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CULTURAL AND ENVIRONMENTAL RESPONSE TO DROUGHT AMONG THE MOUNTAIN PIMA

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The Mountain Pima of Chihuahua, Mexico, were adversely affected by a severe drought in late 1987 and 1988 which greatly reduced crop yields. The people responded by sale of livestock, temporary migration for wage labor, and increased utilization of noncultivated plant resources. Changes in availability of wild resources differed from species to species. *Arctostaphylos pungens* showed zero yield in 1988; yields of *Opuntia* spp. and *Berberis pimana* were greatly reduced. *Hymenocallis pimana, Dahlia coccina, D. sheriffii, Agave shrevei* spp. *matapensis, Arbutus xalapensis, A. arizonica, Prunus gentryi* and *P. serotina* var. *virens* showed negligible decreases in yields, as did several weedy species, including *Amaranthus hybridus, Portulaca oleracea, Jaltomata procumbens,* and *Physalis* spp. Roots of *Prionosciadium townsendii* increased in availability because of a decrease in the percentage of the population undergoing reproduction. The observed increase in wild plant utilization agrees with predictions of the diet breadth model of optimal foraging theory.

KEY WORDS: Drought, optimization, Mexico, diet breadth

Traditional agricultural peoples often tend to rely more heavily on noncultivated resources during times of crop failure than during years of adequate production (Campbell 1986; Grivetti 1979; Rahmato 1988; Scudder 1971). Indeed, many wild plants and animals serve as famine foods, utilized only during times of hardship Bhandari 1974; Irvine 1952; Spittler 1989; Minnis 1991). Other common responses to drought stress include migration for wage labor and sale of livestock and other assets (Mortimore 1987; Swinton 1988).

During the latter half of my fieldwork in the Mountain Pima village of Nabogame, Chihuahaua, Mexico (October 1986–November 1988) (Fig. 1), the region underwent a period of extreme drought. This allowed me to observe cultural responses to the crop failures and the impact of the drought on the abundance of cultivated and noncultivated resources.

Optimization theory predicts that diet breadth should increase during times of stress, as less preferred resources are added to the diet (Pyke 1984). Pate (1986) observed, however, that diet breadth decreased among the Ngatajara of Australia during stress because of decreased availability of resources. My observations among the Mountain Pima, however, correspond to the predictions of the model.

Rainfall in the Sierra Madre Occidental is bimodal, with two rainy seasons and two dry seasons (Fig. 2) (Hastings 1964). The winter rainy season lasting from late December to early March is characterized by frontal storms coming from the northwest, while the summer rainy season from late June to early September consists of thunder showers carried by southeasterly winds (Wallén 1955). The 1988 drought covered most of the North American continent and was caused by

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FIGURE 1 Map showing Mountain Pima communities of Nabogame, Chihuahua, and Yécora, Sonora, Mexico.

warm ocean currents in the Pacific Ocean (Trenberth *et al.* 1988). The winter rains that year failed almost entirely in the Mountain Pima area, while the thunderstorm season began about two weeks late and ended a month early. The spring dry season from April to June was unusually hot and dry, with no rainfall at all. Even the evergreen oaks, which constitute the dominant feature of the natural landscape, lost their leaves during this time. In contrast, 1986 and the first half of 1987 had been unusually wet.

Such severe droughts are very common in Mexico history (Castorena *et al.* 1980; Sancho y Cerbera & Pérez-Gavilán Arias 1978). Some of the cultural responses to such catastrophes have had major impacts on subsequent history (Hassig 1981). The Sierra Madre Occidental is a region of medium drought risk by Mexican standards (Sancho y Cerbera & Pérez-Gavilán Arias 1981).

Increases in pest problems during agricultural droughts are not uncommon and may be due to lowered plant defenses, higher nutrient content within plant tissues, a more suitable physical environment for pest growth, or other, more complex factors

