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OCCUPATIONAL EXPOSURE TO *ASPERGILLUS* BY SWINE AND POULTRY FARM WORKERS IN PORTUGAL

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Aspergillus is among a growing list of allergens that aggravate asthmatic responses. Significant pulmonary pathology is associated with *Aspergillus*-induced allergic and asthmatic lung disease. Environments with high levels of exposure to fungi are found in animal production facilities such as for swine and poultry, and farmers working with these are at increased risk for occupational respiratory diseases. Seven Portuguese poultry and seven swine farms were analyzed in order to estimate the prevalence, amount, and distribution of *Aspergillus* species, as well as to determine the presence of clinical symptoms associated with asthma and other allergy diseases in these highly contaminated settings. From the collected fungal isolates (699), an average incidence of 22% *Aspergillus* was detected in poultry farms, while the prevalence at swine farms was 14%. The most frequently isolated *Aspergillus* species were *A. versicolor*, *A. flavus*, and *A. fumigatus*. In poultry farms, *A. flavus* presented the highest level of airborne spores (>2000 CFU/m³), whereas in swine farms the highest was *A. versicolor*, with an incidence fourfold greater higher than the other mentioned species. Eighty workers in these settings were analyzed, ranging in age from 17 to 93 yr. The potentially hazardous exposure of poultry workers to mold allergens using sensitization markers was evaluated. Although no significant positive association was found between fungal contamination and sensitization to fungal antigens, a high incidence of respiratory symptoms in professionals without asthma was observed, namely, wheezing associated with dyspnea (23.8%) and dyspnea after strenuous activities (12.3%), suggesting underdiagnosed respiratory disturbances. Further, 32.5% of all exposed workers noted an improvement of respiratory ability during resting and holidays. From all the analyzed workers, seven were previously diagnosed with asthma and four reported the first attack after the age of 40 yr, which may be associated with their occupational exposure. Some of the fungi, namely, the *Aspergillus* species detected in this study, are known to induce hypersensitivity reactions in humans. This study confirmed the presence and distribution of *Aspergillus* in Portuguese poultry and swine farms, suggesting a possible occupational health problem and raising the need for preventive and protective measures to apply to avoid exposure in both occupational settings.

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In the native type of poultry and swine husbandry, the control of infectious diseases is difficult due to lack of proper biosecurity measures, intense farming, and greater germ load in the farm premises (Sajid et al. 2006). Exposure to bioaerosols in the occupational environment of poultry and swine farms may be associated with a wide range of adverse health effects in animal facilities, and environmental conditions are favorable for the development of a wide variety of fungal species (Duchaine et al. 2000). It is well established that fungi grow and sporulate easily in poor quality bedding or contaminated feedstuffs in indoor farm environments. Inadequate ventilation and dusty conditions also increase the risk of exposure to aerosolized spores (White 2010).

Occupational exposure may occur by inhalation of dust generated during the handling and processing of contaminated crops and feeds. This route of contamination produces adverse health problems in workers (Chang et al. 2001; Cormier et al. 2000; Reboux et al. 2006) and animals, especially avian species (Lair-Fuller et al. 2006).

Respiratory disease is a well-recognized occupational problem among these workers, leading to higher morbidity and mortality from certain respiratory disorders. Several studies indicated that the prevalence of work-related respiratory symptoms such as wheeze, cough, and dyspnea is unusually high among farmers (23–50%) (Rylander et al. 1990; Skórska et al. 1998; Radon et al. 1999). The major respiratory manifestations produced by fungi include allergic bronchopulmonary mycoses (ABPM), hypersensitivity pneumonitis, fungal sinusitis, allergic rhinitis, and severe asthma with fungal sensitization (SAFS) (Simon-Nobbe et al. 2008). In fact, exposure to environmental fungi is associated with worsening asthma symptoms, lung function, hospital admissions, and asthma-related deaths (Agarwal and Gupta 2011). Due to these factors and the findings that higher counts of hyphal fragments and spores augment the worsening of asthma severity, there is an increased interest in the role aerosolized fungal fragments play in respiratory manifestations (Green et al. 2006).

