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Rizika výskytu hlodavců a IPM ve skladech obilí a sladovnického ječmene

Current Threats Of Rodents and Integrated Pest Management (IPM) for Stored Grain and Malting Barley

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Synantropní hlodavci patří mezi celosvětově významné škůdce v zemědělských a potravinářských provozech. Hlodavci působí rozsáhlé škody nejen konzumací plodin a komodit, ale také jejich kontaminací trusem a močí, dále jsou významnými přenašeči patogenů nebezpečných pro člověka. Právě kontaminace prostředí trusem a močí patří mezi nejvíce přehlížené a podceňované škody, které mají zdravotní a hygienický význam. V tomto přehledovém článku jsme se zaměřili právě na shrnutí dostupné literatury, která se zabývá kontaminací skladů a následných zpracovatelských provozů.

Fraňková, M., Stejskal, V., Rödl, P., Aulický, R., 2016: Current threats of rodents and Integrated Pest Management (IPM) for stored grain and malting barley. Kvasny Prum. 62, No. 10, pp. 306–310
Synanthropic rodents belong to the worldwide dominant vertebrate pests occurring in agricultural and food industry environment. Rodents have enormous potential to cause multiple damages to human resources by feeding on crops and stored commodities and by their faecal and urine contamination. The latter is associated with a risk of transmission of pathogens into food and feed chain. In spite of its health and hygienic significance the risk of faecal contamination of stored grain is often under-rated by store-keepers and farmers due to insufficient published summary information. Therefore in this overview, we summarised the relevant key-literature resources dealing with hazards associated with contamination of grain stores and food processing plants by rodents.

Fraňková, M., Stejskal, V., Rödl, P., Aulický, R., 2016: Das Risiko vom Nagetierauftreten und IPM (integrierte Schädlingsbekämpfung) in den Getreide- und Braugerstenlagern. Kvasny Prum. 62, Nr. 10, pp. 306–310
Zu den weltweitbedeutenden Schädlingen in den Landwirtschaftlichen und Lebensmittelbetrieben gehören die synantropischen Nagetieren. Die Nagetiere verursachen erheblichen Schaden nicht nur durch die Getreide- und Rohfrüchtenkonsumation sondern auch durch die Kontamination der Getreide von Fäkalien und Urin, weiterhin sind bedeutende Überträger der für den Mensch gefährlichen Pathogene. Insbesondere die Umweltkontamination durch Fäkalien und Urin gehört zu den meist vernachlässigten und unterschätzten Schaden, die eine gesundheitliche und hygienische Bedeutung haben. Dieser übersichtliche Artikel fasst die Übersicht der verfügbaren Literatur über Lager- und Verarbeitungsbetrieben zusammen.

Keywords: *stored grain, barley, rodents, contamination, urine, faeces*
Klíčová slova: *skladované obilí, ječmen, hlodavci, kontaminace, moč, trus*

1 INTRODUCTION

Norway rat (*Rattus norvegicus*) (*Fig. 1*), roof rat (*R. rattus*) (*Fig. 2*), and house mouse (*Mus musculus*) (*Fig. 3*) are the most dangerous synanthropic pest rodent species at the worldwide scale. The ranking demonstrated by Capizzi et al. (2014) showed that no other rodent species have such a widespread range and such variety of impacts in agriculture, urban areas, ecosystems, forestry, public health, etc. Therefore, the aim of this study was to provide a short overview of the selected pestilential effect of rodents on agricultural and food industry stores and animal farms, with inclusion of our original photo-documentation. Additional and updated photos and references of our work can be found on the scientific webpages of the authors: http://rodentscience.com/english/.

