J. Ethnobiol. 4(1):29-43 May 1984

EVIDENCE OF WOOD-DWELLING TERMITES IN ARCHAEOLOGICAL SITES IN THE SOUTHWESTERN UNITED STATES

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ABSTRACT.—Distinctively shaped fecal pellets of wood-dwelling termites have been recovered from a number of Southwestern archaeological contexts ranging from 600-2000 years of age. Pellet presence in a site may derive from prehistoric use of termite-infested firewood, or may signal actual termite colonization in the roofs and walls of ancient dwellings. Recovery of abundant uncarbonized pellets throughout strata should alert the archaeologist to possible post-occupational site disturbance; these same uncarbonized pellets may be useful in tracing the prehistoric geographic distributions of various Southwestern termite species. Carbonized pellets shrink differentially, depending on conditions under which they burned, and cannot be used to infer termite species identification and distribution.

INTRODUCTION

Some primal termite knocked on wood
And tasted it, and found it good,
And that is why your Cousin May
Fell through the parlor floor today.
Ogden Nash (1942)

When Ogden Nash wrote about termites with tongue in cheek, he acknowledged an insect whose history and habits have undoubtedly long interfaced with those of man. There is now evidence that wood-dwelling termites have lived close to humans in the American Southwest for at least ten centuries. Termite presence in prehistory may be signaled by distinctive fecal pellets recovered from ancient soil samples.

The archaeological record commonly reveals organic items that defy careful attempts at identification; often an ethnobiologist must be content with providing a thorough morphological description to share with colleagues. Escalated attempts at identification are justified if an unknown type occurs repeatedly in deposits at a single site, or in several locations that vary in both space and time. In the Southwestern United States a decade passed between recognition of a small item originally labeled the "Tule Springs Unknown" (Bohrer 1972:22), and its identification by an entomologist as a wood-dwelling termite fecal pellet. The connecting link was provided by a sharp-eyed graduate student who realized that small items associated with termite nests in California and Utah looked just like unidentified specimens he had observed while sorting plant and insect parts from archaeological soil samples. Subsequent comparison by the author of ancient charred "Tule Springs Unknown" specimens from a number of archaeological deposits with modern wood-dwelling termite fecal pellets confirmed the identity of the ancient unknown.

THE NATURAL HISTORY OF WOOD-DWELLING TERMITES

In contrast to earth-dwelling termites that actually inhabit soil, wood-dwelling termites are entirely confined to wood, the whole colony generally living within a small section of trunk or branch (Light 1946a). These termites enter wood directly from the air during swarming, and remain there throughout the life of the colony. Wood-dwelling termites comprise two major types: the dry-wood insects that attack only sound, dead wood with a relatively low moisture content, and damp-wood termites that require moister, often decaying wood. Dry-wood termites can easily invade and live in wood located high above ground such as the wooden rafters of an adobe dwelling; they require no contact with the ground throughout colony life. In contrast, damp-wood termites may often be encountered in buried wood along water-courses or in buried stumps.

Distribution.—About forty species of termites inhabit the continental United States. Nearly all species are native, having been here for millenia before humans arrived on the continent. People, however, modify termite distribution by providing for their spread into new and unoccupied areas (Kofoid 1946a:7). Activities such as the transport of infested soil, wood, household furniture, and living plants provide a means by which termite colonies become established in regions wholly new for some species. Lines of fence posts and poles connecting cities and villages facilitate the spread of termites from one locality to another. Termites now inhabit colder northern regions, warmed by the same fossil-fuel burning furnaces that keep people warm.

Two families comprising five genera of wood-dwelling termites are known from native habitats in the Southwestern United States today (Table 1) They include species of both restricted and extensive distribution. Over half of the nine species occur below 1130m. Patterns of plant use vary widely among the termites, with some occurring in few plants, while others are found in a variety of plants in a broad range of habitats.

