WOODWORM-A NECESSARY CASE FOR TREATMENT? NEW TECHNIQUES FOR THE DETECTION AND CONTROL OF FURNITURE BEETLE

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Abstract—Woodworm or furniture beetle *Anobium punctatum* can cause serious damage to wooden objects and the structural timber in buildings. In the light of recent evidence of the reduced incidence of this pest in museum objects and in buildings it is timely to re-examine the need for chemical treatments and also to evaluate some of the alternative techniques.

Over the years, treatments have been carried out with a wide range of chemicals to control infestations and prevent damage. Many of the treatments which were previously used are no longer acceptable for reasons of safety and legislation.

Trials have shown that traps with pheromone lures can be used for the detection of adult *Anobium*. Monitoring programmes using these traps coupled with environmental monitoring and control mean that decisons on the need for treatment can be based on hard evidence of active pest presence rather than of fear generated by old emergence holes. If and when it is deemed that treatment is needed then the options for use of residual chemicals can be considered together with alternative treatments such as heat, cold, and atmospheric gases.

By applying sound principles of pest management to *Anobium*, it should be possible to target control more effectively and at the same time decrease the incidence of unnecessary treatments with pesticides.

HISTORICAL OCCURENCE OF *ANOBIUM PUNCTATUM*

There is no doubt that woodworm or common furniture beetle *Anobium punctatum* is regarded by many as being one of the most destructive pests in the UK. It has long been associated with man and his timber dwellings and artifacts and evidence of one of the oldest recorded infestations comes from archaeological excavations of Roman material in York (Eboracum) (Buckland, 1976). The species was first described from Swedish specimens by De Geer in 1774 as *Ptinus punctatus* and it is rather strange that the species does not seem to have been known to Linnaeus. The more familiar name *Anobium punctatum* was first adopted by Petro Rossi in 1794. The first published reference to *Anobium punctatum* in the UK was by Stephens in 1839 who stated that it was abundant in old houses throughout the country. It is a common insect out of doors where it attacks the dead parts of trees and fallen timber and logs. It is also found throughout temperate Europe and has been spread by man to Australia, New Zealand, South Africa and the eastern seaboard of North America.

BIOLOGY AND PAST PEST STATUS

The biology and ecology of *Anobium punctatum* is comprehensively covered by Hickin (1975) and the life cycle in the UK can be summarised as follows:-

Adults emerge from May to July and will fly under certain conditions. After mating the females lay eggs preferentially in rough wood, end grain or cracks and crevices. Adults will live for 20 to 30 days

Eggs hatch within 15 to 25 days and then the larvae tunnel in the wood for a period of 2 to 5 years depending upon temperature, wood moisture content and nutrition. The number of larval instars is thought to be 6 but it is difficult to find a definitive statement in the literature. The larval tunnels are packed with excreta (or frass) which has a characteristic barley grain shape.

When fully grown, the larvae tunnel towards the surface of the wood and make an enlarged pupal chamber. Adults emerge from the pupae in 2–3 weeks and then the adult chews through the remaining wood leaving a characteristic circular exit hole 1.5–2 mm in diameter.

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The incidence of *Anobium punctatum* infestation in buildings is fairly well documented because of surveys carried out by Government Agencies and companies carrying out remedial wood treatment, however, there are no comparable data for infestation in objects. The pest status of *Anobium punctatum* in buildings gradually increased in the years before 1940 and then dramatically in the next 15 years. This was probably due to the large amount of poor quality unseasoned timber used in the house construction after the war. Infestation in buildings probably reached its peak in the late 1950's and early 1960's. Although considerable structural damage can be caused by the tunnelling of the larvae in floor boards and roof timbers, the importance of this pest as a causative agent of structural rather than aesthetic damage has probably been over-emphasised. Damage to furniture and other wooden objects in historic collections has been severe in the past, particularly when objects have been stored in unheated buildings or in damp basements and attics.

The beetle will successfully breed in a variety of coniferous and hardwood timber and there is some disagreement as to which are the most susceptible woods. It is frequently stated that *Anobium* has a preference for wood which has been cut at least 20 years but this seems to be contradicted by other work which shows that fresh sapwood is the most suitable for rapid development. One point of agreement is that animal glue birch ply is very susceptible to attack and can be destroyed very rapidly. In view of the very wide range of wood and wood products which can be attacked by *Anobium* it is clear that the nutritional requirements of this pest can be met by a wide range of woody materials.

