CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

No. 66 2011

THE OCCURENCE OF MITES (ACARI) ON WALLS INFESTED WITH MOULDS IN DWELLING HOUSES

Marlena PIONTEK[1*], Katarzyna ŁUSZCZYŃSKA[1], Krzysztof SOLARZ[2],
[1] Institute of Environmental Engineering
University of Zielona Góra
Szafrana st 15, 65-516 Zielona Góra, Poland
[2] Department of Parasitology
Medical University of Silesia in Katowice,
Jedności st. 8, 41-218 Sosnowiec, Poland

Moulds and mites, a serious allergenic threat, are present in dwelling buildings with mycological biodeterioration. The problem becomes even more serious if among allergenic fungi there are species which are mycotoxicogenic and cause human and animal mycosis, such as: *Aspergillus versicolor* Tiraboschi and *Scopulariopsis brevicaulis* Bainier. The most common mites found in buildings in temperate climates are *Dermatophagoides pteronyssinus* and *D. farinae*.

Keywords: dwelling buildings, moulds, domestic mites, human diseases (allergies, mycoses, mycotoxicoses)

1. INTRODUCTION

The Lubuskie Province (Poland) is a representative area of many buildings situated in the moderate climate zone. In this area mycological and mycotoxicological researches were conducted in dwelling buildings infested with moulds [24]. In over 250 flats 27 species of moulds belonging to 30 kinds were isolated [26]. The frequency of occurrence was established for the isolated species of moulds in the flats included in the research. For this purpose, a five level scale (1-5) created by Piontek [23, 24] was used. Ten species of moulds most frequently were found on the walls in the flats. Five of them were present very often (5) and often (4). Those were respectively: *Penicillium chrysogenum*

* Corresponding author. E-mail: M.Piontek@iis.uz.zgora.pl

Thom, *Cladosporium herbarum* Link ex Gray, *Mucor racemosus* Fresenius, *Ulocladium chartarum* Simmons and *Aspergillus versicolor* Tiraboschi. At the same time, they endangered the health of the inhabitants of houses with fungal deterioration. It does not mean though, that it is not necessary to study the other species of moulds. *Stachybotrys chartarum* Hughes is an example of a highly hazardous species, which is occasionally present in building materials (frequency 1), but more often in air conditioners. The effects of exposure to this fungus were lung haemorrhages and deaths of infants [9, 16].

Moulds are often present in buildings. Apart from a number of negative effects, such as the bio-deterioration of building and finishing materials, aesthetics of the interiors, irritating "smell", they also deteriorate the sanitary state of flats. They are the cause of a number of diseases affecting people and animals. Known threats caused by moulds are: allergies, mycoses, and mycotoxicoses [24]. The biggest mycotoxicological threat for people living in flats infested by moulds is *Aspergillus versicolor,* which produces micotoxin sterigmatocystin ST, which has neurotoxicological, immunosuppressive and hepatocarcinogenic effects [24]. The International Agency for Research on Cancer classified it as one of human carcinogens 2A [15]. This fungus is often present on building materials, but does not always produce a carcinogenic mycotoxin. Mycotoxinogenic and highly productive strains that produced significant amounts of ST (> 500 mg kg^{-1} biomass) were less frequently found [25].

About 50% of moulds isolated from walls are capable of synthesizing mycotoxins dangerous to people and animals [31]. Ten species are relatively capable of surviving in the tissues of vertebrates and causing mycosis. *Scopulariopsis brevicaulis* Bainier is one of them [26]. It is quite often found in nail mycosis in human infections, it affects people with the impaired immunity system. It was present in damaged skin, the lungs and the digestive system. It belongs to BSL 2 (*biosafety levels*), [10, 11]. This species additionally proved to be food for mites (*Acari*), [26].