2 CONSUMPTION OF COMMODITIES AND FOOD

Rodents are able to feed on extreme variety of stored raw or finished commodities and products (e.g. *Fig 4*). According to Food and Agriculture Organization of the United Nations the estimates of the rodent-related postharvest losses vary profoundly (3% - 50%) depending on the specific local conditions (Brooks and Fiedler, 1999). It is claimed that postharvest losses are usually much higher in the developing countries than in the developed countries (e.g., Ahmad et al., 1995; Brown et al., 2013). We were not able to find some

Fig. 1 Norway rat *(Rattus norvegicus)* (photo: P. Rödl)

Fig. 2 Roof rat (*R. rattus*) (photo: P. Rödl)

Fig. 3 House mouse (*Mus musculus*) (photo: P. Rödl)

Fig. 4 Mice inside bread (photo: P. Rödl)

experimentally substantiated estimate concerning the current losses caused by rodents on stored commodities and processed food in the EU. It is especially difficult to get information on losses and problems concerning food industry, since it is a very sensitive topic. The reason is that food problems caused by rodents usually hits the headlines of media and tabloid press.

3 TRANSMISSION OF PATHOGENS, PARASITES AND VECTORS

Undoubtedly the most damaging effect of rodents is associated with pathogen transmission causing serious human and animal diseases. There are two main routes how rodents can spread pathogens – by biting humans/animals or by humans consume food products or water contaminated with rodent faeces or urine. Rodents are also associated with dangerous arthropods - such as fleas (*Xenopsylla cheopis*) or ticks (*Ixodes ricinus*, *I. persulcatus*) - recognized as pathogen vectors and biting harm of pets or humans. According to worldwide review by Meerburg et al. (2009) rodents are able to host and transmit more than 60 species of pathogenic viruses, bacteria and various parasites (e.g. Sporozoa, Cestoda, Trematoda, Nematoda etc.). These pathogens cause dangerous diseases as Hantavirus Pulmonary Syndrome, viral fevers, hepatitis E, tick-borne encephalitis in the case of viruses, and salmonellosis, campylobacteriosis, leptospirosis, Lyme diseases, Murine typhus, *Bartonella* infections, Tularemia, plaque in the case of bacteria.

Other potential sources of pathogens and/or arthropods are rodent cadavers. Majority of rodents die under cover (Fenn et al., 1987) and such hidden carcasses may represent a reservoir for secondary infestation (e.g. insects; *Fig. 5*). Despite only small number of cadavers is found above ground after a control programme (Harrison et al., 1988), in the case of poor or even absent sanitation they still pose an important health risk.

Fig. 5 Ants feeding on a mice cadaver potentially ingesting pathogenic bacteria (photo: M. Fraňková)

4 TRANSMISSION OF TOXINOGENIC FUNGI IN GRAIN STORES

Although mycotoxins are of natural origin, they belong among the most dangerous chemicals. They may be produced by various species fungi ("moulds") growing on the stored grain, dust and surface of store structures. Farmers are familiar with rodents as dangerous seed-feeders in grain stores. Less known is a fact that rodents are efficient fungi vectors although it was scientifically documented by the pilot study performed in the Czech grain store (Stejskal et al., 2005) where mycological analysis of house mouse faeces revealed 35 species of fungi such as *Aspergillus niger*, *Penicillium aurantiogriseum,* etc., and 12 of them were potential producers of mycotoxins (see *Fig. 6*).

Table. 1. The list of fungi isolated from mouse fecal pellets associated with grain stores from August to November 2003 (Legend: 1–21 -serial No. of sampled pellet, F – frequency of the particular species in samples, EG – ecological groups, F – pre-harvest fungi, S – post-harvest fungi, C – coprophagous fungi)