CURRENT PEST STATUS

A recent survey by Berry *et al* in 1993 shows quite clearly that there has been a marked decline in the importance of *Anobium* as a structural pest in domestic properties the UK in recent years (Fig 1). There appears to be very little or no incidence of infestation in houses built after 1960 and there is also a 50% drop of infestation levels in property built before that date compared to a previous survey by Tack in 1966. Berry (1995) suggests that the reduction of infestation in newer houses may in part stem from the increased use of synthetic materials and the use of preservative treated timber. However, his main explanation for the overall drop in infestation levels even in the age groups of houses built before 1940 which were previously susceptible is probably also due to the

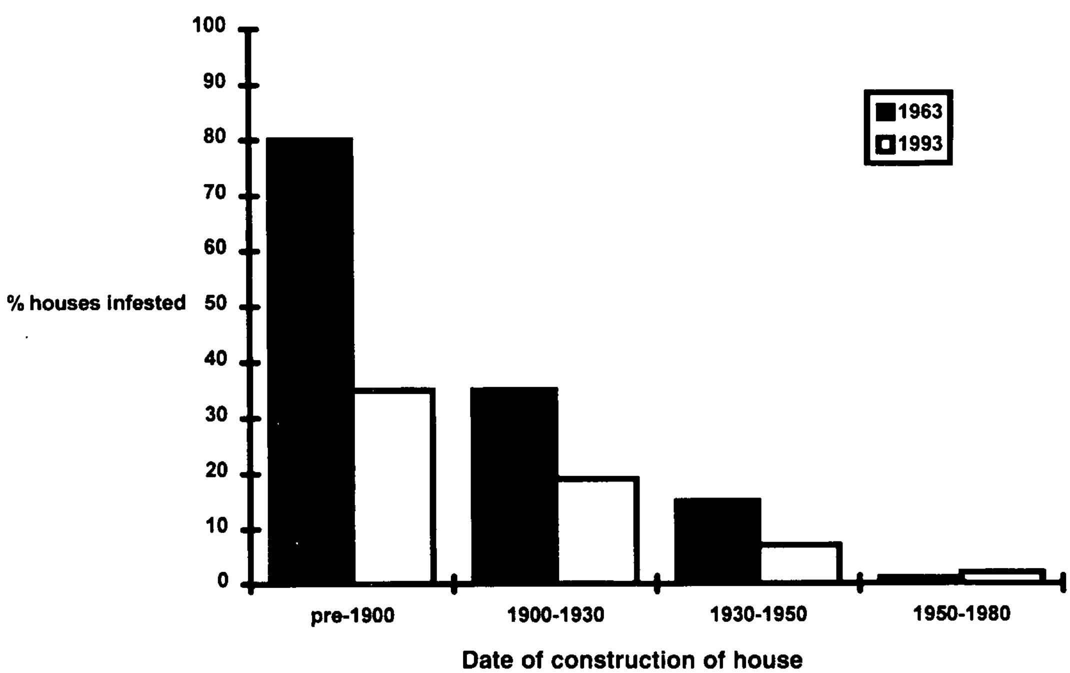

Figure 1. Incidence of *Anobium punctatum* in houses [Data from Berry, 1995]

increased levels of heating and ventilation which have now been fitted in most houses. Larvae cannot establish themselves and complete development below about 65% relative humidity (equivalent to about 15% moisture content in timber) and moisture content of timber is unlikely to exceed this value in a modern efficiently heated and ventilated building. This is also supported by the apparent drop in active *Anobium* infestation of objects in museum collections. Although many objects have signs of past infestation, the only active infestation is seen in recently introduced objects or those which have been kept in unheated outbuildings.

