The comparative occurrence of two xylophagous Coleoptera damaging wood of historic buildings in Transylvania, Romania

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Abstract

The research has been made on 120 historical monuments: citadels, castles, palaces, churches, cultural institution, schools, etc. made of either brick or wood, in use or abandoned, for which biological examinations were made between 1990-2002.

The species considered are *Anobium punctatum* De Geer, 1774 and *Xestobium rufovillosum* De Geer, 1774, as they have the highest frequency in timber.

The study emphasizes their occurrence on the affected building elements: beams, floors, walls, floor frames, roof frames and vaults, according to their constituting wood essences.

The association and interdependence between the attacks of the considered insects and the fungi are pointed out.

Keywords: xylophagous coleoptera, occurrence, historical monuments, timber, fungi.

Introduction

The present results are based on the study of 120 historical monuments, in a just report between those made of brick (60) and wood (60).

The research was made during a period of 12 years, between 1990- 2002. The 120 historical monuments are: 1 Palace (Apor), 8 Castels (Arcalia, Bran, Peleş, Pribileşti, Satulung, etc.), 2 Mansions (Henter, Bolomei), 4 Citadels (Făgăraş, Oradea, Racoş, Râşnov), 15 Cultural Institutions, among them 5 Museums (Alba Iulia, Lipova, Săcele, Turda, Sibiu), 3 Secondary Schools (B. Gabor in Aiud, Honterus in Braşov, G. Lazăr in Sibiu), 1 Library (Braşov), 1 Art Gallery (Sfântu Gheorghe), 23 Churches and Monasteres made of brick, among them 12 Evangelics (Bistriţa, Braşov, Câlnic,Cisnădioara, Herina, Moşna, Ruşi, Saschiz, Sibiu, etc.), 6 Orthodox (Bixad, Orlat, Sibiel, Sâmbăta de jos, Şercăiţa, Tg. Secuiesc), 2 Reformates (Daia Secuiască, Mociu), 1 Catholic (Cluj-Napoca) and 1 Unitarian (Cluj-Napoca), 8 brick houses (Sibiu, Baia Mare, Sighişoara, etc.), 4 timber houses plastered up (Rimetea, Tg. Secuiesc, Sacele, etc.), 40 timber churches (Baica, Bârsana, Broşteni, Budesti, Cehei, Corund, Deseşti, Frasin Deal, Ieud, Julita, Lăpus, Mierag, Nadiş, Putna, Racâş, Şinca Noua etc.).

We tried to include examples of the whole scale of monuments, from different historical periods (XVIth – XIXth centuries), in ruins or in use, the most known and visited till the abandoned ones.

We analyzed the data concerning the wood essences used in different parts of the buildings and the main Coleoptera attacks. The species considered are *Anobium punctatum* and *Xestobium rufovillosum* (Anobiidae) as they have the highest frequency in timber.

Material and methods

In order to identify the timber essences, the macroscopic and microscopic characteristics have been used. The microscopic preparations were made by dividing the timber after being boiled.

The xylophagous insects were identified by the flight holes, the type of sawdust and the adult insects collected.

For the fungi, one took into consideration the sporous bodies, the dimension of the spores, the type of mycelium and rot produced.

The identification of the timber essences was made according to GHELMEZIU and Suciu (1959), of insects according to Hickin (1968), Freude, Harde, Lohse (1969), Cymorek (1974) and that of macromycetes according to Bernnichia (1990), Breitenbach & Kranzlin (1989), Courtecuise (1994), Erikson & Ryvarden (1973-1980), etc.

Results and discussions

1. Timber essences identified with historical monuments buildings in Romania

Coleoptera xylophaga are specific of a certain essence and sometimes of a part of the timber such as sapwood or can decay a larger number of essences be them either only softwood or hardwood or both of them. Knowing the constituent timber essences as a potential trophic basis, one can forecast the presence of various types of decay.

Timber essences were analyzed according to the main elements of a building, i.e. sole beams, walls, floors, floor frames, vaults, roof frames, coverings.

