Natural Insecticides and Insect Repellents in Antiquity: A Review of the Evidence

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Archaeoentomological and palaeobotanical research at the Late Bronze Age site of Akrotiri on the Greek island of Santorini has suggested that natural insecticides and insect repellents were used in the storerooms of the site. A wide range of methods such as airtight storage, use of plant and animal substances, oils, minerals and ash were employed to control insect pests and reduce storage losses. Archaeological evidence from other sites as well as relevant information given by the documentary sources and the ethnographic record is reviewed. © 1995 Academic Press Limited

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Introduction

Natural substances with real or imaginary insecticidal properties are still widely used against ectoparasites and food pests throughout the world. In those areas where the modern agrochemical industry has yet to achieve dominance and, in the context of a growing mistrust of synthetic insecticides, they remain a potentially important area of research (cf. Golob & Webley, 1980; de Luca, 1981). Whilst most ectoparasites must have arrived with their respective hosts (Hakbijl, 1989; Sadler, 1990), in northern Europe at least, the earliest evidence for the serious insect infestation of stored products is perhaps a reflection of the economies of scale which first developed within the Roman period (Buckland, 1990). The beginnings of pest problems and potential remedies must, however, go back to the origins of Old World agriculture in the Near East and beyond, when a number of species became strongly associated with human activities, able to exploit the need to store substantial quantities of food and seed through the winter. In the case of one important pest, the grain weevil, Sitophilus granarius L., this association became so close that the species is unknown in the wild (Buckland, 1990).

The integrated study of contextual, sediment, plant macrofossil, and animal, particularly insect, remains from suitable archaeological deposits provides an opportunity to trace the history of not only the pests themselves but also of at least some of the potential remedies applied to foodstuffs to combat losses. In addition, Egyptian and Classical literary sources provide a number of indicators of what should be sought in the fossil record.

Ancient References to Pest Control

The oldest documentary sources which refer explicitly to natural remedies are from Egypt (Bodenheimer, 1928). The medical compendium known as the Ebers Papyrus of c. 1600 BC includes both chemical and organic substances recommended as insecticides. The meaning of several remains obscure and the division between what is essentially magical, perhaps palliative, and effective substances is inevitably lacking. Not surprisingly, fleas, gnats and biting flies figure heavily:

“Remedies prepared to expel fleas in a house: ‘thou shalt besprinkle in with natron water, until (they) pass away’...”

Ebers Papyrus (Ebbell, 1937).
Other substances include dry *int*-fish against serpents, *bbt*-plant and charcoal for flies, fat of *gmn*-bird for biting flies and fresh *balanites* against gnats. *Kkt*-animals, presumably grain weevils, *S. granarius* L., which ate the corn in the barns, were controlled by using the burnt dung of gazelle, diluted in water (*Ebers Papyrus* XCVIII). The advantages of sulphur as a fumigant were also known and widely practised during near contemporary Homeric Greece, Odysseus saw fit to use fire and brimstone to fumigate his palace after the slaughter of Penelope’s suitors (Homer, Od. XII 490–494). In Egypt, the widespread practice of mummification provided an abundant, if unusual source of dried stored product liable to insect attack and both true flies, Diptera, and hide beetles, Coleoptera, Dermestidae, are recorded from mummies (Lesne, 1930; Curry, 1979). Several of the substances employed in the processes of mummification including bitumen, natron, and salt, as well as helping to desiccate the corpse (David & Tapp, 1984), could also have been deemed to have had insecticidal properties.

The more accessible Classical and Byzantine sources refer to the problems of insect infestation (Beavis, 1988) and provide concrete evidence of the use of aromatic plants, oils, and minerals either as insecticides or repellents. The overall impression gained is that insects were thought to have an aversion to strong smells and tastes. Olive oil was believed to be a particularly effective insecticide (Aristotle, HA VIII 27, Hipp. Cant. LXXI 14, Aelian IV: 18), especially when mixed with other substances. Theophrastus appears to be writing from direct observation when he (DCP VI 5.4) notes that “all insects find oil oppressive for they avoid the smell of it” and, (op. cit.) “the cause in the case of olive oil is to be found in pungency just as with marjoram and the like, for insects avoid them all”. Pliny (HN XIX lvii 178) provides a range of alternative insecticides: “sea slime”, ashes, “chalk”, wormwood, charcoal and cowdung, mixed in water; the latter is also mentioned by Vergil (Georg. I 178). Stored crops might also be protected using either “chalk” from Chalcis or Caria, and special earths from Olynthos and Cerinthos in Euboea, were held to prevent the grain from rotting (Pliny, NH XIX 305; Varro, RR I LVII). Apparent pesticidal qualities are explained by Theophrastus (DCP VI): “some earths, such as clay, are considered sweet” (3.3), whilst “ashes acquire a certain flavour” (3.5).