A mycological analysis also gives reason for determining potential allergological threats posed by moulds in buildings [27, 28]. From among the most common molds found on the walls in houses there are six species which respectively (beginning with the most common allergens) cause inflammations in people: *Penicillium chrysogenum, Aspergillus niger, Cladosporium herbarum, Aspergillus versicolor, Alternaria alternata* and *Aspergillus flavus* [30]. The source of allergens in moulds are proteins. They belong to four entirely different products of moulds, which can be dangerous to human health [21]. Proteins cause immediate reactions within a few minutes since exposure (allergy type 1), [6, 8] and the release of histamine without the mediation of IgE, nonimmunological reaction – pseudoallergies [20].

The range of deteriogenic micro-organisms encountered in houses is wide, extending from bacteria (including actinomycetes) to yeasts, moulds and wood-rotting and plaster fungi in the *Ascomycetes* and *Basidiomycetes*. Consequently, indoor bioaerosols can contain a variety of deteriogenic bacteria, yeasts and both spores and mycelial fragments of actinomycetes and filamentous fungi. The substrates on which these deteriogenic microorganism grow include surface coatings on the walls, wood, carpets and other soft furnishings, the soil of potted plants and foodstuff which is damp [7].

House dust mites are regarded as the main cause of allergies in housing all over the world [2], whereas in mouldy flats the danger of allergies increases, because besides mites (*Acari*), bacteria and nematodes (*Nematoda*), moulds are also quite often present. The most abundant and most often reported mites found in dwelling buildings in temperate climates are *Dermatophagoides pteronyssinus* and *D. farinae* (*Acari, Astigmata, Pyroglyphidae*). In most studies on domestic mites in houses, also in Poland [12, 13, 32, 33, 34], samples have usually been obtained from beds, carpeted floors and upholstered furniture as the three main types of indoor micohabitats of these acarines [2]. It should be emphasised, that natural and/or possible sources of different domestic mites in house dust are still not quite known [35].

Recent research proved that among 77 species of moulds present in houses in the area of the Lubuskie province in Poland a few more species are food for mites. Therefore research concerning the coexistence of mites and moulds on the walls in buildings was conducted.

2. METHODS AND MATERIALS

2.1. Place of sampling

In houses fungi were obtained from the inner surfaces of building barriers with visible mouldiness: parts of walls, ceiling tiles, plasters, plasterboards, plaster panels, finishing materials (paints, wallpapers, binders, floorings, building paper) and others. Methods used in the research and presented in this paper are described in detail by Piontek [24].

2.2. Sampling

Samples were taken directly from the place where moulds were present onto surfaces with four nutrient media (two synthetic media, Cz, SNA and two natural media MEA and PDA, using Petri dishes).

2.3. Cultures of moulds for taxonomic research

Samples were incubated in a cultivating room covered with a white sheet in a room temperature of 18º-22º C with the diurnal rhythm of day and night. Clean (axenic) cultures were isolated from the mixed initial cultures by passaging onto two media: Czapek – Doxa (Cz) and malt agar (MEA). The time of passaging the cultures and observation of the species isolated took about 21 days. Furthermore, the cultured strains of moulds were then examined and identified in order to determine their taxonomical rank.

2.4. Identification of moulds

Species of moulds were determined by macroscopic and microscopic examination on the basis of their morphological and physiological features according to [31]. The colonies on the Petri dishes were observed macroscopically with a binocular (stereomicroscope). The moulds on the Petri dishes and in microscopic preparations were observed microscopically with a Nikon TMS microscope.

2.5. Acarological analysis

Mites were mounted in a Hoyer medium on slides, and the species and life stages were determined with the aid of an Axioscope 2 Zeiss compound microscope.

