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RISK OF OCCUPATIONAL ALLERGY TO STORED GRAIN ARTHROPODS AND FALSE PEST-RISK PERCEPTION IN CZECH GRAIN STORES

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Abstract: Arthropods are a documented cause of occupational allergy in cereal stores. Since the current allergenic risk of various arthropods in grain stores is not known, we evaluated its extent using data from the Czech Republic (CZ). We surveyed 514 grain storage units for pest composition and density. Recalculating literature data we established 4 density dependent classes of pooled mite "allergy-risk level" (ARL) in stored grain: (i) safe-ARL: 0 mites.g^{-1} grain, (ii) low-ARL: up to 1 mite.g^{-1} grain, (iii) high-ARL: from 1 to 5 mites.g^{-1} grain, (iv) danger-acute asthma-ARL: higher than 5 mites.g^{-1} grain. Farmers (15) were questioned for pest taxon-related pesticide treatments. Mites constituted the largest group of collected pests (92%) followed by psocids (5%), beetles (3%) and moths (0%). 60% of mites belonged to known allergen producing species; the most abundant were *Acarus siro*, *A. faris*, *Tyrophagus putrescentiae* and *Lepidoglyphus destructor*. Grain samples belonged to the established ARL classes as follows: (i) safe-ARL: 37% (ii) low-ARL: 53%; (iii) high-ARL: 6%; (iv) danger-acute asthma-ARL: 4%. The enquiry among farmers revealed that almost no pesticides were targeted solely to control mites. This study suggests that mites represent, due to their allergenic potential, density and frequency, the most serious source of allergens in stored grain in CZ. However, the medical aspect of pest control – such as allergy avoidance strategy – is overlooked since grain feeding insects were mostly chemically controlled, regardless of their relatively low density and allergen production in comparison with mites.

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INTRODUCTION

Food production and storage facilities are frequently infested by various pest arthropods [4, 21, 31, 32, 36] that contaminate the environment by allergens and pathogens [3, 10]. The continual presence of insects and mites in workplaces may lead to the development of occupational allergenic diseases of farmers, millers, bakers and other food industry operators [2, 26, 37]. In particular, the exposure to dust of infested grain is associated with a number of adverse allergic health outcomes, including conjunctivitis, rhinitis, dermatitis and asthma [12]. Cereal stored commodities may be occupied by 4 groups of pest arthropods including mites (Acari), psocids (Psocoptera), beetles Coleoptera) and moths (Lepidoptera) [31, 32]. These groups do not represent an equal allergy health-risk because of their different allergenic, invasive and reproduction potential [3, 30]. Avoidance of exposure to indoor allergens is an important element in the treatment of allergic occupational disease [24] realized via physical or chemical control of pest populations in grain stores [33]. Farmers usually control only the most serious pests; the decision which arthropod is a key pest lies solely on the personal opinion of the particular farmer. However, Mumford [19] warns that the semi-qualified farmer's estimate may under- or overrate the actual risk of a particular pest and population. Underrated pest infestation risk may result in threat to public health by allergens contaminating the working

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environment or food, and overrated risk (i.e. "zero arthropod tolerance") may result in redundant pesticide treatment. It has been documented [19] that UK farmers consistently overrated the threat of some groups of pest with the result of redundant pesticide spraying. The latter may have, besides toxicological, also immunological implications as some pesticides proved to be allergens [6, 15]. This implies that a thorough scientific pest risk assessment is needed. However, qualitative and quantitative data on the differential occurrence of stored-food pests is available only for some countries [3]. In addition, even in these countries, farmers and food managers have almost no idea on the allergy-risk caused by a particular pest group and its population density to infested stored grain. It is felt that safety or "allergy risk levels" (ARLs) should be established for the key groups of stored product pests in order to facilitate the decision making process of farmers and environmental safety officers.

In this work, we therefore (i) evaluated the composition of pest-arthropods and the intensity (frequency and density) of their infestation in stored food-grain, (ii) estimated mite density dependent ARLs in food-grain, (iii) evaluated the current risk of occupational mite-related allergy in the grain stores in the CZ, based on the newly established ARLs, and (iv) explored the differential targeting of chemical treatment in terms of pest taxon (i.e mites, psocids and beetles).