Table and fig. 1 present the synthesis of the data obtained from the analysis of the 120 monuments. One can notice that certain essences prevail with certain parts of the building. Thus:

with sole beams, hard wood, oak (70%) and evergreen oak timber (7%) and more rarely softwood, fir or spruce timber (17%);

with walls, oak and evergreen oak timber (62%), but often fir and spruce timber (25%), more rarely they are found in mixtures of other deciduous trees (ash, sycamore maple, beech, elm, birch), or hardwood and softwood (17%);

floors, especially those made of planks, are almost exclusively of fir or spruce timber (70%), and those from parquet, of oak (10%) and beech timber (6%);

floor frames are of fir or spruce (80%), and, more rarely, oak timber (13%);

wooden churches arches are made, in most cases, of fir or spruce planks (71%), in few cases of oak and evergreen oak (15%), but vaults made of mixtures have also been signaled (8%);

with roof frame, softwood are prevalent, fir or spruce (59%), and quite rarely pine (2%), and among hardwood, the most frequent is oak (29%) and more rarely evergreen oak (5%) and other timber (5%);

shingles coverings are especially made of softwood, fir or spruce (91%) and, more rarely, oak (5%) and beech timber (5%).

Our study reveals that in Romania a wide variety of essences are used, most of which being non-lasting (fir, spruce, ash) or perishable (beech, sycamore maple, birch) and are preferred as nourishment by pests, especially by the xylophagous insects.

2. Comparative occurrence of coleoptera xylophaga in various parts of the building

Our experiments along the years identified various species of xylophagous insects of the Hymenoptera, Lepidoptera and Coleoptera orders.

As tab. 2 shows, the most frequent decays are produced by *Anobium punctatum* in fir and spruce timber and occur especially in floor frames (94%) and vaults (74%), sole beams (57%), floors (52%), with medium occurrence for walls (31%) and roof frames (27%). This species can decay both soft and hardwoods. In the cases where we came across mixtures of essences (ash, sycamore maple, beech, birch, etc.) occurrence is highly incidental in vaults (100%), walls (80%), roof frames and floor frames (66%), floors (50%), but in the case of oak, attacks are highly incidental only in floor frames (83%) and quite low with floors (12%), sole beams (10%) and roof frames (3%).

Xestobium rufovillosum occurred most frequently in oak, for sole beams (84%) and floor frames, especially where are inbuilt (83%), as well as in roof frames (64%). For fir and spruce timber, in roof frames elements, frequency is medium (41%) and lower in floor frames (22%). In these cases, too, the most exposed are by far, the inbuilt parts or those covered with various materials which do not allow ventilation and keep humidity from infiltrations.

As for the most frequent species: *Anobium punctatum* and *Xestobium rufovillosum* we endeavored to reveal the interrelationship between them, on the one hand, and with the fungi, on the other hand.

3. Occurrence of the *Anobium punctatum* decay in fir and spruce timber buildings elements.

Anobium punctatum (Tab. and Fig. 3) can develop either alone, or in combinations with fungic decays or decays of other xylophagous insects. It was most frequently met in combinations with *Coniophora puteana* (Schumach.) P. Karst (1868) fungi decays in floor frames (22%) and in floors (21%) and *Serpula lacrymans* (Wulfen) J. Schrot (1885) in floors (12%) and floor frames respectively (11%). In combination with *Fibroporia vaillantii* (DC.) Parmasto (1968) occurs more frequently in vaults (18%) and frame floors (8%).

In combinations with other fungi decays, for which the species could not be identified, it is present in sole beams (42%), vaults (18%), and roof frames (11%).

Table 1. The wood essences used in the main part of buildings.

Nr.	Parts of buildings	Nr. of constructions	Fir + Spruce		Pine		Oak		Evergreen Oak		Beech		Other deciduous trees		Mixture	
			Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	40	7	17			28	70	3	7			2	5		
2	WALL	51	13	25			27	53	4	9					7	14
3	FLOOR	83	58	70			8	10			5	6			12	14
4	FLOOR FRAME	45	36	80			6	13							3	7
5	VAULT	38	27	71			4	10	2	5			2	5	3	8
6	ROOF FRAME	103	61	59	2	2	30	29	5	5			2	5	3	3
7	ROOF	44	40	91			2	5			2	5				