Some of the more aromatic plant substances utilized as insecticides were also employed as condiments and perfumes, and this may lead to problems of interpretation in the archaeological record. Coriander is noted by Pliny for several purposes (HN XXI, xxxii 216–lxxxi 220; XX xxiii 43; XVIII xiv 73) and its seeds acted as a preservative for meat, a poison for intestinal parasites, an additive in flour, bulgur and other food, a medicine with magical properties, and an insect repellent (Palladius, I 19; Dioscorides III 71 (Δημητρακός, 1930)). Palladius (op. cit.) also notes that insects could be repelled by sprinkling the stored crop with coriander or fleabane leaves. The use of coriander seems to have been long standing in the Mediterranean and the best appears to have been imported from Egypt. It is referred to in Mycenaean Linear B sources as a condiment in food and drink (Ventris & Chadwick, 1973) and perhaps as an ingredient in perfumes (Shelmerdine, 1985).

Several of the Classical sources provide direct advice on the preparation and storage of foodstuffs. Infested lentils should be floated, separated, dried in the sun, and treated with “*silphium* root” and vinegar (Palladius, VIII 3.2; Columella, RR II 10 16; Pliny, HN XVIII lxxiii 308). Columella (ibid.) suggests the piling of the crop over jars of vinegar, placed on a bed of ashes and coated with pitch, or storage in plastered casks, which had contained salted fish. Pliny (op. cit.) and Varro (RR I vii, 2) advise storage in oil jars covered with ashes. Most of the agricultural writers recommend sprinkling legume seeds and cereals in storage with *amurca*, a mixture of oil lees with soda (HN XVIII lxxiii 305; Cato, DA XCV, XCVI, XCVII). *Amurca* was also recommended as an insecticide incorporated into structures, mixed with lime plaster for the walls and earth for the floors of granaries (Columella, RR 1.6, 10). Storage in the ear, where the less damaged grain allowed fewer pests access, was also employed (Pliny, HN XVIII lxxiii 306). Pits used for storage are noted by both Varro and Pliny in Cappadocia, Thrace (RR I, Cvi, 2), Spain and Africa. The need to exclude air in pit storage was recognized and claims for successful preservation of wheat for up to 50 years and millet for a century are noted (Pliny, NH XVIII, 306); the base of each *sirus* was covered with straw (Varro, op. cit.). Varro also refers to storage in caves in Ambraica.

Despite the apparent wealth of literary evidence, it is unlikely that all the substances and methods used are recorded in the surviving sources. In present day rural Greece, Halstead (in Wardle, 1987) has noted both the use of dung-lined baskets and the dousing of pulses with olive oil before storage (Halstead, 1990) as insect deterrents. Bouchelos and Mourikis (in Golob & Webley, 1980) record the mixing of marjoram, *Origanum vulgare* and dill *Imula graveolens*, with cereals to reduce weevil damage and such techniques may have a long history. Also, the use of bay leaves against moths is a very well known practice in Greek households. The identification of some plants, such as Pliny’s *Silphium*, regarded as extinct by some commentators (Liddell & Scott, 1861; Lewis & Short, 1894) because of Pliny’s own comment (HN XIX, 41), as a species of the genus *Ferula*, the giant fennel, by others, remains a problem. The various recommended earths and chalks remain problematic. Further evidence, however, is potentially available in the archaeological record and a critical evaluation of ethnographic sources may also lead to improved interpretation.
The Archaeological Evidence

In a review of the archaeological record of storage pests, Kslev (1991) has argued that levels of infestation in antiquity were significantly lower than in more recent times. Although a number of New World species were absent, the principal pests were present by the Bronze Age and large scale storage and movement of commodities is evident in the Near East and eastern Mediterranean world. On the island of Crete, 20–30% of the ground floor areas of the early Knossos, Mallia and Phaistos palaces were used for storage (Halstead, 1981). Later, during the 14th century BC, when the storage capacity of the palaces was reduced, Linear B tablets refer to large quantities of grain from Dawo, an area located somewhere around the Messara plain (Halstead, 1992). Large concentrations of stored products are inevitably more liable to serious insect attack, and action against losses due to insect infestation is likely to have had to be taken in the Minoan store rooms. The grain weevil, *S. granarius*, is recorded from LM II Knossos (Jones, 1983), but one find is insufficient to allow discussion.