MATERIALS AND METHODS

Occurrence, frequency and population density of pest groups/species

Sampled sites. The grain samples were obtained from 147 geographically isolated grain storage facilities in the Czech Republic (Central Europe) in the period 1996–1998. Each storage facility consisted of several store-units, where each unit was represented by one bin or flat-store chamber. We took samples from 514 store-units, which represent an average "inspection rate" of 3–5 store-units per each storage facility. Each of the 514 obtained samples (2.5 kg grain) consisted of 5 sub-samples (0.5 kg grain) taken from 5 sampling points per store-unit (for technical details see Stejskal [32]).

Treatment of samples and data. To extract micro-arthropods (mites and psocids), each sample (2.5 kg) was gently mixed and a 200 g sub-sample was exposed on the Berlese-Tullgren funnel (24 hrs, 50°C). Extracted mites were sorted out and mounted on microscopic slides for identification. Macro-arthropods (i.e beetles and psocids) were sieved-off using mechanical sieves. The abundance of each species was recalculated to 1 kg of grain sample. In alergological studies, mite densities are expressed per g of dust [7, 11, 16]. Since the content of dust was previosly estimated (13) we recalculated mite grain denisty to mites density per g of dust.

Table 1. Frequency of infestation and abundance parameters of arthropod pest groups occurring in Czech grain stores.

pets group	frequncy %	total abundance	mean	maximum
mites	71	996,404	1939	90,675
psocids	24	59,356	115	19,700
beetles	38	34,723	68	3,265
total	87	1,090,483	707	90,675

Table 2. List of mite pests infesting Czech grain stores (n – number of extracted individuals from all samples (N=514), taken from 147 Czech grain stores).

species	n
Acarus siro	333,114
Tydeus interruptus	140,005
Acarus farris	119,740
Tarsonemus granarius	93,838
Tyrophagus putrescentiae	90,067
Tyrophagus longior	74,655
Lepidoglyphus destructor	50,693
Cheyletus eruditus	31,210
Chortoglyphus arcuatus	18,597
Caloglyphus berlesei	12,000
Caloglyphus oudemansi	10,350
Tyrophagus miripes	4,200
Cheyletus aversor	3,885
Cheyletus trouessarti	3,396
Haemogamasus pontiger	3,390
Tyrophagus perniciosus	1,398
Eulaelabs stabularis	1,139
Androlaelaps casalis	947
Alliphis siculus	792
Cheyletus malaccensis	690
Blatosicius tarsalis	488
Glycyphagus privatus	325
Leiodinychus krameri	298
Acaropsellina docta	285
Lepidoglyphus michaeli	220
Blattisocius keegani	191
Proctolaelaps pygmaeus	175
Spinibdella lignicola	168
Ctenoglyphus plumiger	50
Hypoaspis lubrica	30
Acarus immobilis	20
Aleuroglyphus ovatus	10
Glycyphagus domesticus	10
Pyemotes herfsi	10
Tyrophagus neiswanderi	10
Tyrophagus tropicus	10

Mite allergy-risk levels (ARLs)

Mite density related allergy risk. The estimation of mite allergy-risk levels (ARLs) was based on published mite densities per g of dust causing human health problems [14, 24]. Exposure to more than 100 mites.g^{-1} dust (1 mites.g^{-1} grain) is considered to increase the risk of sensitization and symptoms, while exposure to more than 500 mites.g^{-1} dust (5 mites.g^{-1} grain) may increase the risk of acute asthma attacks [14, 24]. Based on these data, we estimated the following five classes of "Allergy-Risk-Level" (ARL) for occupational allergy in grain stores: (i) safe level (mite-free grain), (ii) low risk level (up to 1 mites.g^{-1} grain), (iii) high risk level (from 1 to 5 mites.g^{-1} grain), (iv) danger – acute asthma – level (higher than 5 mites.g^{-1} grain).

