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Aboriginal Exploitation of Pandora Moth Larvae in East-Central California

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INSECTS were food resources throughout most of aboriginal California and the Great Basin (Kroeber 1925; Essig 1934; Barrett 1936; Steward 1938), but they seldom attract much attention from anthropologists and their role in these economies is generally assumed to have been secondary or ephemeral in character. It is virtually certain that insects never ranked with such staples as artiodactyls, acorns, or pine nuts; however, in certain contexts they may have contributed significantly to the native diet. Before relegating such resources to some ancillary status, it is necessary to evaluate fully the nature of the overall economy and its various situational constraints. This paper examines one insect, the Pandora moth (*Coloradia pandora lindseyi* Barnes and Benjamin), and its role in the native subsistence systems of east-central California.

Exploitation of Pandora moth larvae by the Mono Lake and Owens Valley Paiute has been the focus of varied attention in the literature for over seven decades. By and large, however, these accounts were not based on firsthand observation, and thus there has developed a corpus of misleading, often conflicting, information. The first part of this paper presents a critical evaluation of these discrepancies using both published and unpublished ethnographic, entomological, and archaeological data. Subsequent sections assess the importance of this resource relative to both short- and long-term regional subsistence strategies.

BACKGROUND

First identified in 1863 from a single specimen collected in Colorado (Chamberlin 1922:69), a number of distinct subspecies of the Pandora moth are now known to be distributed throughout montane regions of the western United States (Carolin and Knopf 1968:1; Carolin 1971). The subspecies *lindseyi* is endemic to the West Coast, with a range extending from the Cascade Range of Oregon south into Mexico (Barnes and Benjamin 1926; Ferguson 1971:92-94). Within the study area (Fig. 1), the principal host tree is Jeffrey pine (*Pinus jeffreyi*), although in mixed stands lodgepole pine (*P. murrayana*) may also be attacked (Keen 1928, 1952: 83; Carolin and Knopf 1968:1, 7).[1]

The life cycle of the Pandora moth generally lasts two years, with major infestations occurring roughly every 20-30 years. These intensive episodes usually span a period of 4-8 years (2-4 generations) before yielding to natural control factors (Keen 1952:83; Carolin and Knopf 1968:1, 7). Although some early entomological literature suggests that tree mortality occurs as a direct result of defoliation during major infestations (e.g., Patterson 1929; Wygat 1941), more recent evidence indicates that such occurrences are atypical and rare. Deaths, if any, are normally attributable to secondary attacks by other pests (B. Roettgering, personal communication 1980; M. Wagner, personal communication 1985;

Wagner and Mathiasen n.d.).

The "normal" life cycle of the Pandora moth begins with emergence of adults from their pupal cases in July, mating taking place shortly thereafter. The egg clusters, which are deposited on the bark or needles of host trees, undergrowth, or ground litter, hatch in about 40 days. Upon emergence, the caterpillars ascend the trees and feed on the needles (except for the terminal buds) until the onset of winter. They hibernate in the needle clusters, and with the beginning of spring conditions resume feeding until the last week in June or first week in July. At this time they descend from the trees to pupate in the loose, volcanically derived soils (Aldrich 1912, 1921; Carolin and Knopf 1968: 4-5; Miller and Wagner 1984; B. Roettgering, personal communication 1980). It is during this brief period that the larvae, referred to

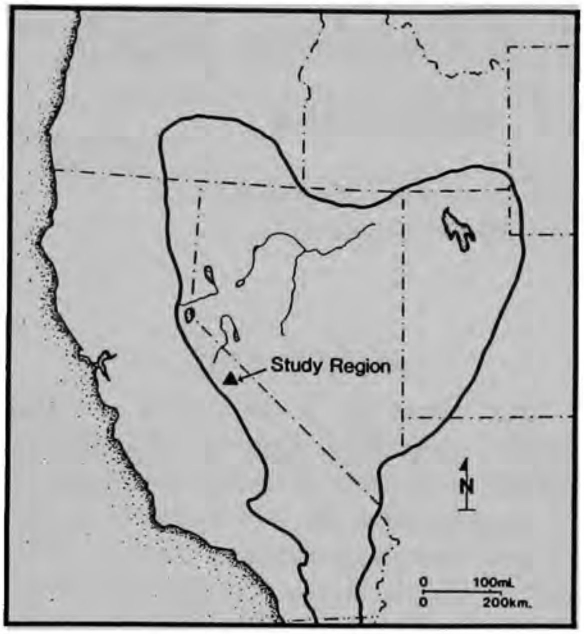

Fig. 1. Location of the study region within the Great Basin.

Fig. 2. Photograph of *piagi* collection trench near Indiana Summit, Mono County, California.

