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INSECT DAMAGE TO ABORIGINAL RELICS AT BURIAL AND ROCK-ART SITES NEAR CARNARVON IN CENTRAL QUEENSLAND

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Abstract

Damage to Aboriginal artwork on rock faces in the Carnarvon region of central Queensland by species of mud-nesting wasps, principally *Sceliphron laetum* (Smith), and by subterranean termites is described. A more serious conservation problem is the severe damage being caused by the termite *Nasutitermes carnarvonensis* (Hill) to human remains at many burial sites. Details reported here are the first confirmed account of this habit for an Australian termite. Infestation of burials may be related to nesting and water requirements of the termites. Insect species associated with the art sites are listed, and prospects for the prevention of damage by mud wasps and termites are discussed.

Introduction

With the increased emphasis in recent years on the preservation of Aboriginal sites has come a recognition of the threat posed to relics by some insects. Most attention has been focused on the serious and more visible damage to rock-art panels by the activities of mud-nesting wasps and by termite "trails" (galleries) (Naumann 1983; J. A. L. Watson pers. comm.). There is only brief mention in the archaeological literature of insect damage to human cadavers or skeletal remains in Australia, and rarely has the species responsible been identified (Haglund 1976; Watson and Abbey 1986; Wood 1976).

Over the past several years, the Queensland National Parks and Wildlife Service and the Australian Institute of Aboriginal Studies have been engaged in the recording of Aboriginal sites in the Carnarvon area. In the course of this program, serious conservation problems were identified not only with insect damage to rock paintings but also with severe damage by subterranean termites to skeletal remains at many burial sites (Walsh 1984). The assistance of the Queensland Department of Forestry's Entomology Group was enlisted, particularly in regard to the termite problem, and joint investigations commenced in December 1981. Preliminary findings are reported in this paper.

The Carnarvon region and its archaeological significance

The Carnarvon Range, so named by explorer Thomas Mitchell in 1846, forms a very small portion of an extensive geological province often referred to as "The Carnarvons". This area of almost 86 000 km^2 of mainly sandstone country, bounded approximately by the townships of Blackall, Springsure, Banana and Injune, has in recent years become more aptly known as the Central Queensland Sandstone Belt. Its dissected terrain is formed by at least 24 individual ranges radiating from the Great Divide, and its Jurassic/Triassic sandstones host one of Australia's richest concentrations of archaeological sites. Innumnerable eroded rock shelters and overhangs have provided ideal settings for Aboriginal burial sites and rock art panels. Environmental conditions in the region have permitted an often remarkable state of preservation of organic material.

The traditional Aboriginal groups of this area developed elaborate mortuary practices, as complex as any elsewhere in Australia. Human remains were usually deposited in selected rock shelters in intricately decorated bark burial cylinders. Various kinds of bark were used in the making of these cylinders, but by far the most commonly found surviving specimens are of the budgeroo tree, *Lysicarpus angustifolius*. The entrance of each shelter, typically a narrow, shallow cave in the rock face, was generally blocked by means of logs or large stones to form a burial "vault".

Burial goods in the form of weapons, artefacts and ceremonial objects were sometimes deposited with the cylinders together with burial food such as small animals and the fruit of the local zamia palm, *Macrozamia moorei*. Such caches, often very well preserved, provide a valuable insight into both the ceremonial and secular activities of the area's former inhabitants.

Of special significance in the rock art of this region is the strong bias towards stencilled motifs. Silhouettes of artefacts and weapons depicted by the stencil technique provide an accurate, measurable record of items of day to day use by the Carnarvon Aborigines (Fig. 1).

Surveys and identifications

During the period 8-11 December 1981, we inspected numerous burial and rock art sites in the Carnarvon Region where conservation problems had been identified previously. Collections were made of termites, wasps and other insects found within the shelters or on the rock faces at each site and the insect damage examined and photographed. Termite collections were also made in areas adjacent to the sites. A trial insecticide treatment was carried out on termites affecting relics at one site.

In the period from 1982 to 1984, further insect collections and field observations were made (by G.W.) in the course of site recording work in the area. Rearing of nest-building species from collected nests, dissections of nests, and identifications of insects collected during the study were undertaken at Indooroopilly.