ARL based classification of samples from Czech grain stores: The samples obtained from Czech grain stores were sorted according to ARL classes in order to estimate the risks of actual occupational allergies related to current mite infestation. ARL based classification of samples was made for pooled mite species and separately for all allergenic mites. That is for mites which compounds are documented to bind human IgE – that include *Acarus siro*, *A. farris*, *Glycyphagus domesticus*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae*, *Aleuroglyphus ovatus*, *Chortoglyphus arcuatus* and *Cheyletus eruditus* [3, 16, 17, 20].

Pest risk perception of farmers and pest specific control measures

In Czech Republic, stored-grain pests are controlled by chemicals that include pesticide sprays (organophosphates, pyrethroids) and fumigants (phosphine). Czech law requires that a protocol must be elaborated and archived for grain chemical treatment, enabling to trace-back the target pests of the treatment. We were able therefore to obtain the data from 15 farmers on the total number of stored-grain chemical treatments to control beetles, psocids and mites, in those grain stores from which the arthropod-infested samples originated.

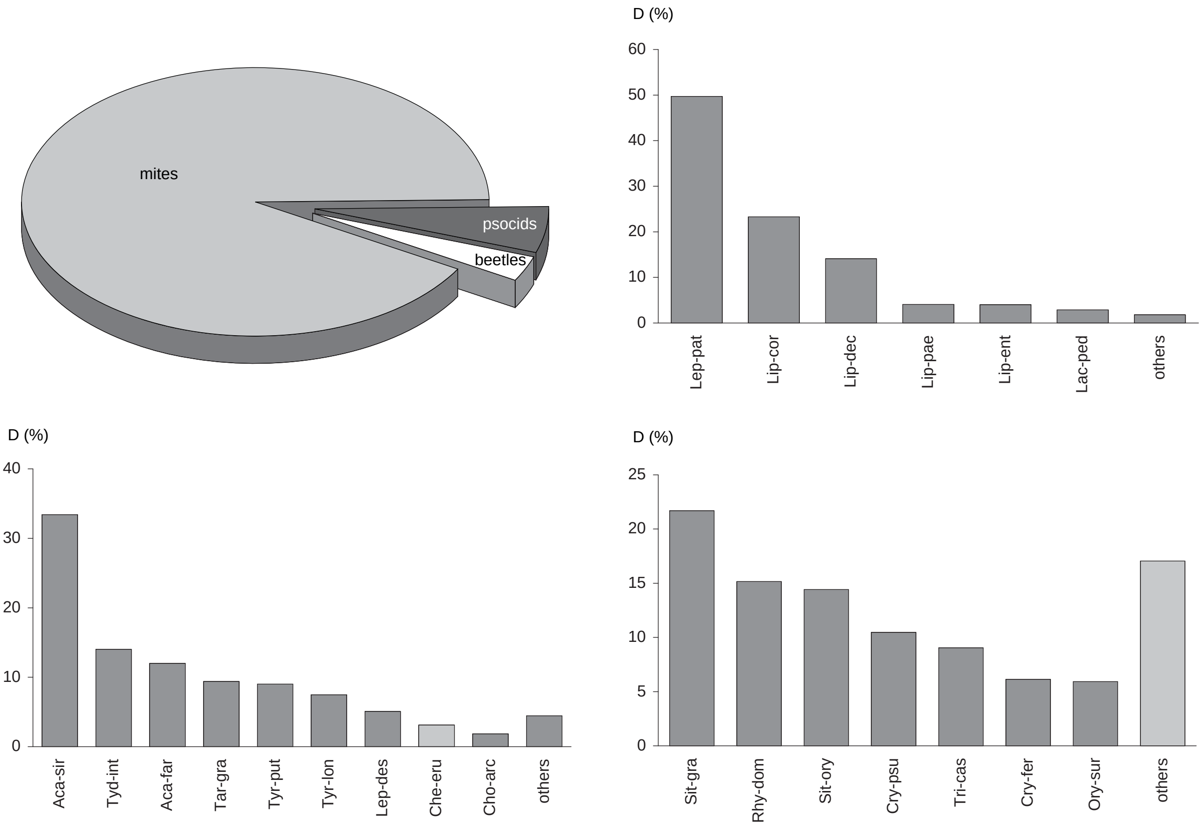
RESULTS

Occurrence, frequency and population density of pest groups/species

Altogether 83% of grain samples were infested, containing more than 1 million pest-arthropod individuals. Mites were the most abundant and frequent arthropod group followed by psocids and, beetles (Fig. 1, Tab. 1); moths were completely absent. We collected 36 mite species (> 1,000,000 individuals), 32 beetle species (cca 35,000 individuals), and 10 psocid species (cca 60,000 individuals). The evaluation based on the abundance data from all samples shows that the most important species within each taxon were: Mites (Tab. 2): *Acarus siro*, *Tydeus interruptus*, *Acarus farris*,