species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	F (%)	EG
Alternaria alternata (Fr.: Fr.) Keissl.			+																			5	F
Arthrinium arundinis (Corda) Dyko et B. Sutton				+																		5	S
Aspergillus candidus Link	+			+												+						14	S
Aspergillus flavus Link												+	+									10	S
Aspergillus niger Tiegh.					+		+							+		+					+	24	S
Aspergillus ochraceus K. Wilh.					+																	5	S
Aspergillus versicolor (Vuill.) Tirab.									+				+									10	S
Cladosporium cladosporioides (Fresen.) de Vries		+																				5	F
Cladosporium herbarum (Pers.: Fr.) Link					+		+		+													14	F
Epicoccum nigrum Link					+		+															10	F
Eurotium repens de Bary, anam. *Aspergillus reptans* Samson et W. Gams		+		+									+	+	+		+					29	S
Geotrichum candidum Link																			+	+		10	S
Microascus brevicaulis S. P. Abbott, anam. *Scopulariopsis brevicaulis* (Sacc.) Bainier		+											+	+		+	+	+				29	S
Mucor circinelloides Tiegh. f. *circinelloides*		+																				5	F
Mucor dimorphosporus Lendn. f. *dimorphosporus*					+				+													10	F
Mucor hiemalis Wehmer f. *hiemalis*						+																5	F
Mucor mucedo Fresen.							+	+			+								+			19	3
Mucor wosnessenskii Schostak.																				+		5	F
Mycocladus corymbifer (Cohn in Licht.) Váňová												+										5	F
Penicillium aurantiogriseum Dierckx	+												+					+		+		19	S
Penicillium chrysogenum Thom				+													+					10	S
Penicillium coprobium Frisvad CCF 3180							+															5	C
Penicillium coprophilum (Berk. et M. A. Curtis) Seifert et Samson CCF 3179							+															5	C
Penicillium corylophilum Dierckx CCF 3293														+								5	S
Penicillium expansum Link	+																					5	S
Penicillium miczynskii K. M. Zalessky																					+	5	F
Penicillium olsonii Bainier et Sartory														+			+					10	S
Penicillium polonicum K. M. Zalessky								+														5	S
Penicillium rugulosum Thom														+			+					10	S
Penicillium solitum Westling	+							+							+							14	S
Penicillium viridicatum Westling																				+		5	S
Penicillium sp.										+												5	S
Rhizopus arrhizus A. Fisch.												+								+		10	S
sterile white mycelium			+																			5	?
Thamnidium elegans Link	+	+		+							+											19	C
number of species	5	5	2	5	5	1	6	3	3	1	2	3	5	6	2	3	5	2	2	5	2		

Fig. 6 The list of fungi isolated from mouse faecal pellets associated with grain stores (Legend: 1-21 – serial No. of sampled pellet, F – frequency of the particular species in samples, EG – ecological groups, F – pre-harvest fungi, S – post-harvest fungi, C – coprophilous fungi); ex Stejskal et al., 2005.

5 CONTAMINATION BY FAECAL DROPPINGS AND OTHER CONTAMINANTS

Rats and mice seriously contaminate environment, stored commodities and food products by urine (it is a strong source of unpleasant odours), faecal droppings and hairs (*Fig. 7*). Although it has been known that daily faecal production of rodents is enormous, surprisingly, until recently there was little scientifically estimated information on species-specific defecation rate. Recently Fraňková et al. (2015) estimated that single caged rat produces on average 66 faeces per day, while Frynta et al. (2012) documented that a single caged mouse produces on average 70 faeces per day. In a room study (Aulický et al., 2015) the non-caged mice produced more than 100 faeces per day and individual; thus a single mouse may theoretically leave more than 30.000 droppings on one spot within a year period. LaVoie et al. (1991) were likely the first scientists who experimentally evaluated contamination rate of a simulated grain store by house mice. The knowledge of usual pattern of spatial distribution of rodent faeces is a necessary prerequisite for early detection of faeces. Aulický et al. (2015) recently evaluated house mice faeces density and their relative allocation in a typical mouse home range around its shelter. They found that the risk of food spoilage was high. Even a single mouse invasion into a simulated store caused serious floor contamination (97.3 faeces/m^2) and the average daily defecation rate was 102.2 faeces/individual out of which 7% was located in the food and water vicinity (Aulický et al., 2015).

