Evidence of Termites in the Pleistocene Asphalt of Carpinteria, California

by

John F. Lance

Thesis Presented in Partial Fulfillment of Requirements

for the Degree of Master of Science, California Institute of Technology

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Abstract

Fossilized fecal pellets of termites are found in pine wood preserved in the Pleistocene Carpinteria asphalt deposits, Santa Barbara County, California. Both pellets and wood are thoroughly impregnated by tar. This material is associated with characteristic plant remains found in the Carpinteria asphalt. The pellets resemble in size and shape those of the modern termites, Kalotermes minor and Zootermopsis angusticollis or Z. nevadensis. The distribution of these species today includes the Monterey peninsula. Here a living Monterey forest assemblage of plants closely resembles that which existed in and about the Carpinteria asphalt accumulation during the Pleistocene.

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Introduction and Acknowledgments

Termites are among the most primitive of living insects, and they are well-known as fossils from the Tertiary, particularly in the Old World. In the Western Hemisphere, fossil termites are found in the Eocene of Tennessee (Collins, 1925), and in the Miocene shales of Florissant, Colorado (Scudder, S., 1883; Cockerell, T.D.A., 1913; Snyder, T.E., 1925), while fossilized fecal pellets were described by Rogers (1928; 1938) from the Pliocene of California and by Light (1930) from the Pleistocene of Florida.

In the summer of 1945 the writer found numerous fecal pellets of termites on pieces of wood preserved in the Pleistocene asphalt deposits at the Higgins ranch near Carpinteria, Santa Barbara County, California. The wood was found in association with typical

plant remains comprising a part of the Pleistocene Carpinteria flora as described by Chaney and Mason (1933).

Before commercial exploitation of the asphalt deposits was abandoned, the excavation near Carpinteria had been enlarged to form a pit approximately 600 feet long and 300 feet wide. The termite remains were taken from the eastern edge of the present pit, east of the original fossil localities, and near the top of the Pleistocene horizon. The stratigraphic difference between the two localities is less than 10 feet. Although the excavated Pleistocene floral remains were rather sparsely represented, no vertebrate fossils have been discovered by any recent digging in this section of the pit.

The writer wishes to acknowledge his debt to Dr. Chester Stock for guidance and helpful interest in the work. Thanks are also expressed to Dr. W. D. Pierce for loan of comparative material, and to Professor G. F. Beck of the Central Washington College of Education for his study of the wood. Mr. R. von Huene assisted in making the photomicrographs.

Fossil Termites

Termites are believed to have been derived from the Protoblattidae, a Pennsylvanian and Permian group believed to be also ancestral to the Blattidae, or roaches. According to Wheeler (1923),

termites probably reached a complete social and structural development in late Cretaceous or early Tertiary. However, no termite fossils are known from earlier than the lower Tertiary. A termite was reported by Collins (1925) from the lower Eocene of Tennessee, and a middle Eocene termite has been described by Cockerell (1916) from Burmese amber. Eocene and Oligocene termites have been described from England and East Prussia, being found in the latter locality preserved in Baltic amber. The insects are known from the Miocene of many parts of Europe and from the Miocene shales of Florissant, Colorado.

No fossil termites have been reported from the Pliocene, but Rogers (1928; 1938) has recorded termite fecal pellets replaced by opal in the Pliocene of California. The Pleistocene gum copal of Africa has yielded termites, and Light has described an occurrence of fossilized fecal pellets of a termite from the Pleistocene Seminole beds of Florida. These pellets have been shown to be probably related to the genus Kaletermes, very likely to K. schwarzi, a form now occurring in the same area.

Although there have been reports of termites from at least four localities in the Western Hemisphere, the Florissant beds remain the only major occurrence. The Eocene termite from Tennessee was described from a single wing imprint. This was identified as of the genus Mastotermes, which includes the most primitive known termites,

living or fossil. One species of the genus is now found in Australia. The opalized pellets described by Rogers, from Santa Barbara County, California, were originally thought to be an example of opal pseudomorphous after quartz, but a close examination shows the unmistakable characteristics of termite pellets.