3. RESULTS

There are associations of moulds on mouldy walls in houses (rarely single species, monoculture). Apart from moulds, there are also bacteria, mites and nematodes, which are frequently present. A sort of biological membrane (trophic microchain) is formed with consecutive levels of succession. All mites belong to *Tyrophagus putrescentiae* (*Acari, Astigmata, Acaridae*). A total of 29 mite specimens were found, including 19 females, 5 males and 5 tritonymphs. This storage and domestic mite is fungivorous and many species of moulds are their food. Dead organisms, their excrements and exuviae, on the other hand, supply fungi with organic substances [22]. In the mycological research conducted in the Lubuskie Province by Piontek [24] in flats, such a protocooperational system (interspecies interaction) was present in flats moulded for a longer period of time (years) between mites and ten species of moulds: *Acremonium strictum, Aspergillus niger, Botryotrichum piluliferum, Chaetomium elongatum, Epicoccum nigrum, Penicillium aurantiogriseum, P. chrysogenum, Rhizopus stolonifer, Trichotecium roseum, Ulocladium botrytis*. Recently such interaction was observed with two further species: *Cladosporium herbarum* and *Scopulariopsis brevicaulis,* [26]. Among the twelve species of

moulds mentioned three species: *Penicillium chrysogenum* Thom, *Cladosporium herbarum* Link ex Gray and *Aspergillus niger* van Tieghem are classified as allergenic fungi (according to Schata et al. [30]. Those species are at the same time most frequently present on inner building barriers of houses. Six species of moulds belong to BSL 1 category (*biosafety levels* – classification of biosafety of fungi potentially pathogenic for humans and animals): *Penicillium chrysogenum* Thom, *Cladosporium herbarum* Link ex Gray, *Aspergillus niger* van Tieghem, *Acremonium strictum* W.Gams, *Ulocladium botrytis* Preuss, *Rhizopus stolonifer* (Ehrenberg ex Link) Lind i.e. fungi which cause coincidental, superficial, noninvasive or light infections. One of the twelve species mentioned in Table 1, *Scopulariopsis brevicaulis* Bainier is the biggest mycological threat, it belongs to the BSL 2 category, whereas five species of moulds are capable of synthesizing dangerous mycotoxins: *Penicillium chrysogenum* Thom, *Aspergillus niger* van Tieghem, *Chaetomium elongatum* Czerepanova, *Penicillium aurantiogriseum* Dierckx, *Trichotecium roseum* Link ex S.F.Gray.

Table 1. Moulds present on inner surfaces of building barriers together with mites according to the frequency of their presence in rooms [according to Piontek (24)].

No.	Species of moulds	occurrence in houses
1.	*Penicillium chrysogenum* Thom	5
2.	*Cladosporium herbarum* Link ex Gray	5
3.	*Aspergillus niger* van Tieghem	3
4.	*Acremonium strictum* W.Gams	3
5.	*Ulocladium botrytis* Preuss	3
6.	*Chaetomium elongatum* Czerepanova	2
7.	*Rhizopus stolonifer* (Ehrenberg ex Link) Lind	2
8.	*Botryotrichum piluliferum* Saccardo et Marchal	1
9.	*Epicoocum nigrum* Link ex Link	1
10.	*Penicillium aurantiogriseum* Dierckx	1
11.	*Scopulariopsis brevicaulis* Bainier	1
12.	*Trichotecium roseum* Link ex S.F.Gray	1

4. DISSCUSION

Many species of moulds can pose all the dangers or only those selected and described above. *Aspergillus flavus* and *A. fumigatus* can cause allergies of the respiratory system, lung diseases, so called aspergilloses and can produce carcinogenic mycotoxins. Similar effects are caused by a number of fungi of the *Penicillium* order. Also, some species of *Fusarium* and *Mucor* produce micotoxins and cause allergies [29].