Fig. 7 Rodent faeces and hair are contaminants (photo: P. Rödl)

6 EXTEND OF DROPPING CONTAMINATION

The presence of long term established rodent population leads to production of large amount of droppings, which represent the widespread problem especially in grain stores, an abundant food resource

Fig. 8 The layer of black rat droppings, which fall down directly from the ceiling joists on the floor of the empty grain store (photo: M. Fraňková)

Fig. 9 The detailed view on the contaminants (droppings, hairs, gnawed material) fall down from the ceiling joists on the floor (photo: M. Fraňková)

(Butler and Mickel, 1955). In the case of roof rats, known for their climbing ability and preference for the upper parts of buildings, there is an additional potential of contamination of grain. Defecation at the upper parts of building unavoidably leads to the situation when droppings fall down and contaminate the space below. In the case of grain store, significant number of droppings falls on the grain surface even in the absence of direct contact between rats and grain. Such kind of contamination was recorded on the floor of an empty grain store (*Fig. 8, 9*). We found a layer of droppings accumulated under the ceiling joists where the rats move. It is obvious, that in the case of the filled grain store, similar amount of dropping contaminate directly the grain.

7 STEEL SILOS FOR GRAIN STORAGE MAY NOT BE PROOF FROM RAT INFESTATION AND CONTAMINATION

Steel stored-grain silo structures have traditionally been considered to be rodent infestation and contamination proof. Recently, Stejskal and Aulický (2014) published the first European report of heavy contamination (up to 26 faecal pellets/m^2 of grain surface) of grain stored in steel silos by faeces of roof rat (*R. rattus*). Since the size of rat faeces and barley grains proved very similar, the separation of these two materials using sieves is problematic. In addition, there was high density of faeces accumulated on conveyor belts (*Fig. 10*) of the grain-transport technology in the store. It was impossible to load fresh and clean grain without admixing it with the rat faeces present on contaminated conveyor belts. Thus movement of the conveyor belts contaminated by rat faeces represented a dangerous route of contamination for the grain in the silos.

Fig. 10 Conveyor belt contaminated by rat droppings in grain store (photo: V. Stejskal)

8 INJURY TO PACKAGES AND SPILLAGE LOSSES

Plant seeds (including barley) are mainly not stored in metal silos, but in paper, cardboard, plastic or wooded packages (for the detailed recent overview and photos see Stejskal et al., 2014). All of the three main rodent pest species have great ability to penetrate most of these packages and feed on the content (*Fig. 11*). Moreover, mice population may develop hidden inside (*Fig. 12*) or among bags with seeds without leaving external signs of activity. During storage or manipulation of the injured bags the content is spilled on the floor and into cracks and crevice where is frequently spoiled by moulds and storage insects and mites. In addition, the moisture and/or scattered grains from injured bags may make floors slippery and lead to accidents (Hamel, 2010).

Fig. 11 Mice are injurious to bags with seed (photo: V. Stejskal)

Fig. 12: Hidden mice infestations inside bags which contain cereal grains (photo: V. Stejskal)

9 CONCLUSIONS

Rodents are very adaptable economic and public health pests (Buckle and Smith, 2015) and they belong among the most frequent pests at farms and food industry facilities both in developing as well as in developed countries. For example, Wildey (2002) reported farm survey from the United Kingdom showing that rodents infested about 70% of grain stores. Various reviews – including this one – demonstrate that rodents are not only abundant pests but they cause great variety of dangers to human population and human resources. There are several intensively studied topics, e.g. a phenomenon of resistance to anticoagulant rodenticides, toxic effects of rodenticides to non-targets species and ecology of rodent pests. On the other side, there are still some difficulties and/or troubles commonly occurring in food processing industry (as demonstrate the pictures in this overview), but only scarce or absent in peer-reviewed literature, e.g. hoarding behaviour, secondary insect infestation caused by the hidden hoarded food, risk of rodent contaminants and specific studies dealing with risk analysis in grain stores and food stores. Nevertheless, irrespective of high pest effects and frequency of problems in stores and food industry, rodents seem to be an overlooked pest group in many EU countries in terms of research support (see for example Stejskal and Honek, 2015).

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