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 ORIGINAL PAPEER

The conservation of wooden heritage items exhibited in the open against the attack of noxious insects

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Abstract.
The paper entitled "The conservation of wooden heritage items exhibited in the open against the attack of noxious insects", has as a main objectives the presentation of the species of xylophagous coleopterans that act as a decaying factor to wood involved in the realization of heritage items. We have also collected informations concerning the morphological aspects, biology, ecological and ethological data, aspects of damage to wood, and also the testing and the study of some methods for monitoring, prevention and control of the attacks.

Keywords: insects, coleopterans, wood heritage, preservation

1. Introduction

The organic substance from the wood is subjected to the processes of biodegradation up to its primary constituents. The protection need of the wood, the prevention or delay of the degradation processes as well as treatment activities, imposed the knowledge of the material structure and its causal factors of deterioration. The study of the effects of degradation processes led to the knowledge of causes and the complex of pathogenic factors. This information is essential in the understanding of the mechanisms involved in the deterioration of the wooden material.

Xylophagous insects occupy a primordial place in the degradation of wood. The secondary and tertiary xylophagous coleopterans are the most commonly encountered insects, as pests affecting the wood of heritage goods. They live in the old wood, depreciated by the action of Fungi.

The main objectives of the PhD thesis, entitled *The Conservation of the Patrimony Goods made of Wood and Exhibited Outdoors against the Insect Pests*, that this present material refers at, are: knowledge of the harmful xylophagous species of coleopterans from the established sites, the synthesis of scientific information regarding the morphology, biology, ecology and ethology of the harmful xylophagous insects, aspects of the attack, and the testing and study of some methods for the monitoring, control and combat of the attack.

2. History of the researches The damages provoked by the insect pests, in general, and those xylophagous ones, in particular, referring to the wood degradation have led to the development of deep research on morphology, biology, ecology and the control possibilities of insect pests. In parallel, it has developed a complementary field, the applied entomology, being realized studies on the degradation caused by xylophagous insects, with applications on control possibilities and combat of these attacks.

2.1. Worldwide researches

Research conducted in the last years in terms of xylophagous pest focused extensively on the study of individuals of the species *Xestobium rufovillosum*, referring to biology, ecology and ethology of the species: the preferences for the nutrient substrate, the mating behaviour, the influence of abiotic factors in the development of individuals, the relationship with other insects, control. Among the more important authors, we mention: P. White, M. Birch, St. Church, C. Jay, J. E. Rowe and Keenlyside (1993), Steven R. Belmain, Walter M. Blaney and MSJ Simmonds (1998, 1999), Chris Wood (1999), D. Goulson, MC Birch, TD Wyatt (1993, 2002) and others.

There were published complex works regarding the insect pests, knowledge and their control, direct implications in the conservation of the patrimony goods. Among more important authors, we mention: Hickin Norman E. (1963, 1968); Sutter Hans-Peter (1992); Pinniger David (1994); Caneva G., Nugari M. P. and Salvadori O. (1997); Csóka Gy. and Kovács T. (1999); Chiappini E., Liotta G., Reguzzi M. C. and Battisti A. (2001); Shin Maekawa and Roberto Boddi, Simona Calza, Maria Rizzi, Andrea Santacesaria (2002).

2.2. Researches in Romania

In Romania, the studies, concerning the issues of conservation of the patrimony goods made of wood, were approached by a small number of researchers; they were published in various publications of speciality or as individual papers.

Negru Ştefan published in 1966 a paper in the Journal of Museums about the wooden death watches, pests in museums. The study deals with the species from the family Anobiidae, the conservation of the wood pieces, prevention of the attack and control techniques. Other authors dealt issues related to the conservation of the cultural goods: Vlăduţ et al. (1974), Ramiro Georgescu (1977), GeorgeYuga (1979).

Mustaţă Gheorghe and Mustaţă Mariana starting from 1977 maintain a research activity for the knowledge and control of biological pests of the mobile and immobile cultural goods. The studies were made for the deep knowledge of morphological, biological and ecological data of the pests and the testing of some combating methods and control correlated to the principles of conservation of the patrimony goods (1977, 1978-1979, 1994, 1998, 2001, 2006, 2009).

Livia and Corneliu Bucşa perform research with regard to the degradation caused to the patrimony goods by Fungi and insects (1978, 1998, 2004, 2005, 2009).

Information on the conservation of the patrimony goods in terms of pest insects control were presented in various volumes with common papers on the theme of preservation-restoration. Among authors, we mention: Păun J. And Vultureanu M. (1977), Corneliu Ponta (2003), Mirela Brăilean and Ecaterina Dediu (2003) – utilization of radiations in treatments of control, Paula Dora Pascu (1998, 2000) – plant extracts, an alternative to chemical treatments in the control of insect pests.

Oprea Florea (2006) – aspects related to biology, ecology and the mode of attack of the xylophagous insects with proposals and recommendations of control and treatment.

Since 2000 at the Faculty of Biology, ”Alexandru Ioan Cuza University”, there have been put the bases of a program of master degree in the field of conservation of patrimony goods, within the direction of the University Reader PhD Mariana Mustaţă. A series of dissertation works were finalized; then, theses of doctorate led by Professor Mustaţă Gheorghe in the field of the conservation of patrimony goods attacked by insects. Among them: Crudu S. (2005), Moldovan G. (2007), Mosneagu M. (2009), Axinte L., their results were presented within various scientific sessions and later they were published in specialty catalogues.

3. Characterization of research sites and the presentation of the main wooden species

In Chapter II, there are presented the main stations of research in which the studies were carried out. The large dimensions, complexity, big number of objects displayed outdoors and the diversity of the used wooden material, make from these researching points real true ecological ecosystems, where the variety of ecological niches give the possibility of a detailed study of the species of interest.

Thus, two special points of research were established respectively, Museum of Traditional Folk Civilization ”ASTRA” in Sibiu and the National Village Museum ”Dimitrie Gusti”, Bucharest.

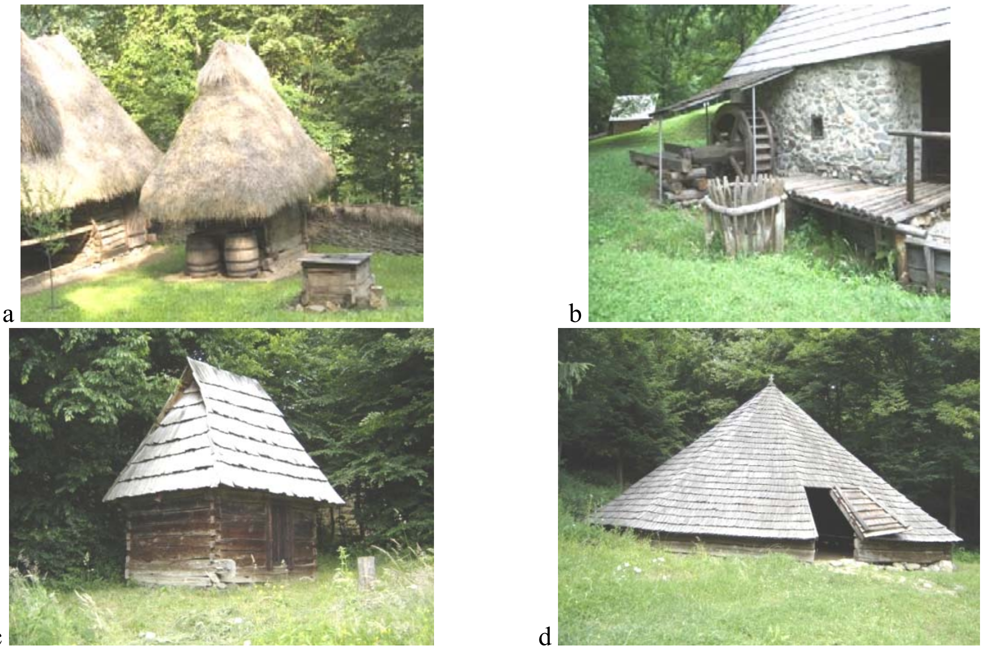
3.1. “Astra” Museum of Traditional Folk Civilization

Due to its position (hilly zone 4 km away from the town of Sibiu, in Dumbrava Forest with a predominant tree vegetation made up of deciduous species), ASTRA Museum of Traditional Folk Civilization is integrated in a microclimate with slightly higher relative humidity values throughout the year and lower temperatures, with an average of about 8°C. The influences on the zone microclimate and hydrographic network are due to the presence of a lake located in the middle of the museum with a surface of about 6 hectares.

The museum covers an area of 96 ha of land with altitudes ranging between 448 and 503 m, with amplitudes of the differences in level between 20-50 m. Of the total area of the museum there are used for exhibition about 42 ha, the rest acting as buffer and recreational zone. Within the exhibition space, approx. 6 ha are lakes, 5.2 ha swamps and reed plot, 8.5 ha pasture, 0.7 ha thickets and 22.6 ha forest with clearings (Bucşa, 1978, 2005).

As in other museums with exhibitions outdoors, ASTRA Museum of Traditional Folk Civilization is located near the town, being a transition zone between the natural environment and the artificial urbanized one.

