).

Biomass was calculated using least-squares analysis of logarithmic data (Reitz 1979b; Wing and Brown 1979). Formulae used to obtain biomass estimates are on file at the Zooarchaeology Laboratorys of the University of Georgia and the Florida State Museum. Biomass for Kenan Field was not calculated since the necessary weight information was not readily available. Diversity was calculated using the Shannon-Weaver Diversity Index (Shannon and Weaver 1949) and equitability was calculated using the Sheldon Evenness Index (Sheldon 1969). Species were grouped into classes for analysis. "Commensal" species include amphibians and small rodents. Snake remains are so rare in the collection that these reptiles were probably commensal animals and are included as such at Kings Bay.

RESULTS

Two basic characteristics upon which reliable faunal analysis depends are sample size and screening procedures. These field-related variables affect faunal samples dramatically. It has been demonstrated that samples of fewer than 200 individuals and 1400 bones are subject to biases which influence both species diversity and equitability (Casteel 1976-1977; Grayson 1978, 1981; Wing and Brown 1979). Using these measures as guidelines for adequacy, all of the samples discussed here are reliable, with the possible exception of that from North of the Shell Ring Drain, with 5462 bones but only 107 individuals. Faunal remains identified from the four sites are listed in Tables 1-4. The Shell Ring Drain faunal list is almost identical to that of the other samples, so that while diversity may be depressed the list and proportions of fauna are probably reliable. Equitability at North of the Shell Ring Drain may be inaccurate, however; the low MNI may be a result of using a minimal distinction method (MNI site) (Grayson 1973). This method was used because the units were contiguous, representing a single midden component.

TABLE 1.–*Species List for Kenan Field (Crook, 1978)*

Species		MNI	
		No.	%
Didelphis virginiana	Opossum	1	0.3
Scalopus aquaticus	Mole	5	1.3
Sylvilagus sp.	Rabbit	13	3.3
Sciurus niger	Fox squirrel	1	0.3
Peromyscus sp.	Mouse	1	0.3
Sigmodon hispidus	Hispid cotton rat	3	0.8
Cetacea	Dolphin	1	0.3
Procyon lotor	Raccoon	16	4.0
Mustela vision	Mink	1	0.3
Mephitis mephitis	Striped skunk	2	0.5
Lutra canadensis	Otter	1	0.3
Odocoileus virginianus	Deer	38	9.6
Bos taurus	Cow	1	0.3
Unidentified Bird		4	1.0
Aix sponsa	Wood duck	1	0.3
Meleagris gallopavo	Turkey	1	0.3
Zenaidura macroura	Dove	1	0.3
Passeriformes	Song bird	1	0.3
Alligator mississippiensis	Alligator	1	0.3
Kinosternon subrubrum	Musk turtle	17	4.3
Deirochelys reticularia	Chicken turtle	3	0.8
Malaclemys terrapin	Diamondback terrapin	18	4.5
Terrapene carolina	Box turtle	7	1.8

TABLE 1.–(Continued)

Chelonia mydas	Green turtle	1	0.3
Anolis carolinensis	Green anole	2	0.5
Ophisaurus sp.	Glass lizard	1	0.3
Unidentified snake		7	1.8
Colubridae	Colubrid snake	5	1.3
Agkistrodon piscivorus	Cottonmouth	1	0.3
Rana/Bufo sp.	Frog or Toad	12	3.0
Rajiformes	Skates & Rays	10	2.5
Lepisosteus sp.	Gar	24	6.0
Elops saurus	Lady fish	1	0.3
Clupeidae	Herring	5	1.3
Ariidae	Sea catfishes	64	16.1
Ariopsis felis	Hardhead catfish	23	5.8
Bagre marinus	Gafftopsail catfish	27	6.8
Archosargus probatocephalus	Sheepshead	6	1.5
Cynoscion nebulosus	Spotted sea trout	5	1.3
Micropogonias undulatus	Atlantic croaker	11	2.8
Pogonias cromis	Black drum	28	7.0
Scianops ocellatus	Red drum	1	0.3
Stellifer lanceolatus	Star drum	2	0.5
Mugil sp.	Mullet	19	4.8
Paralichthyes sp.	Flounder	5	1.3
Total		398	

TABLE 2.–*Species List for Savannah Phase Features from the Kings Bay Site, 9Caml71.*

Species	Ct	MNI		gms	Biomass	
		No.	%		kg	%
Unidentified Mammal	66	–	–	26.6	0.54	5.3
Didelphis virginiana Opossum	2	1	0.4	0.5	0.01	0.1
Scalopus aquaticus Mole	2	1	0.4	0.3	0.009	0.09
Unidentified Rodent	3			0.1	0.003	0.03
Peromyscus sp. Mouse	8	2	0.8	0.2	0.006	0.06
Sigmodon hispidus Cotton rat	10	3	1.2	1.4	0.036	0.4
Procyon lotor Raccoon	8	1	0.4	3.1	0.07	0.7
Odocoileus virginianus Deer	20	3	1.2	112.8	2.03	19.9
Unidentified Bird	6	–	–	3.2	0.07	0.7

TABLE 2.—(Continued)

Species	Ct	MNI		gms	Biomass	
		No.	%		kg	%
Anatidae Duck	1	1	0.4	0.3	0.007	0.07
Mergus serrator Mergansor	1	1	0.4	0.3	0.007	0.07
Unidentified Turtle	119	–	–	35.55	0.394	3.9
Kinosternidae Mud turtles	9	5	1.9	3.1	0.1	1.0
Kinosternon sp. Mud turtle	3	–	–	0.9	0.04	0.4
Emydidae Basking turtles	14	–	–	9.9	0.15	1.5
Malaclemys terrapin Diamondback terrapin	44	5	1.9	44.5	0.46	4.5
Sceloporus undulatus Fence lizard	1	1	0.4	0.5	–	–
Colubridae	1	1	0.4	0.1	0.001	0.01
Opheodrys aestivus Rough green snake	3	1	0.4	0.1	0.001	0.01
Amphibian	1	–	–	0.03	–	–
Frog/Toad	2	–	–	0.15	–	–
Bufo sp. Toad	5	3	1.2	0.35	–	–
Rajiformes Skates & Rays	15	1	0.4	0.5	0.008	0.8
Dasyatis sp. Sting ray	1	1	0.4	0.2	0.03	0.3
Unidentified Fish	1183	–	–	134.9	1.94	19.0
Amia calva Bowfin	3	2	0.8	0.35	0.015	0.1
Lepisosteus sp. Gar	77	5	1.9	8.35	–	–

TABLE 2.–(Continued)

Species	Ct	MNI		gms	Biomass	
		No.	%		kg	%
Elops saurus Lady fish	1	1	0.4	0.1	0.005	0.05
Brevoortia sp. Herring	19	3	1.2	0.5	0.026	0.3
Siluriformes Catfishes	7	–	–	0.7	0.01	0.1
Ariidae Sea catfishes	293	–	–	35.1	0.62	6.1
Ariopsis felis Hardhead catfishes	51	10	3.9	7.9	0.15	1.5
Bagre marinus Gafftopsail	217	15	5.8	85.7	1.41	13.8
Lobotes surinamensis Triple tail	45	2	0.8	40.7	0.63	6.2
Archosargus probatocephalus Sheepshead	5	3	1.2	1.7	0.026	0.3
Sciaenidae Drums	31	–	–	4.95	0.157	1.5
Bairdiella chrysoura Silver perch	31	11	4.3	1.4	0.06	0.6
Cynoscion sp. Sea trout	28	10	3.9	4.45	0.16	1.6
Larimus fasciatus Banded drum	1	1	0.4	0.6	0.03	0.3
Leiostomus xanthurus Spot	5	5	1.9	0.3	0.017	0.2
Menticirrhus sp. Kingfish	1	1	0.4	0.1	0.007	0.07
Micropogonias undulatus Croaker	7	5	1.9	0.8	0.047	0.5
Pogonias cromis Black drum	13	3	1.2	2.55	0.097	1.0

TABLE 2.—(Continued)

Species	Ct	MNI		gms	Biomass	
		No.	%		kg	%
Stellifer lanceolatus Star drum	478	122	47.5	17.7	0.377	3.7
Bairdiella/Stellifer sp.	155	14	5.4	2.85	0.104	1.0
Mugil sp. Mullet	88	7	2.7	2.95	0.094	0.9
Paralichthyes sp. Flounder	50	6	2.3	7.4	0.17	1.7
Unidentified Bone	—	—	—	136.9	—	—
Total	3134	257	—	743.2	10.195	—

TABLE 3.—*Species List of Bourbon Field, 1980-1981.*

Species	Ct	MNI		gms	Biomass, kg	
		No.	%		Kg	%
Unidentified Mammal	3271	—	—	2272.51	29.95	43.9
Scalopus aquaticus Mole	3	3	0.5	0.76	0.02	0.03
Sylvilagus sp. Rabbit	47	12	2.1	21.61	0.44	0.6
Unidentified Rodent	1	—	—	0.01	0.0004	0.0006
Cricetidae New World mice	9	—	—	0.38	0.01	0.01
Sigmodon hispidus Hispid cotton rat	10	3	0.5	0.94	0.02	0.03
Carnivore	1	—	—	0.01	0.003	0.004
Ursus americanus Bear	1	1	0.2	1.9	0.05	0.07
Procyon lotor Raccoon	78	22	3.9	99.75	1.77	2.6
Mustelidae Mink family	3	—	—	0.72	0.02	0.03

TABLE 3.–(Continued)

Species	Ct	MNI		gms	Biomass, kg	
		No.	%		Kg	%
Mephitis mephitis Skunk	5	2	0.4	2.55	0.06	0.09
Odocoileus virginiana Deer	492	63	11.2	1365.37	19.06	27.9
Unidentified Bird	57	—	—	14.65	0.25	0.4
Laridae Gull Family	1	1	0.2	0.6	0.01	0.01
Icteridae Blackbird Family	1	1	0.2	0.02	0.0006	0.0009
Unidentified Reptile	3	—	—	0.06	—	—
Unidentified Turtle	2711	—	—	894.95	3.91	5.7
Kinosternon subrubrum Mud turtle	55	20	3.6	16.82	0.26	0.4
Emydidae Basking turtles	222	—	—	121.75	0.98	1.4
Deirochelys reticularia Chicken turtle	14	1	0.2	23.5	0.26	0.4
Malaclemys terrapin Diamondback terrapin	46	8	1.4	54.03	0.53	0.8
Trionyx ferox Softshell turtle	1	1	0.2	0.41	0.2	0.3
Unidentified Snake	15	—	—	0.85	0.01	0.01
Colubridae Colubrid snakes	8	7	1.2	0.4	0.005	0.007
Elaphe sp. Ratsnakes	1	(1)	—	0.1	0.001	0.002
Viparidae Pit vipers	2	1	0.2	0.62	0.009	0.01
Amphibian	8	—	—	0.07	—	—
Rana/Bufo sp. Frog/Toad	49	19	3.4	2.61	—	—

TABLE 3.—(Continued)

Species	Ct	MNI		gms	Biomass, kg	
		No.	%		kg	%
Chondrichthyes Sharks & Rays	7	–	–	0.22	0.03	0.04
Sharks	44	11	2.0	2.05	0.28	0.4
Rays	18	10	1.8	0.24	0.04	0.06
Dasyatis sabina Atlantic stingray	2	2	0.5	0.8	0.1	0.1
Unidentified Fish	5435	–	–	187.46	2.68	3.9
Lepisosteus sp. Gar	64	12	2.1	10.26	0.23	0.3
Clupeidae Herrings	484	24	4.3	4.15	0.10	0.1
Ariidae Sea catfishes	920	194	34.5	300.47	4.7	6.9
Ariopsis felis Hardhead catfish	141	(26)	–	12.51	0.22	0.3
Bagre marinus Gafftopsail catfish	191	(30)	–	35.14	0.61	0.9
Perciformes Perciform fishes	2	–	–	0.19	0.007	0.01
Pomatomus saltatrix Bluefish	15	1	0.2	0.24	0.01	0.01
Archosargus probatocephalus Sheepshead	12	7	1.2	2.4	0.04	0.06
Sciaenidae Drums	24	–	–	6.42	0.19	0.3
Bairdiella chrysoura Silver perch	20	12	2.1	0.77	0.03	0.04
Cynoscion sp. Sea trout	12	8	1.4	4.47	0.14	0.2
Leiostomus xanthurus Spot	8	8	1.4	0.1	0.01	0.01

TABLE 3.–(Continued)

Species	Ct	MNI		gms	Biomass, kg	
		No.	%		kg	%
Micropogonias undulatus Croaker	28	19	3.4	4.38	0.15	0.02
Pogonias cromis Black drum	54	21	3.7	5.84	0.2	0.3
Scianops ocellatus Red drum	9	7	1.2	18.77	0.4	0.6
Stellifer lanceolatus Star drum	14	11	2.0	0.16	0.01	0.01
Mugil sp. Mullet	679	43	7.6	8.3	0.19	0.3
cf. Eleotridae Sleepers	2	2	0.4	0.03	0.002	0.003
Paralichthyes sp. Flounder	20	5	0.9	1.18	0.03	0.04
Diodontidae Porcupine fishes	1	1	0.2	0.91	–	–
Unidentified Bone	–	–	–	1321.22	–	–
Totals	15331	563	–	6827.33	68.228	–

TABLE 4.–*Species List for North of the Shell Ring Drain*

Species	Ct	MNI		Weight	Biomass	
		No.	%	Gm	Kg	%
Ud. Mammal	391	–	–	2173.91	26.5	63.1
Sylvilagus sp. Rabbit	68	6	5.6	41.06	0.7	1.7
Cricetidae New World Mice	3	–	–	0.15	0.005	0.01
Peromyscus sp. Mouse	2	1	0.93	0.03	0.001	0.003
cf. *Sigmodon hispidus* Cotton Rat	1	1	0.93	0.10	0.003	0.01

TABLE 4.—(Continued)

Species	Ct	MNI		Weight	Biomass	
		No.	%	Gm	Kg	%
Delphinidae Dolphin Family	1	1	0.93	29.39	0.5	1.2
Procyon lotor Raccoon	3	1	0.93	10.15	0.21	0.5
Odocoileus virginianus Whitetail Deer	51	2	1.9	270.40	4.06	9.7
Ud. Bird	117	–	–	18.95	0.30	0.71
Anas sp. Surface-feeding Duck	28	3	2.8	15.97	0.25	0.60
Rallidae Rail	3	1	0.93	0.54	0.01	0.02
Icteridae Blackbird Family	1	1	0.93	0.19	0.005	0.01
Ud. Turtle	71	–	–	20.41	0.24	0.57
Emydidae	69	–	–	24.20	0.27	0.64
Malaclemys terrapin Diamondback Terrapin	60	2	1.9	37.23	0.36	0.86
Ud. Snake	1	–	–	0.05	0.0007	0.002
Colubridae Non-Poisonous Snakes	1	–	–	0.05	0.0007	0.002
Coluber constrictor Black Racer	1	1	0.93	0.08	0.001	0.003
cf. Viparidae Poisonous Snakes	1	1	0.93	0.20	0.003	0.01
Ud. Amphibian	2	–	–	0.02	–	–
Rana/Bufo Frog/Toad	11	2	1.9	0.42	–	–
Squaliformes Sharks	1	1	0.93	0.01	0.002	0.005
Dasyatis sabina Atlantic Stingray	2	1	0.93	0.01	0.002	0.005

TABLE 4.–(Continued)

Species	Ct	MNI		Weight	Biomass	
		No.	%	Gm	Kg	%
Ud. Fish	2872	–	–	279.37	2.83	6.7
Ariidae Sea Catfishes	489	–	–	95.31	1.5	3.6
Ariopsis felis Hardhead Catfish	583	54	50.5	149.01	2.32	5.5
Bagre marinus Gafftopsail Catfish	106	4	3.7	32.10	0.54	1.3
Sciaenidae Drum Family	33	–	–	27.47	0.45	1.1
Bairdiella chrysoura Silver Perch	16	8	7.5	0.68	0.03	0.07
Cynoscion regalis Weakfish	9	7	6.5	0.61	0.03	0.07
Leiostomus xanthurus Spot	11	6	5.6	0.17	0.01	0.02
Pogonias cromis Black Drum	155	1	0.93	102.87	1.20	2.9
Scianops ocellatus Red Drum	12	1	0.93	0.37	0.02	0.05
Mugil sp. Mullet	3	1	0.93	0.04	0.002	0.005
Ud. Bone	284	–	–	14.68	–	–
Totals	5462	107	–	3346.27	42.36	–

While the samples from these coastal sites are generally outstanding in terms of size, there remains screening biases. As is the custom where fine-screen recovery methods are used, soil from entire units was screened through ¼ in mesh, but only a portion of the unit was screened through 1/8 in mesh (Kings Bay) or 1/16 in mesh (Sapelo Island). For analysis, faunal remains collected from the ¼ in zone and fine-screened column samples and features were combined. Obviously it is not accurate to present as a single, unified sample a collection in which roughly 6% of the soil was screened through 1/8 or 1/16 in mesh and the remaining 94% was collected by ¼ in mesh. As a result of such a combination there is an over representation of large bones, representing species such as deer, and a reduction in small species such as star drum.

TABLE 5.—*Exploitation Patterns*

MNI

	Kenan		Bourbon		NSRD		Kings Bay	
	No.	%	No.	%	No.	%	No.	%
Terrestrial Mammals	73	18.3	100	17.8	9	8.4	5	1.9
Cetacea	1	0.3	–	–	1	0.9	–	–
Birds	8	2.0	2	0.4	5	4.7	2	0.8
Turtles and Gator	47	11.8	30	5.3	2	1.9	10	3.8
Snakes	13	3.3	8	1.4	2	1.9	–	–
Fish, Sharks, Rays	231	58.0	398	70.7	84	78.5	228	88.7
Commensals	25	6.3	25	4.4	4	3.7	12	4.7
Total	398	–	563	–	107	–	257	–

Biomass

	Bourbon		NSRD		Kings Bay	
	Kg	%	Kg	%	Kg	No.
Terrestrial Mammals	21.4	72.8	4.97	48.4	2.11	33.6
Cetacea	–	–	0.5	4.9	–	–
Birds	0.01	0.03	0.27	2.6	0.01	0.2
Turtles	1.25	4.3	0.36	3.5	0.6	8.9
Snakes	0.01	0.03	0.004	0.04	–	–
Fish, Sharks, Rays	6.7	22.7	4.16	40.6	3.5	56.3
Commensals	0.04	0.1	0.004	0.04	0.05	0.8
Total	29.36	–	10.27	–	6.27	–

This observation becomes critical when evaluating the results in Table 5 which provides a summary of major groups of fauna represented at each site. The primary taxa at all four sites are marine animals, while marsh and terrestrial fauna are generally minor by comparison. The most striking anomaly is observed from the Savannah Phase features at Kings Bay where less than 2% of the individuals are mammals. Recall that this is the collection where 100% of the soil was screened through 1/8 in mesh, rather than only 6% at Sapelo Island sites.

The importance of this anomaly can be seen in two more examples. The first example compares three components of the Kings Bay Site (Table 6). The San Marcos zone material was recovered with ¼ in screen while all of the column samples were recovered by 1/8 in screen. While the difference between deer and small drums might be the result of cultural factors, it is more likely to be a function of screen-size. With only 50 individuals represented, the San Marcos column sample provides only a relative basis for comparison, but it does serve to explain the difference between the San Marcos Zone example and the Savannah phase features where the MNI is similar.

For the second example, the Bourbon Field shell midden tests were reevaluated (Table 6). Each unit was excavated 94% using ¼ in screen and 6% was fine-screened. When the column samples are examined alone, terrestrial mammals provided only 2% of the individuals and fish 89%, a distribution similar to that of the Savannah phase features and San Marcos column samples at Kings Bay.

For the purposes of this analysis, it seems reasonable to conclude that features and column samples where 100% of the sample was recovered in the same screen size are more reliable than samples collected unequally by different screen sizes.

DISCUSSION

It is common to consider the Mississippian subsistence strategy as more or less uniform based upon horticulture and hunting, primarily of deer (Cleland 1966; Smith 1975). While in many interior areas this may well have been the case, it seems reasonable to predict that there would be variation on this theme in response to locally available food stuffs. The response might be so precise that populations occupying the same environment separated by only 81 km of coast may have practiced different subsistence strategies, none of which emphasized deer. There also appears to have been a subsistence shift between Savannah and Irene phases on Sapelo Island as evidenced by the differences in faunal assemblages from the North of the Shell Ring Drain site and the two villages.

When the faunal assemblages from Kenan Field and Bourbon Field are compared there were few striking differences (Table 5). These two sites are primarily Savannah/Irene phases, although Crook does not think they were occupied simultaneously (personal communication). The only substantial difference is in the amount of turtles consumed at Kenan Field compared with Bourbon and a related reduction in the volume of fish. The Kenan materials are more diverse than those at Bourbon, perhaps because of the more extensive salt marsh bordering Kenan Field compared to that of Bourbon. Another interesting contrast is found between the use of mullets *(Mugil* spp.), star drum *(Stellifer lanceolatus),* silver perch *(Bairdiella chrysoura),* and herrings (Clupeidae) at Bourbon and the virtual absence of these animals at Kenan. These fishes should be equally common on both sides of the Island. The mullets at Bourbon Field were small individuals, represented primarily in the 1/8 in mesh samples, the same screen size in which star drums *(S. lanceolatus),* silver perches *(B. chrysoura),* and herrings (Clupeidae) are most likely to be recovered. It appears that a fine-meshed, mass-capture technique was used extensively at Bourbon and seldom used at Kenan Field. If not occupied throughout the year, Bourbon may have been occupied intentionally at specific periods to take advantage of these species. Although they could have been captured off of Kenan Field, it is possible that it was more efficient to catch these fish at Bourbon for reasons not evident today.

TABLE 6.—*Comparison of Fine-Screened (FS) and ¼ in-Screened Samples*

	Sapelo Island				Kings Bay				Savannah	
	Bourbon C.S. + F.S.		NSRD F.S.		San Marcos Zone ¼"		San Marcos C.S.* F.S.		Features F.S.	
	MNI	%	MNI	%	MNI	%	MNI	%	MNI	%
Terrestrial Mammals	3	1.9	9	8.4	37	18.0	2	4.0	5	1.9
Cetacea	—	—	1	0.9	—	—	—	—	—	—
Birds	—	—	5	4.7	8	3.9	2	4.0	2	0.8
Reptiles	4	2.6	4	3.7	26	12.7	2	4.0	10	3.8
Fish, Sharks, Rays	139	89.1	84	78.5	127	61.9	43	86.0	228	88.7
Commensals	10	6.4	4	3.7	7	3.4	1	2.0	12	4.7
Total	156	—	107	—	205	—	50	—	257	—
Deer	2	1.3	2	1.9	13	6.3	1	2.0	3	1.2
Stellifer/Bairdiella	22	14.1	8	7.5	1	0.5	5	10.0	147	57.2

+ Bourbon Column Samples
* San Marcos Column Samples

It is generally agreed that Sapelo Island and Kings Bay were occupied historically by two distinct groups: Guale at the northern location and Timucuans at Kings Bay and points south (Milanich and Proctor 1978). It is tempting, therefore, to interpret the difference observed between the aboriginal Sapelo Island data and the Kings Bay data as cultural ones. In order to keep recovery technique relatively constant, the column-sample data from Bourbon Field should be compared with the Savannah Phase features at Kings Bay. The animals of choice at Kings Bay were clearly small drums, primarily the star drum *(S. lanceolatus).* Neither mullets *(Mugil* spp.) nor herrings (Clupeidae), the dominant species at Bourbon, are common at Kings Bay. The emphasis on star drums at Kings Bay strongly suggests an intentional effort to acquire this fish to the exclusion of other animals. Star drums prefer more saline waters than do some other estuarine fishes. More data are needed about natural differences between the two areas and human use of both locations before this difference can be ascribed cultural significance, but there does appear to be tentative evidence for such a difference.

The later coastal strategy, here represented by the Irene component at North of the Shell Ring Drain, was different in some aspects from earlier subsistence patterns. In the first place, deer are a minor component. Since deer bones were more likely to be recovered than the fishes because of recovery techniques, this suggests low numbers of deer taken by the inhabitants. This finding may also be the result of differential distribution of refuse as the midden was deposited, since the excavation units were contiguous at the site rather than randomly distributed over a wide area as at the other Sapelo Island sites and at Kings Bay. Placement of excavation units would affect MNI aggregation. The two striking features of this sample are the abundant remains of sea catfishes (Ariidae), primarily the hardheaded catfish *(Ariopsis felis),* and the somewhat increased number of bird elements. The presence of so many catfishes may indicate a primarily hook-and-line technology in contrast to an earlier net technology. The presence of both spots *(Leiostomus xanthurus)* and silver perches *(B. chrysoura)* suggests continued use of nets, weirs, or basketry scoops although both fish will take hooks. Use of birds during this period is unusual for aboriginal subsistence on the Georgia coast, but not unusual for historic occupations (Reitz 1979a, 1979b; Smith et al. 1981). The San Marcos component at Kings Bay also reflected an increased use of birds (Table 6). This may have been the result of European influence on the aboriginal hunting strategy.

While fishing was clearly a major activity at all of these sites, fish were not the only source of animal protein in the diet. Biomass was calculated for three of the sites. As might be expected, terrestrial mammals, primarily deer, contributed a substantial amount of biomass. However, deer contributed over 50% of the biomass only at Bourbon Field. Based on sampling considerations, the figures from the Savannah Phase features at Kings Bay are thought to give the most accurate picture of the diet. They show that fishing and hunting were both important activities, with fishing somewhat more so.

The diversity and equitability figures also demonstrate this point. Diversity ranged from 2.0 at North of the Shell Ring Drain to 3.2 at Kenan Field. Equitability range was 0.65 to 0.83. In terms of individuals (MNI) the strategy was one in which a few major species and a number of less important ones were used. In terms of biomass, considering only the Savannah Phase features from Kings Bay, once again a limited range of species was used, with a few animals being more important than the others. Diversity range was 1.4 to 2.2 and equitability 0.39 to 0.64. The most important animals were drums, particularly silver perches, and star drums; sea catfishes; deer; diamond-back terrapines; and occasionally spots and croakers.

The major biotope exploited appears to have been the tidal creeks. Terrestrial areas were exploited primarily for deer; very few other mammals, freshwater or terrestrial turtles, and birds were taken. The fishes, sharks, rays, sea turtles, diamond-back terrapins, bottle-nosed dolphins, and alligators could have been taken in the nearby marshes and tidal creeks. Most fishing could have been done from shore or in shallow waters.

Seasonal indicators are less apparent than could be expected from other geographical areas. The species used are primarily multi-seasonal and those few animals which are restricted seasonally were not exploited to any great extent. Distinctly warm weather species such as sea turtles and sharks attest to warm weather occupation at the Kenan, Bourbon, and North of the Shell Ring Drain sites. Herrings and fingerling mullets at Kenan, Bourbon, North of the Shell Ring Drain, and Kings Bay may document a cold weather occupation (DEIS 1978). Star drums and silver perches are more abundant in the fall and spring and suggest fall and spring occupations at all sites. It appears that occupation of sea-island locations was not confined to a single summer residence, but was either intermittent throughout the year or continuous. This possibility is partially supported by ethnographic and archaeological evidence (Crook 1978).

Fishing technology clearly emphasized techniques appropriate to the capture of small fishes. Star drums *(S. lanceolatus)* have an approximate maximum length of 15 cm (Hoese and Moore 1977) and silver perch *(B. chrysoura)* have a maximum length of about 23 cm. The mullets recovered at most sites, particularly at Bourbon Field, were also in this size range. Spots *(L. xanthurus)* and croakers *(Micropogonias undulatus)* are small fishes; spots occasionally attain 25 cm in length and croakers about 6 cm in length. The small drums might have been caught by hook and line, but not the mullets. The quantity of small drums and the presence of mullets suggest use of impoundment or trapping devices such as nets, scoops, or weirs. Nets could have been placed across tidal creeks, while weirs could have been used where the bottom was firm such as near oyster bars. Even catfishes (Ariidae) and the small sharks found in these collections could have been captured by these devices. Such mass capture techniques would indicate group-subsistence efforts were in use.

CONCLUSIONS

The data presented here suggest resources of the estuarine environment were selectively exploited. Sites were occupied perhaps during more than one season as these resources became available. Mass-capture techniques may have been employed in securing selected species, most of which were small drums and mullets, while other estuarine species and deer were also taken. Among the sites there is sufficient variations of represented fauna suggest there were strategies specific to each location with some evidence for temporal and cultural variation as well. However, these samples conform to a general coastal pattern which includes the following: use of deer to some extent, varying from site to site but rarely more than 50% of the biomass or 11% of the individuals; low use of birds; occasional use of turtles, both marine and aquatic; heavy use of marine fishes, primarily small drums and sea catfishes. Use of large numbers of small fishes suggests a fishing technology employing nets and weirs rather than hand-lines or trot-lines.

Clearly more work needs to be done on coastal subsistence, with appropriate concern for field techniques. Based on these collections it can be predicted that systematic column sampling will undoubtedly produce faunal samples over the 200 MNI mark. On that basis it is recommended that future excavators submit for identification and analysis only their column samples and features. It can be argued that 1/4 in mesh is inadequate for sampling coastal aboriginal shell middens. It is also inappropriate to use 1/4 in screen for the bulk of the soil and fine-screen only a portion, but combine the species lists. Archaeologists need to consciously make a decision concerning screen sizes to use in the field as recommended by Thomas (1969). If these guidelines are followed, it may be that the full complexity of coastal subsistence of mainland, marsh-island, and sea-island sites along the Georgia coast for all times periods will be revealed.

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BIOLOGICAL CLASSIFICATION FROM A GROOTE EYLANDT ABORIGINE'S POINT OF VIEW1

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ABSTRACT.–This paper reviews the contributions of Berlin, Bulmer, Dwyer, Hunn and Randall to the interpretation of folk classification systems. The problems of comparison of folk taxa with scientific taxa, of determining the degree of perception of discontinuity, of assessing the cognitive status of folk taxa and of the nature of folk taxonomies are identified and discussed. Biological classification from the view point of Aborigines on Groote Eylandt in northern Australia is described using Berlin's set of terms as a convenient reference point. Examples given provide additional evidence for the notion of a basic unit of perception within folk classification systems though this unit cannot as yet be satisfactorily defined. It is suggested that folk taxa may be arranged in contrast sets according to purpose and that only those sets required for the purpose would be called on to generate a hierarchical classification.

INTRODUCTION

In recent years increasing interest has been taken in the principles of folk classification. Research workers have been fascinated by the relatively high degree of correspondence between folk biological taxa and scientific taxa. Our scientifically trained minds immediately see the parallels between folk categories at different levels of inclusiveness and the scientific hierarchy. The major contributions based on exhaustive studies of either the plant or animal kingdoms in a particular culture have been from Conklin (1954), Bulmer and co-workers (1968-1977), Berlin, Breedlove and Raven (1974), Hunn (1977) and Hays (1979). Each of these researchers has described the folk classification system of the area studied as hierarchically organized. However, while these folk classificatory hierarchies are similar in many ways, researchers have interpreted them from different perspectives which has led to different taxonomic structures accompanied by different sets of terms.

The reasons for these differences I consider to be threefold. Dwyer (1976:425) identified two of these issues in reporting his analysis of Rofaifo mammal taxonomy, viz. 1) 'To what extent does the folk classifier perceive the same entities as the scientific zoologist?' and 2) 'What is the cognitive status for folk of taxa located at different levels of their zoological taxonomy?' The third issue has been raised by Randall (1976:544), viz. Are hierarchical classification systems stored as such in the memory or are they only a result of classification behavior on the part of the folk classifier?

THEORETICAL ISSUES

Comparing perceptions.–Dwyer has pointed out that determining the correspondence between two systems is a question of perception. There must be some way of establishing their relation. He selected the scientific species as the objective unit with which folk taxa, regardless of status, must be compared. Berlin advocated comparison of the scientific species with his folk genera, though he has also compared it with his folk species (Berlin et al. 1973:267-8, 1974:102). However I agree with Hunn (1977: 64) that 'it is not the case that the scientific species *must* be selected.' I understand him to be saying that, while the scientific species is indeed a basic objective unit, irrespective of evolutionary theory, we need to take cognizance of the range of scientific species in a given environment before determining the degree of correspondence. Hunn has devised what he calls a coefficient of dissimilarity, which is calculated after removing any scientific taxa that cannot be found in the local environment plus scientific taxa below the level of (labeled) terminal folk taxa. This measure is not affected by the cognitive status of folk taxa. It utilizes scientific taxa as the objective basis of comparison with folk taxa of whatever status. It should be noted that despite the objectivity of the scientific species it necessarily has a cognitive status within the scientific classification hierarchy.

Implicit in Dwyer's first question is the western scientifically oriented view point. The question could equally have been framed: To what extent does the scientific zoologist perceive the same entities as the folk classifier? As there are many folk classification systems but essentially only one scientific classification system comparison would certainly be easier if the degree of correspondence is determined with reference to the scientific system. But a further difficulty is in determining a unit from within the folk classification system to which general agreement can be given. To my mind no-one has yet been able to suggest a satisfactory objectively defined unit from within the folk system.

Berlin, Breedlove and Raven (1973:215) proposed the folk genus, defined largely on the basis of the distinction between primary and secondary lexemes. Thus generic taxa are so called because they are labeled by generic names. Hunn (1977:45) has suggested that this association of taxa and names should be verified by specifying independent criteria for recognizing types of names and types of taxa. I have heard Berlin has now had second thoughts in the light of more recent examples that do not fit easily into his original scheme.

Bulmer and Tyler (1968:349) proposed the specieme or folk species which is the lowest level taxon defined in terms of multiple criteria. The specieme is seen as a 'natural' category within the environment—'something crying out to be named,' as someone has said. But Bulmer too has had second thoughts about this concept in the light of Kalam interchangeable usage of names at apparently different levels of inclusiveness. The rejection of these two apparently objective units brings us to the second issue raised by Dwyer.

Cognitive status and perception of discontinuity.—Assessing the cognitive status for folk of taxa within their zoological (or botanical) taxonomy revolves around what are perceived as 'natural' categories within their environment. Bulmer (1970, 1974) considered that, in the case of locally familiar organisms, the majority of folk taxa corresponded to 'natural' categories, i.e. to those defined on the basis of multiple criteria. When such folk taxa correspond to recognized scientific taxa it is then tempting to assume that these folk taxa refer to 'natural' categories of equivalent cognitive status. It is much easier to match taxa with scientific species, genera, families, etc. than it is to establish with certainty that they are 'natural kinds' in the perception of the local people (Bulmer, pers. comm.).

In discussing Lévi-Strauss's concept of *espèce* which has been translated as species, Bulmer (1970:1072) identified one of the assumptions underlying Lévi-Strauss's argument, viz. 'that in any total folk-classification of plants and animals there are certain important lower order categories which are seen as "objective" by the users of the classification . . . ' Bulmer (1970:1081) then argued that 'Karam zoological classification, at the lowest level, is concerned with objective discontinuities in nature.' He considered that the basis of such objectivity is in the observable differences between biological species although he recognized that not all folk taxa will be classified in a biologically realistic manner.

Hunn (1977:50) has indicated that the majority of folk taxa can be recognized by characteristic configurations and are defined by significant discontinuities between contrasting categories. Underlying his mathematical treatment of these discontinuities is the assumption that the points at which discontinuities are perceived vary from culture to culture, and between folk and scientific taxa because the perception of discontinuity—in Hunn's terms, the perceptual salience—varies. Hunn's approach seems to readily include all folk taxa whereas Bulmer's approach accepts some and makes exception for others.

The perception of discontinuity may be affected by: 1) identifiable characteristics, 2) cultural significance, and 3) frequency of observation. If the identifiable characteristics of two or more scientific taxa are minimal and there is little or no difference in their cultural significance then they may be perceived as one entity even though the differences between them may be recognized. Similarly, if an animal or plant is only rarely encountered it may be included with another scientific taxon, and thus again be perceived as one entity. At this point I would differ with Bulmer and Dwyer who consider terminal unlabeled subdivisions of taxa to have the same status as labeled terminal taxa. To me they appear to have fallen into the trap of assuming that correspondence with scientific taxa implies the same degree of perception of discontinuity despite Bulmer's awareness of this trap (Bulmer, 1970:1078). Discontinuities are not perceived at the same point.

As against Bulmer and Dwyer, I would say that the basic perception of discontinuity, the *basic* units as seen by folk themselves, must firstly be labeled, i.e. named, and secondly be undivided, i.e. perceived as a unitary whole which, on occasion, can be further subdivided. Linguistically labeled subdivided taxa, such as Berlin's folk species, represent a different degree of perception. Their identifiable characteristics would not be expected to differ as much as the identifiable characteristics separating undivided taxa, though the subdivided taxa may still be defined on the basis of multiple criteria. Linguistically unlabeled subdivisions of a taxon represent a different degree of perception again. I fail to see how an unnamed subdivision of a taxon can have the same conceptual content as a labeled taxon nor, for that matter, how a secondary lexeme can have the same conceptual content or cognitive status as an undivided primary lexeme. Berlin, Breedlove and Raven (1973:240) go so far as to say that there are different psychological processes involved in distinguishing taxa at different levels of inclusion.

I think it is implicit in the work of Berlin, Hunn and Hays that it is only the named taxa, at least at the lowest levels, which truly reflect the perception of discontinuity and thus of 'natural' categories. There are differences in the degree of the perception of discontinuity as indicated above. It is these differences which give rise to differing cognitive status and thus the different levels of a taxonomy.

The problem arises in seeking to assess the cognitive status of those taxa at the lowest levels and likewise of taxa at higher levels of inclusion. It is at this point that Berlin has confounded the questions of perception and of cognitive status as Dwyer (1976:433) claims. Berlin's folk genus purports to convey both cognitive status and perception of discontinuity—without, however, the degree of discontinuity being satisfactorily defined.

Hunn (1977:51) has sought to redefine the status of generic taxa in terms of 'the width of the gaps isolating taxa and the "width" of heterogeneity, of the taxa themselves.' The major difficulty of such a formulation, as Hunn himself has said, is the problem of measurement.

The nature of folk taxonomies.—Berlin, Breedlove and Raven (1973:216) have recognized folk generic taxa as the basic building blocks of all folk taxonomies, i.e. the most commonly referred to groupings of organisms in the natural environment and the most salient psychologically. They have then ranked folk taxa by inclusion relationships to produce five levels of inclusiveness (Fig. 1).

They have allowed for the possibility of intermediate levels but the latter are generally covert in their experience. Equivalent rank, or cognitive status, is maintained for taxa of equivalent lexemic status and psychological salience. Thus the majority of folk generic taxa are found at Level 2 regardless of whether or not they are terminal taxa. Some taxa of generic rank, i.e. unaffiliated generics, are raised in level because of the lack of a superordinate taxon. Although Tzeltal does not have labeled unique beginners for the plant and animal kingdoms, Berlin, Breedlove and Raven's hierarchical classification has allowed for this possibility. They have essentially taken the observed system, started at the top and worked down in order to impose the levels of their hierarchy but allowing the same rank to appear on more than one level. Hunn (1977:53) and Hays (1979:253) essentially followed Berlin, Breedlove and Raven's schema but with minor modifications.

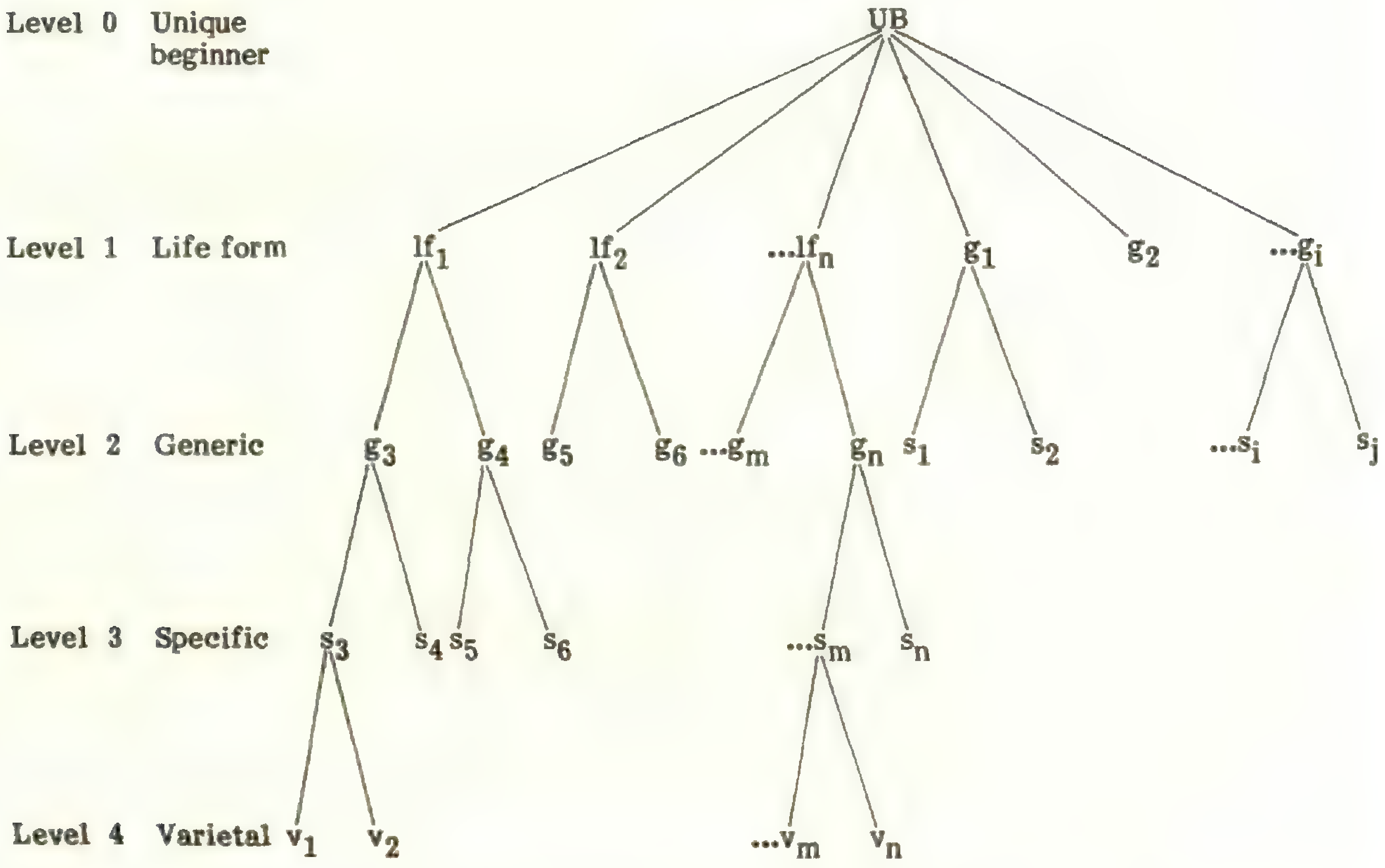

FIG. 1–Schematic presentation of Berlin's schema. (Adapted from Berlin, Breedlove & Raven, 1974:26).

In establishing his hierarchical classification of Kalam vertebrates Bulmer (1968: 622) began with the most inclusive labeled taxa, i.e. primary taxa, and worked downwards, through as many as three additional levels, to the terminal taxa. A schematic interpretation of Bulmer's data is shown in Figure 2 for comparative purposes.