Nature and Occurrence of Material

Before describing the fossil pellets, the distinctive characteristics of modern termite pellets should be noted. These pellets are the excreta of certain kinds of termites, notably the so-called damp-wood and dry-wood types. The rectum in these termites is so constructed that the pellet is extruded with a characteristic ovate shape, impressed with six flat or rounded sides which are separated by double longitudinal ridges divided by narrow grooves (Child, H. J. in Kofoid, C.A., pp. 33-83, 1934). The general appearance is thus roughly that of a hexagonal prism with rounded ends, sometimes slightly more pointed at one end. The exact shape of a pellet depends upon the type of termite and its diet, particularly with regard to moisture content. The pellets of dry-wood termites tend to be smaller and more characteristically impressed than those of the damp-wood termites, the pellets of the latter often being shapeless or rounded (Castle, G.B., in Kofoid, C.A., pp. 264-282, 1934).

If the termite is living in relatively damp wood, the pellets often tend to cling at random to the sides of runways, but in drier wood they fall and collect at the bottoms of chambers, or are carried to the exterior.

Cockroaches and certain kinds of beetles (Van Dyke, E. C., in Kofoid, C.A., pp. 323-335, 1934), particularly the Anobiid beetles or death watches, produce pellets which have superficial resemblance to those of termites. However, in each instance the pellets may be distinguished from those of termites by their longer and narrower dimensions and by a lack of the characteristic impressed shape.

The fossil pellets were found on pieces of tar-impregnated wood associated with floral remains typical of the Carpinteria deposits. Most of the pieces of wood are small chips and parts of branches, averaging not more than four or five inches in length, but one root four feet long was found to have pellets distributed throughout. This root was imbedded in two sides of a block of asphaltic sand which had been torn loose by power shovels used in former excavations. Although this block was not in place, the smaller fragments are from excavations in which they were closely associated with Pleistocene pine cones, pine needles, and seeds. No vertebrate remains were found, and the plant materials are by no means so abundant as those in the pits from which the original Carpinteria

flora and fauna were described.

Samples of the termite infested wood were sent to Professor George F. Beck who very kindly consented to examine them. Professor Beck states (letter to C. Stock, dated January 30, 1946) that the specimens represent the genus Pinus.

The termite pellets occur as granular masses adhering to the wood. In many cases, these masses fill or partially fill what were obviously old runways and chambers of a termite colony. The fossil pellets fall into two groups, and apparently represent a damp-wood termite and a dry-wood one. The damp-wood pellets are larger, averaging about 1.6 mm. in length. The more regularly-formed dry-wood pellets average about .9 mm. in length and are more likely to have one end slightly pointed. Chambers and runways of the old colonies can be clearly seen in several pieces of the wood.

A peculiar feature of the fossil occurrence is shown in Plate It can be seen that the two distinct types of pellets are intimately associated on the same piece of wood. This is unusual, since termites of different colonies of even the same species do not mingle. However, termites of different species and genera have been found existing in the same stump or piece of wood in places where their geographic ranges overlap (Light, S.F., in Kofoid, C.A., pp. 201-207, 1934). It seems probable that in this case the two types of termites inhabited

the same piece of wood, perhaps simultaneously, and that eventually one colony invaded certain chambers abandoned by the other colony.

As Light has pointed out, little has been done in making specific determinations of termites from their pellets. However, on the basis of size and shape it seems likely that the Pleistocene termites found at Carpinteria are the typical West Coast genera of dry-wood and damp-wood termites, Kalotermes minor and Zootermopsis, respectively. The damp-wood pellets suggest either Z. angusticollis or Z. nevadensis, more probably the latter, because of its smaller size.