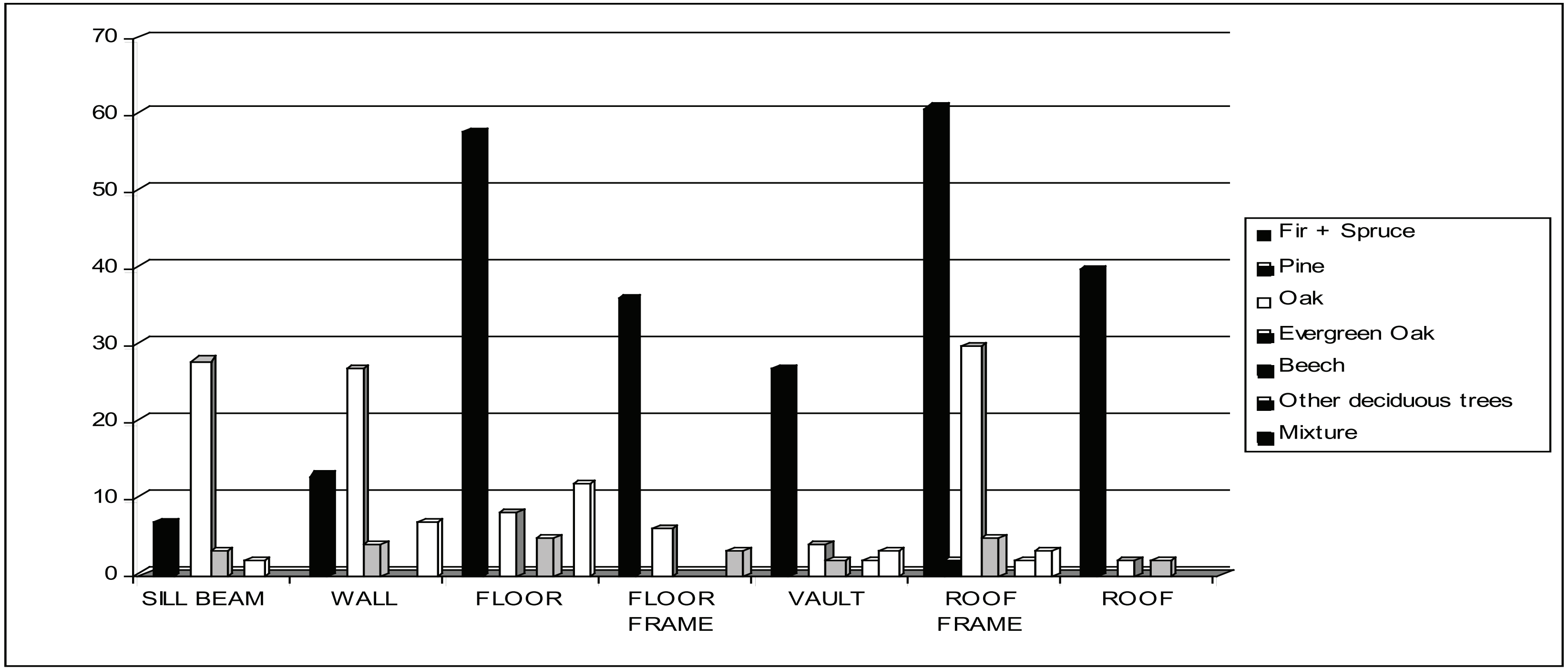


Table 2. The occurrence of xylophagous species in different parts of constructions.

Nr.	PARTS OF CONSTRUCTIONS	WOOD TIPE	NR. MON	Ap		Xr		Hb		Lb		Em		Cv	
				Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	fi+sp	7	4	57	1	14								
		oa+eo	31	3	10	26	84								
		be													
		mx	7	6	86	6	86								
2	WALL	fi+sp	13	4	31	4	31	8	61					1	8
		oa+eo	31			17	55								
		be													
		mx	7	7	100	7	100								
3	FLOOR	fi+sp	58	30	52	3	5								
		oa+eo	8	1	12	1	12			2	25				
		be	5	4	80					1	20				
		mx	12	6	50										
4	FLOOR FRAME	fi+sp	36	34	94	8	22	1	3			1	3		
		oa+eo	6	5	83	5	83								
		be													
		mx	3	2	66	2	66								
5	VAULT	fi+sp	27	20	74	5	19	2	7			2	71	1	4
		oa+eo	6	2	33	4	66								
		be	2	2	100	2	100								
		mx	3	3	100	3	100								
6	ROOF FRAME	fi+sp	61	17	27	25	41	27	44						
		oa+eo	36	1	3	23	64								
		be													
		mx	3	2	67	2	67								

Table 3. The occurrence of *Anobium punctatum* on fir and spruce construction parts.

Nr.	Parts of constructions	Nr. Const.	Ap		Ap+Cp		Ap+Sl		Ap+Fv		Ap+Fn		Ap+Xr+F		Total	
			Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	7	1	14							3	42			4	56
2	WALL	13	1	8			1	8			2	15			4	31
3	FLOOR	58	10	17	12	21	7	12			1	2			30	52
4	FLOOR FRAME	36	16	44	8	22	4	11	3	8	2	6	1	3	34	94
5	VAULT	27	7	26	3	11			5	18	5	18			20	73
6	ROOF	61	3	5	2	3			1	2	7	11	4	7	17	28