Perhaps the most extensively discussed evidence for storage of grain is that utilizing deep pits; the interpretation has been supported by experimentation and the use of ethnographic parallels (e.g. Gast & Sigaut, 1979, 1981; Fenton, 1983; Sigaut, 1988), but there are few sites where preservation is sufficient to allow the interpretation of plant and animal assemblages in terms of storage technique. The use of pit or jar storage may have been surmised from the surviving evidence on many sites (cf. Sigaut, 1988), but only in situations where catastrophic events have led to survival *in situ* of container and contents can a direct association be examined. This problem has led to much discussion of later prehistoric and Roman four post structures, conjectured as being for grain storage, in Britain and adjacent areas of the Continent (cf. Gent, 1983).

Whilst a little livestock in the food would have had to be tolerated by most people until the development of modern insecticides, higher levels of insect infestation are potentially lethal and measures were necessary for control. Occasionally heavily infested grain may have been burnt after disposal and have remained sufficiently discrete in midden accumulations for analysis (e.g. Osborne, 1977; Buckland, 1982). It is unfortunate that integrated studies of such deposits have yet to be achieved. Ritual deposition of offerings in tombs offers further potential for such studies, for example, in Egypt (cf. Alfieri, 1931; Burleigh & Southgate, 1975; de Vartavon, 1990).

The interpretational criteria of immediate destruction and preservation are met particularly well by the Late Bronze Age settlement of Akrotiri on the island of Santorini in the Aegean, which was destroyed by an eruption during the mid-2nd millennium BC. The resulting hot ash fall not only charred much of the stored products in their storage vessels but covered the site with several metres of tephra. Excavation was begun by the late S. Marinatos in 1967 and has been continued by C. Doumas since 1974 (Doumas, 1978; 1980; 1990). Buildings are preserved to at least second storey level and stored products remain preserved in the storerooms. The most completely examined structure, in terms of its palaeoecology, the West House, so called because it lay on the west side of the excavated area, provided extensive botanical samples of pulses, mainly *Lathyrus clymenum*, and cereals, principally barley, *Hordeum* sp. (Surpachi, 1987; 1990; 1992). A preliminary study of the associated insect remains has been published elsewhere (Panagiota Koupoulou & Buckland, 1991). The range of pests and other synanthropic insects identified includes many of those which are regarded as troublesome at the present day, and also a blind flightless weevil, *Troglobrychus cf. anophthalimus* Schm. The relatively low level of infestation of the pulses, at only 8%, might suggest that some sorting, perhaps by flotation or panning to remove infested seeds, had been attempted before storage. It is unlikely that the farmers would differentiate between the field pests, like the Bruchid, *Bruchus rufipes* Hbst, which were carried into the store in the seeds to complete their development, and those pests which were resident in the stores, having been introduced, like *S. granarius* in grain or seed corn from elsewhere. All are likely to have been seen as generated spontaneously within the stored crop.

Measures were taken against pest losses. Airtight storage is one of the most common and effective ways of preservation, widely advocated until recent times even amongst the more developed nations (Dendy & Elkington, 1920) and still widespread in many areas (Sigaut, 1988). In the West House, there are clear indications of the sealing of the ceramic containers (pithoi) with stone covers and unbaked clay. The technique, however, relies on the build up of carbon dioxide from the respiring seeds to levels sufficient to suffocate the pests and as the clay jars had a porous texture they alone would be insufficient to maintain this. Storage vessels may have been sealed by coating internally with olive oil or simply by the expedient of using pots previously employed in the storage and transport of oil for cereals and pulses. What is clear is that at Akrotiri there is no correlation between vessel morphology and decoration, and stored commodities. Ethnographic evidence from the Aegean and Cyprus provides examples of sealing methods applied in premium storage vessels. In Cyprus, the potters from Phini, who produced large pitharia, used a mixture of hot pitch and turpentine to seal the pot walls (London, Egoiomenidou & Karageorghis, 1990). In Crete, the potters of Thapsano achieved a similar effect by filling recently fired pitharia with water and leaving them to stand for several days (Jones, 1986). In the absence of an effective technique of dry storage in pots, it is evident from Theophrastus (DCP VI 5.4) that wet storage in oil provided a potential alternative. In the
Santorini assemblages, the presence of numerous examples of the weevil *T. cf. anopphalimus*, associated with *Lathyrus clymenum*, in jars is difficult to explain. Most species in the genus are essentially troglobitic (Giordan, 1988), although two are recorded in damp litter on the forest floor, a habitat which was once much more extensive in the Mediterranean. It is most likely that its origin as stored-product pest lies in pit or cave storage of stored products and it need not be endemic to Santorini, having been accidentally introduced with imported produce. Dry foodstuffs are unlikely to provide a suitably humid habitat and it is probable that the pulses, containing the insect, had been treated with either olive oil or vinegar; both would have deterred the more usual insect pests, which are largely associated with dry situations.