DEVELOPMENT OF PHEROMONE TRAPS

Mating and reproduction is one of the aspects of *Anobium* biology which is a key to the establishment of infestation. Years of observations by many entomologists have shown that the mating and flight behaviour is very variable depending upon weather conditions of temperature and humidity during the time preceding and following adult emergence from the wood. The apparent calling behaviour of female beetles near emergence holes suggested that she produces an attractant sex pheromone to lure male beetles. Studies by White and Birch (1988) provided the evidence that the sex pheromone was a complex heterocyclic molecule apparently identical to that produced by the biscuit beetle *Stegobium paniceum*. Synthesis of the one active isomer of this complex molecule which has 7 other isomers proved very demanding and preliminary laboratory testing with various batches of synthetic material produced very variable results. However, in 1995 the first batch of commercially available lures were produced by AgriSense and a sticky trap incorporating these lures was marketed under the name of the Anobid Trap.

Early trials with the pheromone at the Welsh Folk Museum at St Fagans have provided encouraging results. Different trap types and lures were suspended in and around historic buildings in the museum some of which were known to harbour established populations of *Anobium.* Although variability in catch made analysis of the results difficult, the suspended Anobid traps baited with 1mg of pheromone in a lure caught 59 beetles from June to August compared to the unbaited controls which trapped only one insect. Fig 2 shows the results from pheromone traps in two areas in the museum and the peak catch on the traps in July is much later than would be predicted from the stated emergence times. The results of this trial showed that more beetles were caught on pheromone-baited traps but we need to know far more about the behavioural responses of beetles to environmental conditions and the pheromone.

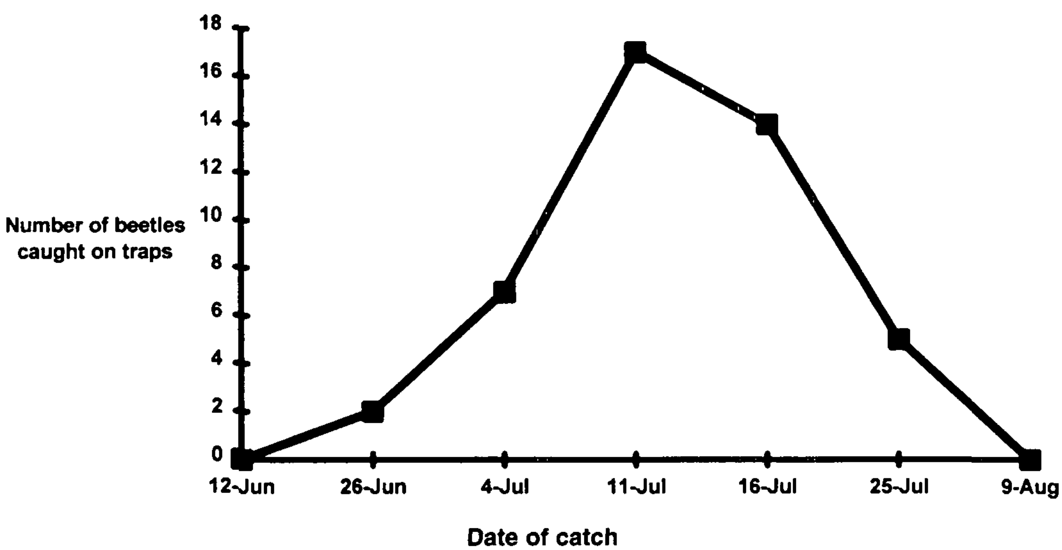

Figure 2. *Anobium punctatum* catch on pheromone traps

INSECTICIDE TREATMENTS

Chemical methods to prevent woodborer attack and to treat infested timbers were developed as part of the 19th century burgeoning industrial chemical industry. By-products from the manufacture of coke from coal such as coal tars, creosotes and organic solvents were found to be biocidal. Pretreatment of timbers with such chemicals allowed susceptible woods to be used and their working life extended. However their persistent smell and staining characteristics made them only applicable to external situations such as wooden fencing, telegraph poles, etc. Purer more effective biocides were developed in the early 20th century with materials such as pentachlorophenol being developed in the USA in the 1930's as a wood preservative. This was rapidly followed by the specific development of insecticides such as dieldrin and lindane.

