THE DIVERSITY OF COLEOPTERANS AND THE IMPACT OF THEIR ATTACK ON THE OLD BOOK COLLECTIONS IN THE EAST OF ROMANIA

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Abstract. The paper presents the species of Coleoptera that have caused damage to old book collections in the East of Romania. 18 species of Coleoptera out of 5 families were identified. The degradation caused by insects affected both the book block and the covers, causing aesthetic and functional damage.

Keywords: Coleoptera, pests, books, biodeterioration

Rezumat. Diversitatea coleopterelor şi impactul atacului acestora in colecţiile de carte veche din Estul României. Lucrarea prezintă speciile de coleoptere care au produs daune in colecţii de carte veche din estul României. Au fost identificate 18 specii de coleoptere din 5 familii. Degradările produse de insecte au afectat atât blocul de carte, cât şi copertele, producând daune estetice şi funcţionale.

Cuvinte cheie: Coleoptera, dăunători, cărţi, biodeteriorare

Introduction

Information about harmful insects from old book collections in Romania was published by Mustaţă (1978, 1998, 2001), Gămălie & Mustaţă (2005, 2006), Gămălie-Moldovan (2005, 2006), Moşneagu (2005, 2009, 2014), Moşneagu & Mustaţă (2007). The authors reported the presence of species belonging to the orders of Blattodea, Coleoptera, Lepidoptera, Psocoptera, Thysanura. The large number of harmful insects is determined by the variety of materials in the structure of the old books (paper, cardboard, wood, adhesives, leather, textiles). Among the reported pests, coleopterans caused the most significant damage, being able to eat all the components of organic origin in the structure of books. Cockroaches, booklice and silverfish produce superficial erosions and stains but are not able to cause significant damage to books. Lepidoptera mainly damage the textile materials in the bookbinding (covers, sewing threads). Beetles are those that produce flight holes and galleries in the textblock and covers, thus endangering the integrity of the books, texts and decorations.

Coleopterans cause aesthetic damage to books (1.0-3.5 mm diameter flight holes, galleries, excrement, deformations, superficial erosions, chromatic alterations) and functional (cracks, fractures, loss of material). In the larval stage, the insects dig galleries, eat the materials and eliminate excrements, while in the adult stage, the insects produce flight holes in the surface of the books for the mating flight.

Material and Methods

The research was carried out on 20 collections (libraries, museums, churches) from

the counties of Bacău, Iași, Neamț, Suceava, Vaslui, insects (living or dead), larvae, larval exuviae and excrements being collected. 1029 books from 16-19th century were studied. The books' textblock were made of manual or industrial paper, and from wood or cardboard covered in leather, leather substitute or paper for the hardcovers. Yarns of vegetable (hemp, linen) or animal (wool) origin were used for sewing. Animal glue and wheat paste were used for the bindings.

Identifying the species was performed by means of binoculars, by observing the characteristics of the external and internal morphology of the adults, larvae, larval exuviae collected from the books.

The frequency of the species was calculated in relation to the total number of books studied according to the formula: F1 = p1 / P1 x 100, where p1 - the number of books in which a species was found and P1 - the total number of researched books. Also, the frequency of the species was calculated in relation to the number of collections in which it was identified, using the formula F2 = p2 / P2 x 100, where p2 - the number of collections in which a species was identified and P2 - the total number of collections investigated.

Results and Discussion

Out of the 1029 books studied 120 showed no traces of an insect attack. Signs of an insect attack (flight holes, larval galleries) were identified in 375 books, but they did not have remains of biological material to identify harmful species. Insects (whole or fragments, adults or larvae) and excrements were taken from 534 books, which allowed the identification of the harmful species. Thus, 18 species of Coleoptera were identified that are part of 5 families of beetles: Anobiidae, Curculionidae, Dermestidae, Ptinidae, Tenebrionidae (Table 1).

Table 1. Frequency of coleopterans identified in the old book collections in eastern Romania.