Inhaling large amounts of spores and parts of mycelia influences human health. It can not be expected that in the case of visible moulds on the walls there will be no health problems among the inhabitants, including allergic diseases such as: bronchial asthma (*mould asthma*), allergic alveolitis (*alveolitis allergica, extrinsic allergic alveolitis*, *hypersensivity pneumonitis*), allergic rhinitis and sinusitis, atopic conjunctivitis, organic dust toxic syndrome (ODTS), chronic fatique-like syndrome [19]. Allergens of moulds concentrated in poorly aired rooms are a serious danger to people with an atopic disease [3]. It is known that fungal spores of the *Aspergillus, Cladosporium* and *Penicillium* order present in humid buildings can cause asthma and/or rhinitis among atopic inhabitants. Over 10% of people suffer from atopic diseases (hay fever, atopic asthma). Atopy is a genetic inclination for an increased synthesis of class IgE antibodies in comparison to antigens common in the environment (e. g. moulds and mites) [21].

T. putrescentiae belongs to the storage mites which are common inhabitants of dust of different stored agricultural products and are responsible for profession-related allergies among farmers, as well as causing sensitisation among bakers and grain workers [1, 17, 36]. These mites may also be a source of exposure to allergens in dwellings. A CRIE analysis of the *T. putrescentiae* extract utilizing sera from 24 farmers from the USA exposed because of their profession identified 14 allergens [1]. Immunoblotting using sera of the farmers identified a 16-kDa protein as a major IgE-binding component of *T. putrescentiae* extract (allergen *Tyr p* 2) [1, 17]. This allergen shows more than 50% sequence identity with *Lep d* 2 of *L. destructor* and about 40% with allergens of *Dermatophagoides* spp. [4]. The number of allergens actually identified in extracts of *T. putrescentiae* was comparable to the number that was identified in the extracts of the house dust mites *Dermatophagoides* spp. [1, 2, 4, 14, 17, 18, 36].

5. CONCLUSIONS

Experiments on animals proved that the respiratory system distributes toxins quite effectively. Their inhalation causes a systemic toxic effect more effectively than their permeation per mouth or peritoneum [5]. Since a large amount of spores inhaled with air causes allergies, it is worth connecting mycotoxiticy and allergenicity of moulds, and it is worth continuing the initiated researches on the coexistence of mites and moulds in dwelling houses.

ACKNOWLEDGEMENTS

Katarzyna Łuszczyńska is a scholar within Sub-measure 8.2.2 Regional Innovation Strategies, Measure 8.2 Transfer of knowledge, Priority VIII Regional human resources for the economy Human Capital Operational Programme co-financed by European Social Fund and state budget.

REFERENCES

1. Arlian LG, Vyszenski-Moher DL, Johansson SGO, van Hage-Hamsten M., 1997. Allergenic characterisation of *Tyrophagus putrescentiae* using sera from occupationally exposed farmers. Ann Allergy Asthma Immunol, 79, pp. 525-529.
2. Arlian L, Platts-Mills TAE., 2001. The biology of dust mites and the remediation of mite allergens in allergic disease. J Allergy Clin Immunol, 107.
3. Bogacka E.,1997. Choroba budynków [Sick buildings syndrome]. Mikol Lek., 4, pp. 233-237.
4. Eriksson TLJ, Johansson E, Whitley P, Schmidt M, Elsayed S, van Hage-Hamsten M.,1998. Cloning and characterisation of a group 2 allergen from the dust mite *Tyrophagus putrescentiae*. Eur J Biochem, 251, pp. 443-447.
5. Flannigan B., 2001a. Microbial aerosols in buildings: origins, health, implications and controls. In: Rozkład i korozja mikrobiologiczna materiałów technicznych [Mikrobial Biodegradation and Biodeterioration of Technical Materiale], II Konf. Naukowa, Politechnika Łódzka, Łódź, pp.11-27.
6. Flannigan B, Mc Cabe EM, Mc Garry F., 1991b. Allergenic and toxigenic micro-organism in houses. J Appl Bacteriol,79, pp. 61-73.
7. Flannigan B., 2001b. Deteriogenic micro-organism in houses as a hazard to respiratory health. International Biodetrioration &Biodegradation 48, pp. 41-54.
8. Gravesen S, Frisvad JC, Samson RA., 1994. Microfungi. Munksgaard Publishers, Copenhagen.
9. Hodgson MJ, Morey P, Leung WY, Morrow L, Miller D, Jarvis BB, Robbins H, Halsey JF, Storey E., 1998. Building – associated pulmonary disease from exposure to *Stachybotrys chartarum* and *Apergillus versicolor*. J Occup Environ Med, 40, pp.241–249.
10. Hoog de GS.,1996. Risk assessment of fungi reported from humans and animals. Mycoses, 39, pp. 407-417.