Fig. 3. Photograph of *piagi* collection trench near Indiana Summit, Mono County, California, during its use in 1963. (Courtesy R. Warren).

as *piagi*, were harvested by both the Mono Lake and Owens Valley Paiute (Aldrich 1912; Way 1920a, 1920b).[2]

To facilitate subsequent discussion, the following is a summary of the collection process based strictly on firsthand observations made between 1920 and 1982 (Way 1920a, 1920b; Miller and Hutchinson 1928; R. Warren 1963, personal communication 1985; Walter and Fowler 1982; Fowler and Walter 1985). The observations recorded by Guy Way (Way 1920a, 1920b) are the earliest known first-hand narratives of the process and constitute an invaluable source of comparative information.

> When the larvae descended from the host trees, groups of harvesters would excavate trenches [see Figs. 2 and 3] around the bases of a number of pines or, alternatively, clean out a number of previously constructed trenches. The descending caterpillars, after becoming trapped in these depressions, were collected in baskets, mixed with heated soil, and left to cook for 30 minutes to an hour. Afterward, the processed larvae were separated from the soil by winnowing and laid out to air dry

Fig. 4. *Piagi* storage structure at CA-MNO-799 near Indiana Summit, Mono County, California.

> in the shade for a period of at least two days. In former times, the *piagi* were subsequently stored in nearby bark-covered, wood-framed shelters [see Figs. 4 and 5] for future use.

Discrepancies between these first-hand accounts and more widely circulated descriptions (Aldrich 1912; Keen 1928; Essig 1931, 1934:185; Steward 1933:256; Carolin and Knopf 1968:7) are addressed individually as appropriate.

NATURE OF THE RECORD

The foregoing description suggests that three kinds of archaeological manifestations might be expected to result from the process of *piagi* exploitation: collection trenches, used to entrap or amass descending caterpillars; hearths or cooking areas, used to prepare the larvae for storage; and, at some locations, structures within which the dried insects were stored. Other associated features or artifacts probably would be scarce since procurement localities were used sporadically, they were occupied for only a short duration, and any attendant activities would have offered little opportunity or reason for the accumulation of debris.

Over 60 percent of the Jeffrey pine and mixed Jeffrey-lodgepole pine forested areas in the Long Valley-Mono Basin region had been subjected to intensive archaeological surveys as of January 1985 (Fig. 6). These efforts have documented 28 separate *piagi* collection localities containing nearly 4,000 recognizable trenches and seven storage

Fig. 5. Ceiling detail of *piagi* storage structure shown in Figure 4.

structures (Fig. 7, Table 1).[3] Two sites, CA-MNO-799 (Basgall 1984) and CA-MNO-1982 (Mone 1986), were intensively examined and provide the basis for much of the following discussion.

Collection Trenches

Although impressive, the number of reported trenches almost certainly is an underrepresentation of the actual figure because of differential identification and the vagaries of preservation. First of all, the figures were extracted from existing site survey records, most of which indicate the number of rings at a given site in relative terms (e.g., in excess of "x" trenches). Additionally, the ephemeral nature of collection trenches leaves them prone to obliteration through such processes as post-construction tree growth, erosion and collapse, and infilling by soil and duff.

Descriptions provided by Way (1920a, 1920b), Miller and Hutchinson (1928), R. Warren (1963, personal communication 1985), Walter and Fowler (1982), and Fowler and Walter (1985) show general agreement in the fact that trenches were typically from 10-16 in. (ca. 25-41 cm.) deep and approximately 24 in. (ca. 61 cm.) wide. Archaeological data from CA- MNO-799 (Basgall 1984:Figs. 4-7) and CA- MNO-1982 (Mone 1986:Table 2) are in accordance with these ethnographic dimensions, slight discrepancies being attributable to either methodological variation (in the measurement process) or increased disturbance to the older features.