It is now understood that the pathogenesis of diseases like asthma and other allergic diseases is determined by interactions between host, genes, and environment (Penders et al. 2010; Vercelli 2010). Identification and quantification of fungi by cultural methods enables the detection of viable fungal elements, which are believed responsible for higher risk of asthma in workers (Samson et al. 2000). Among the filamentous fungi, *Aspergillus* species have been closely linked with exacerbations of asthma and other respiratory allergic diseases. Particles with aerodynamic diameter of approximately 1 to 4 μm are deposited in the lower respiratory tract. Therefore, conidia of *A. fumigatus* are small enough to traverse the terminal respiratory airways and reach the pulmonary alveoli, whereas the larger conidia of some other *Aspergillus* species, such as *A. flavus* and *A. niger*, tend to be deposited in the paranasal sinuses and upper airways (Ben-Ami et al. 2010). Inhalation of some fungal spores leads to colonization and, in damaged airways with retained mucus, germination within the bronchial tree through production of hyphae. In some individuals, this stimulates a T-helper (Th) type 2-mediated inflammatory response involving CD41 T cells, immunoglobulin E (IgE), and immunoglobulin G (IgG) antibodies (Tillie-Leblond and Tonnel 2005).

Sensitization to fungi has been identified in multicenter studies to be a risk factor for severe asthma (Zureik et al. 2002), and the incidence of hypersensitivity to common fungal allergens among atopics has been estimated to range anywhere from as low as 2% to as high as 90% (Brett et al. 2006). As with most allergens, reported variations in sensitization to fungi are dependent upon differences in exposures, the source and batch of commercial skin test extracts, and the methods of analysis.

For biologic agents, few exposure or dose biomarkers have been identified, and their validity for exposure assessment in the indoor environment is often unknown. Determination of the presence of IgE to specific fungi might be a useful component for clinical evaluation in the diagnosis of illnesses that are produced by immediate hypersensitivity, such as rhinitis

and asthma. Testing is usually done in vitro for serum-specific IgE, via skin prick or puncture (Agarwal and Gupta 2011).

The aims of this study were to determine the prevalence of *Aspergillus* sp. in poultry and swine farms, to quantify the detected species in order to assess possible adverse health effects in workers, and also to evaluate possible occupational respiratory symptoms of the workers of these settings.

MATERIALS AND METHODS

Environmental Samples

Air samples from seven poultry and seven swine farms were collected at 1 m height, using an air sampler (Millipore) with a velocity air rate of 140 L/min. The collected air was directly impacted onto malt extract agar supplemented with chloramphenicol (MEA). Air collection was also performed at outside the premises, since this location is regarded as the reference site. Surface samples were collected by swabbing the surfaces of the same indoor sites, using a 10 by 10 cm square stencil disinfected with 70% alcohol solution between samples according to the International Standard ISO 18593 (2004). The obtained swabs were then plated onto MEA. All the collected samples were incubated at 27°C for 5 to 7 d. After laboratory processing and incubation of the collected samples, quantitative (colony-forming units [CFU]/m³ and CFU/m²) and qualitative results were obtained, with identification of the isolated fungal species. For species identification, microscopic mounts were performed using tease mount or Scotch tape mount and lactophenol cotton blue mount procedures. Morphological Identification was achieved through macro- and microscopic characteristics as noted by Hoog et al. (2002).

Clinical Samples

The evaluation of the specific IgE in serum was performed only in poultry workers (14 women and 33 men) and in a control group comprised of 28 individuals (19 women

and 9 men) randomly selected from the same region. The subjects in the control group were students, professors, or nonprofessor employees of an academic institution. The average age of the control was 33 with ages ranging between 19 and 54 yr.

Blood samples were taken from workers and specific IgE levels were measured using the ImmunoCAP system (Sweden Diagnostics) according to the manufacturer's instructions. Sensitization to fungi was defined by the positivity of specific fungal serum IgE assay. IgE levels >0.35 kU/L were regarded as positive. Two different mixtures of fungal allergens were tested in order to detect specific IgE antibodies. Mixture 2 included allergens from *Penicillium notatum*, *Cladosporium herbarum*, *Aspergillus fumigatus*, *Candida albicans*, *Alternaria alternata*, and *Helminthosporium halodes*, and mixture 4 included allergens from *Aspergillus fumigatus*, *Aspergillus terreus*, *Aspergillus niger*, and *Aspergillus flavus*.