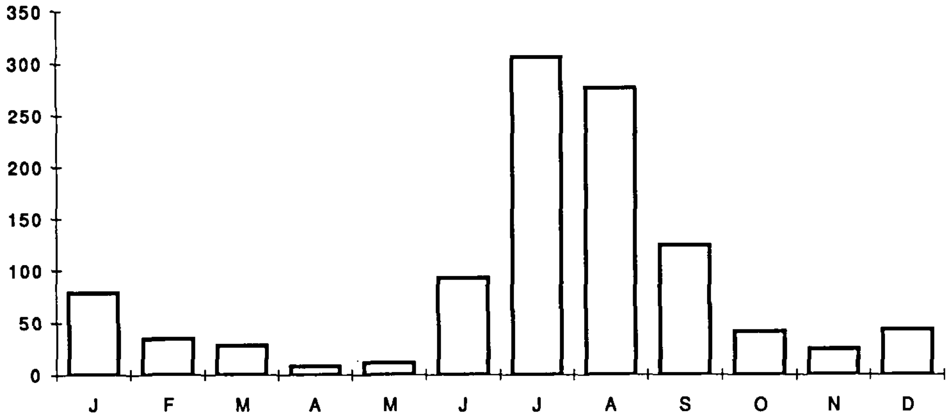

FIGURE 2 Yearly rainfall in Yécora, Sonora (after Hastings 1964).

(Mattson & Haack 1987). As an indirect result of the 1988 drought, the potato crop in Nabogame was attacked by scabareid beetle larvae. This reduced the yields of the crop even further than the direct effects of the drought.

The Mountain Pima cultivate maize, beans, squash, potatoes and several other crops, and raise cattle, horses, donkeys, pigs, and goats (Dunnigan 1970, 1983; Laferrière 1991). They also forage for several noncultivated plants and animals as food sources (Laferrière *et al.* 1991 a,b; Laferrière 1991). During years of adequate crop yields, noncultivated edible plants constitute only a small portion of the total diet (Laferrière 1991). Several studies have suggested that noncultivated resources are frequently more important as sources of vitamins and minerals than for their protein or carbohydrate contributions (Bye 1981, Connor *et al.* 1978, Cerqueira *et al.* 1979, Laferrière *et al.* 1991 a,b). Wild plants become extremely important in the Mountain Pima diet during certain seasons of the year. Most of them are available in summer, where stores of the previous year's harvest are running low.

METHODS AND MATERIALS

Ethnographic information was obtained by interviews and participant observation. Interviews were conducted with male and female residents of Nabogame, a community of approximately 70 individuals, all of Mountain Pima descent. The town is located 18 km northwest of Yepachi, a community of 1200 Pima and mestizo inhabitants. Yepachi contains several small shops and is served by truck traffic and daily bus service to Chihuahua City.

I interviewed both older Pima-speaking residents and their more acculturated adult offspring. Interviews were conducted in Spanish. I also participated in cheese making and in maize and bean harvesting during 1986, 1987 and 1988, and observed potato and squash harvests. I was thus able to make direct measurements of food production by weighing bags of food and multiplying this by the number of bags produced. Yields in 1986 were reduced because of a Pacific hurricane which destroyed much of the vegetation that July. Yields in 1987 and 1988 were reduced by the drought which began in August 1987. This was unanimously regarded by the Mountain Pima as the worst drought in living memory.

Estimates for crop yields in good years are based on data supplied by Mountain Pima consultants. They estimated for me the number of bags of storable material produced by a field of a given size, which enabled me to extrapolate the total yield. Values for yields of wild species reflect my own observations, supplemented with information obtained in interviews. I observed foraging of several plants and made collections of certain species for nutritional analysis (Laferrière *et al.* 1991 a,b). Some of the same bushes from which I collected fruits in spring of 1987 were barren during the drought of 1988. Yields of wild species were estimated by weighing the amount of edible material produced by a few plants and multiplying this by the number of plants within 5 km of the village.

RESULTS

Crop yields in Nabogame during 1988 showed significant decline from good years as a result of the drought. Net yields of potato were negative, largely because of the damage done by the beetle larvae. This was particularly catastrophic since potatoes represent the only good source of vitamin C in the Mountain Pima winter diet. Wheat yields were close to zero. Maize, beans, and squash showed some positive returns, but greatly reduced from expected yields except for peaches (Fig. 3). Production of goat- and cow-cheese was also greatly reduced.