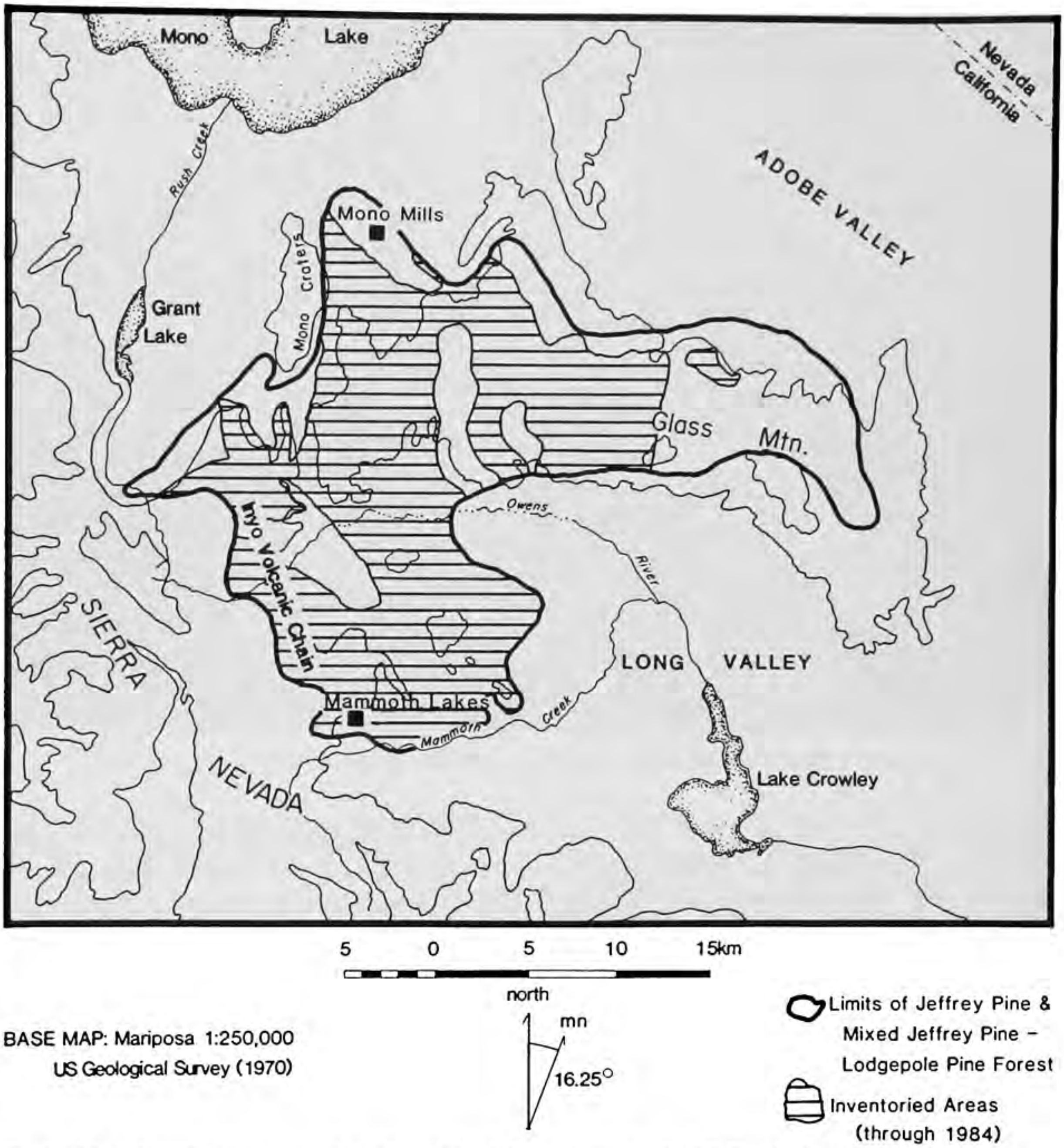

Fig. 6. Map showning the surveyed portion of the Jeffrey pine and mixed Jeffrey-Lodgepole pine forested areas of the Long Valley-Mono Basin region.

It is unlikely that such variability is culturally or technologically meaningful.

Differing descriptions of outer trench wall configuration probably relate to the same problem. Whereas Way (Miller and Hutchinson 1928:159) noted that these were excavated with sidewalls as nearly vertical as possible, Davis (1965:32) indicated that the "trench walls" were undercut. Since other accounts attest to the fact that inner