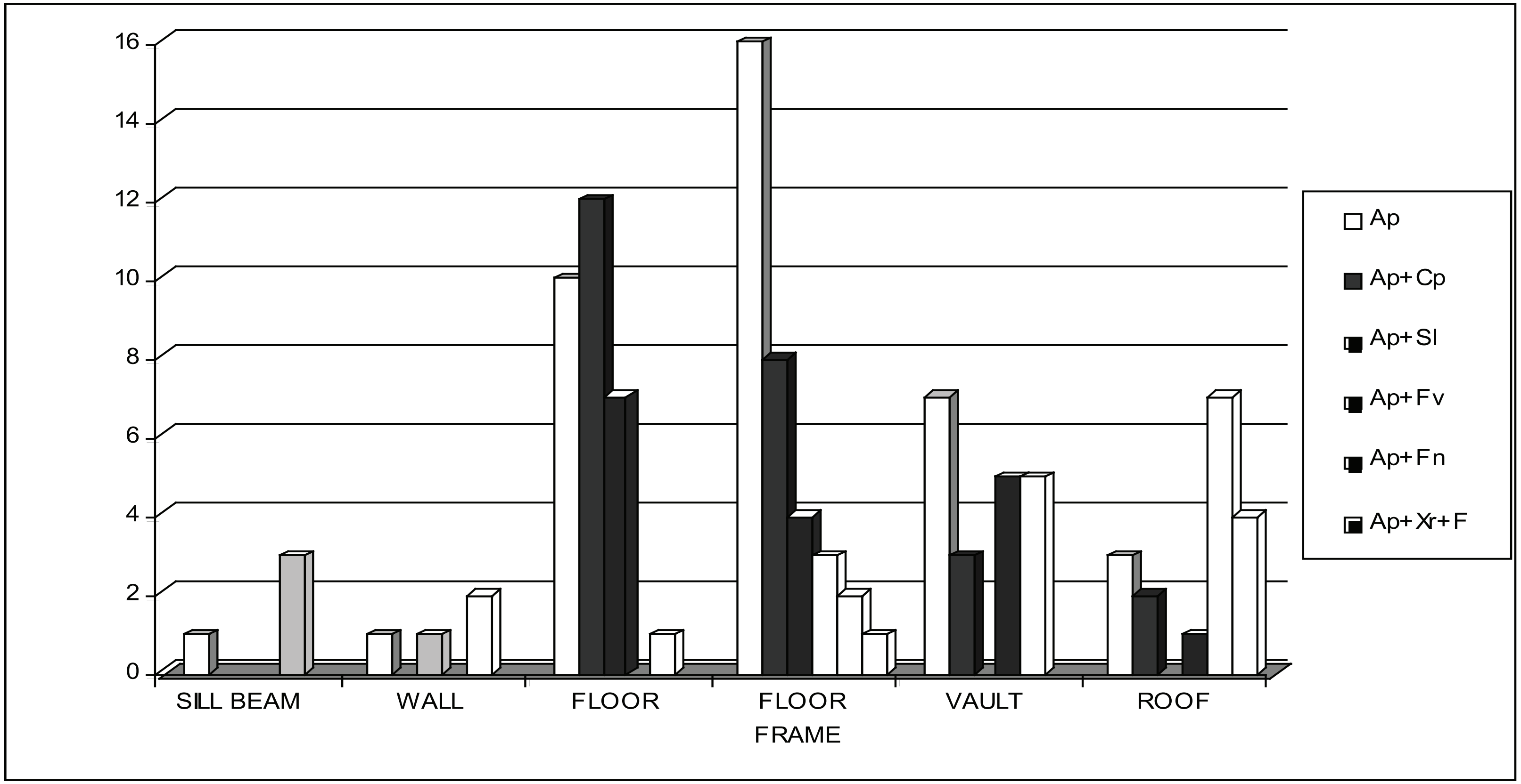
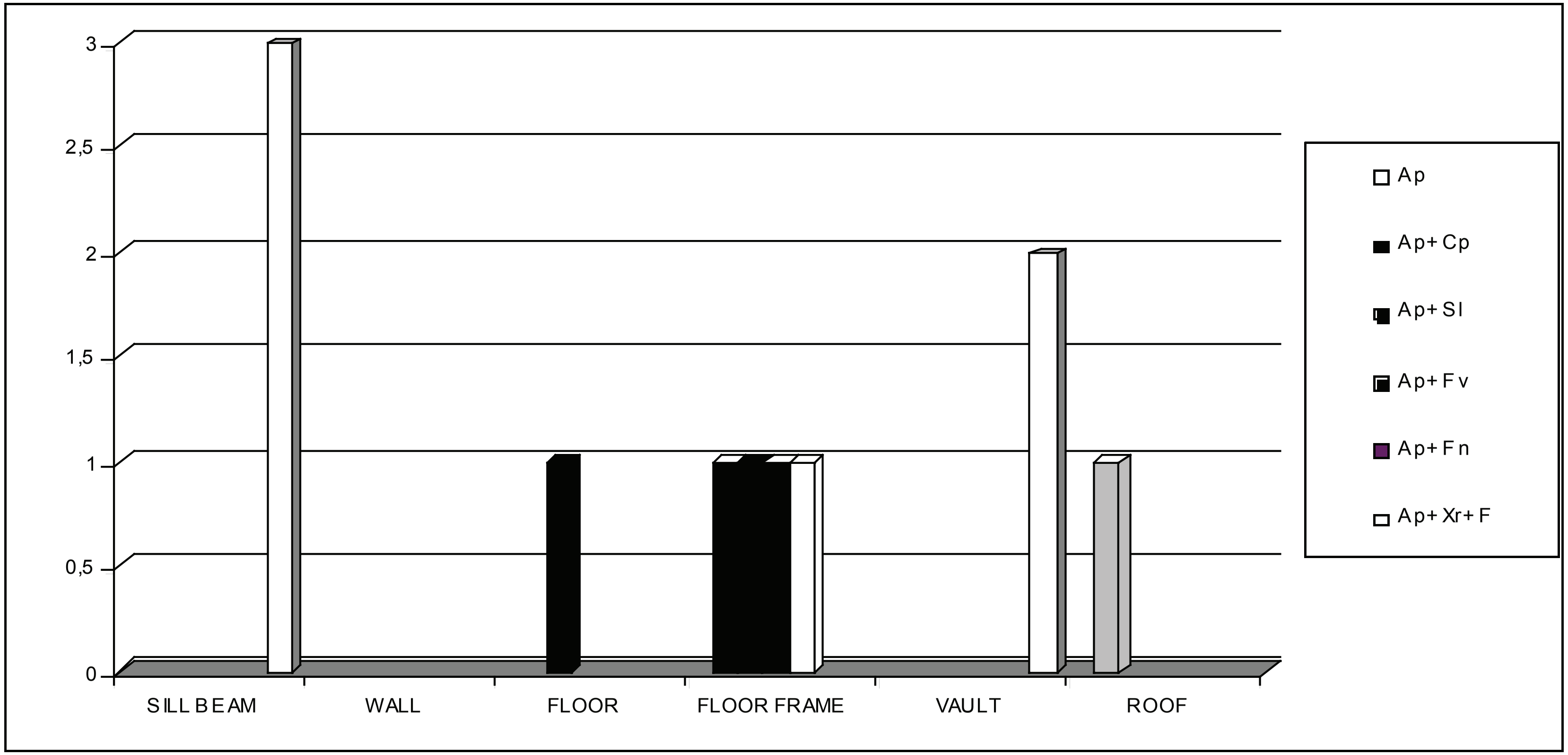