Table 3. List of insect pests infesting Czech grain stores (n – number of extracted individuals from all samples (N=514) taken from 147 Czech grain stores).

species	n
beetles	
Sitophilus granarius	7,535
Rhizopertha dominica	5,270
Sitophilus oryzae	5,011
Cryptolestes pusillus	3,636
Tribolium castaneum	3,147
Cryptolestes ferrugineus	2,135
Oryzaephilus surinamensis	2,061
Typhaea stercorea	1,032
Ptinus tectus	908
Ptinus fur	864
Ptinus raptor	668
Latridius minutus	495
Tenebrio molitor	493
Ahasverus advena	477
Palorus subdepressus	357
Tipnus unicolor	113
Attagenus pellio	110
Attagenus unicolor	105
Niptus hololeucus	87
Ptinus clavipes	75
Mycetophagus quadriguttatus	40
Ptinus latro	26
Anthrenus festivus	20
Ptinus villiger	13
Cryptophagus pilosus	13
Anthicus floralis	10
Anobium punctatum	10
Palorus ratzeburgi	6
Cryptolestes turcicus	3
Tribolium confusum	2
Stegobium paniceum	1
Lasioderma serricorne	1
psocids	
Lepinotus patruelis	29,525
Liposcelis corrodens	13,838
Liposcelis decolor	8,377
Liposcelis paeta	2,441
Liposcelis entomophila	2,391
Lachesilla pedicularia	1,710
Liposcelis brunnea	818
Lepinotus reticulatus	139
Trogium pulsatorium	108
Lepinotus inquilinus	10



Mites: Aca-sir – *Acarus siro*, Tyd-int – *Tydeus interruptus*, Aca-far – *Acarus faris*, Tar-gra – *Tarsonemus granarius*, Tyr-put – *Tyrophagus putrescentiae*, Tyr-lon – *Tyrophagus longior*, Lep-des – *Lepidoglyphus destructor*; Che-eru – *Cheyletus eruditus*, Cho-arc – *Chortoglyphus arcuatus*; psocids: Lep-pat – *Lepinotus patruelis*, Lip-cor – *Liposcelis corrodens*, Lip-dec – *Liposcelis decolor*, Lip-pae – *Liposcelis paeta*, Lip-ent – *Liposcelis entomophila*, Lac-ped; beetles: Sit-gra – *Sitophilus granarius*, Rhy-dom – *Rhizopertha dominica*, Sir-ory – *Sitophilus oryzae*, Cry-pus – *Cryptolestes pusillus*, Tri-cas – *Tribolium castaneum*, Cry-fer – *Cryptolestes ferrugineus*, Ory-sur – *Oryzaephilus surinamensis*.

Figure 1. Relative abundance (D) of pest arthropods in 514 grain samples obtained in Czech grain stores.

Tarsonemus granarius, T*yrophagus putrescentiae*, *Tyrophagus longior*, *Lepidoglyphus destructor*; *Cheyletus eruditus* and *Chortoglyphus arcuatus*; Psocids: (Tab. 3) *Lepinotus patruelis*, *Liposcelis corrodens*, *Liposcelis decolor*, *Liposcelis paeta* and *Lachesilla pedicularia*; Beetles: (Tab. 3) *Sitophilus granarius*, *Rhizopertha dominica*, *Sitophilus oryzae*, *Cryptolestes pusillus*, *Tribolium castaneum*, *Cryptolestes ferrugineus* and *Oryzaephilus surinamensis*.