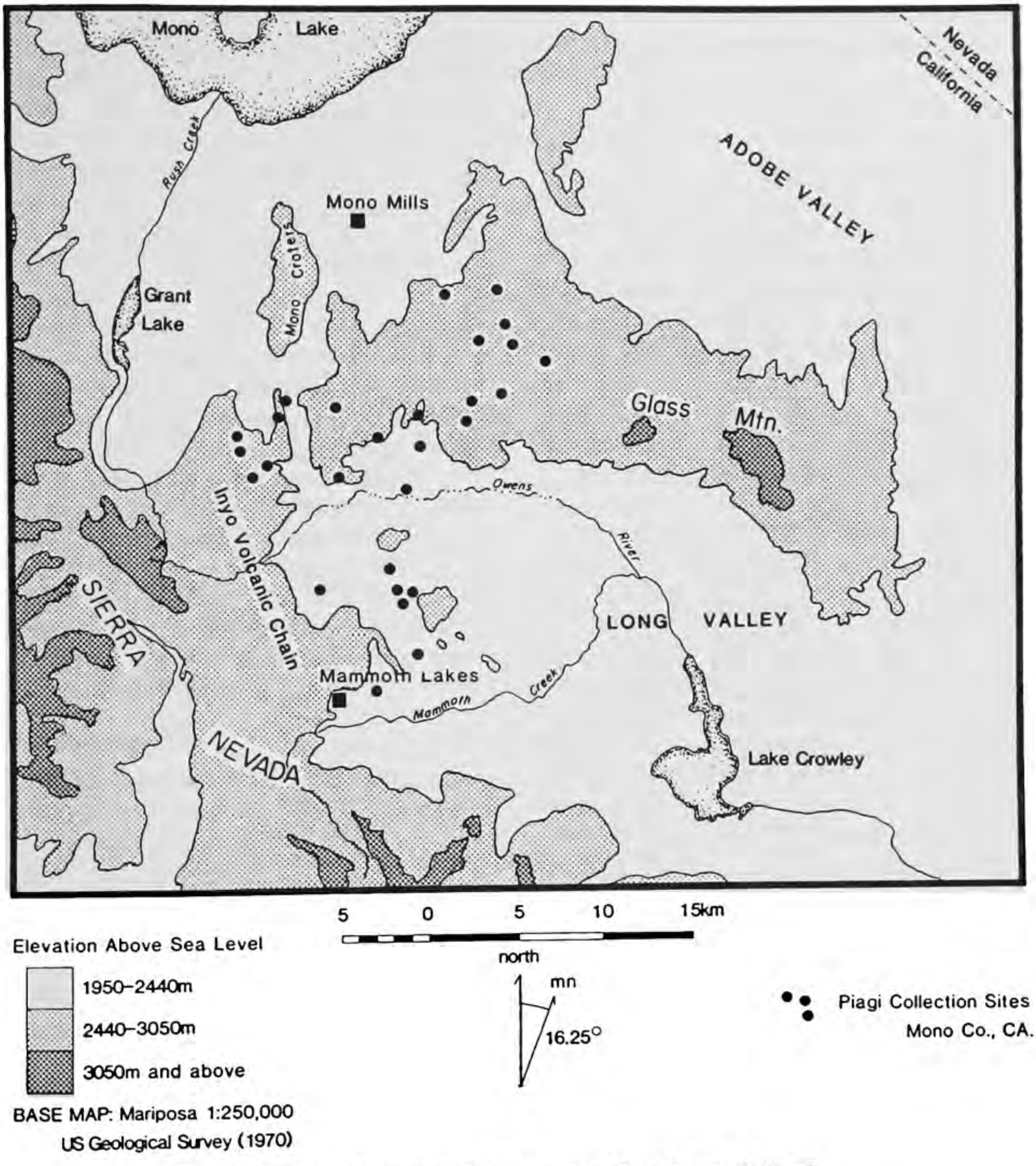

Fig. 7. Distribution of known *piagi* collection sites, Mono County, California.

walls sloped downward from the base of the trees (e.g., R. Warren, personal communication 1985; Fig. 3), it is assumed that Davis was referring to the outer walls. Although it is unclear from Davis' description whether she actually observed this, other details in

Table 1
ATTRIBUTES OF KNOWN *PIAGI* COLLECTION LOCALITIES, MONO COUNTY, CALIFORNIA
(Based on Existing Site Records)

Site Number	Number of Trenches	Storage Structures	Other Associations
CA-MNO-462		2	
CA-MNO-466	114+		1 obsidian flake
CA-MNO-544	600+		obsidian flakes
CA-MNO-664	27		26 obsidian flakes
CA-MNO-763	55+		
CA-MNO-764	318+		
CA-MNO-780	60+		
CA-MNO-781	3		
CA-MNO-782	1		rock shelter
CA-MNO-799	1,400+	3	obsidian flakes, hearth feature
CA-MNO-832	13		obsidian flakes
CA-MNO-859	111+		obsidian flakes
CA-MNO-862	35+		obsidian flakes
CA-MNO-864	20+		1 obsidian flake
CA-MNO-865	8		
CA-MNO-868	40+		6 obsidian flakes
CA-MNO-1703	41		
CA-MNO-1704	60+		
CA-MNO-1707	50+		
CA-MNO-1708	250+		
CA-MNO-1711	222+		16 obsidian flakes
CA-MNO-1982	55+		obsidian flakes
CA-MNO-2031	250	1	16 obsidian flakes, 1 metate
CA-MNO-2035	30	1	1 obsidian flake, historic debris
CA-MNO-2036	100		2 obsidian flakes
CA-MNO-2064	64		obsidian flakes
CA-MNO-2065	42+		obsidian flakes
CA-MNO-2139	8		obsidian flakes
Totals			
28 sites	3,977+	7	

her report suggest that her information was from a secondary source. Nonetheless, excavation profiles from a number of trenches at CA-MNO-799--the same locality discussed by Davis (1965)--show some tendency for the peripheral trench wall to be undercut (Basgall 1984:Fig. 4). Thus, it seems likely that these differences relate to both individual preference and the relative stability of soils at a given locale.

Roasting Hearths

The representation of roasting hearths at archaeological localities is limited, probably as a result of uneven recording and poor preservation conditions. Only one somewhat problematic feature of this sort, located at CA-MNO-799 (Basgall 1984), has been reported to date. This feature was approximately 4 m. (13 ft.) by 6 m. (19.7 ft.) in extent and contained varying quantities of charcoal and ash, interspersed by various kinds of historic trash (e.g., cans and broken glass). Charcoal concentrations were densest toward the center of the feature; peripheral areas contained only scattered carbon and wisps of ash (Basgall 1984:25-28). Because no direct evidence of *piagi* processing (e.g., burnt larvae) was found in the burned area, its relationship to such activities can be inferred only through its loose association with nearby collection trenches and a storage structure. The feature configuration, however, is consistent with ethnographic data, which imply that roasting hearths would leave little more than a slight depression and charcoal-laden soil. Both attributes would likely disappear given the highly acidic and disturbed soils characteristic of the region (Weaver and Hall 1984:6-20). Duff accumulation and forest fires subsequent to aboriginal use would further obscure surface manifestations of hearth features.