Termite damage at burial sites

Walsh (1984) listed termites as one of the most serious natural threats to burial sites in the C.Q. Sandstone Belt. He has recorded extensive termite damage to relics at many sites but concluded that the full extent of this type of degradation may never be known because of the widespread pilfering and destruction of burials by visitors over the years. In June 1979, termite specimens were collected (by G.W.) for identification from an upper Warrego burial site. It is interesting that when these specimens were shown to an elderly local Aborigine Mr Fred Lawton, he became upset and insisted that these were "bad white ants ... that eat the old murris" (Aborigines). This concern was not expressed over samples of other local termites, indicating that the Aborigines of the area were aware of the burial destruction by this type of termite and thus that the habit was not new.

The termite was identified as *Nasutitermes carnarvonensis* (Hill) (J. A. L. Watson pers. comm.), a species about which little is known other than the original description by Hill (1942). Although Hill mentioned a large *N. carnarvonensis* nest on the ceiling of a cave, there is no record of this species (or the closely allied *N. exitiosus* (Hill)) attacking skeletal remains (J. A. L. Watson pers. comm.).

The Upper Warrego site was visited again in December 1981 to document observations. The burial chamber from which previous samples were taken was a shallow cave in a vertical, deeply weathered rock face. The cave was a few metres above ground level and was approachable only by ladder (Fig. 2). Inside the cave lay scattered bones and skulls of a multiple burial, the position of these remains indicating disturbance of the burial at some time by animals or man (or both). The bones were almost completely covered by carton (building material used by termites, composed of faecal matter mixed with materials from the environment) of an active colony of *N. carnarvonensis* (Fig. 3). Some of the bones were almost paper-thin having been eroded by the termites. A close examination of one of the skulls showed that the orbital and nasal cavities, upper jaw and cranial base were completely blocked by carton (Fig. 4, 5). The whole of the cranial cavity was filled with thin-walled multi-partitioned carton. Numerous workers and soldiers were seen but we were unable to search the material in the cavity for reproductives or immature stages which would have identified this as a "true" nest since we were concerned that attempts at dissection of the carton would further damage the fragile skull. Termite galleries criss-crossed the walls of the cave, joining the workings on bones and skulls and sometimes disappearing into rock crevices. A number of hardwood logs once used to block the mouth of the cave showed signs of termite attack although the outer timber of these logs was still largely sound.

FIG. 1—Stencil art on a rock overhang at Lady Springs, in the headwaters of the Warrego River, Queensland.

FIG. 2—Burial caves in a deeply weathered sandstone outcrop in the upper Warrego area. The termite *Nasutitermes carnarvonensis* was found attacking skeletal remains in the cave on the left. The entrance to this cave was decorated with artwork.

FIG. 3—Interior of cave showing termite carton over bones and skull of a disturbed burial, and termite gallery on wall (right) connected to skull workings. Logs showed evidence of termite attack but their outer casing was sound.

