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DOCCUMENTARY STUDY OF THE BIO-ECOLOGY OF THE XYLOPHAGOUS BEETLE *ANOBIUM PUNCTATUM* DEGEER 1774, PEST OF THE PATRIMONIAL WOODEN OBJECTS

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Abstract: *Anobium punctatum* DeGeer 1774 (Coleoptera: Polyphaga: Anobiidae), generally known as 'the common furniture beetle' or 'woodworm', is the most important pest causing the degradation of wooden heritage items. Both the larvae and the adults are xylophagous. Both the larval and the adult stages cause damages to the wooden objects. The wood ingested is further processed in the digestive tube by a microflora specialized in cellulose degradation. The adults bore into the wood a nuptial gallery, in which the copula and the egg-laying occur. The larvae bore galleries irregularly developed, in which they pupate. The adults make an emergence gallery and get out after the larva metamorphosis. The wooden pieces are degraded by the galleries situated inside the wood, but especially the entrance and exit orifices. These holes may then have an influence on the possible rotting of the wood piece by favoring an optimal microclimate for the xylophagous microorganisms. The methods of pest control are physical (gamma radiations, temperature decrease), chemical (gassing, impregnation or instillation with various compounds) and the biological ones (bacteria or micromycetes, both in sporulated or free form). In this paper are presented informations on the species biology and ecology, tested pest control methods, according to the literature. The advantages of the biological control methods, including the results obtained by the Romanian researches until now are highlighted.

Keywords: *Anobium punctatum, life cycle, patrimonial wooden objects, control*

INTRODUCTION

The study of the bio-ecology of the coleopteran *Anobium punctatum* are of current interest, their outputs being used in order to develop or to improve the pest control methods. The majority of the control methods have been developed for the conservation of the book and / or wood and timber objects and artifacts (Moza, 2013; Moşneagu, 2005). Until recently only a small number of researches concerning the elaboration of new pest control methods for heritage items were undertaken. In Romania, currently there is an increased interest concerning the biological control of the *A. punctatum* in the spaces where wooden heritage items are preserved. In this paper, data from multiple sources concerning the species' biology and various control methods will be presented.

Taxonomic Rank (Bouchard *et al.*, 2011)

Regnum: Animalia
 Phylum: Arthropoda
  Classis: Insecta
   Ordo: Coleoptera
    Series: Bostrichiformia
     Suprafamilia: Bostrichoidea Latreille, 1802
      Familia: Anobiidae Fleming, 1821

Genus: *Anobium* Fabricius, 1775
Species: *A. punctatus* (DeGeer, 1774)

Nomeclatural History

The species was described by DeGeer in 1774 and was initially attributed to the genus *Ptinus*. One year after, the species was included in the genus *Anobium*. The specific name has 7 junior subjective synonyms, from which 6 are specific names (*Anobium pertinax* Fabricius, 1775, *A. domesticum* Geoffroy, *in* Fourcroy, 1785, *A. striatum* Olivier, 1790, *A. cylindricum* Marsham, 1802, *A. latreillei* Dufour, 1843, *A. pumilis* J. Leconte, 1865) and one is described as a subspecific name – variety (var. *caelatum* Mulsant *et* Rey, 1864) (Pic, 1922). Apart from the specific name, which is valid, the rest are invalid, being recognized as synonima for the specific names, according to the regulations of the International Code for Zoological Nomenclature, 3rd edition. (Ride *et al.*, 2012)

Distribution:

Mondial Its range covers the temperate boreal forests from the northern part of the Western Palearctic province (Bőhme, 2005) and the eastern part of the Nearctic region (Pickering, 2016), being also reported from the Neo-Zeelandic region (figure nr. 1). Over the time, *A. punctatus* became synanthropic, adapting to the majority of the regions where optimal conditions for its development were met.

Figure 1. Geographical distribution
(https://www.discoverlife.org/mp/20m?kind=Anobium+punctatum)

In **Romania** *A. punctatum* was recorded as *A. pertinax* from Transylvania “Common in our mountains and hillsides”) (Petri, 1912).

General External Morphology (Diagnosis):

Adult (Imago): Length: 5 (3.5 – 6 mm range) to 9 (7.9 – 9.2 mm range). Colour: light to dark brown (Figures 8 and 9). Head: +/- hypognathous, dorsally covered by the anterior margin of the pronotum. Antennae elongate, 11-segmented, to the ♂♂ the 9th and the 10th antennomeres have the same length as the antennomeres 1 to 8 together, the interior side of the last three distal antennomeres +/- rounded, the exterior side +/- straight (sub-flabellate). Pronotum: (in dorsal view) with two posteriorad cornicles, the apex sinuated and the base linear, the postero-median part dilated in form of a bulge (in lateral view). Body: Dorsal side densely and golden shiny pubescent, the hairs more abundant on the lateral sides of the body, dorso-laterad and dorso-posteriorad oriented, creating patterns. Mesothorax with two posterior bulges. Elytra: (in dorsal view) with well-developed and rounded humeral angles, the parallel sides slightly attenuated posteriorad and the apices rounded and slightly obtuse emarginated, the epipleural margin sinuated towards the middle, the apex slightly oriented ventrad (in lateral view). Puncturation: 10 ranges (at the scutellum level), of distinct, deep irregular punctures +/- parallel near the sutural margin, +/- divergent towards the posterior side of the epipleural margin and partially converging after the posterior fifth of the elytron. The pubescence gives the elytra a somewhat striated aspect. Abdomen: 5 visible sternites, each covered with golden pubescence, forming a visible edge at their posterior part. Anal segment of the ♂♂ +/- uniformly rounded. Feet: Tarsal formula 5:5:5 (Pentamera), femora dilated, tibiae thinner and sinuated and tarsi slender, only the preapical one with pulvili, the proximal tarsomere length greater than the following ones (Freude *et al*., 1965, 1969).