Storage Structures

Differential identification and preservation do not, however, appear to offer a reasonable explanation for the distribution of known storage structures. Only seven intact or collapsed structures have been located to date, all in territory traditionally attributed to the Mono Lake Paiute. Given that survey coverage and historic (Euro-American) land-use patterns have been comparable north and south of Glass Mountain Ridge, there is some reason to believe that the spatial profile reflects differences in the storage practices of Mono Lake and Owens Valley groups. Such a pattern is not wholly unexpected in light of the differential distances between collection localities and core settlement areas of the respective populations. Further, there may be significant differences in how *piagi* articulated in the subsistence systems of the Mono Lake and Owens Valley Paiute. These issues are explored more fully below.

Unlike house structures reported from east-central California (Bettinger 1975; Ritter 1980), *piagi* storage facilities are significantly smaller and neither conical nor free-standing in form. Although it has been suggested in some accounts (e.g., Essig 1931) that these structures served as drying (rather than storage) facilities, their small size would offer little area for spreading out larvae and first-hand testimony clearly rejects such a function. There is some formal variability between the known examples, but the structure recorded at CA-MNO-799 by Basgall (1984:28) provides a representative case.

Set against a medium-sized, still-living Jeffrey pine, the structure was framed using logs and branches, with bark slabs serving as the outer cover. A large central beam was butted against the base of the tree and supported on the opposite end with an A-frame. The support consisted of two branches fastened together with baling wire. Additional branches were then placed on the basic superstructure giving the feature an ovate outline. The final construction phase entailed placement of bark slabs over the primary and secondary framing, forming a relatively weatherproof storage facility (Figs. 4 and 5).

The structure at CA-MNO-799 measures approximately 2 m. (6.6 ft.) in length, and roughly 1.2 m. (3.9 ft.) in width. The door height is 1.1 m. (3.6 ft.) and the maximum height of the structure is about 1.7 m. (5.6 ft.). Both the use of historic materials and the calculated ages of nearby collection trenches (Mone 1986) argue that this feature, and probably the six other known structures as well, is less than 100 years old.

The great number of *piagi* collection localities would seem to suggest that exploitation of the larvae was--consistent with indications from historic documents--an established component of regional subsistence strategies during the protohistoric and historic periods. Prior to assessing the importance of the resource system or its possible antiquity, however, an additional issue relative to harvesting practices--the use of smudge fires--is considered.

Smudge Fires

Perhaps the most widely held misconception regarding aboriginal *piagi* procurement involves the use of smudge fires. According to some reports (e.g., Aldrich 1912), smoke from these fires, which were built in the bottom of collection trenches, helped to drive the caterpillars down from the canopy. Essig (1931) provided a more elaborate deviation from the first-hand accounts in asserting that smudge fires, collection trees, and the processing area were encircled by a larger trench that served to both entrap the larvae and control the spread of fire. Again, however, none of the first-hand accounts (Way 1920a, 1920b; Miller and Hutchinson 1928; R. Warren 1963, personal communication 1985; Walter and Fowler 1982; Fowler and Walter 1985) noted the use of smudge fires. Indeed, when queried about this topic, modern collectors consistently indicated that smoke would be of no use to the process (Walter and Fowler 1982:3; Fowler and Walter 1985:159). Archaeological evidence for this practice is, at best, inconclusive. It seems, therefore, that systematic use of smudge fires is unlikely, and the purported practice probably derives from an erroneous interpretation of the roasting facilities.

Circulation of this misconception appears to have resulted from two interrelated events. The first of these involves Aldrich's (1912) initial description of *piagi* collection, which was obtained from a clerk at a Mono Lake store. Later, Aldrich apparently became aware of the fact that his information on smudge fires was in error, and published a correction (Aldrich 1921) based on information supplied by Way (1920a, 1920b). Unfortunately, Aldrich's later paper received little attention and the error was perpetuated. In part, this probably is attributable to the fact that he failed to indicate what the "serious mistakes" (Aldrich 1921:35) in the earlier report were. In any event, the reported use of smudge fires was given wide circulation in the entomological literature (e.g., Essig 1929:671, 1931:35-44, 1934:185; Bodenheimer 1951:291; Keen 1952:85; Carolin and Knopf 1968:7; Furniss and Carolin 1977:195).

A similar proliferation of erroneous second-hand information apparently accounts for references in the anthropological literature to the use of smudge fires. In his ethnography of the Owens Valley Paiute, Steward (1933:256) appears to have relied on Aldrich's articles for all aspects of the *piagi* collection process except those relating to smudge fires. For the latter information, possibly in an effort to check the discrepancies in Aldrich's reports, Steward (1933: 234) relied on an informant who elsewhere he noted was not particularly well informed. Therefore, it appears that readily available ethnological and entomological studies paralleled one another and mutually propagated the error.