Epidemiological Data

Epidemiological data were analyzed by a validated questionnaire in Portugal of the European Community Respiratory Health Survey. This questionnaire in the form of an interview was completed by all workers from both farms and enables (1) determination of incidence of asthma and other allergic disease, (2) characterization of respiratory and skin symptomatology, and (3) determination of effects on health-related work. The software Statistical Package for the Social Sciences (version 19) was used for the statistical treatment.

RESULTS

Aspergillus Prevalence

Twenty-eight different fungal genera were detected in poultry farms from a total of 266 isolates. The prevalence of *Aspergillus* genus in these settings was 22.2%, and 10 different species were identified from the 59 collection points from where *Aspergillus* isolates were obtained (Figure 1). Of the

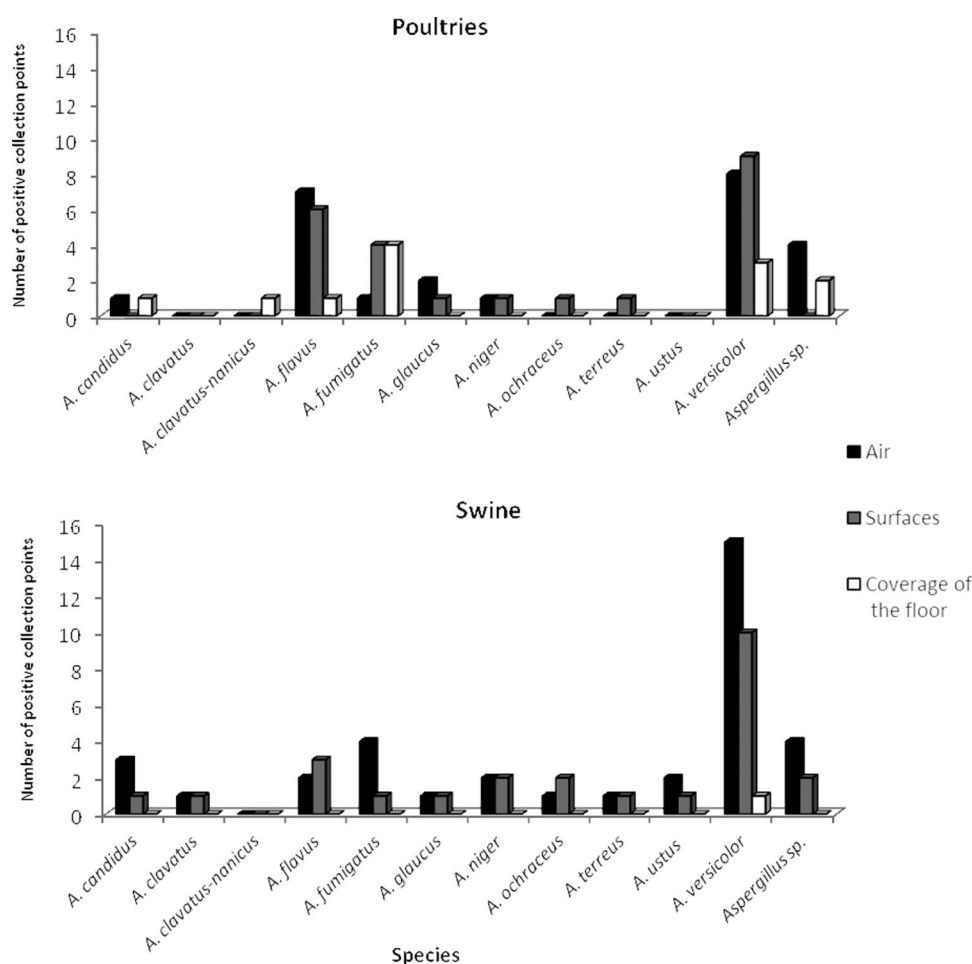


FIGURE 1. *Aspergillus* species distribution in the environments of the seven studied poultry farms and seven swine farms.