The patrimony of the museum includes approximately 120 monuments containing 300 buildings with 16,000 objects of functional inventory.



a b c d

Fig. 1. a, b, c, d - Images with traditional Romanian architecture preserved in the "Astra" Museum

3.2. "Dimitrie Gusti" National Village Museum

Created in 1936, the "Dimitrie Gusti" National Village Museum in Bucharest was initially named the Village Museum in Bucharest. Upon its inauguration, the museum spread over a 5 hectare-surface and had only 30 old men houses, characteristic to the different areas in the country. For their emplacement worked culture professionals, species lists, 1100 workers of various professions and 130 folk craftsmen from the villages where the dwellings were selected. Along the years, the museum surface was increased to about 15 hectares, out of which more than 4 ha are equipped with everything that is necessary for a peasant household (workshops, adjacent constructions, churches etc.), at present the number of constructions present in the exhibition in the open exceeding 300 edifices.

Regarding the variety and percentage of the wooden essences used in creating the constructions within the exhibition in the open, like in the case of the

"ASTRA" Museum of Traditional Folk Civilization, they differ according to the case, pending on the area of origin and utility. It was noticed that in certain architectural elements certain wooden essences are prevalent:

- For blooms– hard essences, oak tree and durmast, more rarely resineferous,
- For walls – oak tree and durmast, and also resineferous such as the fir tree and the spruce, more rarely other deciduous (beech, ash tree, sycamore maple, Turkey oak, elm etc.),
- For floors – planks of fir tree or spruce, for parquetry oak and beech,
- For platforms – fir tree or spruce and more rarely oak tree,
- For roofs – especially resinous (fir tree or spruce), and among deciduous the most frequent is the oak tree,
- Shingle covers are made mainly of resinous essences (fir tree or spruce).

a 
b 
c 
d 

Fig. 2. a, b, c, d - Details with folk architecture exhibited in the museum

4. Results and discussions

4.1. Species of insects harmful to the goods of patrimony, made of wood and exhibited outdoors, reported in Romania

The number of research studies made in Romania with regard to harmful xylophagous coleopterans to museums in general and outdoor museums, in particular, is relatively small. The authors who mention harmful insect species on the goods of patrimony do not study exclusively the wooden pieces exposed outdoors, but generally, they treat the problem of the biodeterioration of cultural goods both from the external environment and the internal one. The fact is argued by the characteristics of the polyphagy of the species of coleopterans considered as being xylophagous species and their adaptability to different substrates both in the external environment and the internal one.

There are listed the species of xylophagous coleopterans, mentioned by other authors, as pests of the cultural goods made of wood and exhibited outdoors in Romania:

1. *Lyctus pubescens* Panz. (Bucşa C., 1998),
2. *Lyctus linearis* Goeze. (Bucşa C., 1998),
3. *Lyctus (Trogoxylon) impressum* Com. (Mustaţă M., 1979, 1994),
4. *Lyctus brunneus* Steph. (Mustaţă M., 1994),
5. *Bostrychus capucinus* L. (Bucşa C., 1998),
6. *Xestobium rufovillosum* Degeer. (Ştefan N., 1966; Mustaţă Gh., Mustaţă M., 1977; Mustaţă M., 1979; Mustaţă M., 1998; Bucşa C., 1998),
7. *Ernobius mollis* L. (Bucşa C., 1998),
8. *Oligomerus brunneus* Sturm. (Bucşa C., 1998),
9. *Gastralus immarginatus* Müll. (Bucşa C., 1998),
10. *Anobium punctatum* Degeer. (Ştefan N., 1966; Mustaţă Gh., Mustaţă M., 1980; Mustaţă M., 1994; Mustaţă M., 1998; Bucşa C., 1998),
11. *Anobium fulvicorne* Sturm. (Bucşa C., 1998),
12. *Anobium rufipes* L. (Mustaţă M., 1994; Bucşa C., 1998),
13. *Anobium denticole* Creutz. (Mustaţă M., 1994; Bucşa C., 1998),
14. *Anobium pertinax* L. (Leon N., 1912; Ştefan N., 1966; Mustaţă Gh., Mustaţă M., 1977; Mustaţă M., 1994; Mustaţă M., 1998; Bucşa C., 1998),
15. *Priobium carpini* Hrbst. (Bucşa C., 1998),
16. *Ptilinus pectinicornis* L. (Mustaţă M., 1994; Bucşa C., 1998),
17. *Ptilinus fuscus* Geoff. (Mustaţă M., 1994; Bucşa C., 1998),
18. *Xyletinus pectinatus* F. (Bucşa C., 1998),
19. *Asemum striatum* L. (Bucşa C., 1998),
20. *Arhopalus rusticus* L. (Bucşa C., 1998),
21. *Gracilia minuta* L. (Bucşa C., 1998),
22. *Nathrius brevipennis* Muls. (Bucşa C., 1998),
23. *Hylotrupes bajulus* L. (Bucşa C., 1998),
24. *Callidium violaceum* L. (Bucşa C., 1998),
25. *Phymatodes testaceus* L. (Bucşa C., 1998),
26. *Xylotrechus rusticus* L. (Bucşa C., 1998),
27. *Myelophilus piniperda* L. (Bucşa C., 1998),
28. *Xyloterus lineatus* Oliv. (Bucşa C., 1998),
29. *Xyloterus domesticus* L. (Bucşa C., 1998),
30. *Xyleborus dispar* F. (Bucşa C., 1998),
31. *Xyleborus monographus* F. (Bucşa C., 1998),
32. *Xyleborus dryographus* Ratz. (Bucşa C., 1998),
33. *Xyleborus saxeseni* Ratz. (Bucşa C., 1998),
34. *Orthotomicus laricis* F. (Bucşa C., 1998),
35. *Hexarthrum exiguum* Boh. (Bucşa C., 1998),
36. *Rhyncolus (Stereocorynes) truncorum* Germ. (Bucşa C., 1998; Mustaţă M., 1998).

4.2. The list of harmful species to the goods of patrimony made of wood, from the external environment, identified in our research

The pests of wood patrimony goods exhibited outdoors are species of polyphagous coleopterans, adapted preferentially to feed with wooden substrate, xylophagous coleopterans. Their presentation include: systematic position, synonymies, geographical distribution, and morphological, biological and ecological data.

The list of harmful species reported, includes: family, orders: *Lyctus linearis* Goeze (Col. Lyctidae), *Ptilinus pectinicornis* L. (Col. Anobiidae), *Anobium punctatum* Degeer. (Col. Anobiidae), *Xestobium rufovillosum* Degeer. (Col. Anobiidae), *Ernobius mollis* L. (Col. Anobiidae), *Hylotrupes bajulus* L. (Col. Cerambycidae), *Hexarthrum exiguum* Boh. (Col. Curculionidae).

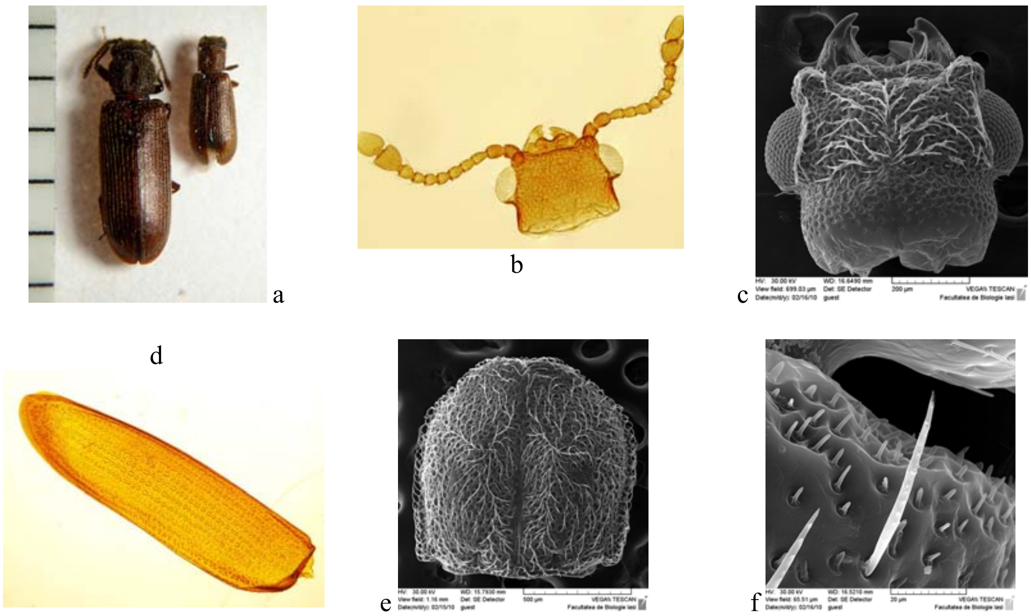


Fig. 3. a, b, c, d, e, f - Presentation of the specie *Lyctus linearis* Goeze (Coleoptera, Lyctidae)

a) General view of *Lyctus linearis* adults
b) Head of *L. linearis* specie
c) Head of *L. linearis* specie
d) Secondary wing of the specie *L. linearis*
e) Pronotum of the specie
f) Detailed view of sensitive areas of the antennae of the *L. linearis* specie