Mite allergy-risk levels (ARL) in Czech grain stores

Table 4 shows the proportion of mite infested samples in various ARL classes, indicating that most of the grain samples represented at least low allergy risk (ARL ii–iv), while one third of the grain samples indicated a safe allergy level (ARL i). The dangerous acute asthma-risk level (ARL iv) was present in the lowest number of grain samples. The proportion of samples assigned to the ARL classes was similar for both pooled mite species and individual species of allergenic mites (*A. siro*, *A. farris*, *G. domesticus*, *L. destructor*, *T. putrescentiae*, *A. ovatus*, *C. arcuatus* and *C. eruditus*) (Tab. 4).

Farmers' pest risk perception and pest specific control measures

As apparent from Table 5, almost 100% of the pesticide chemical treatments (15 farmers reported 118 grain treatments during a 3 year period) of stored grain were applied to control beetles (115 treatments) (especially *Sitophilus* spp., *Tribolium* spp., *Oryzaephilus* spp., and *Cryptolestes* spp.) while almost no treatments (3 treatments conducted in 2 grain seed producing companies) were applied solely to control mite or psocid populations.

DISCUSSION

Pest group/species occurrence, frequency and population density

We found that a large proportion (83%) of samples of stored grain suffered from infestation of stored-product arthropods. As expected, the contribution of various pests to the overall infestation of grain in the Czech stores differed dramatically: mites were the most abundant and frequent arthropod group followed by psocids and beetles. Although the presented data on pest infestation comes from the Czech Republic, we believe that the results are of general interest, since high mites abundances occur in grain stores in many European and Asian countries [7, 30, 31]. Very similar mean density and species composition of the mite-infested Czech Republic samples were reported for Denmark [11]. Nevertheless, abundance, frequency and dominance of various mite species may vary from country to country [7]. The humid climate of seaside countries apparently supports higher populations of grain- and dust-mites than continental and arid geographical zones [18].

Mite allergy-risk levels (ARLs)

Up to the present time, allergens have been identified in 4 stored product mites [3], and the extracts of 4 other species showed specific IgE determinations [16, 17, 20]. Interestingly, in our study the allergen producing mites (*A. siro*, *A. farris*, *L. destructor*, *T. putrescentiae*, *C. arcuatus* and *C. eruditus*) were the most abundant species. Psocids show some allergen potential [23], but relevant observations focused on particular species are missing. Among beetles, extracts from *Tribolium* spp. and *Sitophilus* spp. showed specific human IgE reactivity [1, 8]. This suggested that the most important producers of allergens were mites in the condition of Czech grain stores, followed by psocids, while beetles seem to play minor role as allergenic contaminators. This is why we have attempted to establish ARLs only for mites. We found that 37% and 53% grain samples belong to safe-ARL or low-ARL, while 6% and 4% grain samples was ranked to high-ARL or danger-acute asthma-ARL. Our results indicate that the most serious actual mite associated risk of occupational allergy was traced in ca 10% of Czech grain stores.

Looking in the literature, there are both many proponents and opponents of using critical levels/thresholds in various decision-making processes due to inherent simplification of real-word dynamic processes. Nevertheless, it cannot be overlooked that critical thresholds have brought huge benefits in the practical decision-making in many areas of public health, medicine and agriculture. Critical thresholds are available for pesticide and mycotoxin residuals in food products. Medical doctors use various diagnostic numerical scoring systems of symptoms to estimate the level of disease severity, which facilitates the evaluation of the health state of patients and the choice of an appropriate curative treatment [28]. Safety and economic critical thresholds have been established for many plant pest to indicate either the need for treatment to suppress the pest population [25], or that infested food or environment is safe/dangerous to human health (e.g. DALs – defect action levels, 21, 22). We are aware of many intricacies in establishing medical or agricultural critical thresholds [34, 35], not excluding thresholds for mite allergens. For example, Custovic and Chapman [5] indicated that mite counts might not always

Table 4. Allergy threshold levels (ARL) found in samples (N= 514) taken from 147 Czech grain stores (absolute numbers and percentage of samples in ARL levels).