Table 4. **The occurrence of *Anobium punctatum* on oak construction parts.**

Nr.	Parts of constructions	Nr. Const.	Ap		Ap+Cp		Ap+Sl		Ap+Fv		Ap+Fn		Ap+Xr+F		Total	
			Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	31											3	10	3	10
2	WALL	41													0	0
3	FLOOR	8			1	12									1	12
4	FLOOR FRAME	6	1	17	1	17	1	17	1	17					4	68
5	VAULT	9											2	22	2	22
6	ROOF	36	1	3											1	3



4. Occurrence of the *Anobium punctatum* decays in oak timber buildings elements

Anobium punctatum (Tab. and Fig. 4) appears in oak only in the case of floor frames and roof frames (3%), and in combination with fungi decays of *Coniophora puteana*, *Serpula lacrymans* and *Fibroporia vaillantii* in floor frames (17%), and in combination with *Fibroporia vaillantii* and other unidentified fungi decays in vaults (22%) and sole beams (10%).

5. Occurrence of *Xestobium rufovillosum* in fir and spruce timber buildings elements

Xestobium rufovillosum (Tab. and Fig. 5) in fir and spruce develops alone in but few cases, in roof frames (3%) and floor frames (3%).

It was most often met in roof frames (36%), in combination with *Coniophora puteana*, *Serpula lacrymans*, *Fibroporia vaillantii* and other species of fungi, unidentified yet.

The combination with *Anobium punctatum* and other unidentified species of fungi is to be met in vaults (11%), floors (3%) and floor frames (3%).