a b c

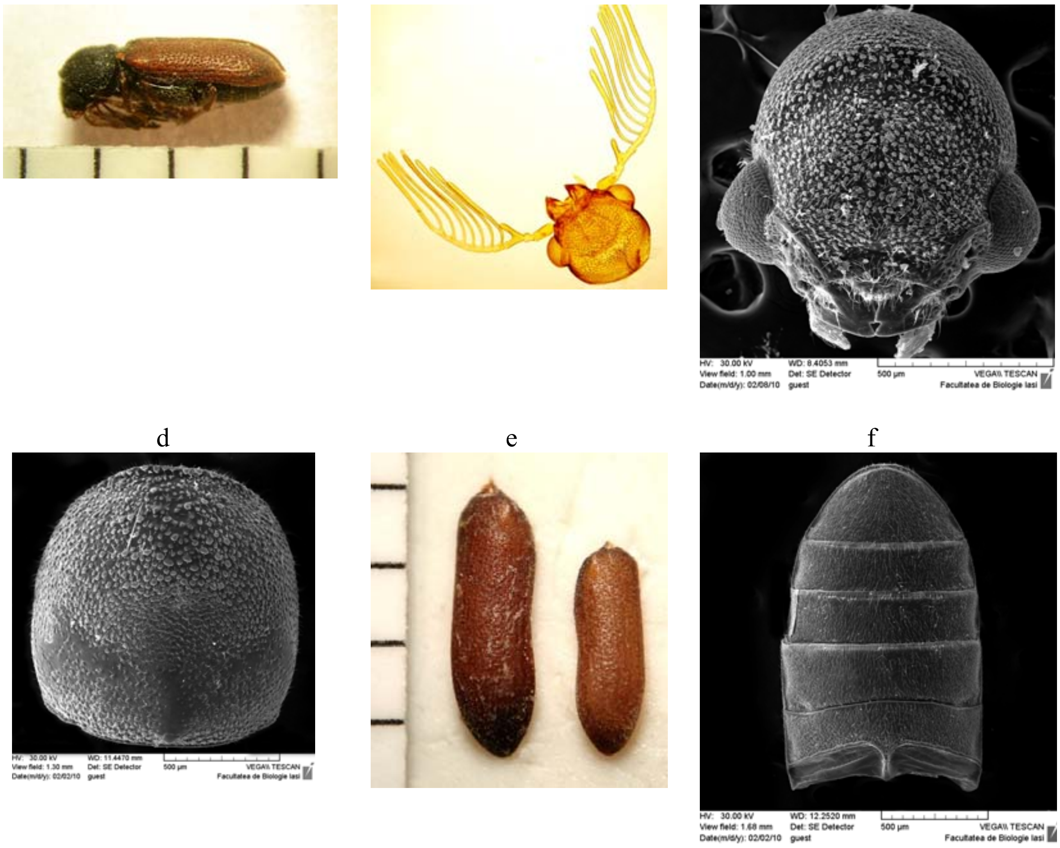
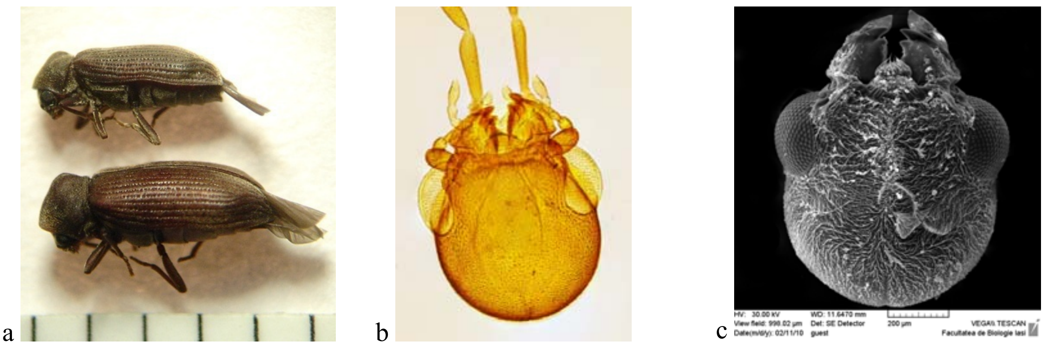


Fig. 4. a, b, c, d, e, f - Presentation of the specie *Ptilinus pectinicornis* L. (Coleoptera, Anobiidae)

a) General view of *Ptilinus pectinicornis* male
b) Head of *P.pectinicornis* male
c) Head of *P.pectinicornis* male
d) Pronotum of the specie
e) Secondary wings of the specie *P.pectinicornis*
f) Ventral view of the abdomen of the specie



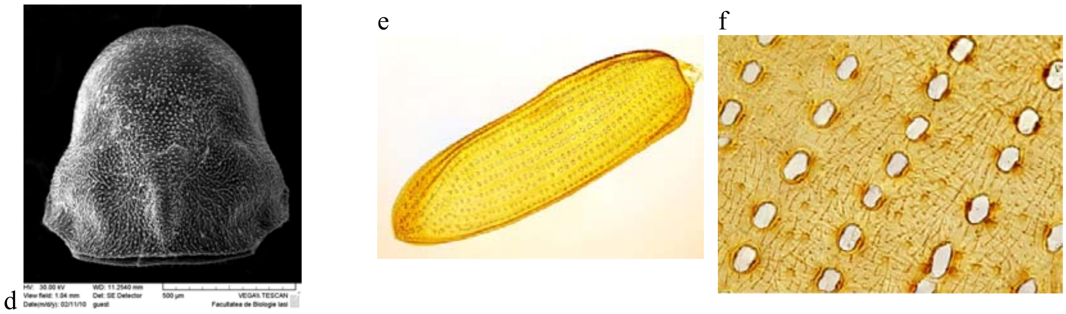


Fig. 5. a, b, c, d, e, f - Presentation of the specie *Anobium punctatum* Degeer. (Coleoptera, Anobiidae)

a) General view of *Anobium punctatum* adults
b) Head of *A. punctatum* specie
c) Head of *A. punctatum* specie
d) Pronotum of the specie
e) Secondary wing of the specie *A. punctatum*
f) Detailed view of the texture of the secondary wing

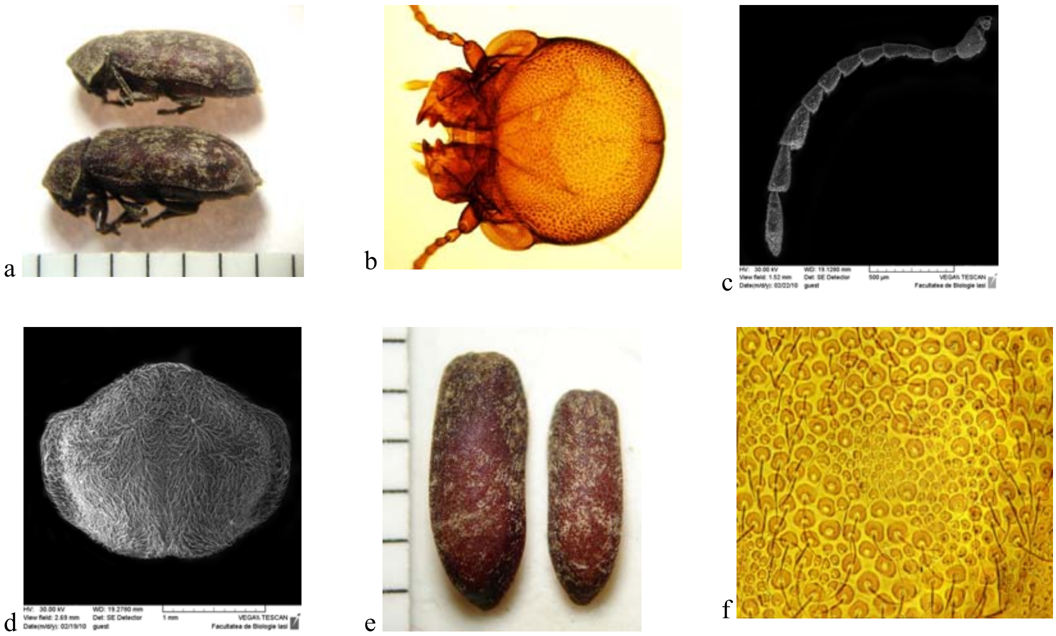


Fig. 6. a, b, c, d, e, f - Presentation of the specie *Xestobium rufovillosum* Degeer. (Coleoptera, Anobiidae)

a) General view of *Xestobium rufovillosum* adults
b) Head of *X. rufovillosum* specie
c) Antennae of the specie
d) Pronotum of the specie
e) Secondary wings of the specie *X. rufovillosum*
f) Detailed view of the texture of the secondary wing