The Mountain Pima responded to the crisis in three ways. First, the young men in the community went to work in the sawmill in the nearby town of Yepachi. A few travelled further seeking wage labor in cities at lower elevations. Second, people sold livestock for shipment by truck to Chihuahua City. Many animals died in Nabogame despite the selloff. This sale combined with the wage labor resulted in an influx of cash permitting significant import of food from the outside. People obtained flour, potatoes, pasta, cabbages, cookies, soft drinks, and other items from

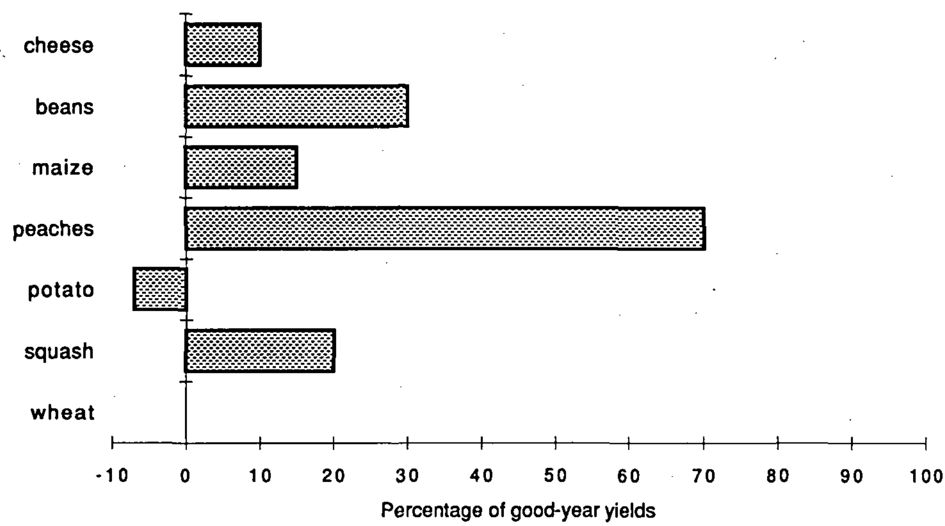

FIGURE 3 Yields of cheese and crop plants in 1988 in Nabogame compared with values expected in years of adequate rainfall.

stores in Yepachi. This constituted a large portion of the diet during the drought and was essential to the people's survival.

The third option was to increase utilization of the wild plants, especially quelites. This was done to a certain extent during 1987–88, but several people reported that this was much more important in the past. The construction of the road through Yepachi in the mid-1970's has permitted much more accessibility to goods and employment than in the past.

The most important noncultivated plant foods include pads and fruits of prickly-pear cacti (*Opuntia* spp.); quelites, or wild edible greens (especially *Amaranthus hybridus, Portulaca oleracea,* and *Chenopodium leptophyllum*); fruits of capulín (*Prunus serotina* var. *virens*), ahuasiqui (*P. gentryi*), pato amarillo (*Berberis* (*pimana*), tomatillo (*Physalis* spp.), tulusin (*Jaltomata procumbens*), madroño (*Arbutus xalapensis* and *A. arizonica*), and manzanilla (*Arctostaphylos pungens*); and roots of saraviqui (*Prionosciadium townsendii*) (Laferrière *et al.* 1991a). Prickly-pears are common in open forests and abandoned fields. Both fruits and pads are utilized extensively by the Mountain Pima, as well as by many other peoples (Laferrière *et al.* 1991a; Meyer & McLaughlin 1981; Russell & Felker 1987). Quelites are common weeds in planted and fallow fields but are commonly eaten during the summer rainy season (Bye 1981; Laferrière *et al.* 1991a). Tomatillos and tulusín are also agricultural weeds, but bear fruits eaten primarily by children (Davis & Bye 1982; Laferrière *et al.* 1991a). Saraviqui occurs on canyon embankments shaded by sabino (*Cupressus arizonica*). Its starchy, aromatic roots are a prized potato substitute (Laferrière *et al.* 1991a). Palo amarillo also occurs in shaded canyons, producing scarlet berries which are edible though very sour (Laferriére & Marroquín 1990). Ahuasiqui (*Prunus gentryi*) and cauplín (*P. serotina* var. *virens*) occur along streambanks and produce edible drupes (Laferrière 1989; Laferrière *et al.* 1991a). These plants are used even during good years.