Food.—The food of termites is cellulose, one of the more resistant and durable products of photosynthesis. Cellulose is extremely abundant in the xylem, or conducting tissue, of woody plants. In general, sapwood is more appealing to a termite because it contains less lignin and a greater amount of useful organic compounds than heartwood; likewise, un-seasoned wood is more vulnerable to termite attack, as is wood felled in the summer (Kofoid 1946b:571). While termites exhibit preferences when offered a variety of wood types (Williams 1946:572) they will often eat whatever is available; even redwood, cedar and cypress, often touted as "termite resistant", are vulnerable. Five of the termites listed in Table 1 are known to live in six or more native plants. Others opportunistically inhabit whatever tree products humans make available to them. These records suggest that choice of host material may sometimes be as much controlled by proximity as any other factor. If adequate moisture and minimum temperature requirements are met, wood-dwelling termites might be able to survive in at least some of the woody plant species in any given region.

Most termites can break down the cellulose of their plant hosts because of a symbiotic relationship with various *Protozoa* and bacteria that live in their gut (Kofoid 1946a: 5; LaFage and Nutting 1977). Undigested residue containing from 40-60% lignin, less than 30% carbohydrates, and negligible nitrogen is eliminated (LaFage 1976:98; Lee and Wood 1971:393). Because of the relatively low moisture content of the wood they eat, wood-dwelling termites often produce compact recognizable fecal pellets (Light 1946b: 215).

Fecal Pellets.—A typical pellet of a wood-dwelling termite is a small, hard, oblong object possessing six surfaces. At the angles between the six surfaces, longitudinal ridges are often visible (Fig. 1). One end of the pellet is usually blunt, while the other may appear slightly tapered or rounded reminding one of a bullet (Fig. 2). The sides of the pellet are generally parallel to one another, but may slope to one end as in pellets of *Paraneotermes*. The sides may be flattened, slightly convex or sometimes concave. Pellet color is quite variable, apparently related to the kind of wood being eaten (Castle 1946:281). The author has seen white, tan, brown, black and mottled modern pellets. Pellet surface texture appears finely granular at 60x magnification; when cut in cross section, the interior is of a solid homogeneous texture similar to the exterior.

Length and width of modern termite pellets vary with species. Fifty randomly chosen, entire pellets of eight Southwestern wood-dwelling species were measured under

TABLE 1.—*Ecological and plant-host data on wood-dwelling termites of the Southwestern United States.*

Type of Termite; Family and Species	Geographical Distribution and Elevational Range	Observed Plant Hosts of Various Natural Habitats and Man-made Habitats/Structures				References
		Desert	Riparian	Mountain	Introduced Plants or hosts provided by humans	
Dry-Wood Termites: Family Kalotermitidae						
Incisitermes banksi[1] (Synder)	Rare and little known termite of Sonoran desert scrub in southeastern Arizona, in grassland in south-central Texas, and from Sonora and Chihuahua, Mexico. 640-1100m (2100-3600')	*Prosopis juliflora* var. *velutina*	—	—	—	Nutting 1979:308-310; Weesner 1965:59
Incisitermes fruticavus (Rust)	Recently described termite from southern California. 660-700m (2160-2300')	*Simmondsia chinensis*, *Rhus ovata*	—	—	—	Rust 1979
Incisitermes minor[2] (Hagen)	Wide geographical and ecological range, from southwestern California, north to Washington State, east to eastern Arizona, north into Utah, south into Baja, California and west into Sonora, Mexico. 0-1675m (0-5500')	—	Sycamore, walnut, cottonwood, ash, Arizona cypress, Monterey cypress, *Umbellularia californica*, driftwood	*Juniperus deppeana*, pinyon pine, white cedar	maple flooring, pine firewood, hard pine fence, all types of man-made structures	Banks & Snyder 1920: 136; Light 1946b:210; Weesner 1970:488; Wm. Nutting, personal collections.