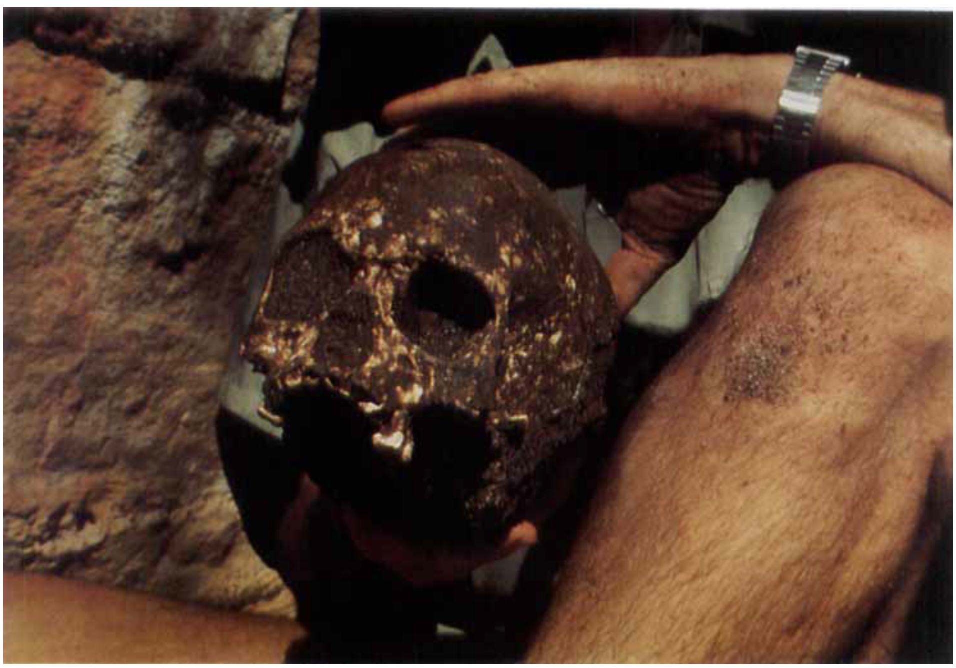

FIG. 4—Skull showing orbital and nasal cavities blocked with termite carton.

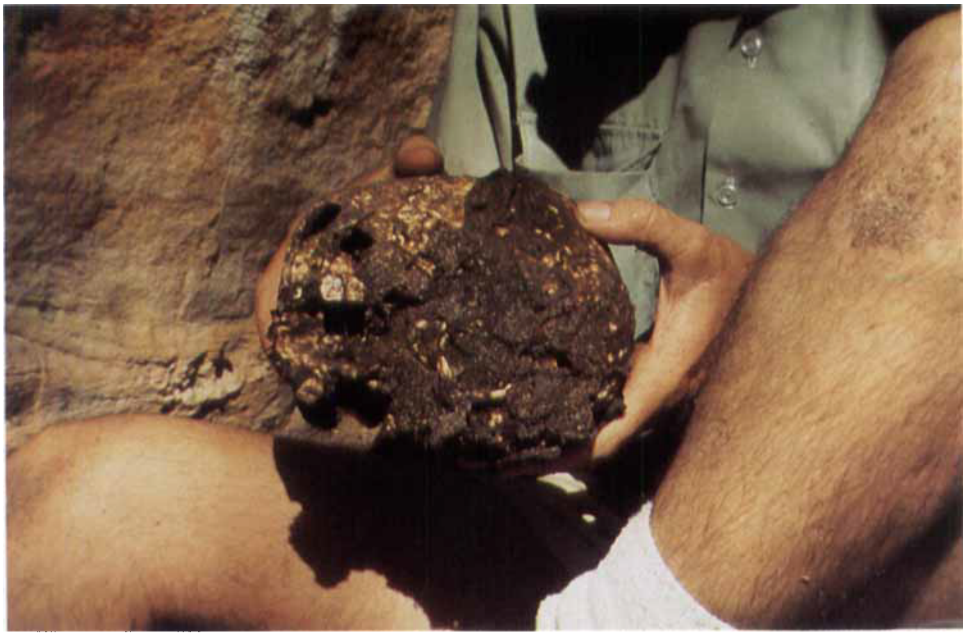

FIG. 5—Base of cranium enclosed by termite workings.

FIG. 6—Burial chamber (top) (previously disturbed) in Precipice sandstone formation in the upper Maranoa area, with its burial cylinder (on ground) removed for inspection.

FIG. 7—Close-up of "head" showing tooth embedded in nest material.