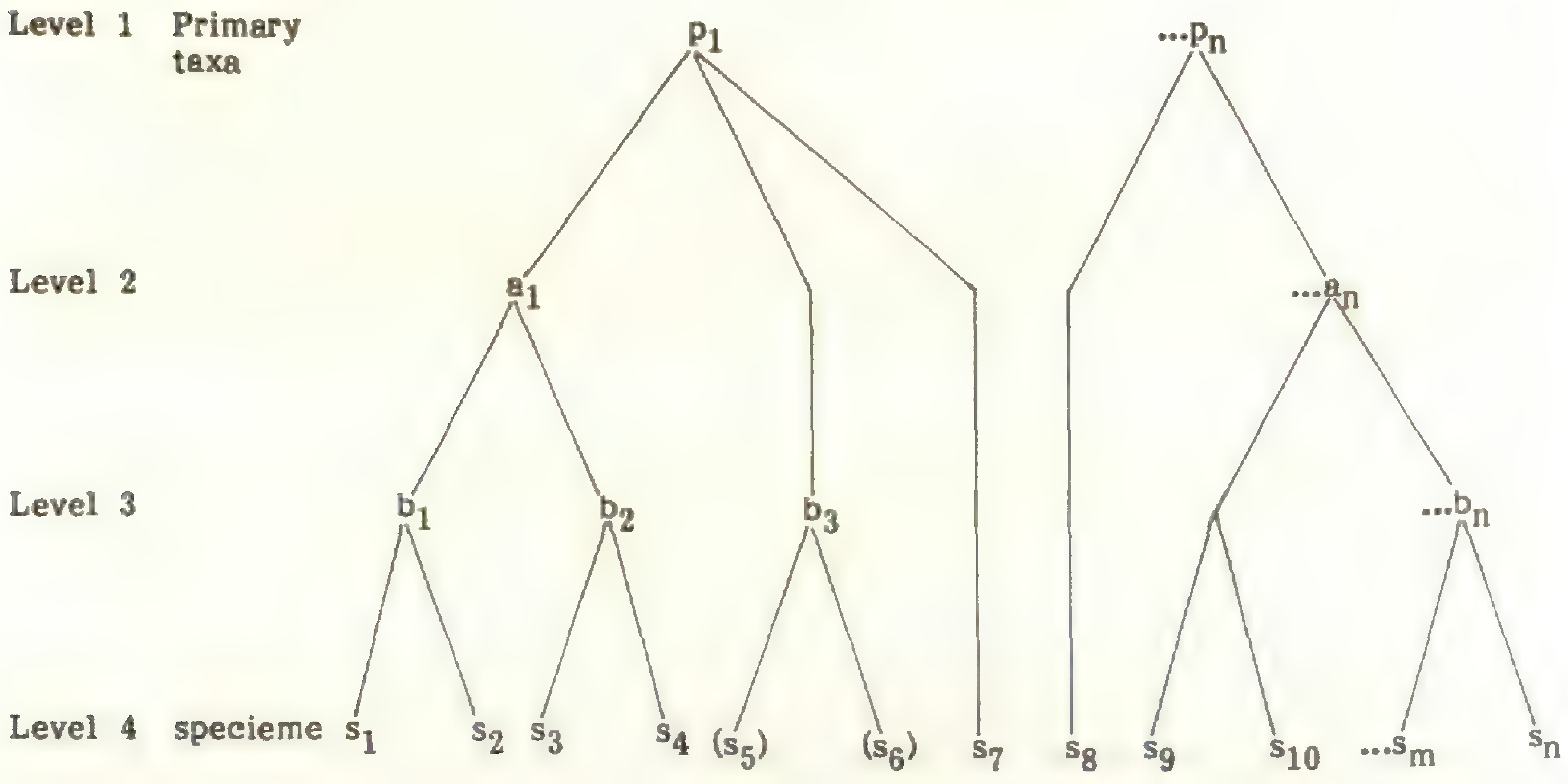

FIG. 2–Schematic interpretation of Bulmer's data.

Bulmer's primary taxa vary considerably in their degree of internal variation. In his experience terminal taxa may be at any of four levels but most are at Level 2. In the majority of cases it is the terminal taxa which represent the 'natural kinds' or folk species that Bulmer considered the Kalam themselves recognize. In some instances these 'natural kinds' are unlabeled subdivisions of a terminal taxon and could be considered as covert species. Thus the rank, or cognitive status, of folk species cannot be fixed within the hierarchy, either by position or by the terminology employed. I find it difficult to accept that the cognitive status of the basic units of perception can be variable.

Dwyer (1976:435) used Bulmer's concept of 'specieme' or folk species but reversed the levels applied to taxa. In other words he worked from the bottom upwards through categories of increasing inclusiveness. Again a schematic interpretation of Dwyer's data has been provided for comparative purposes (Fig. 3).

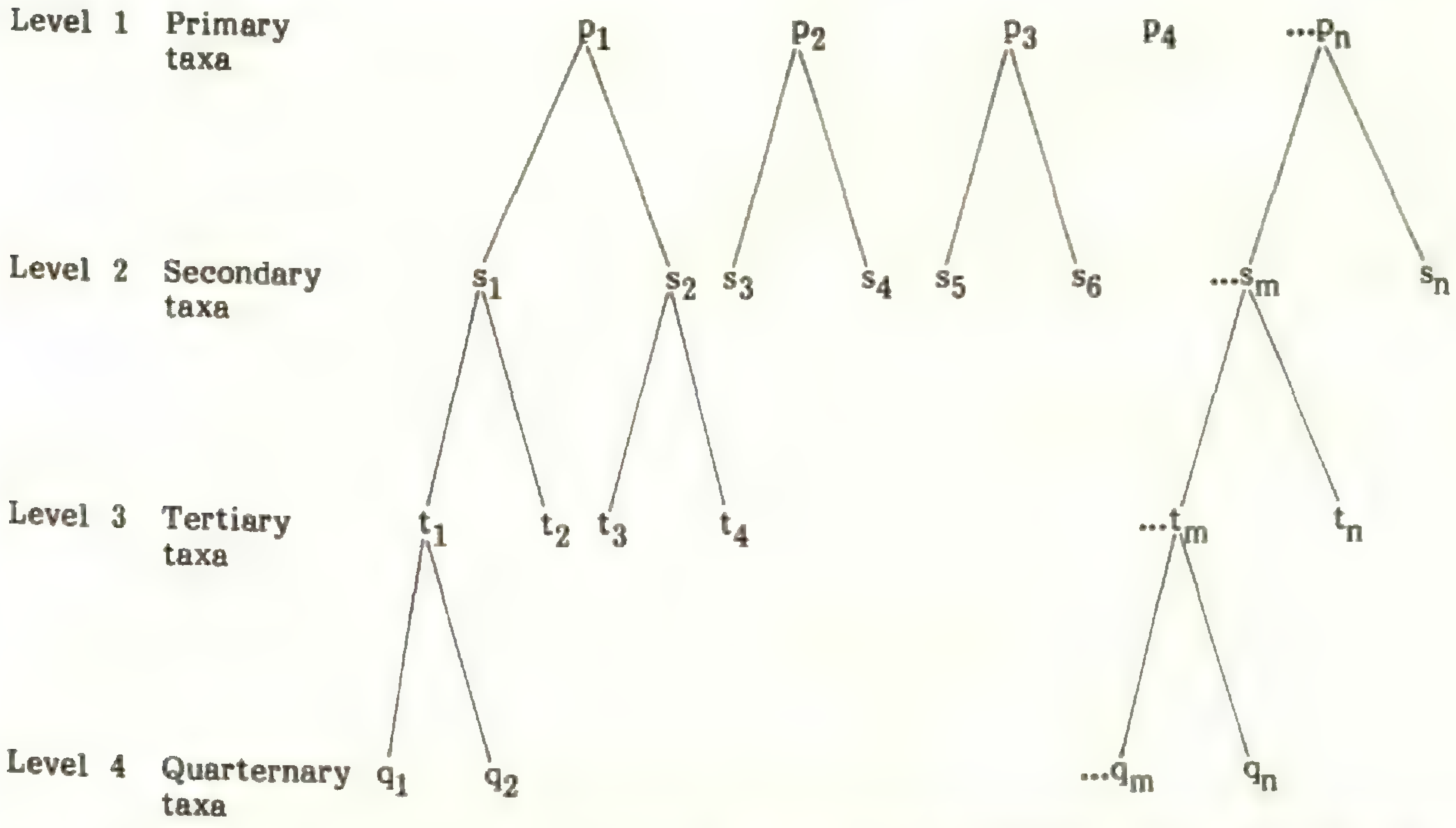

FIG. 3–Schematic interpretation of Dwyer's data. ( ) designate unlabeled taxa at the lowest level.

From the figure it will be seen that unlabeled subdivisions of taxa have been given equivalent rank to labeled undivided taxa. As indicated in the previous section, I would question the validity of Dwyer's interpretation. Since Dwyer's study is limited essentially to mammals he gives no examples of taxa equivalent to Berlin's unaffiliated generics. However he does give examples of taxa not included in any but the highest level of inclusiveness.

Each of these workers has assumed that there is a valid observable hierarchical system of folk classification. Randall (1976:546) questioned this, suggesting that while the various adjacent levels of a hierarchy may well represent valid relationships, the total hierarchy is something contrived in the mind of the informant, generated by appropriate questioning. The trouble, as Randall has seen it, is that there may be instances of non-transitive relationships appearing in such hierarchies where, for argument's sake, a scrub oak is a kind of oak and an oak is a kind of tree but a scrub oak is not a tree, it is a shrub.

Randall favored a non-hierarchical classificatory schema, based on an association between categories and their perceptual characteristics stored directly in the memory (Fig. 4). By his mixing of categories from a variety of special purpose classification systems, e.g. food classification, with the general purpose biological classification system, the complexities of Randall's system are mind-bogging, especially if there is a high degree of binomialisation.

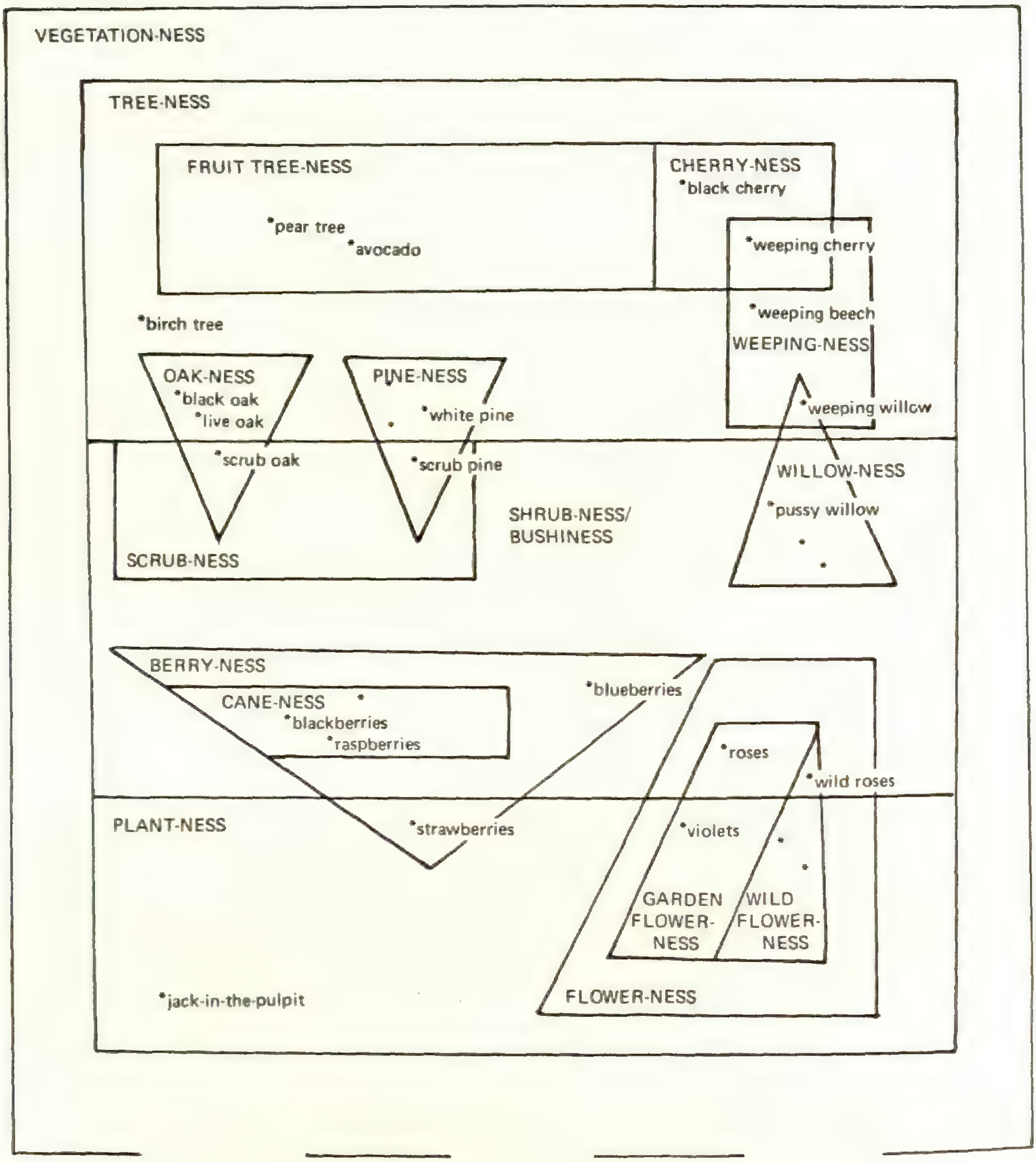

FIG. 4–Randall's model. A memorisation of characteristics model of some English plant categories. (Randall, 1976:551).

In other words the basic problems still remain: How do we determine what are 'natural' categories within a folk classification system? How do we determine their cognitive status? and, How is the folk classification system derived? I want to return to these questions after first discussing biological classification from the point of view of Groote Eylandt Aborigines.

GROOTE EYLANDT CLASSIFICATION

Groote Eylandt, which is roughly 40km wide and 60km long, is situated in the Gulf of Carpentaria, (Fig. 5). I have been living at Angurugu on Groote Eylandt since 1975.[2]

FIG. 5 – Map showing Groote Eylandt and surrounding islands in relation to the mainland of Australia.

The language spoken by the Aborigines of Groote Eylandt is Anindilyakwa, a language that is confined almost entirely to Groote Eylandt and surrounding islands. This language is characterized by its multiple noun classes, its extensive prefixing and suffixing systems, and by its very long words.[3]

I have drawn on a comprehensive inventory of some 220 plant taxa obtained largely by Dulcie Levitt (1981), and some 420 animal taxa, many of which were first recorded by Judith Stokes, linguist with the Church Missionary Society at Angurugu. Although the list of folk taxa is virtually complete the number of scientific species represented by these taxa is still not finalized. Much of my work in the early stages of the project was in obtaining scientific classification of animal specimens. Having gained familiarity with almost all animal and plant kingdom taxa on the island, at least through references if not with the actual specimens, I then turned my attention to the classification system as a whole.

Much of the information which follows has been patiently imparted to me by Peter Nangurama, a man about 55 years old of the Wurrawilya clan with an extraordinary knowledge of the plants and animals on the island. He is a recognized local authority. I have also learned a tremendous amount from a number of the old women. It is only the older folk who lived as young adults in the bush who have any extensive knowledge. There have been very few discrepancies in the naming of taxa but there may be slight changes when some of the less clearly defined areas, such as covert categories, are checked with other people.

For convenience I shall use Berlin's set of terms as a point of reference in describing Anindilyakwa taxa.

The Plant Kingdom: Amarda.—Unlike the majority of languages, Anindilyakwa has terms which are used as unique beginners both for the plant kingdom, viz. *amarda,* and for the animal kingdom, viz. *akwalya.*[4] The term *amarda* is also used to refer to one of the two life form taxa. These taxa are based on binary opposition of woody vs. non-woody. Thus *eka* refers to all woody plants, viz. trees and shrubs, and *amarda* includes all non-woody plants, viz. grasses, sedges, rushes, herbs, vines, creepers, ferns, seaweeds and so on (Fig. 6).

The only plant which does not fit unambiguously into these two life form taxa is the cycad or burrawang, *Cycas angulata.* The burrawang stem is soft rather than woody, despite its tree-like form, but is deep-rooted like other trees.

Within the woody plants there is a total of 114 generic taxa. Nangurama has grouped them into eight categories, partly on the basis of similarity in form and partly on the basis of shared habitat. Three of these categories are further subdivided into three or four categories. One of these latter categories is named, viz. *alyukwurra* the paperbarks. The seven taxa included within *alyukwurra* (Fig. 7) all appear to have the same psychological salience as other generic taxa, such as the examples in Figure 6. Thus *alyukwurra* has been interpreted as a labeled intermediate taxon in Berlin's terms.

The non-woody plants include a total of 79 generic taxa. Nangurama has grouped these taxa into three large covert categories and one small one which includes the six seaweed taxa. An alternative grouping was proposed by another local authority on the basis of root form. He divided each of the two larger categories into two. The existence of these alternative categories suggests that they may not be as well-defined as the covert categories reported by Berlin, Breedlove and Raven (1968:294-296).

In comparison with the data on plants presented by Berlin, Breedlove and Raven and by Hays, there are extraordinarily few labeled taxa of specific rank in Anindilyakwa. One example is in the group of grasses with awned seeds *dingarrkwa. Dukwulyadada dingarrkwa* meaning 'white seeds' refers to *Aristida browniana* and *dumurrijungwa dingarrkwa* meaning 'black seeds' refers to *Pseudopogonatherum irritans,* neither of which has particular cultural significance. Other examples of specific taxa found are big-leaved/ small-leaved (3 generic taxa), good/ bad (of no use) (1generic taxon), and the 'real' or 'true' one, (several instances).

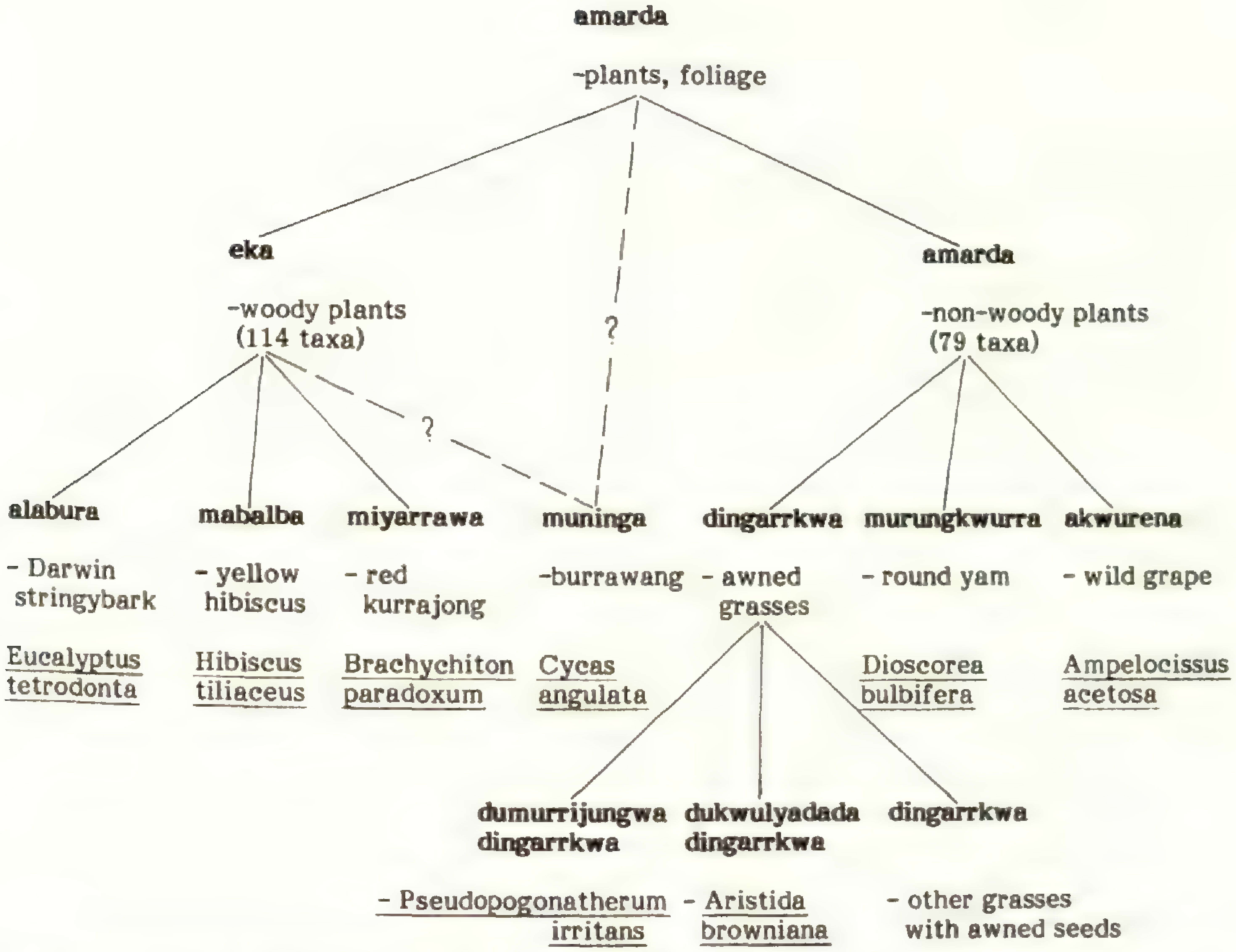

FIG. 6–Biological classification in the plant kingdom from an Anindilyakwa speaker's point of view. Numbers of taxa are those designated generic by Berlin.

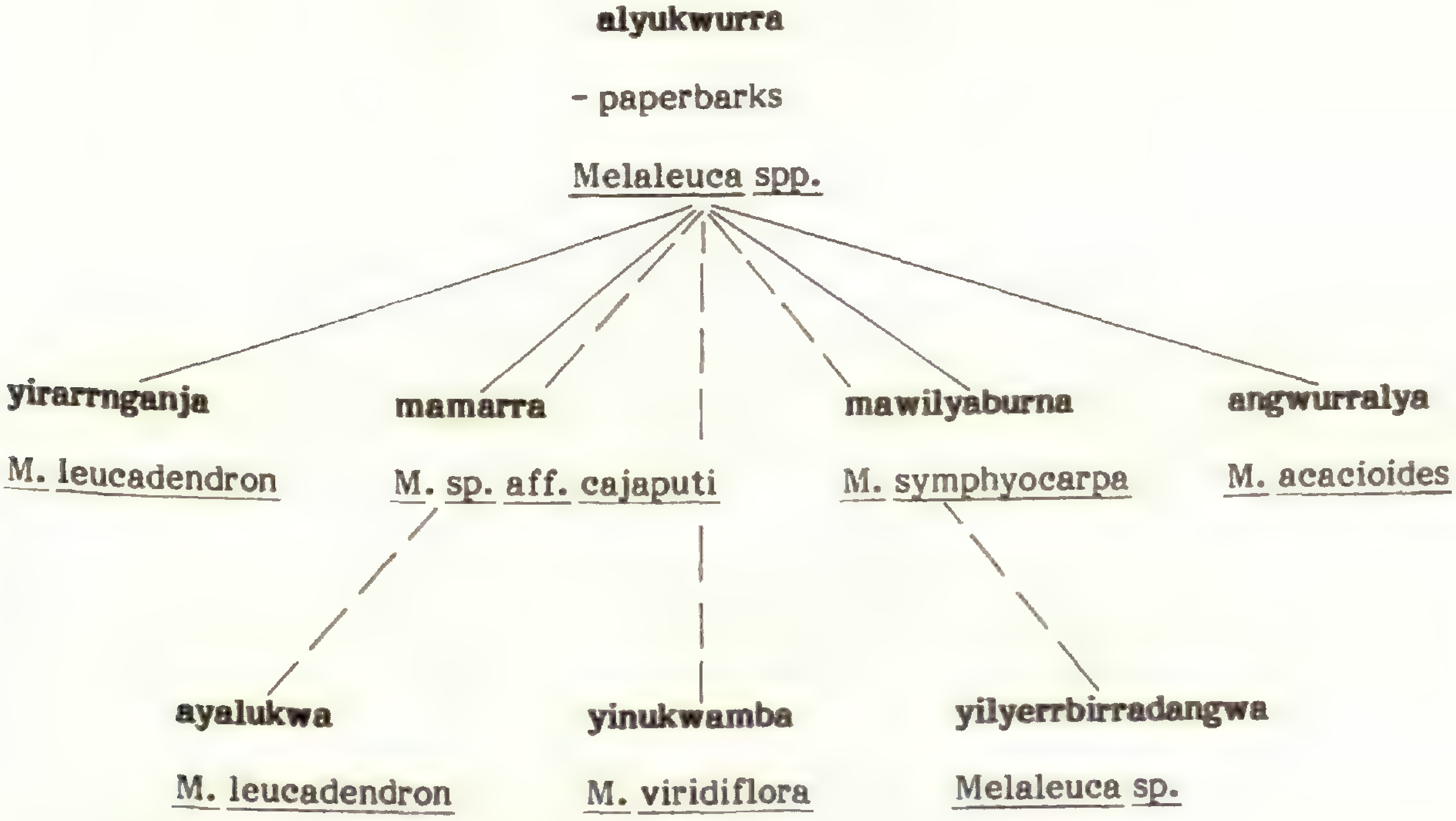

FIG. 7–Terminal taxa included within the folk taxon *alyukwurra* paperbarks.

The Aborigines of Groote Eylandt were hunters and gatherers who relied largely on fish and turtles, some land animals and on bush fruits and roots. They ate few seeds and no leafy vegetable matter. It will be interesting to see if other hunter-gatherer societies also have such a sparsity of folk specifics. If so it would support my contention that folk specifics and folk varietals may have developed largely in societies where agriculture plays a significant role in the economy and there is a subsequent need to make finer distinctions within a taxon. This seems to be a corollary of Berlin, Breedlove and Raven's finding that the proportion of folk specifics is much higher among cultivated and protected plants than among other plants (Berlin et al. 1974:99).

The Animal Kingdom: Akwalya.—As previously noted the unique beginner for the animal kingdom is *akwalya*. The first division (Fig. 8) including *akwalya* 'animals in the sea' and *yinungungwangba* 'animals on the land' seems strange in comparison with scientific thinking.

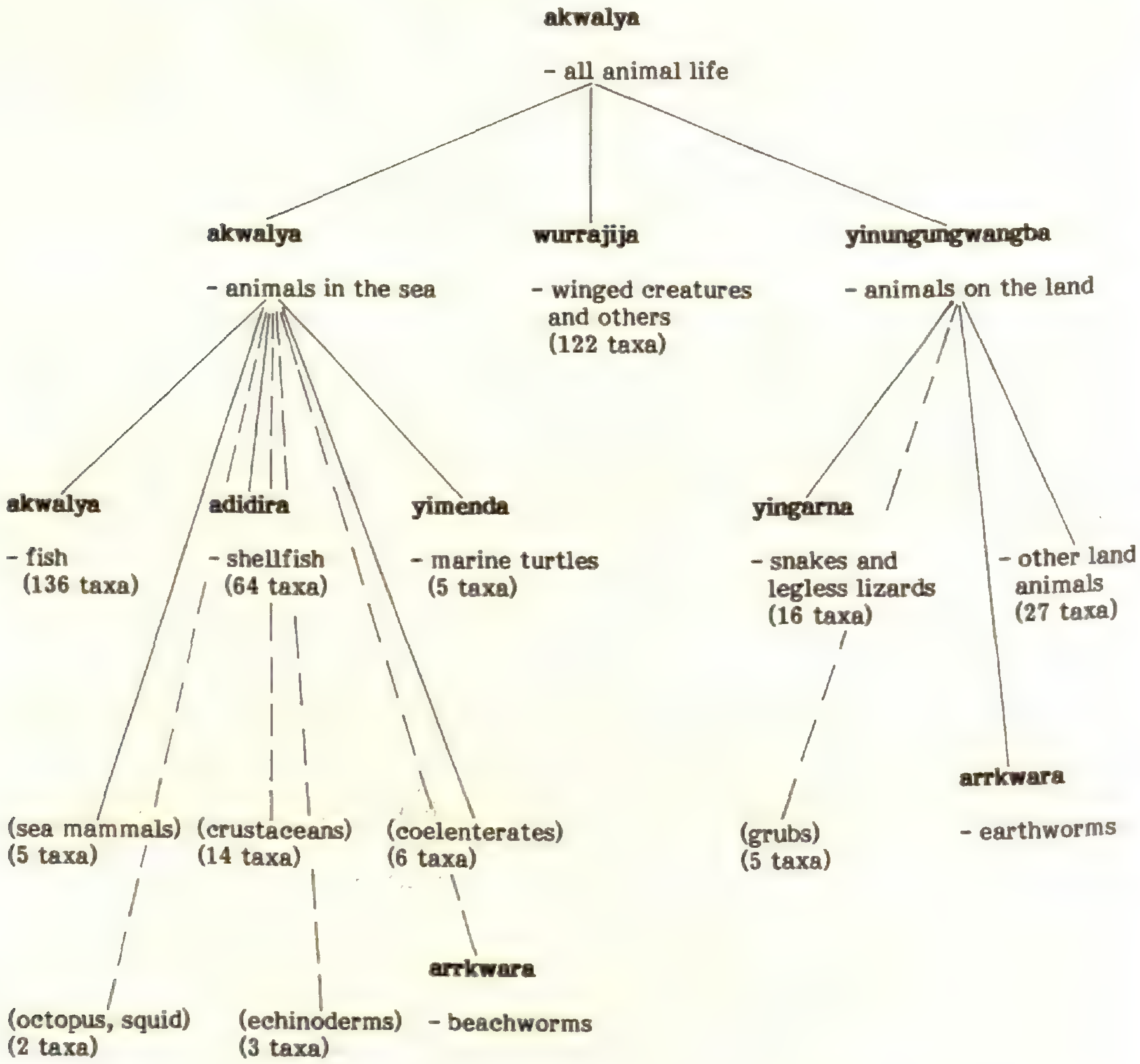

FIG. 8—Biological classification of the animal kingdom from an Anindilyakwa speaker's point of view. Numbers of taxa are those designated generic by Berlin.

However the naming of these two categories reflects the basic dichotomy between life in the sea and on the land that is borne out in other areas of life for the people of Groote Eylandt. The old Anindilyakwa word for women, *warningaribumanja*, when literally translated, means 'people of the land' whereas the men are people of the sea. Although it became apparent that this division was the source of a number of anomalies resulting in nontranstivity, e.g. land snails that are classified with marine molluscs, there was no way in which this division could be deleted, despite my informants' awareness of the need to stick to purely animal classification without interference from special purpose uses such as food source. To me it seems that habitat must be accepted as a valid factor influencing folk biological classification. At least for the Groote Eylandt Aborigine at this level of inclusiveness, habitat cannot be dismissed as interference from a special purpose classification.

There has been some difficulty as to the relative status of *wurrajija* 'winged creatures and others'. Nangurama wanted this taxon to be included within both land animals and sea animals, which would have violated normal taxonomic principles. Another knowledgeable man has given *wurrajija* equal status to land and sea animals. The latter view point is followed in Figure 8. This aspect of the classification system needs to be checked further.

The primary focus of the taxon *wurrajija* appears to be birds. When asked for defining features of the taxon, the immediate response given was 'wings'. It is thus easy to see how most insects, flying foxes and bats are included. Both winged and non-winged forms of green tree ants in particular are easily recognized. Green tree ants crawl on one's body as do other ants and insects, ticks, spiders and even scorpions and caterpillars. So one can understand how the taxon has been extended to include almost all arthropods. Grubs that live inside trees or in the ground are an exception.

Nangurama arranged sea birds (34 generic taxa) into two large and three small covert categories. He considered land birds (40 generic taxa) as one large covert category in contrast to six covert categories of insects (45 generic taxa) and one covert category of bats and flying foxes (3 generic taxa).

Labeled life form taxa included within *akwalya* 'animals in the sea' are *akwalya* 'fish', *adidira* 'shellfish' and *yimenda* 'marine turtles'. *Akwalya* 'fish' divides into *aranjarra* which includes all the cartilaginous fish and *akwalya* which includes all the bony fish (112 generic taxa) including a small subdivision of freshwater fish (8 generic taxa) (Fig. 9).[4]

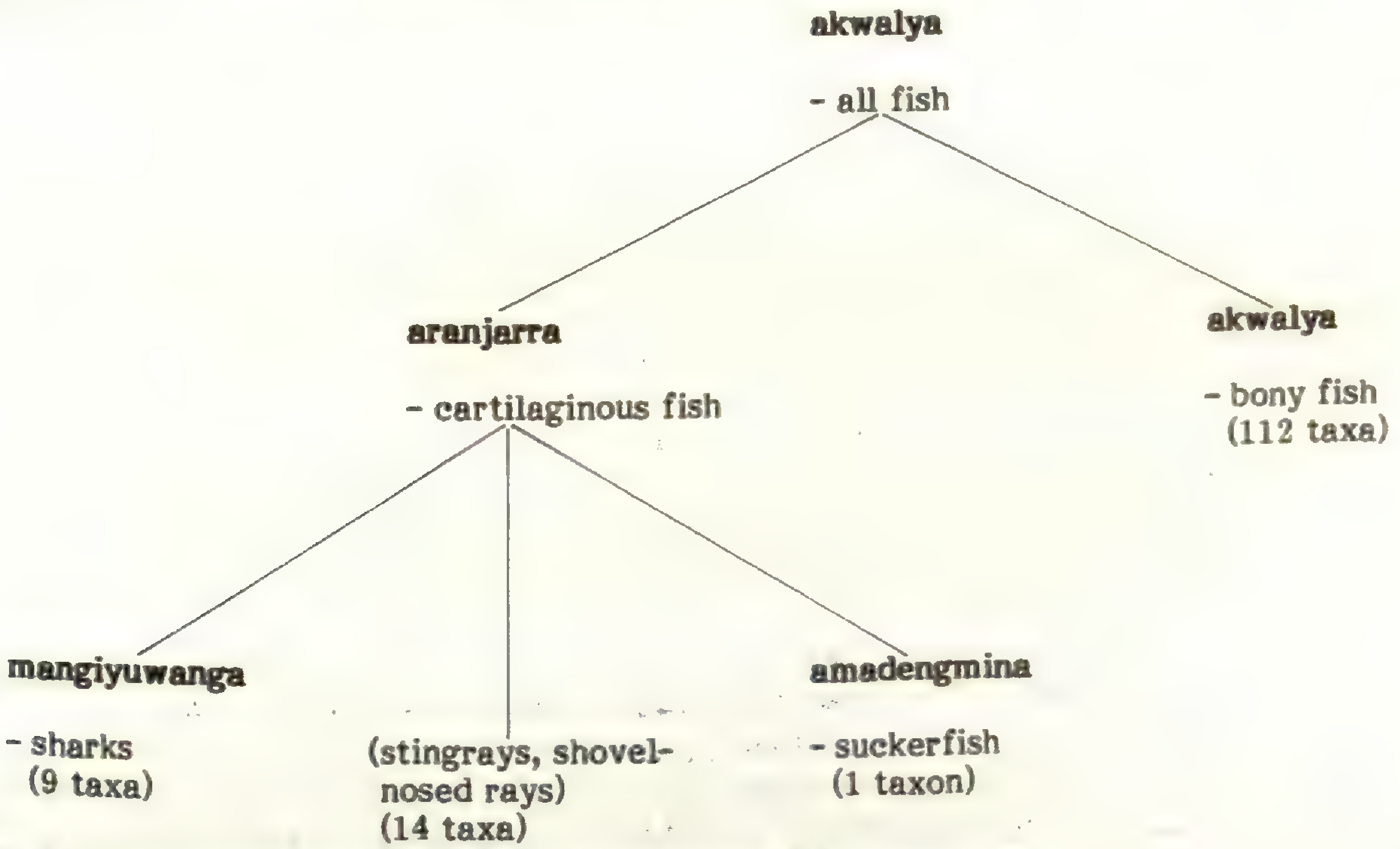

FIG. 9–Labeled categories within the folk taxon *akwalya* fish.

Aranjarra is further subdivided into *mangiyuwanga* 'sharks' (9 generic taxa), an unlabeled category which includes stingrays (11 taxa) and shovel-nosed rays (3 taxa) and the generic taxon *amadengmina* 'suckerfish'. This means that, in Berlin's terms, there are labeled intermediate categories at two levels, an unusual feature in relation to other languages.

The life form taxon *adidira* includes almost all members of the phylum Mollusca and also hermit crabs. The only exceptions are the octopus and the squid. Nangurama has given five covert categories of five or more taxa and fifteen covert categories of one to three taxa, making a total of 64 generic taxa. Land snails (2 taxa) and freshwater mussels (1 taxon) are included in this life form and are thus examples of nontransitivity.

The taxon *yimenda* 'marine turtles' is interesting because of its apparent status as a life form taxon but one which includes only five, or at the most, six generic taxa. Life form taxa tend to include a large number of generic taxa (Hunn 1977:44). In addition to the labeled taxon *yimenda* 'marine turtles' there are three significant but covert taxa which can be glossed as Crustacea, marine mammals and Coelenterates. Scientific categories such as these are very distinctive and yet are limited in species diversity, or at least in readily observable species diversity in a given area such as the seas adjacent to Groote Eylandt. The existence of generic taxa, of equivalent cognitive status to other generic taxa within the total system, within each of these more inclusive categories suggests that these higher level categories should be considered as life form taxa, whether named or covert. These higher level taxa are in contrast to other labeled life form taxa. Thus neither *yimenda* 'marine turtles' nor any of the generic taxa in question can be dismissed as unaffiliated generics.

The largest covert taxon is the Crustacea. There is a labeled intermediate taxon *alkwa* which includes all the bait crabs (9 generic taxa) but not the large edible mud crab, *Scylla serrata.* There are three other taxa of generic rank included in the life form taxon. One of these taxa is *amilyungwurra* 'freshwater yabbies and shrimps' which is now extended to include prawns. In its original meaning it is another example of nontransitivity.

The other two covert taxa are marine mammals (5 generic taxa) and the Coelenterates (6 generic taxa in 2 or 3 groups). There are another three to five groups containing one to three generic taxa and totalling seven or eight taxa. Approximately two thirds of all animal taxa are found in or near the sea.

There is one definite labeled life form taxon within *yinungungwangba* 'land animals'. *Yingarna* includes all snakes as well as legless lizards and the eel *Piscodonophis boro. Yingarna* is subdivided into *dingarna* 'pythons and tree snakes' (9 generic taxa) and *yingarna* which includes the remainder but especially the poisonous snakes (7 generic taxa). Sea snakes are included with pythons and tree snakes and thus provide another example of nontransitivity.

There is some debate as to whether the remaining land animals, i.e. 4-footed land reptiles and mammals, should be polysemously labeled or not. Within this grouping there is a covert taxon of marsupials and rodents (9 generic taxa), another of goannas, lizards and the crocodile (11 generic taxa), another of skinks and geckos (4 generic taxa) and three ungrouped taxa. Although the crocodile is the saltwater species, *Crocodylus porosus,* it is seen as a land animal because it lays its eggs on land. Inclusion of frogs and tadpoles, which were not seen as related by the majority of old people (i.e. pre-contact times), within this group is ambiguous. Otherwise the only unaffiliated generic taxon on land is *arrkwara* 'earthworms'. This taxon is also used for beachworms but because it is unaffiliated has been placed within both land and sea animals, thus avoiding problems of nontransitivity.

Labeled subgeneric divisions in the animal kingdom are rare. Binomially labeled specific taxa are limited to the 'real' one. In most instances where more than one scientific species is included in the one Anindilyakwa taxon, the differences between the species are recognized though not labeled. For example, there are three doves all called *darrawurukukwa. Geopelia humeralis,* the bar-shouldered dove, is larger than the other two species. *G. cuneata,* the diamond dove, is about the same size as *G. striata,* the peaceful dove, but it is not as common as the other two species. The distinctions between the two most common species are clearly recognized and yet there is no indication of any labeled subdivision of the taxon. This folk taxon is one of the best known taxa today. It is also a totemic taxon.

The use of different names for younger forms of certain taxa, where the young are known to develop into the adult form, is more common. These names have not been included in the numbers of generic taxa quoted above. As far as I can establish thus far, there is no case where the so-called young and adult forms represent different scientific species.

DISCUSSION

Where differences between species are recognized but not labeled, such as in the case of the doves, I have interpreted these subdivisions to be unlabeled specific taxa, or covert specifics following Berlin's typology. Bulmer and Dwyer would regard these subdivisions as speciemes. For Groote Eylandters it is generally irrelevant which member of a labeled taxon is considered. As Berlin (1976:392) says, 'subgeneric taxa are recognized (linguistically) primarily because of the close attention they receive as a result of their cultural significance'.

The lack of labeled subdivided taxa and the fact that labeled subdivisions are so rarely used, even if they exist, in this folk classification schema makes it relatively easy to determine the 'natural' categories at the lower levels. Additional evidence that these named categories are basic to the perception of Anindilyakwa speakers comes from an unusual source. Dwyer (1976:441) hints at, but provides only a very general example of, a possible relationship between social organization and biological classification.

Australian Aborigines have a totemic classification system which differs from place to place. On Groote Eylandt each clan has a number of totems which may or may not be folk biological taxa. The relationship with biological taxa in particular is personified so that a man who sees, for example, *wurruweba* a red-winged parrot flying overhead, might say, 'There goes my brother-in-law!' If several scientific taxa are included in the one folk taxon, such as the doves, it wouldn't matter which of the scientific taxa was sighted, nor whether there were any subdivisions, named or unnamed, the relationship would remain the same. Nor is there any example of any totem which is a taxon at a higher level of inclusiveness.

'Natural' categories of this kind are all represented by simple primary lexemes and appear to be of equivalent psychological salience, thus supporting Berlin's concept of a folk genus but, as I have indicated from my previous arguments, we need to be wary of such agreement. Perhaps this agreement does no more than reflect a widespread general pattern of relationship between nomenclature and taxonomy (Bulmer pers. comm.).

This leads into the second question of how we are to determine cognitive status. Whether the term folk genus or folk species or specieme or anything else is applied to the basic units as perceived by Groote Eylandt Aborigines, there seems to be an equivalent cognitive status based on apparently equivalent degrees of cognitive perception. They do not worry about the finer details of discrimination between any subdivisions of the taxon. The unit which they themselves 'see' is the labeled category which is not subdivided. There is one instance in Anindilyakwa of a subdivided taxon where one member of the set is labeled by a simple primary lexeme, viz. *dubudekbuda* oystercatchers, *dubudekbuda dadumamalya* Pied oystercatcher and *dakwurrinya* Sooty oystercatcher. The taxon *dubudekbuda* is a totem of the Warnungwamakwula clan. The name *dakwurrinya* is used specifically in the songs of that clan. I wonder whether subdivisions of taxa need only be referred to in the context of some special purpose, yet at the same time are available for inclusion in the general purpose biological classification. If so, it would give additional substance to Berlin's concept of folk genus. It is this basic labeled 'natural' category which I see as the potential unit of agreed perception of discontinuity *and* cognitive status. I think that is what Berlin, Hunn, Hays and I have all been groping towards. Just how we can objectively define it in a manner satisfactory to all remains a problem.

Randall (1976:550) has raised the issue of special purpose classification systems. Bulmer (1974:24), in commenting on Berlin's schema, has noted that folk taxonomies generally seem to be characterized by considerable flexibility and elasticity, contracting or expanding according to context. Dwyer (1976:438) suggests there is a need for flexibility in that the same folk taxon can apparently change its status within a folk taxonomy. Hunn (1976:520) has said that taxonomic structures are inadequate as models of the process of classification.

In the light of these comments and the dissatisfaction with systems previously outlined, I would support Randall's suggestion that folk taxa are stored in the memory simply as a series of (direct) contrast sets, as defined by Kay (1971:877), but I would suggest that the contrast sets remain free to be manipulated as required rather than fixed within a hierarchy. Each contrast set represents perfectly valid relationships. Such sets could readily be ranked by vertically overlapping set inclusion relationships to produce a hierarchical classification. Nontransitive relationships, (for example, a land snail is not a sea animal), are then explained as inclusion of non-typical members of a set by virtue of form or behavior. In the Groote Eylandt Aboringinal biological classification there is only one contrast set, viz. the dichotomy between land and sea animals included within the unique beginner for the animal kingdom, which gives rise to all nontransitive relationships. Apparent change in status of a folk taxon would be explained by the formation of an additional contrast set at a higher level. I would take this to include polysemy of folk taxa, though I don't think that was what Dwyer intended.

The Groote Eylandt Aborigines can produce a hierarchical food classification system which overlaps considerably but is by no means identical with the general purpose biological classification system (Waddy in press). The overlap of terms such as *akwalya*, which in the food classification systems means all edible flesh, but in the biological classification system means all animal life, highlights the need to be particularly careful that terms included in a particular hierarchy are rightly included for the purpose of that classification. On the other hand their totemic classification system results in an entirely different grouping of folk taxa, completely crosscutting higher biological folk taxa in many instances and lacking in hierarchical depth.

If folk taxa are arranged in contrast sets according to purpose, then only those sets required for the purpose would be called on to generate a hierarchical classification. This would appear to me to provide the flexibility and the potential for overlap which has been observed.

Because Kay's contrast sets are defined upon taxa rather than upon the lexemes that realize them (Kay 1971:874), it seems reasonable that a contrast set may contain unlabeled taxa, i.e. covert categories, as well as, or even in place of, labeled taxa. This does not seem to violate his definition that a contrast set is composed of just those taxa which are immediately preceded by the same taxon.

One problem still remains. Unfortunately, as Berlin (1976) says, members of the same contrast set often do not exhibit the same degree of internal variation. This is where I think that Hunn's idea of monotypic genera or indeed of higher level monotypic taxa can be applied. Certain taxa, termed unaffiliated generics by Berlin Breedlove and Raven (1974:219), do not appear to have the same psychological salience as the more inclusive life form taxa, even though technically they can be included in the same contrast set. Berlin, Breedlove and Raven rank these taxa as generic on the basis of linguistic criteria which are now being questioned. It would seem either that these unaffiliated generics, which may themselves include contrast sets, lack membership in a higher level contrast set or that the next higher level contrast set is one-membered. For such an interpretation to be valid however we still need to be able to define the basic 'natural' category within the folk taxonomy and that to me depends on perception of discontinuity.