TABLE 1.—*Ecological and plant-host data on wood-dwelling termites of the Southwestern United States.* (continued)

Type of Termite Family and Species	Geographical Distribution and Elevational Range	Observed Plant Hosts of Various Natural Habitats and Man-made Habitats/Structures				References
		Desert	Riparian	Mountain	Introduced Plants or hosts provided by humans	
Marginitermes hubbardi[3] (Banks)	Wide geographical range, in low and dry areas of the desert Southwest, from Baja, California to western Mexico, south to Jalisco and from extreme southeastern California across southern Arizona to extreme southwestern New Mexico. 0-1130m (0-3700')	Paloverde, saguaro, cardon	Willow, cottonwood, walnut, sycamore, Arizona ash	—	Western red cedar shakes, teak boat deck, furniture, railway cars, grapevines, mulberry, corn plants, douglas fir stored in Phoenix lumberyard, rafters in adobe structures	Banks & Snyder 1920: 137-139; Weesner 1970: 485; Wm. Nutting, personal collections.
Pterotermes occidentis[3] (Walker)	Within the general limits of the Sonoran desert in southern Arizona and Baja, California. 0-1100m (0-3600')	*Cereus giganteus, Cercidium floridum, Yucca Whipplei, Y. valida, Agave shawii, Idria columnaris*	—	—	—	Weesner 1970:484; To, et al. 1980:113.
Damp-Wood Termites: Family Kalotermitidae						
Paraneotermes simplicornis (Banks)[3]	A termite of hot, arid regions. Extensive range into southeastern California, southern Nevada, Arizona, Texas, Baja, California, Sinaloa, Mexico. 0-1100m (0-3600')	*Prosopis juliflora, Parosela spinosa, Parosela californica, Atriplex, Acacia greggii,* paloverde, saguaro, cholla	Cottonwood, sycamore, Arizona cypress, *Chilopsis*	—	redwood fence posts, pecan, eucalyptus, pyracantha, apricot, citrus, houses	Light 1937:424; Weesner 1970:486; Wm. Nutting, personal collections.

TABLE 1.—*Ecological and plant-host data on wood-dwelling termites of the Southwestern United States.* (continued)

Type of Termite Family and Species	Geographical Distribution and Elevational Range	Observed Plant Hosts of Various Natural Habitats and Man-made Habitats/Structures				References
		Desert	Riparian	Mountain	Introduced Plants or hosts provided by humans	
Family Hodotermitidae						
Zootermopsis angusticollis (Hagen)	Abundant in the more humid forested, coastal areas from southern British Columbia to northern Baja, California. 0-1220m (0-4000') in northern part of range; 0-1830m (0-6000') in southern part of range.	–	sycamore, walnut, laurel, maple	redwood, pine, douglas fir, madrone	pear	Light 1946c:314; Castle 1946:275; Wm. Nutting, personal collections.
Zootermopsis laticeps (Banks)	Near watercourses in the southeastern quadrant of Arizona, as far north as Sedona and eastward into Southwestern New Mexico. 460-1675m (1500-5500').	–	*Populus Fremontii, Alnus oblongifolia, Platanus Wrightii, Salix Gooddingii*	–	pecan	Nutting 1965; Wm. Nutting, personal collections.
Zootermopsis nevadensis (Hagen)	In cooler, drier, higher areas in Vancouver Island, British Columbia, south to central California, and from the Pacific coast east to Montana. 0-1830m (0-6000').	–	–	pine, "fir", redwood, *Juniperus*	–	Banks & Snyder 1920: 122-124; Castle 1946: 275; Weesner 1970:482.

[1]Synonyms are *Incisitermes texanus* (Banks) and *I. lighti* (Snyder).

[2]Synonym is *Incisitermes arizonensis.*

[3]Represents a monotypic genus in North America.

FIG. 1.–Sketch of a typical wood-dwelling termite fecal pellet, enlarged approximately 18x normal size. Cross-sectional view (a) reveals hexagonal shape, while parallel ridges are evident on longitudinal view (b).

FIG. 2.–Longitudinal view of modern *Incisitermes minor* termite fecal pellets, magnified 15x their average length of 1.14 mm. Light colored parallel ridges alternate with darker, slightly concave sides.