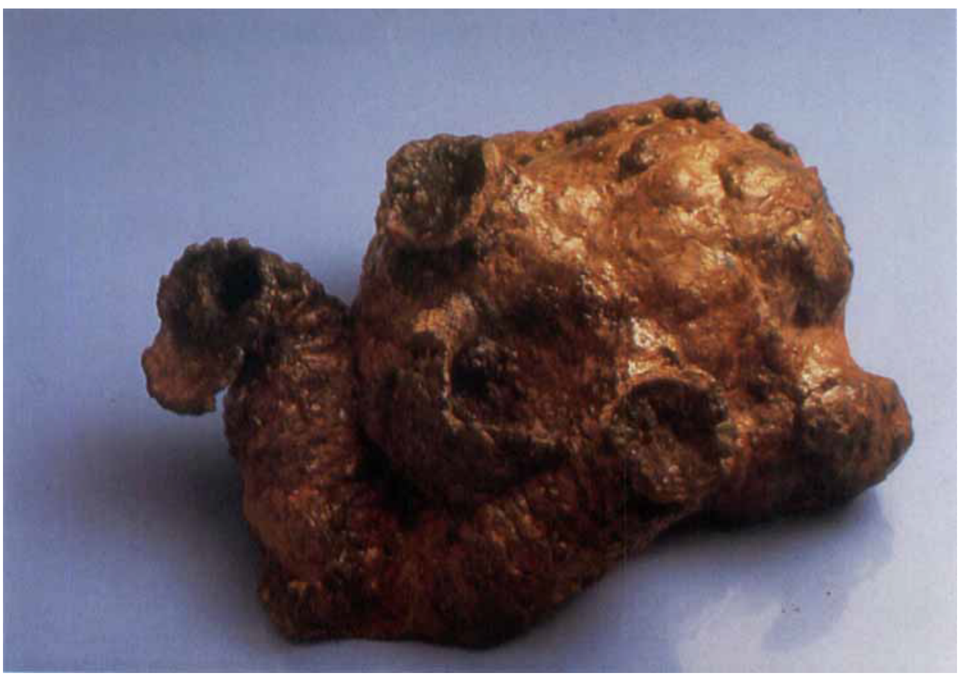

FIG. 8—Resin-impregnated nests of megachilid bees (*Chalicodoma* spp.) are difficult to remove from the rock faces.

Termite samples taken from the skeletal remains, from galleries on the walls of the cave, and from several locations on the cliff face and hill top were all *N. carnarvonensis*. No other termite species was found on this sandstone outcrop but *Schedorhinotermes intermedius intermedius* (Brauer) was found under a log not far from the burial cave. *Nasutitermes carnarvonensis* was also found at the base of a smooth-barked apple tree (*Angophora costata*) away from the outcrop. Hill (1942) records *N. carnarvonensis* from bark and sapwood of a living *Angophora* and from the heartwood of a living ironbark *Eucalyptus siderophloia*.

Walsh (1984) reported that it is not uncommon to encounter the remains of burial cylinders with the outer bark casing reasonably intact but with the skeletal contents eaten by termites. Wooden items deposited in burial sites often remain unmarked while nearby skeletal remains have been almost destroyed. One such site (previously disturbed) in the Upper Maranoa area was inspected in December 1981. The burial chamber was in the face of a Precipice sandstone formation (major cliff-forming unit of the geological province known as the Eramanga Basin), the entrance being approximately 2 m from the ground and once blocked by a short section of log (Fig. 6). The chamber contained an ochre-banded bark cylinder in which the body of a child had been deposited. The outer bark wrapping was virtually intact but the inner bark wrapping and cadaver had been totally destroyed by termites. The interior of the cylinder was occupied by an abandoned termite nest. No skeletal material was evident. However, the finding of a tooth embedded in carton in what once must have been the skull gave proof that the body had been destroyed by termite activity and not pilfered (Fig. 7).

Termite damage at art sites

In comparison to the damage caused to burials, termite activity at art sites in the Carnarvon region is of lesser severity and importance. An analysis by Walsh (1984) of data from 283 art sites in the region showed that 189 sites had no evidence of termite tracks, 65 sites had some tracks but not on the art, 20 sites had some tracks on the art, while only 9 sites had extensive termite damage of art.

Termite tracks can extend up to 100 m from the central nest (which may be a mound, arboreal, subterranean or diffuse depending on the species of termite). Where runways traverse exposed surfaces such as tree trunks and rocks, they are often covered with an arched sheathing of soil, rock fragments or digested wood to form enclosed galleries. At Carnarvon, when the sheathing was removed, a distinctive black mark was left on the paintings and sandstone surfaces. The problem was worse on the softer sandstone types where the staining had penetrated the friable rock surface. In addition to the staining, paintings were sometimes irreparably damaged through the termites chewing at the surface leaving a shallow groove in the rock.