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NOTES

1. The data on Groote Eylandt included herein was first presented in a paper to the Botany Section at the 50th Congress of the Australian and New Zealand Association for the Advancement of Science, Adalaide, May 1980. That paper was rewritten and presented during the symposium, Ethnobiology: Folk classification, uses and knowledge of plants and animals in Australisia, in the Anthropology Section at the 51st ANZAAS Congress, Brisbane, May 1981. I am most grateful to Brent Berlin, Ralph Bulmer, Peter Dwyer, Terence Hays and Kenneth Maddock for their helpful comments on these papers.

2. The provision of a grant-in-lieu-of-salary by the Austrailian Institute of Aboriginal Studies to support this research from April 1976 to March 1981 is gratefully acknowledged.

3. Although many long words in Anindilyakwa are at least partly analyzable most words used in this paper are of one morpheme or are prefixed by a noun class marker of one or two letters. One exception is *yinungungwangba* where yi- is the 'y' noun class marker, *nung-* is normally a prefix meaning 'belonging to' but the significance of *ngwangba* has apparently been lost.

4. The terms *amarda* and *akwalya* are used polysemously. It seems that the primary focus of *amarda* is on non-woody plants such as grasses and that the term has been raised in status for use as a unique beginner. This is akin to the process discussed by Berlin (1972: 66-71) of raising the status of a particular tree name to life form status.

The primary focus of *akwalya* appears to be flesh food, in particular, fish. Within the biological classification system its focus is on fish in general, as evidenced by the very common phase, *'Akwalyuwa,'* given in answer to the question, "Where are you going?" However in appropriate contexts the term *akwalya* can be raised in status to include all animals in the sea or all animal life (as opposed to plants). In this way its use is akin to the double use of the English 'animal' referring both to mammals and to the whole animal kingdom.

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DIFFERENTIAL GRAIN USE ON THE TITELBERG, LUXEMBOURG

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ABSTRACT.—The "Titelberg," Luxembourg, is an Iron Age hillfort which was occupied from La Tene II (ca. 200 B.C.) until the end of the Roman Empire in northern Gaul (ca. A.D. 400). Prior to the Iron Age there was also a Neolithic use of the mountain top in the third millenium B.C. From the Iron Age until its abandonment, the Titelberg was mainly populated by Celtic folk, apparently of the Treveri tribal chiefdom. Carbonized cereal grains have been recovered from most levels. At the emplacement excavated by the University of Missouri, there were a stratified series of mint foundries. From the late Neolithic comes a small variety of wheat, while oats appear as early as the hearths of La Tene II. From the Dalles Floor phase, after the Roman conquest, barley is the most frequently encountered grain. Bread wheat does not make a strong appearance until the late fourth century, when either the last inhabitants of the Titelberg or immigrating Franks left the most recent feature to be excavated. Although the remains are found in the context of a continuing cultural tradition, the particular combinations of cereals recovered change with either major shifts in cultural trajectory or the appearance of intrusive cultures nearby. These changes seem not necessarily "caused" simply by either overt introductions or the prestige of the intrusive culture, but as a way to adjust to other factors, such as taxation, political status, and meat supply.

INTRODUCTION

The Titelberg lies at the extreme southwest corner of the Grand-Duchy of Luxembourg, near the juncture of the Belgian and French borders. It is one of a number of abrupt and fairly low buttes which extend east-west along the southern edge of Luxembourg toward Lorraine, France. The Titelberg rises to about 399 m, dominating the river (called *Chiers* in French, *Kor* in Letzeburgish, and *Korn* in German) and valley 100 m below. The Titelberg rests primarily on Oolitic Dogger limestone of Lower Jurassic age, and contains rich lodes of Lorraine iron ore. On top of the Titelberg are cultural strata which reveal a long history of human occupation from prehistoric through early historic times.

The buttes are the first important elevations east of the English Channel, causing humid westerly winds to drop more than a meter of rain per year on the Titelberg and its environs. This area is known as the "Gutland" and is considered some of the best agricultural land between the Ile-de-France and the Koblenz basin. The surface of the Titelberg extends well to the east, so that there has always been a considerable amount of easily accessible land to till.

Given this favorable environment, one might expect that the fundamental subsistence patterns of the people living on the Titelberg would exhibit little variation, despite immigration, political changes, such as the Roman conquest in the first century B.C., and the Frankish occupation (late fourth, early fifth centuries A.D.), for climatic change during these centuries was not pronounced. Palaeobotanical evidence from the Titelberg tends to confirm the persistance of a well-developed agricultural tradition. However, there appear to have been marked changes in the particular crops favored from one era to the next, which could reflect changing cultural and economic conditions on the Titelberg.

CULTURE HISTORY

In the late 1950's the Luxembourg State Museum began a long-range program of systematic excavation of the Titelberg (Thill 1965, 1966a and b, 1969, 1980; Thill et al. 1971; Metzler and Weiller 1977; Krier 1980a and b). During the summers of 1972-1974 and 1976-1978, excavations were made by a team of archaeologists from the University of Missouri.[1] This research team confirmed the depth of the stratigraphic sequence during excavation of a trench 13.35 m wide by 15 m long while attempting to establish the nature of the pre-Roman occupation of such hillforts.

The University of Missouri excavations on the Titelberg revealed two Neolithic levels, the later one dating to ca. 2000 B.C., (near the beginning of the Bronze Age) by thermoluminescence dating (Rowlett et al. 1980:38-40).

In the third century B.C., or slightly earlier, the Titelberg was settled by Celtic peoples. By the first century B.C. this group of settlers can be identified as members of the Treveri tribe. The Titelberg, by far the biggest hillfort in the Treveran tribal area, is commonly regarded as the main settlement of the tribe (Thill 1965). The central street system was arranged in a rectangular grid, and a coin-minting operation began in the later Iron Age horizons. Gaullish mints operated under the office of the chief, with coins usually bearing either his or the tribal name. This mint continued production through the early period of Roman rule on the Titelberg. Nothing was ever built over the mint except a metal smelter in the fourth century A.D., which appears to have been used in part to melt down debased Roman coinage.

During the period of Roman rule, from the late first century B.C. to the late fourth century A.D., the Treveri remained on the Titelberg, operating a profitable glass, ceramic and iron industry after the razing of the coin mint. At the end of this period, there was a settlement by Franks in the valley below (late fourth and early fifith century A.D.) The Titelberg has not been occupied since that time and was farmed after the Renaissance.

Under Roman rule, in the first century A.D., the capital of the Treveri was shifted east to where the modern city of Trier (Wightman 1970:38-42) stands in western Germany. Entirely new Roman or mixed Gallo-Roman towns were established at places like Mamer and Dalheim in Luxembourg, with the Titelberg relegated to the tribal hinterlands, away from the main highways, and seemingly no longer an officially significant place.

There is indication of considerable cultural continuity on the Titelberg. During the four centuries of Roman rule, the rectangular street grid originating in the Iron Age was retained, and the iron industry and coin minting operation continued. The basic subsistence pattern of cereal agriculture persisted. Manufacture of black marine shell-tempered pottery continued throughout the period, gradually diminishing from 44% to 5% of the ceramic inventory. Tools, such as knives and scalene cutters, and fibulae continued in traditional forms. In the Treveri area names continued as Celtic in formal arrangement although the names themselves were often Italic, Greek, or Hebraic adoptions (Wightman 1970:50-51). According to St. Jerome, Celtic was still the language of association for every day use until his day in the fourth century A.D.

SITE STRATIGRAPHY

Excavations on the Titelberg have produced nearly 50,000 each of potsherds and bone, numerous tools, objects of bronze, iron, lead, glass, and stone, as well as several thousand cereal grains. The main features in which remains have been found are (Figs. 1 and 2): 1) a smelter (North smelter) dating to the fourth century A.D., which contained, besides numerous potsherds, glass and tool fragments, over 200 heat damaged coins, 2) foundations (Fig. 1, e) of a two-room building, 4.4 m by 12 m, above the floor paved

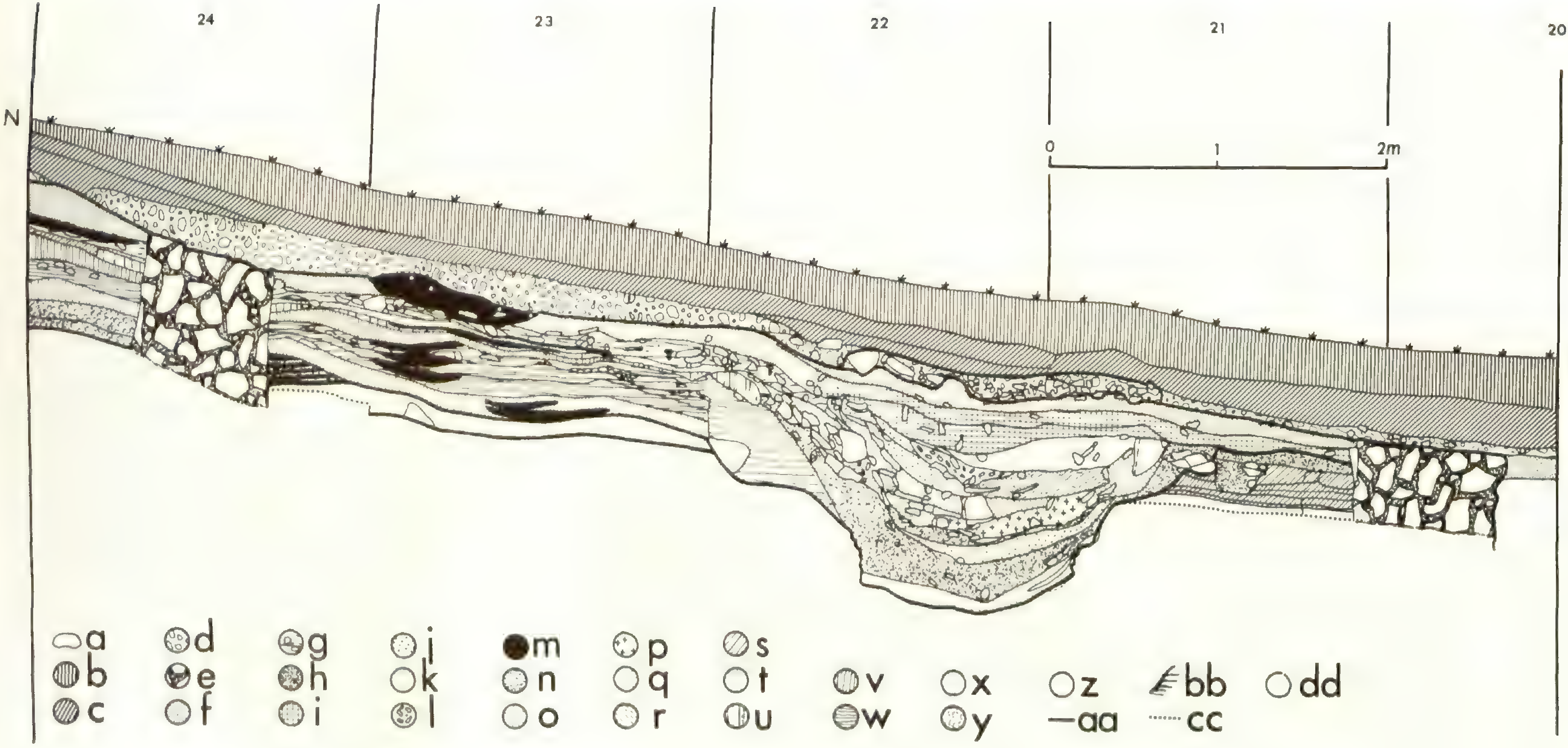

FIG. 1–Floor Profile (50 cm west of J/I line). (a) Stone, (b) Humus zone, (c) Dark brown, (d) Rubble, (e) Stone wall foundation, (f) Light Brown Interior Floor and Light Brown I Exterior, (g) Dalles Floor, (h) Dalles IIIa level [green], (i) Dark Gray-Brown, (j) Cellar fill Brownish Orange, (k) Cellar fill Brownish, (l) Cellar fill Fossiliferous Deposit, (m) House hearths, projected three meters [Dalles floor] or one meter [all other floors] to the east to the profile, (n) Cellar Red-spotted, (o) Cellar Brown Dalles, (p) Cellar Green Clay spotted, (q) Cellar Tan, (r) Cellar Yellow-Orange layer VII, (s) Yellow-Brown Exterior, (t) Yellow-Green Clay Floor, (u) Orange-Clay Floor, (v) Bright Yellow level, (w) Pale brown Floors I-III, (x) Orange Brown Floors I-III, (y) Ash Floors I-IV, (z) Orange, (aa) Lower Neolithic level, (bb) Jurassic outcrop, (cc) Bottom of archaeological cut, (dd) Yellow. Floors are enclosed in heavy line. The Upper Neolithic, scraped away in this location, occurs just under the lowest Iron Age levels exterior to the Ash Floors.

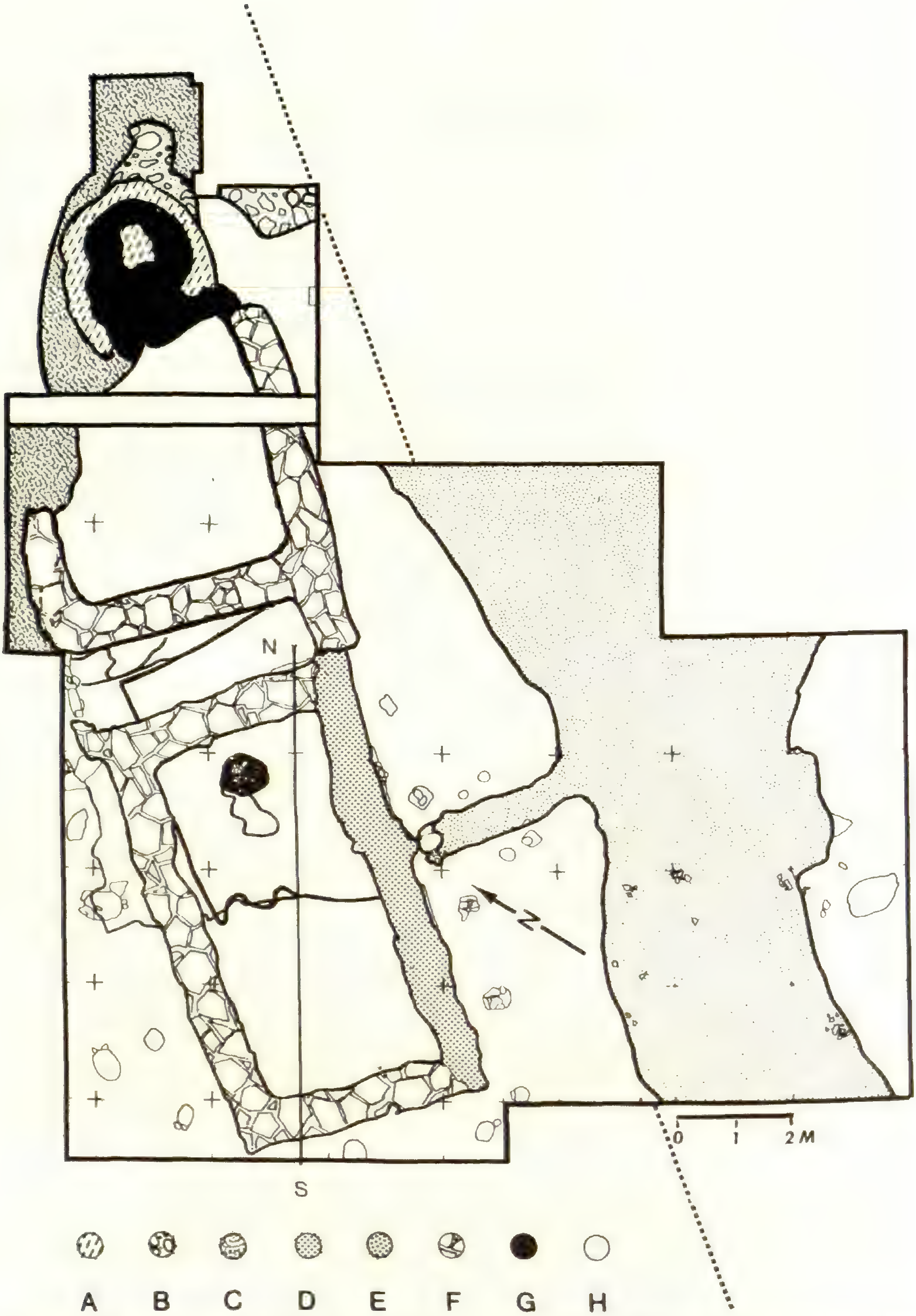

FIG. 2–Plan of Mint Foundries and Side Street. (A) Clay around 4th century smelter, (B) Stone rubble associated with 4th century smelter, (C) Compact rubble associated with 4th century smelter, (D) Gravel paved side street, (E) Plaster filled robber trench, (F) Foundations of Augustan mint foundry, (G) Fireplace of Augustan foundry, (H) Exterior levels. Heavy lines show limits of Dalles Floor (larger enclosed area) and Clay and Earth Floors (smaller enclosed area). Line N-S shows section profile in Figure 1.

with flagstones or dalles (Dalles floor) of Augustan age, built over a series of earlier Iron Age buildings, parallel to the Roman street, 4) a bronze smelter from early Augustan times (late first century B.C.), 5) a succession of at least 14 floors and 13 hearths (Fig. 1, f-h, t-y) beneath the Dalles floor, belonging to the Iron Age buildings. The floors, composed of various clays and ashy earth layers, are the veritable floors of the structures in which people lived and worked. All of the hearths except one are almost directly superimposed on each other. The earliest dated floor (y-Ashy earth II) has a C14 date of 306 ± 55 B.C. Lastly, 6) two Neolithic levels (Fig. 1, aa) one immediately below the Iron Age levels, dating to 2000 B.C., and another 20-25 cm below the later one.

Occupational levels overlying the Augustan levels in the westernmost 5 meters of the excavated area contained evidence, mainly coins, for the second through fourth centuries of Roman occupation.

PLANT REMAINS

Given a certain amount of cultural continuity and a favorable environment for cereal agriculture, one would expect a relatively stable complex of cereal grains utilized. However, the prehistoric plant remains from the Titelberg show fairly drastic shifts in the species and complexes of cereal grains used in different areas. Cereal grains and weed seeds have been recovered from seven levels (Table 1). Seeds were recovered by direct observation in the field and subsequent flotation of soil matrices in which seeds had been found. Some simple flotation was done in the field, but the majority of grains recovered from the Dalles Floor cellar hearth and the North Smelter were retrieved with the aid of chemical flotation described in Bodner and Rowlett 1980. Flotation of randomly selected soil samples has not produced a single seed so far.

TABLE 1.–Distribution of seeds by level.

Level	Date	Feature	Plant Remains
Dark Brown IA	Fourth century A.D.	North Smelter	1000 seeds 88.6% *T. aestivum* (breadwheat) 7.9% *T. monococcum* (einkorn) *T. dicoccum* (emmer) 2.8% *T. spelta* (spelt)
Dark Brown IB	Third century A.D.	includes concentration of finds in rubble heap	none
Dark Brown II	Second century A.D.		*121* seeds 120 *Avena* sp (oats) 1 *T. aestivum* (breadwheat)
Dark Brown III	Second half of first century A.D.		none
Rubble Surface	A.D. 25-50	ruins of the Augustan stone foundation mint	none

TABLE 1. (Continued)

Level	Date	Feature	Plant Remains
Light Brown I	A.D. 10	flagstone floored Dalles Floor house	*2800* seeds (found in hazel twig basket) 1850 *Hordeum vulgare* (barley) 535 Goosefoot *(Chenopodium)* 45 *T. Dicoccum* 5 breadwheat (bindweed) 10 misc. weeds
Clay Floors	50 B.C.- A.D. 1	building floors	none
Orange Brown II	La Tene III	building floors	*46* seeds 31 goosefoot 8 oats 2 breadwheat
Ashy Earth II	La Tene II 306±55 B.C.	building floors	13 seeds 1 Einkorn 1 emmer 1 breadwheat 1 barley 1 oat 8 weeds
Late Neolithic	2000 B.C.		3 *Triticum* spp.

All seeds and grains have been identified by Dr. Maria Hopf of the Romisch-Germanisches Museum in Mainz. Wood and timber pieces were identified by Dr. Ernst Hollstein of the Rheinland - Pfalz Landesmuseum Trier, and Dr. Susan Vehik of Oklahoma University studied pollen from the Titelberg.

Given the fact that plant remains are subject to the vagaries of preservation, recognition, and recovery in the field to a greater extent than other artifacts and ecofacts, some observations can be made concerning the types of cereal grains used at various times. Some of the samples are quite large, and several come from tight associations where there is little likelihood of post-depositional movement biasing the samples.

Neolithic

Neolithic and late Neolithic wheat *(Triticum* spp.) provides a baseline against which to consider later Iron Age and Gallo-Roman grains. One of the three grains found in the later Neolithic level is intact, with some organic debris adhering to it, perhaps glume or carbonized chaff. The second grain is broken. The two grains were found close to each other, near a sherd, a scraper end, and a pendant. A grain impression of apparently the same genus was discerned on the potsherd nearby.

The size of these grains was compared with that of breadwheat, *Triticum aestivum* (cf. *T. sphaeorococcum* and representative compactum identified by Maria Hopf) found on the Titelberg in the Missouri excavations on the North smelter (Table 2). It also compares the size of wheat from Chassemy, France (fifth century B.C.), from the Gallo-Roman site of St. Gengoux-de Scisse, Saone-et-Loire, France (third century A.D.), and a control sample of modern breadwheat from the University of Missouri.

TABLE 2.–Comparative wheat sizes in mm.

Sample	length	breadth	thickness
UMC Standard, carbonized (n=30)	5.48	2.86	3.86
Titelberg, 4th c. A.D. (n=10)	5.24	2.97	2.39
Roman, St. Gengoux, 3rd c.*	5.10	3.5	3.6
Chassemy, France, 5th c. B.C. (n=3)	5.0	3.5	3.5
Titelberg, Neolithic (n=3)	3.6	2.6	1.9

*Hopf et al. 1978:37-45

The fourth century wheat is clearly larger, but it is hypothetically possible that rodent or earthworm activity could have provided the means for later grain to be carried down to the Neolithic level. The probability of such an occurrence was tested using the Student's t-test as formulated by Blalock (1960:148). The test compared the normalized sizes of the grains from the fourth century A.D. smelter and the Neolithic level. The results of a one-tailed test with five degrees of freedom yields a probability of less than 0.025 that the smaller grains could be from the same cereal population as the grains from the North smelter.

The Neolithic grains are also considerably smaller than other grains of comparable or greater age, e.g. einkorn *(T. monococcum)* (5.2 mm long) and emmer *(T. dicoccum)* (5.35 mm long) from the Bandkeramik Tradition Neolithic levels at Entzheim (Bas-Rhin) (Hopf 1975:115-116).

Ash Floor II(y)

The earliest preserved Iron Age plant remains were recovered from the Ash Floor II hearth, early La Tene II, 200 B.C. or before. The seeds and grains found in the hearth are in close association. The remains included Einkorn, emmer, barley *(Horedum vulgare)* and one oat, *(Avena* sp.), and one weedy vetch seed *(Vicia* sp.).

Orange Brown II(x)

The 46 seeds from this level occur in the hearth. Of the 46, 31 are goosefoot *(Chenopodium* sp.). Goosefoot has long been considered seriously an Iron Age cultigen (Rowlett 1968:132), but these seeds may be wild. Barley outnumbers wheat 4:1. The five remaining seeds were weeds, one nipplewort *(Lapsana communis,)* and four bindweeds *(Polygnum convovulus).*

Dalles Floor Cellar (g-o)

The number of grains here dating after the Roman conquest, but when mint operations were continuing, increases dramatically. Finds were from both the Dalles Floor cellar and outside the Dalles Floor cellar and outside the Dalles Floor house. The fireplace provided a sample of about 2,800 cereal grains and weed seeds which were burnt in a hazel twig basket or tray. One thousand eight hundred and fifty of the seeds are barley, 45 are emmer, and only five are breadwheat. There were large numbers of goosefoot seeds (525), bindweed seeds (189), as well as nine other weed seeds, including hemp nettle (61), chess (9), purple cockle (1), nipplewort (12), corn spurry (2), graminae (10), *Astragalus* sp. (2), *Atriplex* sp. (1), and marsh bedstraw (2).

The number of weed seeds present is surprising. The Treveri were, along with the Remi, one of two tribes of Gaul reported by the Romans to have a mechanical reaper (Mertens 1958). The reaper could account for the number of weed seeds present in the sample, although the reaper could have been in operation as early as the Orange Brown II floor. Dr. Maria Hopf has cautiously suggested that the large collection of weed seeds and barley, less nutritious than wheat, was submitted by the conquered Treveri as part of their tax payments to the Romans. Thus, they would have little interest in clearing away the weeds, which would have swollen the total volume of the grain. Since the Romans, in the early days of the Empire, ruled through local leaders, the presence of tax payments in kind at the mint would not be unreasonable, as Celtic chiefs operated the mints producing coins.

The size of this barley may be compared to carbonized modern grain. It is smaller than the modern barley, and also barley from the Roman site at St. Gengoux-de-Scisses, France of the third Century A.D. (Hopf et al. 1978) (Table 3).

TABLE 3.–Comparative barley sizes in mm

Sample	length	breadth	thickness
Dalles Floor (n=50)	5.24 ± .50	2.97 ± .22	2.39 ± .24
St. Gengoux, 3rd c. A.D.*	6.2	3.4	2.6
Modern barley, carbonized (n=50)	7.2	3.94	3.11

*Hopf et al. 1978:37-45

Dark Brown IIB(c)

The early second century A.D. remains show a drastic change from the Dalles Floor level. One hundred and twenty of 121 grains are oats, and only one is breadwheat. These relatively clean finds were found scattered over the top of the last floor of the foundation house and in the exterior levels of Square 25/I. They were not found in close association, but the great preponderance of oats is clear. This makes sense when one looks at the curve of available animal protein through time. As the Roman occupation of the Titelberg continued, the Treveri had relatively less animal protein available to them. Oats, which have a relatively high protein content, may have been propagated to compensate in part for the diminishing availability of animal protein (Fig. 3). It is known that the Romans greatly preferred breadwheat, and encouraged its propagation. This seems to have had little effect on the native habitat Titelberg until the fourth century.

North Smelter (Fig. 2, b)

There are no grain samples dating to the third and early fourth centuries. However there are nearly 1,000 grains from the late fourth/early fifth century smelter where breadwheat is preponderant.

The North Smelter consists of black burnt levels alternating with stony levels. Finds from the smelter include potsherds of the fourth century, rouletted *terra siguillata,* the mouth of a Mayen lobate mouth pitcher and a tear-shaped belt tab. Iron tools were found, as well as fragments of glass and masses of molten bronze. The most frequent finds were coins, 218 total, 88% of which were burnt. The latest coins date to the reign of Constantine, A.D. 318-330. This feature constitutes virtually the only disturbance of the much older series of mint foundry floors.

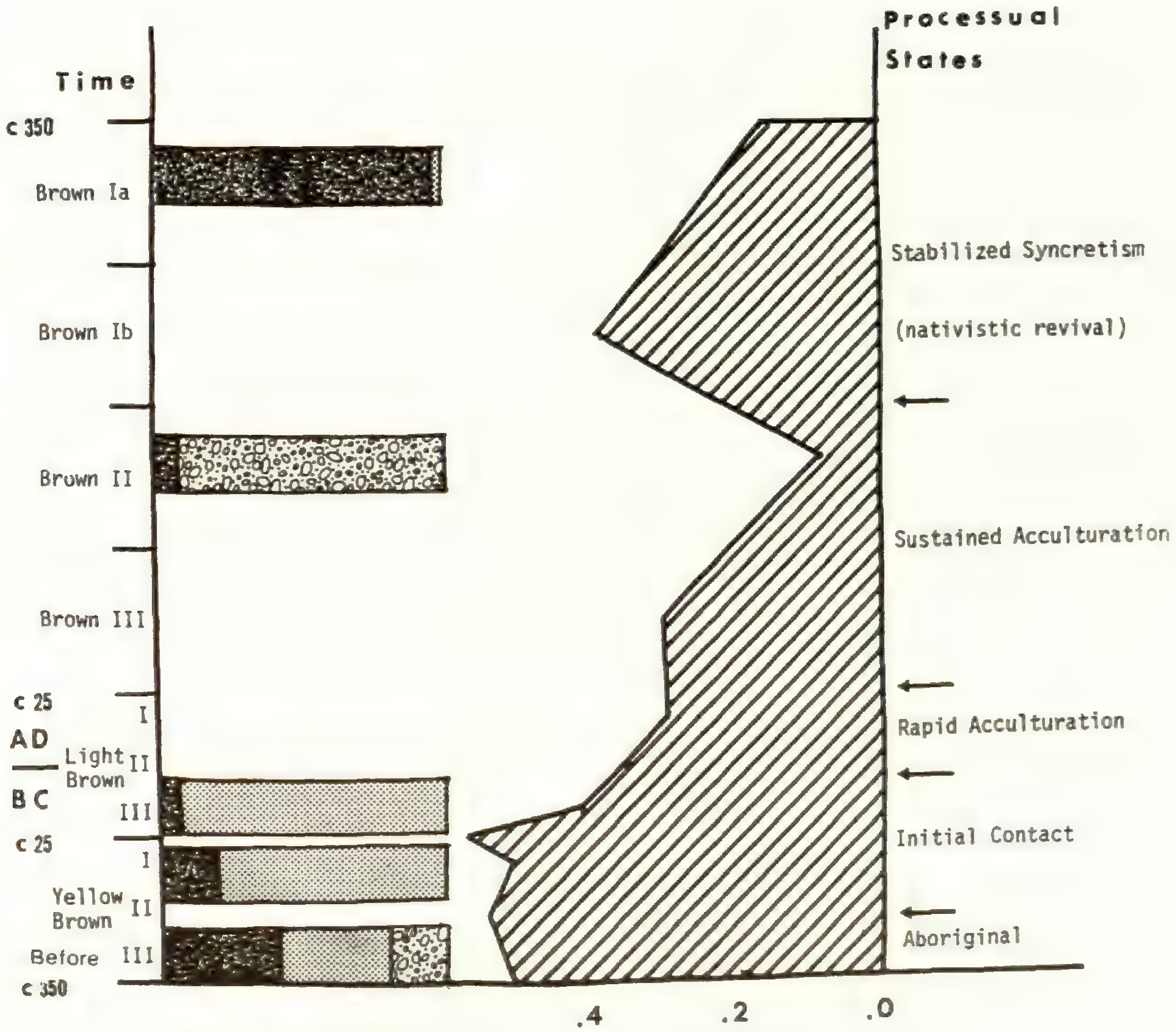

FIG. 3.–Proportions of cereal grain genera in relation to the amount of animal bone per stratum. Diagonal lines–animal bones; black–wheat *(Triticum);* stippled –barley *(Hordeum);* small circles–oats *(Avena).*

The grains from the burnt smelter layers were identified as 88.6% breadwheat. Einkorn and emmer composed 7.9% of the grain, and spelt *(Triticum spelta)* composed 2.8% of the sample. Only five barley grains were recovered from the lower levels as well as vetch, and one sloe-berry stone *(Prunus spinosa).* The breadwheat from the North smelter is smaller than a modern carbonized sample, but less so than any of the other cereal grains discussed above.

The plant remains from the North smelter were found in closer association than those of the second century which were scattered throughout the excavation area but less close than the hearth finds from the Dalles and Iron Age floors.

SUMMARY

The samples of plant remains found in excavations of the Titelberg cannot be considered random or totally representative samples of the total complex of cultigens on the Titelberg. However, there is a clear tendency for one or another of the cereal species to be preponderant in particular horizons. Although the dates and samples must be viewed cautiously, it does not appear that there was as much continuity in the cereal crops grown and utilized as was manifested in other remains, including animal foodstuffs. The changing species of plants cultivated suggests that the emphasis on and preference for different crops changed according to the circumstances of each era. Except for spelt, most of the cereal crops were present by La Tene II, but production varied according to other demands; if one assumes that the grains recovered reflect the degree to which the grains were grown. The changes in crops can hardly be attributed strictly to acculturation in terms of the prestige or official preference of some particular crop, e.g. breadwheat, (favored by Romans) but varied in more subtle and complex ways. One might speculate that cheap, unnutritious grains were concentrated for payment of taxes due to the Roman conquerers, but protein rich oats were grown when animal protein was restricted. Breadwheat, preferred by the Romans, may not have been in wide use here until the fourth century A.D., when the Roman Empire was near collapse. Perhaps the breadwheat was no longer expropriated by the Romans, and thus was available for the natives for the first time. Thus the Treveran Celts of the Titelberg seem to have shifted their cereal production as part of an adjustment to a changing political and economic situation. This may have enabled them to let other aspects of their cultural tradition and everyday life continue relatively unchanged.

ACKNOWLEDGMENTS

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UTILITARIAN/ADAPTATIONIST EXPLANATIONS OF FOLK BIOLOGICAL CLASSIFICATION: SOME CAUTIONARY NOTES

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ABSTRACT.– Attempts to explain the complexity of folk biological classification systems may benefit from utilitarian or adaptationist arguments, focusing on the utilitarian or adaptive value of the behavioral consequences of folk disinctions among organisms. To adequately assess such perspectives it is necessary to resolve a number of theoretical, methodological, and empirical problems, which are identified and outlined in this paper as a first step toward the construction of such theories of ethnobiological classification.

INTRODUCTION

Thorough descriptions of ethnobiological classification systems are now available for a wide range, if not a large number, of societies. Sufficient similarities appear to exist among these impressively detailed taxonomic systems that universal or general principles of folk classification have been proposed (Berlin et al. 1973; Brown 1977, 1979). While the need is great for more field studies and continuing refinement of our developing theory of the *structure* of folk taxonomies, it is clear that our understanding of such logical and linguistic systems as human phenomena requires systematic investigation of the uses to which they are put by those who have created them. Some attempts have been made to relate taxonomic and lexical elaboration to the "cultural significance" of the organisms in question (Berlin et al. 1974), but this latter concept is only beginning to be operationalized and is fraught with difficulties (Hays n.d., and discussion below).

One approach to the question of the function of folk taxonomies represents a merging of traditional ethnobiological concerns with more recent "cognitive" orientations, and may be designated the "utilitarian/adaptationist perspective." In this view, the environment is regarded as a setting in which people must satisfy their physical needs, i.e., a setting to which they must *adapt.* Folk biological classification would then be regarded as a way by which people systematically organize, store, and retrieve environmental information which will enable them to accomplish this adaptation. Thus, a utilitarian/adaptationist perspective would seek to identify the practical consequences of folk conceptual and terminological distinctions, and ultimately explain folk taxonomies as structures which are motivated by a concern with these consequences.

If such an explanation of folk classification could be established, not only might we understand better how these systems function in people's lives, but there is also the hope that folk taxonomic studies could aid in the reconstruction of lifeways which are no longer directly observable, as Diamond (1966) implies by interpreting the detailed taxonomy of birds among the New Guinea Fore people as "an economic relict of disappearing food habits."

A utilitarian/adaptationist perspective clearly holds promise for a wide range of ethnobiological and anthropological concerns. However, if my own experience in attempting to operationalize some of the necessary key concepts (Hays n.d.) is a valid indicator, we must resolve a number of serious theoretical, methodological, and empirical problems before we can determine how much of a role pragmatic considerations play in the structuring of folk models of the biological world. In this paper I identify some of these problems in the hope of advancing their discussion and solution.

DISCUSSION

First, it is important to be clear about just what is at issue. Anyone who has lived in a small-scale society with a subsistence-based economy, as I did in Ndumba in the Papua New Guinea highlands, is aware of the intimate knowledge of biology and ecology (as well as geology, pedology, and meteorology) which people employ as they extract their livelihood from local resources. What is *not* at issue in the present discussion is whether "knowledge" can and does have practical consequences for people. Rather, the question at hand is whether *folk classification systems*—viewed as particular kinds of organization of knowledge—play a part in "adaptation," and the degree to which we can explain their structure and contents in such terms.

To restate what I would propose as a central thesis of a utilitarian/adaptationist perspective: (a) People draw conceptual contrasts among classes of biological organisms, and (b) usually label these concepts with standardized linguistic expressions, in order to (c) facilitate the organization, storage, retrieval, communication, and deployment of knowledge or information about the natural world, which (d) results in differential behavioral or attitudinal responses to these organisms, with (e) consequences that are, in some specifiable sense, useful, beneficial, or "adaptive." While this statement may not fully represent the views of those who are beginning to articulate formal "adaptationist" proposals (Hunn 1980), it has the advantage of explicitly pointing out some possible directions for such inquiries and, at the same time, making it easier to identify likely sources of problems.

A second point of needed clarity pertains to the *kind of* folk taxonomy we are trying to explain. An important contrast must be drawn between "general purpose" and "special purpose" classifications (Berlin et al. 1966; Hunn 1977). The latter are employed by people in restricted domains of activity or interest, as in classifications of organisms as "edible" or "inedible"; "flowers" or "weeds"; "wild animals," "zoo animals," or "pets," and so on. Special purpose folk taxonomies are unquestionably motivated by functional or "practical" concerns. The productive question is whether general purpose taxonomies (which, in all known societies, are based primarily on morphological attributes of organisms), are *also* informed by utilitarian considerations.

We must also ask *whose* classification system we are trying to explain. If we mean to focus on conceptual and terminological systems that are "cultural" in the sense that they are widely-shared within a particular population, then we must attend to the facts of individual variation in biological knowledge, and determine just which concepts, contrasts, and names really are shared (Hays 1974, 1976). When, for example, Reichel-Dolmatoff (1976) claims that a Tukano shaman in the Amazon "has to know, name and categorise" all of the contents of his local ecosystem in order to serve as an "ecological broker," we have not necessarily learned anything about either the extent or significance of an *average* Tukano's knowledge of this same environment. Similarly, an argument that a particular contrast between two plants, say, is important to a folk medical practitioner in choosing therapeutic medicines, by itself says nothing about why that same contrast might be drawn, if it is, by a "typical" person who has no such specialized needs. To explain why particular contrasts exist within the putatively-shared folk classification system, we must determine whether there are underlying utilitarian concerns which are also shared. On the other hand, we may wish to include specialized knowledge which is irregularly distributed within a population if by "culture" we mean a composite "pool" of knowledge in a community. In either event, we must be explicit about the concept of culture we are going to use before we can identify properly the variables we are seeking to examine.

If a utilitarian/adaptationist (or any other) explanation of folk classification is to be adequate, it must account for the system as a whole, or at least for a significant proportion of it, rather than for selected segments. I could report, for example, that Ndumba distinguish between two kinds of *'una,* within a larger category *hohondi,* which includes various beans. One kind, "genuine" *'una (Lablab purpureus* (L.) Sweet) is eaten, while the other, *nerira* (a wild form of *Phaseolus lunatus* L.), is shunned since to eat it is said to cause vomiting. Here we surely have a case in which knowledge of the distinction between these two plant classes could be seen to have practical consequences. However, this is a carefully selected example from Ndumba plant classification, and it is *not* generally true of the polytypic folk plant taxa that their members contrast so neatly in terms of their uses. Rather than casual illustrations of useful, or even "adaptive," contrasts, we must ask for generality from proposed explanations of folk classification.

Those of us who seek to find "adaptive" value in any instance or system of knowledge or behavior must join the ranks of biologists and others for whom the definition of "adaptation" has become a complex and often confusing issue (Alland 1975). A utilitarian/adaptationist perspective would, it seems, contend that cultural knowledge enables people to meet their needs—whether these be thought of in terms of sheer survival, reproductive success, "adjustment" to environmental perturbations, or some other end—better than they could if they did not have this knowledge. With respect to folk classification systems, this would mean that conceptual contrasts among classes of plants and animals result in behavior which is more "adaptive" than if such distinctions were not made. It will be the responsibility of those of us who speak of adaptive outcomes to state explicitly and clearly just how these are to be judged.

A related question is whether, when we are seeking the practical consequences of folk distinctions among organisms, we are concerned only with *real* consequences or also with those which are only imagined to exist? For example, in Ndumba morphological features are used to subdivide yams *(Dioscorea* spp.) into 19 named types in the shared folk taxonomy; one of the traits so employed is the overall shape of the tuber. One kind of yam is forbidden to males during a certain stage of their youth on the grounds that to eat it would cause them to grow "crookedly," just as the tuber itself is "crooked." One might say that this is a taxonomic contrast which reflects "utilitarian" *Ndumba concerns,* but it is highly questionable whether a boy's physical growth pattern really would be affected if he confused the forbidden yam with another. Those who would argue for the adaptive or utilitarian value of folk distinctions must deal with this issue, not only with regard to food sources and related prohibitions, but also with respect to such areas of ethnobotany as ethnomedicine, where we find many careful distinctions drawn among plants on the basis of reputed phytochemical properties for which there is either no, or negative, scientific evidence.

If the issues raised so far in this discussion can be resolved satisfactorily, we must next ask how we would generate hypotheses and systematically test them; i.e., what would we count as evidence relevant to a utilitarian/adaptationist argument, and how would we go about obtaining and evaluating it?

Viewing folk taxonomies as systematic organizations of concepts which function in directing bahavior with regard to the conceptualized environment, reasonable hypotheses might take a form such as: "Folk taxonomic contrasts correspond to contrasts in behavioral responses to the respective organism classes." (An apparently positive case would be the already-cited contrast in Ndumba between "genuine" *'una* and *nerira,* which corresponds to eating the former and avoiding the latter.) In slightly less cumbersome language, we might hypothesize: "Folk taxonomic contrasts correspond to contrasts in *uses* of the respective organism classes." Indeed, the "economic" orientation of most representations of utilitarian/adaptationist perspectives would suggest the replacement of "behavioral response" with "use." However, operationalizing the notion of "use" entails serious difficulties (Hays 1974, 1980, n.d.). There are at least two methodological issues contained in the apparently straightforward matter of identifying contrasts in "uses" of particular plants or animals. The first concerns just *what* will be counted as a "use," and the second involves the degree of specificity required in classifying two or more "uses" as *contrasting.*

In identifying "uses" of resources, one encounters examples such as the previously-cited *nerira* in Ndumba, which is not "used" in any ordinary sense of the word; rather, it is *avoided.* Similarly, the felling of a particular tree called *nraamma' saasira* is avoided because it is believed that such an act would cause the woodsman's wife's or mother's breasts to "dry up and die." There are also examples of organisms which are "used" only indirectly, as when a hunter seeks out a particular kind of tree because a preferred type of game animal is believed to favor its fruit, or build a nest in its branches. Many other examples could be adduced of plants and animals which have these kinds of significance or *salience* for people even though they may not be "used" in the sense that one "uses" resources for food, medicine, implements, and the like.

If we are concerned with identifying and assessing the behavioral consequences of distinctions among plants or animals, i.e., the "usefulness" of knowledge, we need to employ a notion of utility which incorporates organisms' variable salience—thus my preference for phrasing hypotheses in terms of "contrasts in behavioral responses." With such an approach, we can then talk reasonably about contrasts among given plant or animal classes in terms of their contrasting salience.

A key question remains: Do plant or animal classes in particular contrast sets correspondingly contrast in terms of salience (i.e., differential behavioral responses)? That is, do we find that the various kinds of sweet potatoes, beans, snakes, or grasshoppers are differentially responded to in the real world in other than classificatory and nomenclatural ways? This appears to be the main hypothesis that utilitarian/adaptationist approaches must test.

On the surface it is certainly the case that some classes of organisms appear to be functionally equivalent, i.e., there are no contrasting behavioral responses readily discoverable. In Ndumba, for example, *all* snakes are responded to in the same ways: all are killed on sight, none is eaten, and none is "used" in any way that I was able to discover in 16 months of residence there. Other contrast sets could be identified where the same appears to be the case, as in sets of food plants, all of which are cooked and eaten in the same manner.

If, in fact, there are folk contrast sets the members of which are truly functionally equivalent, this would constitute a challenge to the notion that conceptual distinctions correspond to, and thus reflect, differential utility or salience. Before this can be determined, the second methodological issue referred to earlier must be addressed—how finely might we need to distinguish "uses" or differential responses for ethnographic adequacy? For example, if two different flowers are said to be equally suitable for use in personal decoration, are they equivalent, or might there not be subtle contrasts which are manifested only when the would-be wearer chooses, say, on the basis of mood? If the latter is true, is this the kind of difference which we will want to consider *enough* of a difference to say that the flowers have contrasting uses? If so, then it is unlikely that any two classes would be considered truly equivalent, but we are risking here the possibility of reducing our analysis to an identification of trivial distinctions which are not obviously the kinds of contrasts utilitarian/adaptationists usually have in mind when they speak of the "adaptive" value of folk contrasts. Moreover, as we pursue contrasts in behavioral responses we must be wary of the danger of indefinite "splitting" or "lumping" of resource "uses" which not only renders it unlikely that a satisfactory description of a particular folk system will emerge, but also that comparative studies will be all the more difficult.

