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CURRENT STATUS AND TREATMENTS FOR *ANOBIUM PUNCTATUM*

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Abstract This paper outlines the current status in Europe of *Anobium punctatum* and reviews its biology, environmental requirements and food sources. It will also review historic insecticidal treatment methods, their efficacy and the long term problems their residues may cause. It evaluates the efficacy of current treatments used both commercially and domestically for the control of outbreaks and the developing methods of monitoring, using insect traps and attractants, to detect the early presence of an infestation. It reviews the affect of the recent EU Biocides Regulations on chemical and non-chemical treatment options.
Key words Biocides Directive, fumigation, anoxia.

HISTORICAL DISTRIBUTION

Woodworm, or common furniture beetle, *Anobium punctatum*, is considered to be one of the most destructive pests of timber in the United Kingdom and Northern Europe. Wood-boring beetles closely related to *A. punctatum* have been found in amber from the Eocene period. They lived in dead trees and fallen logs long before man came on the scene. One of the oldest recorded infestations in the UK of *A. punctatum* comes from archaeological excavations of Roman material in York (Buckland, 1976). The species was first described from Swedish specimens by Degeer in 1774 as *Ptinus punctatus*. It seems strange that the beetle does not seem to have been known to Linnaeus. The name *Anobium punctatum* was the first adopted by Petro Rossi in 1794.

The first published reference in the UK was by Stephens in 1839 who stated that it was abundant in old houses throughout the country. It was also a relatively common insect out of doors where it attacked dead parts of trees, fallen timber and logs. The beetle is found throughout Europe. Hedges (2013) mapped the distribution of *A. punctatum* in Europe from the evidence of damage to wooden printing blocks. He has shown a clear pattern of distribution from 14th century to the 19th century of *A. punctatum* north of a line about 46 degrees. South of that line the damage to the wood blocks has been caused by another species of wood borer, *Oligomerus ptilinoides* which is the predominant wood borer in South Europe. *A. punctatum* has spread to Australia, New Zealand, North Africa, South Africa, the Eastern Seaboard of North America and Asia.

BIOLOGY AND PEST STATUS IN THE PAST

The biology and ecology of *A. punctatum* is covered by Hickin (1975) and Ridout (2000, 2012). The life cycle in the UK can be summarised as follows: Adults emerge from April to July and will fly under certain conditions of temperature and light and will live for 20-30 days. The females lay eggs in rough wood, end grain, cracks or crevices and sometimes in old flight holes. The eggs hatch within 15-25 days and the larvae tunnel into the wood for a period of 2-5 years depending on temperature, wood moisture content and nutritional value of the wood. The larval tunnels are packed with excreta (frass) which has a characteristic gritty feel and barley-grain shape when seen under a microscope. The number of larval instars is thought to be six. When they are fully grown, the larvae tunnel towards the surface of the wood and make an enlarged pupal chamber. Adults emerge from the pupae after 2-3 weeks and the adult chews through the remaining wood leaving a characteristic circular exit hole1.5-2 mm diameter.

The incidence of *A. punctatum* infestation in buildings was well documented in the past because of surveys carried out by Government agencies and companies doing remedial wood treatment. The incidence of *A. punctatum* in buildings increased in the years immediately before 1940, and then dramatically over the next 15 years. This was probably due to the large amount of unseasoned timber used in house repairs and construction after World War II. Infestation in buildings probably reached its peak in the late 1950s and early 1960s. Although damage can be caused by the tunneling of larvae, the importance of this pest as a causative agent of structural damage has probably been over-emphasised. Evidence from museum collections shows that damage to furniture and other wooden objects has been severe in the past, particularly when objects have been kept in unheated buildings or in damp basements and attics.

The beetle will breed in a variety of coniferous and hardwood timber (Hickin, 1975), including; fir, pine, maple, poplar, beech, ash, elm and oak. It is frequently stated that *A. punctatum* has a preference for wood which has been cut at least 20 years. This seems to be contradicted by evidence which shows that relatively fresh sap-wood is the most suitable for rapid development. Plywood made with animal glue adhesive is susceptible to attack and can be destroyed very rapidly because of its increased nutritional value.

A survey by Berry et al. (1993) showed that there had been a marked decline in the importance of *A. punctatum* as a structural pest in domestic properties in the UK over the latter years of the 20th Century. There appeared to be very little or no incidence of infestation in houses built after 1960 and there was also 50% drop in infestation levels in property built before that date compared with a previous survey (Tack, 1966). Berry (1995) suggested that the reduction in infestation in newer houses may partly be due to the increased levels of heating and ventilation now found in most houses. Larvae cannot establish themselves and complete development below about 65% relative humidity (equivalent to 15% timber moisture content). The moisture content of timber is not likely to exceed this value in an efficiently heated and ventilated building.

The effect of lower humidity and moisture content on the restriction of infestation of historic collections is also convincing. The only active infestation seen in museum collections in the last 30 years have been from recently introduced objects which have been kept in unheated outbuildings. None of the major museums in the UK known to the authors have active infestation of *A. punctatum* in their buildings or recent collections, other than open air museums with vernacular buildings.