In addition, several plants are utilized sparingly during good years, but more extensively during crop failures. Use of some of these has declined or been entirely eliminated in recent years. Chuguilla (*Agave shrevei* spp. *matapensis*) is utilized for both its immature flowering stalks and its fleshy leaf bases (Gentry 1982; Laferrière *et al.* 1991a; Mitich 1976). It occurs on steep cliffsides and in oak forests (Laferrière 1991). Cebollín (*Hymenocallis pimana*) is a geophytic species extremely common in nonplowed grassy areas (Laferrière 1990). Older members of the Mountain Pima community report that the subterranean bulbs of this species were used as a famine food in the past after being boiled in lye to remove toxic alkaloids (Laferrière 1991). Acorns (fruits of *Quercus* spp.) were also reportedly used in the past but not at present (Laferrière 1991). Indeed, informants disagreed concerning which of the local acorn species were utilized. Kachana tubers (*Dahlia coccinea* and *D. sherffii*) are edible and are common in shaded canyons (Laferrière *et al.* 1991a; Whitley 1985). Manzanilla (*Arctostaphylos pungens*) forms extensive thickets in drier, well-drained areas (Laferrière 1991). Although its amber berries are dry and mealy, they are edible and nibbled on occasionally (Laferrière *et al.* 1991a). Madroño (*arbutus xalapensis* and *A. arizonica*) is a common forest tree producing edible orange fruits (Laferrière *et al.* 1991a).

Productivity of noncultivated species varied markedly between species (Fig. 4). Weedy species were abundant during the rainy season, albeit for an abbreviated period. The rains did provide adequate moisture for luxuriant growth of quelites. Supply of quelites is virtually infinite at that time, since there is quick replacement of any plants harvested. The people destroy far more quelites in weeding their fields than they could possibly consume. Tomatillos and tulusín were also present in the

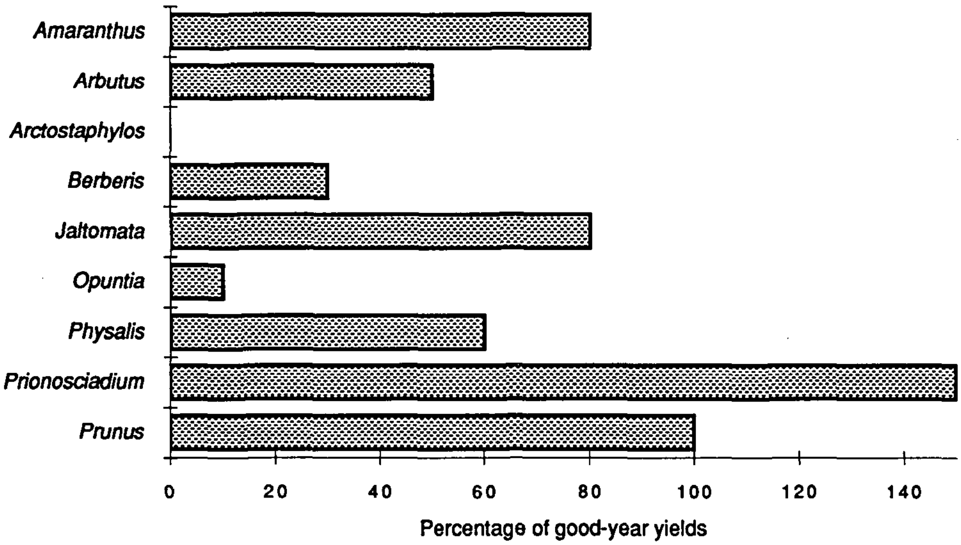

FIGURE 4 Yields of wild plant foods in 1988 in Nabogame compared with 1987.

fields both years. Wild plants showed a more mixed picture. Yield of manzanilla berries suffered a 100% decline, since the plants flowered in April during a heat spell in the dry season. The flowers dried without setting fruit. Supplies of kachana tubers and leaf bases of chuguilla were untouched by the drought because they are slow-growing storage organs. Ahuasiqui, capulín, and madroño were also largely unaffected, probably due to their preference for moister habitats along creeks. Palo amarillo, however, showed a marked decline in berry production despite its occurrence in similar mesic habitats. This may be due either to a shallower root system or to the fact that palo amarillo, like manzanilla, flowered in April.

Yields of pads and fruits of prickly-pear were down by an estimated 80-90%. The decrease in productivity of the prickly-pear fruits was partly due to the direct results of the drought, and partly because the cattle were utilizing the mature pads of these plants as their reserve food supply. Of the three species present in Nabogame, nopal temporal (*Opuntia* cf. *robusta*) and nopal de zorra (*O.* cf. *macrorhiza*) were utilized the most heavily by the cattle. Nopal de duraznillo (*O. durangensis*) was left largely undisturbed. This species did, however, experience a large decline in fruit production.