ART level	i	ii	iii	iv
	absolutly safe	posible risk level	danger level	acute allergy risk
	abundance (ind.g^{-1}grain)			
	0	up to 1	1–5	5 and more
All mite species				
total	150	291	39	34
%	29	57	8	7
Allergenic mites				
total	191	273	30	20
%	37	53	6	4
The most important species				
Acarus farris				
total	482	27	1	4
%	94	5	0	1
Acarus siro				
total	377	115	10	12
%	73	22	2	2
Aleuroglyphus ovatus				
total	513	1	0	0
%	100	0	0	0
Chortoglyphus arcuatus				
total	503	6	4	1
%	98	1	1	0
Glycyphagus domesticus				
total	513	1	0	0
%	100	0	0	0
Cheyletus eruditus				
total	389	118	7	0
%	76	23	1	0
Lepidoglyphus destructor				
total	340	166	7	1
%	66	32	1	0
Tyrophagus putrescentiae				
total	439	71	1	3
%	85	14	0	1

reflect the level of allergens as allergens persist in dust after mite population decline. This implies the urgent need for more information about mite population dynamics and stability of mite allergens in grain stores in various geographical areas to establish more precise and season-dependent ARLs. The ARLs proposed in this work cannot be considered as definite but they represent a first attempt to establish a practical decision making tool to manage mite allergens in grain dust. It is felt that even approximate values of ARLs may be of great practical value while (i) comparing actual allergenic risk at various food/store facilities as an integral part of national public health programmes for avoidance of exposure to indoor allergens, and (ii) evaluating efficacy of storage mites' control.

Farmers' pest risk perception and pest-specific control measures

Provided that the abundance and frequency of allergen-producing mites is much higher than of beetles, it is surprising that their control is almost neglected in Czech grain stores. Despite the abundance of mites being higher than that of insects, we found that pesticide treatments were triggered almost exclusively by the presence of internally feeding beetle pests (Tab. 5). As indicated by conclusions from the recent colloquium of COST Action 842 this selective approach to stored product pests is not unique in Europe [37]. Farmers are traditionally trained to control pests only to prevent crop weight loss, while the medical aspect of pest control is neglected. Large (1–4 mm) macro-arthropods (beetles, psocids) are believed to cause huge weight loss, while small (0.2–0.8 mm) micro-arthropods (mites) are expected to cause negligible feeding loss; invisible allergenic contamination is not taken into account. This is in accordance with psychological theory [29] claiming that people frequently use simple judgment rules that rely on readily apparent context (e.g. physical size) information. Furthermore, it was described that conservative pest-control decision making of farmers may not be based on the real pest risk assessment, but only on personal or traditional beliefs and attitudes [9, 19]. So it seems that the greatest challenge is to educate farmers about mites and allergens. However, even if we will be able to provide medical data, reasoning systematic monitoring, and controlling mites below critical ARLs in grain stores, it will still not be easy to implement them into practice. We can hardly expect voluntary actions in terms of allergen avoidance since farmers are not penalized for presence of mites or their allergens in grain. Farmers investing in mite control would suffer by comparative market economic disadvantage with those who do not. Thus, the only viable option is that farmers have to control medically important mites bellow ARLs by law. The current absence of any legal regulatory measures is amazing provided that mites are not only allergenic but also suspected of transmiting and hosting toxinogenic fungi [10] and unconventional slow diseases such as scabies and Creuzfeld-Jakob [27].

Table 5. No. of pesticide treatments of stored grain and their targeting at various pest groups occurring in Czech grain stores in 1996-98 as a result of questionnaire obtained from 15 Czech farmers.

Farmer No.	No. of pesticide treatments	No. of treatments against beetles	No. of treatments against mites/ psocids
1	24	24	0
2	3	3	0
3	15	13	2
4	5	5	0
5	3	3	0
6	4	4	0
7	8	8	0
8	12	12	0
9	9	9	0
10	3	3	0
11	5	5	0
12	7	6	1
13	1	1	0
14	14	14	0
15	8	8	0

CONCLUSION

This study suggests that mites represent, due to their allergenic potential, density and frequency, the most serious source of allergens in stored grain in the Czech Republic. However, the medical aspect of pest control – such as allergy avoidance strategy – is overlooked since mostly grain feeding insects are chemically controlled, regardless of their relatively low density and allergen production in comparison with mites. Our recent findings and those of other researchers [31, 32, 33] indicate that increased attention should be paid to grain-infesting mites in terms of their monitoring and control. This message should reach not only the agricultural practice but also the public health authorities and policy makers.