30x magnification with an ocular micrometer (Table 2). Pellet diameter, measured midway along the length before tapering begins, is generally less variable than pellet length, measured from blunt to tapered end. A larger sample of 200 pellets of *Pterotermes* revealed population statistics nearly identical to those of the smaller 50-pellet sample, suggesting that a 50-pellet sample was representative.

ARCHAEOLOGICAL DISTRIBUTION IN THE AMERICAN SOUTHWEST

Wood-dwelling termite fecal pellets have been clearly documented in a number of archaeological contexts in association with humans in the Southwestern United States (Table 3). These pellets span broad geographical and elevational ranges, and derive from a variety of ancient Southwestern cultural traditions. All pellets are from contexts at least 600 years old, up to perhaps 2000 or more years of age.

Most of the prehistoric specimens appeared charred to investigators (Fig. 3); these ancient organic items probably preserved through time because exposure to fire rendered them unappealing to degradative organisms. At each ancient site, such criteria as context of recovery, carbonized condition, and presence of protective non-cultural sediment over cultural debris were employed to help rule out the possibility that these pellets might be unrelated to the period of site occupation. A few tan specimens, apparently not carbonized, were also judged to relate to site occupation by the criteria of site context and location beneath protective non-cultural overburden. Preservation of non-carbonized fecal pellets may be due to both pellet content and environment of deposition. Items with a high proportion of lignin are not a food resource for most organisms, although some Basidiomycetes can thrive on lignin (Leo and Barghoorn 1976:4). Because these fungi function optimally only in moist, aerobic settings, termite fecal pellets buried in dry, oxygen-restricted sediments, may have been unable to support decomposers.

TABLE 2.—*Diameter and length measurements on 50-pellet samples of eight wood-dwelling Southwestern termites.*

Species	Pellet diameter (mm)			Pellet length (mm)		
	Range	x̄	σ	Range	x̄	σ
Pterotermes occidentis (Walker)	.59 - .83	.71	± .06	1.17 - 1.57	1.37	± .10
Zootermopsis angusticollis (Hagen)	.56 - .82	.69	± .063	.89 - 1.31	1.10	± .103
Zootermopsis laticeps (Banks)	.55 - 1.07	.81	± .13	.98 - 2.14	1.56	± .29
Incisitermes minor (Hagen)	.54 - .74	.64	± .048	.93 - 1.35	1.14	± .104
Marginitermes hubbardi (Banks)	.53 - .69	.61	± .04	.82 - 1.10	.96	± .068
Paraneotermes simplicornis (Banks)	.45 - .61	.53	± .04	.51 - 0.87	.69	± .09
Incisitermes banksi (Snyder)	.40 - .56	.48	± .04	.63 - 0.91	.77	± .07
Incisitermes fruticavus (Rust)	.40 - .56	.48	± .04	.70 - 1.00	.85	± .076

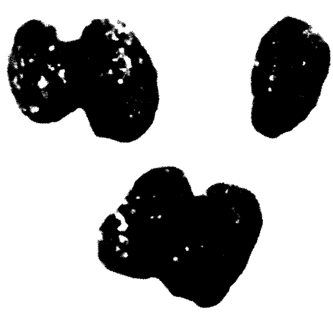

FIG. 3.—Longitudinal view of prehistoric charred termite fecal pellets from a site along the Gila River near Florence, Arizona. Although the pellets are magnified 17x their average length of .87 mm, they probably shrank when burned. Sometimes ancient pellets occur fused to one another.

CULTURAL SIGNIFICANCE OF TERMITE FECAL PELLETS IN ARCHAEOLOGICAL SITES

Two possible routes of introduction of termite fecal pellets into ancient dwellings include transport in locally gathered firewood, and infestation of roof or side-wall construction material.