It is very important to reveal that the reference material mentions *Xestobium rufovillosum* as specific of oak and other hardwoods (elm, ash, beech, poplar, chestnut, willow, etc.) and appears entirely "unusual for coniferous timbers" (Hickin 1968). Fischer (1941) noted that he had never met the *Xestobium rufovillosum* decay in a building where there is only coniferous timber, but the decay may extend to this type of timber if it is contiguous to oak infested. To conclude, the decay may be present only in oak or other hardwood timbers. Berry (1994) noted that in exceptional cases the decay may be found in coniferous timber exclusively.

For the majority of buildings where we encountered *Xestobium rufovillosum* infestation in fir and spruce, no elements of oak or other hardwood timbers were present. These findings invalidate the opinions of the above mentioned experts.

Xestobium rufovillosum together with *Coniophora puteana* and *Serpula lacrymans* was frequently noticed in churches and old buildings.

Our examinations definitely pointed out that *Xestobium rufovillosum* is able to decay fir and spruce timber both alone and in combinations with fungi decays. Fungi decay can either precede insect decay, occur simultaneously, or follow it.

Timber that is initially decayed by *Xestobium rufovillosum* increases its hygroscopicity and absorbs humidity more rapidly and in a greater amount enabling thus the settling and development of fungic decay. As an example, we can quote the case of the Peleş Castle, where the outer fir timber and incorporated with the basic parts in the stone terraces suffered from a *Xestobium rufovillosum* decay some years ago and enabled the emergence and rapid spreading of a *Serpula lacrymans* decay.

In the same castle, with the dead-floor under the parquet, made of fir thick planks, we encountered a simultaneous decay of *Fibroporia vaillantii* and *Xestobium rufovillosum*.

The infestations of *Xestobium rufovillosum* identified by us with fir and spruce timbers and deal are especially localized at the ends of the beams included in the brickwork, the beams of the plastered floor frames, the dead-floors or fragments of roof frames covered with brickwork, which denotes preference of the species for a higher humidity than that which is normal for timber introduced in the work and ventilated.

6. Occurrence of the *Xestobium rufovillosum* decays in oak and mixtures of oak and other hardwoods elements

Xestobium rufovillosum (Tab. and Fig. 6) was identified in the sole beams, with fragments of sapwood, without being associated with other types of attacks (19%), but it is most frequently associated with *Phellinus cryptarum* (58%) and decays the heartwood.

The sole beams of wooden churches are exposed to biological degradation when they get in contact with the ground or when the stone foundation of dry stonework is incorporated in concrete. The most rapid process of decay is suffered by the beams situated on the northern and western sides, where humidity is higher and lasts almost throughout the year. Even if the beam does not look decayed, the presence of the *Xestobium rufovillosum* flight holes is a proof of fungic decay on the inner side of the timber.

As for the walls, the attack of insects emerges in the sapwood area (24%) and when associated with *Phellinus cryptarum* it penetrates the heartwood (17%) also. Fungic decays emerge where the covering was badly damaged and rain infiltrations persisted for a long period of time.

The attack of *Xestobium rufovillosum* is the most frequent in the roof frames (47%) because younger trees whose sapwood area hadn't been removed were used.

There were rare cases in which the decay was combined with the one produced by *Coniophora puteana* in roof frames (6%) and sole beams (3%) and unidentified fungi (2%).

Table 5. The occurrence of *Xestobium rufovillosum* on fir and spruce construction parts.

Nr.	Parts of constructions	Nr. Const.	Xr		Xr+Cp		Xr+Sl		Xr+Fv		Xr+Ap		Xr+Fn		Xr+Ap+F	
			Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	7					1	14								
2	WALL	13			1	8	1	8			2	15				
3	FLOOR	58							2	3			1	2	2	3
4	FLOOR FRAME	36	1	3			3	8	1	3			2	5	1	3
5	VAULT	27									2	7			3	11
6	ROOF	61	2	3	7	11	4	6	4	6			7	11	1	2