Walsh listed "honeycombing" of rock as a problem at 196 of the 283 sites surveyed. In some places the sandstone surface was peppered with small holes and the outer few centimetres of rock riddled by a maze of tunnels or small chambers. Occasionally, termite tracks were found over the honeycombed surface leading into the perforations. The honeycombing may be the result of selective water erosion of the surface, but termites are capable of using and enlarging such features. In man-invaded environments, foraging termites will often damage materials they cannot digest, e.g. plastic, rubber, metal or mortar, and have been found nesting in materials such as polystyrene foam (Hickin 1971). It is also possible that, in some cases, the honeycombing process may be initiated by the nesting activities of anthophorid bees of the genus *Amegilla*, which often nest in banks of clay or soil and have been known to tunnel into soft mortar between bricks. I. D. Naumann and J. A. L. Watson (pers. comm.) noted hundreds of closely adjacent entrances, each several millimetres in diameter, in an area of sandstone at Laura, which they thought may have been made by this type of bee. A species of *Amegilla* was collected from a rock overhang at Carnarvon although no tunneling was observed.

No live termites were collected from galleries on artwork during 1981 or on other visits (by G.W.). J. A. L. Watson (pers. comm.) stated that such galleries are often deserted during the dry season and may be reinhabited during the wet season. Several termite species (*Coptotermes acinaciformis* (Froggatt), *Heterotermes ferox* (Froggatt), *Microcerotermes turneri* (Froggatt), *Nasutitermes carnarvonensis* (Hill), *Nasuititermes magnus* (Froggatt) and *Schedorhinotermes intermedius intermedius* (Brauer)) were found in areas adjacent to the sites near Carnarvon and could have been responsible for the galleries damaging the artwork. Watson *et al.* (1984) recorded species of *Coptotermes, Schedorhinotermes, Nasutitermes* and *Termes* from artwork at Laura.

Mud wasp damage at art sites

Walsh (1984) reported that mud wasp nests were present at 155 of the 283 art sites surveyed, but no figures are available on the proportion at which artwork was defaced by these. Collections of wasps, bees and other insects were made, and nests sampled, at a number of art sites in the region in December 1981, and during 1982-1984 (by G.W.) at various art sites in both Clematis (older sandstone unit beneath Precipice unit) and Precipice sandstone types in the Carnarvon Range area and in the headwaters of the Comet, Maranoa and Warrego Rivers.

Wasps and bees found in this survey are listed in Table 1. Primary nest builders pose most threat to the artwork. Secondary nest builders occupy abandoned nests and modify or partition them to suit their own needs. Ground nesting species are visitors to the rock faces and shelters and sometimes build their tunnels in soil beneath overhangs. With the exception of *Amegilla* they posed no threat to rock art.

Table 1. List of mud nesting and ground nesting Hymenoptera (wasps and bees) collected at art sites in the Carnarvon region over the period 1981-1984

PRIMARY MUD NEST BUILDERS	SECONDARY MUD NEST BUILDERS
Abispa ephippium (F.) (Eumenidae)	*Auplopus* sp. (Pompilidae)
Eumenes latreillei Saussure (Eumenidae)	*Odynerus bicolor* Saussure (Eumenidae)
Eumenes philanthus Saussure (Eumenidae)	*Paralastor alexandriae* Perkins (Eumenidae)
Pison spinolae Smith (Sphecidae)	*Pison auratum* Shuckard (Sphecidae)
Pison sp. P57 (ANIC provisional species number) (Sphecidae)	*Chalicodoma abdominalis* (Smith) (Megachilidae)
	Chalicodoma aurifrons (Smith) (Megachilidae)
Pison sp. nr *erythrogastrum* Rohwer (Sphecidae)	*Chalicodoma dinognatha* (Cockrell) (Megachilidae)
Sceliphron formosum (Smith) (Sphecidae)	*Chalicodoma paracallida* (Rayment) (Megachilidae)
Sceliphron laetum (Smith) (Sphecidae)	*Chalicodoma ramulipes* (Smith) (Megachilidae)