Pest family	Pest species	Ratio of species frequency to number of books studied F1 (%)	Ratio of species frequency to number of collections studied F2 (%)
Anobiidae	*Anobium punctatum*	10.86%	55.00%
	Lasioderma serricorne	0.19%	5.00%
	Stegobium paniceum	59.93%	40.00%
	Ptilinus pectinicornis	0.37%	10.00%
	Xestobium rufovillosum	19.29%	65.00%
Curculionidae	*Stereocorynes truncorum*	0.94%	5.00%
Dermestidae	*Attagenus pellio*	1.31%	20.00%
	Attagenus piceus	0.19%	5.00%
	Anthrenus polonicus	0.56%	10.00%
	Anthrenus museorum	0.37%	5.00%
	Anthrenus verbasci	0.19%	5.00%
Ptinidae	*Mezium affine*	0.37%	5.00%
	Niptus hololeucus	0.37%	5.00%
	Ptinus fur	2.25%	35.00%
	Ptinus brunneus	1.69%	20.00%
	Ptinus raptor	0.56%	10.00%
	Ptinus villiger	0.19%	5.00%
Tenebrionidae	*Tribolium castaneum*	0.37%	10.00%

59.93% of the 534 books from which insects were taken, were harmed by *Stegobium paniceum*. The species *Anobium punctatum* and *Xestobium rufovillosum* harmed about 10-20% of the books. The other species were found in a somewhat small number (0.19-2.25%)

compared to the total number of books that had been studied (Fig. 1).

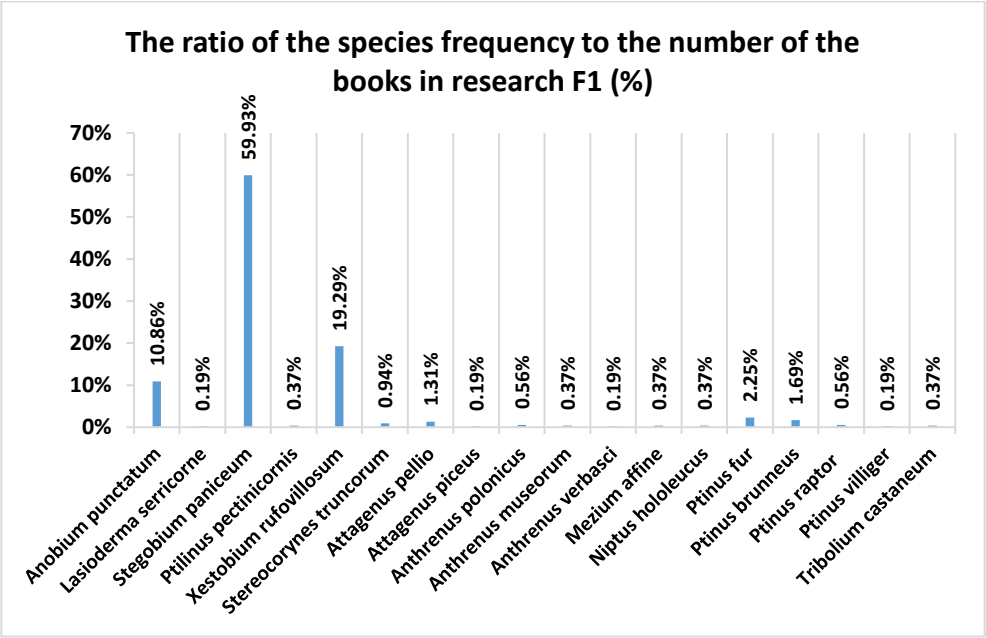

Figure 1. The ratio of the species frequency to the number of the books in research.

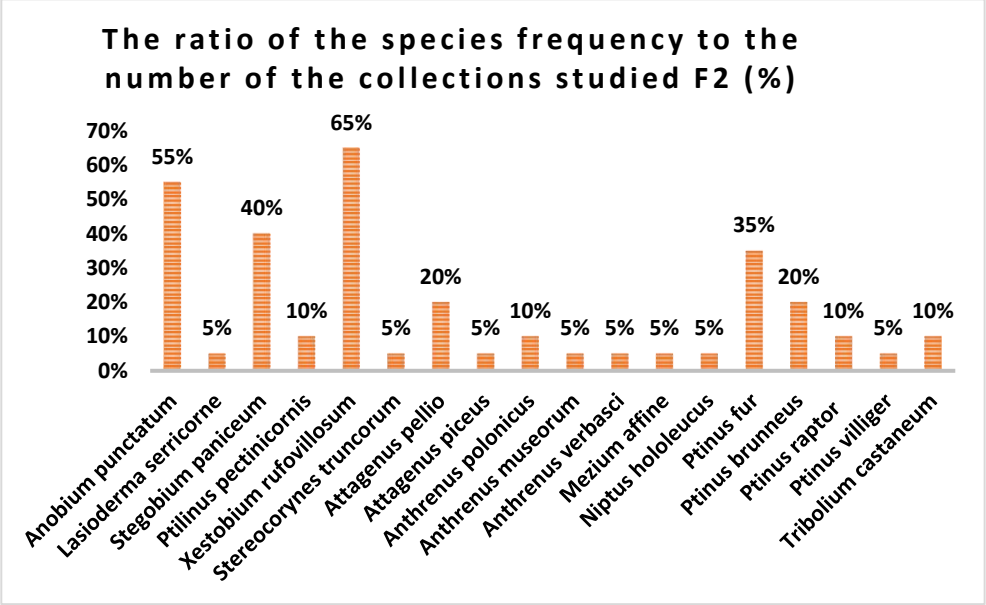

Figure 2. The ratio of the species frequency to the number of the collections in research.