Firewood.—Shrubs and trees brought in for firehearth fuel may have provided one very likely avenue for termite debris to enter a dwelling. Both living and dead termite colonies

TABLE 3.–*Termite fecal pellets in association with ancient human habitations in the Southwestern United States.*

Site Name	Location and Elevation	Main Vegetation Today	Cultural Affiliation and Time	Context of Recovery	Average length and width (mm) of pellets; notes; condition of pellets[1]	References
Hay Hollow	Central Arizona, near Snowflake; 1750m (5750')	Scattered pinyon and juniper, with *Sporobolus* grassland.	Mogollon Tradition; small house clusters of hunters and gatherers; 300 B.C.-300 A.D.	On floor or entryway of two structures, and in 7 separate firepit samples, plus 1 burial.	.77 x .495 (n=10); three are conical; Charred.	Bohrer 1972:23 as "Tule Springs Unknown"
La Ciudad	Arizona, along the Salt River, near Phoenix; 335m (1100')	Paloverdes and urban vegetation in the Lower Sonoran Life Zone.	Riverine Hohokam Tradition; sedentary agriculturalists; 900-1100 A.D.	Fourth most common item in over 70 1-2 liter dirt samples from trash areas. Also in 1 of 8 pit house floors.	.84 x .52 (n=17); Charred.	Gasser 1981 as "Tule Springs Unknown"
ARIZ U:15:19	Arizona, along the Gila River near Florence; 460m (1500')	*Larrea, Cercidium,* and saguaro.	Hohokam Tradition, Civano Phase; post 1300 A.D.	Feature 509 (SN498), a surface structure that burned down; burial inside.	.86 x .53 (n=6); plus 3 clusters of 8-10; Charred.	Charles Miksicek unpublished data.
				Hearth (SN497), in structure 509.	.87 x .49 (n=5); Charred.	Charles Miksicek unpublished data.
				Feature 522 (SN3114), surface structure.	.83 x .53 (n=13) clusters; Charred.	Charles Miksicek unpublished data.
					1.60 x .75 (n=1); Charred.	Charles Miksicek unpublished data.
ARIZ U:15:87	Arizona, along the Gila River near Florence; 460m (1500').	*Larrea, Cercidium,* and saguaro	Hohokam Tradition, Soho Phase; 1150-1250 A.D.	Feature 20 (SN401), a post-reinforced pithouse.	1.90 x .93 (n=2); Charred.	Charles Miksicek unpublished data.
Fresnal Shelter	New Mexico, in Sacramento Mts. near Alamogordo; 1920m (6300')	*Larrea, Prosopis, Juniperus,* pinyon and grasses.	Archaic Hunting and Gathering Tradition; limestone rock shelter; 1600 B.C.-1 A.D.	Grass-lined cist, Cat. No. 01.C26.85. Disturbed area, Cat. No. 01.C30-22. Cat. No. 01.C31.18	1.12 x .57 (n=2); Tan 1.10 x .60 (n=1); Charred. 1.00 x .60 (n=1); Charred.	Bohrer 1981 as "Tule Springs Unknown"; Irwin-Williams 1979:41

TABLE 3.—*Termite fecal pellets in association with ancient human habitations in the Southwestern United States.* (continued)

Site Name	Location and Elevation	Main Vegetation Today	Cultural Affiliation and Time	Context of Recovery	Average length and width (mm) of pellets; notes; condition of pellets[1]	References
Salmon Ruin	New Mexico, near Farmington; 1780m (5840')	*Juniperus, Atriplex, Artemisia* and grasses.	Anasazi Tradition, sedentary agricul-turalists; stone and adobe pueblo; 1100-1300 A.D.	In 25 of 64 flotation samples from floors and trash.	.85 x .41 (n=4); Some charred; others tan.	Adams 1980a; Adams 1980b; Bohrer & Adams 1977:199 as "Tule Springs Unknown"

[1] All pellets measured by the author.

would be expected to harbor some pellets in the colony chambers and passageways; burning might slowly heat these protected pellets as the fire etched into the fuel source. Eventual carbonization of the pellets might result. The irregular occurrence of charred termite pellets in samples from a site in Phoenix, Arizona (Gasser 1981:359) could reflect the occasional use of termite-infested wood for hearth fuel. Charred pellets in seven separate fire-pit samples at a site near Snowflake, Arizona (Bohrer 1972), may also owe their presence to this mode of introduction.