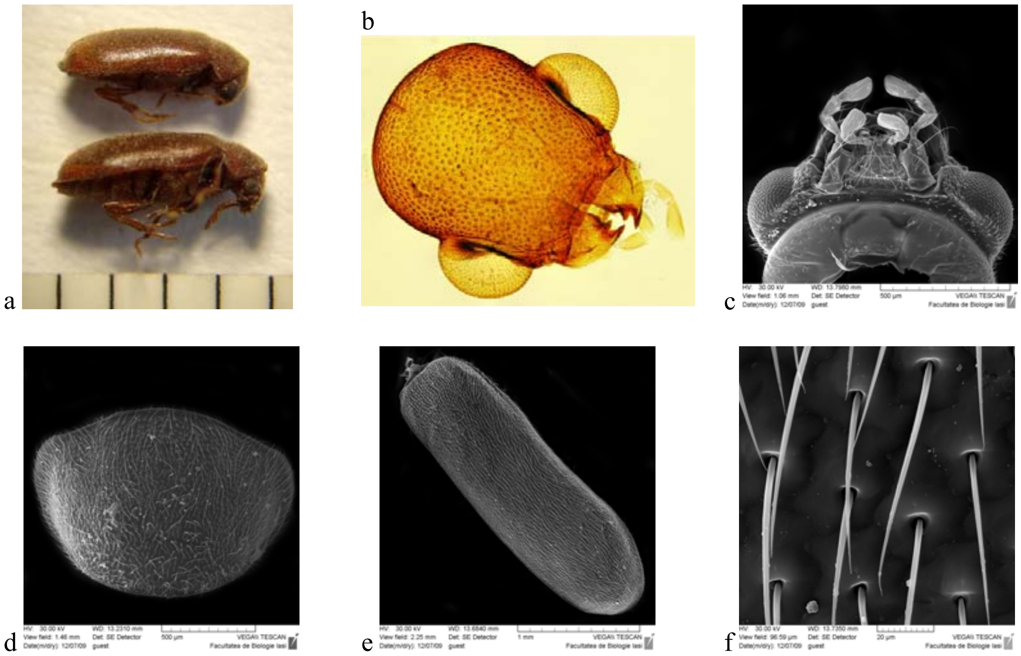
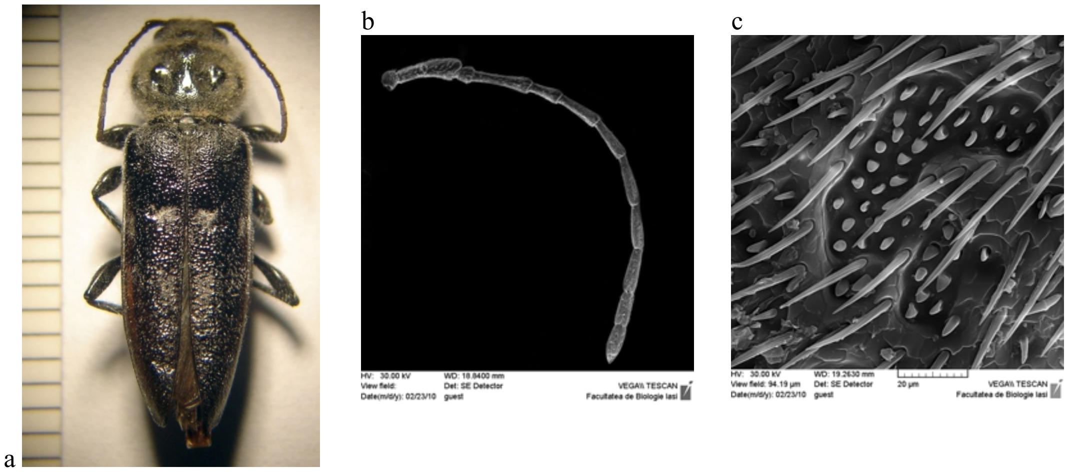


Fig. 7. a, b, c, d, e, f - Presentation of the specie *Ernobius mollis* L. (Coleoptera, Anobiidae)

a) General view of *Ernobius mollis* adults
b) Head of *E. mollis* specie
c) Detailed ventral view of the fore end of the specie
d) Pronotum of the specie
e) Secondary wing of the specie *E. mollis*
f) Detailed view of the texture of the secondary wing



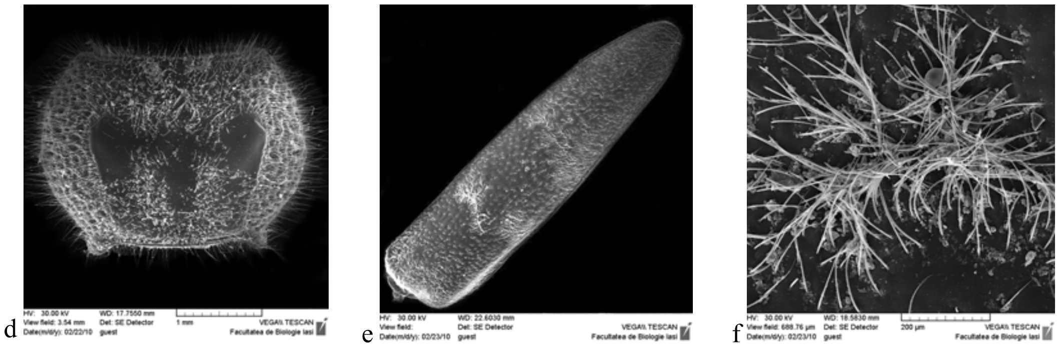


Fig. 8. a, b, c, d, e, f - Presentation of the specie *Hylotrupes bajulus* L. (Coleoptera, Cerambycidae)

a) General view of *Hylotrupes bajulus* female adult
b) Antenna of *H. bajulus* specie
c) Detailed view of sensitive areas of the antennae of the *H. bajulus* specie
d) Pronotum of the specie
e) Over all view of the secondary wing of the specie *H. bajulus*
f) Detailed view of the texture of the secondary wing

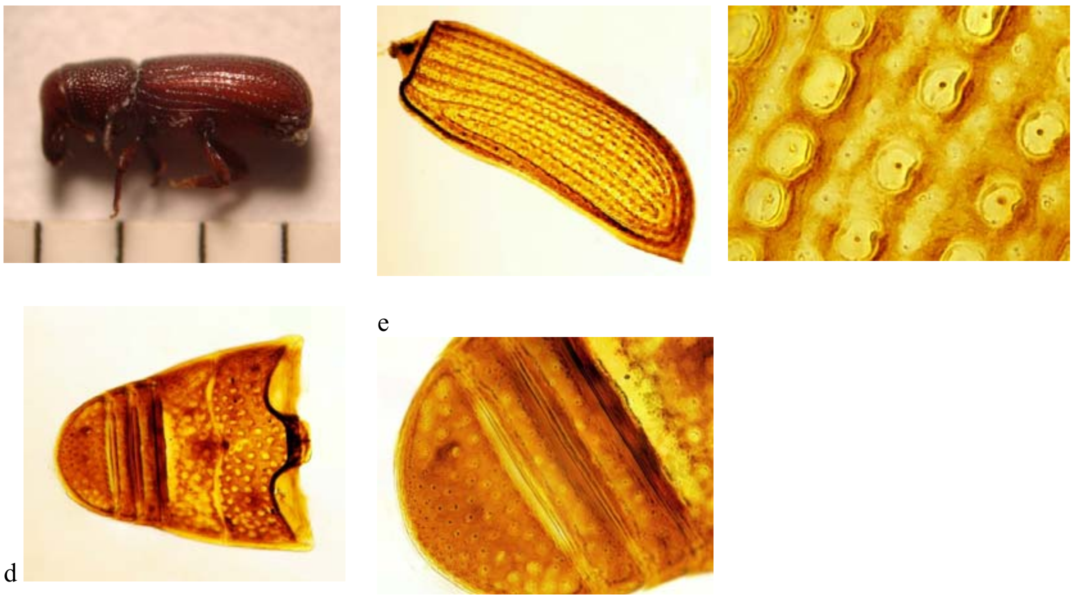


Fig. 9. a, b, c, d, e - Presentation of the specie *Hexarthrum exiguum* Boh. (Coleoptera, Curculionidae)

a) General view of *Hexarthrum exiguum* adult
b) Secondary wing of the specie *H. exiguum*
c) Detailed view of the texture of the secondary wing
d) Ventral view of the abdomen of the specie
e) Detailed view of the tip of the abdomen of *H. exiguum*

5. Biological data on some harmful insects to patrimony goods made of wood and exhibited outdoors

In this chapter, the following sub chapters are presented: sexual maturation, reproduction, development of xylophagous coleopterans, egg, egg mass-laying of eggs, postembrionary development, larval stage, pupal stage, post metabolic development-adult stage, sex ratio and the life cycle of species.

6. Ecological and ethological data on some harmful insects to the goods of patrimony made of wood and exhibited outdoors

6.1. Ecological data

In this sub chapter there are presented the following aspects: the influence of abiotic factors on xylophagous coleopterans (temperature and humidity, light, nutrition support, nutritional preference in the xylophagous species in association with the depreciation of the wood by Fungi), the influence of biotic factors on xylophagous coleopterans (symbiotes, sinoecia, parasitism, predatorism).

In our paper there are presented information with regard to the main digestive particularities for the main species of harmful insects to the wood, the presence or absence of symbionts, the mode of digestion of the lignin and cellulose, the preference for certain wooden species, depending on the content of certain substances, the degree of microbiological depreciation, etc.

The installation of secondary and tertiary xylophagous coleopterans is characterized in most cases by the emergence and development of a previous attack of fungal origin that makes a ”preparation” of the wooden mass that transform enzymatically the matter in a nutritive substrate easier to digest for most of the above-mentioned insect species. In our research we tried to establish some correlation between the degradation of wood by the xylophagous insects and the incidence of development of the biodeteriogenic microfungi on the wooden substrate. I performed rearings of cultures in laboratory in order to determine the genus of strains of microfungi which developed on medium of culture seeded with pieces of wood taken from the museum attacked by insects.

Following the microscopic analysis of the smears made on the basis of the developed colonies grown on Petri dishes with culture media, there could be identified Fungi species belonging to seven genera with biodeteriogenic species whose action is harmful to cultural goods made of wood, whether or not it is related to the attack of the xylophagous insects.