Life cycle

Anobium punctatum is univoltine (one generation per year). After 10 days, from the eggs develops the larva, which metamorphosis take place in a pupal chamber. Its' life span varies from 365 to 1825 days (one to five years). This interval can vary in correlation with the environmental factors, presence and abundance of the food supply, temperature and humidity. Also, the larva presents winter diapause (Moza, 2013).

The feeding occurs all along the larval stage, the individuals boring irregularly-branched galleries which are filled with fine sawdust (Figures 2 and 3).

Figure 2. Emergence holes (https://commons.wikimedia.org/wiki/Category:Anobium_punctatum#/media/File:BroomstickDestroyedByWoodworm_3866.jpg)

Figure 3. Galleries in a book (https://en.wikipedia.org/wiki/Bookworm_(insect)#/media/File:Bookworm_traces.JPG)

The interval between the pupal and the adult stages (Figures 4 and 5) lasts from 35 to 45 days and it takes place into a pupal chamber, padded with sawdust strengthened with larval secretions.

Figure 4. Adult, dorsal view (https://commons.wikimedia.org/wiki/File:Anobium_punctatum_(Geer,_1774)_(28692210695).png)

Figure 5. Adult, ventral view (https://commons.wikimedia.org/wiki/Category:Anobium_punctatum#/media/File:Anobium_punctatum_under.jpg)

The adults leave the pupal chamber through a flight gallery with an emergence hole (Figure 8) which has a diameter between 1 and 1.5 mm. After emergence, they live between 14 and 21 days (two to three weeks). As adults, the individuals are feeding more or less intensive, in order to achieve the maturation of their gonads, and, after mating, the female lays the eggs. The males die short time after the copula and the females after the oviposition.

Attack detection

Usually, due to the small dimensions of the galleries' orifices, the attack can rarely observed in an incipient phase. The sinuous pattern of the galleries bored by the larvae can be clearly seen on the attacked objects (Figure 3).

From the various methods for the early attack detection some rely on pheromone-baited sticky traps (El-Sayed, 2019), other simply on the gluing of a piece of paper on the surface of the object being suspected to have been attacked. In the first case, adults are trapped, in the second one, holes can be seen through the paper, where the galleries open, and, sometimes, some fine sawdust on the closest horizontal flat surface situated underneath the holes.

We presume that the most demonstrative method for observing and deducing the 3D pattern of the galleries would be the inspection of a book which has suffered an attack - the galleries are practically serially sectioned (*e.g.* as in the case of the histological serial sectioning of an organ). By serial scanning of each of the pages, followed by ulterior computer-assisted graphical design, the shape of the galleries can be deduced.

Also, the most useful and non-invasive methods could rely on the use of the X-rays or the Computer Tomographic technique, in order to obtain a two- (respectively) three-dimensional aspect of the galleries - as they are used in the investigations of various biological objects and artefacts.

Control methods

Various control methods have been developed (as used in the curation of the biological and art collections):

1. Physical methods: ionising radiation, heat shock, freezing. The first one may be quite costly, but it's the most effective, the others being more or less efficient (especially in the initial phase of the attack).

2. Chemical methods are based on the use of organic substances, both natural (Creosote) synthetic (Carbon tetrachloride), natural identically, as the pheromones (Stegobinone) and inorganic ones (Sulphur dioxide). The chemical methods have a variable degree of effectiveness, which is influenced by external variables (micro-climate conditions) or internal ones (age, development stage, health state etc.). From those, the pheromone ones display the greatest selectivity.
3. Biological control methods (Kern, 1994; Morales & Rochling, 1994; El-Sayed, 2019) involve the use of various facultative entomopathogenic bacteria (*Bacillus thuringiensis*), micromycetes belonging to various taxonomic groups (*Aspergillus* spp., *Beauveria bassiana, Isaria farinosa* (*syn. Paecilomyces farinosus*), *I. fumosorosea (P. fumosoroseus)*, *Metahrizium* spp.) The effectiveness of the biological control methods have high degrees of effectiveness and specificity. These can be modulated in the laboratory by growing the selected microorganism for several generations on specific hosts.
4. Integrate control methods, involving the use of an insecticide (*e.g.*: Silafluofen (Kern, 1994; Morales & Rochling, 1994;) in order to reduce and maintain the pest population numerical values under the damage threshold, together or followed by the use of a biological control agent (*e.g.*: *Beauveria bassiana*) in order to reduce them to a minimum.

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