Infestation of Wooden Roof Beams and Wall Supports.—Perhaps ancient dwellers in the Southwest experienced termite damage to various parts of their homes or towns. Puebloans of the Anasazi Tradition, as evidenced at Salmon Ruin in northwestern New Mexico, built stone and adobe towns that had multi-layered roofs of plant materials. For example, one room had a roof that consisted of a basal layer of large wooden beams (vigas) of *Pinus*, *Juniperus* and *Pseudotsuga* (douglas fir), topped by smaller trunks (latillas), a layer of *Salix* (willow) twigs, and finally *Juniperus* bark, all interspersed with mud and dried plant parts (Adams 1980c). Such a roof, many meters above ground level and supported by sturdy walls of adobe and stone, was vulnerable to attack by termites. Airborne infestation by wood-dwelling termites could be signaled by hexagonal fecal pellets that might drop to floors below and be recovered in soil samples taken centuries later. While Dr. William Robinson of the Laboratory of Tree-Ring Research in Tucson, Arizona has not observed termite damage in any of the large prehistoric beams taken from structures in the Chaco, Mesa Verde or Kayenta Cliff Dwelling areas (Letter Jan. 8, 1982), perhaps the smaller latilla or twig layers provided suitable nesting sites. Finding termite-galleried wood in ancient roof debris is needed to confirm this hypothesis.

Prehistoric dwellers of the Hohokam Tradition in Arizona built structures unlike the communal pueblos of the Anasazi. Single houses, often partially sunken into the ground, were common among the Hohokam. The side walls of dwellings constructed at Snaketown, a large Hohokam town in central Arizona, were fashioned of such plants as *Populus* (cottonwood) and *Prosopis* (mesquite), and occasionally of *Juniperus*. Mesquite and cottonwood were also used for the overhead rafters and lighter layers that comprised the roof (Sayles 1938:81; Haury 1978:72). One can speculate that these plant materials may have housed termites.

ENTOMOLOGICAL/ENVIRONMENTAL SIGNIFICANCE

The broad geographic and elevational distribution of termite fecal pellets in the archaeological record posed the intriguing possibility of discerning the prehistoric distribution pattern of termites. Entomologists might appreciate a prehistoric biogeographical view of termite range, while archaeologists might have yet another means to infer local site conditions by knowing what termites lived nearby. Length and width measurements of modern pellets were secured to determine if one or perhaps a few of the species could be distinguished from all others. The resulting dichotomous key based on modern termite pellet population statistics (Fig. 4) revealed that, as with any naturally varying group of organisms, some species had unique attributes while others had pellets with characteristics shared in common by one or more species.

The real problem with identifying ancient termites from their pellet morphology does not lie with overlapping population characteristics however. Carbonization experiments performed on carefully measured populations of modern pellets revealed that shrinkage in both length and width dimensions can be moderate to severe (Table 4), depending upon amount of oxygen present and length of time exposed to fire. The variable nature of termite pellet shrinkage parallels that found by researchers undertaking modern seed carbonization experiments. Seed size changes due to burning vary with inherent seed differences (Renfrew 1973:11-13), moisture content (Stewart and Robert-