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REFERENCES

1. Alanko K, Tuomi T, Vanhanen M, Pajari-Backas M, Kanerva L, Havu K, Saarinen K, Bruynzeel DP: Occupational IgE-mediated allergy to *Tribolium confusum* (confused flour beetle). *Allergy* 2000, **55**, 879-882.

2. Alvarez MJ, Tabar AI, Quirce S, Olaguibel JM, Lizaso MT, Echechipia S, Rodriguez A, Garcia BE: Diversity of allergens causing occupational asthma among cereal workers as demonstrated by exposure procedures. *Clin Exp Allergy* 1996, **26**, 147-153.

3. Arlian LG: Arthropod allergens and human health. *Annu Rev Entomol* 2002, **47**, 395-433.

4. Campbell JF, Arthur FH, Mullen MA: Insect management in food processing facilities. *Adv Food Nutr Res* 2004, **48**, 239-295.

5. Custovic A, Chapman M: Risk levels for mite allergens. Are they meaningful? *Allergy* 1998, **53 (Suppl. 48)**, 71-76.

6. Gassner M: Allergies in agriculture. *Schweitz Rundsch Med Prax* 1996, **85**, 950-960.

7. Hage-Hamsten-van M, Johansson SG: Storage mites. *Exp Appl Acarol* 1992, **16**, 117-128.

8. Herling C, Svendsen UG, Schou C: Identification of important allergenic proteins in extracts of the granary weevil (*Sitophilus granarius*). *Allergy* 1995, **50**, 441-446.

9. Heong K, Escalada M: Quantifying rice farmers' pest management decisions: beliefs and subjective norms in stem borer control. *Crop Prot* 1999, **18**, 315-322.

10. Hubert J, Stejskal V, Kubatova A, Munzbergova Z, Vanova M, Zd'arkova E: Mites as selective fungal carriers in stored grain habitats. *Exp Appl Acarol* 2003, **29**, 69-87.

11. Iversen M, Korsgaard J, Hallas T, Dahl R: Mite allergy and exposure to storage mites and house dust mites in farmers. *Clin Exp Allergy* 1990, **20**, 211-219.

12. Jeebhay MF, Robins TG, Lehrer SB, Lopata AL: Occupational seafood allergy: a review. *Occup Environ Med* 2001, **58**, 553-562.

13. Kozmina, NP: [*The organization and techniques of sampling grain, legume and oil plants*.] Press in SZN, Prague 1957 (in Czech).

14. Lau S, Falkenhorst G, Weber A, Werthmann I, Lind P, Buettner-Goetz P, Wahn U: High mite-allergen exposure increases the risk of sensitization in atopic children and young adults. *J Allergy Clin Immunol* 1989, **84**, 718-725.

15. Mitsche T, Borck H, Horr B, Bayas N, Hoppe HW, Diel F: Pyrethroid syndrome in an animal keeper. *Allergy* 2000, **55**, 93-94.

16. Musken H, Franz JT, Wahl R, Paap A, Cromwell O, Masuch G, Bergmann KC: Sensitization to different mite species in German farmers: in vitro analyses. *J Investig Allergol Clin Immunol* 2003, **13**, 26-35.

17. Musken H, Franz J, Paap A, Cromwell O, Masuch G, Bergmann K: Sensitisation to different species in German farmers: clinical aspects. *J Invest Allergol Clin Immunol* 2000, **10**, 346-351.

18. Mumcuoglu KY, Gat Z, Horowitz T, Miller J, Bar-Tana R, Ben-Zvi A, Naparstek Y: Abundance of house dust mites in relation to climate in contrasting agricultural settlements in Israel. *Med Vet Entomol* 1999, **13**, 252-258.

19. Mumford JD: Farmer's perceptions and crop protection decision making. **In:** *Proc. BCPS decision making in the practice of crop protection. 6-7 April 1982*, 13-19. Univ. Sussex, Brighton 1982.