The ecological conditions of the Carpinteria region in Pleistocene time, which are regarded as having been similar to those now existing on the Monterey Peninsula in Monterey County, California, give some support to these tentative determinations. The three species of termites named above all occur at present in the Monterey area. In fact, although California has at least 19 known species of termites, only 4 are found in the coastal and moist mountain regions (Light, S.F., in Kofoid, C.A., pp. 118-126, 1934). In addition to the three mentioned, Reticulitermes hesperus, called the Western subterranean termite, does not leave the typical impressed fecal pellets.

Carpinteria Pleistocene Assemblages

A preliminary report on the Carpinteria fossil material was made in

1927 by Hoffman, Stock, Miller, Chaney, and Mason. Since that time various authors have discussed the flora and fauna in greater detail. A. H. Miller, (1932), L. H. Miller (1931), and I.S. DeMay (1941) have described the bird life, Wilson (1941) the mammals, Chaney and Mason (1933) the plant life, and Grant and Strong (1934) have written on the invertebrate fauna. In a chapter in the paper on the flora, Irma Webber discussed the wood from the deposits. Putnam (1942), in a paper on the geomorphology of the Ventura region considered the geologic and physiographic features of the accumulation.

According to Chaney and Mason, most of the flora grew on a coastal slope, and a large proportion of the remains was brought to the site of accumulation by running water and impregnated by an asphaltic deposition. This conclusion is based on the water-worn character of much of the material, particularly chips of wood, and on the evidence of fungus decay shown by more than half of the wood, which decay would not have set in had the plant remains fallen directly into a tar pool. Furthermore, plants are preserved in nearby sediments of the Carpinteria formation where there has been no impregnation by tar and, also, a greater variety of species is represented than would be expected to be growing in the immediate vicinity of the accumulation. The occurrence of water-worn chips of redwood and Douglas fir, to the exclusion of twigs and cones of these species, suggests transportation from some distance away, as does the appearance of floral elements in the collection charac-

teristic of a dry, inner coastal region. These semi-arid elements include a few remains referable to the digger pine, California juniper, and Arctostaphylus glauca. A large representation of additional types of manzanitas, now associated with the Monterey pine forests, suggests that a heavy growth of underbrush existed with the Carpinteria forest.

Chaney and Mason (1930) made the suggestion that in Pleistocene time a peninsula, which included the area now represented by Santa Cruz Island, extended westward from the California mainland, partly enclosing an embayment. What is now the Carpinteria area occurred near its head. Pleistocene plant remains have been uncovered on Santa Cruz Island and the evidence points to the fact that remains of Douglas fir and Santa Cruz pine found in the Carpinteria asphalt did not grow at that locality, but were transported there either along the peninsula or across the embayment. The view is also advanced that the redwood specimens were brought down from the north by off-shore currents. This would indicate that the site of deposition was nearer the seashore than is suggested by the sparsity of aquatic birds in the avifauna.

The wood in the Carpinteria deposit was reported by Webber in a chapter in the paper on the flora. A total of 5,499 specimens of wood from the asphalt were examined (Chaney and Mason, 1933). Most of these were pieces of trunks or branches less than 2 inches in diameter, or were small fragments termed "chips". The water-worn character of many of the

specimens and the high percentage of fungus decay indicated that deposition was probably in alluvium that was later impregnated by tar. No evidence of termite infestation was reported in any of the wood.

From his study of the Carpinteria Pleistocene mammalian fauna, Wilson (1933) concluded that, although the presence of the shrew, chipmunk, and tree squirrel substantiates the sylvan environment at the site of deposition as inferred from the flora and avifauna, the appearance of the kangaroo-rat, horse, bison and Camelops, which normally live in more open country and in a semi-arid climate, suggests that the accumulation occurred near the edge of a forest and that there was a fluctuation in tree and plant cover during the time of entrapment. Wilson further states that the preponderance of juvenile to sub-adult individuals suggests their great susceptibility to entombment in a tar trap, and the possibility that the trap operated in an area which afforded tree and shrub cover to young individuals. He regards the age of the fauna as not older than Rancho La Brea, and possibly younger.