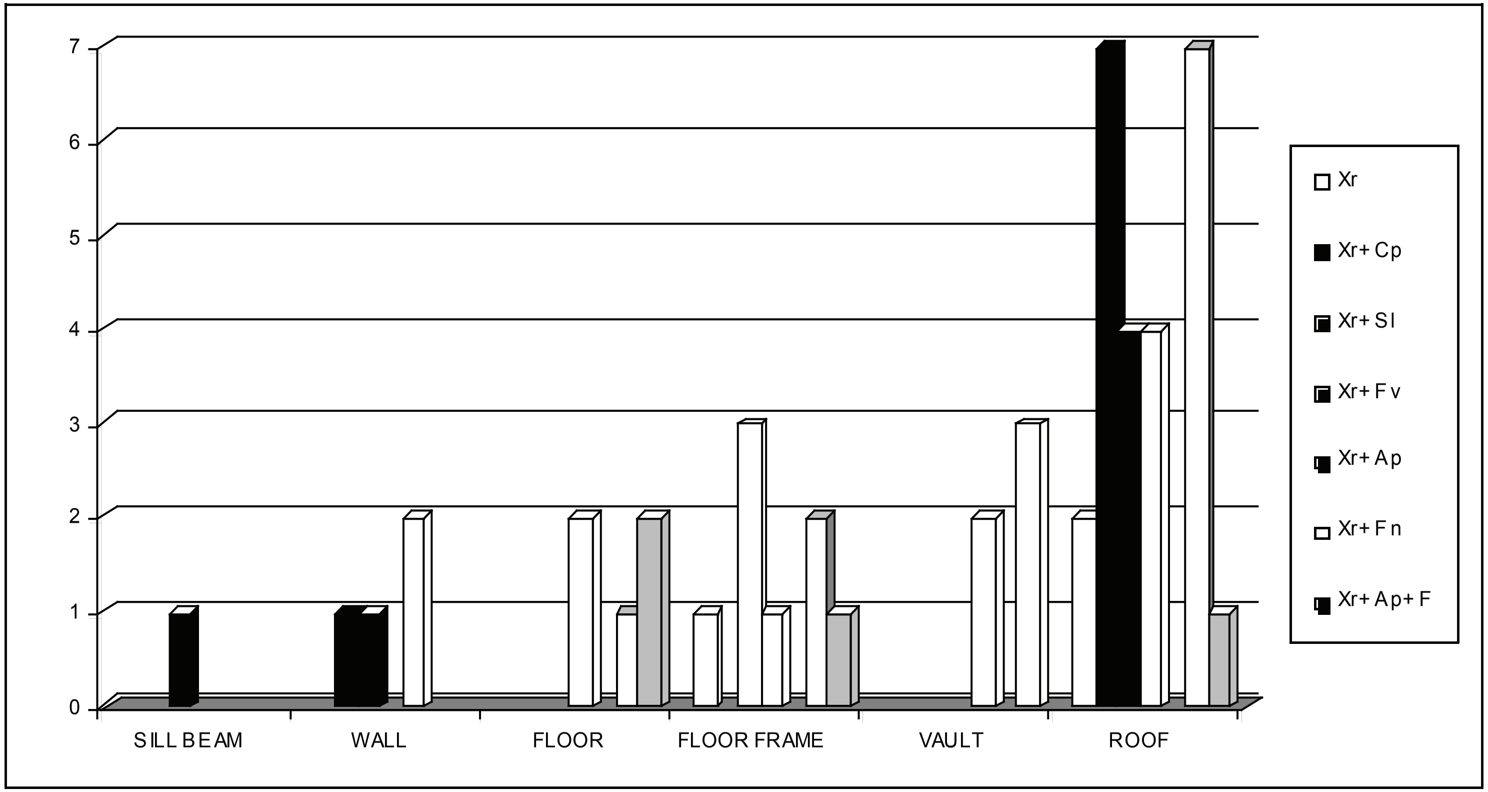
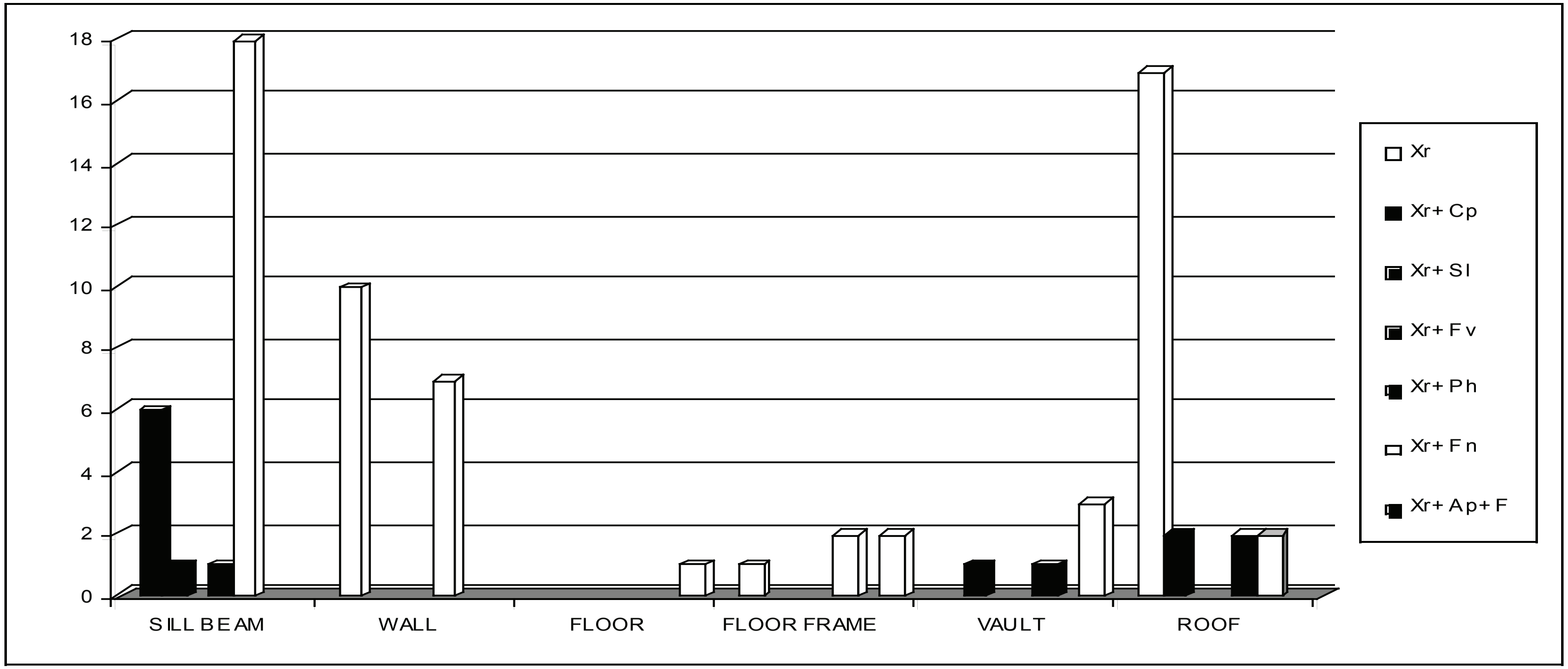