GROUND NESTING
Amegilla sp. (Anthophoridae)
Batozonellus vespoides Smith (Pompilidae)
Bembecinus hirtulus Smith (Sphecidae)
Bembix sp. (Sphecidae)
Cerceris froggattii Turner (Sphecidae)
Cerceris sp. (Sphecidae)
Exeirus lateritius Shuckard (Sphecidae)
Fabriogenia consociata Turner (Pompilidae)
Sphex ermineus Kohl (Sphecidae)
Turneromyia ahrimanes Turner (Pompilidae)

Intact mud wasp nests visually disfigure, and at a number of sites at Carnarvon, paintings were almost completely obscured by massed nests. When nests erode away naturally or are physically removed, part of their mud base may be left adhering to the surface. Sometimes the mud stains the friable sandstone and, occasionally, paint fragments may be detached with the nest.

Sceliphron laetum (Smith) is the most common builder of mud nests on rock surfaces at Carnarvon, as it is at Kakadu (Naumann 1983) and Laura (Naumann and Watson pers. comm.). Its biology has been described by Naumann (1983). Of the other primary nest builders listed, *S. formosum* (Smith) and *Pison* species were reasonably common at most sites visited while *Abispa* and *Eumenes* were generally more rare. The relative abundance of the different nest types encountered varied greatly between sites.

Most of the secondary builders listed occupied old nests of *S. laetum*. Three of these species *Pison auratum* Shuckard, *Odynerus bicolour* Saussure and *Paralastor alexandriae* Perkins were also recorded from Kakadu, and *P. alexandriae* from Laura. Five species of *Chalicodoma* were collected at Carnarvon and are listed here as secondary builders. It is possible that some of these may be primary, using both mud and resin to construct their nests (J. King pers. comm.). Specimens of *Chalicodoma dinognatha* (Cockrell) and *C. paracallida* (Rayment) were reared from a nest which appeared to have been built by *S. laetum* and modified by an eumenid (Fig. 8). Such recycling of nests illustrates the difficulty of classifying building habits of species and determining sequence of ownership.

Discussion

References to the Carnarvon art sites date back almost 100 years, with a description by Parrot (1888) of the famed "Goat Cave" in the Expedition Range. Meston (1901) first described burial sites in the upper Maranoa area. Although the early literature mentions pilfering of burials, no reference is made to the deterioration of art and relics by natural agencies. More recent work by Beaton (1977), Quinnell (1976) and Morwood (1979) has greatly enlarged knowledge of the archaeological content and significance of the region. While attention has been drawn to the problem of natural deterioration of very friable sandstone, mainly due to water seepage on the poorly bonded surfaces, conservation aspects involving insects have, until recently, been largely neglected.

Bone destruction

There are few references in the literature to insect damage of skeletal remains in Australia. Wood (1976) describes termite erosion of a skull and some bones from a burial site in the Brooloo Range of southeast Queensland. Thin-walled and partitioned carton material was noticed inside the cranial cavity, but the species responsible was not discovered. Haglund (1976) attributed scratches and erosions on bones from the Broadbeach Aboriginal burial ground on the south coast of Queensland to chewing by scarab beetle larvae. There are recent reports of damage to cave burials and archaeological material in Arnhem Land and northern Queensland by species of *Microcerotermes* and *Mastotermes* which, like *Coptotermes acinaciformis*, readily damages bones in laboratory experiments (Watson and Abbey 1986).

This is the first confirmed account of an Australian termite (*N. carnarvonensis*) causing major damage to human remains. The reason(s) for this habit is not clear, since termites are cellulose feeders and bone is composed mainly of calcium, phosphates and other salts, and organic carbon and nitrogen. In Panama, Thorne and Kimsey (1983) observed attack by *Nasutitermes nigriceps* (Haldeman) on vertebrate carrion and suggested that such feeding may supplement protein/nitrogen requirements of the termites. Similar suggestions have been made in regard to incidental feeding on carrion by a number of other insect species (Downes 1973; Wylie 1982), and may apply to bone-feeding by *N. carnarvonensis* in central Queensland. The possibility that ageing may render the bones more attractive to termites was considered. The burials inspected at Carnarvon all predate European contact as evidenced by their traditional form (e.g. items such as stone axes deposited with the caches). However, while Watson and Abbey (1986) demonstrated termite attack on recent bone (including weathered bone) in the laboratory, and showed that weathered bones from long-dead animals still contained nitrogen levels similar to those attributable to the collagen content of fresh bone, they found that very old bones (> 1000 years B.P.) appeared to be unattractive to termites and were treated much as a neutral substrate by these insects.