This last point raises the final methodological issue I will consider here: Is it possible to obtain closure in utilitarian/adaptationist investigations? In the immediate context of this discussion, is it possible to determine when one has an adequately thorough knowledge of local plant or animal "uses" (including subtle contextual factors) to employ a final list of "uses" so that classes of organisms can be compared in these terms? I would say that some classes of plants and animals in Ndumba have *no* "uses" (and no salience, either, so far as I can discover, as in the various types of butterflies which "just are" so far as Ndumba are concerned). Yet, it might be said that there *are,* in fact, "uses" which I would observe or otherwise discover with further fieldwork. Obviously that is a possibility but just as obviously this is an argument that is capable of infinite extension and one which is likely to render our hypotheses *unfalsifiable,* and thereby useless. Certainly one could never prove a negative, such as "there is no conceivable context in which plant or animal *x* is used (or used slightly differently)."

As we attempt to develop and test utilitarian/adaptationist hypotheses after careful consideration of the points I have raised in this paper, we must beware of dooming our efforts to inconsequentiality by resorting to such "escape clauses" as contending that the hypotheses will, in fact, be confirmed once we have more data. This is one of several all-too-common counterproductive escape clauses resorted to by proponents of what Gould and Lewontin (1979) have called the "adaptationist programme." They assail biologists who try to save particular approaches by following certain styles of argument, for example, "If one adaptive argument fails, try another"; "If one adaptive argument fails, assume that another must exist; a weaker version of the first argument"; or, "In the absence of a good adaptive argument in the first place, attribute failure to imperfect understanding of where an organism lives and what it does" (Gould and Lewontin 1979:586-587).

CONCLUSION

My objective in this paper has been to point out some of the problems and traps which need to be resolved and avoided in order for a utilitarian/adaptationist approach to be tested adequately in ethnobiology. My own belief is that we will ultimately understand folk classification systems as products of a number of complex, interacting factors: biological discontinuities in nature, chance historical events, "utilitarian" human concerns, human cultural concerns in a broader sense, intellectual curiosity, and constraints deriving from the nature of human perception and cognition.

Such a belief can itself be a trap, of course, when "a number of complex, interacting factors" becomes a shibboleth which excuses failure to pursue any particular factor as far as it will lead. I would hope that the suggestions in this paper will encourage, rather than discourage, the careful pursuit of a utilitarian/adaptationist perspective so long as it will be possible to also determine just how far it will *not* take us, and how much we will have to consider these other factors.

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FOLK ZOOLOGICAL LIFE-FORMS AND LINGUISTIC MARKING

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ABSTRACT. – Folk zoological life-form terms are added to languages in a highly regular manner. Elsewhere (Brown 1979a) cross-language data have been assembled showing that life-forms of the triad FISH, BIRD, and SNAKE are lexically encoded first by languages, although in no particular order, followed by WUG (e.g., American English *bug)* and MAMMAL. The present paper reports recent research which has led to some revisions in the encoding sequence. However, its primary purpose is to outline how the sequence fits into the framework of linguistic marking developed over the years by Jakobson, Greenberg, and others. Linguistic marking involves variables such as life-form term frequency of use, term complexity (phonological or morphological), and acquisition by children learning langauge. Consideration of zoological life-form classification as it relates to these variables shows that there is a universal marking hierarchy for animal life-form concepts.

INTRODUCTION

Folk zoological life-forms are the most inclusive, comprehensive animal classes regularly found in languages. In a study published in 1979 I assemble evidence from 112 globally distributed languages showing that five life-forms, FISH, BIRD, SNAKE, WUG (e.g., American English *bug)* and MAMMAL are added to languages in a highly regular order (Brown 1979a). Since 1979 research has continued with the goal of expanding and refining cross-language data upon which the animal life-form encoding sequence is based. This has led to some revisions in originally described generalizations which are outlined here. However, the major purpose of this study is presentation of evidence showing that the zoölogical life-form encoding sequence fits into the framework of linguistic marking developed over the years by Jakobson (1941), Greenberg (1966, 1969, 1975), and others.

METHODS

Revised animal life-form encoding sequence

In the original study (Brown 1979a) cross-language data were compiled from two major sources: (1) dictionaries and (2) nondictionary sources. Nondictionary data were collected through personal communications with individuals who gathered information firsthand in the field, through reference to published and unpublished monographs and articles treating folk animal classification, and by me directly from informants. Of the 112 languages initially surveyed, dictionaries were primary sources for 78 cases and nondictionary sources were drawn on for the remaining 34.

Since nondictionary sources deal primarily with animal naming and classification, they are obviously more reliable with respect to thoroughness and accuracy of biological reference than dictionary sources. The fact that most data assembled in the original study were gathered from dictionaries meant that the initial investigation was necessarily preliminary. Ideally most data in terms of which uniformities in folk biological classification are determined should be compiled from nondictionary sources. I have recently assembled life-form data from nondictionary sources for 144 languages (Brown 1981a). This has led to certain changes in the animal life-form encoding sequence. The revised encoding sequence is presented in Figure 1.

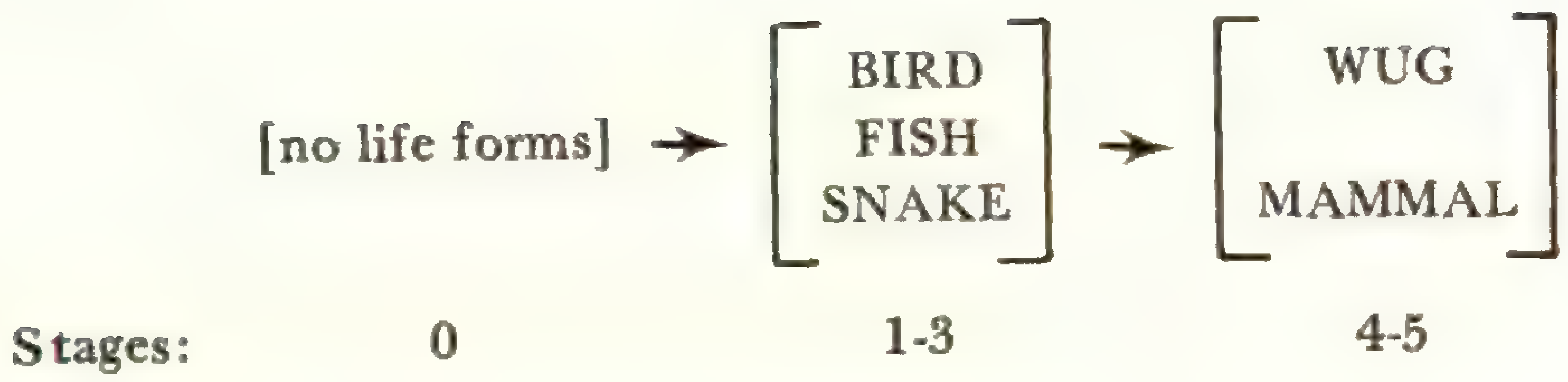

FIG. 1—Revised folk zoological life-form encoding sequence (Brown 1981a).

DISCUSSION

The encoding sequence of Figure 1 is interpreted as a series of stages in the growth of folk zoological life-form vocabularies with one life-form term being added at each stage. Stage 0 languages totally lack terms for animal life-forms. Stage 1 languages encode one, Stage 2 languages encode two, and Stage 3 languages encode three of the life-forms FISH, BIRD, and SNAKE. At Stage 4 languages add a term for either WUG or MAMMAL. The remaining animal life-form class is encoded at Stage 5.[1]

The critical features associated with the five life-forms of the encoding sequence are as follows:

BIRD	Large creature (relative to creatures such as bugs) possessing wings and usually having feathers and a bill or beak. (This life-form always includes birds. In its greatest extension it includes birds and flying mammals such as bats.)
FISH	Creature possessing a streamlined body and fins, usually having gills. (This life-form always includes true fish. In its greatest extension it includes true fish and fish-shaped mammals such as dolphins and whales).
SNAKE	Featherless, furless, elongated creature usually lacking appendages. (This life-form always includes snakes and/or worms. In its greatest extension it includes snakes, worms, lizards, eels, and occasionally, other elongated creatures such as reptile-like insects.)
WUG	Small creature other than those included in BIRD, FISH, and SNAKE. (This life-form always encompasses bugs, i.e. insects and other very small creatures such as spiders, and frequently is extended to worms. Occasionally the category also includes other creatures such as lizards, tortoises, and frogs if these are small.)[2]
MAMMAL	Large creature other than those included in BIRD, FISH, and SNAKE. (This life-form always includes mammals. It is often extended to other large animals such as iguanas and crocodiles and, in addition, to such creatures as tortoises and frogs if these are large.)[3]

To a greater or lesser extent each of the above five categories encodes a large, pan-environmental discontinuity in nature. (As noted presently, the status of WUG and MAMMAL as true discontinuities is problematic.) In other words, each is a linguistic reflection of a morphologically distinctive, but highly heterogeneous grouping of creatures found in most environments inhabited by humankind. Thus these categories are distinguished from other general animal classes which do not encode discontinuities in nature but rather are based on criteria other than gross morphology. Such criteria include animal habitat (e.g., house vs. forest), edibility (e.g., poisonous vs. nonpoisonous, tabooed vs. nontabooed), symbolic status (e.g., sacred vs. profane), relationship to human beings (e.g., flying vs. crawling vs. trotting vs. burrowing), and so on. In the literature on folk biological classification those categories based on the latter criteria are identified as "special purpose" classes while those encoding discontinuities in nature are called "general purpose" classes.

Clearly there are other large zoological discontinuities in addition to the five noted above which are pan-environmental. Examples include ants, spiders, wasps, moths and butterflies, and toads and frogs to mention a few. However, the discontinuities treated in my investigation are singled out for special attention because they appear to be especially significant for humans. This special importance is mirrored cross-linguistically in folk zoological classification. For example, these discontinuities are consistently encoded by languages. In other words, they are realized as labeled zoological classes over and over again. Most importantly, categories reflecting them tend to be the most polytypic animal classes of languages. Four folk zoological taxonomies studied in detail would appear to support this observation. Tables 1-4 list the most polytypic "general purpose" animal classes found in Chrau (Thomas 1966), Kyaka Enga (Ralph Bulmer, personal communication), Ndumba (Terence Hays, personal communication) and Tzeltal (Hunn 1977) respectively.

TABLE 1. *Seven most polytyic general purpose animal classes in Charu (extracted from Thomas 1966).*

Class	Number of immediately included labeled classes
sŭm (BIRD)	17
ca (FISH)	12
vih (SNAKE)	7
kyôq ("frog"/"toad")	5
si ("louse")	5
khlang ("bird of prey")*	5
ong ("wasp")	5

*khlang is not included in sŭm (BIRD).

TABLE 2. *Eight most polytypic general purpose animal classes in Kyaka Enga (Ralph Bulmer, personal communication).*

Class	Number of included terminal labeled classes
yaka (BIRD)	180
kau (SNAKE)	71
sa (MAMMAL ("large mammal"))	32
mugi ("frog"/"toad")	19
wi (MAMMAL ("small mammal"))	13
mena ("pig")*	13
maemae ("butterfly"/"moth")	7
re ("ant")	7

*mena is not included in either sa ("large mammal") or wi ("small mammal").

TABLE 3. *Nine most polytypic general purpose animal classes in Ndumba (Terence Hays, personal communication).*

Class	Number of immediately included labeled classes
kuri (BIRD)	86
to’vendi (WUG)	49
fai (MAMMAL (“large mammal”))	15
kaapa’raara (SNAKE)*	11
faahi (MAMMAL (“small mammal”))	10
feqana (“frog”/“toad”)**	9
kaapura’rora (“butterfly”/“moth”)	8
kaa’puri (“ant”)***	8
quara (“pig”/“domestic mammal”)****	8

*kaapa’raara is immediately included in to’vendi (WUG).
**feqana is immediately included in to’vendi (WUG).
***kaapura’rora and kaa’puri are both immediately included in to’vendi (WUG).
****quara is not included in either fai (“large mammal”) or faahi (“small mammal”).

TABLE 4. *Eight most polytypic general purpose animal classes in Tzeltal (extracted from Hunn 1977).*

Class	Number of immediately included labeled classes
mut (BIRD)	106
čanbalam (MAMMAL)	36
čan (SNAKE)	23
č’o (“small rodent”)*	12
šuš (“wasp”)	10
ʔam (“spider”)	10
čay (FISH)	8
čanul haʔ (“water bug”)	8

*č’o is immediately included in canbalam (MAMMAL).

Tables 1-4 show that BIRD, FISH, SNAKE, WUG, and MAMMAL, if encoded, are consistently among the most polytypic animal classes in a taxonomy. Indeed, with the single exception of the Tzeltal FISH category (Table 4), classes encoding the five zoological discontinuities are the most polytypic animal categories in all four languages. The Tzeltal exception is due to the fact that the language is spoken in a mountainness region of southern Mexico where fish are severely restricted in number and diversity. Similarly, Kyaka Enga and Ndumba are spoken in highland regions of New Guinea where fish are virtually lacking, accounting for the fact that these languages do not encode FISH.

Six languages among the 144 recently surveyed treat WUG and MAMMAL in a special manner. Instead of encoding WUG and MAMMAL in separate categories, creatures of these groupings are lumped together in a single labeled class. These “combined WUG-MAMMAL” categories typically include bugs and mammals and frequently extend to other creatures which are neither birds, fish, or snakes, such as lizards, turtles, frogs, and so on. Distributional considerations indicate that languages encode combined WUG-MAMMAL only after addition of all three classes of the initial triad, BIRD, FISH, and SNAKE.

While zoological life-forms are typically encoded through use of a single label, they are sometimes lexically realized in other ways. For example, languages may lack a term for a class extended to mammals in general, but lexically encode MAMMAL through the binary opposition "large mammal"/"small mammal" (e.g., Ndumba, see Table 3). Languages doing so are judged as having a MAMMAL life-form in my studies (Brown 1979a, 1981a). In some cases, languages may encode only one-half of a binary opposition, e.g., only "small mammal." These languages are also judged as having MAMMAL life-forms. Binary opposition is particularly prevalent in the encoding of SNAKE. SNAKE is frequently recognized through the binary contrast "small elongated animal"/"large elongated animal." The "small elongated animal" category usually encompasses worms alone while the "large elongated animal" class is usually restricted to true snakes.

Explanatory framework

I (Brown 1979a, 1981a) have proposed an explanatory framework to account for the developmental priority of BIRD, FISH, and SNAKE and the late emergence of WUG, MAMMAL, and combined WUG-MAMMAL. Incorporated into this framework are three principles of naming-behavior: (1) criteria clustering, (2) binary opposition, and (3) dimension salience.

Criteria clustering occurs when certain features of natural objects correlate or cluster thus producing discontinuities in nature. Criteria clustering underlies encoding of BIRD, FISH, and SNAKE. For instance, Bruner et al. (1956: 47) cite the example of birds, creatures possessing feathers, wings, and a bill or beak. A creature's possession of feathers is highly predictive of wings and a bill or beak, so much so that an expectancy of all these features being present together is built up. This expectancy can lead to the lexical encoding of BIRD. Similarly, FISH and SNAKE have respective sets of defining features showing high levels of mutual predictability. The occurrence of fins predicts a streamlined body and gills, and greatly elongated creatures usually lack appendages as well as feathers and fur. In brief, BIRD, FISH, and SNAKE constitute salient discontinuities in nature and, thus, are natural candidates for lexical encoding. (See Hunn [1976, 1977] for a detailed consideration of the influence of discontinuities in nature on folk classification).

The late encoding of WUG, MAMMAL, and combined WUG-MAMMAL is in part a function of their relative indistinctiveness as natural discontinuities vis-a-vis the distinctiveness of BIRD, FISH, and SNAKE. Each of the former three groupings is exceptionally heterogeneous and demonstrates little criteria clustering. For example, while most mammals have four appendages used for locomotion and/or object manipulation, so do many other animals including such common creatures as lizards, salamanders, frogs, and turtles. Consequently, possession of four appendages is not particularly predictive of other faunal characteristics such as fur or hair. Exemplars of WUG have even less in common than creatures included in MAMMAL. WUG, for example, encompasses animals having legs and lacking them, having wings and lacking them, having segments and lacking them, and so on. Combined WUG-MAMMAL, of course, aggregates the heterogeneity pertaining to WUG and MAMMAL.

The principles of binary opposition and dimension salience underlie the encoding of WUG and MAMMAL. Classification through binary opposition is a common feature of language. Physical and conceptual dimensions are universally encoded initially through binary contrast, e.g., deep/shallow, sharp/blunt, rough/smooth, good/bad. Only later are such dimensions recognized by single terms, e.g., depth, sharpness, texture, and value respectively. The priority of binary contrast in dimension encoding is often apparent in the development of terms for whole dimensions. These are frequently derived from one of the two labels for associated oppositions: for example, depth from deep and sharpness from sharp.

Sometimes classification of natural objects involves their "dimensionalization." In other words, they are treated as if they are distributed along a dimension and are encoded through binary contrast. When this occurs, the dimension involved is invariably size. The importance of size in biological classification illustrates the principle of dimension salience. Dimensions are not particularly salient if they only apply to a small number of different objects. Since all biological organisms vary by size, there is a strong tendency for this dimension to underlie encoding of plant and animal classes through binary contrast.

After the three major zoological discontinuities are encoded as life-form classes, there remains a large and varied group of creatures which are not affiliated with life-forms. These left over or "residual" creatures often include mammals, lizards, frogs, turtles, snails, worms, and bugs to mention just the more obvious ones. Life-form encoding beyond BIRD, FISH, and SNAKE usually involves lexical recognition of subgroupings of these animals. However, among residual creatures distinct discontinuities are not easily discerned since criteria clustering is not much, if at all, in evidence. As a consequence, languages usually resort to a common classificatory strategy that need not necessarily involve distinct discontinuities, that is, binary opposition based on the salient dimension size. Thus the addition of WUG and MAMMAL encodes the contrast "small residual creature"/"large residual creature."[4]

There is another way of dealing with residual creatures which is occasionally resorted to by languages. Instead of lexically recognizing them through binary opposition based on size, some languages simply regard residual creatures, both large and small, as forming a unified grouping which is encoded by use of a single term. This, of course, creates combined WUG-MAMMAL life-form classes.

The relative rarity of combined WUG-MAMMAL among the 144 languages surveyed (Brown 1981a) suggests that humans are usually disinclined to use classificatory strategies that do not incorporate substantive defining features. Membership in a combined WUG-MAMMAL category does not involve substantive characteristics of creatures but rather their lack of membership in other life-form classes, i.e. their residualness. On the other hand, the binary contrast WUG/MAMMAL does entail a substantive feature, that is, animal size. The relatively high frequency of occurrence of the latter contrast among the world's languages indicates that humans are somehow more comfortable with life-form classes which are anchored in objective reality, even if only minimally so.

Folk biological life-forms and societal scale

In two studies I report that size of both botanical (Brown 1977) and zoological (Brown 1979a) life-form vocabularies is positively correlated with societal scale. Languages having few biological life-form terms are usually spoken by people living in small-scale societies with little of the political integration, social stratification, and technological elaboration found in large urban societies where people speak languages usually having many life-form terms.

The special usefulness and aptness of biological life-forms in large-scale societies may relate to the increasing separation of humans from direct reliance and dependence on the natural environment in these societies. The typical individual in a small-scale society can usually name and identify hundreds of separate plant species (Berlin et al. 1974; Conklin 1954; Hays 1976), while typical nonspecialist members of modern urban society might do well to name and identify even one hundred (Dougherty 1978). When people lose detailed knowledge of plants and animals including names for them, less specific terms, such as life-form labels, tend to grow in number and become increasingly salient. Addition of biological life-form classes to languages, then, indexes a general decrease of interest in and concern with the world of plants and animals.

Salience of biological classes can be measured through frequency of use of terms for them in ordinary language. The more frequently used words of a language tend to label more salient classes and the less frequently used words, less salient categories. Thus, in languages of modern nation-state societies terms for animal life-form classes generally should be more frequent in use than terms for less general animal categories. Tables 5-7 organize information relating to the salience of animal concepts (classes) as measured by frequency of use of terms for them in three nation-state languages, American English, Arabic, and Peninsular Spanish respectively. As expected, these tables show that animal life-form classes for the most part are ranked among the very most salient animal categories in these languages.

TABLE 5. *Ranking of the 66 most salient animal concepts in American English based on frequency of occurrence of terms for them in written language (extracted from the "Lorge-Thorndike Semantic Count" found in Thorndike and Lorge 1944).*

FREQUENCY	ANIMAL CONCEPT(S)
1000+	"animal/creature/beast" (849 animal, 324 creature, 202 beast), horse
582	dog
482	FISH (fish)
348	BIRD (bird)
266	robin
247	WUG (216 insect, 31 bug)
246	SNAKE (127 snake, 54 serpent, 65 worm)
234	cattle
205	lion
202	cat
195	sheep
175	goose
162	rabbit
160	deer
155	cow
148	toad
145	wolf
143	pig
131	bee, crow, monkey, seal
114	rat
112	eagle
111	duck
108	cardinal
103	chicken
98	bull
90	lamb, mule
89	spider
87	ant
84	elephant
81	hound
75	goat, mouse, possum
72	beaver
69	ox
68	cock
62	shark
61	trout

TABLE 5 (Continued)

FREQUENCY	ANIMAL CONCEPT(S)
58	muskrat
56	mole
54	cricket
52	owl
50	calf, dragon, dragonfly, hen, kitten, pony
48	fowl
47	buffalo
44	badger
43	donkey, hare, hog
42	fox
41	squirrel, gorilla, hawk
40	turtle, lark, tiger

Tokens (running words counted) = 4,500,000

TABLE 6. *Ranking of the 44 most salient animal concepts in Arabic based on frequency of occurrence of terms for them in written language (extracted from Landau 1959).*

FREQUENCY	ANIMAL CONCEPT(S)
59	"animal/creature"
31	BIRD
30	"dog"
27	"lion"
26	"camel"
16	FISH
12	"horse"
10	SNAKE (9 "snake," 1 "worm"), "locust"
9	WUG
8	"cow"
6	"deer," "mule," "elephant," "bee"
5	"monkey/ape"
4	"reptile/burden animal," "goat," "spider," "cat"
3	"mosquito," "sheep," "wolf," "ostrich," "cock"
2	"swine," "hen," "fly," "leech," "vulture/eagle," "ant"
1	"duck," "fox," "ox," "buffalo," "dove," "donkey," "giraffe," "hawk," "hyena," "scorpion," "lynx/leopar," "cobra," "tiger"

Tokens (running words counted) = 272,178

TABLE 7. *Ranking of the 65 most salient animal concepts in Peninsular Spanish based on frequency of occurrence of terms for them in written language (extracted from Buchanan 1941).*

FREQUENCY	ANIMAL CONCEPT(S)
214	"animal/creature"
207	BIRD
188	"horse"
160	"dog"

TABLE 7 (Continued)

FREQUENCY	ANIMAL CONCEPT(S)
117	"bull"
115	FISH
82	"lion"
73	"cat"
71	"cow"
58	"cock," "ox"
53	SNAKE (35 "snake," 18 "worm")
45	"goat," "chicken"
41	"mouse"
40	"fly (insect)"
39	"pig"
38	"eagle"
37	"sardine"
34	"cattle," "pigeon," "donkey"
33	"mule"
32	"wolf"
31	"fox"
29	"butterfly"
27	"hare," "turkey"
26	"parrot"
25	"spider," "snail," "frog," "tiger," "sheep"
23	"mosquito"
22	"bee"
21	"ant," "toad"
20	"partridge," "rabbit," "raven"
19	"duck"
18	"grub," "monkey," "crab," "blackbird"
15	WUG
14	"elephant"
13	"thrush," "cricket"
12	"locust"
11	"mole"
10	"hog," "cardinal," "bear"
9	"flea," "falcon"
8	"turtledove," "reptile," "lizard," "woodpecker"
7	"deer," "swallow"
6	"whale," "clam"

Tokens (running words counted) = approximately 1,200,000

Salience rankings of animal concepts (classes) presented in Tables 5-7 are based on frequency of occurrence of terms for them in written rather than spoken language.[5] Animal concepts ranked in each table constitute a group of the most salient animal classes in a language. For example, those of Table 5 are the 66 most salient animal categories in American English by frequency of use criteria. Animal concepts are ranked from the most salient one in a language to the least salient of the pertinent group. In a number of cases different terms of a language label the same animal class. Frequency counts for these are added together to yield an overall count for the class. For example, American English WUG has a frequency score of 247 which is the sum of the occurrences of *insect* (216) and *bug* (31) in a token of approximately 4,500,000 running words. The frequency score for the concept SNAKE in each of the three languages is the sum of counts for "snake" and "worm" classes. Individual scores for the latter two animal concepts are also given.

Tables 5-7 show that two zoological life-forms, BIRD and FISH are among the six most salient animal concepts in each of the three nation-state languages. In addition, SNAKE is found among the 11 most salient animal concepts in all three. In two languages, American English (Table 5) and Arabic (Table 6), SNAKE and WUG have virtually the same high degree of salience (see frequency scores for these). Only Spanish (Table 7) has a life-form concept, WUG, which shows a relatively low salience ranking. It should also be noted that the most general faunal concept of all, "creatures, beasts, or animals in general," is ranked first in salience in all three languages.[6]

Since people living in small-scale societies have less need for general animal concepts than people of nation-state societies, it is probably the case that life-form classes and other general animal categories, if encoded, are not especially salient for them. As it happens, most of the world's languages apparently lack very broad "unique beginner" or "kingdom" classes encompassing plants in general or animals in general (Berlin 1972; Berlin et al. 1973), indicating that cross-linguistically these are not very salient for speakers of nonnation-state languages. In addition, word frequency data from small-scale society languages should show that many, if not most, generic animals classes are ranked higher in salience than animal life-form classes, in sharp contrast to the relative rankings of generics vis-a-vis life-forms presented in Tables 5-7 for nation-state languages. Unfortunately, adequate word frequency counts for small-scale society languages are not now available to test this proposition.

The association between size of biological life-form inventories and societal scale indicates a tendency for the number of life-form terms to increase with increases in the scale and complexity of societies. Since societal scale has generally increased during the course of human history, especially so during the last several thousand years, it follows that biological life-form vocabularies in the vast majority of cases have grown rather than shrunk in size and, thus, that the animal life-form encoding sequence is basically additive in nature. This conclusion has been borne out in several studies which have used the comparative method of historical linguistics to reconstruct biological life-form growth in the histories of several genetic groups of languages (cf. Fowler 1972; Brown 1979b, 1981b, 1981c; Brown and Witkowski 1982).

Life-forms and linguistic marking

Cross-language regularities in animal life-form classification are related to linguistic marking. The framework of marking has been developed over the years by Jakobson (1941), Greenberg (1966, 1969, 1975), and others. Marking involves all components of language: phonology, grammar, and the lexicon. Marking in the lexicon entails a distinction between marked and unmarked words. The animal life-form encoding sequence is in fact a universal marking sequence or hierarchy. Terms for BIRD, FISH, and SNAKE are regularly unmarked in languages vis-a-vis terms for WUG and MAMMAL which are marked.

There are several diagnostic features of marking that tend to co-occur in typical marking relationships. Some of these are as follows:

Unmarked Item	Marked Item
1. The implied in an implicational relationship.	1. The implier in an implicational relationship.
2. Earlier acquisition by languages.	2. Later acquisition by languages.

3. Greater frequency of use (in text or spoken language).	3. Lesser frequency of use.
4. Less complex (phonologically or morphologically).	4. More complex.
5. Earlier child acquisition.	5. Later child acquisition.

Marking features 1 and 2 are closely interrelated and entail a cross-language perspective. An implicational relationship is evident when the occurrence of a certain item in languages implies or predicts the occurrence of another item, but not vice versa. For example, the cross-language data (Brown 1979a, 1981a) show that if a language has a WUG term, it will have terms for FISH, BIRD, and SNAKE. However, if a language has a term for any one of the latter three life-forms, it will not necessarily have a label for WUG. Thus WUG implies FISH, BIRD, and SNAKE, but none of these imply WUG. Similarly both MAMMAL and combined WUG-MAMMAL imply the former three life-forms, but not vice versa. Thus, WUG, MAMMAL, and combined WUG-MAMMAL are marked vis-a-vis BIRD, FISH, and SNAKE which are unmarked (feature 1).

Implicational associations involving lexical items are often the synchronic result of cross-language regularities in the order in which these items are acquired languages. Such relationships form the basis for the proposal of an animal life-form encoding sequence (Brown 1979a, 1981a). For example, the fact that WUG implies BIRD, FISH, and SNAKE but not vice versa is understandable if languages regularly encode BIRD, FISH, and SNAKE before encoding WUG. In addition to implicational relationships there is independent evidence which corroborates the acquisitional hypothesis outlined in Figure 1. This is evidence developed through the comparative approach of historical linguistics showing that languages add animal life-form terms to their vocabularies in the order of the encoding sequence (cf. Brown 1981b; Brown and Witkowski 1982). In terms of this evidence alone, one could determine that FISH, BIRD, and SNAKE are unmarked relative to WUG and MAMMAL which are marked (feature 2).

Marking features 3, 4, and 5 are closely interrelated but these associations are realized in individual langaugues rather than across languages in the manner of features 1 and 2. For example, Zipf (1935, 1949) has shown that frequency of use (feature 3) correlates strongly with phonological (or orthographic) length of words (feature 4). High frequency is associated with short word length and, thus, with less complexity, and low frequency with long length and more complexity. This correlation is attributable to efficiency of communication factors: efficiency is enhanced when frequently used words are short rather than long. Since unmarked items are less complex than marked items and since they occur more frequently, it is not surprising that they tend to be acquired by children learning language before marked items (feature 5).

Since the animal life-form encoding sequence is also a marking hierarchy, it should reflect other criteria of marking in addition to features 1 and 2. For example, in individual languages we should expect that terms for BIRD, FISH, and SNAKE occur more frequently in ordinary use than terms for WUG and MAMMAL (feature 3).

Frequency of use

Above, data are presented showing that folk zoological life-form names are among the most frequently used animal terms in three languages affiliated with nation-state societies. In Table 8 similar data are compiled for 11 nation-state languages showing that frequency of use of the five animal life-forms of the encoding sequence correlates strongly with the order in which these are added to languages. In other words, an additional feature of marking, frequency of use, attests to the universal marking hierarchy for animal life-forms which is also evidenced by other marking features such as implicational relationships and language acquision order.

TABLE 8. *Frequency ranking of folk zoological life-forms in eleven nation-state languages.*

LANGUAGES	FREQUENCY RANKING				
	High	. . . .	. . . .	. . . .	. . . . . Low
Arabic	BIRD (29)	FISH (16)	SNAKE (10)	WUG (9)	MAMMAL (n.f.)
Brazilian Portuguese	BIRD (291)	SNAKE (142)	FISH (133)	WUG (43)	MAMMAL (<5)
Chinese	FISH (12)	BIRD (9)	SNAKE (<9)	WUG (<9)	MAMMAL (<9)
French	BIRD (108)	SNAKE (62)	FISH (54)	WUG (45)	MAMMAL (<5)
German	FISH (1025*)	BIRD (612*)	SNAKE (598*)	WUG (<100)	MAMMAL (<100)
Italian	FISH (17)	BIRD (10)	SNAKE (8)	WUG (4)	MAMMAL (<4)
Japanese	BIRD (16)	SNAKE (11)	FISH (8)	WUG (6)	MAMMAL (6)
Rumanian	BIRD (53)	SNAKE (28)	FISH (19)	WUG (<4)	MAMMAL (<4)
Russian	BIRD (114)	FISH (84)	SNAKE (32)	WUG (<13)	MAMMAL (<13)
Spanish	BIRD (207)	FISH (115)	SNAKE (53)	WUG (15)	MAMMAL (<5)
U.S. English	FISH (1079)	BIRD (770)	SNAKE (380)	WUG (372)	MAMMAL (27)

*close estimate
n.f. = not found among tokens surveyed
( ) enclose absolute frequency figure
< = less than

Each language of Table 8 is affiliated with life-form growth Stage 5 having all five animal life-forms of the encoding sequence. Frequency data presented in Table 8 are extracted from word frequency counts based on written rather than spoken language.[7] Frequency figures (given in parentheses) are based on counts for more than one lexical item when more than one word denotes the same life-form in a language. For example, in U.S. English two terms, *bug* and *insect*, designate WUG. The individual frequencies of these items are 65 and 307 occurrences respectively yielding a total frequency for WUG of 372. Similarly, the Peninsular Spanish BIRD figure, 207, is an aggregation of counts for its two BIRD terms, *pájaro* (66 occurrences) and *ave* (141 occurrences). In addition, frequency counts for SNAKE in several languages (Arabic, Brazilian Portuguese, French, German, Spanish, and U.S. English) are aggregations of counts for "snake" and "worm" terms. In some cases frequencies of "worm" terms are so low that they are not given in sources, thus meaning that for some languages counts for "snake" terms alone yield figures for SNAKE. Chinese and Japanese are exceptional among the 11 languages since they both lump worms with bugs in WUG and lack "worm" labels.

Without exception, in each of the 11 languages (Table 8) BIRD, FISH, and SNAKE occur more frequently in written usage than WUG. Table 8 also shows that these three are more frequent than MAMMAL in all languages. However, frequency counts for

MAMMAL are almost certainly deflated for some languages and, hence, are not entirely reliable. This is due to the fact that terms for "creatures in general" are sometimes used secondarily to designated MAMMAL such as occurs in American English with *animal.* The same is probably true of "animal" terms in the several Romance languages represented. Terms for "creatures in general" occur in these languages at very high frequencies. For example, U.S. English *animal* has a frequency of 1226 compared to 1079 for FISH, the most frequently occurring English animal life-form (see Table 8). It is impossible to calculate with any degree of reliability what proportion of *animal's* occurrences involve MAMMAL as the intended referent as opposed to "creatures in general." Since counts for MAMMAL in Table 8 do not include these unknown values, they undoubtedly underrepresent MAMMAL's true frequency of use in some languages.[8]

Complexity of form

Unmarked words tend to be less complex than marked words. For example, in American English *bird, fish,* and *snake* are all monosyllabic while *insect, mammal,* and *animal* (secondarily MAMMAL) are disyllabic and trisyllabic. However, complexity of form is a somewhat less reliable measure of markedness than frequency of use since exceptions are relatively often encountered. In other words, marked terms are more than occasionally found to be equal in complexity or even less complex than unmarked terms. For instance, the alternative American English WUG label, *bug,* like unmarked, *bird, fish,* and *snake,* is monosyllabic. In addition, with regard to phonological complexity *bug* is simpler than two of the three unmarked terms: *bug* [bəg], *bird* [bɨrd], *snake* [sneyk], and *fish* [fiš]. And, of course, *bug,* is simpler than all three unmarked items with respect to orthographic segment count: *bug* (three), *bird* (four), *snake* (five), and *fish* (four). The criterion of complexity of form, then, reflects a strong tendency rather than an absolutely determinate phenomenon.

When lexical items maintain the same relative marking values across languages, as do folk zoological life-form terms, then on the average unmarked terms should be less complex than marked terms. With this expectation in mind, I have calculated average orthographic length of animal life-form terms encountered in the 144 languages surveyed in the recent animal life-form study (Brown 1981a). This was achieved by simply counting the number of orthographic segments of words for a life-form class, summing them, and then dividing that sum by the number of terms counted.[9] In the case of SNAKE, orthographic segment counts for "snake" terms, "snake and worm" terms, and "worm" terms were aggregated and this total was divided by the number of terms counted. Average orthographic length of animal life-form labels are as follows (from shortest to longest):

FISH: 4.87 segments
SNAKE: 5.53 segments
BIRD: 5.66 segments
MAMMAL: 5.75 segments
WUG: 6.70 segments

These figures, of course, are another reflexion of the universal marking hierarchy for folk zoological life-forms. On the average, terms for BIRD, FISH, and SNAKE which are unmarked are shorter in orthographic length than terms for WUG and MAMMAL which are marked. This marking relationship can also be expressed in a slightly different manner using averages. The average length of terms for BIRD, FISH, and SNAKE considered together is 5.38 segments compared to an average length of 6.14 segments for terms for residual creatures considered together (including terms for combined WUG-MAMMAL).

Above it is noted that animal life-form terms tend to be more numerous and salient in languages spoken in large-scale societies than in those spoken in small-scale ones. For example, frequency data are presented showing that animal life-form words tend to be among the most frequently used names for creatures in three languages affiliated with nation-state societies. Since frequency of use is inversely correlated with complexity of form, it follows that average orthographic length of animal life-form terms in nation-state languages should be less than that of corresponding terms in small-scale society languages.

Of the 144 languages surveyed (Brown 1981a), seven are regularly spoken by peoples living in large-scale, nation-state societies: Cantonese, Indonesian, Mandarin, Northeastern Thai, American English, Czech, and Japanese. Table 9 presents the average orthographic length of life-forms in these languages compared to the average lengths calculated for life-forms in all languages surveyed (the overwhelming majority of which are affiliated with small-scale societies). With the exception of calculations for MAMMAL, these figures accord with the hypothesis that animal life-form classes are more salient for people of large-scale societies than for those of small-scale ones. Another way of putting this is that animal life-form terms of nation-state languages are unmarked vis-a-vis corresponding terms of small-scale society languages (cf. Dougherty 1978).

TABLE 9. *Average orthographic length of animal life-form terms of nation-state languages compared to average length of life-form terms of all 144 languages surveyed in Brown (1981a).*

AVERAGE ORTHOGRAPHIC LENGTH

LIFE-FORMS	Nation-State Languages	All Languages
FISH	3.14 segments	4.87 segments
SNAKE	4.10 segments	5.53 segments
BIRD	4.14 segments	5.66 segments
WUG	5.00 segments	6.70 segments
MAMMAL	6.00 segments	5.75 segments

Child acquisition

Chase (1980) has investigated child acquisition of folk zoological life-forms in two languages, Juchitan Zapotec (Oaxaca, Mexico) and American English. His general conclusions are that child speakers of both languages learn animal life-form terms and associated concepts in the order of the animal life-form encoding sequence (Figure 1). Thus, by child acquisition criteria BIRD, FISH, and SNAKE are unmarked relative to WUG and MAMMAL which are marked.

Of Chase's two investigations the American English study provides more insights into life-form acquisiton by children than the Juchitan Zapotec study. Juchitan Zapotec has only two animal life-forms of the encoding sequence, FISH and SNAKE. Since all children interviewed by Chase controlled terms for these life-forms, the Juchitan Zapotec study sheds little light on order of life-form acquisition. However, the language also has incipient WUG and MAMMAL life-form classes (Brown and Chase 1981). Incipient life-forms are similar to full-fledged life-forms in that criteria of membership are identical except that incipient classes do not extend to known organisms having their own label.[10] Thus, for example, in Juchitan Zapotec only unknown and unnamed bugs are included in incipient WUG. This is overtly recognized by adult speakers of the language (Brown and Chese 1981). On the other hand, child speakers of Juchitan Zapotec often extend terms for incipient WUG and MAMMAL to named creatures as well as to unnamed ones. This parallels lexical overextensions by children frequently cited in the psycholinguistic literature (cf. Lindfors 1980:170-171). Of course, children later acquire the adult usage of these terms.

Chase's (1980) American English study has both stratificational and longitudinal aspects. Initially Chase interviewed ten white, middle class children living in northeastern Illinois ranging in age from approximately three to nine years. Seventeen months later seven of these ten were reinterviewed and six additional children were incorporated into the study at that time. Chase found that number of animal life-forms possessed by children correlates perfectly with age, the youngest having fewest and the oldest having most. In addition, the composition of life-form inventories possessed by these children indicates that they acquired them in the order of the encoding sequence. For example, no child was discovered to have a combination of life-forms such as BIRD, FISH, and WUG (lacking SNAKE and MAMMAL). In the follow up study of some children most had acquired additional animal life-forms, again in accordance with the order of the encoding sequence.

Chase (1980) used two strategies for determining possession of knowledge of folk zoological life-forms. All children were first presented with a stack of cards with realistic animal pictures (mostely in color) pasted on them. Among these all major animal groupings (mammals, insects, amphibians, reptiles, etc.) were well represented. Children were asked to sort these into piles of creatures that "go together." They were then asked to supply names for both piles and individual cards. In addition to stimulus materials, Chase used traditional ethnoscientific techniques (cf. Black 1969) to elicit inclusive relationships.

In addition to paralleling the lexical encoding sequence (Fig. 1), order of acquisition of animal life-forms by American children shows some interesting language-specific details. This order is outlined in Figure 2. Children ranging in age from roughly three to five and one-half years have knowledge of only two life-forms, FISH and SNAKE (labeled *fish* and *snake* respectively). Before reaching six years in age they learn a third life-form, BIRD (labeled *bird).* At around the age of seven years WUG is acquired (labeled variously *bug* or *insect).* Finally MAMMAL (labeled variously *animal* or *mammal)* is learned after the age of eight years or thereabout.

$$\begin{bmatrix}\text{FISH}\\ \text{SNAKE}\end{bmatrix} \rightarrow [\text{BIRD}] \rightarrow [\text{WUG}] \rightarrow [\text{MAMMAL}]$$

FIG. 2. Order in which American children acquire folk zoological life-forms (Chase 1980).

This acquisitional order seems to be related in part to American children's knowledge of generic terms for creatures. The younger children interviewed by Chase were unable to identify individual fish pictures by generic names (e.g., *trout, bass, catfish,* etc.) with the exception of the shark (called *jaws* by some) and names for individual snakes were not known. On the other hand, they were able to assign generic terms to numerous bird pictures (e.g., *penguin, seagull, parrot, duck, owl,* and so on). Perhaps as a consequence, when sorting pictures, all fish were usually put into a single pile and all snakes were placed in another pile (sometimes also including worm pictures), but birds were often left ungrouped, that is, each bird picture constituted its own pile of one. Children sorting pictures thusly possessed knowledge of FISH and SNAKE life-form classes, but not BIRD.

Children lacking a BIRD life-form are not unfamiliar with the word *bird.* However, they simply do not use the term in a way corresponding to adult American usage; in other words, they do not use it as if it were a label for a full-fledged life-form class. Rather, they apply *bird* only to those creatures with feathers, wings, and a bill or beak which are unknown to them and cannot be identified by use of a generic term. Consequently, for these children known creatures such as ducks, parrots, owls, and so on are definitely not *birds* in their system. Thus younger American children use *bird* as a label for zoological class having the characteristics of incipient life-form categories described above.

Marking and principles of naming-behavior

An important question is what factors determine linguistic marking? Specifically, in this context, what generates the marking hierarchy for folk zoological life-forms? Since the relative marking values of BIRD, FISH, SNAKE, WUG, and MAMMAL are uniform across languages, conditions affecting these values must themselves, for the most part, be regular across languages. Probable influences are the principles of naming-behavior proposed earlier an an explanatory framework accounting for uniformities in animal life-form encoding.

Fundamentally, the animal life-form marking hierarchy is a linguistic reflection of criteria clustering in the physical world, that is, it mirrors the indistinctiveness of WUG and MAMMAL as natural discontinuities relative to the distinctiveness of BIRD, FISH, and SNAKE. In other words, terms for BIRD, FISH, and SNAKE are unmarked vis-a-vis terms for WUG and MAMMAL because the physical objects labled by the former three terms figure into highly salient breaks in nature while those labled by the latter two do not. However, criteria clustering alone does not explain these marking distinctions. Such breaks are consistently followed by humans in classifying and naming objects because they are innately inclined to do so. The marking hierarchy, then, is in part attributable to internal constraints on humans in the processing of external stimuli.

CONCLUSION

The close agreement of physical-perceptual constraints and linguistic marking values for animal life-forms indicates that the former are converted or translated into the latter. The categories BIRD, FISH, and SNAKE are naturally salient and are always encoded first in the development of zoological life-form lexicons. This physical salience is also converted through lexical encoding into linguistic salience which is manifested through typical marking effects such as high frequency of use, simplicity of form, and early acquisition by children learning language.

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NOTES

1. In the initial animal life-form study (Brown 1979a) Stage 0 was not recognized. In addition, the earlier version of the encoding sequence proposed that WUG regularly precedes MAMMAL. Data assembled later (Brown 1981a) do not support such a proposal. The original determination of the priority of WUG vis-a-vis MAMMAL was influenced in part by the fact that the vast majority of language cases surveyed were extracted from dictionaries (see Brown 1981d for a discussion of this point).

2. WUG is a mnemonic derived from *worm* and *bug.*

3. *Animal* is more commonly used than *mammal* as a MAMMAL life-form label by speakers of American English. Since *animal* is also used as a unique beginner term to refer to creatures in general, it is not employed as a life-form gloss to avoid ambiguity of reference.

4. Terence E. Hays working with Ndumba (Tairora) speakers of New Guinea and Eugene S. Hunn working with Tzeltal speakers of Mexico independently identified "residual" biological classes during the early 1970's. For discussions of the role of residualness in folk biological classification, see Hays (1974) and Hunn (1976, 1977).

5. Frequency of occurrence of terms for these concepts are extracted from word frequency books, respectively Thorndike and Lorge (1944), Landau (1959), and Buchanan (1941). In the case of American English only one frequency count of the several found in Thorndike and Lorge (1944) is used, i.e., the "Lorge-Thorndike Semantic Count." In Tables 6 and 7 Arabic and Spanish animal concepts are denoted by English glosses. Associated frequency scores are those of actual animal terms. Actual terms and their frequency scores are given in Table 5 for American English.