1.	Diameter .40-.45mm	*Incisitermes banksi, I. fruticavus*
1.	Diameter greater than .45mm	2.
2.	Diameter .45-.53mm	3.
2.	Diameter greater than .53mm	4.
3.	Length .51-.87mm, conical shape	*Paraneotermes*
3.	Length .63-1.00mm, rectangular	*Incisitermes banksi, I. fruticavus*
4.	Diameter .53-.61mm	5.
4.	Diameter greater than .61mm	14.
5.	Length greater than .93mm	6.
5.	Length less than .93mm	11.
6.	Length .93-.98mm	*Marginitermes, I. minor, I. fruticavus, Zootermopsis angusticollis*
6.	Length greater than .98mm	7.
7.	Length .98-1.10mm	*Marginitermes, I. minor, Z. laticeps, Z. angusticollis*
7.	Length greater than 1.10mm	8.
8.	Length 1.10-1.17mm	*I. minor, Z. laticeps, Z. angusticollis*
8.	Length greater than 1.17mm	9.
9.	Length 1.17-1.35mm	*I. minor, Z. laticeps, Z. angusticollis, Pterotermes*
9.	Length greater than 1.35mm	10.
10.	Length 1.35-1.57mm	*Z. laticeps, Pterotermes*
10.	Length greater than 1.57mm	*Z. laticeps*
11.	Length less than .63mm, conical	*Paraneotermes*
11.	Length .63-.93mm	12.
12.	Conical shape	*Paraneotermes*
12.	Rectangular shape	13.
13.	Length .63-.82mm	*I. banksi, I. fruticavus*
13.	Length greater than .82mm	*I. banksi, I. fruticavus, Marginitermes, Z. angusticollis*
14.	Diameter .61-.74mm	15.
14.	Diameter greater than .74mm	16.
15.	Length less than .93mm	*Marginitermes, Z. angusticollis*
15.	Length greater than .93mm	6.
16.	Diameter .74-.83mm	17.
16.	Diameter greater than .83mm, length .98-2.14mm	*Z. laticeps*
17.	Length less than 1.17mm	*Z. laticeps, Z. angusticollis*
17.	Length greater than 1.17mm	18.
18.	Length 1.17-1.57mm	*Z. laticeps, Z. angusticollis, Pterotermes*
18.	Length greater than 1.57mm	*Z. laticeps*

FIG. 4.–Dichotomous key to whole, uncarbonized modern fecal pellets from wood-dwelling termites living in the Southwestern United States.

TABLE 4.—*Mean size measurements of modern termite fecal pellets before and after exposure to heat.*

Dimension	Oxygen-rich carbonization[1] of *Incisitermes minor* pellets			Anaerobic carbonization[2] of *Pterotermes occidentis* pellets		
	Before Exposure (n=50)	After Exposure (n=50)	% Shrinkage	Before Exposure (n=50)	After Exposure (n=37)	% Shrinkage
Length	1.14 mm	1.06 mm	7	1.26 mm	.86 mm	32
Diameter	.64 mm	.60 mm	6.6	.73 mm	.51 mm	30

[1]Carbonized in a coffee can over an electric hot plate for three minutes.

[2]Carbonized inside aluminum foil buried in hot coals for over one hour.

son 1971:381), as well as maturity, evenness of carbonization and total amount of charring (Brugge 1965:49). It would be impossible to know, in this case, how much shrinkage had been experienced by pellets recovered from the ashes of an ancient firepit. Since the bulk of pellets recovered from Southwestern archaeological sites to date have been carbonized[1], at present the size dimensions give no clues to the identity of the termites. As uncarbonized pellets are recovered, however, they should be classified in the hopes that both environmental information and the distribution of prehistoric termites may become known.

TERMITES AS AGENTS IN THE DISTURBANCE OF ARCHAEOLOGICAL SITES

In addition to suggesting prehistoric termite biogeography, abundant uncarbonized pellets in an ancient site might serve as a clue to pre or post-depositional modification of strata. For example, wood-dwelling termites could easily inhabit dense organic deposits that are typical of dry caves or rock overhangs in the American Southwest. As termites utilized buried wood, sediment mixing could occur as internal, now-empty spaces collapsed downward. The archaeologist should consider such a natural transformation process in deposits that reveal broad distribution and fair numbers of uncarbonized pellets.

Earth-dwelling termites could also play a major role in soil mixing of non-cave archaeological sites, where moisture content is generally higher. Termites in North America have been known to mix, alter, invert and obliterate soil horizons, as well as create new horizons and affect the spatial boundaries of different soils (Wood and Johnson 1978:325). Not only might termites mix soils, but they could also provide channels for air and water to move downward through deposits and thus increase chances of oxidation of organic material and destruction by fungi and bacterial degradative organisms. Since earth-dwelling termites do not produce recognizable six-sided fecal pellets, spotting their former presence in a site would be difficult.