The consensus as to age of the Carpinteria fauna and flora is that they are approximately equivalent to Rancho La Brea and McKittrick, being possibly slightly younger than the former and slightly older than the latter. The tar pools were probably situated near the edge of a forest of Monterey pine, with heavy underbrush, and with adjacent patches of open grasslands. The site of deposition was on a coastal plain, but

nearness to a shore line is not expressed by any noticeable strand influence on the composition of the fauna. The climate was colder and more humid than that existing in the vicinity of Carpinteria today. The apparent discrepancies as to mode of accumulation have been discussed by Putnam (1942). The water-worn character of many of the plant remains as well as the diversity of plant types indicate transportation from a distance of some of the materials. Lack of evidence of attrition in most of the bones of the collection and the high percentage of predatory forms and of young individuals suggest a typical asphalt seep entrapment. According to Putnam, tar seeps are now operating as traps in the Upper Ojai valley, and the accumulations are being enriched from time to time by material transported to them by seasonal floods. Similar conditions might well explain the seeming paradox at Carpinteria.

Termites in the Californian Area

Although at least 19 species of termites are known in California, only 4 of these constitute the fauna of the coastal and moist mountain area: Kalotermes minor, Zootermopsis angusticollis, Z. nevadensis, and Reticulitermes hesperus (Light, S.F., in Kofoid, C.A., pp. 118-126, 1934). Since R. hesperus is a subterranean termite and does not leave impressed pellets, it will not be considered here, although it is of

major economic importance.

Kalotermes minor, the common dry-wood termite, has the greatest known range of American wood-dwelling termites. It is found in California in a narrow zone along the coast. Except for the fog belt of the San Francisco region, it extends as far north as Mendicino county. Although it does not thrive on moist wood, and cannot long exist in decayed wood, it has been found inhabiting the same log with Paraneotermes simplicornus, the desert damp-wood termite, and its range overlaps that of the damp-wood termites. Kalotermes is typically found "in dead branches, stubs of living trees, stumps, and occasionally in logs, chiefly along streams or in canyons, and along the forest edge." (Light, S.F., in Kofoid, C.A., pp. 201-207, 1934).

Zootermopsis angusticollis is confined to Western North America, and is the largest Pacific Coast termite as well as the most primitive Nearctic type. It requires much moisture, and is the more common damp wood termite in the more humid coastal areas, with a known range from Victoria, B. C. to the Mexican border. Z. angusticollis usually locates its colonies in damp, often decaying wood, and is frequently found in wood buried in or lying on the ground. (Castle, G.B., in Kofoid, C.A., pp. 264-282, 1934).

Z. nevadensis is less well-known than Z. angusticollis, but is similar, with only a few notable differences. It is smaller, and its range is more restricted; it is the more common damp wood termite in

cooler, drier, higher areas, and ranges from Vancouver Island to central California, and eastward to Montana. On the coast, its range extends as far south as the northern part of Monterey county. Z. nevadensis is forest-dwelling, primarily of the transitional zone.

Summary

Two types of fossil pellets found in pine wood in the Pleistocene Carpinteria asphalt resemble closely those of Kalotermes minor and Zootermopsis angusticollis or Z. nevadensis. Distribution of these termites at the present time includes the Monterey peninsula on which is found a Monterey forest assemblage like that which occurred at Carpinteria during the Pleistocene. It thus appears safe to assume that the fossil material represents termites which inhabited both damp-wood and dry-wood. This is in accord with evidence that varied ecological conditions existed during the accumulation of the Carpinteria flora and fauna.

It is worth emphasizing that no wood infestation by termites was noted among more than 5000 specimens examined in the collections previously obtained at Carpinteria. It seems likely that termites inhabited some of the pine wood after it was washed down from higher inland slopes and scattered in the vicinity of the tar pits, and that petroliferous impregnation occurred later.

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