CATERPILLARS IN THE SUBSISTENCE-SETTLEMENT SYSTEM

Based on even a cursory review of the ethnographic literature, it seems apparent that both the Mono Lake and Owens Valley Paiute regarded *piagi* as a highly prized foodstuff. Eldredge (1923) provided a particularly graphic illustration of this fact in recounting how several Mono Lake residents left employment to collect caterpillars in 1911.[4] However, just because a particular resource is exploited--even one that is valued--does not mean that it was a focal component of the broader subsistence system. Other factors, including the predictability in timing, distribution, and productivity of the resource, conflicts between these factors and the availability of other (perhaps more reliable and productive) resources, and the inherent storability of a resource must be considered when assessing its actual significance (Jochim 1981; Smith 1983; Basgall 1984:3-7, n.d.). There are really two parts to this problem. The first is to determine whether *piagi* use would be energy efficient (how the return rate compares to that of other potential resources) and under what situations its use would be expectable. The second is whether the resource constituted a significant component of the native economic system and had a major influence on broader subsistence-settlement strategies. These may or may not have convergent solutions.

A number of recent attempts have been made to evaluate cost/benefit data for various resources commonly exploited by aboriginal Great Basin populations (e.g., Bettinger and Baumhoff 1983; Simms 1984, 1985). In contrasting the acquisition costs and nutritional data provided by Simms (1985:120-121, Tables 2-3) to those available for Pandora moth larvae (Fowler and Walter 1985:162, Table 1), it is apparent that *piagi* ranks higher than most vegetal resources included in Simms' study. With an estimated return rate of between 1,840-2,753 calories per hour (cal./hr.), caterpillars are surpassed only by cattail pollen (2,750-9,380 cal./hr.). Foods such as pine nuts (collected when the cones were dry, 841-1,408 cal./hr.), ricegrass (301-392 cal./hr.), and wild rye (921-1,238 cal./hr.) yielded lower return rates in Simms' experiments. Return rates reported by Simms (1985:122, Table 4) for selected Great Basin faunal resources are consistently higher than those derived for moth larvae. Finally, it is worth comparing the nutritional composition of these same resources. Data provided by Fowler and Walter (1985:162, Table 1) suggest that *piagi* are comparable to many plant resources in protein content, but have a substantially greater fat component. Notwithstanding certain questions regarding the reliability of Simms' (1984, 1985) experimental data--which were obtained during very short periods by an inexperienced collector--the collective information suggests that Pandora moth larvae constitute an amply efficient resource. Indeed, if these rankings are even roughly correct, *piagi* would have been fully competitive with virtually all vegetal resources from the standpoint of energy.

A remaining consideration is to evaluate the more inclusive role of *piagi* within east-central California subsistence-settlement systems. Some insight is provided by contrasts between the roles of the so-called "armyworm" among the Pomo of west-central California and the Bogong moth among certain aboriginal groups in the highlands of southeastern Australia (Barrett 1936; Flood 1976, 1980; Swezey 1978; Gould 1980; Basgall 1984). In both instances the insect was, following Barrett (1952:108), considered "highly esteemed." Unlike the Bogong moth, however, the "armyworm" was unpredictable in terms of its periodicity, distribution, and abundance, and it could not be stored for any length of time. Further, when it was available, scheduling often conflicted with the harvest of other, more productive, foodstuffs. As a result, the "armyworm," although considered desirable, never became an important dietary component nor had a strong influence on broader Pomoan subsistence-settlement strategies. A similar perspective can be employed in assessing the overall significance of *piagi* within eastern Sierran cultural systems.

As noted previously, major outbreaks of the Pandora moth, lasting up to eight years, are known to occur at 20-30-year intervals within any given subset of its range (Keen 1952:83; Carolin and Knopf 1968:1). At first glance, such apparently wide periodicity would seem to place *piagi* in the category of a "delicacy," harvested when available but never assuming the status of a pivotal dietary component. However, closer examination of the ethnographic and entomological literature suggests this was not the case.

The earliest recorded indication that *piagi* was, in fact, both a predictable and reliable resource comes from Way (Miller and Hutchinson 1928:160), who reported that the leader of the collecting party he accompanied (which harvested about 1.5 tons of larvae) had gathered caterpillars 35 times in his lifetime. Such a frequency requires that significant quantities of larvae be available during stretches *between* major infestations. Additional support for such an inference is provided by recent entomological studies. These reveal that hatching diapause for the Pandora moth includes annual emergences (as opposed to biennial ones) of roughly equal numbers of females and males for at least five years beyond the typically cited cycle (Carolin 1971:23). Further, it is now known that forested areas of Mono County contain a permanent--if low density--population of these insects (B. Roettgering, personal communication 1980; M. Wagner, personal communication 1985). It seems apparent, therefore, that *piagi* were more predictable in terms of availability than originally was thought.