11. Hoog de GS, Guarro J.,1995. Atlas of clinical fungi. Centralbureau voor Schimmelcultures (CBS), Baarn and Delft, Netherlands.
12. Horak B.,1987. Preliminary study on the concentration and species composition of bacteria, fungi and mites in samples of house dust from Silesia (Poland). Allergol Immunopathol , 15, pp.161-166.
13. Horak B, Dutkiewicz J, Solarz K.,1996. Microflora and acarofauna of bed dust from homes in Upper Silesia, Poland. Ann Allergy, Asthma Immunol, 76, pp. 41-50.
14. Hubert J, Kudlikova I, Stejskal V.,2004. Review of digestive enzymes of stored product and house dust mites. Phytophaga, 14, pp. 695-710.
15. IARC.,1993. Some naturally occurring substances: food items and constituents, heterocyclic aromatic amines and mycotoxins. In: International Agency for Research of Cancer. Monographs on the evaluation of the carcinogenic risk of chemicals to humans, 309-395. IARC, Lyon.
16. Jarvis BB, Sorenson WG, Hintikka E -L, Nikulin M, Zhou Y, Jiang J, Wang S, Hinkley S, Etzel RA, Dearborn DG.,1998. Study of toxin production by isolates of Stachybotrys chartarum and Memnoniella echinata isolated during a study of pulmonary hemosiderosis in infants. Appl Environ Microbiol, 64, pp. 3620 – 3625.
17. Johansson E, Borga A, Johansson SGO, van Hage-Hamsten M.,1994. Allergenic characterization of Acarus siro and Tyrophagus putrescentiae and their crossreactivity with Lepidoglyphus destructor and Dermatophagoides pteronyssinus. Clin Exp Allergy, 24, pp. 743-751.
18. Kronqvist M, Johansson E, Magnusson CGM, Olsson S, Eriksson TLJ, Gafvelin G, van Hage-Hamsten M.,2000. Skin prick test and serological analysis with recombinant group 2 allergens of the dust mites L. destructor and T. putrescentiae. Clin Exp Allergy 30, pp. 670-676.
19. Krysińska-Traczyk E., 2001. Alergizujące i toksynotwórcze grzyby pleśniowe w rolniczym środowisku pracy [Allergenic and toxic moulds in the agricultural labour environment]. In: Rozkład i korozja mikrobiologiczna materiałów technicznych [Mikrobial Biodegradation and Biodeterioration of Technical Materials]. II Konf Naukowa, Politechnika Łódzka, Łódź, pp. 95-97.
20. Larsen FO, Clementsen P, Hansen M, Maltbæk N, Gravesen S, Skov P, Norn S.,1996. The microfungi Trichoderma *viride* potentiates histamine release from human bronchoalveolar cells. *APMIS*, 104, pp. 673–679.