I determined the following species: *Mucor sp*. and *Rhizopus sp*. (Family Mucoraceae), *Verticillium sp*. (Hypocreaceae), *Apergillus sp*. and *Penicillium sp*. (Trichocomaceae), *Alternaria sp*. (Pleosporaceae), *Aureobasidium sp*. (Dothioraceae).

From Table no. 1 it results that the genera of micromycetes with the highest presence are: *Rhizopus sp*. found in 10 of the 18 analysed samples and *Penicillium sp*. found in 8 cases. The other genera found have an inferior presence to the first two mentioned: *Aspergillus sp*. and *Mucor sp*. were found in 3 of the studied samples, and *Verticillium sp*., *Aureobasidium sp*. and *Alternaria sp*. were found each in just 2 of the analysed samples.

Table 1 - The presence of the genera of micromycetes on the number of analysed samples

Plate no.	**Type of the wooden essence**	**Species of mycromicetae**
1	Oak tree wood with attack of *Xestobium*	*Penicillium sp.* *Aspergillus sp.*
2	Oak tree wood with attack of *Xestobium*	*Penicillium sp.* *Alternaria sp.*
3	Oak tree wood with attack of *Xestobium*	*Penicillium sp.* *Rhizopus sp.* *Aspergillus sp.*
4	Oak tree wood with attack of *Xestobium*	*Mucor sp.*
5	Old oak tree decayed by insects, without active attack	*Penicillium sp.* *Aureobasidium sp.*
18	Oak tree wood with attack of *Xestobium*	*Penicillium sp.*
6	Oak tree wood with attack of *Anobium*	*Rhizopus sp.*
7	Oak tree wood with attack of *Anobium*	*Rhizopus sp.*
19	Oak tree wood with attack of *Anobium*	*Aureobasidium sp.* *Aspergillus sp.* *Alternaria sp.*
8	Resinous wood attacked by *Anobium*	*Rhizopus sp.*
9	resinous wood attacked by *Anobium*	*Rhizopus sp.* *Mucor sp.*
10	resinous wood attacked by *Anobium*	*Penicillium sp.* *Rhizopus sp.*
20	resinous wood attacked by *Anobium*	*Rhizopus sp.*
11	Beech with attack of *Ptilinus*	*Penicillium sp.* *Verticillium sp.* *Rhizopus sp.*
12	Beech with attack of *Ptilinus*	*Rhizopus sp.*
13	Beech with attack of *Ptilinus*	*Mucor sp.*
14	Elm with attack of *Lyctus*	*Rhizopus sp.*
15	Elm with attack of *Lyctus*	*Penicillium sp.* *Verticillium sp.*

There is a relationship between the depreciation of the wood by the xylophagous Fungi and then the installation of the xylophagous insects attack. Thus, we have a proof that xylophagous insects prefer the wood attacked by Fungi.

The insects live in biological associations called biocoenoses. The populations in a biocoenosis are in a dynamic equilibrium directly correlated with the surrounding environment. In the operation of a biocoenosis there are intra- and interspecific relationships, the inter-reciprocity and interdependence, each species is related to certain environmental conditions (microclimate, substrate nutrient, biotic relationships), which makes its existence in that ecosystem.

Natural enemies of the insects are all living organisms that live on their behalf, influence their development, limiting or preventing the reproduction, or causing their death. The main categories of natural enemies of insects are microorganisms (yeasts, bacteria, viruses), vegetable multicellular organisms (Fungi) or animals (entomophages).

The main types of biological correlations are: parasitism and predatorism.

In our research we aimed at observing the trophic relationships that exist between the species of parasitoids, recorded in the stationary points and the identified harmful species.

In Table no.2 there are presented the parasitoid species reported in our research and in Figure no. 10 the trophic relationships that can be drawn between these and insect pests to the goods of patrimony, made of wood and exhibited outdoors.

Table 2 - The suprataxa and the species of parasitoids reported in our research

HYMENOPTERA	
ICHNEUMONOIDEA	
ICHNEUMONIDAE	
PIMPLINAE	
Liotryphon	*crassiseta* Thomp.
Ephialtes	*planifrons*
Ephialtes	*spp.*
POEMENIINAE	
Neoxorides	*collaris* Grav.
Deuteroxorides	*spp.*
MESOCHORINAE	
Mesochorus	*facialis* Bridgm.
Mesochorus	*anomalus* Holmgr.
Mesochorus	*confusus* Holmgr.
Mesochorus	*pectoralis* Ratz.
BRACONIDAE	
HELCONINAE	
Aspicolpus	*erythrogaster* Tobias
DORYCTINAE	
Spathius	*exarator* L.
Hecabolus	*sulcatus* Curt.
CHALCIDOIDEA	
PTEROMALIDAE	
PTEROMALINAE	
Trichomalus	*helvipes* Walk.
Lariophagus	*distinguendus* Foerst.
PLATIGASTROIDEA	
SCELIONIDAE	
Trimorus	*spp.*

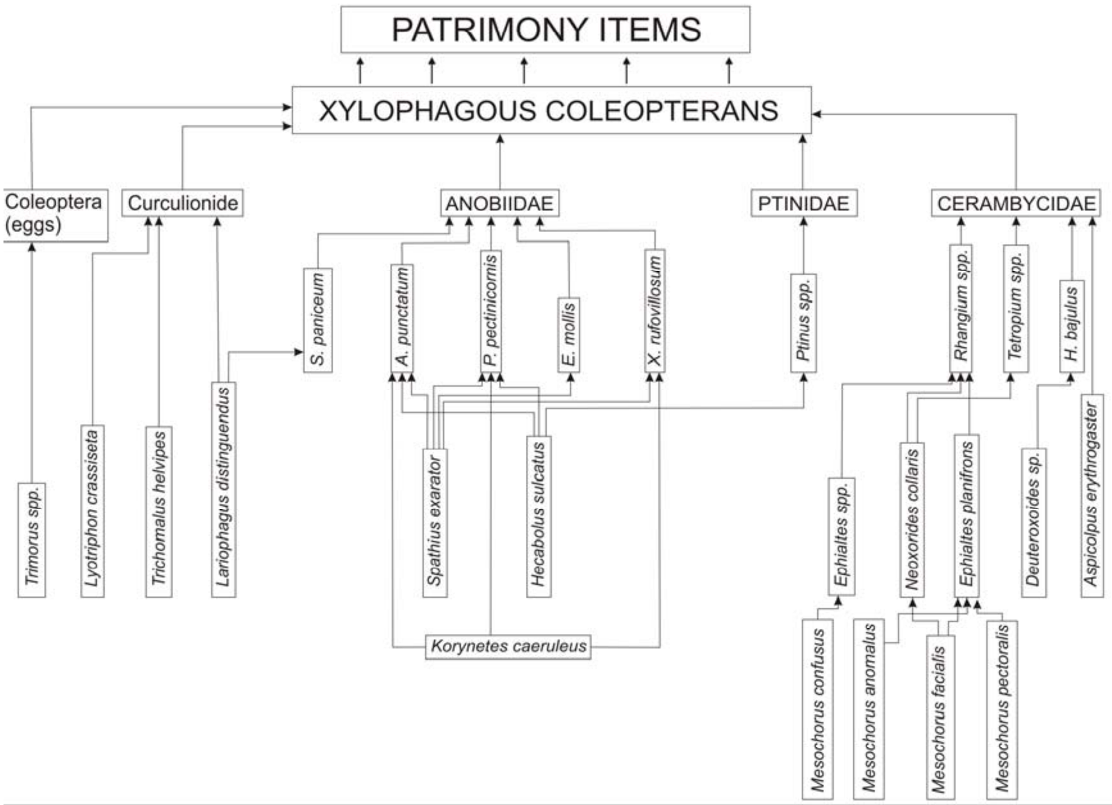


Fig. 10 - Trophic relationships among the species harmful to patrimony items and entomoparasites

Korynetes caeruleus Degeer (Coleoptera, Cleridae) is one of the most reported predators of the species *Anobium punctatum*, it was also reported as being a predator of the species *Xestobium rufovillosum*. I found the species *Korynetes caeruleus* at the ”ASTRA” Museum of Traditional Folk Civilization in Sibiu. Becker mentions the species *Opilo domesticus* Sturm. (Coleoptera, Cleridae), as the most important predator of the species *Anobium punctatum* in Germany. The species *Opilo mollis L.* is also cited as predator of the species *A. punctatum*.

Within the Order Coleoptera, different species of Cleridae were reported as predators of the family Lyctidae. Among these *Tarsostenus univittatus* Rossi is the most common species (Gerberg, quoted by Hickin,1968).

6.2. Ethological data

In this chapter there are presented information referring to: acoustic signals, mating behaviour, behaviour of laying the egg mass, thanatosis and the behaviour in the larval stage.

7. The situation of the attack of xylophagous coleopterans in the main studied stationaries

The large dimensions of the ethnographic museums in open-air, their complexity, the big number of exposed objects and the used wooden material make of these stationary points real ecosystems, where the variety of ecological niches offers the possibility of a detailed study of the species of interest.

The emergence and development of bio-pests at the wooden monuments follows a gradual degradation specific to the open-air exposed wood.

Thus, one can find out a gradual installation of the attack of insects on the wood in the composition of the patrimony goods, depending on the species of tree (preferentially), the age and the health state of wood; the action of xylophagous micro-Fungi has often an important contribution to the degradation of wood, preceding, in many cases, the attack of insects. The cumulative degradations over time can lead to irreparable deterioration of the wooden pieces, due to gradual installation of attack of different xylophagous insect species and the consecutive development of several generations of a species on the same wooden substrate.