6. In American English the term *animal* is used to designate both "creature in general" and MAMMAL. Consequently, two distinct usages contribute to the high salience of this term (frequency count = 849, see Table 5). Such a dual application may also pertain to the equivalent Spanish word *animal.* It is, of course, impossible to determine what proportion of frequency counts for such polysemous items trace to one usage as opposed to the other.

7. The following word frequency books were used as sources for data presented in Table 8: Arabic (Landau 1959), Brazilian Portuguese (Brown, Carr, and Shane 1945), Chinese (Liu 1973), French (Vander Beke 1929), German (Morgan 1923), Italian (Juilland and Travera 1973), Japanese (Miyaji 1966), Rumanian (Juilland, Edwards, and Juilland 1965), Russian (Josselson 1953), Spanish (Buchanan 1941), and U.S. English (Thorndike and Lorge 1944). Thorndike and Lorge (1944) present several different counts for U.S. English. Frequencies for U.S. English life-forms given in Table 8 are aggregated figures from two of these counts, i.e. from the "Lorge Magazine Count" and the "Lorge-Thorndike Semantic Count." Several word frequency books consulted break counts down according to genre of written materials surveyed, e.g., drama, essays, newspapers, technical/scientific literature. These include sources for Chinese, Italian, Japanese, Rumanian, and Spanish. In each of these cases frequency figures from technical/scientific literature are excluded from counts presented in Table 8 since these do not reflect "folk" usage. The approximate number of running terms (tokens) pertaining to each word frequency study is as follows: Arabic (272, 178), Brazilian Portuguese (1,200,000), Chinese (250,000), French (1,147,748), German (10,910,777), Italian (500,000), Japanese (250,000), Rumanian (500,000), Russian (1,000,000), Spanish (1,200,000), and U.S. English (9,000,000). The considerable differences in ranges of frequency counts for different languages (see Table 8) reflect the fact that counts for these languages are based on tokens which vary considerably in size.

8. The frequency count for U.S. English MAMMAL given in Table 8 is the frequency of occurrence of the word *mammal.*

9. In counting orthographic segments, all symbols occupying spaces in the horizontal presentation of a word are tallied. This includes symbols indicating vocalic length and symbols indicating glottalization of consonants. For example, Huastec θu·m "worm" is judged as having four orthographic segments and č'ičin "bird" as having six. When a language has two or more terms for a single life-form class, e.g., Southern Paiute with "bird" and "large bird," segments of all terms are counted and figure into calculations for that life-form.

10. Incipient life-form classes are also residual biological categories (cf. Hunn 1976, 1977; Hays 1974).

SOCIETY OF ETHNOBIOLOGY, INC.

The Society of Ethnobiology, Inc., is now established as a non-profit corporation. The founding Board of Directors was covened at its first meeting in San Diego, during the Fifth Ethnobiology Conference held in April 1982, by Steven A. Weber, founding president. This Board was enlarged to include the existing editorial board of the *Journal of Ethnobiology*. The full Board then acted as follows:

1. Elected Steven Weber to serve as President of the Society for 1983 and Steven Emslie to serve during that period as Secretary/Treasurer of the Society.
2. Chose Dr. Willard Van Asdall of the University of Arizona to succeed Steven Emslie and Steven Weber as editors of the journal for volumes 3 and 4 (1983-1984). Until further notice, all journal correspondence should continue to be sent to the present editorial office: P.O. Box 1145, Flagstaff, AZ 86002. Authors of manuscripts should refer to the inside back cover of this issue for specific instructions.
3. Chose Dr. Richard S. Felger and Lynn Reitner of the Arizona-Sonora Desert Museum to serve as book review editors. Several journal pages will be devoted to book reviews each number beginning with Volume 3.
4. Chose Dr. Paul Minnis of the University of Oklahoma as host for the Sixth Ethnogiology Conference to be held at Norman, Oklahoma, in 1983 (see notice below).

SIXTH ANNUAL ETHNOBIOLOGY CONFERENCE

The sixth ethnobiology conference will be held in Norman, Oklahoma, on March 18-19, 1983. A reception will be held on Thursday evening, the 17th of March with paper sessions on Friday and Saturday. A call for papers will be issued in January, 1983. For further information contact Dr. Paul Minnis, Department of Anthropology, University of Oklahoma, 455 West Lindsey, Room 521, Norman, OK 73019.

SOCIETY OF ECONOMIC BOTANY MEETINGS

The Society of Economic Botany will hold its 23rd annual meeting at the University of Alabama in University, Alabama, June 14-17, 1982. Featured will be a symposium entitled "U.S. OILSEEDS INDUSTRY–GERMPLASM TO UTILIZATION". Further information can be obtained from C. Earle Smith, Jr., Anthropology, Box 6135, University of Alabama, University, AL 35486.

COMMITTEE FOR NUTRITIONAL ANTHROPOLOGY

The Committee for Nutritional Anthropology is an organization within the American Anthropological Association which fosters communication among scholars interested in issues of nutrition and anthropology. The yearly dues of $5 covers the cost of quarterly newsletters on topics of current interest in the field. To join the organization, send a letter of self-introduction and the dues to the current president:

Dr. Cheryl Ritenbaugh
Department of Community Medicine
University of Arizona
Tucson, AZ 85724

WEST COAST NETWORK OF NUTRITION AND ANTHROPOLOGY

The West Coast Network of Nutrition and Anthropology is an organization of individuals interested in social and biological aspects of food, nutrition and health. Usually, local meetings are held bi-monthly and an annual meeting is held in the San Francisco area to share research reports. The organization dues are $6 per year and should be sent to:

Dr. Angela Little
Department of Nutritional Science
University of California
Berkeley, CA 94720

Dr. Little can supply information on local California meetings. Information on local meetings in the Vancouver, Canada, are can be obtained from:

Dr. Harriet Kuhnlein
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NOTICE TO AUTHORS

The *Journal of Ethnobiology* accepts papers on original research in ethnotaxonomy and folk classification, ethnobotany, ethnozoology, cultural ecology, plant domestication, zooarchaeology, archaeobotany, palynology, dendrochronology and ethnomedicine. Authors should follow the format for article organization and bibliographies from articles in this issue. All papers should be typed double-spaced with pica or elite type on 8½ x 11 inch paper with at least one inch margins on all sides. The ratio of tables and figures to text pages should not exceed 1: 2-3. Tables should not duplicate material in either the text or graphs. All illustrations are considered figures and should be submitted reduced to a size which can be published within a journal page without further reduction. Photographs should be glossy prints of good contrast and sharpness with metric scales included when appropriate. All illustrations should have the author(s) name(s) written on the back with the figure number and a designation for the top of the figure. Legends for figures should be typed on a separate page at the end of the manuscript. Place all tables and figures in consecutive order at the end of the manuscript. Do not place footnotes at the bottom of text pages; list these in order on a separate sheet at the end of the manuscript. Metric units should be used in all measurements. Type author(s) name(s) at the top left corner of each manuscript page; designate by handwritten notes in the left margin of manuscript pages where tables and graphs should appear.

If native language terminology is used as data, a consistent phonemic orthography should be employed, unless a practical alphabet or a more narrow phonetic transcription is justified. A brief characterization of this orthography and of the phonemix inventory of the language(s) described should be given in an initial note. To increase readability native terms should be indicated as ***bold-face italics*** to contrast with the normal use of *italic* type for foreign terms, such as latin binomials. If necessary, the distinction between lexical *glosses*, i.e., English language approximations of a term's referential meaning, and precise English equivalents or definitions should be indicated by enclosing the gloss in single quotation marks.

As the editorship of the journal is changing in 1983, authors should submit their manuscripts beginning in September 1982 to:

DR. WILLIARD VAN ASDALL, Editor
Journal of Ethnobiology
Department of General Biology
University of Arizona
Tucson, Arizona 86721

Manuscripts submitted before September 1982 should be sent to: P.O. Box 1145, Flagstaff, AZ 86002. Authors must submit two copies of the manuscraipt plus the original copy and original figures. Papers not submitted in the correct format will be returned to the author.

NEWS AND COMMENTS

Individuals with information for the "News and Comments" section of the journal should submit all appropriate material to Eugene Hunn, Department of Anthropology, DH-05, University of Washington, Seattle, Washington 98195. Please note that the former *Folk Classification* Bulletin has been incorporated into this section.

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PINE NUTS AS AN ABORIGINAL FOOD SOURCE IN CALIFORNIA AND NEVADA: SOME CONTRASTS

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ABSTRACT.–Seeds of a large number of western species of the genus *Pinus* have been used by the native peoples of the southwestern and Pacific Coast states as food. A sense of uniformity of the food value across species has been engendered by the use of the common term *piñon* to describe pine seeds (colloquially, "nuts"), regardless of species. In fact, a wide variation exists in their food values, especially between the major edible species. The difference is particularly striking in comparing the single-leaf piñon *(Pinus monophylla)* of the Great Basin with the gray or digger pine *(P. sabiniana)* of the Central Valley foothills of California. Each of these species occupies a discrete, non-overlapping territory. However, the level of importance as a food item varies between the Great Basin peoples, for whom *P. monophylla* was a staple, and the California Indians who considered *P. sabiniana* the source of a highly desirable, if incidental, food item.

INTRODUCTION

When the Spanish explorers traveled through the south Coast Ranges of California in the late 18th century, they met Indians along the way who offered them a variety of foods. For the most part these foods were new to the Spaniards, however, one was very familiar, *piñones*, the seeds of the pine trees. One explorer wrote in 1775 concerning these *piñones*, "There are many pine nuts like those of Spain" and, "In the mountains there are seen many pines like those of Spain" (Fages 1937:59, 35). Presumably these pines were either *P. sabiniana* Dougl. (the digger or gray pine) or *P. coulteri* D. Don (the Coulter or big-cone pine). *Pinus sabiniana* would be the better candidate since its notably hard-shelled "nut" (actually seed) would have been the most similar to the piñon of Spain, the seed of *P. pinea* Linn., the Italian stone pine.

The Spanish encountered pine trees and their seed in a number of other places, particularly in the American Southwest (Lanner 1981; Long 1941) and so the term piñon has become commonly attached to the seeds of a number of species of pine. Since there is such concern among botanists over the use of the correct term, seed, versus the colloquial term, nut, the Spanish word piñon forms a nice ambivalent compromise.

When the word piñon (or pinyon) is used it usually means the seed of *P. monophylla* Torr. & Frem. (single-leaf piñon), *P. edulis* Engelm. (New Mexico piñon), or *P. cembroides* Zucc. (Mexican piñon). However, the term is also applied to the seed of a number of other species of pine which causes a certain degree of confusion. This is particularly true in publications listing nutritional values of American foods. These will generally list pignolia and piñon as the two forms of pine nuts (Watt and Merrill 1963:46; Adams 1975:123; Pennington and Church 1980:108). Pignolia clearly refers to the Mediterranean species, *P. pinea*. When the term piñon is used, it is very unclear, although an examination of the nutrient content seems to narrow it down to *P. edulis* or possibly *P. cembroides* (cf., Botkin and Shires 1948:9).

This tendency to use the term "pine nuts" or piñon with no attempt at specification does not present a problem when there is only one species of pine bearing edible seeds found in an area. However, in California there are no less than seven species with edible seeds. The California Indians exploited *P. sabiniana*, *P. lambertiana*, *P. ponderosa*, *P. coulteri*, *P. monophylla*, *P. quadrifolia*, and *P. torreyana* for their seeds (Yanovsky 1936:5-6).

Whereas most of the Indian peoples of California used the pine seed for food (Farris 1982), its importance is largely overshadowed by the acorn. However, the case is quite different for the Indians of the Great Basin for whom the seed of *P. monophylla* was of major importance (Steward 1941:230). Paiute families in the Great Basin would establish their fall encampments near a producing stand of *P. monophylla* and, if the harvest were particularly good, might actually remain in the vicinity through the winter despite the relatively high elevation favored by this species (Steward 1938:232; Bettinger 1976:83).

Although it may be supposed that pine seeds of varying species are similar in their nutritional qualities as well as their availability, this is not the case. In fact, it has been stated:

> This wide and unexpected variation [in nutritional component proportions] between the different species of pine nuts suggests that, if all other commercial nuts were no longer available, their nutrients in any proportion could be supplied by some species of pine nut (Botkin and Shires 1948:12).

With this in mind I would like to turn attention to two particular species which differ radically in many of their physical and nutritional qualities: the *Pinus sabiniana* of California and the *Pinus monophylla* of the Great Basin (Fig. 1). It should be noted that *P. monophylla* is by no means limited to the Great Basin since it appears through the Transverse Ranges of southern California and on down into Baja California (Barrows 1971:310-311; Bean 1972:40; Zigmond 1941:30-32). However, it primacy as a subsistence item occurred in the Great Basin.

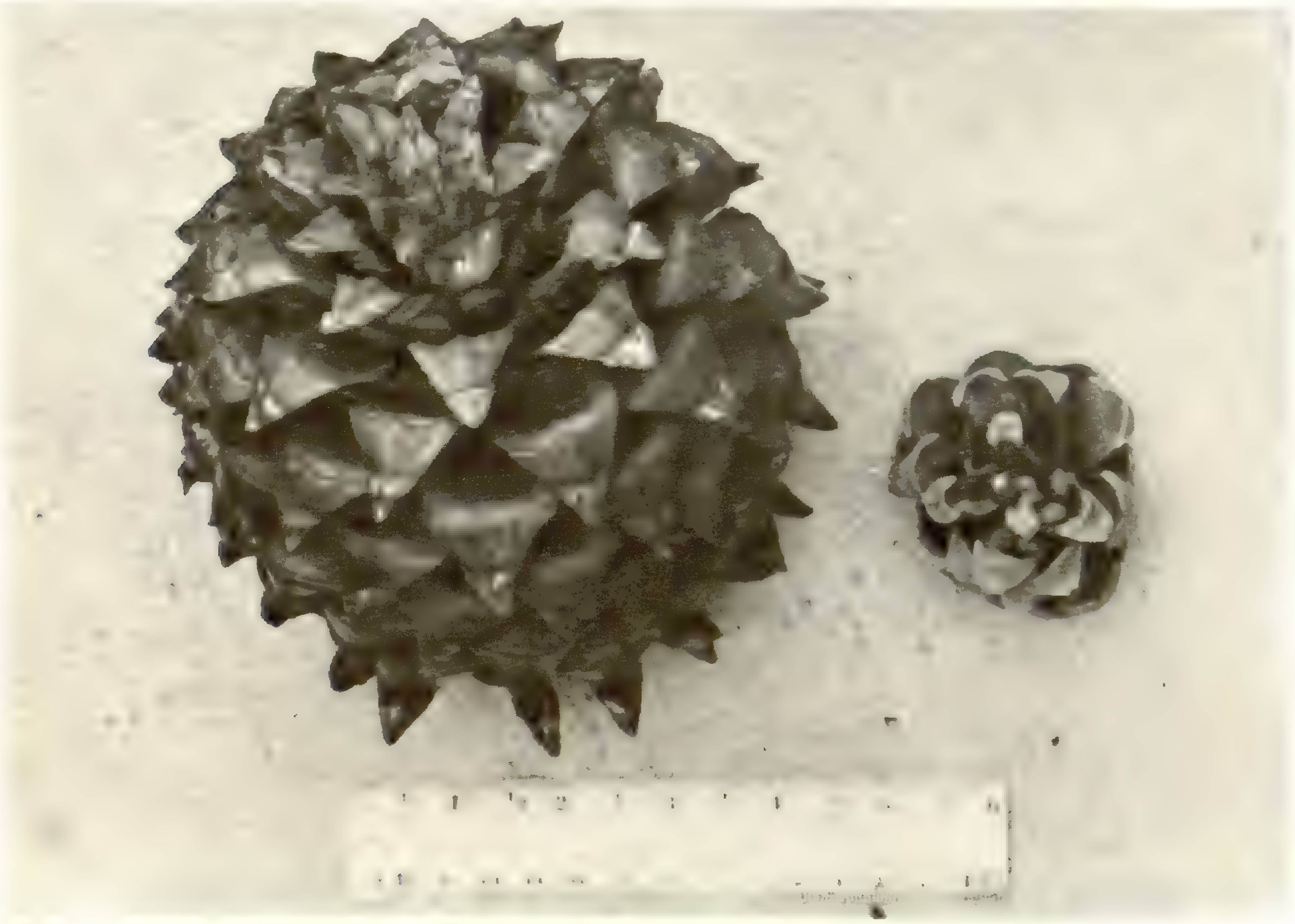

FIG. 1–Cones of *P. sabiniana* (left) and *P. monophylla* (right).

PINUS SABINIANA

This species is most often associated with an environment of grassland and/or chaparral-covered hillsides typical of the foothill regions of the Sierra Nevada and the Coast Range areas of California. It survives well on poor soils such as the serpentinite soils of the Coast Range (Griffin 1965; Jepson 1910:88). It often shares an environment with manzanita *(Arctostaphylos* spp.) and blue Oak *(Quercus douglasii)*, both of which were important as food sources for the California Indians.

When mature, *P. sabiniana* trees may grow from 15-25 m high. The interval between large seed crops is said to be 2-4 years on the average. It takes two years for a cone to produce mature seeds (USDA 1974:609, 611). The cones are large, usually ranging from 10-25 cm in length and often produce over 100 seeds each. It is important to remember that not all of the seeds have developed kernels. The variation from cone to cone can be quite remarkable in terms of size (Griffin 1964). Kernel weight averages 195 mg (Farris 1982; Griffin 1962).

For this study seeds were obtained from 26 cones collected by the author in the Sierra Nevada foothills and the Coast Range. The cones were split apart and the seeds gathered, counted, and separated into those with developed kernels and those with undeveloped kernels. It is fairly easy to separate the seeds with developed kernels. When the seeds are placed in water, the filled seeds sink whereas those with undeveloped kernels float (Griffin 1962:135; USDA 1974:621). Table 1 shows the results of this investigation.

TABLE 1.—*Seed production of 26* P. sabiniana *cones.* *

Cone No.	Total seeds	seeds with developed kernels	seeds with undeveloped kernels
1	137	126	11
2	149	146	3
3	61	4	57
4	137	116	21
5	188	88	100
6	166	58	108
7	111	85	26
8	84	76	8
9	107	72	35
10	186	182	4
11	128	109	19
12	101	85	16
13	92	69	23
14	75	39	36
15	61	41	20
16	74	65	9
17	99	82	17
18	100	87	13
19	79	55	24
20	64	41	23
21	156	111	45
22	162	141	21
23	119	119	0
24	79	69	10
25	113	78	35
26	114	99	15
	X = 113.15	X = 86.26	X = 38.96
	S.D. = 37.8	S.D. = 38.4	S.D. = 69.56
	Range—61-188	Range—4-182	Range—0-108

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*The above cones were obtained from the Sierra Nevada foothills just east of Sacramento and from the Coast Range immediately west of Sacramento on October 13 and 20, 1981. (Herbarium Voucher, Farris 94907, DAV).

Indian people often maximized their efforts by sampling a few cones from a tree before settling down to collect the cones in earnest. This practice is illustrated in some folklore of the Yana and Wintu Indians of the Northern Sacramento Valley. When gathering pine cones the climber would throw down a few from the tree and then ask, "Are the nuts good?" or, "Are the nuts big?" If given an affirmative answer he would continue (Sapir 1910:123-124; DuBois and Demetracopoulou 1931:339-340). Therefore, the averages of 113 seeds per cone and 86 seeds with developed kernels per cone (Table 1) include some cones which would probably have been rejected by the Indians.

The difficulty with collecting digger pine cones is that they usually adhere firmly to the branches and often need to be twisted off by hand. This usually required climbing the trees and such climbing was normally done by men. By contrast, processing of the cones was undertaken by the women (Willoughby 1963:28-29). It is not sufficient to wait for the cones to drop because they only do so after opening their scales while still attached to the tree and scattering the seed over a period of several months. The cone may remain on the tree for as much as seven years after shedding the seed (Jepson 1910: 87). Competition with animals made it advisable to pick the cones before they were ready to open on their own. They were then heated to remove the bothersome pitch and also to get the cones to open somewhat to facilitate the removal of the seeds.

The seeds could be eaten raw, but were commonly roasted either in the cone or in parching trays. In addition they were often ground up into a meal to be boiled as a pine nut soup or baked into a bread. If stored for more than a year the high fat content would cause the seeds to become rancid.

PINUS MONOPHYLLA

In many ways *P. monophylla* forms a striking contrast to *P. sabiniana.* The cone is comparatively tiny, often only 5-8 cm high (Fig. 1). There are only 10-20 seeds in an average cone. The trees are much smaller and more accessible, usually not more than 8 m high. They are found in southern Idaho, Utah, Arizona, California and Baja California. Their range of elevation is generally above 1200 m (Sudworth 1908:35-37; Critchfield and Little 1966:9, 48). The interval between large seed crops is 1-2 years (USDA 1974:611).

The seeds are often quite large and have a high kernel-to-shell ratio. In samples measured by the author the kernel averaged 72-77% of the total weight of the seed while the shell averaged 23-28%. The average kernel weight was 270 mg. The thin shell meant that it was very easy to hull the seeds. Although water flotation is not effective in separating the seeds with developed kernels from those with undeveloped ones, there is a clue in the coloration of the seeds. The dark seeds tend to have the developed kernels while the undeveloped seeds are usually a tan color (Lanner 1981:48).

Indian people obtained the cones by knocking them down with a stick or shaking the tree. As in the case of *P. sabiniana,* men would usually knock the cones off the tree and then the women would collect them and process them (Steward 1941:312-313). However, in an eyewitness account from 1891, the women knocked down the cones, collected them, and processed them (Dutcher 1893:378-379).

Once the cones were down they were heated to open them since they were usually collected prior to full ripening. The seeds could be hulled by rolling them on a flat stone (metate) using a handstone (mano). It appears that even the hulls were eaten in some cases since they were present in human coprolites (fossilized feces) found in southern California desert archaeological sites (Wilke 1978:79). For storage the seeds were cleaned of the chaff and dirt through winnowing and then packed in baskets or, in later times, in cloth gunnysacks.

NUTRITIONAL COMPARISON

Dramatic differences are to be found in nutritional data on the seeds of *P. monophylla* and *P. sabiniana.* Considering three major constituents: protein, carbohydrates and fats, these two species differ significantly. Whereas seeds of *P. sabiniana* have over 25% protein, those of *P. monophylla* have under 10%. On the other hand, *P. monophylla* seeds have over 50% carbohydrate as against a figure below 20% for those of *P. sabiniana* having about 50% fat and *P. monophylla* having only 23% (Table 2).

The amino acid content of the protein found in each species is shown in Table 3. The most limiting amino acid, i.e., the amino acid in least concentration, is determined by means of a scale of "chemical scores." The amino acids are compared against an ideal protein using the formula:

$$\text{Chemical Score} = \frac{\text{mg of A.A. in 1 g. of test protein}}{\text{mg of A.A. in ideal protein}} \quad \text{X } 100$$

The "ideal protein" figures were developed to replace specific foods such as human milk and whole egg which had been used in previous chemical or amino acid score calculations (FAO/WHO 1973:62-64). It is therefore necessary to determine the source of data for the calculations of chemical scores found in other published materials so as not to make erroneous comparisons (e.g., Benson et al. 1973:146; Kaldy et al. 1980:356).

The overall protein score is derived from the score of the most limiting amino acid. This is due to the necessity that "all amino acids must be present at the site of protein synthesis in adequate amounts for protein synthesis to proceed, an equal percentage deficit of any essential amino acid would limit protein synthesis to a comparable degree" (FAO/WHO 1973:62).

The protein scores for *P. sabiniana* and *P. monophylla* found in Table 3 show that lysine is the most limiting amino acid in both species. This is a common finding for plant protein with some exceptions (e.g., legumes). *P. monophylla* ranks considerably higher than *P. sabiniana* in each of the other amino acids with the exception of the sulphur-containing ones (methionine and cystine).

The fat in *P. sabiniana* is composed of 4.3% saturated fatty acids, 50.5% oleic acid (monounsaturated) and 45.2% linoleic (polyunsaturated) acid (Semb 1935:610). *P. monophylla* fat is 85% composed of unsaturated oleate, linoleate, and linolenate acids (Lanner 1981:102; cf. Adams and Holmes 1913).

Although the fiber content was not determined for *P. sabiniana*, it is apparent from Table 2 that crude fiber is generally quite low for pine seeds. The low 1.1% figure for *P. monophylla* would have been substantially increased on occasions when the shells were eaten along with the kernels. However, the hard shell of the digger pine seed would have precluded such a possibility for this species.

The ash content of digger pine is shown to be nearly twice that of *P. monophylla*, although quite comparable to several other pine species (e.g., *P. pinea* and *P. lambertiana*). *P. monophylla* resembles more its Southwest neighbor, *P. edulis*, in this regard. The mineral content shows higher levels for *P. sabiniana* in calcium, iron, manganese and zinc (Table 2).

The energy value of 100 g of *P. sabiniana* is substantially higher than *P. monophylla*, mainly due to the high fat content. The caloric content places *P. monophylla* more on a par with acorn meal than with any of the other pine species shown (Table 2).

CONCLUSION

In discussing the two most highly contrasting species of pine seeds it is clear that there exists a large inter-species variation. This is important to consider when one sees broad generalizations made about pine nuts or piñons. *Pinus monophylla* has been particularly subject to erroneous reporting in the past (see Farris 1980), although a recent author seems better informed (Lanner 1981).

Although *P. monophylla* has had some local commercial success as the source of a cash crop, this has not occurred in the case of *P. sabiniana*, despite the great success of

TABLE 2.—*Nutritional Values of Some Pine Seeds and Acorn Meal.*

Species	Water	Prot.[a]	Fat	Carb.[b]	Fiber[c]	Ash	Kcal/100 g.[d]	Mineral Content[e]			
	(grams/100 grams Edible Portion)							(mg/100 g E.P.			
								Ca	Fe	Mn	Zn
P. sabiniana[f]	3.6	25.0	49.4	17.5	–	4.5	571	5.1	8.4	4.4	13.0
P monophylla[g]	10.2	8.1	23.0	56.3	(1.1)	2.4	450	1.0	1.9	1.3	2.9
P. *pinea*[h]	5.6	31.1	47.4	11.7	(0.9)	4.3	552	14.0	4.4	–	–
P. edulis[g]	3.0	12.0	60.9	21.4	(1.1)	2.7	638	12.0	5.2	–	–
P. lambertiana[f]	3.3	21.4	53.6	17.5	–	4.2	594	4.5	6.7	16.4	7.6
Quercus kelloggii (meal)[i]	11.3	3.8	19.8	64.8	(2.1)	0.3	443	–	–	–	–
Quercus lobata (meal)[i]	8.7	4.8	18.6	65.9	–	2.0	440	–	–	–	–

a. Protein calculated using a 5.3 multiplier for N. (Jones 1931:13; Watt and Merrill 1963:161).

b. Total Carbohydrate figure including Fiber.

c. Crude fiber, absence from table means not calculated.

d. Kcal = g prot. x 3.47 + g carb. x 4.07 + g fat x 8.37 [calculated per 100 g E.P.] (Watt and Merrill 1963:160).

e. Mineral content for *P. sabiniana*, *P. monophylla* and *P. lambertiana* calculated by Carl Keen, UC/Davis using dry-ashing method (Clegg et al. 1981).

f. Farris 1982.

g. Botkin and Shires 1948

h. Anonymous 1963; Watt and Merrill 1963:46.

i. Merriam 1918.

TABLE 3.—*Amino Acid Composition and Chemical Scoring of Seeds of* P. sabiniana *and* P. monophylla.[a]

Essential Amino Acids[b]	Ideal Prot.[c]	Pinus sabiniana			Pinus monophylla		
	mg AA/g Prot.	mm AA/g N.	mg AA/g Prot.[d]	Score[e]	mg AA/g N.	mg AA/g Prot.[d]	Score[e]
Isoleucine	40	145	27	68	213	40	100
Leucine	70	306	58	83	400	75	>100
Lysine	55	125	24	44	123	23	42
Methionine + cystine[f]	35	140	26	74	131	25	71
Phenylalanine + tyrosine[f]	60	343	65	>100	398	75	>100
Threonine	40	123	23	58	188	35	88
Valine	50	233	44	88	281	53	>100
Protein Scores				44			42

a. Farris 1982

b. Only 7 of 8 essential AA determined. Tryptophan lost in hydrolysis of protein sample.

c. FAO/WHO 1973:63

d. $\frac{\text{mg AA/g N.}}{5.3}$ = mg AA/g Prot. for nuts (Jones 1931:13; Watt and Merrill 1963:161).

e. Chemical or Amino Acid Score = $\frac{\text{mg AA in 1 g. test prot.}}{\text{mg AA in ideal prot.}}$ X 100 (FAO/WHO 1973:63).

f. Amino Acids cystine and tyrosine are included because of their sparing action on methionine and phenylalanine respectively.

the very similar Mediterranean species *P. pinea,* the pignolia (Farris n.d.). Indian people had shown great interest in the seeds of both *P. monophylla* and *P. sabiniana,* although the former took on more the quality of a staple food whereas the latter was used mainly as a special treat.

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PAPAGO INFLUENCES ON HABITAT AND BIOTIC DIVERSITY: QUITOVAC OASIS ETHNOECOLOGY

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ABSTRACT.–Quitovac, Sonora, is an oasis and Papago Indian community in the U.S./Mexico borderlands, 54 km from an analagous oasis, Quitobaquito, in Organ Pipe Cactus National Monument. Comparison of the two sites provides insight into how traditional Papago subsistence and land use affects habitat and biotic diversity. Quitovac's springs and modified lagoon have been utilized by Papago farmers for centuries. Around these perennial water sources, Papago land and plant management practices created eight large scale and two small scale vegetation associations. These provided habitat for a diversity of plants, birds and mammals, many of which the Papago harvest for utilitarian or religious purposes. Over 138 species of plants, 14 mammals and 103 birds are documented from a 5 ha study site at the oasis. The concentration of utilized species in certain habitats clearly affects how these habitats are managed. Since the initiation of the study, however, a 125 ha area was cleared and levelled for irrigated agriculture. This has dramatically altered life at Quitovac.

INTRODUCTION

Native American influences on habitats and associated biotic diversity have been the subject of several, recent provocative essays (Linares 1976; Rea 1979; Emslie 1981). It has been hypothesized that the diversification of habitats associated with native agriculture has had a beneficial effect on faunal species richness, due to edge effect phenomena, increased insect and seed availability.

The values of diversified farmland habitats to fauna, and the potential edible or economic return to farmers, were active topics of research among American ecologists earlier in this century (see Dambach 1948). However, as agriculture has become more mechanized, larger fields of single crops with clean borders have taken the place of diversified family farms where the maintenance of cover crop borders, hedgerows, or windbreaks was not only practical but advisable (Burger 1978; Sampson 1981).

Despite the renewed interest in this topic from agricultural ecologists and ethnographers, there are few data with which to compare directly the richness of species (useful or otherwise) associated with native subsistence agricultural habitats with that found in nearby, uncultivated or modern cash crop agricultural ecosystems.

Through the Man and the Biosphere program, we have attempted to document qualitatively and quantatively the plant and wildlife diversity associated with various agro-ecosystems and comparable, uncultivated ecosystems in the Sonoran Desert. The habitat complex, and seed plant, bird and mammal diversity were surveyed at the Papago farming oasis of Quitovac, Sonora and at the similar Quitobaquito, Arizona in Organ Pipe Cactus National Monument, where cultivation has not occurred for over 25 years (Fig. 1). There are considerable differences in the biota associated with the sites. Since the two sites differ more in their management history than their physical character, we focus on Papago land use and subsistence practices at Quitovac which influence habitat and biotic diversity. We hope that this ethnoecological perspective on the last Papago oasis will aid in the archaeological and "natural" historical interpretation of other Sonoran Desert oases, as well as in their management. This study is also the most comprehensive treatment of the folk biology of the western Papago of Sonora, whose knowledge and uses of desert biota is in many ways different from the central Papago emphasized in Castetter and Underhill's (1935) classic work.

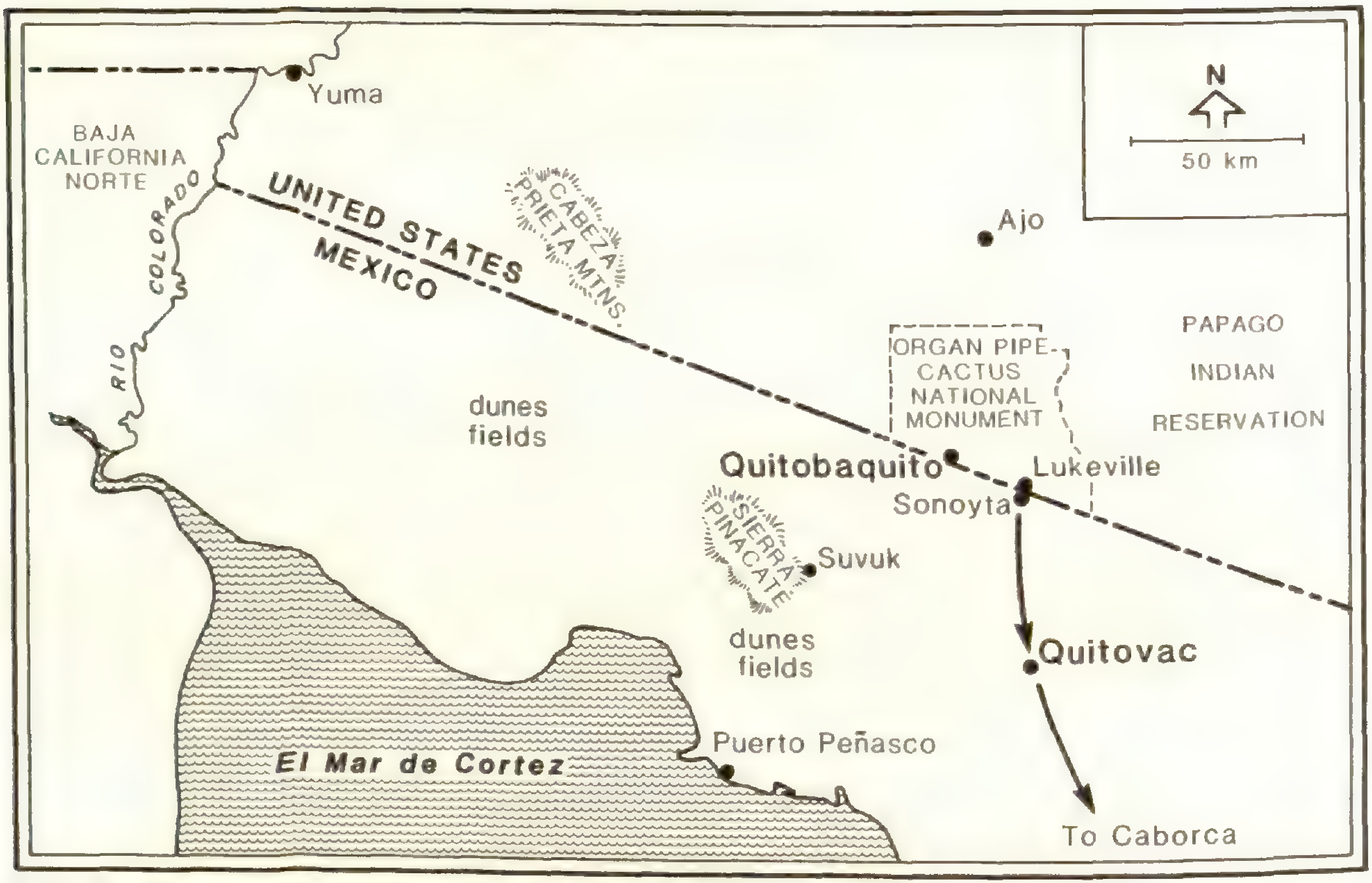

FIG. 1—Map showing Quitovac in relation to Western Papago Country.

THE STUDY AREAS

Quitovac is a spring fed oasis, at an elevation of 350 m, in the *municipio* of Puerto Peñasco, Sonora. It is found 41 km south-southeast of the Sonoyta-Lukeville border crossing, and 54 km southeast of Quitobaquito. Hastings and Humphrey (1969) reported its mean annual rainfall as 21.9 cm; it lies within the transition between the Lower Colorado and Arizona Upland vegetation subdivisions of the Sonoran Desert (Shreve 1951).

The presence of water deposited tufa and marl sediments, some of which contain calcified Rancholabrean megafaunal fossils, indicates that the springs of Quitovac have flowed for millenia. When Juan Manje visited the Papago at the site in 1694, calling it *San Luis de Bacapa*, and *Moicaqui* ('Soft Wash' in Papago), he described it as "close to a high peaked mountain at whose foot were some springs of water and some lakes" (Bolton 1948). In 1774, Anza described the site as "one of the best of all the *Papagueria*, because it has five springs of water . . . which they gather and use to irrigate some small pieces of very sandy land where at most a half a *fanega* of maize can be planted . . . " (Bolton 1930). These observations indicate that Papago water control and agricultural management of Quitovac were well established prior to the introduction of Old World technology, draft animals, and crops.

Kino visited a Papago camp at another set of springs in 1698; his *San Serguio* is surely a site along the springs of the pre-Cambrian Quitobaquito Hills, on the present day U.S.-Mexico border. Kino did not explicitly mention a pond there, so some historians have assumed that one did not form until Anglos built a dam there in the 1860s. Others disagree, observing that the Papago improved springs and excavated basins elsewhere earlier; the Quitobaquito pupfish shows considerable divergence from Rio Sonoyta pupfish populations nearby, suggesting the antiquity of Quitobaquito pond habitat (Robert Rush Miller, pers. comm.). From the 1860s on, the presence of Papago pond-irrigated fields and orchards there are well known (Bell et al. 1980; Nabhan 1982). Organ Pipe National Monument was established in the 1930s, but the Papago continued farming and livestock raising there until 1957. The pond was then a 35 cm deep, swampy marsh edged by a grass flat, riparian trees and an orchard; it was ideal pupfish habitat (Robert Rush Miller, pers. comm.). In 1962, it was dredged to a 1-2 m depth, and has since been managed as a popular birdwatching area.

Not all Papago from the two oases consider themselves to be the distinctive Sand Papago—*(Hia C-eḍ O'odham*, 'In the Sand People'; *Hia Tadk Ku:mdam*, 'Sand Root Crushers'; or *S-'O'obmakam*, 'Apache-like Papago'). However, after an 1851 yellow fever epidemic, some surviving Sand Papago families moved out of the Pinacate region to these nearby oases, or to other western Papago settlements (Bell et al. 1980). At any rate, the Sand Papago regularly visited Quitovac historically, and shared with the people there the use of a number of plants and animals not found elsewhere in *Papagueria* (Nabhan 1980). Since the 1850s, a rain and cactus harvest ceremony called the *Vi'igita*, originally performed among Sand Papago in the Pinacate region to the west, has been observed at Quitovac (Davis 1920; Ives 1936; Bell et al. 1980). Within the following notes on the uses of biota, many of the religious uses are those associated with the *Vi'igita*.

Linguistically, the Quitovac Papago may be intermediate between the *Hia C-eḍ O'odham* and other *Tohono O'odham*. They regularly use the fricative [v] in certain sound environments where most Papagos make a sound closer to the English [w], and occasionally utilize [t] in place of the more commonly used [c] ([ch] in English). Both of these allophones are believed to be proto-Piman (Hale, pers. comm.). We are using the Alvarez and Hale (1970) orthography for *Tohono O'odham*, but are substituting [v] for [w] to reflect the above-mentioned dialect difference.

Currently, 16 houses are maintained by Papago and Papago-*mestizo* families at Quitovac, but not all are lived in year-round. Population has ranged from 27 to 38 individuals since 1960. Papago simply call the place *Vak*, and *Quitovac* is rapidly being replaced by *Bak* as the officially-recognized name for the oasis and the recently established indigenous land reserve there.

METHODS

Study of the plant and bird life, and ethnobiology of Quitovac began in November 1979, and has focused on a 10 ha area surrounding the oasis pond. Through July 1982, 12 visits to the area were made for 2-4 day periods, during which a number of data collecting activities were accomplished. In August, 1981, a more formal comparison of Quitobaquito and Quitovac was initiated, using a 5 ha study site centered on the pond. The study methodology also was used for Quitobaquito as well, with exceptions as noted. Agricultural clearing at Quitovac in autumn, 1981, destroyed the habitat on approximately 3 ha of the study site. Consequently, vegetation transects begun in one area were extended to adjacent areas within the same vegetation associations, and only half the original 5 ha area was sampled for mammals.

Habitat mapping utilized February 1982 hand-held aerial photos taken by Peter Kresan, July 1982 vertical aerial photos taken by Vern Palmer, and a sketched map based on paced distances drawn by Nabhan in September 1980. These three data sources were combined in an attempt to reconstruct the extent of habitat areas prior to the autumn 1981 clearing.

Each of these mappable habitat units was described in terms of plant species, vegetative cover, lifeform mixture, soils and land uses. The project's plant ecologist (K.L.R.) visually discerned discontinua in the vegetative cover of the site. Each unit was sampled for perennials, 75 cm tall or more, via five 30 m line transects placed randomly from a baseline, and via 250 point frame hits for annuals and perennials shorter than 75 cm. Following Karpiscak (1980), cover values from these two methods, including both August 1981 and May 1982 point frame samples, were combined to express a percent of sampled distance with vegetative cover within each habitat. If species were sampled using both methods or during both seasons, the highest value was used. These coverage values were used as indicators of species importance for calculating the diversity (i.e., heterogeneity) of each habitat's vegetation, utilizing both the Shannon-Weaver and Simpson indices as described by Peet (1974). To calculate a plant species heterogeneity value for the entire site, species values within each habitat unit were multiplied by the fraction of the total site area occupied by that habitat, and summed.

Within each habitat unit, either a soil or water sample was taken from a 30 cm column below the surface, and analyzed by the University of Arizona Soils, Water and Plant Tissue Testing Laboratory, from which methodological details may be obtained. Lifeform descriptions follow Shreve (1951). Land uses were observed during visits, and further documented by interviews with local informants. In addition to plants found on vegetation transects, an inventory was made of all seed plant species found within the 5 ha site. Over 300 voucher specimens were collected over a four year period during all seasons, and most have been deposited in the herbaria of the University of Arizona and San Diego Natural History Museum. Nomenclature follows Lehr (1978), to which non-botanists are referred for common English names. Determination of species native or introduced to North America follows Shetler and Skog (1978).

Ethnobotanical interviews were made in Spanish, with Papago frames and lexemes occasionally used to reinforce questions. Although six Quitovac Papago and one Arizona Papago visitor contributed knowledge of plant names and uses, the bulk of the information was derived from the community elder, Luciano Noriego. Over a 3-year period, information was volunteered by Noriego while walking the site with us or while vouchers were being pressed. Additional plants observed directly in use by other residents were noted.

Birds found on the 5 ha site were surveyed during one two-day visit during each of four seasons, and the highest visual or audial count for each species over the two day period taken as the best population estimate. Dawn and dusk surveys of 2-3 hour durations, with extended time spent in dense canopy areas, were sufficient for most idenfifications and population estimates. Dove population projections were based on half hour morning counts. It was assumed that dove visitation to the lagoon occurred at a consistent rate, throughout the morning, with no more than one extended watering per bird each half day. Thus, the half-hour count was multiplied by 8 to estimate the total dove population. Linnaean taxonomy for birds includes recent revisions by Rea (in press).

Notes were taken regarding the habitats in which each bird species spent most of its time, but since few species utilize space for foraging strictly upon the lines of our mappable habitat units, certain habitats were combined (or collapsed) in our calculations. Simpson and Shannon-Weaver diversity indices were then calculated for these revised habitat groupings more useful in discussing bird foraging, and for each 5 ha site (Quitovac and Quitobaquito) as a whole.

Mammal data gathering included the nocturnal setting of Sherman live traps baited with a commercial grain mixture (millet, oat and wheat), the diurnal setting of snap gopher traps, and the visual counts of larger mammals. The Sherman live traps were set in the evening to capture small nocturnal rodents; they were checked and closed the next morning. Trapping took place one night each in December, 1981, March, 1982, and two nights in May, 1982. Traps were set in a grid pattern with 12 m between traps in the same line, and 20 m between lines. At Quitovac, 100 traps were set on the irregularly-shaped undisturbed half of the study area. At Quitobaquito, 200 traps were set each night. For each season, the sites and the habitats within the Quitovac site were compared using the Simpson and Shannon-Weaver indices. The comparisons utilize (a) animal numbers and (b) animal biomass based on individual weights in grams at the time of trapping. Identifications were made in the field utilizing Cockrum (1960), with vouchers collected and identifications confirmed for trapping mortalities. Linnaean taxonomy for mammals follows Hall (1981), with the exception of *Dama,* for which we retain *Odocoileus.*

Interviews on bird and mammal knowledge and uses were occasional throughout the study, but also included 3-4 hours of taped interviews in May 1982 with Luciano Noriego and his grandchildren. A scrapbook of photos or drawings of most bird and mammal species potentially present in the vicinity was shown to Noriego, with explanations of calls, behavior or eating habits discussed. Additional data on animal use come from inspecting hunted carcasses gathered by Papago youth, and from accounts of the Papago *Vi'igita* ceremony.