The most likely explanation at present is that the habit may be related to nesting and water requirements of the termites. Aside from food, water is critical for colony establishment and survival. In the Carnarvon region, caves and crevices provide ideal sites for termite activity and colony development—they are moist, dark and sheltered, and the accumulated soil on the floor of the cave provides building material. Foraging termites may linger in such areas and, over a long period of association with the site, damage skeletal remains. It is suspected that skulls may sometimes be used as nest sites by termites at Carnarvon although this was not confirmed. Termite workings on the Brooloo skull as described by Wood (1976) match those observed at the upper Warrego site (cranial openings blocked and carton partitions internally). Skulls are mentioned as a focus or "headquarters" of termite activity in reports by Light (1929) of *Coptotermes formosanus* Shiraki in graves in China, and by Derry (1911) of unidentified termite species in North African graves. The termite workings in the burial cylinder at the upper Maranoa site were a nest and not casual foraging. No termite attack has been recorded on skeletal remains deposited on ledges (rather than in chambers) in the Clematis sandstone areas of Carnarvon Range. This supports the suggestion that the infestation of burials may be related to nesting and water requirements of the termites.

Whatever the reason for bone destruction, it poses a serious threat for conservation of relics, and may have wider archaeological significance in accounting for the absence of skeletal remains from some sites.

Damage prevention

Termites

Techniques commonly employed for the prevention or control of subterranean termite attack are based on one (or a combination) of 3 main strategies viz.

(i) the locating and physical destruction of the central nest

(ii) the installation of barriers, usually chemical, to prevent termite access

(iii) the introduction into the colony of a poison which is distributed by the termites themselves during grooming, food sharing or the consumption of dead members of the colony.

However, at Carnarvon, there are serious difficulties or constraints associated with all of these methods.

Not all species found at the sites build conspicuous nests, nor are all the many possible nest sites in the deeply creviced sandstone outcrops accessible for inspection. Even where nests are visible, access is often a problem. The large number of sites involved (85) means that manpower for locating and destroying nests becomes limiting. Because of the nature of the terrain (broken and fissured rock) and the position of most relics (in or on rock faces), installation of effective chemical (or mechanical) barriers would be extremely difficult. Other disadvantages are the possible environmental hazard posed by the use of chemicals, the requirement for skilled operators and the logistics associated with work in a remote site. Similar disadvantages with the use of hazardous chemicals apply to the third method listed. Although a trial dusting with arsenious trioxide of occupied termite galleries in the burial chamber at the upper Warrego site was apparently successful, the chemical is toxic, persistent and difficult to obtain. There are presently no suitable alternatives.

Further research on the factors influencing termite attack of burials at Carnarvon may assist in the development of control measures that are quick, safe, target selective, require simple equipment and involve minimal disturbance of the sites. In the meantime, physical destruction of termite nests and workings in the vicinity of the relics (wherever possible) is recommended to reduce the likelihood of attack.

Mud wasps

While damage to artwork can be caused by the activities of both primary and secondary builders, it is the former which are of concern since, without them, the activities of secondary builders must also cease. Naumann (1983) discusses the many difficulties involved in trying to find a solution to the mud wasp problem. From his comments and our own observation it would seem that measures directed at trying to control the wasps themselves at the sites (e.g. use of pesticides, trapping) are likely to be either ineffective, environmentally undesirable or logistically impossible. Physical exclusion of the wasps from the art surface by some form of screening, as suggested by Naumann, would seem to offer the best hope at present of preventing damage. However, care would need to be taken to ensure that the screening did not lead to other conservation problems (e.g., promotion of algal growth on the sandstone surface). Given the large number of sites involved at Carnarvon, screening may be possible at only a few select sites. Further research is needed on the behaviour of the mud nesting species and the development of an effective, inexpensive method of preventing damage to artwork.

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