The presence specificities in a higher proportion of a certain number of species, characteristic for various old wooden species, degraded by Fungi, lead to the emergence of their dominance in the respective ecosystem (such is case of species of Anobiidae).

7.1. Species distribution on wooden species

I observed the differential distribution of the species of xylophagous coleopterans on different wooden species, components of the patrimony goods. Thus, at the construction elements realized of coniferous species (mainly fir and spruce), the high percentage of the attack is held by the species *Anobium punctatum* (Coleoptera, Anobiidae), followed by the species *Hylotrupes bajulus* (Coleooptera, Cerambycidae) and *Ernobius mollis* (Coleoptera, Anobiidae).There is a differentiation of incidence of attack of the species *Anobium punctatum* and *Hylotrupes bajulus,* depending on the elements of construction. In this respect, the species *A. punctatum* has a higher incidence in the foot beams, floors and ceilings, while the species *H.bajulus* holds the greater percentage in the wood of walls and frameworks, the attack being localized mainly in the sapwood of massive wooden pieces.

In the oak wood, the species with the highest presence is *Xestobium rufovillosum* (Col.Anobiidae), found mainly in beams, and also floors and frameworks. In the wood from the elevations of walls is present the species *A. punctatum*, reported also in a lower proportion in floors and base beams.

In the wood of other deciduous species, the xylophagous entomofauna include sspecies of Anobiidae, Lyctidae and fewer Curculionidae. Among Anobiidae, the species *Ptilinus pectinicornis* is characteristic to the beech wood; the species *A. punctatum* and *X. rufovillosum* were also found in other species of deciduous trees. The species of Lyctidae are present in the sapwood of the hard deciduous tree species, of which the species *Lyctus linearis* is characteristic for the elm wood.

7.2. Frequency and abundance of the species

Regarding the frequency of the xylophagous coleopteran species in the studied stationaries, it is pointed out that the family Anobiidae is best represented by those three dominant species: *A. punctatum, X. rufovillosum and P. pectinicornis*.

Referring to the situation of frequency of the main harmful xylophagous coleopteran species at the ”ASTRA” Museum of Traditional Folk Civilization, in Sibiu, it is obvious the high frequency of the main species of Anobiidae, among which the species *P. pectinicornis* having the highest frequency (100%), followed by the species *A. punctatum*, average frequency of 70% and *X. rufovillosum* with an average frequency of 60%.

The abundance of species is correlated with their percentage frequency. The most abundant species is *P. pectinicornis*, but, I note the fact that for the species *L. linearis*, which is not represented with a high frequency, the abundance of the individual species was high.

At the ”Dimitrie Gusti” National Village Museum, in Bucharest, there was observed the same percentages of the main harmful species from the family Anobiidae. The species *A. punctatum* (85%) had the greatest abundance. For the species *P. pectinicornis,* the index of average frequency is 55%, and for *X. rufovillosum* (65 %). In case of the species *H. bajulus*, there was found out a higher frequency than in case of the ASTRA Museum (50%), which is probably due to the presence, in higher number, of the elements of fir tree beams at the buildings exhibited in the museum.

We can conclude that the mentioned xylophagous coleopteran species with high incidence on the goods of patrimony are constant and euconstant species, characteristic to entomofauna in the open–air museums.

7.3. Intensity of the attack

Development of the xylophagous species in the wooden substrate produce damages through the action of the larvae that dig galleries on the duration of the stage, leading to the loss of mechanical strength of the wood and its fragility. The adults hatch openings completes the advanced degradation caused by the galleries of larvae. The attack intensity and the percentage of degradation are proportional to the number of hatching holes present on the wood surface. In some species the mating may occur inside without leaving the substrate (e.g. *X. rufovillosum*). The biological cycle resumes what contributes to a more advanced degradation of infested wood.

Table 3 - The attack intensity for the species with the highest presence on the goods of patrimony made of wood.

Wooden essence/ xylophages species		No. of holes /dm^2	Average hole number
Beech tree wood with attack of *P. pectinicornis* of at least 3 generations		85	118-119
		121	
		150	
Oak tree wood less depreciated by the attack of *Anobium* şi *Xestobium*, of several generations		42	33
		61	
		62	
		18	
		24	
		18	
		14	
		25	
Oak tree wood depreciated by the attack of *Anobium* şi *Xestobium*, of several generations		105	93-94
		98	
		112	
		70	
		82	
Oak tree wood less depreciated by the attack of *Anobium*, of several generations		46	45
		45	
		43	
		46	
Oak tree wood depreciated by the attack of *Anobium*, of several generations		84	138
		161	
		169	

One can observe how in case of the succession of several generations of a species on the same substrate, the degradations are more advanced, the wood extensively losing the structural strength. At the same time, it is evidenced a more pronounced degradation of the wood by insects depending on the age and its state of health, being preferred the older wood, depreciated by Fungi. Also, the installation of the attack of a species favours the emergence of another attack on the same substrate, a fact that leads to the accentuation of degradation of the wooden material.

8. Aspects of degradations caused by the xylophagous insects to the goods of patrimony made of wood and exhibited outdoors

The xylophagous insects reported on goods made of wood belong to different groups in conformity with the nutritive substrate variety, polyphagous and oligophagous. Dajoz (1980) divided the xylophagous coleopterans into strict corticolous (which feed on phloem and live under the bark), strict xylophagous (which live in the wood and feed with it), facultative corticolous (insects of meristem that live either in buds or in cambium, their attack can be extended on phloem and xylem), xylomicetophagous (insects that live in symbiosis with Fungi) and sapro-xylophagous (coleopterans that live in the more or less rotten wood).

In this sense, one can affirm that, although, they are limited to an exclusive environment – the ecological niches they occupy – the xylophagous coleopteran species are diverse.

Thus, one can find out a gradual installation of insects attack on the wood in the composition of the goods of patrimony according to the species of wood (preferentially) the age and health state of the wood.

An important contribution to the wood degradation has the action of the xylophagous micro-Fungi, preceding, in many cases, the attack of insects. A more reduced role has the species that attack the wood in the cutting-processing phase, or sometimes, even before it (primary and secondary xylophages), thus the wood used to the realization of an object will bare traces of these attacks. Also, relatively new wood inserted into the patrimony good together with different interventions of restoration or consolidation can present active attack or they can constitute the trophic base for the installation of other species of xylophagous insects.

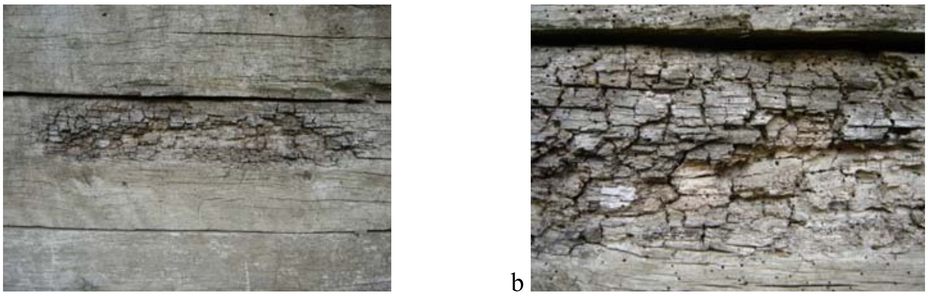
The most pronounced degradations are caused by the activity of individuals in the larval stage, for feeding. The adults of most species of xylophagous coleopterans do not feed, they produce only hatching openings, or for laying the egg mass, so they can cause degradations of less importance than those caused by larvae during the biological cycle.

a

b

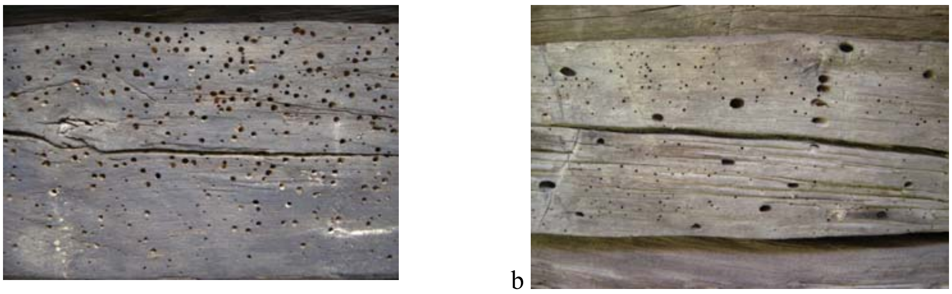
c d

Fig. 11. a, b, c, d – Decay caused to the wood by the combined action of micro-Fungi and the attack of xylophagous insects (original).
a), b) house of fir tree planks, which was originally covered with plaster over wood slat armour, under which a joint attack by Fungi and insects developed.
c), d) beams of plastered fir tree, depreciated by the combined action of the rote and xylophagous insects. The percentage of degradation is higher in the bonding of walls where the present moisture in excess resulted to the faster development of Fungi.



a b

Fig. 12. a, b – Aspects of wood degradation caused by development of micro-Fungi (original). The action of degradation of the Fungi often precedes the attack of the xylophagous insects and it continues in parallel with it, sometimes even after the disappearance of insects from the wooden substrate.



a b

Fig. 13. a, b – wood degradations occurred after the successive installation of attack of the different species of xylophagous coleopterans (original). The concomitant development of several species on the same substrate can be found, but such cases are rarer. Most times, there is a gradual installation of the attack depending on the age and health state of the wood. In case of the image b), a first attack was that of the coleopterans Cerambycidae, most likely in the period in

which the wood was not dry yet, followed by the installation of the attack of the secondary and tertiary xylophagous pests (e.g. Anobiidae).