RESULTS

Through autumn, 1981, Quitovac was a traditional Sonoran Desert farming oasis which included eight large scale (mappable) vegetation associations, and two small scale vegetational features worthy of note (Fig. 2). The mapped vegetation associations provided one element of our descriptions of habitats. Soils, lifeform and seed plant species diversity, and land uses were also noted (Table 1). The two small scale associations, were (a) man-made ditches running into the orchard and field dominated by *Cyperus, Anemopsis, Heliotropium* and *Rumex;* and (b) living, fieldside fence rows including intentionally planted *Salix, Tamarix, Sambucus, Opuntia* and *Prosopis,* which had associated with them piled brush and self-sown *Ambrosia, Bebbia, Olneya,* and *Cercidium.*

These small scale features are best considered part of the diverse field/orchard complex in the south-center of the study site. In both diversity indices based on plant coverage data, the cultivated field is the most heterogeneous vegetation association, and the orchard the second most. The Shannon-Weaver index is typically most sensitive to changes in the importance of rare species in the sample, and the Simpson index to common species (Peet 1974). These cultivated habitats make up less than 10% of the area of the study site, which is important in the interpretation of whole-site diversity index comparisons of Quitovac and Quitobaquito. Because each habitat's coverage values are "weighted" by the percentage of the 5 ha upon which that habitat exists, and Quitovac's cultivated habitats are so relatively small in area, their influence is "diluted" in our whole site calculations. The contrasts between Quitovac's whole-site plant diversity values (.971, Shannon-Weaver; .813, Simpson), and those for Quitobaquito (.822, Shannon-Weaver; .764, Simpson) nevertheless suggest that Quitovac has more diverse vegetation. (Note that the higher the diversity index value, the higher the diversity or heteroteneity).

Floristically, there are considerably more plant species, genera and families represented at Quitovac than at Quitobaquito, no matter how large the areas examined are (Table 2). This is due in part to the number of domesticated species (17) intentionally cultivated within the Quitovac site, but cultivation contributes more than just intentionally sown plants to a flora. There are an additional 59 species of plants found in the field/orchard complex. Many of these can be considered "biologically [as] weeds which are evolutionary and ecological products adapted to survival in habitats disturbed by

FIG. 2—February 1982 oblique photo of Quitovac, four months after bulldozing (Pete Kresan, photo).

TABLE 1.—*Habitats at Quitovac, Sonora (5 ha study site).*

Location and % of total area	Soil or water characteristics	Dominant plant species (highest cover first)	Lifeform mixture	Diversity Shannon-Weaver	Indices: Simpson	Land Uses
A. Open water of lagoon and springs; 10% of area	Spring water: pH, 7.6; soluble salts, 689 ppm; EC x 10^3 1.10; NH_4-N, 0.10 ppm; K, 5.83 ppm	*Potamogeton pulvinatus* *Zannichellia palustris*	Submergent macrophytes and floating algae	—	—	Swimming; aquatic bird hunting; use of water for irrigation
B. Cultivated field of annual crops irrigated from pond and springs; 6.5% of area.	Sandy loam: pH, 8.4; soluble salts, 2121 ppm; EC x 10^3, 3.03; N, 3.75 ppm; P, 1.28 ppm; K; 1.15 meq/L	*Cynodon dactylon* *Cucurbita mixta* *Citrullus lanatus* *Ambrosia confertifolia*	Herbaceous weedy ephemerals, and perennials, plus crop annuals	.947	.856	Tillage, seed sowing, irrigating, and crop harvest, wild greens harvesting
C. Tufa mesa rimming the pond, and nearby scrubland, (including abandoned fields); 27.5% of area	Sandy loam: pH, 7.4; soluble salts, 994 ppm; EC x 10^3, 100; N, 32.13 ppm; P, 11.82 ppm; K, 2.27 meq/L	*Suaeda torreyana* *Prosopis velutina* *Lycium andersoni*	Open, mixed spinescent, drought-decidous and evergreen shrubs and trees	.526	.670	Wild fruit gathering; woodcutting; hunting and trapping
D. Cultivated orchard of irrigated fruit trees, and adjacent fieldside hedge; 2.5% of area	Sandy loam same as (B) cultivated field of annual crops	*Ambrosia confertifolia* *Ficus carica* *Sarcostemma cynanchoides* *Cynodon dactylon*	Broadleaf deciduous tree canopy with broadleaf deciduous shrubs, ephemerals and vines	.831	.818	Cultivated fruit harvesting; irrigation; wild and cultivated perennial transplanting; hunting
E. Ephemeral watercourse (arroyo) and adjacent uncultivated floodplain; 4.5% of area	Loamy sand: pH, 7.6; soluble salts, 504 ppm; EC x 10^3, 0.72; N, 10.2 ppm, P, 8.47 ppm, K, 1.26 meq/L	*Hymenoclea monogyra* *Lycium berlandieri* *Ambrosia ambrosioides*	Microphyllous shrubs, cacti, broadleaf shrubs, and few ephemerals	.514	.604	Grazing; hunting or trapping; cactus harvesting
F. Lagoon edge, shallow holding pond, and ditches, and spring to pond channels 15% of area	Silty loam: pH, 8.3; soluble salts, 6181 ppm; EC x 10^3, 8.83; N, 5.35 ppm; P, 8.23 ppm; K, 2.51 meq/L	*Typha domingensis* *Scirpus olneyi* *Distichlis spicata*	Emergent perennial reeds and grasses	.616	.736	Burning; grazing fiber gathering; medicinal plant gathering from ditches
G. Meadow-like flats with alkaline seeps; 34% of area	Sandy loam: pH, 9.1; soluble salts, 70, 427 ppm; EC x 10^3, 100.6; N, 6.32 ppm; P, 4.78 ppm; K, 31.48 meg/L	*Distichlis spicata* *Wislizenia refracta* *Heliotropium curassavicum*	Perrennial mat-forming grasses, few herbaceous root perennials and ephemerals	.089	.078	Grazing

human activity" (Bye 1981). We consider 18 of these species to be found at Quitovac only within the cultivated field/orchard complex. A complete flora of Quitovac is near completion, and will list each species by its habitats (Nabhan et al., in preparation). It is not surprising that more than 21 post-Columbian introduced species, in addition to 11 species of Old World domesticates, are part of the Quitovac flora, and are more numerous than at Quitobaquito today. These are primarily ephemerals that for millenia colonized fields, trails and roadsides in the Old World, before rapidly spreading through New World deserts (Naveh 1967; Young et al. 1972).

TABLE 2.—*Floristic Richness at two Sonoran Desert oases.**

	5 hectare study site at oasis-pond	8-10 hectare plains around oasis-pond	oasis, plains and closest hills
Quitovac, Sonora			
plant families	45 (41)	49 (42)	55 (44)
genera	115 (100)	131 (106)	139 (114)
species	139 (122)	158 (131)	172 (143)
Quitobaquito, Ariz.			
plant families	32 (30)	37 (35)	38 (36)
genera	71 (69)	92 (90)	101 (99)
species	80 (78)	104 (102)	118 (116)

*Includes only seed plants. Data for Quitobaquito are from Adams (1971); Bowers (1980); and Nabhan and Reichhardt, field notes. Data for Quitovac are from Nabhan, Reichhardt and Rea, (in preparation). Values in parentheses represent adjusted totals that exclude intentionally planted domesticated species.

Table 3 lists the 78 taxa named by Quitovac Papago in their local dialect, as well as the uses of these plants. Over 40 of these utilized species can be found in the field/orchard complex. Even recently introduced species such as *Brassica tournefortii* are utilized in a similar manner to edible greens of considerable antiquity in the region. Terming such a species a "native" subsistence resource is somewhat of a misnomer. Numerous Old World crops and weeds are well-integrated into Papago cuisine even at the agricultural margins of Papagueria. A detailed discussion of how particular plants are used will be included in the Quitovac flora (Nabhan et al., in preparation), but from the data included here it is clear that named and utilized species are largely concentrated in and affect the management of three habitats more than the others: the field, the orchard and the adjacent scrubland. These three habitats are "off limits" to grazing animals most of the time. Such plant uses appear to parallel those which western Papago practiced at Quitobaquito earlier in this century (Bell et al. 1980).

Bird life at Quitovac includes 103 species observed on the 5 ha site during our eight days of survey in 1981-1982. Table 4 indicates that during every seasonal visit, species richness was higher at Quitovac than at Quitobaquito. The diversity indices for the two sites do not show such a clear picture; each site had a more heterogeneous avifauna in two of the seasons. Table 5 shows considerable seasonal variation in bird diversity within each habitat at Quitovac. It appears that the field-orchard complex, and the adjacent microphyllous shrubs in the wash provide the habitats with the most consistent diversity from season to season.

TABLE 3.–*Folk taxa and uses of plants at or near Quitovac, Sonora*

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
'a'uḍ	*Agave deserti*	Desert Agave	food, (fiber?)	X			hills
'auppa	*Populus fremontii*	Cottonwood	(wood?)	X			C
'acĭ vipinoi	*Opuntia leptocaulis*	Desert Christmas Cactus	food, med.	X			E
'adavĭ	*Cucurbita digitata*	Finger-leaved gourd	(med.?)	X			E
babaḍ i:vakĭ	*Heliotropium curassavicum*	Heliotrope	med.	X			B,D$_2$,F,G
bahidaj	*Carnegiea gigantea (fruit)*	Saguaro	food, relig.	X			E, hills
ban manzanilla	*Dyssodia concinna*	Fetid Marigold		X			C
ban vi:v	*Nicotiana trigonophylla*	Desert Tobacco		X			E
bi:bhiag	*Merremia dissecta*	Ornamental Vine		X	?		D
ce:mĭ	*Lophocereus schottii*	Senita	food	X			E, hills
ce:'ul	*Salix gooddingii*	Goodding Willow	relig.		X		D, F
ciolim	*Opuntia acanthocarpa*	Cholla	food	X			E
cucuvis	*Stenocereus thurberi*	Organpipe Cactus	food, wood	X			E, hills
cuhukkia	*Amaranthus palmeri*	Amaranth	food	X			B
cukud ṣoṣa	*Phoenix dactylifera*	Date Palm	wood			X	C
cuvi u:pĭ	*Solanum nodiflorum*	Nightshade		X			D$_2$, F
galnayu	*Punica granatum*	Pomegranate				X	C, D
gepĭ	*Citrullus lanatus*	Watermelon	food			X	B
gisokĭ	*Opuntia violacea*	Purple Prickly Pear	food	X			E
hadsetkam	*Petalonyx thurberi*	Sandpaper Plant		X			E
hakowaḍ	*Phorandendron californicum*	Desert Mistletoe		X			C, E
ha:l	*Cucurbita mixta*	Cushaw Squash	food			X	B
ha:nam	*Opuntia fulgida*	Jumping Cholla	food	X	X		D$_1$, E
ha:sañ	*Carnegiea gigantea (plant)*	Saguaro	wood, util.	X			E, hills
hauk 'u'us	*Bebbia juncea*	Sweet Bush		X			B, D
heña hetam	*Sapium biloculare*	Mexican Jumping Bean	med.	X			E, hills
hoi'idkam	*Olneya tesota*	Ironwood	wood, util.	X			E, hills
hu:ñ	*Zea mays*	Corn	food, relig.			X	E
'i:bhai	*Opuntia phaeacantha (fruit)*	Prickly Pear	food	X			D$_1$, E
'i:hug	*Proboscidea parviflora*	Devil's Claw	(util.?)	X			B
'i:svig	*Echinocereus fasciculatus*	Hedgehog Cactus	food	X	?		C (off area)
'i:watod	*Hymenoclea monogyra*	Burro Brush	"wood"	X			E
jiavul	*Ferocactus covillei*	Barrel Cactus	food	X			E

TABLE 3.–*Folk taxa and uses of plants at or near Quitovac, Sonora* (Continued)

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
kaṣvañ	*Trianthema portulacastrum*	Horse Purslane	food	X			B, C
kauk kuavul	*Condalia globosa*	Bitter Condalia	?	X			C
kek cehedagĭ	*Cercidium microphyllum*	Foothill Palo Verde	food	X			E (off area)
komagĭ 'u'us	*Tessaria sericea*	Arroweed	fiber, util.	X			F (off area)
ko'okomaḍk,kalisp	*Cercidium floridum*	Palo Verde	food	X			D1, E
kotadopĭ	*Datura discolor*	Jimson Weed	(relig.?)	X			B, C
kuavul	*Lycium exsertum*	Wolfberry	food	X			C
	Lycium berlandieri		(food?)	X			E
	Lycium parishii		(food?)	X			E
	Celtis pallida	Hackberry	?	X			C
kui	*Prosopis velutina*	Mesquite	util., (med.?)	X			
	Prosopis glandulosa		food, wood	X	X?		C, D, E
kujul	*Prosopis pubescens*	Screwbean Mesquite	food	X	?		C (off area)
ku'ukpalk	*Portulaca oleracea*	Purslane	food	X			B
milon	*Cucumis melo*	Melon	food			X	B
mo:stas	*Brassica tournefortii*	Mustard	food	X			D2
mu:mṣam	*Plantago insularis*	Wooly Plantain	forage	X			B
mu:ñ	*Phaseolus vulgaris*	Bean	food			X	B
nav	*Opuntia phaecantha (pads)*	Prickly Pear	food	X	X		D1, E
niatum	*Sphaeralcea coulteri*	Coulter Globe Mallow		X			C
nonakam	*Agave murpheyi*	Maguey	food, (fiber?)		X?		C (of area)
ñuñui je:j	*Ambrosia ambrosiodes*	Ragweed	(med.?)	X			D, E
'olas pilkañ	*Triticum aestivum*	Wheat	food, fiber			X	B
'onk i:vakĭ	*Atriplex elegans*	Saltbush	food	X			C
	Atriplex polycarpa		food	X			C
	Atriplex wrightii		food	X			B
	Chenopodium murale		food	X			C
'oñk 'u'us	*Tamarix aphylla*	Tamarisk	wood		X		C, D
'oñk vaṣai	*Distichlis spicata*	Saltgrass	forage	X			D, G
pa:lma	*Washingtonia filifera*	Desert Palm	wood	X	?		C, D
pu:hl	*Trifolium repens*	White Clover	food	X			B, D
s-cuk' oñk	*Suaeda torreyana*	Desert seepweed	(food?)	X			C
si:lantlo	*Coriandrum sativum*	Coriander	food			X	B

TABLE 3.–*Folk taxa and uses of plants at or near Quitovac, Sonora* (Continued)

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
siwol	*Allium spp.*	Onion	food			X	B, D
s-toa bavǐ	*Phaseolus acutifolius*	Tepary Bean	food			X	B
s-toa kuavul	*Lycium andersonii*	Wolfberry	food	X			C, D
su:na	*Ficus carica*	Fig	food			X	D
ṣegai	*Larrea tridentata*	Creosote Bush	med.	X			C, E
tahapidam	*Sambucus mexicana*	Elderberry	food, med.		X		D, F
tohawes	*Encelia farinosa*	Brittlebush		X			B, C
toma:di	*Lycopersicon esculentum*	Tomato	food			X	B
'uduvaḍ	*Typha angustifolia*	Cattail	fiber, food	X			F
'u:dvis	*Vitis vinifera*	Grape	food			X	D (off area)
'u:paḍ	*Acacia greggii*	Catclaw	?	X			C, E
'u:spaḍ	*Zizyphus obtusifolia*	Graythorn	food	X			C
vak	*Scirpus olneya*	Bulrush	relig.	X			F
vakvandam	*Rumex crispus*	Dock	?	X			D2, F
vapko	*Lagenaria siceraria*	Bottlegourd	util.			X	B (off area)
va:s	*Jatropha cinerea*	Limber Bush	fiber	X			E, hills
va:visa	*Anemopsis californica*	Yerba del Mango	med.	X			D2, F
vi:bam	*Sarcostemma cynanchoides*	Climbing Milkweed	gum	X			C, D, E
vihol	*Pisum sativum*	Pea	food			X	B
vipinol	*Opuntia arbuscula*	Pencil Cholla	food	X			E
vipisimal	*Justicia californica*	Hummingbird Bush		X			C, E

A = open water; B = cultivated field; C = mesa scrubland; D = orchard; E = arroyo; F = lagoon edge and channels; G = alkaline flats. D1 = fencerow. D2 = irrigation ditches.

TABLE 4.–*Avian species richness and diversity at two Sonoran Desert oases.*

Locality & Season	No. of species recorded (5 ha)	Diversity Indices	
		Simpson	Shannon-Weaver
Quitovac, Sonora			
August 81	52	.177	.238
Dec.-Jan. 81-2	21	.923	1.202
March 82	42	.960	1.513
May 82	70	.112	.174
Quitobaquito, Ariz.			
August 81	42	.787	1.080
Dec.-Jan. 81-2	18	.870	1.048
March 82	39	.747	.909
May 82	53	.797	1.122

TABLE 5.–*Avian species diversity by habitat at Quitovac, Sonora.*

Index & Habitat	August	Dec.-Jan.	March	May
Simpson				
A	.689	–	.759	.585
C	.924	.444	.790	.922
B&D	.772	.776	.925	.913
E	.747	.864	.840	.929
F&G	.137	.796	.881	.053
Shannon-Weaver				
A	.568	–	.721	.608
C	1.136	.276	.728	1.217
B&D	.878	.673	1.163	1.272
E	.670	.911	.881	1.203
F&G	.170	.826	1.020	.067

The open water (A) and pond fringe habitats (F and G) varied drastically from season to season. This was due in part to the autumn, 1981, draining and clearing of the lagoon. It was too shallow for any swimming waterfowl in January, 1982, and most pond fringe cover was removed. The pond was being utilized again by waterfowl by early spring and refilled to over 1.2 m deep by May.

Quitovac is attractive to a number of species of wading shorebirds in addition to waterfowl; these include some migrants and vagrants that have no muddy, open shoreline upon which to land at Quitobaquito. Quitovac also serves as a drinking place for much larger populations of columbiforms, particularly White-winged Doves, than does Quitobaquito. Both sites support a large number of "desert riparian" insectivores, including icterids, flycatchers, woodpeckers and wood warblers.

Table 6 presents data on 30 species of birds known to be named and/or utilized by the Papago at Quitovac. This is not a particularly large percentage of the local avifauna. The poor eyesight of our primary Papago consultant, as well as the limited time spent on interviews regarding birds, may contribute to this low number.

TABLE 6.—*Folk taxa and uses of birds at or near Quitovac, Sonora.*

Papago Name	Scientific Name	Common Name	Food	Relig.	Documented	
					On Site	Nearby
ba'ak	*Aguila chrysaetos*	Golden eagle		X		X
cem vahum	*Micrathene whitneyi*	Elf owl				X
ciwicuic	*Charadrius vociferus*	Killdeer			X	
cuhugam	*Dendrocopos scalaris*	Ladder-backed woodpecker			X	
cukuḍ	*Bubo virginianus*	Great horned owl			X	
cuk vacuk	*Fulica americana*	American coot	X		X	
ge'e visag	*Pandion haliaetus*	Osprey				X
ge'e hawañ	*Corvus corax*	Common raven		?	X	
gi:dowal	*Progne subis*	Purple martin			X	
haupal	*Buteo jamaicensis*	Red-tailed hawk		X	X	
hewel mo:s	*Sayornis saya*	Say's Phoebe			X	
ho:hi	*Zenaida macroura*	Mourning dove	X		X	
ho:kuḍ	*Campylorhynchus brunneicapillus*	Cactus wren				X
kakucu	*Callipepla gambeli*	Scaled quail	X		X	
kokova	*Athene cunicularia*	Burrowing owl				
ko:kuḍ	*Ardea herodias*	Great Blue heron	X		X	
ko:logam	*Phalaenoptilus nuttalli*	Common Poor-will				X
ñui	*Cathartes aura*	Turkey vulture			X	
ñupuḍ	*Chordeiles acutipennis*	Lesser night hawk			X	
si:pak	*Cardinalis* spp.	Cardinal, Pyrrhuloxia			X	
ṣaṣañ	*Agelaius phoeniceus*	Red-winged blackbird			X	
	Xanthocephalus xanthocephalus	Yellow-headed blackbird			X	
	Quiscalus mexicanus	Common grackle			X	
	Molothrus ater	Brown-headed cowbird			X	
	Molothrus aeneus	Bronzed cowbird			X	
ṣu:g	*Mimus polyglottus*	Mockingbird			X	
taḍi	*Geococcyx californianus*	Roadrunner			X	
toa u'uwhik	*Ardea alba*	White heron			X	
	Ardea thula				X	
tova*	*Meleagris gallopavo*	Turkey	X	X		X
va'akek	*Tyrannus* spp.?	Kingbirds			X	
vac̣ukek	Anatidae	Ducks	X		X	
vahum	sp. in Strigidae or Tytonidae	Owls			?	
vakokam	*Icterus cucullatus*	Hooded oriole			X	
	Icterus galbula	Baltimore oriole			X	
vipismal	Trochilidae	Hummingbirds			X	

**Meleagris gallopavo* (turkey), though not now kept as a domesticated bird at Quitovac, is found at a nearby Sonoran Papago village.

TABLE 7.–*Folk taxa and uses of mammals at or near Quitovac, Sonora.*

Papago Name	Scientific Name	Common Name	Food	Relig.	Wild	Domestic	Reported On Site	Reaching Nearby
('alĭ)'u:phia	*Spologale putoris*	Spotted skunk			X			X
ban	*Canis latrans*	Coyote		X	X		X	
cekolĭ	*Spermophilus variegatus*	Rock squirrel	X		X			X
cuavĭ	*Vulpes velox*	Kit fox			X			X
cuk cu:vĭ	*Lepus californicus*	Black-tailed jackrabbit	X		X		X	
cuṣoiñ	*Ovis canadensis*	Bighorn sheep	X		X			X
cuvho	*Thomomys umbinus*	Pocket gopher			X		X	
dahivo	*Dipodomys merriami**	Merriam's kangaroo rat			X		X	
ge:vo	*Lynx rufus*	Bobcat	X		X		X	
ge'eju koson	*Bassariscus astutus*	Ringtail	X	X	X			X
gogs	*Canis familiaris*	Dog				X		
havañ	*Bos taurus*	Cattle	X			X		
hoho'i	*Erethizon dorsatum*	Porcupine			X			X
huavĭ	*Odocoileus hemionus*	Mule deer	X	X	X			X
kaṣo	*Urocyon cinereoargenteus*	Gray fox			X			X
ka:vĭ	*Taxidea taxus*	Badger	X	X	X			X
kaviyu	*Equus caballus*	Horse				X	X	
kiñs, misciñ ko:ji	*Dicotyles tajacu*	Javelina	X		X			X
ko:ji	*Sus scrofa*	Pig	X			X	X	
koson	*Neotoma albigula**	White-throated woodrat	X		X		X	
ku'wid	*Antilocapra americana*	Pronghorn	X	X	X			X
mavit	*Felis concolor*	Mountain lion			X			X
mu:la	*Equus caballus x E. asinus*	Mule				X	X	
nahaggiu	*Peromyscus eremicus**	Cactus mouse			X		X	
	*Perognathus intermedius**	Desert pocket mouse			X		X	
nanakam	*Phyllostomatidae*	Leaf-nosed bats			X		?	
	Vespertilionidae	Vespertilionid bats			X		?	
ṣelik	*Spermophilus tereticaudus*	Round-tailed ground squirrel			X		X	
si:kĭ	*Odocoileus virginianus*	White-tailed deer	X		X			X
toa cu:vĭ	*Lepus alleni*	Antelope jackrabbit	X		X		X	
to:bĭ	*Sylvilagus audobonii*	Desert cottontail	X		X		X	
'u:phia	*Mephitis mephitis*	Striped skunk			X			X
vavuk	*Procyon lotor*	Racoon			X			X

*Live-trapped in study site.

Waterfowl, doves and quail are the major bird foods utilized by Quitovac Papago. These are taken with .22 rifle, slingshot, or a trip-trigger deadfall box trap made of saguaro ribs, called a *kakast*. Feathers of several bird species are used ceremonially on staffs and prayersticks during the *Vi'igita*. These surely include Golden Eagle and turkey; probably Red-tailed Hawk and Great Horned Owl, and possibly raven. Unfortunately (for us!), some are painted bright colors, and others are old and misshapen from years of use, so that casual observation during the ceremony was not enough to confirm identifications noted in the literature (Cano-Avila 1979; Davis 1920).

The mammals which we consider to be present on Quitovac's 5 ha study site include the same four small rodent species live-trapped at Quitobaquito (see those marked with asterisks in Table 7); a trapped gopher; and nine other taxa observed during our visits. Five of these 14 species are domesticated mammals. The Papago report that 13 additional species can be found in nearby mountain ranges and valleys; particularly in times of drought, certain of these mammals may attempt to drink at the lagoon. Yet due to near-continuous human presence, we doubt whether mammals such as deer and javelina drink or browse at Quitovac as frequently as they do at Quitobaquito.

Although the same four rodent species were eventually trapped at both sites, trapping at Quitobaquito in December and March resulted in more species and individuals than at Quitovac (Table 8). Unfortunately, no trapping was done at Quitovac prior to the clearing; but mammal diversity was obviously less than at Quitobaquito in the first months following this habitat destruction. The May diversity indices based on mammal weights were higher for Quitovac, while those based on mammal numbers were higher for Quitobaquito. This is because packrats *(Neotoma)* contributed 70% of the weight of trapped mammals at Quitobaquito, but only 30% of the total number of individuals trapped.

Table 7 provides ethnozoological data on 31 mammal taxa occurring in the Quitovac vicinity which the Papago there name and/or utilize. Of the 15 taxa utilized for food, most are now shot with .22 rifle; it has been decades since bow hunting and on-foot drives were regularly used.

Of religious uses, the tail of the ringtail *(Bassaricus)* and many parts of the mule deer *(Odocoileus hemionus)* are apparently still utilized in the *Vi'igita*. We could neither confirm nor deny the *Vi'igita's* ceremonial enactment of killing other large mammals (such as pronghorn) in addition to mule deer, as Davis (1920) suggested.

Finally, dogs, horses, and cattle are ever-present at Quitovac, and in many ways limit the presence of other animals. Pigs and chickens as well as other domesticates are occasionally kept in the village, but their influence is not so obvious.

TABLE 8.–*Mammal species richness and diversity at two Sonoran Desert oases (based on live-trapping).*

		Diversity Indices			
	No. of	Based on Weight		Based on Numbers	
Locality & Season	species	Simpson	Shannon-Weaver	Simpson	Shannon-Weaver
Quitovac, Sonora					
Dec. 81	0	–	–	–	–
March 82	1	0	0	0	0
May 82	4	.686	.545	.493	.410
Quitobaquito, Ariz.					
Dec. 81	1	0	0	0	0
March 82	4	.427	.332	.667	.477
May 82	4	.469	.393	.675	.532

CONCLUSIONS

Recently, human ecologists have hypothesized that native Americans formerly managed habitats in ways that encouraged diversity, resulting in benefits in environmental stability or food abundance and reliability (Nabhan and Sheridan 1977; Brush et al. 1981; Emslie 1981). The meaning of diversity, the best ways to measure it, and its relationship to environmental stability are all controversial among theoretical ecologists (Peet 1974, Murdoch 1975). Nevertheless, Altieri (1980) has demonstrated that in agricultural situations, there is clearly a positive correlation between plant diversity in fields, and stability with regard to vulnerability to animal pests.

Utilizing several measures of diversity, we have compared two oases: Quitovac, a "traditional" agricultural setting until the autumn, 1981 clearing in preparation for modern mechanized groundwater agriculture; and Quitobaquito, formerly much like Quitovac, but managed as a wildlife sanctuary in a National Monument since the late 1950s. Because of the removal of cattle and certain introduced plants, as well as the earlier cessation of farming, most Park Service managers would consider that Quitobaquito is undergoing secondary succession "back" to a more natural, perhaps more diverse, condition.

Yet when compared to Quitobaquito, Quitovac is more diverse in terms of plants, somewhat more diverse in birds, and not nearly as diverse in mammals, despite recent habitat disruption. The richness of biota at Quitovac has provided its inhabitants with a diversity of foods, medicines and ceremonial paraphernalia, over and above any cash crops produced there. At Quitobaquito, only dying figs and pomegranates, a few field weeds, and the outlines of ditches persist to suggest that additional species (and habitats?) may have been present a few decades ago. The implications of these differences should be well understood by archaeologists.

To fully explain the present differences between the two oases, it is necessary to consider Papago land use activities. Figure 4 illustrates subsistence-related land uses at Quitovac, some of which affect only target species, while others impact upon all species of one life-form, or a food chain based in a particular habitat. Since we feel that these activities account for the differences in biotic diversity between Quitovac and Quitobaquito more than do other historic or contemporary factors, we will discuss each activity in Figure 4 (according to its letters) in the context of both sites. The habitats in which these activities take place are shown in Figure 3 and described in Table 1. Some activities may take place in more than one habitat.

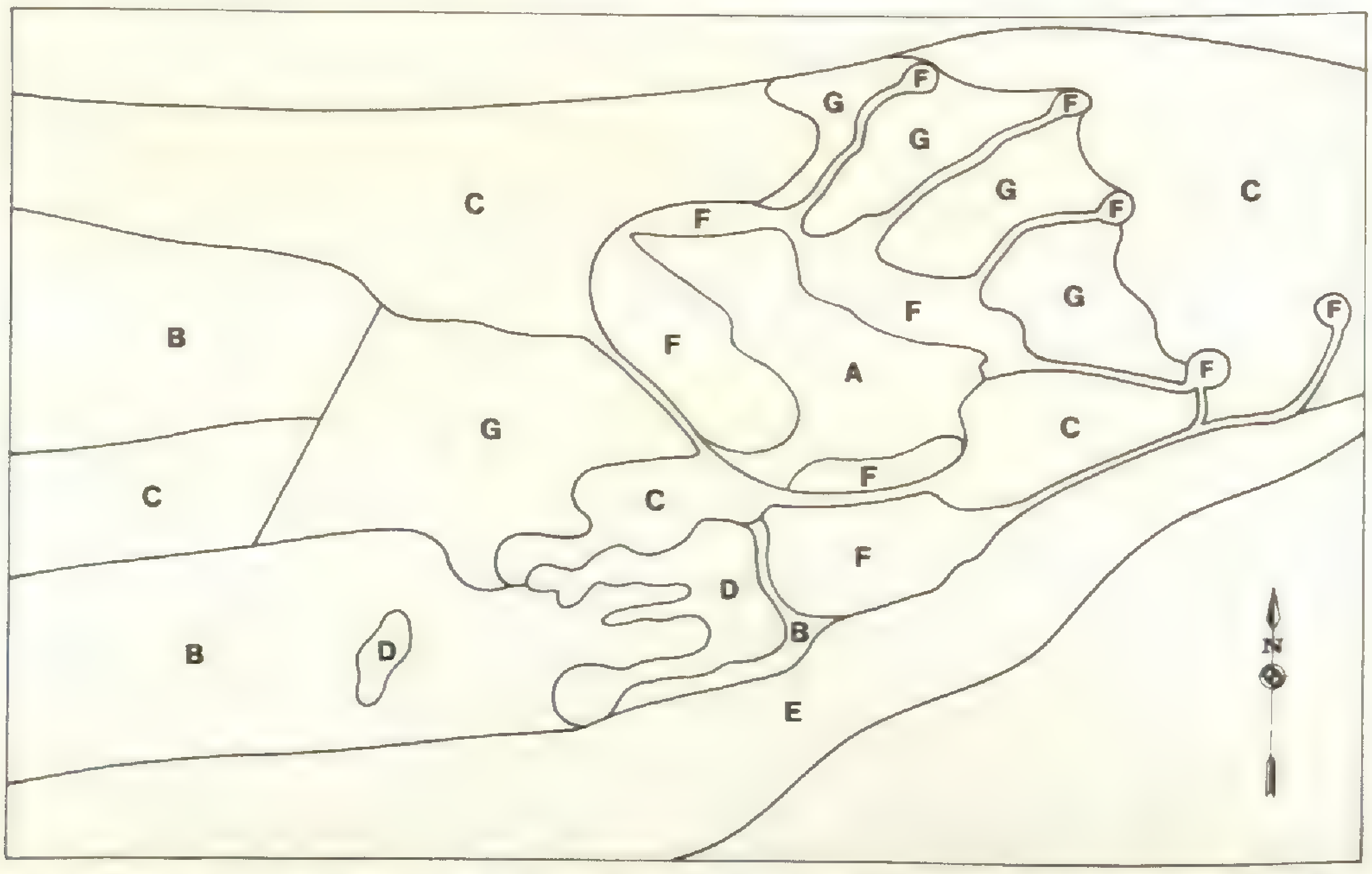

FIG. 3—Oblique map of habitats at Quitovac, reconstructing pre-August 1981 conditions, based on Figure 2.

FIG. 4–Papago land uses affecting biotic diversity (see text for explanation). Illustration by Paul Mirocha.

At Quitovac, wild plant gathering occurs in the field as well as on the pond fringe and in the arroyo (A). Humans compete with birds for saguaro and wolfberry *(Lycium)* fruit; Davis (1920) reported that 120 gallons (454 1) of cactus wine was consumed at the *Vi'igita* alone. Since only a small percentage of the seeds produced naturally germinate in favorable sites, it is unlikely that wild fruit gathering reduces plant population sizes. Likewise, the wild greens (eg., *Chenopodium)* harvested are so abundant in good years and produce so many propagules that whole plant harvesting probably does not diminish populations.

The mosaic of disturbed soil, low shrub cover (fence rows and pomegranate bushes) and generally the greater availability of fruits and seeds (and presumably insects, which we did not monitor) at Quitovac promote larger numbers of grackles, Northern Cardinals, Pyrrhuloxia, Canyon Towhees, White-crowned Sparrows and certain transients such as Black-headed and Blue Grosbeaks. However, mistletoe and wolfberry fruits are more abundant, in season, at Quitobaquito. These are utilized by mimids, bombycillids, and several other semi-frugivorous groups.

Although intentional burning could locally-extirpate fire-susceptible species, it is largely practiced on the pond fringe (B). Emergent *Scirpus* and *Typha* stands with much accumulated dead standing crop are annually "cleaned out" at low water, in part so that newer tender shoots will be available to livestock. The plants regenerate, but the temporary openings between them provide habitat for rails, herons, and other wading birds.

Livestock grazing and browsing probably eliminates certain palatable species from the area altogether (C). Along channels from the springs to the lagaoon, Quitovac lacks the tender *Eustoma exaltam* and *Centaurium calycosum* found at Quitobaquito. Livestock disperse and "plant" seeds. They also compete with other mammals.

Plowing and other forms of periodic soil disturbance release the wild seed reservoir in the soil for germination (D). Some weed seeds, including *Amaranthus*, and *Proboscidea* have their dormancy broken by light exposure (Wiese and Davis 1967; Anderson 1968); a plow's superficial covering encourages germination. At Quitobaquito, due to lack of periodic soil disturbance, few ephemeral or weedy annuals germinate. Plowing also exposes invertebrates to blackbirds and grackles, that readily feed in open furrows (Carothers 1974).

The planting of living fence rows (E) provides field- and pond-edge borders that flycatchers (7 spp.) regularly utilize as perches from which to feed. The planting of *Salix*, *Prosopis* and *Tamarix* has provided some of the most intensively utilized habitat at Quitovac; at Quitobaquito, fewer *Salix* are regernating on their own. The brush woven between fieldside fence rows provides habitat for the few *Neotoma* at the Quitovac site.

Hunting and trapping, primarily of quail and dove, reduce population numbers only slightly today (F). Occasionally other, rarer bird species are killed with slingshots. Cottontails and jack rabbits are hunted around the fields, but their populations do not appear to be threatened.

Irrigation of selected areas (G) provides moisture to germinate and bring to seed numerous plant species. Plants such as *Anemopsis*, *Spergularia* and *Heliotropium* thrive in irrigation ditches. Flowing water, and increased humidity attract certain insects, and in turn attract birds (e.g., phoebes).

Transplanting and tending of domesticated perennials such as palms and figs provide Quitovac with its most diverse habitat (H). The shade, and multiple strata are heavily utilized by orioles, woodpeckers, cowbirds and migrating insectivores (flycatchers, vireos, and wood warblers). At Quitobaquito, the last dozen or so pomegranates and figs are dead or senescing, and palms have been removed.

Large carnivorous birds (families or flocks of Black Vultures, Turkey Vultures, Red-tailed Hawks, Harris' Hawks) were common and conspicuous throughout the day at Quitovac. They were attracted by several large dead or nearly dead cottonwoods formerly standing in open fields where the birds could drink and bathe. In spite of constant human activities, these large birds were quite at ease at Quitovac. In contrast, hawks and vultures only incidentally flew over the Quitobaquito oasis.

The large cottonwoods at Quitovac also attracted Purple Martins and several other swallow species. However, at Quitobaquito the immediate juxtaposition of open pond and mesquite bosque attracted much higher breeding and post-breeding populations of Phainopeplas than we found at Quitovac.

Finally, intentional seed sowing (I) provides grain, melons, legumes and forage utilized by humans and other animals. The only domesticated annual at Quitobaquito is safflower *(Carthamnus)*, which is feral along roadsides in northern Mexico.

The dynamic habitats at Quitovac have provided food, water and shelter to humans and other lifeforms for centuries. Recently, however, much of this habitat was removed when 125 ha of land was cleared for groundwater irrigated agriculture. The project was promoted by governmental agencies to provide economic opportunities for Papagos. While Quitovac residents look forward to increased crop production in the future, to this date the development has not been completed due to political and economic problems. Residents clearly lament the unnecessary destruction of fence rows, abandoned houses, and other historic structures, as well as the disruption of the springs. Future pumping of groundwater will likely influence flow to the pond. Thus re-establishment of riparian habitat is questionable. As at Quitobaquito in the 1950s, sustainable, traditional agriculture, and the "wild" resources associated with it were not evaluated to any extent before a different course of management was initiated (Nabhan 1982).

Johnson et al. (1977) have argued that habitat destruction has contributed more to the post-1600 extinctions of 120 bird and mammal species than have hunting, trapping and other "direct causes." In doing so, Johnson and colleagues rightfully call for further efforts to protect "endangered" wild habitats. It may be worth considering that diverse agricultural habitats, including certain ones maintained by native American farmers for centuries, are also now endangered. It is unlikely that one could find environments more rare or more vulnerable than those found in desert oases like Quitovac or Quitobaquito. Their loss will affect not only the bird and mammal populations sustained by them, but may impoverish the life of the human community as well.

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PSYCHOACTIVE PAINTED PERUVIAN PLANTS THE SHAMANISM TEXTILE

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ABSTRACT.—From a cache of over 200 Chavín textiles found in the Ica Valley on the Peruvian south coast in 1969, one is particularly intriguing. Exhibited in the San Diego Museum of Man's 1980 analysis of South American shamanism, this 2000 year old cloth is painted with images of transformation and transcendence. Of special interest is the representation of three plants shown in connection with a jaguar, winged deer, hummingbirds, shamans, and a deity. While this textile has been described before in the context of the others in the group, the present paper addresses the plants specifically. One plant is very likely to be the hallucinogenic San Pedro cactus *(Trichocereus pachanoi);* another is more tentatively suggested to be seed pods of the psychoactive acacia *(Anadenanthera peregrina* or *A. colubrina).* The third plant, while still eluding precise classification, must be considered as a possible narcotic as well.

INTRODUCTION

Over 2000 years ago a Chavín artist of ancient Peru painted a cotton textile with a religious message which is dramatically clear today. The message is shamanism and the textile is remarkable because all of shamanism's basic elements are represented on it: the shaman, his animal familiar, his means for entering a trance to contact the supernatural world, and a deity from that world (Fig. 1). This cloth is hereafter referred to as The Shamanism Textile. Now fragmentary and measuring 54.61 x 68.58 cm, the cloth is a plain weave, 1/1 (1 warp thread by 1 weft thread), of S-spun cotton *(Gossypium barbadense)* and is painted with tan and brown colors (pigments as yet untested) over the ecru

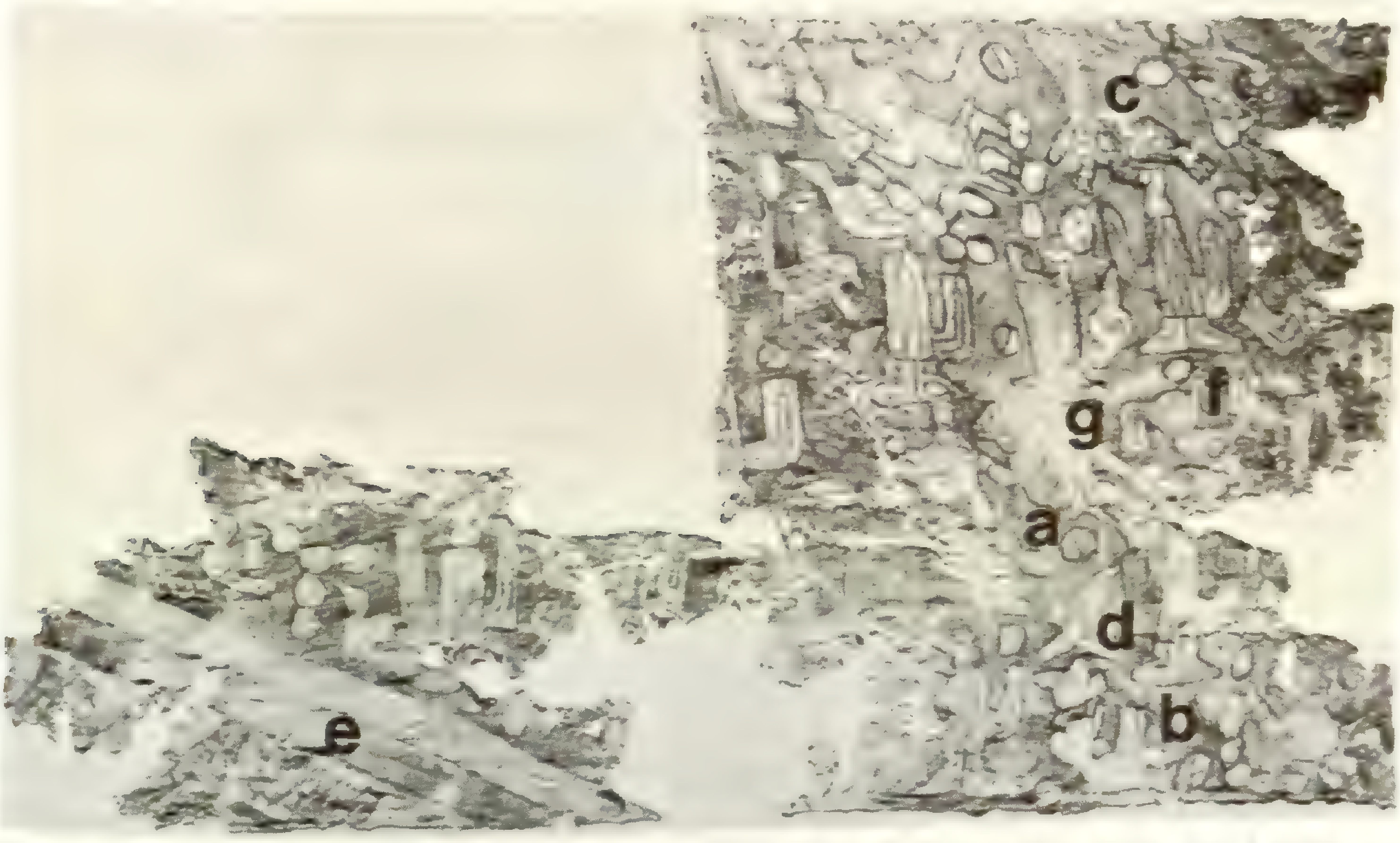

FIG. 1—The Shamanism Textile: a. shaman grasping *Anadenanthera* pods, b. San Pedro cactus, c. jaguar, d. hummingbird, e. Staff God, f. winged deer, g. mystery plant.
(Ken Hedges photo)

tone of the natural cotton. A total of 65 extant motifs is assignable to 12 categories (Table 1).

DISCUSSION

The Archaeological Context

The Shamanism Textile, along with the others in the cache, was reportedly found at the site of Carhua in the Ica Valley on the south coast of Peru by *huaqueros* (grave robbers)[1]. However, on stylistic grounds, the textiles belong to a quite different locale; they are most comparable to the art of the Chavín type site, Chavín de Huántar, situated in the eastern Andes at an elevation of 3135 m above sea level, and 644 km distant from Carhua (Fig. 2). Therefore, it is most likely that the textiles were carried from the locus of manufacture, possibly Chavín de Huántar, to the south coast (Cordy-Collins 1976:272; Conklin 1978:7).