Despite the apparent availability of some larvae on an annual basis, both historic and contemporary data consistently indicate that *piagi* were harvested only every other year. Details provided by Way's consultant suggest that this pattern can be traced back to at least the early 1800s (Miller and Hutchinson 1928:160). This biennial gathering pattern was probably a result of the fact that alternate, off-year, collections were less productive (see Carolin 1971). Decreased abundance during portions of this cycle should not, however, be taken to mean that off-year collections were never undertaken and that biennial harvesting was always the norm. Energy data reviewed above clearly indicate that larvae would have been taken and lower yields would still have been particularly important, especially in years when other resources were scarce. Further, off-years with poor harvests could have been supplemented to some extent by yields obtained during alternate (good) years since *piagi* would preserve for at least a year under traditional conditions (Walter and Fowler 1982:5; Fowler and Walter 1985:161-162). Inasmuch as the timing of caterpillar availability did not conflict with the scheduling of other important subsistence resources (Steward 1933; Bettinger 1982), they were storable, and collection territories were owned by particular family groups, at least historically (Walter and Fowler 1982:5; Fowler and Walter 1985:159), *piagi* appear to meet the criteria of a significant dietary component.

TEMPORAL DIMENSIONS OF *PIAGI* USE

As noted above, other than the collection trenches, procurement localities contain few archaeological remains. Even when present, such remains are limited to a few obsidian flakes, charcoal smearing from the roasting facilities, and the odd storage structures. While these indicators might, in some instances, provide limited chronological data, none can clearly be linked to actual trench use. In the case of flaked-stone debitage, any direct association is suspect owing to the fact that (1) the region was a node in an extensive trans- Sierran obsidian exchange network (Basgall 1983; Hall 1983, 1984; Bouey and Basgall 1984); and (2) the forested areas under consideration were and continue to be prime habitat for artiodactyls. Given these considerations, sparse flaked-stone scatters may just as likely reflect exchange-related obsidian production or retooling and butchering activities. Therefore, considerations of age, with respect to both individual collection localities and to the industry in the region as a whole, are best assessed through indirect means.

The upper age limit of Jeffrey pine in the eastern Sierra is roughly 500 years (Jenkinson MS:16). Historic accounts of *piagi* collection indicate that trenches were constructed only around trees over 18 in. in diameter at breast height (Miller and Hutchinson 1928: 159; note that "breast height" is defined by silvical convention as a point 4.5 ft. above ground surface), or about 150 years in age.[5] During the major Pandora moth outbreak of 1978-1981 in the study area, trees of lesser size/age had few, if any, caterpillars. It would appear, then, that apparent ethnographic selectivity could relate to differential return rates for trees of various sizes. On the basis of these data, the maximum date reasonably expectable in an exposed archaeological context would be on the order of about 300 years for a trench associated with a living tree. Perhaps another 100 years could be added to this general chronology by using rings from trees cut prior to the turn of the century (e.g., during the operation of Mono Mills between 1880 and 1914 [see Maule 1938:44; Jackson 1985]). However, data from CA-MNO-799 and CA- MNO-1982 (Mone 1986:Table 2) suggest that extant trenches, at least at these locations, are substantially younger than this maximum potential age.

Obviously, in each of these instances two assumptions are operative. The first of these involves the premise that collection techniques have remained consistent since their inception. T. Balint (personal communication 1979) has observed that at least some modern harvesters gather the larvae by hand without using collection trenches. This approach, though probably employed in the past as well, would compromise or restrict the overall caterpillar yield. It seems likely that more casual procurement is a result of changing dietary adaptations--the role of *piagi* shifting from that of a major subsistence resource toward that of a "delicacy," important more for reasons of tradition. There may well be an energy rationale behind this change, but vagaries and complexities of the acculturation process preclude making such a simple attribution.

The second assumption in this chronological model concerns when in the tree's growth given trenches actually were constructed (i.e., at or after reaching ca. 150 years of age). During his observation of collection activities, R. Warren (1963, personal communication 1985) noted that the inner and outer walls of newly constructed trenches were roughly one and three feet, respectively, from the bases of the trees. Undoubtedly, the subsurface extent of the tree trunk and root systems were a consideration with respect to these distances. If it is assumed that the spatial relationship between the inner trench wall and the tree trunk has been consistent, a relative, albeit crude, compensatory age adjustment can be made when assessing individual *piagi* rings. Relying on the growth rate formula outlined above, a given Jeffrey pine can be expected to increase roughly one inch in diameter for every eight years of life. Therefore, if a given trench never was reused after initial construction, it probably would be obliterated by increasing tree girth and associated soil uplift within approximately 200-300 years. Hence, progressive obscuration (or lack thereof) should allow for adjustment to the maximum age estimates for individual trenches. In light of preservation constraints, recently deposited volcanic ejecta (see below), and the upper age limit of Jeffrey pine, it seems unlikely that trenches older than 500 years are still in existence. As a result, suggestions regarding the greater time depth for this subsistence practice are necessarily reliant on inferences drawn from other facets of regional subsistence-settlement trends.