20. Neto HJC, Rosario NA, Hubert J, Zdarkova E, Oliveira CH: Skin test reactivity to *Cheyletus eruditus* (Ce) in atopic patients. *Allergy* 2002, **57(Supl. 73)**, 287-287.

21. Olsen AR: Regulatory action criteria for filth and other extraneous materials. II. Allergenic mites: an emerging food safety issue. *Regul Toxicol Pharmacol* 1998, **28**, 190-198.

22. Olsen AR: Regulatory action criteria for filth and other extraneous materials. III. Review of flies and foodborne enteric disease. *Regul Toxicol Pharmacol* 1998, **28**, 199-211.

23. Patil MP, Niphadkar PV, Bapat MM: *Psocoptera* spp. (book louse): a new major household allergen in Mumbai. *Ann Allergy Asthma Immunol* 2001, **87**, 151-155.

24. Platts-Mills TA, Vaughan JW, Carter MC, Woodfolk JA: The role of intervention in established allergy: avoidance of indoor allergens in the treatment of chronic allergic disease. *J Allergy Clin Immunol* 2000, **106**, 787-804.

25. Pedigo LP, Hutchins SH, Highley LG: Economic injury levels in theory and practice. *Annu Rev Entomol* 1986, **31**, 341-368.

26. Revsbech P, Dueholm M: Storage mite allergy among bakers. *Allergy* 1990, **45**, 204-208.

27. Rubenstein R, Kascsak RJ, Carp RI, Papini M, LaFauci G, Sigurdarson S, Wisniewski HM: Potential role of mites as a vector and/or reservoir for scrapie transmission. *Alzheimer's Disease Review* 1998, **3**, 52-56.

28. Silva PS, Fonseca MC, Iglesias SB, Carvalho WB, Bussolan RM, Freitas IW: Comparison of two different severity scores (Paediatric Risk of Mortality [PRISM] and the Glasgow Meningococcal Sepsis Prognostic Score [GMSPS]) in meningococcal disease: preliminary analysis. *Ann Trop Paediatr* 2001, **21**, 135-140.

29. Silvera DH, Josephs RA, Gieslinger RB: Bigger is better: The influence of physical size on aesthetic preference of judgments. *J Behav Decision Making* 2002, **15**, 189-202.

30. Sinha RN, Paul TC: Survival and multiplication of two stored-product mites on cereals and processed foods. *J Econ Entomol* 1972, **65**, 1301-1303.

31. Sinha RN, Watters, FL: *Insect pests of flour mills, grain elevators, and feed mills and their control*. Research Station Winnipeg, Manitoba. Publication 1776. 1985.

32. Stejskal V, Verner PH: Long term changes of cockroach infestations in Czech and Slovak food-processing plants. *Med Vet Entomol* 1996, **10**, 103-104.

33. Stejskal V, Hubert J, Kucerova Z, Munzbergova Z, Lukas J, Zdarkova E: The influence of the type of storage on pest infestation of stored grain in the Czech Republic. *Plant Soil Environ* 2003, **49**, 55-62.

34. Stejskal V: Economic Injury Level and preventive pest control. *J Pest Sci* 2003, **76**, 170-172.

35. Stejskal V: Inversion relationship between action threshold and economic/aesthetic injury level for the control of urban and quarantine pests. *J Pest Sci* 2002, **75**, 158-160.

36. Thind BB, Dunn JA: A laboratory evaluation of a regulated airflow through wheat at four combinations of temperature and humidity on the productivity of three species of stored product mites. *Exp Appl Acarol* 2002, **27**, 89-102.

37. Tee RD, Gordon DJ, van Hage-Hamsten M, Gordon S, Nunn AJ, Johansson SG, Taylor AJ: Comparison of allergic responses to dust mites in U.K. bakery workers and Swedish farmers. *Clin Exp Allergy* 1992, **22**, 233-239.

38. Zdarkova E, Wakefield M, Lukas J, Hubert J: Biological control of pest insects and mites with special reference to entomophorales. **In:** *Proceeding of 2nd Meeting of WG4 of COST (Action 842)*. RICP, Prague 2002.