Chavín Shamanism

Elsewhere I have argued that, as a group, the textiles functioned as a catechism which brought a religious message from one non-literate society to another in pictographic form, and that the message concerned the ascendency of a new Chavín deity (Cordy-Collins 1976). Furthermore, I have contended that the Chavín peoples' religion was shamanistic and was based on plant hallucinogens (Cordy-Collins 1977, 1980).

Simply stated, shamanism is a means by which order and balance are maintained within a society. The shaman is the focal character in the system and through his intercession with the supernatural world, homeostasis is sustained. To achieve homeostasis the shaman (1) enters a trance (frequently induced by plant hallucinogens), (2) transforms into his animal familiar (usually the jaguar), and (3) then flies upward to the spirit world where he intercedes with the supernaturals residing there.

The hypothesis proposed for the textiles' presence on the south coast is that they served as a medium of a proselytizing movement from a Chavín central locus. Furthermore, Chavín religious iconography has been shown to consistently include hallucinogenic references. Curls emanating from the nostrils of supernatural images seems to represent the mucus discharge which results from snuffing hallucinogenic powder (Chagnon 1968:

TABLE 1.–*Comparative frequency table of motifs on The Shamanism Textile in present, fragmentary state.*

Element	Number of appearances
Staff God	1, very fragmentary
double ring	1 section above Staff God
feline, spotted	1
partial plant (San Pedro?)	1, less than half remaining
mystery plant	2, both in bloom; 1 fragmentary
deer, winged	4
misc. unidentified objects	4, all fragmentary
shamans	5
San Pedro cactus	6: 4 in bloom, 1 not, 1 unclear
acacia seed pods	6: 5 held by shamans, 1 fragmentary
hummingbirds	16
floating circles	18: 1 sexpartite, 5 quadrupartite, 4 halved, 5 plain

FIG. 2—Map of Peru locating Carhua, reported site of textile cache, and Chavín de Huántar, site of the Chavín art style's definition.

5; Cordy-Collins 1980). Chavín artists' use of hallucinogenic snuff has also been suggested by Donald Lathrap (1973:96). In addition to psychoactive snuff, the hallucinogenic San Pedro cactus has also been identified in Chavín religious art (Cordy-Collins 1977:360; Lumbreras 1977:23; Sharon and Donnan 1977:377-379). Therefore, any attempts to decipher Chavín iconography should test for hallucinogenic and shamanistic references. A refinement of the aforementioned general hypothesis accounting for the presence of Chavín textiles on the south coast, specifically aimed at the iconography of the textile under discussion here, argues that all the motifs on the textile in Figure 1 refer directly to the general proselytizing message: plant hallucinogen-based shamanism supported a deity new to Chavín religion. The following discussion will concern itself with the possible representation of (1) hallucinogenic plants, (2) a shamanistic complex and, (3) the new Chavín deity.

Analysis of The Shamanism Textile's Components

To unravel the textile's message, ethnographic studies of South American shamanism made over the last century are invaluable. Shamans' transforming agents in South America today are commonly plant hallucinogens, and the most readily identifiable design on the textile appears to be one of these, the San Pedro cactus *(Trichocereus pachanoi)* (Fig. 3). A columnar, ribbed plant, San Pedro is used by coastal Peruvian shamans today to achieve a trance state whereby the supernatural world is opened to them; San Pedro's active alkaloid is mescaline[2]. Traditionally, shamanic curing sessions employing the cactus occur at night when the flower blooms. Apparently the act of blooming is particularly important because the language of the curing session makes continued use of the blooming metaphor (Sharon 1978:107). Therefore, it seems especially significant that in four of the five cases where identification is possible, the painted San Pedros are in bloom. It is pertinent to note that the proposed San Pedro cacti, as represented on the textile, have no more than four ribs. This is contradictory to fact: *T. pachanoi* has between six and eight ribs. However, modern Peruvian shamans believe that four-ribbed San Pedro cacti do exist and are especially potent *because* of the four ribs (Sharon and Donnan 1977:376). The number four is a magical, ritual one in modern shamanism. Therefore, it is entirely possible that four-ribbed San Pedros are entirely mythical. This is an important point to which I shall return.

The second motif on The Shamanism Textile which may be a plant hallucinogen appears as linear clusters of circular elements. It is possible that this motif represents *Anadenanthera peregrina* (acacia) seed pods (Fig. 4). *A. peregrina* has a documented use


FIG. 3–San Pedro cactus growing at Chavín de Huántar, Peru. (Jack L. Riesland photo)

FIG. 4–*Anadenanthera peregrina* (after Schultes 1976).

in South America extending back to 1496 (Schultes and Hofmann 1979:116). As shamanic trance-inducing agents, the seeds are removed from the pods and ground into powder for snuffing or, in some cases, it is reported that the seeds were simply chewed. Whereas actual *A. peregrina* pods average about 20 cm in length, the motifs on the textile appear to be much larger relative to the individuals who seem to be holding them. However, in defense of the argument, the size of the hummingbirds relative to everything else indicates that true scale was not a particular concern of the Chavín artist. Yet, there is a second objective which might be leveled against interpreting the proposed plant as *A. peregrina.* Actual acacia pods split open along their sides rather than interdigitally between the seeds as seems to be indicated on the textile. Nonetheless, some *A. peregrina* pods evidence severe constriction on the pod between individual seeds (cf., Schultes and Hofmann 1979:117, lower photograph). Finally, though, the point must be made that the geographical zone occupied by the Chavín artist who painted the textile was not that where the psychoactive acacia grows. *Anadenanthera peregrina* is apparently native to the tropical lowlands drained by the Orinoco River. Nevertheless, it is documented that there was extensive trade of the drug into the highlands (Schultes and Hofmann 1979: 117). What makes the discussion of the motif particularly intriguing is that we cannot be certain of the form the drug was in when traded: whether in whole pods, individual seeds, or as ground powder. If it was brought into the highlands in either of the latter two forms, then we would not expect the Chavín artist to necessarily be aware of its appearance while growing, except by heresay from the traders. Though the identification as *A. peregrina* is tentative, it should be noted that some of the animals on the textile appear with muzzle emanations which could well represent nasal discharge which results from inhalation of hallucinogenic snuff.

The third proposed plant on The Shamanism Textile presents a conundrum. Only two images of the motif appear, one complete and one fragmentary. That they are plants seems reasonable to assume because the roots of the complete example are metaphorically shown as truncated serpents (Fig. 5) just as they are with the San Pedro cacti. Serpents appear throughout Chavín art as a sort of visual pun known as "kennings" (Rowe 1967:82)^3 and snakes as plant roots are known from another Chavín textile which depicts cotton plants (Cordy-Collins 1979: Figs. 3, 7-9). Furthermore, a flower-like ele-

FIG. 5–Detail of The Shamanism Textile showing the complete representation of the mystery plant (Alana Cordy-Collins photo).

ment appears atop the motif in question. Therefore, I think it likely that the mysterious image is that of a plant. But what plant? Given the context, one might expect it would be a plant with hallucinogenic properties. One of the problems in identification is that of proper scale, a problem discussed in reference to the supposed acacia pods. Another problem is the uncertainty of the viewer's vantage point; Chavín art occasionally makes use of simultaneous Picasso-like views. One more difficulty is the abstract quality of the painting itself; and, finally, many hallucinogenic plants used by shamans today are still unclassified. The plant's diagonal lines are intriguing; they could be gashes to allow for the draining and collecting of sap as with rubber trees. If this is the meaning of the lines, perhaps the plant can be compared with the virola tree *(Virola* spp.), the resinous sap of which is gathered by contemporary Amazonians to be employed as a snuff ingredient. However, currently shamans obtain virola resin by scraping the inner bark, not by gashing the tree. An alternative interpretation is that the mystery plant is really a flower, since the upper portion is very flower-like. Finally, two more possibilities must be entertained: either the plant might by mythical as the four-ribbed San Pedro cactus discussed earlier seems to be, or it might simply have been unknown to the Chavín artists in its live, growing form, as has been suggested for *A. peregrina.* Here too, it could have been that the processed hallucinogenic substance alone was imported by Chavín people. Therefore, they would have had to depend on foreign descriptions or on their own imaginations to create a visual image of the plant.

Taken by themselves, the three proposed plants may not seem to make a particularly strong case for a definition of the painted Chavín cloth as "The Shamanism Textile." However, like any archaeological data, these three iconographic motifs must be studied in their context in order to arrive at a meaningful interpretation.

As stated at the beginning of this discussion, shamanism is a complex, the trance-inducing agents being but one element in the system. Other elements include the shaman, his animal familiars, spirits and supernaturals from the netherworld. It can be demonstrated that most, if not all, these elements are present on the textile, thus providing both a context for the identification of trance-inducing agents—psychoactive plants—and for the overall interpretation of the painted cloth as The Shamanism Textile.

The figures associated with the presumed acacia pods may be shamans. While the bodies of these individuals are anthropomorphic, their faces are decidedly zoomorphic (compare these faces with those of the deer and feline below). This could indicate that these individuals are shamans in the process of transformation. Composite faces in Chavín ceramic art seem to represent states of transformation (Figs. 6, 7). Alternatively, these creatures may be spirits, specifically spirits of the acacia. Among the Waika Indians of southern Venezuela and Brazil who regularly make extensive use of *A. peregrina* snuff, spirits called *Hekula* are believed to communicate with them during their snuff-induced ecstatic trances (Schultes and Hofmann 1979:118-119).

According to widely-held Amazonian beliefs, once the transforming agent is ingested, the shaman is no longer human in form, but jaguarian. One spotted feline appears with his paw resting on an opened cactus bloom. Emanations exude from his muzzle. I have previously suggested that such emanations in Chavín art refer to the use of hallucinogenic snuff (Cordy-Collins 1980). Therefore, a reasonable interpretation of the motifs' juxtaposition is that the jaguar is the transformed shaman, intimately associated with the transforming media[4].

The hummingbirds are also appropriate inclusions because, due to their ability to draw nectar from flowers by sucking, the birds are equated with the shaman who, in curing, sucks the pathogens from his patients' bodies. Here, however, the bird/shaman association extends even further: in eight instances on The Shamanism Textile the hummingbirds are depicted with their beaks abutting the cacti as if to draw out the transforming juices. Furthermore, invariably all birds in a shamanic context symbolize the shaman's magical flight to the realm of the deities.

One deity, even though only partially extant, can be precisely identified. This is the Staff God, the new Chavín supernatural around whom revolved the proselytizing movement which brought the textile cache to the south coast. The deity has been somewhat reconstructed in Fig. 8. Comparable Staff Gods evidence the same headdress form, an inverted agnathic fanged mouth with serpents (Figs. 9, 10).

Deer are apparently very old shamanic symbols, extending back at least to the Upper Paleolithic period in Europe (Furst 1976). Today in Peru the deer acts as a metaphor for the swiftness and elusiveness of the shaman. The wing on its back reinforces the shaman's power of flight. Additionally, at least one of the deer on the textile is shown with muzzle emanations, probably relating to the use of hallucinogenic snuff. The deer's association with hallucinogens is corroborated by a Chavín ceramic bottle showing the deer in direct association with a San Pedro cactus (Cordy-Collins 1976: Fig. 110).

Therefore, it can be seen that, even without the identification of the three proposed hallucinogenic plants, the message this textile carries is shamanism as a complex of interrelated elements. Yet, because shamanism as it is known today throughout South America and as it has been documented since the 15th century, has made consistent use of plant hallucinogens to achieve the desired state of ecstacy and communication with the spirit world, it is reasonable to assume that such plants also played an important part in the shamanism of South America's prehistoric past. It is reasonable to suggest that the three otherwise unidentified motifs on The Shamanism Textile are meant to represent plant hallucinogens.

CONCLUSION

A Chavín painted textile from Precolumbian Peru has been, by means of iconographic analysis and ethnographic analogy, shown to be a very important document.

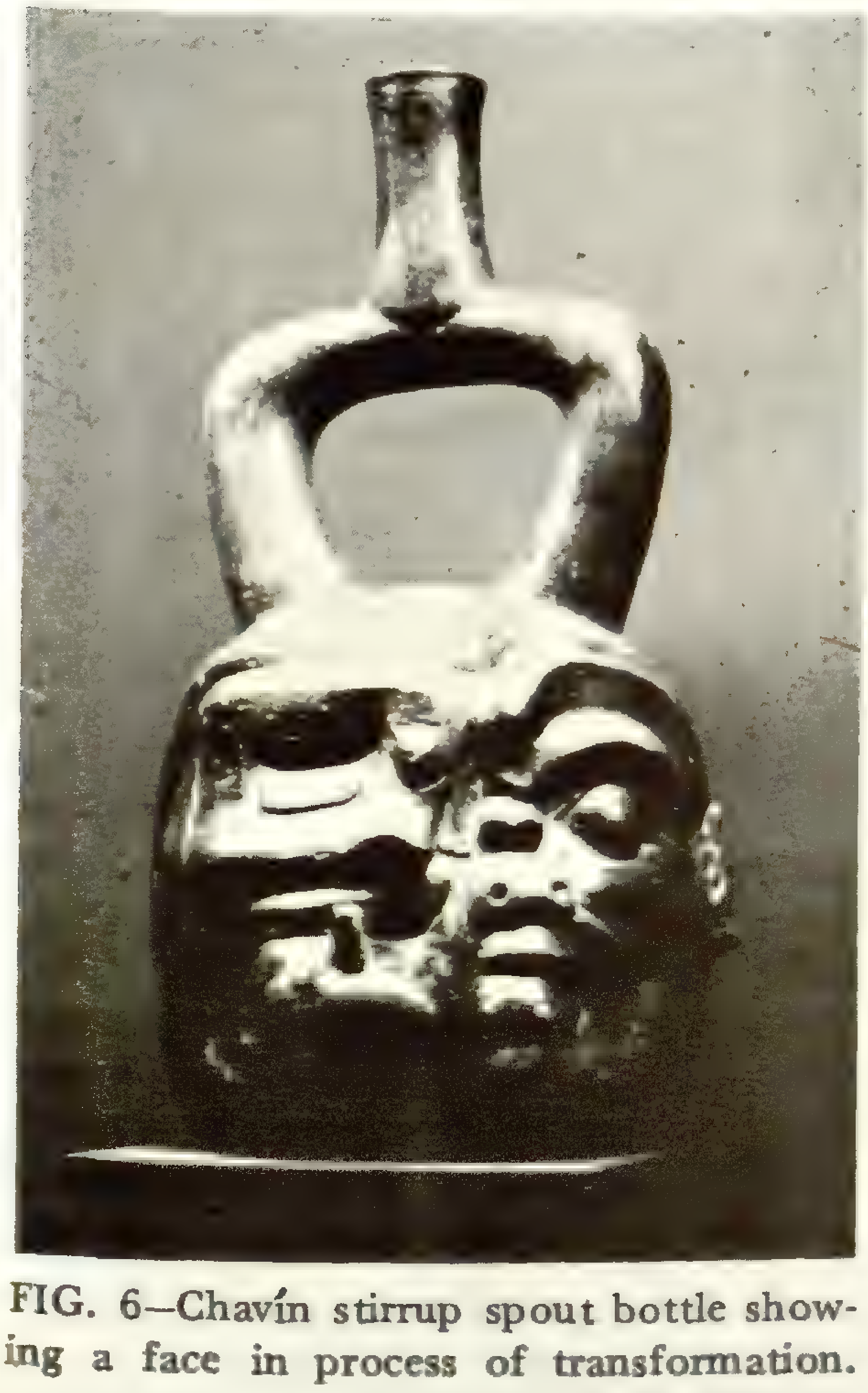

FIG. 6—Chavín stirrup spout bottle showing a face in process of transformation. (Junius B. Bird photo)

FIG. 7—Chavín stirrup spout bottle showing a face in process of transformation. (Jack L. Riesland photo)

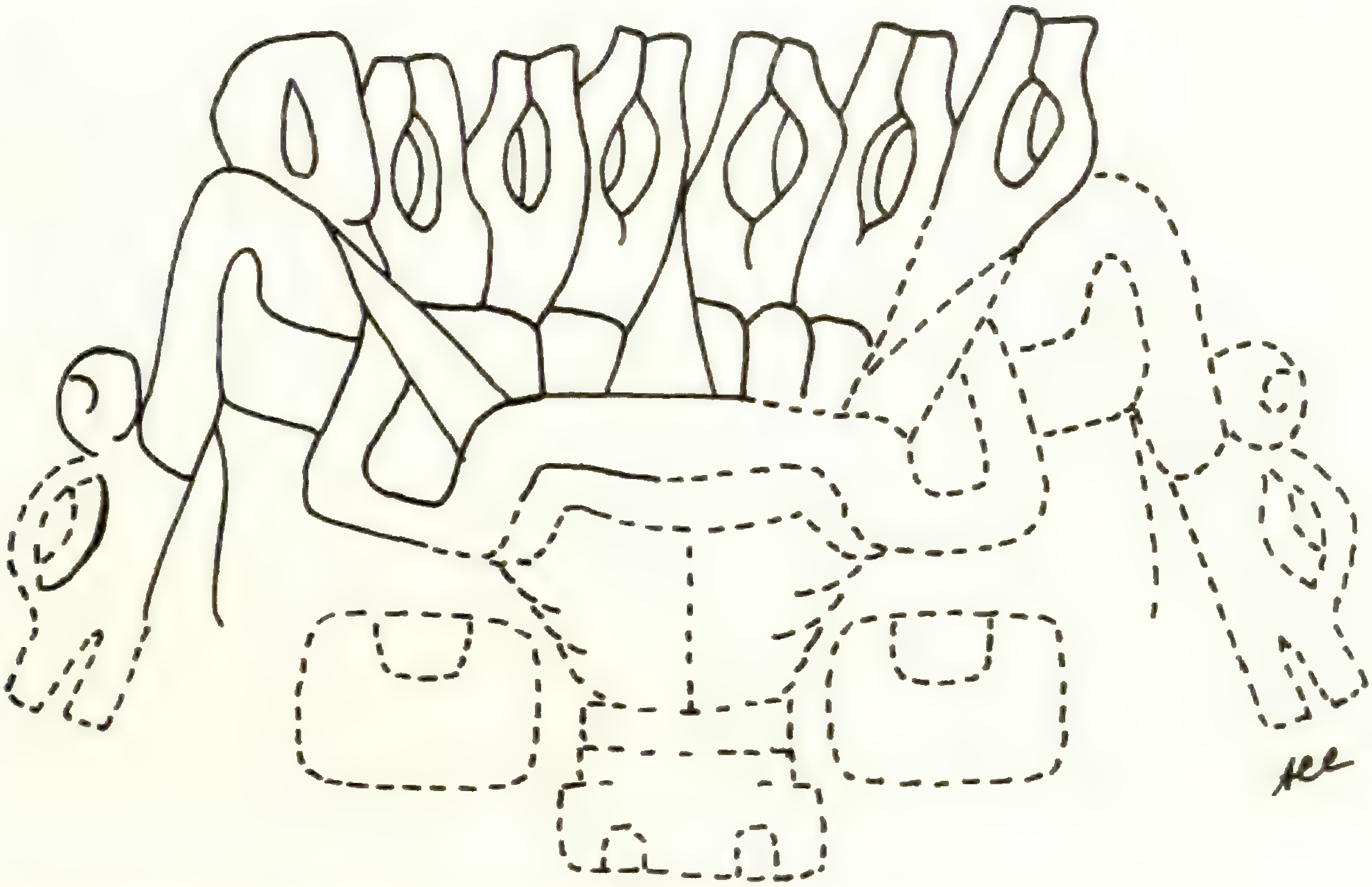

FIG. 8–Partially reconstructed Staff God face from The Shamanism Textile.
(Alana Cordy-Collins drawing)

FIG. 9–Staff God on Chavín textile showing same headdress type as on The Shamanism Textile. (F.E. Landman photo)

FIG. 10–Staff God on border of Chavín textile showing same headdress as on The Shamanism Textile.
(Alana Cordy-Collins photo)

Not only does it corroborate earlier independent interpretations that Chavín society's religion was shamanistic, but it suggests specific plants used in its shamanistic practices. Of the three plants shown, one seems to be San Pedro cactus, another may be acacia seed pods, but the third image eludes identification. Nevertheless, because the cactus and acacia are both hallucinogens used in South American shamanism today, it seems extremely likely that this image with plant features may be similarly interpreted. While it may be that future research will reveal the exact nature of the mysterious motif, it should be born in mind that Chavín art is highly conventionalized with a strong mythological component. That the Chavín artists consistently chose to represent San Pedro cactus with four ribs instead of the actual six to eight suggests mythological/spiritual concerns were in a sense more real than the everyday world about them. Therefore, it would be a mistake to look upon Chavín botanical representations as mirrors of the actual ecology in Peru in the second millenium B.C.

NOTES

1 Because the textiles were not excavated archaeologically, the locale of their discovery—supposedly Carhua—is undocumented. However, because conditions for optimum preservation of organic materials exist on the south coast, it is very probable that the textiles were discovered near Carhua, if not precisely there.

2 Although Britton and Rose (1920) report San Pedro growing at elevations from 2000 to 3000 m, Sharon and Donnan (1977:375) have repeatedly observed it growing at sea level along the north coast of Peru.

3 "Smaller bodily appendages [in Chavín art] are usually compared to snakes, and in this way they usually issue directly from the body . . ." (Rowe 1967:79).

4 While there might be some objection to identifying the feline on the textile as a jaguar, rather than an ocelot, a pampas cat or *gato montes*, it should be noted that native South Americans do not make the same taxonomic distinctions as do Westerners. The term "jaguar" is a general generic referent which is sometimes broken down into more specific subtypes. For instance, Theodor Koch-Grünberg reported during 1917-1928 that the Taulipang shamans of Venezuela refered to themselves as "the black jaguar . . .the tapir jaguar . . . the puma jaguar . . . the multi-colored jaguar . . ." (cf., Furst 1968:158). These animals, whose outward appearances are distinct were, nonetheless, all categorized as jaguars.

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OOLIGAN GREASE: A NUTRITIOUS FAT USED BY NATIVE PEOPLE OF COASTAL BRITISH COLUMBIA

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ABSTRACT.–Marine fat, derived from several sources, was formerly used to great extent by Northwest Coast Indians as a flavor enhancer of many foods as well as for medicinal and ceremonial purposes. The most prominent source of food fat used by British Columbia native people has been from the *ooligan (Thaleichthys pacificus* Richardson, Osmeridae) a small fish which is harvested in bulk in early spring, allowed to ripen in large bins, and then rendered to give a pungent, golden, thick oil called "*ooligan* grease". Samples from five preparations of this fat were made in 1981 from the Nuxalk Community of Bella Coola, B.C. and several nutrient analyses were done. Fatty acids, expressed as mean and range of percent methyl esters were: saturated at 32.2 (30-33), monounsaturated at 64.5 (63-66), and polyunsaturated at 0.9 (0.8-1.1). The principle fatty acid was oleic acid. In addition, there are small amounts of Kjeldahl N (16-19 ug/g), Ca 27-206 ug/g) and P(70-100 ug/g). Analyses with high pressure liquid chromatography yielded the following mean and range values for three fat soluble vitamins: vitamin A-20 ug/g (18-29); vitamin E-220 ug/g (148-279); vitamin K - 10 ug/g (4-13). It is concluded that *ooligan* grease is a nutrient-rich food fat that is currently consumed much less frequently than it was formerly.

INTRODUCTION

Food fat derived from several marine species was used to a great extent in the past by Northwest Coast Indians. Uses of fat from seal and porpoise (Suttles 1951), whale (Drucker 1951) and salmon (K'san, People of 1981) have been described; however, the most prominent food fat for British Columbia native people is recognized as that rendered from the small fish, *Thaleichthys pacificus* (Macnair 1971). This fish is commonly noted as the *ooligan, eulachon, eulachen, olachen, olachon*, or *oolachan*, depending on the pronunciation of the various B.C. native groups, and the interpretation of the writer. In this paper, the spelling "*ooligan*" is used, since this closely approximates the term commonly used by the Nuxalk People of Bella Coola who graciously provided samples of "*ooligan* grease" for the analyses reported here.

Thaleichthys pacificus grows to a maximum length of 30 cm, and returns in early spring to fresh water rivers for spawning after spending 2-3 years at sea. The important rivers for harvesting these fish are the Stikine, the Nass, the Skeena, the Kitimat, the Bella Coola, the Kingcome, the Klinaklini, and the Fraser (Macnair 1971). In addition to use of the fish as a source of rendered fat, native people have used the *ooligan* as a popular flesh food. The fish is eaten fresh after one of several possible methods of preparation (boiling, baking, grilling, etc.), and it can also be preserved by smoking, drying, salting or freezing–or in combinations of these processes.

The fat rendered from *T. pacificus* is commonly called "grease". It is widely used as a condiment with many foods, such as dried fish, potatoes, native root foods and vegetables (McIlwraith 1948; Kuhnlein et al. 1982; Niblack 1970; Rohner 1967; Turner 1975). It is also used as an ingredient in the preparation of bread, stews or salads (Hawthorne et al. 1960; Edwards 1978). In addition, *ooligan* grease was formerly used extensively as a preservative in that cakes of dried berries were submerged in boxes containing the fat, thus protecting the fruit from oxidation and pests.

As well as being a prominent traditional food, *ooligan* grease is used as a native medicine for skin rashes or for the treatment of various internal ailments (McGregor 1981; Garfield and Wingate 1966; Edwards 1978). It was also used as an all-purpose lubricant for wood and leather items (Edwards 1978).

The cultural significance of *ooligan* grease cannot be underestimated, as it was (and continues to be) a prominent food and gift during feasts and potlatch ceremonies. Early ethnographers among the Nuxalk and Kwakiutl people noted that it was a sign of poverty for a family to be without *ooligan* grease (McIlwraith 1948; Curtis 1915).

There is documentation for preparation and use of *ooligan* grease by the Tlingit (Oberg 1973), Tsimshian (Stewart 1975; Boas 1916; Garfield and Wingate 1966) Kwakiutl (Macnair 1971; Curtis 1915; Rohner 1967), Kitimat Haisla (Hawthorne et al. 1960), Gitksan (K'san, People of 1981) and Coast Salish (Barnett 1955). This list is not a complete one, since many native groups obtained *ooligan* grease by travelling to the rivers to help residents with fish harvest and preparation, or by trade.

The process of preparing the rendered fat, and the consequent flavor of the final product, differ among the groups of native people. Usually, the fish are "ripened" in bulk to develop the flavor and to permit decomposition of the carcas for easier release of the fat during cooking. The exact changes in the fish carcass due to microbial action are not known. Ethnographic accounts describe cooking the fish in water heated with hot rocks or over an open fire using a bin with a metal bottom. In addition to procedural variations among native groups, there are preferences and opinions of families on how to make the best *ooligan* grease.

PREPARATION OF *OOLIGAN* GREASE BY THE NUXALK PEOPLE

The people of the Nuxalk community in Bella Coola, British Columbia, prepare *ooligan* grease from fish entering the Bella Coola River in early spring. The time of arrival of the *ooligans* ultimately depends on weather conditions, but usually the first fish appear in late March. In early April, when the seagulls hover over the river which is "black with *ooligans*," the fish are seine-netted into boats and hauled in buckets onto shore and packed into bins built on the river bank. The size of the fish bins, called "stink boxes" by the Nuxalk people, varies. An average-sized box will hold 6300 kg of *ooligans*, and is constructed from cedar planks to be 2-3 m square and 1.5 m high. The floor of the bin is customarily lined with cedar *(Thuja plicata* Donn) boughs to permit adequate drainage. When full, the box is covered, and the contents left to ripen. Depending on the weather, this process will take from 4-14 days. Each family has their own way of telling when the ripening is complete—either by smell, or by feeling the texture of the decomposing fish.

Some Nuxalk people preferred, in the past, to use only the fattier, female fish for the grease-making process. Today it is the custom to use the entire catch. Usually, it is the men who net the fish, and haul the catch into bins. At the time of cooking the grease, the whole family spends the day, or the weekend, at the riverbank, with women supervising the cooking process.

If the fish are properly ripened, a 6300 kg bin will yield around 380 l of prepared grease. The ripened fish are placed into boiling water contained in a cooking box with a metal bottom that is placed on supports over an open fire. The contents are slowly simmered to extract the fish oil. It is essential to cook slowly, to prevent boiling and frothing, so that the oil from the fish will "melt away" and rise to the surface of the water layer. When cooking is complete more water is carefully added to the bin to make a distinct water/oil interface. The oil is then scooped off into metal pots and the fish residue is either released to the river via a trough from the cooking box, or taken for garden fertilizer.

The oil is then reheated to the frothing point to skim off any particulates. This is accomplished by some families with the addition of red-hot stones to the metal pot. The families who use this method say they do it to get the "hot rock flavor" they like so much. Others reheat the grease slowly on a portable kerosene stove to complete the skimming process. Still others will reheat it two or three times on a portable stove to ensure that the grease is "safe" and will not get "strong tasting" during storage.

When the final cooking is finished, the resulting fat is a golden, pungent, thick oil which is poured into gallon jugs and is usually stored in a cool part of the home. A few families also store grease in a freezer. Everyone maintains that grease which is properly cooked and bottled will keep for several years at room temperature. Those who store it frozen say they do so to keep the flavor from getting "strong."

An interview study of Nuxalk families (Kuhnlein 1981), revealed that slightly more than 50% of families still use *ooligan* grease to some degree. The quantity used per family varied from 7 to 38 l of grease per year. Although there were five fermenting bins yielding upwards of 2000 l of grease for the village in 1981, this was distributed within the community of about 600 people. Nuxalk elders still use *ooligan* grease as a medicine, and it still has a prominent role in cultural activities. The following foods have been observed (by author HK) to be eaten with *ooligan* grease in the Nuxalk community: dried fish, smoked and cooked fish, potato, herring roe, salmon roe, seaweed *(Porphyra perforata* Agardh.), bannock, and homemade bread. Spring greens eaten with *ooligan* grease include the shoots of salmonberry *(Rubus spectabilis* Pursh), thimbleberry *(Rubus parviflorus* Nutt.) and cow parsnip *(Heracleum lanatum* Michx).

Today, marketed fats such as lard, hydrogenated fat, corn oil and margarine are commonly used by native people, and these have replaced the use of *ooligan* grease as a regular meal-time food. An essential step in the documentation of nutritional consequences of this adaptation is the identification of the nutrient components of *ooligan* grease. Although *ooligan* grease has always been considered as a generally healthful food by native people, no reports of its nutrient composition have yet appeared in the scientific literaure.

METHODS

Samples of *ooligan* grease were taken in 1981 from five different preparations made in the Nuxalk community of Bella Coola, British Columbia. The samples were poured from the family container into acid-washed 200 ml teflon bottles which were then frozen and stored at -15^{o} C until later analysis. Analyses were completed for proximate composition, minerals, fatty acids, and vitamins A, E and K.

Proximate composition was assessed with standard techniques. Moisture was determined in quadruplicate by drying at 70^{o} C overnight and then to constant weight at 60^{o} C in a vacuum oven. Ash determinations were made on the dried samples at 550^{o} C in a muffle furnace. Total lipids were determined with method 16.052 of the A.O.A.C. Methods Manual (1970). Total Kjeldahl nitrogen was determined with standard procedures (McQuaker 1976).

Mineral elements were assessed with a nitric-perchloric acid digest of the sample on an inductively coupled plasma-atomic emission spectrometer (McQuaker et al. 1979a, 1979b). Determinations were made for Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, P, Pb, Sb, Sr, Ti, V and Zn.

Fatty acids were determined as percent methyl esters using standard gas chromatograph procedures after the samples were saponified and methylated with boron trifluoride.

Vitamin A was assayed fluorimetrically as retinol according to the method of Thompson et al. (1978) using 100 mg of oil, or with high pressure liquid chromatography (HPLC) on a silica column. Vitamin K was determined with HPLC with a C^{18} reverse phase column (Vydac 201 TP 0.32 x 25 cm) installed in a Spectra-Physics HPLC system (SP 8700 solvent delivery system, SP 8400 UV/vis detector, SP 4100 computing integrator). Vitamin K_1 (Sigma V-3501) was used as the standard. Duplicate analyses within a laboratory were within 10.5% of each other.

Cholesterol was detectable at <5 ng/mg oil using a mobile phase of 1:1 acetonitrile-isopropanol and reading at 200 nm.

Vitamin E was measured with HPLC using the method of Thompson and Hatina (1979). A spectrofluorometer set at 290 nm excitation and 330 nm emission was used as a detector.

RESULTS AND DISCUSSION

The results of analyses of *ooligan* grease for proximate composition, fatty acids, calcium and phosphorus are given in Table 1. As anticipated, the primary energy com-

TABLE 1. *Composition of* ooligan *grease.*

Component	Mean[a]	Range
Fat, %	>99	–
Moisture, %	0.16	0.09-0.24
Ash, %	< 0.02	0.005-0.02
N (Kjeldahl), ug/g	18	16-21
Ca, ug/g	68	27-206
P, ug/g	85	70-100
Fatty acids	– – – – – – % methyl esters – – – – – –	
14:0	6.4	5.7-7.2
14:1	0.3	0.3-0.4
16:0	17.9	17.0-18.3
16:1	7.1	6.3-8.0
18:0	4.1	3.9-4.4
18:1	54.6	52.2-57.8
18:2	0.8	0.7-1.0
18:3	0.1	0.1-0.1
20:0	0:3	0.3-0.4
20:1	1:2	1.2-1.2
20:5 or 22:1	1.3	1.3-1.5

[a] Mean of 5 samples

ponent was fat with less than 1%, by weight, of the oil being the combined components of moisture, ash, and nitrogen. Extrapolating these small amounts of nitrogen to protein with a factor of 6.25, there was less than 0.01% protein present. Carbohydrate content, determined by difference (the sum of fat, moisture, protein, and ash subtracted from 100) was negligible. Calcium and phosphorus were the major minerals found, although at these levels, (6.8 mg/100 g calcium and 8.5 mg/100 g phosphorus) *ooligan* grease would make a very small contribution to daily dietary needs, even if consumed in large quantities. Of the minerals determined, iron, magnesium and zinc were the only other minerals present. These occurred inconsistently in the samples and in small quantities (5-10 ug/g) and also would not have contributed significantly to dietary needs.

Determination of the fatty acid content revealed that the primary fatty acid was monounsaturated oleic acid (18:1). There was a mean content of 54.6% of this fatty acid. The second most prominent was the saturated fat, palmitic acid (16:0), with a mean content of about 18%. There were small amounts of polyunsaturated acids (18:2 and 18:3), so that the ratio of polyunsaturates to saturates was very low. However, the total unsaturated fat content is approximately 65%, which exceeds that of commonly used animal fats, such as butter, lard, beef fat and mutton fat. It is similar in unsaturated fat content to that of poultry fat (Brignoli et al. 1976: Reeves and Weihrauch 1979).

The resolution of the longest chain acids was not complete, so that it was not known whether this small component (1.3-1.5%) was eicosapentaenoic acid (20:5) or the longer chained cetoleic acid (22:1), or a combination of these two. Eicosapentaenoic acid has been identified in diets containing fish oils which are consumed by Greenland Eskimos. The fatty acid, at 2.6% of fatty acids in the total diet, is though to contribute to a low incidence of ischemic heart disease in these people (Bang et al. 1980).

The results of the analysis for three fat-soluble vitamins are given in Table 2. The samples are rich in vitamin A. At the mean level of the samples reported here, it would take less than 50 g (2.5-3.5 tablespoons) to provide the adult daily need for vitamin A, which is 800-1000 retinol equivalents, or ug of retinol. It is often thought that the diets of native people are low in vitamin A if they do not consume carotene-rich vegetables

TABLE 2. *Three fat-soluble vitamins in* ooligan *grease*

Sample	Vitamin A[a]	Vitamin E[b]	Vitamin K[b]
	ug/g		
1	18.0, 18.7	232	7.5
2	29.2, 26.5	279	12.5
3	18.2, 18.3	148	13.5
4	16.5, 10.7	183	4.0
5	23.0, 19.5	259	11.0
Mean	21.0, 18.7	220	9.7

[a] Vitamin A was determined as retinol in two laboratories

[b] Vitamin E was determined as α-tocopherol and vitamin K as K_1 (see text)

and fruits or vitamin A containing fats such as butter or fortified margarine. It is clear from the data presented here that the use of *ooligan* grease as food or medicine, even if irregularly consumed, could provide most of the retinol needed. Since vitamin A is efficiently stored hepatically (Food and Nutrition Board 1980), there is every reason to believe that vitamin A deficiency would be unlikely to occur among people who regularly use *ooligan* grease.

The vitamin E levels found in these samples (148-279 ug/g) are considerably higher than those reported for fats from several uncooked finfish (McLaughlin and Weihrauch 1979). Since the entire body of the *ooligan* is used in the preparation process, higher amounts of tocopherol anticipated to be contained in the fish liver and other organs would also contribute to the tocopherol content of the final product.

At a mean level of 22 mg of α-tocopherol per 100 g of oil, it would take less than 3 tablespoons to meet dietary standards for adults. Ethnographic accounts indicate that one cup or more was consumed medicinally or at special ceremonies. Among those families who consume *ooligan* grease in Bella Coola today, it is the usual practice to have a few tablespoons at one meal during the day. Although vitamin E deficiency has been documented in B.C. Indians (Desai and Lee 1974), greater deficiency among inland-residents than coastal residents was reported. Our results indicate use of *ooligan* grease would be protective against vitamin E deficiency.

There is no dietary standard for vitamin K, although it is known that this nutrient is essential for efficient blood coagulation in humans (Food and Nutrition Board 1980). It is thought that most of that needed by humans is synthesized by intestinal bacteria; however, it has also been noted that the average mixed diet supplies 300-500 ug of vitamin K daily, primarily from plant sources (Olson 1973). Therefore, the vitamin K_1 reported here for *ooligan* grease (4-13.5 ug/g) would have a very minor influence on nutritional status for this nutrient. Vitamin K_1, phylloquinone, is usually found in plants, but is also stored in the liver of animals who consume plants. The origin of this nutrient in the *ooligans* is probably from sea algae, and it is rendered into the final product having been present in the liver of the fish or in intestinal algal residues.

Vitamin D content of these samples of ooligan grease has yet to be confirmed. To date, this vitamin was undetectable in the samples using the method of Thompson et al. (1982).

The composition of *ooligan* oil in comparison to other fats which are commonly used by native people in the Nuxalk community is given in Table 3. The saturated fats of

TABLE 3.–*Composition of* ooligan *grease in comparison to other fats (per 100 g)*[a]

	ooligan grease	pork lard	corn oil	margarine
Saturated Fat, %	32.3	39.2	12.7	13.2
Monounsaturated Fat, %	64.5	45.1	24.2	45.8
Polyunsaturated Fat, %	0.9	11.2	58.7	18.0
Vitamin A, RE	1,985	–	–	993[b]
Vitamin E as α-tocopherol, mg	22.0	1.2	14.2	12.9
Vitamin K as K_1, mg	1.0	–	–	–

[a] Values for marketed fats are primarily from Reeves and Weihrauch (1979).

[b] from Health and Welfare Canada (1979).

ooligan oil are similar to lard and higher than that present in corn oil and corn oil margarine. The total unsaturated fat, that is the combined monounsaturated and polyunsaturated fats, of *ooligan* grease is similar to that of corn oil. There is no doubt about the superiority of *ooligan* grease in providing vitamin A, E, and K in comparison to the other three fats.

Today native families often use marketed fats such as lard and margarine in food preparation, and it is reasonable to assume that these have replaced *ooligan* grease as the major dietary fat. This is further implicated by the extent of village *ooligan* grease preparation in comparison to former days. As previously stated, in 1981 there were five ripening fish bins yielding in the vicinity of 500 gallons of oil for use by a community of about 600 people. In 1982, there were four *ooligan* ripening bins on the north bank of the Bella Coola River. In contrast, the contemporary Nuxalk elders recall that it was usual to have eight or ten different family preparations of ooligan grease each spring, and that everyone would use it as a regular food. Unfortunately, percapita consumption cannot be calculated since population records were not kept, and in addition, it is common knowledge that the grease was a favorite trade item to neighboring groups in exchange for other foods or household goods. Nevertheless, it is quite clear that current practice is that only about half of the Nuxalk people use *ooligan* grease today, and that marketed fats are used frequently.

In conclusion, *ooligan* grease is a nutrient-rich food fat that is used less today than it was formerly. It continues to be obtained with ingenious low-cost native technology from local resources. Although the labor required for fish harvesting and grease preparation is considerable, this food has been the object of much cultural activity and is still highly appreciated by many native people of Coastal British Columbia.

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USE OF WILD CHERRY PITS AS FOOD BY THE CALIFORNIA INDIANS

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ABSTRACT.–Central and southern California Indians prized the fruit of Holly-Leaved Cherry, *Prunus ilicifolia* (Nutt.) Walp. [Rosaceae], much more for its seed kernel or pit than for the surrounding fleshy pulp. A survey is made of *Prunus* pit consumption by various California groups, and preparation methods are described. Though these pits contain poisonous hydrocyanic acid, it is shown that native people recognized the danger and, through proper treatment, were able to produce a safe and desirable food. Subsistence, social, economic and ritual roles of *Prunus* pits in California Indian life are discussed, followed by comments on changes in recent times.

INTRODUCTION

The genus *Prunus*, a member of the Rose Family [Rosaceae], contains a number of our cultivated fruit trees: plum, peach, apricot, almond and cherry. There are several wild shrubs in the same genus which are native to California, and it is not surprising that the fruits of these were eaten by the indigenous peoples. What is surprising is that in some areas the pits were eaten, for they contain potentially dangerous levels of cyanide. This paper discusses these wild *Prunus* pit foods in California, the methods of dealing with their toxicity, and the roles they played in California Indian life.

NATIVE SPECIES AND THEIR USE

Prunus *in California*

There are seven species of *Prunus* indigenous to California. The following brief descriptions, summarized from Munz and Keck (1959), emphasize distribution, plant size and nature of fruit; season of ripening is not given but can be estimated from flowering times.

P. emarginata. Bitter Cherry. Mountains throughout California from San Diego County north, elevations up to 2700 m; in Yellow Pine and Red Fir Forests and Chaparral. Shrub to small tree, 1-6 m high. Drupe red, bitter, 6-8 mm diameter. Flowers April to May.

P. subcordata. Sierra Plum. Coast Ranges from Santa Cruz Mountains north, and Sierra Nevada from Kern and Tulare Counties north to Modoc County, elevations below 1800 m; Yellow Pine Forest. Shrub to small tree, 1-6 m high. Fruit 1.5-2 cm long, red-purple, edible. Flowers March to May.

P. fremontii. Desert Apricot. Colorado Desert from Palm Springs south to Baja California. Shrub to small tree, 1.5-4 m tall. Fruit yellowish, hairy, 8-14 mm long, dry. Flowers February to March.

P. andersonii. Desert Peach. East side of the Sierra Nevada from Kern and Inyo Counties north, 1100-2700 m elevation. Shrub 1-2 m tall. Fruit 12 mm long, hairy, with thin, dry pulp. Flowers March to April.

P. fasciculata. Desert Almond. Mojave and Colorado Deserts at 750-2000 m elevation; variety *punctata* occurs in Santa Barbara and San Luis Obispo Counties. Shrub 1-3 m tall. Fruit dry, hairy, 8-12 mm long. Flowers March to May.

P. virginiana var. *demissa.* Western Chokecherry. Coast Ranges and Sierra Nevada, below 2500 m; Yellow Pine Forest, Chaparral, Foothill Woodland. Shrub or small tree, 1-5 m high. Fruit 5-6 mm across, dark red, bitter but edible, especially late in the season. Black-fruited variety *melanocarpa* occurs in northernmost California. Flowers May to June.

P. ilicifolia. Holly-Leaved Cherry, Islay. Coast Ranges from Napa County south to Baja California, Santa Catalina and San Clemente Islands. Similar-appearing Catalina Cherry, subsp. *lyonii*, is restricted to the Channel Islands of Anacapa, Santa Cruz, Santa Rosa, Santa Catalina and San Clemente (Smith 1976:164); below 1500 m in Chaparral and Foothill Woodland. Shrub or small tree, 1-8 m tall. Fruit red (rarely yellow), 12-15 mm long, with thin, sweetish pulp. Catalina Cherry fruit is darker and larger, 12-24 mm long. Flowers April to May.

Distribution of Prunus *Foods*

Fruit. – The fruit of all these wild *Prunus* species is characterized by having a large stone and relatively little pulp. What pulp there is is often rather dry. Nonetheless, Indian peoples throughout the state did make use of this fruit pulp, and many are stated to have prized it as a food source. The Cahuilla were fond of Desert Peach (Bean and Saubel 1972:119); the Mendocino County Indians relished Sierra Plum and made long trips to get it since it was not common in their region (Chesnut 1902:356). The species most used for fruit appear to have been Sierra Plum, Western Chokecherry and Islay. The fruit was usually eaten fresh from the trees, but it was sometimes dried and stored for later use (Bean and Saubel 1972:119-121; Chesnut 1902:356; Barrett and Gifford 1933:162; Zigmond 1981:54; Harrington, n.d.). The Luiseño preferred to let the fruit sit for a few days before eating it, to improve the taste (Sparkman 1908:194, 232).