In our research (on site, laboratory), we could find out the different morphology of the dejections of the main studied insect species, depending on the species and the attacked wooden species.

Based on the morphology of the dejections it was possible to determine the pests, taking into account that they are removed from the galleries through corresponding holes on the surface.

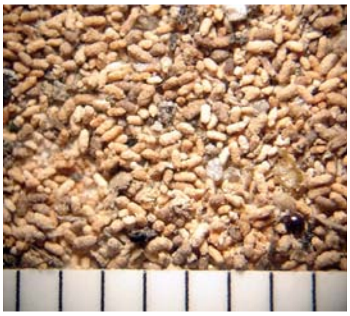


Fig.14 - Aspect of sawdust caused in the beech tree wood by th species *Anobium punctatum* (original)

Fig. 15 - Aspect of sawdust caused by species *Lyctus linearis* in the elm tree wood (original)

Fig. 16 - Aspects of sawdust caused by species *Ptilinus pectinicornis* in the beech tree wood (original)

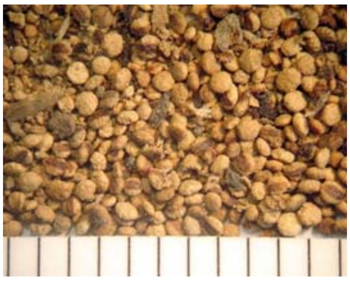


Fig. 17 - Excrements of the species *Xestobium rufovillosum* in the oak tree wood (original)

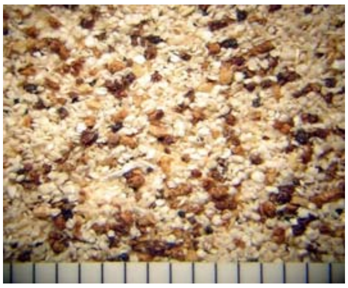


Fig. 18 - galleries and sawdust from fir tree wood caused by the species *Ernobius mollis* (original)

Fig. 19 - aspects of the sawdust caused by the activity of species *Hylotrupes bajulus* in th fir tree wood (original)

The installation of the agents of microscopic biodegradation (bacteria, Fungi), favours enzymatically the wooden substrate for the installation of the attack of xylophagous insects.

Degradations occurring in the wooden mass due to the biodegradators is observed microscopically on the wood fibre, causing irreversible changes.

We proposed the illustrated documentation of the modifications that are produced at the level of the wooden fibre: constitution and colour modifications.

Thus, in our research, we have made a comparative analysis of the structural aspect of the healthy wooden fibre in comparison with the fibre passed through processes of enzymatic degradation. The research was conducted on samples of three species of trees (fir, beech and oak), with the highest incidence within the goods of patrimony exposed in the open-air.

To exemplify in the present paper, we included only the illustration for the resinous wood – the species fir tree (*Abies alba* Mill.).

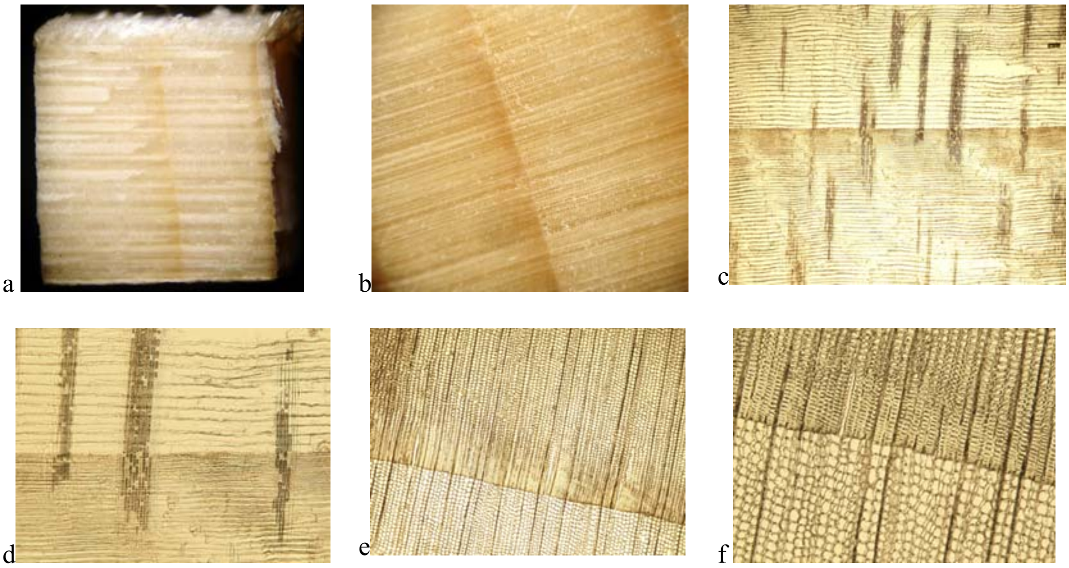
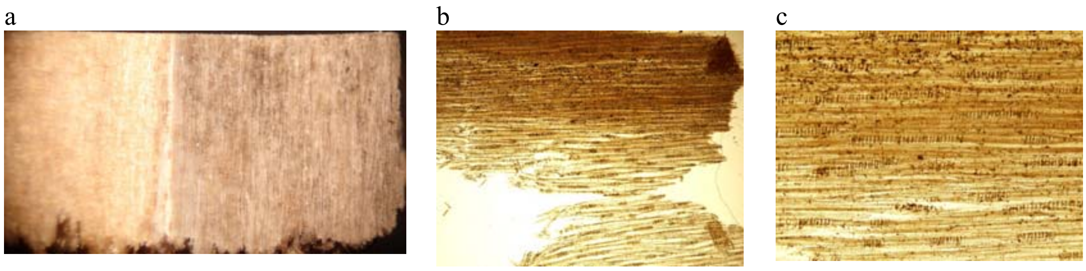


Fig. 20. a, b, c, d, e, f – Healthy fir tree wood (original)
a) macrophotography in a longitudinal section;
b) section in the transversal plan
c, d) the fibre of the healthy wood in longitudinal section;
e, f) – healthy fir tree wood in transversal section



d e f

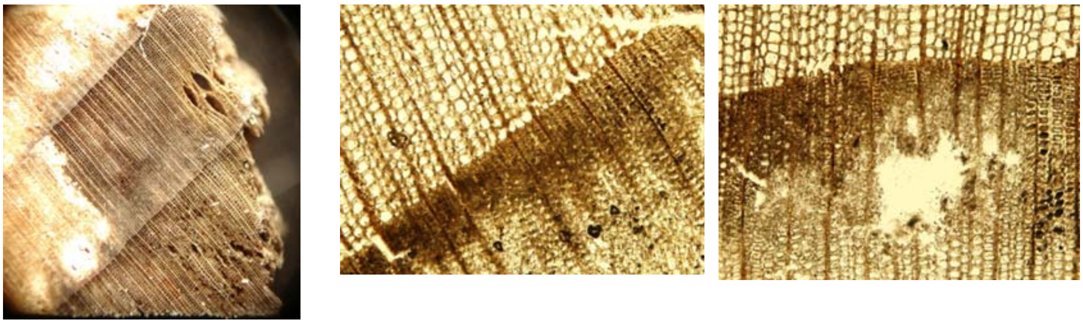


Fig. 21. a, b, c, d, e, f – Decayed fir tree wood (original)
a) macrophotography in longitudinal section;
b, c) microscopic aspect of the wood fibre in longitudinal plan
d) macrophotography after a section in transversal plan;
e, f) microscopic aspect of the wood fibre in transversal section

9. The active conservation of the goods of patrimony made of wood and exhibited outdoors, attacked by insects

The needs for keeping in time of the objects, goods of any kind have created the premises to appear the notions of conservation, preservation, in a scientific discipline in order to preserve the goods in their complex (structure, form, message, meaning, function and others).

In the present moment, (2012), conservation as scientific discipline operates in two main directions: *preventive conservation* and *curative conservation*. The first one must have a permanent and constant character for creating and monitoring of some favourable conditions of preventive measures with general application or directed on casuistry particularities. The second direction has a temporary character, when deciding the intervention with curative treatment methods to stop and eradicate active attacks. Professional ethics requires a careful approach of the techniques of preventive conservation, taking into account that the aim should be to prevent rather than to treat.

Referring to preventive conservation measures, in our research, there are given information about the permanence of characteristic methods of preventive conservation, the importance of timely detection of active attacks, the identification of species and the correct valuation of the risk degree which an attack involves.

It is also mentioned the importance of monitoring the environmental factors and the microclimate parameters, cleaning of the environment and the quarantine of the newly introduced objects in collections/lab.

The curative conservation describes effective measures of treatment to halt and eliminate the installed attack. In the application of curative measures one can distinguish two stages: the location of the attack and the control. In the first stage, isolation and quarantine measures are taken (disassembly, removal of parts if necessary); in the second stage, the actual control by various methods (physical, chemical, biological). In the choosing of controlling methods one takes into account the nature of the attacked object, the species or the wooden constitutive species, the involved insects and Fungi species as well as their development stage. The punctual effectiveness of treatment requires the knowledge of sensitivity of each stage of development, the mode in which it responds to a specific treatment as well as the lethal doses.