SUMMARY

Fecal pellets from wood-dwelling termites had been isolated from Southwestern United States archaeological soil samples for at least ten years before their identification was secured. Potential avenues for the introduction of termite fecal pellets into ancient

dwellings include plant materials carried in as fuel, and infestation of roof or wall supports. Often the pellets are charred in ancient deposits. Carbonization experiments performed on modern pellets in the presence and absence of oxygen reveal that termite pellets shrink from 6-30% in both length and diameter. Therefore, the possibility of inferring ancient termite distribution from the morphology of carbonized pellets from archaeological sites seems remote. While this particular record is mute regarding biogeographical and ecological data, other non-burned records may not be so. In a dry site, such as a cave or rock overhang, widespread occurrence of non-burned pellets could signal extensive termite colonization and potential mixing of site deposits. The identification and interpretation of insect remains from archaeological sites remains a largely unexplored, and undoubtedly rich, source of information.

ACKNOWLEDGMENTS

The keen sense of observation of Mr. Alan C. Reed, while a graduate student at Eastern New Mexico University, provided the first clue that an unknown item from a number of Southwestern archaeological sites might derive from termites. Without reservation Dr. William L. Nutting of the Department of Entomology, University of Arizona, confirmed the hunch. Dr. Nutting also provided guidance and, along with Dr. Michael K. Rust of the University of California, Riverside, supplied me with modern termite fecal pellets for examination. Vorsila L. Bohrer not only recovered and described the first "Tule Springs Unknown" specimens, she also served as the catalyst for this study. My parents Louise and Adrian Rogers assisted with technical details, and Cynthia Lindquist photographed the modern and ancient pellets. Colleagues in ethnobiology, noted in Table 3, kindly sent me ancient termite pellet specimens for scrutiny.

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NOTE

[1]To distinguish naturally black items from those turned black by exposure to heat, one can gently scratch the specimen against a piece of white paper, and a carbonized item will generally leave a slight streak or smudge.

Book Review

The Desert Smells Like Rain: A Naturalist in Papago Indian Country. Gary Paul Nabhan. San Francisco: North Point Press, 1982. 148 pp., illus., $12.50.

From an overture punctuated by spadefoot toads and desert thunderstroms, to a *pastorale* of bird-song around a desert oasis, and a crescendo of *mariachi* and Papago polka bands, **The Desert Smells Like Rain** presents an intimate view of the Sonoran Desert and its native people. Ethnobiologist Gary Nahban shares his experiences and insights while studying run-off agriculture and traditional crops in the borderlands of Arizona and Sonora. These adventures include a trek to *I'itoi's* cave in the Baboquivari Mountains, a visit to a saguaro wine-drinking and rain-bringing ceremony, expeditions to two relic oases in the desert, and a pilgrimage to the *Fiesta* of San Francisco Xavier in Magdalena, Sonora. Along the way he introduces the reader to his Papago acquaintances, who are more friends than just informants.

In other chapters, Gary Nabhan explores the relationship between the disappearance of traditional foods and dietary patterns and the endemic increase of diabetes, cardiovascular problems, and other nutrition-related diseases among the Papago. He also examines the native view of the indigenous wild relatives of important cultivated plants. Wild tepary beans, gourds, cotton, and tobacco are all considered to be plants that Coyote, the trickster deity, has stolen or otherwise spoiled. An important theme throughout **The Desert Smells Like Rain** is Papago cognition of the changing hydraulic regime of the Sonoran Desert and the abandonment of traditional floodwater farming.

Ethnography, germplasm conservation, linguistics, and traditional agriculture are interwoven with insight, myth, and humor in **The Desert Smells Like Rain**. An extensive collection of notes and references is included, but in the back of the book where it doesn't interrupt the flow of the text.

Gary Paul Nabhan should be added to the list of authors that includes Alfred Russel Wallace, Charles Darwin, Edgar Anderson, and Stephen Jay Gould, natural history writers with the unique talent of being able to present a tremendous amount of information in an enjoyable and very readable style.

CHM