In the 20 collections studied, the species *Xestobium rufovillosum* (65%), *Anobium punctatum* (55%) and *Stegobium paniceum* (40%) were found most frequently. *Ptinus fur* was identified in 35% of locations (fig. 2). *Attagenus pellio* and *Ptinus brunneus* were identified in 20% of locations. The species *Lasioderma serricorne, Ptilinus pectinicornis, Stereocorynes truncorum, Attagenus piceus, Anthrenus polonicus, Anthrenus museorum, Anthrenus verbasci, Mezium affine, Niptus hololeucus, Ptinus raptor, Ptinus villiger* and *Tribolium castaneum* were identified in 5-10% of collections.

The large number of books harmed by *Stegobium paniceum* is determined by the large number of old books glued with wheat paste. When the book has a wooden cover, the attack is insignificant, the damage being reduced to a few galleries between endsheets and wood, or near the spine. When the cover is made of cardboard, *Stegobium paniceum* causes great damage, larvae and adults invading the entire cover. Over the years they produce dozens of galleries and flight holes that fracture infested materials (Fig. 3a-b). From the covers, the larvae have the ability to penetrate the textblock, 5-8 mm deep, producing galleries of 1.0-1.5 mm in diameter.

The species *Anobium punctatum, Xestobium rufovillosum, Ptilinus pectinicornis* were usually identified in books with wooden covers. Being xilofagous species, they have the ability to digest paper and wood in the structure of books. These species are the only ones capable of fracturing the textblock and covers when digging galleries to feed or fly from the book (Fig. 3c-g).

The galleries of *Xestobium rufovillosum* are large, with a diameter of about 3.5-4.0 mm, filled with shredded paper and cookie-shaped faecal pellets (Fig. 3e).

The high presence of *Xestobium rufovillosum* in old books was associated with their presence in the buildings that housed the collections. Buildings with high humidity in the walls (churches, memorial houses), over time, are biodegraded by fungi. Rotten wood attracts *Xestobium rufovillosum* insects and, thus, the insects reach the books from the wood of the buildings.

The attack of Ptinidae and Curculionidae was encountered as well in books with high humidity and signs of fungal attack (colored spots released as a result of their biological activity). The flight holes and galleries produced by the spider beetles are at the level of the cardboard covers and the endsheets (fig. 3h-k). *Stereocorynes truncorum* caused damage both in the textblock and in the covers (flight holes of about 2 mm in diameter).

The keratophagous Dermestidae reach the books after they have been attacked by xilophagous species. They eat the dead insects, and then they attack the components of animal origin in the book (wool, glue). The damage caused by the species of *Attagenus* sp. and *Anthrenus* sp. is relatively small, major problems occurring only when they eat the textile fibers in the seam of the book.

The damage caused by coleopterans are unsightly (especially when there are living or dead insects in the galleries), destroying the texts and decorations of the books (fig. 3c-g). From the damaged volumes, shredded materials, excrements full of spores of microorganisms, hairs of larvae (especially skin beetles) fall down. These tiny residues cause health problems for people who inhale them.

Figure 3. Damaged books by: *Stegobium paniceum* (a-b), *Xestobium rufovillosum* (c-f), *Anobium punctatum* (g), *Ptinus fur* (h-j), *Mezium affine* (k); combined attack of *Xestobium rufovillosum* and *Stegobium paniceum* (l).

Conclusions

A number of 1029 books from 20 old book collections from museums, churches, libraries in 5 counties in eastern Romania were studied. 18 species of coleopterans have been identified that have caused damage to the books. The species *Stegobium paniceum, Xestobium rufovillosum* and *Anobium punctatum* are the most common and cause the most significant damage in old book collections. Books kept in high humidity conditions were attacked by *Xestobium rufovillosum, Ptinus* sp. and curculionides. Cardboard covers are the most exposed to insect attack, being accessible to all the identified species. *Stegobium paniceum* causes major damage in the books with carboard covers glued with wheat paste.

In books with wooden covers, the greatest damage is caused by xylophagous insects of the species *Anobium punctatum* and *Xestobium rufovillosum*.

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