In the preservation field, the curative conservation methods are structured in *physical treatments, chemical treatments, biological methods* and *integrated control*.

The physical treatments include the use of traps, treatments through radiation, the heat treatments and anoxia.

I have experimented the effects of treatment through cryogenation on the species of degraded wood. There were used samples from three different species (fir, beech and oak), wooden species mainly used in patrimony goods exhibited outdoors.

The results of our research confirm the mentions of Strang (1996), referring to the utilizations of packing up in folio of polyethylene as a way to get a high hygric constancy index. A second conclusion is that the relative humidity values of the wood are higher after the thermal treatment of cryogenation. The phenomenon might be explained by the fact that at the low temperature a part of the percentage of water content by the wood packing, condenses on the internal part of the film, and later, during the gradual return to the ambient temperature, is to be reabsorbed by capillary action, resulting in a higher relative humidity in the immediate substrate of the wooden mass.

There was observed a better resistance of the healthy wood to that degraded one, of that treated after the foliation to that which was not bladed and respectively of non-cryogenated wood to that subjected to this treatment. There are exceptions which prove the fact that there is not a necessarily strict rule in this regard.

It is plausible and logical that a wooden species is to be more sensitive after a freeze-thaw process The exceptions mentioned are due to the structural peculiarities of each species and of different parts of a tree between them, two pieces of wooden material of the same tree may have different characteristics, given by the physiological particularities of the plant on different parts – sapwood, duramen, pith, etc.

Although, the *chemical control* is one of the most toxic methods for environment and human, it is used to eradicate the insect pests due to their efficiency, ignoring some side effects.

A wide range of substances have been tested and used in different combinations or singular, as a unique treatment, with various possibilities of application – brush, spray, injection, gassing, etc.

On the whole, the used chemicals have different actions on the insects. The insecticides kill them, the insectstatics inhibit their growth and reproduction, the repellents repel the installation of attack.

In our studies there are presented information referring to the classification of insecticides according to the mode of action, the nature of the active substance and aggregation state. There are presented the most usual chemical substances used in the insecticide treatments, structured on groups of compounds, being mentioned advantages, disadvantages, side effects, methods of implementation. The most known groups are: organochlorine insecticides, organophosphorus insecticides, carbamates, pyrethrins, synthetic pyrethroids, inorganic compounds, organic compounds and halogenated compounds.

Biological control is an ecological alternative to the chemical treatments and their toxicity. Utilization of entomophages (parasitoids and predators) is successfully applied in some branches of Entomology. At the same time utilization of pathogenic microorganisms (viruses, viral bacteria) could provide satisfactory results.

The utilization of predators, parasitoids, viral preparations require their rearing in the laboratory and subsequently their spreading in nature.

The *integrated control* is based on ecological, biological foundations and protection of the environment. There are included physical, chemical and biological methods. Biological methods occupy an important percentage within the schemes of integrated control.

Considerations on active conservation of cultural goods made of wood

As a principle of ethics, preventive measures should be foreground to those curative ones. It is known, that it is easier to prevent than to treat, to make savings than to spend. Thus, the attitude towards the measures of conservation is one that, in the last years, tends towards the implementing of long time preventive measures. The foundations of a *preventive conservation* have an oldness of more than a decade and a half, but its implementation at the level of awareness of prevention is more recently.

In this regard, currently, we speak about the education of the museum staff, the public and, in general, to all those who come into contact with the patrimony good (avoid the outbreaks of infection, keeping of goods). The implementation of this principle at the level of individual consciousness is imperatively necessary in order to have the guarantee of some positive results in the area of preventive conservation.

There are included the knowledge and information related to storage conditions and exposure, the maintenance of spaces (cleaning, aeration, ventilation etc.) monitoring of parameters of microclimate values, transport and handling.

In the situations in which the conservation status of the object requires the need of some interventions with curative methods, it is necessary the judicious choice of the type of intervention based on a preliminary study of casuistry. The current rules require the utilization of some intervention methods with minimized negative effects, non-polluting for the environment and nontoxic for humans. The exceptions must be justified by the particular circumstances of each situation individually, the appeal for chemical treatments with highly toxicity being approached as a last alternative, when the method will be the only effective way to ensure the eradication of infestations in question.

The integrated control strategy joins several methods, with punctual directed action, or a general one, in order to achieve a maximum effect of the treatment with minimal side effects for object, environment and human.

The sustainability in time of a good is an attribute that is in connection, primordially, with the conditions, methods and the technique of original execution. Thus, the utilizations of a traditional technique whose consequences are known, is a feature to be followed to ensure a starting point that foresees a lower percentage of installing the attack of bio-pests.

The principled interventions in conformity with the restoration ethics impose the utilization of some materials compatible with those original ones whose properties have been tested and are known. Moreover, the respecting of the integrity of an object under all aspects (including the materials introduced into the object) imposes the utilization of the classical materials and techniques identical to those of the original.

Selective References

Bucşa Corneliu, (1998) – Teză de doctorat, *Coleoptere xilofage din pădurea Dumbrava şi Muzeul tehnicii populare Sibiu. Studiu sistematic, ecologic şi biologic*, Universitatea Babeş-Bolyai, Cluj-Napoca;

Bucşa Livia, Bucşa Corneliu, Zeleniuc Octaviana, (2004) – *Ocurenţa principalelor coleoptere xilofage la monumentele istorice din România*, în *Acta oecologica*, vol. XI, 1-2, pp. 85-101;

Bucşa Livia, Bucşa Corneliu, (2005) – *Agenţi de biodegradare la monumentele istorice din România. Prevenire şi combatere*, Ed. Alma Mater, Sibiu;

Caneva G., Nugari M. P., Salvadori O., (1997) – *La biologia nel Restauro*, Nardini Editore, Firenze;

Chiappini E., Liotta G., Reguzzi M.C., Battisti A., (2001) – *Insettti e restauro*, Calderini Edagricole, Bologna;

Csóka Gy., Kovács T., (1999) – *Xylophagous Insects*, pp. 34-41, Forest Research Institute, Budapest;

Eleanor Groden, David B. Wallace and Richard A. Casagrande, (1999) – *Powderpost Beetles*, University of Rhode Island Fact Sheet;

Graham, K., (1967) – *Fungal-insect mutualism in trees and timber*, Annu. Rev. Entomol, nr 12, pp. 105- 126;

Halperin J. and K.-U. Geis, (1999) – *Lyctidae (Coleoptera) of Israel, Their Damage and Its Prevention*, Phytoparasitica 27(4): xxx-xxx;

Hansen, L.S., Jensen, K.M., (1996) – *Upper lethal temperature limits of the common furniture beetle Anobium punctatum (Coleoptera: Anobiidae)*, in International Biodeterioration & Biodegradation, Elsevier, pp. 225-232;

Hansen, L.S., Jensen, K.M. – *Heat treatement of the common furniture beetle Anobium punctatum (Coleoptera: Anobiidae), at temperature between 45 degrees and 54 degrees C. under dry and humid conditions*, in Nordic symposium on insect pest control in museum (3), Stockholm, 24-25 September 1998; Naturhistoriska riksmuseet, pp. 36-41;

Hickin Norman E., (1963)– *The Insect Factor in Wood Decay*, pp. 25-270, Hutchinson of London;

Koch, A, (1960)– *Intracellular Symbiosis in Insects*, în Annual Review of Microbiology 14, pp. 121-140;

Liotta G., (1998) – *Gli insetti e i danni del legno*, Nardini Editore, Firenze;

Martin E. Weaver şi F. G. Matero, (1997) – *Conserving buildings, Guide to Techniques and Materials, Revised Edition*, Preservation Press, John Wilei & Sons, Inc.;

Mustaţă Maria (1998)– *Insecte dăunătoare bunurilor de patrimoniu*, Editura Universităţii „Al. Ioan Cuza”, Iaşi;

Mustaţă M., Mustaţă Gh., Andriescu I., Mitroiu M. (2006)– *Biologia dăunătorilor animali*, Ed. Junimea, Iaşi;

Mariana Mustaţă, Gh. Mustaţă, (2009) – *Biologia în conservarea operei de artă*, Editura Universităţii „Al. Ioan Cuza”, Iaşi;

Oprea Florea, (2006) – *Biologie pentru conservarea şi restaurarea patrimoniului cultural*, Ed. Maiko, Bucureşti;

Parkin, E. A. (1940) – *The digestive enzymes of some wood-boring beetle larvae*, în J. Exp. Biol. 17 (4), pp. 364-377;

Pinniger David, (1994) – *Insect Pests in Museums*, Archetype;

Sutter Hans-Peter, (1992) – *Holzschädlinge an Kulturgütern erkennen und bekämpfen*, pp. 60-103, Verlag Paul Haupt, Bern . Stuttgart . Wien;

Vintilă Eugen, (1978) - *Protecţia lemnului şi a materialelor pe bază de lemn*, pp. 42-66, 252-277, Ed. Tehnică, Bucureşti;

William F. Lyon, (1991) – *Powderpost Beetles*, Ohio State University Extension Fact Sheet – Entomology, Kenny Road, Columbus, OH 43210-1000..