In the post-war period from the 1950's lindane (hexachlorocyclohexane, γ-HCH) dominated the non-agricultural insecticide market. It is a white to pale cream crystalline organochlorine insecticide readily soluble in most organic solvents but insoluble in water. It has excellent insecticidal properties against a broad spectrum of insects including *Anobium* and has a relatively low mammalian toxicity. Owing to its low odour and non-staining properties its use inside commercial and domestic buildings was widespread. Although a persistent insecticide, γ-HCH has a high vapour pressure and will sublime off a treated material in time. The increasing concerns regarding long term toxic and carcinogenic effects of this chemical led to the use of γ-HCH declining rapidly in the late 1970's and early 1980's. It has now been replaced by more effective insecticides with lower toxicity and hazard.

The 1980's saw a change in attitude in the UK in the ubiquitous use of insecticides with concerns over health and environmental damage. The Pesticides Regulations Act 1986 and other environmental and health and safety legislation encouraged the use of safer insecticides with lower persistency and better application methods to minimise the amount of necessary treatment. Synthetic pyrethroids, derived from pyrethrins from the insecticidal flower pyrethrum, have over the last ten years become the major chemicals used in the treatment of *Anobium* and other woodborers. In most commercial formulations the active ingredient is either permethrin or cypermethrin used at a concentration of approximately 0.2% in a carrier. Synthetic pyrethroids are the current favoured insecticides for *Anobium* treatments owing to their relatively low mammalian toxicity coupled with their highly insecticidal properties allowing the use of very low dosage rates. They are virtually odourless with non-staining properties and they are environmentally more acceptable owing to their very low phytotoxicity and breakdown in the soil or by light.

Insecticidal treatments against woodborers are usually carried out by applying the insecticide diluted in a carrier to the surface to be treated. Traditionally the earlier organochlorine insecticides were dissolved in an organic solvent such as white spirit and applied by painting or spraying. The treatment was effective as the solution could penetrate deeply into the wood surface killing larvae, pupae and emerging adults. However, the toxicity of organic solvents together with their flammability and high cost encouraged the development of water-based emulsions which were safer, cheaper and less toxic. The drawback of water-based formulations is that they have poor penetration and swell wood fibres making the treatment unsuitable for finished domestic woodwork. Additionally, the penetration of water-based formulations into timber surfaces is low the treatments do not kill deep seated larvae until they eventually came to the surface to pupate and emerge. This last drawback has partly been overcome by the micro-emulsions which have the insecticide dispersed in minute droplets within a water-based systems. Under certain conditions they can achieve penetration equivalent to an organic solvent-based system. However, water-based systems must still be used with care on objects which are sensitive to moisture damage

Three further insecticidal methods are currently in use for the eradication of woodborers. Dichlorvos vapour from 'slow-release' insecticidal strips have been shown to be effective against emerging adults. In suitable locations such as lofts and attics the placing of dichlorvos strips annually for 3–4 years has been shown to be effective in reducing populations. Similarly, pyrotechnic smokes which produce clouds of insecticidal particles which settle on all horizontal surfaces nearby will kill many emerging adults and repeated annual treatments will progressively reduce the infestation. A low toxicity treatment has been developed recently by Rentokil plc. using an ultra-low volume fogging system to deposit a very low concentration of boric acid on exposed timbers. The toxicity of the boric acid is too low to kill emerging adults but quite sufficient to kill the tiny larvae as they emerge from newly laid eggs and over a period of years the infestation then dies out.

Currently, chemical treatments are used only when some residual toxicity is required to prevent infestation of vulnerable timbers or where other options such as fumigation are not viable. Where a chemical treatment is necessary then the minimal use of the safest material and delivery system must be used.

ALTERNATIVE TREATMENTS

The search for alternative control measures for the control of *Anobium* has been prompted by the pressure to reduce the use of the fumigant methyl bromide and the almost certain eventual withdrawal of this chemical from worldwide use. There are also concerns regarding the residues which arise from the use of persistent residual insecticides and the entire pest control industry is having to re-examine the priorities for treatment based on evidence of live infestation rather than as a prophylactic insurance.