21. Nielsen KF, Gravesen S, Nielsen PA, Andersen B, Thrane U, Frisvad JC.,1999. Production of mycotoxins on artificially and naturally infested building materials. Mycopathologia, 145, pp. 43–56.
22. Piontek M., Grzyby pleśniowe [Moulds]. Atlas. Wydawnictwo Politechniki Zielonogórskiej, Zielona Góra 1999.
23. Piontek M., 2001. Moulds occurring in buildings of the Lubuskie province, Poland. In: Rozkład i korozja mikrobiologiczna materiałów technicznych [Mikrobial Biodegradation and Biodeterioration of Technical Materials]. II Konferencja Naukowa, Politechnika Łódzka, Łódź, pp. 86-94.
24. Piontek M., 2004. Grzyby pleśniowe i ocena zagrożenia mikotoksycznego w budownictwie mieszkaniowym [Moulds and estimation of mycotoxic threat in dwelling buildings]. Wydawnictwo Uniwersytetu Zielonogórskiego, Zielona Góra, 174 pp.
25. Piontek M., 2007. Strains of *Aspergillus versicolor* Tiraboschi synthesizing sterigmatocistin and the differentiation of mycotoxic risk dependent on their productivity in housing buildings. *Mycotoxin Research*, 23, pp. 34-38.
26. Piontek M.,2008. Mycosis risk caused by occurrence of *Scopulariopsis brevicaulis* (Sacc.) Bain. in housing buildings. In: Mycotoxins and moulds, 8th International Conference, Kazimierz Wielki University of Bydgoszcz, Bydgoszcz, pp. 16.
27. Piontek M, Bednar K.,2006. Mycotoxicity of alergenic moulds in dwelling buildings. In: 28 Mycotoxin Workshop, Kazimierz Wielki University of Bydgoszcz, Bydgoszcz, pp 62.
28. Piontek M, Piontek R, Bednar K.,2004. Alergenic moulds in dwelling buildings. In: Mikotoksyny i patogenne pleśnie w środowisku [Mycotoxins and phatogenic moulds in the environment], VI Międzyn Konf Nauk,. Akademia Bydgoska, Bydgoszcz pp.195-199.
29. Rejmer P.,1997. Podstawy ekotoksykologii [Basis of ecotoxicology]. Wydawnictwo Ekoinżynieria, Lublin.
30. Schata M, Jorde W, Elixmann JH, Linskens HF.,1989. Allergies to molds caused by fungal spores in air conditioning equipment. Environ Internat, 15, pp. 177–179.
31. Samson RA, Hoekstra ES, Frisvad JC, Filtenborg O.,2000. Introduction to food and airborne fungi. Sixth Ed. Centralbureau voor Schimmercultures (CBS), Utrecht.
32. Solarz K.,2001a. Risk of exposure to house dust pyroglyphid mites in Poland. *Ann* Agric Environ Med, 8, pp.11–24.
33. Solarz K., 2001b. Pyroglyphidae (Acari : Astigmata) in Poland. Distribution, biology, population ecology and epidemiology. Acta Zool Cracov, 44, pp. 435–528.

34. Solarz K.,2004. Distribution and ecology of allergenic mites in Poland. Phytophaga, 14, pp.675–694.
35. Solarz K, Seńczuk L, Maniurka H, Cichecka E, Peszke M., 2007. Comparisons of the allergenic mite prevalence in dwellings and certain outdoor environments of the Upper Silesia (Southwest Poland). Int J Hyg Environ Health, 210, pp. 715-724.
36. Szilman E, Szilman P, Solarz K, Brewczyński P, Sieroń AL.,2004. Sensitization to the storage mite *Tyrophagus putrescentiae* in urban population of Upper Silesia (Poland). Wiad Parazytol, 50, pp. 471-476.

WYSTĘPOWANIE ROZTOCZY (*ACARI*) NA ŚCIANACH PORAŻONYCH GRZYBAMI PLEŚNIOWYMI W BUDOWNICTWIE MIESZKANIOWYM

S t r e s z c z e n i e

W budownictwie mieszkaniowym z biodeterioracją pleśniową znajdują się grzyby pleśniowe i roztocze stanowiąc poważne zagrożenie alergogenne. Problem jest o wiele groźniejszy jeżeli wśród grzybów alergogennych są gatunki mikotoksynotwórcze i wywołujące grzybice u ludzi i zwierząt jak *Aspergillus versicolor* Tiraboschi oraz *Scopulariopsis brevicaulis* Bainier. Najczęściej występującymi roztoczami w budownictwie są *Dermatophagoides pteronyssinus* i *D. farinae*.