Current research in east-central California suggests that between roughly 600 and 1,300 B.P. there were major changes in regional subsistence and settlement patterns, affecting both the breadth of the dietary components and the intensity with which certain resources were exploited (Bettinger 1977; Bettinger and Baumhoff 1982; Weaver 1985; Basgall et al. 1986). This shift saw more regular use of high-cost resources (particularly vegetal products), and, apparently, the emergence of more sophisticated logistical organization. Energy data available for *piagi*, apparently superior to those of numerous plant resources (Simms 1984, 1985), are consistent with the notion that regular caterpillar exploitation might predate the more general subsistence intensification characteristic of the late prehistoric period. In being storable, caterpillars provide an equivalent to many seed resources, but have the added advantage of a high fat content. This latter may have been especially important during winter months, when the availability of animal-derived body fats is at a minimum (Speth and Speilman 1983). Although it seems probable that the time depth of *piagi* use is substantial, its role almost certainly became more significant with the general expansion of the subsistence base sometime after 1,300 B.P. That caterpillars attained a more focal position during the later period is likely, perhaps being more crucial to Mono Lake groups due to greater resource shortages in that region. This could partially account for the concentration of storage structures in the more northerly portions of the study area, reflecting an emphasis on logistical organization and a concern for more extensive harvesting. Such a conclusion is also supported by the fact that, in addition to all of the known storage structures, 75 percent of the known collection sites and 89 percent of all known collection trenches are located north of Glass Mountain Ridge within traditional Mono Lake Paiute territory.

Notwithstanding these general expectations regarding the trajectory of *piagi* use, the subsistence potential of the region may have been affected by a sequence of late Holocene volcanic events. Around 1,200 B.P., and again between 600 and 550 B.P., significant eruptions occurred in both the Inyo Craters and Mono Craters. These events blanketed the Long Valley-Mono Basin region with pumiceous deposits of varying depths. There is also some evidence for another local eruption around 800 B.P. (Hall 1983, 1984; Weaver and Hall 1984; Miller 1985; K. Sieh, personal communication 1985). Such events would have had a major effect on portions of the Pandora moth's habitat, although it is unlikely that the entire Jeffrey pine association would have been equally impacted. Without attempting to quantify the exact effects of such disturbances, it is safe to surmise that repeated eruptions would have reduced the productivity and availability of caterpillars in the area. Further, preexisting archaeological indicators of larvae collection, if extant, would have been buried.

SUMMARY

Using a variety of historic and archaeological data, it has been shown that both the anthropological and entomological literature have propagated a number of errors regarding the techniques employed in *piagi* procurement by the Mono Lake and Owens Valley Paiute. It has been argued that the resource was efficient from an energy standpoint, and its predictability, abundance, and storability contributed to its key role in regional subsistence-settlement systems. Although extant archaeological indicators probably do not predate 500 B.P., indirect evidence suggests that caterpillar exploitation has considerable antiquity in the area. It is probable, however, that the resource attained greater importance in the later prehistoric period when regional subsistence adaptations generally intensified.

NOTES

1. In other areas of the Desert West, the principal host trees variously include ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. murrayana*), sugar pine (*P. lambertiana*), and Coulter pine (*P. coulteri*) (Carolin and Knopf 1968).

2. Generally, the term "*piagi*" refers to any caterpillar or worm. Its application to a specific larva (and whether it was used as a foodstuff) is dependent on the particular groups, subgroups, or geographic location involved (Steward 1934:436, 436 fn.; C. S. Fowler, personal communication 1985).

3. Reports on file at the Inyo National Forest and the Eastern Information Center of the California Archaeological Inventory also note the existence of seven additional *piagi* collection locales, for which archaeological site records have not been completed. These contain a total of 26 trenches (one locus also has a single obsidian flake).

4. Another incident suggestive of the importance of *piagi* is also mentioned by Way (Miller and Hutchinson 1928:160) who reported that in about 1850 *piagi* were also plentiful on the western slope of the Sierra Nevada and that the Mono Lake Paiute crossed the crest to collect caterpillars within the territory of another tribe (Western Mono?). Certainly the western slope of the Sierra is within the habitat range of *C. pandora* and, in fact, Brewer (Farquhar 1966:540) described what likely were collection trenches in the Vermillion Valley area of Fresno County in the early 1860s. Further, inter-group relations between eastern Sierran and Western Mono groups are known to have long existed. However, while it is possible that such events did occur, no other data presently known to us support a conclusion that such excursions took place regularly or even at all.

5. Without increment borings, the age of an individual tree can be estimated using the following: Jeffrey pine generally requires about 10 years to reach breast height after germination; thereafter a tree adds about eight annual growth rings for each 1 in. increase in diameter at breast height (W. Chandler, personal communication 1982).

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