Heating and Freezing

Exposing objects to temperatures of above 50°C or below -18°C have been used to control many insect pests and there is a comprehensive review of the published work on the effects of temperatures by Strang (1992). Although the techniques of freezing to -30°C have been successfully employed for the treatment of textiles and natural history specimens it is difficult to find examples of successful treatments against wood borers including *Anobium*. Hansen (1992) showed that exposures of *Anobium* eggs to -14°C produced 99% mortality although two insects emerged from eggs exposed to -30°C. The tolerance of eggs and larvae to low temperatures is undoubtedly due to their evolutionary adaption to survival in dead trees and logs in winter.

The application of heat to kill insect pests in objects has been used for many years but was never widely used against woodborers because of the damage caused by shrinkage and cracking of timber (Strang, 1995). Indeed regular treatment of *Anthrenus* infested natural history specimens in wooden drawers was often discontinued because of the damage to the wooden carcases. The development of heat chambers with sophisticated humidity control such as those used by Thermolignum (Child, 1994; Pinniger, 1996) has opened up the possibility of treatment of delicate wooden objects without risk of damage due to drying. The Thermolignum cycle of temperature up to 55°C and back to ambient in 18 hours with constant humidity levels is sufficient to kill all stages of woodboring beetles including *Anobium punctatum*. (Ertelt, 1994).

The use of heat or cold to kill insects in structural timber presents practical problems because of the difficulty of achieving extremes of temperature in bulky timber which is a very good insulator. The only current commercial application of high temperature to structural infestation is against termites in the USA.

Atmospheric gases

Both nitrogen and carbon dioxide have great potential as gases to replace methyl bromide in fumigation treatments. However, the efficacy of these gases is greatly reduced at temperature less than 30°C and very long exposures may be needed at lower temperatures (Daniel and Hanlon, 1995). In a series of laboratory trials conducted at CSL for the Victoria and Albert Museum, samples of wood containing *Anobium* larvae were continuously exposed to 99% nitrogen at 20°C for different periods of time. Table I shows that 13% of larvae survived 3 weeks exposure and a small number (4%) of larvae survived even 5 weeks continuous exposure to 0.3% oxygen. This supports the findings of Paton and Creffield (1987) who stated that *Anobium* have evolved to survive the low oxygen conditions produced in their own tunnels.

Table 1. Effects of length of exposure of *A. punctatum* larvae to nitrogen at 20°C on emergence of adult beetles

Exposure period in weeks	Number of adult beetles emerged	% of control emergence
Control	118	100
1	64	54
2	99	83
3	15	13
4	4	3
5	5	4

DEVELOPMENT OF CONTROL STRATEGIES BASED ON DETECTION AND TARGETED CONTROL.

It is clear that many treatments of buildings and objects are carried out because of the presence of *Anobium* emergence holes and frass and the fear that active infestation may cause further damage. In many cases, close examination of the damage shows that the emergence holes and frass are very old and that the infestation died out many years previously because of either treatment or environmental conditions. The action which is necessary should be targeted at identifying live infestation and then selecting the most appropriate control method if live insects are present. Strategies should also be aimed to prevent Anobium infestation becoming established.

DETECTION OF INFESTATION

Isolate any suspect objects in polythene bags before the adult emergence time in summer.

Clean any suspect areas around object or structural timber before adult emergence time and check for fresh frass during the summer.

Examine emergence holes closely, keep a record of existing damage and compare after incubation through the summer to establish whether there are new holes.

Use inspection and pheromone traps to monitor for the presence of live adults. Check objects or structural timber for evidence of emergence from wood.

CONTROL OF INFESTATION

When actual evidence of live infestation has been found, consider the implications of damage whether in objects or structural timber.

OBJECTS

Isolate immediately and either :-

(a) Keep under conditions of 60% rh or below.
(b) Treat at -30°C in a freezer.
(c) Treat at 52°C with controlled constant humidity.
(d) Treat by fumigation with methyl bromide.
(e) Expose to carbon dioxide or nitrogen with long exposures unless temperatures are 25°C or more.

STRUCTURAL TIMBER

(a) Attempt to reduce humidity to 60% or less
(b) Treat affected areas with an approved remedial wood preservative

With the legal and environmental need to reduce unecessary use of pesticides it is essential that all the current techniques are employed to ensure that future remedial treatments against *Anobium* are based on evidence of living infestation rather than fear of the unknown.

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