Pits. – Some groups, particularly those in central and southern California, preferred to throw the fruit pulp away and eat the pits.

To find out which groups made significant use of *Prunus* pits for food, a survey was made of Culture Element Distribution lists (C.E.D.) compiled for California in the 1930s and 1940s. These lists vary widely in the degree of detail they provide. Usually, plants are merely described as "eaten", without specifying the exact part used or the method of preparation. A further difficulty is that botanical names are rarely included in this type of anthropological literature, and common names are often incorrectly applied. Nonetheless, C.E.D. lists can still give some indications of traits important in a cultural group. Other ethnographic sources were also checked where they were available.

Though *Prunus* fruit was eaten in many areas, there is virtually no evidence of use of pits in northeastern California (Voegelin 1942; Beals 1933; Gifford and Klimek 1936), central Sierra (Aginsky 1941; Barrett and Gifford 1933; Gayton 1948a, 1948b), southern Sierra (Driver 1937a; Gayton 1948a; 1948b; Voegelin 1938; Zigmond 1981), northwestern California (Driver 1937b; Curtin 1957; Foster 1944; Schenck and Gifford 1952), or Round Valley (Essene 1942; Chesnut 1902; Goodrich et al. 1980). Some groups, such as the Maidu (Hill 1972), Shastan (Silver 1978), Northern Paiute (Kelly 1932), Atsugewi (Garth 1953), and Yana (Elsasser 1981), may have made flour of the fruit pulp or mashed whole *Prunus* fruit, seeds and all, but most of this information is ambiguous. Great Basin and Plateau groups did make a pemmican-like food of mashed *Prunus* fruit and seeds (Stewart 1940; Ray 1942), and this practice may have extended slightly into northeastern California. In addition, one northern Pomo consultant said "wild plums" – presumably *Prunus* pits – were stored in grass-lined pits indoors, but this was not mentioned by other Pomo, and no further information was given (Gifford and Kroeber 1937:181).

In contrast to the rest of the state where evidence is scanty, in the central coast and southern California every tribe is listed as preparing "wild plum seed meal" (Harrington 1942; Drucker 1937). This concentration of *Prunus* pit foods seems rather curious until it is compared with the distribution of the seven *Prunus* species in California.

The practice of making "wild plum seed meal" coincides quite closely with the range of Holly-Leaved Cherry or Islay, *Prunus ilicifolia*, as shown in Figure 1. The name "Islay" is a Hispanicized version of *slay'*, the Salinan word for the plant, and is the common name historically used by most Indian people to refer to the plant, the fruit, and the food made from the pits (Harrington 1944:38). This species was used by all peoples within its range south of San Francisco Bay. It is the only one which was consistently specified as being sought for its kernel or pit everywhere it occurs. Although some groups like the Cahuilla (Bean 1972; Bean and Saubel 1972) used other species as well, *P. ilicifolia* was

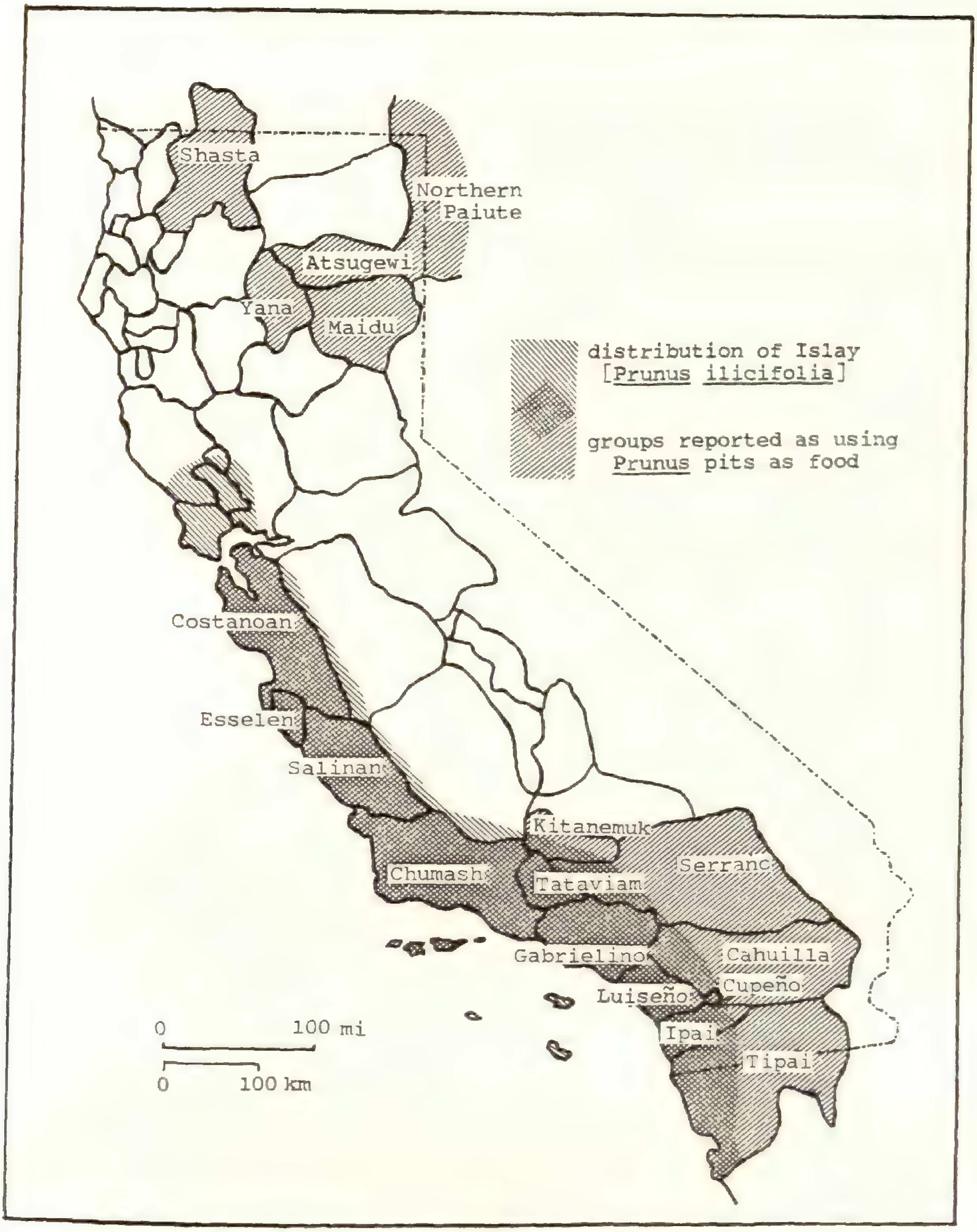

FIG. 1–Comparison of *Prunus ilicifolia* range with consumption of *Prunus* spp. pits by California Indian groups. Northern California tribes outside the range of *P. ilicifolia* may have used *P. subcordata* and *P. virginiana* var. *demissa*. Other species were available but not used.

the most important one for pit exploitation. Thus, "wild cherry pit meal" would be a more appropriate designation than "wild plum seed meal."

Prunus *Pit Preparation*

Methods of preparing foods from the seeds of *Prunus* will now be described as they were practiced by each tribe within the range of *P. ilicifolia*. These methods are briefly

TABLE 1.—*Patterns of* Prunus *pit preparation on the central coast and in southern California.*

Tribe	Leached	Roasted	Mush	Cakes*
Costanoan	(–)	+		(+)
Salinan				+
Esselen				(+)
Chumash	(–)			+
Tataviam				
Kitanemuk	+			+
Serrano	+			
Gabrielino	(+)		(+)	
Luiseño	+		+	
Cahuilla	+	(+)	+	+
Cupeño	+			
Ipai	+	+	(+)	+
Tipai	+		+	(+)

*"Cakes" includes balls, patties, "tamales," "tortillas"

\+ stated as present by at least one source
(+) probably present
(–) probably not present
blank space indicates lack of information

summarized in Table 1. No information was encountered for Patwin, Wappo, Pomo or Coast Miwok, all at the northernmost end of the range of Islay.

Costanoan. – Seeds of the Islay, or Holly-leaf Cherry *(Prunus ilicifolia)* were ground to produce a meal that was eaten (Levy 1978b:491). Details are provided in the ethnographic notes of John P. Harrington (n.d.), now being prepared for publication by Barbara Bocek of Stanford University. The Islay pits were heated in warm water to remove the clinging fruit pulp, following which they were dried for a while, then opened by hitting with a stone. At this point the two consultants disagreed: one said the shelled pits were further dried and then eaten with no additional preparation; the other said the kernels were put in water, sugar added to sweeten[1], then roasted overnight in a grass-lined hole. They could then be eaten, or one could "take them to people." The taste was compared to that of beans or chestnuts. No mention was made of the form of the final product–bread, mush, or cakes–or of storage, although the fruit was apparently gathered in some quantity. Isabel Meadows, Harrington's primary Rumsen consultant, told him that the term "Islay" did not include Western Chokecherry, *P. virginiana* var. *demissa* as identified from specimens. She also said that the fruit of this latter species was eaten but that the pits were not (Bocek, pers. comm.).

Esselen. – "Cherry stones" were given as an item of the diet (Hester 1978:497). No further details were found, but the method was probably similar to that of the Salinans.

Salinan. – As noted, the common name Islay is a Salinan loan word. According to early Spanish explorer Fages, an item of Salinan diet was "a fruit like a red plum or cherry, from the seed or pit of which, with its surrounding substance they make good tamales. They call it *yslay,* and they eat the little meat which the pit contains" (Priestley 1937:59). Mason (1912:121) refers to "chuckberries" being eaten; this may refer to chokecherries, but no preparation method is given.

Chumash. – The diarist of the 1542 Cabrillo voyage recorded that the Indians of the Santa Barbara Channel made "tamales" of a white seed the size of maize; these were good food (Bolton 1925:30). When the fruit pulp is removed, the shells of the Islay pits fit this description. Other observers indicated that Islay was still being used as a food as late as the 1890s; they said it was ground, cooked, and made into balls which were esteemed highly (Caballeria y Collell 1892:17-18; Bard 1894:4).

While other authors merely mention that the Chumash ate Islay pits (Orr 1943; Grant 1978), Harrington's unpublished field notes provide considerable detail about the exact preparation methods they followed. These notes form the substance of a major Chumash ethnobotanical study by the present author, to be published at a later time.

Harrington's principal Ventureño Chumash consultant, Fernando Librado, commented that the Chumash ate the fruit, but that the kernel was the "really esteemed" part of the Islay. The fruit was gathered by hand, picking into a large bag hung around the neck. It was piled up until the pulp rotted, then the pulp and skin were rubbed off and the shells cracked open. Another consultant said that the pits were first boiled "until done," then allowed to sit overnight before cracking. After the kernels were removed, they could be used right away or stored for later use in a big basket in the house.

Leaching was mentioned by only two consultants in the Chumash area, and they disagreed on the method used. Fernando Cardenas, a non-Chumash man of Santa Ynez, said the whole kernels were placed in a sack and repeatedly dipped into hot water, then ground into meal (Saunders 1934:59). Harrington's last Barbareño Chumash consultant, Mary Yee, said the Islay was leached after it was "mashed" [=ground?] by letting water run through it in a basket in the creek. Neither of these methods is the same as that used by the Chumash for leaching acorn meal, which was usually done in a twined tray. None of Harrington's older consultants, who had been living in an earlier time when Islay was being prepared regularly, mentioned any leaching process. If the Chumash did leach Islay, they probably followed the method used by the Kitanemuk, described below.

To cook, the Islay was boiled for a long time–one person said three hours–in a stone olla. Acorn mush, by contrast, was cooked in baskets with heated stones. After it was cooked, the Islay was mashed like beans using a wooden paddle-like implement, and molded into cakes or balls which were sometimes rolled in pinole flour (Timbrook 1980:277). All of the Chumash consultants mentioned these balls; apparently Islay was eaten only in this form, never as mush. If a person had been gathering Islay a long way from home, the entire preparation process could be done in the field, but it was more usual to do it at home.

The finished Islay balls were arranged on a tray ready for eating; they could be kept for a week or more. Chumash consultants compared the taste to beans, as the Costanoans did, and commented that they liked it very much. Most indicated that Islay was usually eaten as an accompaniment to meat such as baked gopher or squirrel.

Of the plant specimens collected by Harrington's Chumash consultants, all of those labeled as Islay were *Prunus ilicifolia* (Fig. 2). This is by far the most common species in Chumash territory. Obispeño Chumash Rosario Cooper mentioned gathering two kinds, but no corresponding specimens are extant, and there is no evidence that the Chumash used more than one species in the manner described. Cooper may have meant green and ripe Islay fruit, which were segregated by the Kitanemuk (see below).

Tataviam. – Very little published information is available about this group. "Berries of Islay *(Prunus ilicifolia)*" have been listed as the fifth most important vegetable food for the Tataviam, after yucca, acorns, sage seeds and juniper berries (King and Blackburn 1978:536). This inference was drawn from Harrington's (n.d.) notes on the Kitanemuk, Gabrielino, Chumash and San Bernardino Mountain Serrano; presumably the Tataviam were like these neighboring groups in making more use of the Islay pits than of the fruit itself. No information is given on preparation.

Kitanemuk. – Once again the major source of information is Harrington's (n.d.)

FIG. 2–Specimen of *Prunus ilicifolia* collected and labeled by Harrington's Barbareño Chumash consultant Lucrecia Garcia, ca. 1928. Photo courtesy of the National Anthropological Archives, Smithsonian Institution.

field notes. Tejon area consultants said that only the ripe and sweet islay fruits were chosen for eating fresh, as some were not sweet. Usually they threw the pulp away, for the kernel was the really esteemed part of the Islay [a phrase also used in Harrington's Chumash notes].

They would begin picking the Islay when it was still green and keep on until after it ripened, and even pick it up off the ground. They picked the fruit by hand but never beat the tree or hit it with a stick, for it was considered to be delicate. They kept the green and the ripe, including fallen, fruit in separate piles; the shells of the green Islay were used at a later stage of preparation. The fruit was brought home and piled on a swept dirt floor in the house for several days until the pulp rotted. It was then washed off in the creek by rubbing it between the hands.

For the initial preparation stage, water was heated in baskets with hot stones and either poured over the Islay or the Islay put into the water. The water was not boiling, and the Islay remained in it only a short time, about ten minutes. Then someone would break open a pit and pinch the kernel to see if it was "done." The water was poured off and the pits spread in the sun to dry for two or three days. The shells were cracked by rolling on a metate with a stone held horizontally in both hands[2] and the hulls removed from the kernels.

At this point the shells of the green Islay, which had been kept separate, were burned and the ashes moistened to make a dough which was molded into cakes like soap. The kernels of both the red and green Islay were mixed together after this. Only the green fruit shells were used to make the ash cakes. The shelled kernels were stored in sacks or in big storage baskets to keep them for winter use.

The Islay kernels were cooked in an olla with water, which was changed two or three times during the cooking process. One consultant said the kernels were boiled for awhile before the water was poured off, but another said the water was poured off before it boiled. New cold or lukewarm water was added, heated and changed twice when the kernels were old, and three times when they were new because the latter were more bitter. This changing of water was thus both a cooking and a leaching process.

Following this leaching stage, hot or cold water was added and the kernels boiled until done. This was said to take a long time, from morning till afternoon, for the kernels were very hard. While the pot of Islay was boiling, an amount of the prepared ash cake equal to the last joint of two fingers was added to the pot so the Islay would not be bitter; this was added only to Islay, not to any other food[3]. One consultant said they added no salt or anything to the Islay, indicating that different cooks had somewhat different recipes.

When the Islay was done and the water had almost all cooked away, it was mashed in the cooking olla and molded into little balls the size of biscuits. They were reddish colored like beans. The balls were put into a tray and would keep about three days without souring. They were considered fine to eat with roasted meat.

Kitanemuk consultants knew nothing of there being two kinds of Islay, which had been mentioned by the Obispeño Chumash woman; "when ripe there are many kinds, white, black, purplish, etc., but it is all Islay" (Harrington, n.d.). It is not known whether Harrington obtained voucher specimens for this area, or whether other species in addition to *P. ilicifolia* were prepared in a similar way.

Serrano. – The Culture Element Distribution indicates that the Serrano made "wild plum seed meal" and that the seeds were leached whole (Drucker 1937:9). Further details are no doubt to be found in Harrington's notes, now being studied by Michael Lerch of the San Bernardino County Museum.

Gabrielino. – Both Gabrielino and Fernandeño are listed as having made wild plum seed meal (Harrington 1942:8). Johnston (1962:33) notes that "the pits of the wild plum bushes yielded a good seed for grinding into meal. In fact the native fruits were more useful in this fashion than for their pulp, which was often rather sour and dry." At present the species of this "wild plum" is unknown, although perhaps later investigation of Harrington's notes and specimens will be revealing.

Luiseño. – Hollyleaf Cherry or "Islaya" *(P. ilicifolia)* was one of many types of seeds used by the Luiseño, and was formerly an important article of diet in some parts of their territory (Bean and Shipek 1978:552; Sparkman 1908:194). The pulp of the fruit was eaten, but the kernel was the principal part used. The fruit was spread in the sun until thoroughly dried, when the shells were cracked and the kernels extracted. These were ground into flour which was leached and cooked in exactly the same manner as acorn meal: leached in a basket or sand basin with hot or warm water, cooked in a pottery vessel into a mush which was eaten cold (Sparkman 1908:193-194). Some

Luiseño groups leached the seeds whole (Drucker 1937:9). Chokecherry fruits were eaten, but the pits were apprarently not used (Sparkman 1908:194, 232).

Cahuilla. – The kernel of Islay, *P. ilicifolia,* was used much more than the fruit pulp. These "plums" were gathered in large quantities in August and spread in the sun until the pulp was thoroughly dried. The shells of the pits were then broken open and the kernels extracted. These were crushed in mortars, leached in sand basins, and boiled into mush (Barrows 1900:60-61). At least one Cahuilla group was said to leach the seeds whole, before preparing the meal (Drucker 1937:9). The ground meal was sometimes made into a tortilla-like food (Bean and Saubel 1972:120), reminiscent of the "tamales" of the Salinans or the Chumash and Kitanemuk Islay balls.

The pits of Western Chokecherry, and possibly also Desert Apricot and Desert Peach, were ground into a meal and prepared in the same way (Bean 1972:43; Bean and Saubel 1972:119-121). This is one of a very few instances where the use of *Prunus* pits is explicitly ascribed to any species other than *P. ilicifolia,* though all species were used for their fruit.

These fruits were gathered by women. The plants are often found near villages and acorn gathering sites. It has been speculated that *Prunus* fruits may have been sought during the acorn harvest (Bean and Saubel 1972:120), but Islay ripens as much as two months earlier, so this is doubtful.

Cupeño. – The Cupeño made "wild plum seed meal" and leached the seeds whole (Drucker 1937:9). They were observed soaking acorns and "plum seeds" in Warner's Hot Springs to leach them (Bean and Saubel 1972:128). No further information was found.

Ipai/Tipai (Diegueño). – Two species of "plum" and three of "cherry" were gathered (Luomala 1978:600). These may have been, respectively, Desert Peach and Desert Apricot [plums] and Chokecherry, Bitter Cherry and Islay [cherries] ; but there is no ethnographic documentation of Kumeyaay [=Tipai] use of pits of species other than *P. ilicifolia* (Hedges 1980:132). Bitter seeds like those of plums were treated like acorns: pounded in a bedrock mortar, sifted, and leached. Seed flours in general were made into mush, cakes, and stews with vegetables (Luomala 1978:600). All Diegueño groups were listed as leaching the seeds of "wild plum" after grinding (Drucker 1937:9).

The Santa Ysabel Ipai ate the fresh fruit of *P. ilicifolia.* The large seed was then cracked, the kernel extracted and pounded in a mortar, and the meal made into patties and roasted (Hedges 1967:34). Leaching is not mentioned here. The roasted patties may be similar to the Cahuilla tortilla-like food made from Islay.

The Southern Diegueño [=Tipai] also used "wild plum" seeds, probably Hollyleaf Cherry (Hedges 1980:131). These were cracked with a mano and metate. The meats were spread in the sun to dry, then rubbed between the hands and tossed in a coiled basket to remove the hulls. After grinding in a rock mortar, they were leached in a basket like acorns, but with only cold water. They were then cooked into a mush in a pot directly on the fire (Spier 1923:334-335). Clan ownership of patches of wild plum trees has been reported in Tipai territory (Spier 1923:307).

The Tipai of Baja California continue to use *P. ilicifolia* seeds even to the present day. The outside pulp is eaten and then the seeds are broken and ground up, and the inner meat is leached [and cooked?] to make a mush. Consultants say it is a harsh food, does not taste very good, and gives them a stomach ache if they have to eat it regularly. But it forms a staple when families are too poor to buy food (Hinton 1975: 217-218).

Historical Sources. – It was noted that Spanish explorers described Salinan and Chumash as making "tamales" of a seed which could only be Islay, *P. ilicifolia.* Natural historian Longinos Martinez wrote in 1792: "The [seeds] most commonly consumed by the gentiles [unconverted Indians] of New California [include] a large seed they call *silao* which, although it is somewhat bitter, they wash, dry, and roast; it is one of their most important foods" (Simpson 1961:46). Surely this also refers to Islay.

The widespread importance of the food to the natives of California is also indicated in the *Diccionario de Mejicanismos*, translated: "Islay, *Prunus ilicifolia.* Tree of both Californias which produces a kernel, called by the same name, which the Indians gather and dry for food, first grinding and sifting it, although it is rather small" (Santamaria 1978:620).

TOXICITY OF *PRUNUS*

Islay, and possibly other *Prunus* species as well, were obviously important in California Indian life. Before considering the diverse roles played by this plant, the problem of its toxicity must be discussed. Several *Prunus* species contain the cyanogenic glycoside amygdalin, which reacts with hydrolyzing enzymes in plant tissue to form hydrocyanic acid [HCN] (Kingsbury 1964:23-26). This "cyanide" is often associated with a bitter taste and distinctive smell also noticeable in pits and leaves of domestic *Prunus* species. Indian consultants always commented on the bitter taste of *Prunus* fruits, recognized the fact that they could make one sick, and said that special preparation was necessary to avoid this. As one Chumash woman noted, "it is a trick to make the Islay. It is poisonous. If you don't know how to make it, it turns out bitter" (Harrington, n.d.).

Most studies of HCN toxicity in *Prunus* have been done on the leaves, because of the danger of livestock poisoning. Before anything definite can be said about its danger to humans, more work must be done on the fruit since that is the part people eat. Related cyanogenic glycosides are also found in cassava or manioc, an important root crop of the tropics which has been thoroughly studied (Lancaster et al. 1982). This plant may be assumed to be somewhat comparable in its toxicity, at least until *Prunus* seeds can be more thoroughly studied. In this section, native statements and practices will be compared with what is known of the toxic characteristics of *Prunus.*

Severe symptoms and even deaths are reported in ruminant animals that consumed *Prunus* leaves. However, human digestive systems are quite different so our symptoms would not necessarily be the same; humans are less susceptible than animals to cyanide poisoning (Kingsbury 1964:24-27). Native consultants [Chumash, Kitanemuk, Tipai and others] usually noted that Islay could give one stomach aches or cause one to spit up blood or poisonous phlegm. One Chumash said that when the Indians had tuberculosis they were spitting up blood, but they blamed it on the Islay (Harrington, n.d.). This indicates that people had been known to get quite ill from eating it.

Cyanide content of plants varies widely, depending both on environmental factors and on the plant part used. Environmental factors include climate, rainfall, soil fertility and season of the year, so that plants growing in different areas or even next to one another can have different amounts of toxins (Kingsbury 1964:26; Lancaster et al. 1982:15). The Cahuilla have another way of explaining this: a shaman was angered by his people so he caused a bitterness to enter the Islay fruits, and ever since then the fruit has been better in some areas than in others (Bean and Saubel 1972:120). The Kitanemuk selected the less bitter fruit to eat raw (Harrington n.d.); this practice was probably widespread.

Differences in HCN content are also found in different parts of the plant. In cassava, the peel has substantially higher content than the flesh of the same root (Lancaster et al. 1982:15). In *Prunus,* large tender leaves on vigorous new shoots have much more HCN than do the leaves on old woody growth (Kingsbury 1964:366). Consultants from several California groups warned against eating too much fresh Islay fruit, an indication it may have high HCN content.

Related to this is the volatility of the cyanide molecule. The HCN content is much lower in dried *Prunus* leaves than in fresh ones, the free cyanide having been lost in the drying process (Kingsbury 1964:366, 368). That this might be true of the fruit as well is indicated by the Luiseño practice of letting Chokecherries sit for a few days to improve the taste before eating them (Sparkman 1908:194). And the Kitanemuk changed the Islay leaching water three times for the more bitter new kernels, but only twice for old ones (Harrington, n.d.).

Cyanide is eliminated rapidly from the animal body; it is not dangerous if amounts consumed are small and spaced over a period of time (Kingsbury 1964:24, 25, 368). This too is reflected in native statements on *Prunus:* "It makes one very sick to eat lots of raw Islay, but not if one doesn't eat it like a hog" [Costanoan] ; "If you sit and eat much of the ripe Islay you can get sick" [Kitanemuk] (Harrington, n.d.).

In the case of cassava, most native preparation methods appear designed to bring about contact between the cyanogenic glycosides and the hydrolyzing enzymes which are also present. This is done by breaking the cell wall, for example by pounding or grating. The HCN is then eliminated by volatilization or by solution in water. Drying, boiling and steeping cassava were all found to remove the free cyanide rapidly and effectively (Lancaster et al. 1982:16).

These same methods—pounding, drying, steeping and boiling—were also elements of native Californian Islay preparation. In general the fruit was first piled up until the pulp rotted and could be discarded, then the pits were shelled and further dried. This drying, both before and after shelling, might contribute to natural HCN volatilization. The next step was usually grinding or pounding the kernels to meal, which would break down the cell structure and permit hydrolysis and volatilization of the cyanogenic glycoside molecules. Although leaching was not practiced by all groups, steeping the kernels in several changes of water or pouring water through the ground meal would put more of the free cyanide into solution and carry it away. Finally, cooking the Islay would remove more cyanide. Although the glycoside amygdalin in *Prunus* is not identical to the linaramin and lotaustralin in cassava, the above preparation methods could well be a factor in the edibility of both potentially dangerous plants.

The technology for exploitation of poisonous, tannin-rich acorns has an antiquity of at least 5000 years in California (Harrison and Harrison 1966:77). Perhaps leaching techniques were developed first for acorns and then extended to other large seeds like *Prunus* and the even more poisonous Buckeye *(Aesculus californica).* It has already been noted that many California groups, especially the southern ones, prepared Islay in the same manner as they did acorns.

In summary: despite the lack of much available information on the toxic effects of HCN in *Prunus* pits, several things are clear. People ate these pits and even enjoyed them. The bitter taste and poisonous properties vary widely with environmental conditions and seem to have been dealt with effectively by preparation methods of the Native Californians.

IMPORTANCE OF ISLAY IN CALIFORNIA INDIAN LIFE

Seeds of Islay *(Prunus ilicifolia)* and possibly other species were a staple food of Indian groups along the central coast and southern California. Chumash consultants frequently mentioned Islay in the same breath as acorns and Chia, their two other most important foods. Islay pit foods seem to have occupied a place in the meal similar to that of acorns, usually being eaten as an accompaniment to meat.

The importance of certain foods in peoples' lives is revealed in their oral tradition. When animals were people, in a time before humans appeared on earth, they had many human characteristics and engaged in many of the same activities that the Indians themselves later did. Islay is included among major plant foods in Chumash myths. In one story, Coyote was stronger than his opponent in a battle because he had had a good breakfast of meat and *shukuyash,* Islay balls (Blackburn 1975:216). In another story, Coyote demanded supper from Widow Toad, and she gave him acorn mush and Islay followed by two freshly caught birds (Ibid.:227). There are many other examples.

Diversity of food resources characterized native Californian life, but in many areas "failure of the acorn crop was the most dreaded disaster" (Loeb 1926:175). Storage and trade of foodstuffs helped to avert seasonal and local shortages. Islay was gathered in late summer or fall; most groups shelled and dried the kernels and stored them for later use. While Islay was usually less abundant and less concentrated than acorns, it could have been especially important in poor acorn years. More northern groups considered Buckeye as starvation food when acorns were unavailable (Levy 1978a:402). Islay could have filled this role in the south, although most native consultants said they enjoyed eating it any time.

Nutritional analyses of *Prunus* kernels are few, since the pits have usually been considered poisonous. However, one study (Earle and Jones 1962) indicated that seeds of an unnamed *Prunus* species have 33.4% protein and 43.3% oil by dry weight. These quantities are greater than the highest value for acorns, and well over double the average value for acorns. There is probably some variation between species, but the Rose Family as a whole ranks higher than acorns in protein and oil. In contrast to acorns, *Prunus* seeds were found to contain virtually no starch.

Although processing and cooking might change nutrient value, the above analysis indicates that Islay pits probably have high food value. Being very high in protein and oil but low in starch, Islay would thus play a different role in nutrition from that of acorns, even though the two were eaten in the same context within the meal. Quality of Islay protein and oil should be analyzed and eating practices further studied before conclusions can be drawn.

But the role of "wild plum seeds" in central and southern California Indian life cannot be fully understood if they are merely seen as a more or less nutritious, storable resource that was eaten like acorns. Islay pits were also important in many less immediately material ways.

One of these functions was social. Costanoans prepared Islay foods which could be taken to people (Harrington, n.d.), presumably as a gift or friendly gesture. A similar function can be attributed to the Chumash and Kitanemuk Islay balls, which kept well and would be easy to carry to others or to have readily available to offer to visitors. The importance of sharing food is well known. Simple hospitality also imposes an obligation, however subtle, upon the recipient to return the favor at a later date. In this way a person who once gave food could be more assured of being able to get food in times of scarcity. Barbareño Chumash Luisa Ygnacio told Harrington (n.d.) how to say, "Give me a piece or cake of boiled Islay," a phrase which would stand a visitor in good stead.

Large-scale, organized economic exchange between groups functions to distribute goods, including food, more evenly in space as well as in time. This sort of trade was very important to many California Indian groups, and trading was most intensive between peoples who lived in different habitats. The inhabitants of the Northern Channel Islands, for example, were great traders. According to mainland Chumash consultants, the islanders had Islay and Chia but they were lazy and did not bother to gather them. They spent their whole time drilling shell-bead money, which they traded to the mainlanders for large quantities of Islay, Chia and acorns. The basket hat was the standard for measuring seeds for purchase; one hatful of Islay was worth two of acorns (Harrington, n.d.; King 1971).

Although the island Chumash probably did in fact gather some local *Prunus*, manufacturing specialization is often found in areas where food resources are not concentrated or not reliable. It was important for the islanders to make money to keep the trade networks operating, so that they could count on having access to staple plant foods in the event of a shortage on the islands. The population of the Santa Barbara Channel area was extremely high, and it was sustained largely by trade. Islay played a prominent role in this economic activity.

Major ceremonial gatherings which drew people from over a wide area were often the context for trade (Blackburn 1976). Among the Chumash, Islay was one of the foods that people brought whenever there was to be a festival or ceremonial gathering. It was given as offerings or obligatory ritual gifts, scattered on the ground before the dancers, or thrown over the assembled crowd of onlookers, either in the form of shelled dried kernels, or as cakes prepared in advance. Offerings of Islay, Chia and other seeds were made at the fall harvest and winter solstice ceremonies (Hudson et al. 1977; Hudson et al. 1978:141).

Collections were also taken at Chumash secular dances, one of the most interesting of which was the Fox Dance. As the Fox Dancer was performing, the singer sang in the Santa Rosa Island language that the Fox would desire to eat balls of cooked Islay. At this point, the ceremonial leader would begin to carry around a big burden basket and collect Islay and other things from the people (Hudson et al. 1977:71). Foodstuffs thus otained would be saved by the local chief to distribute to his people in times of need. Similar practices were probably followed by other California groups as well.

Islay and other food items like acorns and Chia that played a role in ceremonial situations were therefore more than just food. They were of symbolic importance and constituted a sacrifice or contribution made by each person toward the welfare of the whole group. This contribution was perceived in a religious way. Because of the power that Sun and other supernaturals had over human life, prayers, rituals, sacrifices and offerings of food were essential to human survival (Hudson et al. 1977).

Throughout California, "first fruits ceremonies" were held for major resources such as salmon and acorns (see C.E.D. lists already cited). This was apparently not done for *Prunus,* although the Chumash, and probably others, held harvest ceremonies at the end of the season (Hudson et al. 1977:43). Santa Ynez Chumash families would go at different times to gather Islay on a local ranch. They built fires "to keep the bears away," and met at night for singing, dancing and praying. Similar special ritual behavior associated with food gathering was also described for piñon nuts (Harrington, n.d.). It is probable that these practices were intended to thank the earth, *khutash,* for the harvest.

Prayers were addressed to plants of extreme religious importance, such as *Datura,* before gathering them (Applegate 1975:10). There is no indication that *Prunus* was such a plant, but its potential spiritual power for Native Californians is shown by the fact that Islay could become one's dream helper, as has been reported among the Kumeyaay [=Tipai] (Hedges, pers. comm.).

Change

Beginning with missionization in the 18th century, life for central and southern California Indians changed dramatically. Restricted mobility and dependence on mission agriculture encouraged conversion to the white man's diet, but many people continued to gather their favorite wild foods whenever possible. Despite population decline and acculturation, some individuals still used Islay after 1900. But native consumption of such wild plant staples has virtually died out in this century for several reasons (Cook 1941). Plants are less accessible due to private ownership of property, and much land has been cleared for suburban development. One Costanoan sadly described having her "orchard" taken away from her when a house was built next to some big Islay trees she used to harvest (Harrington, n.d.). Another factor is that Indian people who hold regular jobs lack time to gather and prepare traditional foods. And the dominant culture has imposed social sanctions against "Indian food," reducing the motivation to continue its use.

On the Santa Ynez Reservation, most of the old traditional seed foods fell into disuse when the last generation of Chumash language speakers died (Gardner 1965:285-286). People living on the reservation now seem to have no recollection of the Islay kernel balls which their ancestors so relished, and which once played a multifaceted role in Indian life. Although food is an important way of asserting one's cultural identity, it is unlikely that the new generation of activists will revive the difficult process of Islay preparation.

Abandonment of traditional foods is true of surviving California Indian people in other areas as well. Even the Cahuilla, some of whom occasionally eat native foods for variety, no longer prepare Islay pits (Bean and Saubel 1972:25-26). The only people who still eat *Prunus* seeds appear to be the Tipai of Baja California, and they do so only to stave off starvation when they cannot afford to buy store food (Hinton 1975:217-218). Soon Islay mush, balls and cakes will be forgotten altogether.

SUMMARY AND CONCLUSIONS

It has been the purpose of this paper to draw attention to a food which was formerly of great importance to Indian peoples over a large section of California. Although potentially poisonous, the kernel of *Prunus ilicifolia*—called Holly-Leaved Cherry, Islay, or "wild plum seed"—was rendered safe to eat by native preparation methods, and it was even considered delicious. This food was a staple for many Indian groups, providing variety in taste and nutrient content from the more famous acorn.

It was also stressed that food is more than just something to eat. It is a focus for social interaction, brings wealth to its providers, and gives one a better relationship with the supernatural. It is also a statement of cultural identity. Though unnoticed by most people today, the humble wild cherry pit once did all these things.

ACKNOWLEDGEMENTS

I am most grateful to Elaine Mills of the National Anthropological Archives for assistance in my study of the John P. Harrington notes and specimens, and to Barbara Bocek and Ken Hedges for providing data on Costanoan and Kumeyaay, respectively. A shorter version of this paper was presented at the Fifth Ethnobiology Conference in San Diego, April, 1982.

NOTES

[1] Sugar was introduced in mission times, but there was a widely used native sweetener: honeydew deposited by aphids on certain grasses (see, e.g., Voegelin 1938:19).

[2] The two-handed mano, operated with a rolling motion on a flat metate, may have been introduced by Mexicans. The aboriginal form was probably a smaller, one-hand mano used on a basin milling stone.

[3] An analogous practice was followed by the Miwok, who used oak bark ashes to "sweeten" acorn bread (Barrett and Gifford 1933:38).

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NEWS AND COMMENTS

SIXTH ANNUAL ETHNOBIOLOGY CONFERENCE

The sixth annual Ethnobiology Conference will be held at the University of Oklahoma in Norman. Papers will be presented during morning and afternoon sessions on March 18-19, 1983, with a reception on the evening of March 17. The conference banquet is scheduled for Friday evening, March 18. A CALL FOR PAPERS AND REGISTRATION FORMS WILL BE MAILED IN MID-DECEMBER. Sponsoring units within the University are the Department of Anthropology, the Department of Botany and Microbiology/Bebb Herbarium, the Stovall Museum, and the Oklahoma Archaeological Survey. For further information, contact:

Dr. Paul E. Minnis, Department of Anthropology
455 West Lindsey, Room 521, University of Oklahoma
Norman, OK 73019 / (405) 325-3261

SOCIETY FOR ECONOMIC BOTANY

The Society for Economic Botany will hold its 24th annual meeting at Miami University, Oxford, Ohio, June 13-15, 1983. This year's symposium will deal with ETHNOBOTANY IN THE NEOTROPICS. Information on the meeting can be obtained from Dr. Charles Heimsch, Botany, Miami University, Oxford, Ohio 45056 or Dr. Hardy Eshbaugh, Systematic Biology Program, National Science Foundation, Washington, D.C. 20550. Those wishing to contribute papers should contact Dr. Gregory Anderson, Biological Sciences Group, University of Connecticut, Storrs, CT 06268.

MELVILLE AND ELIZABETH JACOBS RESEARCH FUND

Whatcom Museum Foundation

The Melville and Elizabeth Jacobs Research Fund invites applications for small individual grants to support research on Native American cultures primarily of northwestern North America. The fund is designed to facilitate field research rather than analysis of previously collected materials. Appropriate are field studies of any aspect of culture and society, with emphasis on expressive, conceptual, and purely linguistic systems. (Projects in archaeology, physical anthropology, urban anthropology, and applied anthropology or applied linguistics will not be funded). Awards range from $200 to approximately $800; salary cannot be supplied, and only minimum living expenses can be considered. For further information and application forms, contact the Melville and Elizabeth Jacobs Research Fund, Whatcom Museum of History and Art, 121 Prospect St., Bellingham, Washington 98225. Application deadline is February 15, 1983.

CEPAF

The Universidade Federal do Maranhão, São Luís, Maranhão (Brazil) has just announced the formation of the Centro de Pesquisas Antropológicas e Folclóricas (CEPAF). The Center will initially operate in conjunction with the Departmento de Biologia of the University.

CEPAF will serve to stimulate and coordinate research in folklore and anthropology in Maranhão and the region. Particular emphasis will be given to ethnoecology and related studies (ethnobotany, ethnozoology, ethnoentomology, etc.). Plans also include collection of general folkloric materials and study of culture change in the soon-to-be industrialized São Luís area.

Anyone interested in assisting with the formation of CEPAF or desiring additional information should contact:

Dr. Darrell A. Posey, Director
Centro de Pesquisas Antropológicas e Folclóricas
Departmento de Biologia, Universidade Federal do Maranhão
65,000 São Luís, Maranhão (Brasil)

ETHNOBIOLOGY IN THE NEWS

Ethnobiology is newsworthy. I am impressed by the frequency of reports of ethnobiological interest in my own daily newspaper, the *Seattle Post-Intelligencer,* some of which I summarize below. I encourage you to submit similar "Ethnobiology in the News" items, with or without commentary, as well as comment and clarification of items reported in this column in previous issues. In this way, we may better appreciate and more effectively respond to the substantial latent interest of the general public in our field.

The PI of June 3, 1982, under the headline (with photo) "Crane Makes Whoopie," reported that a Whooping Crane *(Grus americana)* named Tex gave birth (sic.) to her first chick at Baraboo, Wisconsin, after six weeks of performing a mating dance with her human "beau," one George Archibald, director of the International Crane Foundation. Tex won't perform with another crane because "she thinks she's a person." Archibald made an all-out effort this year, living with Tex from April 1 to May 20, taking walks with her and helping her build her nest, in addition to the dancing. Tragically, a later news item reported that Tex had been killed by marauding raccoons.

According to the PI "Smelly Durian has some Friends." This fruit (of the tree *Durio zibethinus*, Bombacaceae), which "looks like a curled up porcupine" and smells like rotten eggs, has been banned by Malaysian Airlines. The Durian Lovers Association, chaired by University Sains Malaysian professor Rahim Said, came to the defense of this "much maligned fruit" by designing a special airline carrier of styrofoam with charcoal inserts to absorb the smell. A more serious threat to this fruit comes from destruction of mangrove trees, essential roosting habitat for a bat species thought to be "solely responsible for pollinating Malaysian durian trees." A graphic example of complex chains of ecological causality.

The PI reviewed (November 8, 1982) a letter in *The Lancet* noting a Sydney (Australia) University study of fruits of *Terminalia ferdinandiana,* showing it to have 50 times the Vitamin C concentration of oranges, the highest concentration known. This tree is a favorite of Aboriginal children on Australia's northwest coast.

A PI medical column by a Dr. Coleman reported that a Dr. Roy B. Altman of the University of Miami is investigating the value of the venom of a species of Bolivian ant in treating arthritic pain and inflammation. Local natives find these ants on a jungle tree called "tree of the devil." If you can contribute more detailed information on these features, I would appreciate receiving your letters.

A final news item, this forwarded by Brent Berlin, University of California at Berkeley, was reported by an anonymous author in the 1936 Yearbook of Agriculture.

> "It is probable that there have been more fertile mules than have been discovered. Dr. C. M. Morgan of Springview, Nebr., reports a fertile mare mule which has produced two foals by a stallion. A fertile Abyssinian mule was recorded in the *Journal of Heredity* (vol. 20, pp. 33-34, 1929) by Bashahaward Habterwold. The author remarks that the popular idea that wide crosses result in sterile hybrids is due in part to the fact that there is no great attempt to breed such hybrids" (p. 185).

Berlin notes that he is "always on the look-out for practical information of an ethnobiological nature." I hope you will be likewise.

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NOTICE TO AUTHORS

The *Journal of Ethnobiology* accepts papers on original research in ethnotaxonomy and folk classification, ethnobotany, ethnozoology, cultural ecology, plant domestication, zooarchaeology, archaeobotany, palynology, dendrochronology and ethnomedicine. Authors should follow the format for article organization and bibliographies from articles in this issue. All papers should be typed double-spaced with pica or elite type on 8½ x 11 inch paper with at least one inch margins on all sides. The ratio of tables and figures to text pages should not exceed 1:2-3. Tables should not duplicate material in either the text or graphs. All illustrations are considered figures and should be submitted reduced to a size which can be published within a journal page without further reduction. Photographs should be glossy prints of good contrast and sharpness with metric scales included when appropriate. All illustrations should have the author(s) name(s) written on the back with the figure number and a designation for the top of the figure. Legends for figures should be typed on a separate page at the end of the manuscript. Do not place footnotes at the bottom of the text pages; list these in order on a separate sheet at the end of the manuscript. Metric units should be used in all measurements. Type author(s) name(s) at the top left corner of each manuscript page; designate by handwritten notes in the left margin of manuscript pages where tables and graphs should appear.

If native language terminology is used as data, a consistent phonemic orthography should be employed, unless a practical alphabet or a more narrow phonetic transcription is justified. A brief characterization of this orthography and of the phonemix inventory of the language(s) described should be given in an initial note. To increase readability native terms should be indicated as ***bold-face italics*** to contrast with the normal use of *italic* type for foreign terms, such as latin binomials. If necessary, the distinction between lexical *glosses,* i.e., English language approximations of a term's referential meaning, and precise English equivalents or definitions should be indicated by enclosing the gloss in single quotation marks.

As the editorship of the journal is changing in 1983, authors should submit their manuscripts to:

DR. WILLARD VAN ASDALL, Editor
Journal of Ethnobiology
Department of General Biology
University of Arizona
Tucson, Arizona 85721

Authors must submit two copies of the manuscript plus the original copy and original figures. Papers not submitted in the correct format will be returned to the author.

NEWS AND COMMENTS

Individuals with information for the "News and Comments" section of the journal should submit all appropriate material to Eugene Hunn, Department of Anthropology, DH-05, University of Washington, Seattle, Washington 98195. Please note that the former *Folk Classification Bulletin* has been incorporated into this section.

SUBSCRIPTIONS

Subscriptions to the *Journal of Ethnobiology* should be addressed to P.O. Box 1145, Flagstaff, Arizona 86002. Subscription rates are $25.00, institutional; $15.00 regular membership, for U.S., Canada, and Mexico; foreign subscribers add $6.00. Write checks payable to *Journal of Ethnobiology.* Defective copies or copies lost in shipment will be replaced if written request is received within one year of issue.

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