Although the incidence of *A. punctatum* has clearly dropped to very low levels in buildings with good air circulation and/or climate control, there does seem to have been a recent increase in buildings which have been designed to be more energy efficient. Better insulation, reduction in ventilation and air movement all help to create micro-climates with higher levels of humidity which allows *A. punctatum* to develop. Couple this with an increase in higher starch content sustainable-grown wood and you may have increased damage by woodworm.

DETECTION AND MONITORING OF INFESTATIONS

Several detection methods have proved partially successful, including measuring respiratory carbon dioxide and the use of high frequency acoustic detectors (Vaiedelich and Le Conte, 2013) and ultra wide band radar sensors (Herrmann et al., 2013). Detection can often be difficult as the larvae do not eat and move continuously, especially at lower temperatures. Detection of active infestations is usually by observation of fresh exit holes and the accompanying faecal material (frass). The mobility of the adult beetles is defined by the surrounding temperature; they will not normally fly at temperatures below 20°C. They have been caught on sticky fly papers (Kigawa, 2013) and in standard sticky traps (Child, 1993). The sex pheromone attractant for *Anobium punctatum* is known but is difficult to isolate from its stereoisomers (White and Birch, 1988).

Differentiating between active infestations and inactive ones can be difficult. Owing to the long larval development, emergence holes may appear over a number of years. Recording the holes and noting new ones in successive years has proved successful in long-term monitoring (Creffield, 1991). Adhering a patch of tissue paper with a water soluble glue over affected areas and observing any new emergence holes through it in the following years has proved successful.

TREATMENTS

Treatment options against furniture beetle infestations have changed radically in the last 20 years. The former use of toxic insecticides and fumigants has now largely been superseded by environmental manipulation and new generation insecticides.

ENVIRONMENTAL CONTROL

Experimental data confirms that *Anobium* larval growth is halted at timber moisture contents below 12% (Ridout, 2000). This relates to an ambient relative humidity of 65-70%. Temperatures below 15°C inhibit movement, mating and eating and lower temperatures are increasingly fatal to all stages. Low temperature control limits state that infested material kept at -18°C for 2 weeks will kill all insect stages. At -30°C the treatment time is reduced to 1 week. The affected material needs to be sealed in a plastic bag with minimum air content to provide a micro-climate and prevent damaging condensation. Temperatures 52°C and above will kill all stages in 1 hour (Strang, 1992 and 1995). Raising air temperatures lowers ambient relative humidity so care must be taken to humidify the heated air.

Anoxia. Reducing oxygen levels to below 0.5% will kill by a combination of suffocation and desiccation (Biebl and Lang, 2013). Objects are placed in gas-tight containers and the air replaced with inert gases such as nitrogen, or oxygen absorbers are used to reduce the oxygen content to below 0.3%. The treatment is only effective at temperatures above 20°C and for extended periods of time (several weeks).

Mechanical Treatments. Non-chemical treatments to kill eggs and deep seated larvae include the use of microwaves and gamma radiation (Steinbach 2013).

Fumigation. Fumigation treatments involved highly toxic gases such as hydrogen cyanide and methyl bromide. Fumigant gases currently allowed in the European Union include phosphine. Sulfluryl fluoride (Drinkall, 1996) is currently registered as an effective fumigant in many countries, and carbon dioxide as a concentration of 60% has been used as a fumigant at high temperatures. In the European Union, sulfluryl fluoride, carbon dioxide and nitrogen are registered under the Biocides Directive 528/2012 to specific companies.

Insecticides. The Biocides Directive 528/2012 which came into force on September 2013 is designed to harmonise the use of biocides. These are active substances intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means. The affect of the legislation has been the demise of many currently used insecticides, as they no longer conform to the new regulations or are un-economic to register them.

Treatments against *Anobium* using insecticides require them to be effective for several years as they are surface treatments which kill eggs and emerging adults. They have the perceived problem of pesticide residues that may persist for many years. Some manufacturers are replacing their active ingredients with alternatives such as insect growth regulators. Insecticidal treatments against *Anobium* traditionally used insecticides such as lindane (□-hexa-chlorohexane), DDT (dichlorodiphenyltrichloroethane), dissolved in an organic solvent. Because of the toxicity and flammability of the solvent modern formulations are now micro-emulsions of the insecticide in water. Application onto affected material is by spraying or by fogging. Treatments using pyrotechnic insecticides have been successfully used against wood-boring insects (*Anobium* and *Xestobium rufovillosum*) in difficult to reach structural timbers (Ridout, 2000). Releasing the pyrotechnic smokes over successive years is intended to kill emerging adults and eggs.

NEW DEVELOPMENTS

Increasingly the treatment of structural and decorative timber against wood-boring infestations is continuing to moving away from the use of toxic insecticides. As a result of the new EU Biocides Directive, companies are concentrating more on the use of environmental solutions and the use of non-chemical treatments.

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