One plant, saraviqui, showed an increase in availability for human because of the drought. Saraviqui is a semelparous member of the family Umbelliferae. It lives for 3–5 years producing only one or two large leaves, storing its photosynthate in its large taproot. When environmental conditions are favourable, it produces a flowering stalk 2–3 m tall, then sets seed and dies. Once the flower stalk has been initiated, the root becomes tough, woody, and inedible. Only prereproductive specimens are useful as human food. During 1987 20–30% of the Nabogame population was in flower, but during 1988 I observed only a single flowering individual. With the exception of that one plant, in the middle of a spring, the entire population was in a vegetative state and hence available for human consumption.

DISCUSSION

The diet breadth model of optimization theory offers a generalized explanation for the increased utilization of noncultivated plants. The model predicts that the choice of whether to utilize a less-favored resource is determined solely by the abundance of more favored resources (Smith 1983). Hence a shortfall in the preferred species will necessitate relying on less favored species regardless of the abundance of the less-favored species, provided the yields are greater than zero. Rankings of resource preference may change because of changes in search times and harvest efficiencies.

Pate (1986) found that in Australia, resources held in low preference by the Ngatatjara suffered more from drought than those of high preference. Hence the drought resulted in a decline in diet breadth, exactly the opposite of the prediction of the model. However, the model predicts only the response of the foragers to the stressed situation, not the availability of the resources themselves. The Mountain Pima results do generally correspond to the predictions.

Noncultivated resources are generally less preferred by agricultural peoples because of lower returns per unit time invested, or because tannins, oxalates, or some other substances prohibit utilization in large quantities (Laferrière *et al.* 1991a). Wild foods can be difficult to digest, low in nutrition, and sometimes even with a negative net energy return (Hassig 1981). Some of the famine foods, such as cebollín, require extensive processing which add considerably to the cost. Crops also tend to require a lot of overhead, but yields per hour invested are much greater.

The diet breadth model, however, also predicts that the choice of whether to use the less-preferred resources should be all-or-nothing, i.e. no "partial preferences" (Pyke 1984). The micronutrient contributions from noncultivated resources may be essential in preventing the utilization from disappearing completely during good years. More complex linear and nonlinear optimization models are necessary to deal adequately with these situations (Laferrière 1991).

The use of noncultivated resources was undoubtedly even more important during past droughts than at present. Neither emigration for wage labor nor selling of livestock would have been as readily accessible prior to the construction of the road through Yepachi. The first is still not a viable option for women and old men. Some species such as acorns and cebollín bulbs have been abandoned entirely. Techniques for processing these two plants are known only to a few older individuals.

Some noncultivated species in the study were affected by drought even more than some cultivated ones. Increased utilization extends both to species with reduced (but positive) yields and to plants such as quelites which are less affected. Perennials tend to have more extensive root systems than annuals under the same environmental situations. This explains the resistance of peaches and many of the wild species to the drought. Manzanilla and prickly-pear, being upland species, have less access to ground water than riparian species. Annuals flourished in Nabogame during the short rainy season, even in 1988. Had the crop plants been able to mature as rapidly they might have showed yield declines comparable to those of the weedy species.

Other researchers have also noted increases in availability of wild plants during droughts. Some Australian plants increase fruit production during long dry spells, while other fruits are more readily available because they decompose more slowly (Gould 1980; Pate 1986). Melon yields in the Kalahari increase during drought because of fires set to encourage new growth and attract game animals (Hitchcock 1979).

Reliance on a wide variety of resources often enables people to adjust to shortfalls in one or a few areas (Spittler 1985; Starr 1987; Swift 1973; Swinton 1988; Turton 1977). Utilization of a number of resources can contribute a variety of nutrients during good years, as well as providing backup mechanisms during crises. The effects I observed in yield depletion in 1988 could well have been different had the timing of climatic events been altered. Gathering provides a succession of foods maturing throughout the year, some of which may be resistant to the effects of drought (Scudder 1971). Some resources, such as chuguilla leaves and kachana tubers, may be available year-round. Dependence on a few annual crop plants requiring a long rainy period increases risk even though it results in higher yields.

Use of several different wild plant species also prevents overdepletion of any single population. Human utilization can have a positive, negative, or neutral effect on plant populations. Any intense, prolonged negative impact is unsustainable. Many of the Mountain Pima resources, especially saraviqui, are becoming rare due to overutilization and overgrazing. Use of such depletable resources as reserve food supplies rather than for everyday subsistence would permit natural regeneration of the populations.

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