Palladius' recommendation (VIII, 3.2) to store grain in containers previously used for salted fish appears to be reflected at prehistoric Santorini, where fish scales were noted in several samples from the West House, in both cracked pulses and barley. It is also possible that dried fish could have also been hung in the storerooms over the pithoi in order to deter insect infestation.

Natural plant insecticides, also referred to in the Classical sources, vary between those, like laurel, having effective qualities and those whose effects might have been similar to that of fish remains, more effective at masking the taste of the uric acid and other waste products of the pests to the human palate than actually controlling the problem. Several of the possible substances are unlikely to be distinguishable from the residues of crop weeds to the palaeobotanist, but the presence of leaves of *Thymelaeae cf. hirsuta* consistently in all samples from pithoi in the West House suggests its deliberate addition to stored crops. The plant grows in maritime sandy and rocky places around the Mediterranean (Polunin & Huxley, 1965), is an unlikely weed, and is very common on the island today, in the garrigue zone. Both Theophrastus (EP VI, 2.2) and Pliny (HN XIII, 114) refer to the use of the plant as a remedy against the poison of snakes, but it appears likely that it was also deemed to have had insecticidal properties. Curiously, a connection with snakes is borne out by the seeds of another “contaminant”, *Echium* spp., in one of the samples of bulgur from the West House. These were of such a size that they would have been trapped by the sieving which had evidently been used to remove impurities from the foodstuff and it is probable that they were deliberately added after preparation. Pliny (HN XXV, 104) describes the plant as an antidote to snake venom. Evidence of sieving is also present in samples of *Lathyrus clymenum* from Room 5 in the West House. Two samples (16 and 20/29) appear to represent the primary usable grain and the tailings from the same crop; both had similar weed flora and evidence of Bruchid infestation, the former at less than 1% and the latter at 8%. Amongst the prime pulses were seeds of coriander, *Coriandrum sativum*. All were broken in half and of such a diameter that they would have passed through the mesh which appears to have been employed in separating the crop before storage.

Evidence of putative insecticidal plants from other sites is less complete but the presence of *Coriandrum sativum*, *Nigella sativa* and *Trigonella foenumgraecum* in botanical samples from the tomb of Tutankhamun (de Vartavan, 1990) could be similarly interpreted. Cow dung was also noted in some of these samples and this is mentioned by both Pliny and Vergil as a potential insecticide. As an essential feature of plants used as insecticides appears to have been their aromatic character, the curious find from Roman deposits in Chichester, southern England, of seeds of stone pine, *Pinus pinea*, a native of the Mediterranean and Portugal, mixed in with wheat, *Triticum* sp., is probably to be similarly explained.

Whilst the recognition of plant insecticides relies on the detection of unusual assemblages, the uses of mineral substances is less easily substantiated. The most convincing evidence is that presented by Robert Miller (1987) from Tell el Amarna, the workmen’s village associated with the construction of the tombs of Akhenaton and Tutankhamun. Loose ash was noted spread around the base of querns and this was interpreted as a deliberate act for protection of the flour against insect infestation. Miller (op. cit.) provides ethnographic parallels for the use of plant ash as an effective insecticide in East Africa and notes the efficacy of several fine mineral powders in destroying insects by abrading their integument and reducing their ability to resist dehydration. It is probable that Pliny’s earth of Cerinth and Cyrenia were such substances, perhaps finely comminuted gypsum, although they have yet to be recognized. In Santorini, the fine grained tephra, found in several pithoi, is as likely to be the result of its deliberate addition as an insecticide, as the result of the percolation downwards of the fine component of the tephra from the eruption which destroyed the site.

**Conclusion**

The evidence from Santorini indicates the need for careful, integrated assessment of all aspects of stored product residues recovered from archaeological contexts. Not only apparent weed floras require examination in terms of possible insecticidal use, but also the matrix should be sampled for trace of inorganic insecticides. The possibility that apparent food residues detected on the surface of pots may be a reflection of surface treatment to provide an airtight seal should also be considered.

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References