Table 6. The occurrence of *Xestobium rufovillosum* on oak and oak + other deciduous tree mixture construction parts.

Nr.	Parts of constructions	Nr. Const.	Xr		Xr+Cp		Xr+Sl		Xr+Fv		Xr+Ph		Xr+Fn		Xr+Ap+F		Total	
			Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
1	SILL BEAM	31	6	19	1	3			1	3	18	58					26	83
2	WALL	41	10	24							7	17					17	41
3	FLOOR	8													1	12	1	12
4	FLOOR FRAME	6	1	17							2	33			2	33	5	83
5	VAULT	9			1	11					1	11			3	33	5	55
6	ROOF	36	17	47	2	6					2	6	2	6			23	65



Conventional signs of tables and figures

Ap = *Anobium punctatum*
Xr = *Xestobium rufovillosum*
Hb = *Hylotrupes bajulus*
Lb = *Lyctus bruneus*
Cv = *Calidium violaceum*
Em = *Ernobium molis*
Pp = *Ptilinus pectinicornis*
He = *Hexarthrum exiguum*
Cp = *Coniophora puteana*
Sl = *Serpula lacrymans*
Fv = *Fibroporia vaillanti*
Ph = *Phellinus cryptarum*
F = *Fungi*
Fn = Fungi unknown

Cartwright & Findlay (1936) consider that *Phellinus cryptarum* is able to produce a more rapid decay of oak timber than any other species and that *Xestobium rufovillosum* is often found adjacent to the active fungus or present in the rotten timber after the death of the fungus.

The development of the *Xestobium rufovillosum* larvae depends on the humidity and the age of the timber. In newly put out oak timber, the development lasts about 5 years and in the older and dry one, between 10 and 20 years. It is also specified that, to complete its development, a larva needs to bore about 14 m of galleries inside the timber (Feilden B. M., 1996). Considering these data and analyzing the amount of degraded timber and the number of flight holes, for certain elements, we realized that only a part of the insects reach mature age.

The spreading of the decay is limited by the humidity of the support. Where it goes below 10-15%, the insects and the fungi, with the exception of *Serpula lacrymans*, can no longer develop and the decay stops in a natural way.

These findings explain the limitation of the decay spreading in the areas with infiltrations, where timber is included in the brickwork or covered with filling or insulating materials which do not allow ventilation and maintain humidity for a long period of time. The intensity of the attack in these parts is quite high, even if the number of flight holes is low and the wood, in the majority of cases it is so deeply decayed that it needs replacing.

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