TABLE 1. Quantitative Results Obtained From *Aspergillus* Isolation From the Air, Surfaces and Coverage of the Floor in the Analyzed Settings

	Poultry farms			Swine		
	Air (CFU/m ³) (range)	Surfaces (CFU/m ²) (range)	Coverage of the floor (CFU/g) (range)	Air (CFU/m ³) (range)	Surfaces (CFU/m ²) (range)	Coverage of the floor (CFU/g) (range)
<i>A. candidus</i>	0–40	0–1 × 10 ^{−4}	0–5 × 10 ⁴	0–60	0–1 × 10 ^{−4}	0
<i>A. clavatus</i>	0	0–2 × 10 ^{−4}	0–1 × 10 ⁴	0–20	0–2 × 10 ^{−4}	0
<i>A. clavatus-nanicus</i>	0	0	0–1 × 10 ³	0	0	0
<i>A. flavus</i>	40–>2000	0–>1 × 10 ^{−2}	0–12.5 × 10 ³	0–20	0–1 × 10 ^{−4}	0
<i>A. fumigatus</i>	0–80	0–1.1 × 10 ^{−3}	0–1 × 10 ⁴	0–100	0–1 × 10 ^{−4}	0
<i>A. glaucus</i>	0–40	0–1 × 10 ^{−4}	0	0–40	0–6 × 10 ^{−4}	0
<i>A. niger</i>	0–80	0–1 × 10 ^{−4}	0	0–20	0–2 × 10 ^{−4}	0
<i>A. ochraceus</i>	0	0–2 × 10 ^{−4}	0	0–20	0–6 × 10 ^{−4}	0
<i>A. terreus</i>	0	0–1 × 10 ^{−4}	0	0–100	0–1 × 10 ^{−4}	0
<i>A. ustus</i>	0	0	0	0–240	0–1 × 10 ^{−4}	0
<i>A. versicolor</i>	40–960	0–>3 × 10 ^{−2}	0	0–>2000	0–3 × 10 ^{−2}	0–5 × 10 ³
<i>Aspergillus spp.</i>	0–220	0	0–1 × 10 ⁴	0–40	0–6 × 10 ^{−4}	0

Note. *Aspergillus spp.* refers to not identified species or species with lower representativeness, such as *A. sidowii* and *A. niveus*.

22% of *Aspergillus* genus, *Aspergillus versicolor* was the most frequent species found (33.9%), followed by *A. flavus* (23.7%) and *A. fumigatus* (15.3%). *Aspergillus flavus*, however, presented the highest level of airborne spores (>2000 CFU/m³) (Table 1). From the analyzed surfaces, *A. versicolor* was detected in higher number ($>3 \times 10^{-2}$ CFU/m²). Floor samples presented the highest count of *Aspergillus* colony-forming units (Table 1).

With respect to the seven swine farms, 39 different fungal genera were detected from a total of 431 isolates. The prevalence of *Aspergillus* spp. in these settings was 14.4%, which was lower than in poultry farms. Twelve different *Aspergillus* species were identified among the 62 collection points from which *Aspergillus* isolates were obtained (Figure 1). Despite the three most common species being similar to poultry farms, in this setting *A. versicolor* presented the highest airborne spore counts (>2000 CFU/m³) and highest overall prevalence (41.9%), followed by *A. flavus* and *A. fumigatus* (8.1%) (Table 1). From the analyzed surfaces, *A. versicolor* was detected in higher numbers ($>3 \times 10^{-2}$ CFU/m²) (Table 1).

Clinical Data

Eighty workers in these settings were analyzed, namely, 47 (58.8%) workers in poultry and 33 (41.2%) in swine farms. The average age of the workers was 42, predominantly between 31 and 58 yr (76%). Poultry workers were employed at those settings for an average of 17 yr, with individuals exposed from 1 yr (minimum) to 35 yr (maximum). Fourteen workers (30%) work in poultry farms for less than 10 yr, 9 (19.6%) at 10–20 yr, 13 (28.3%) at 20–30 yr, and 10 (21.7%) at more than 30 yr. Regarding swine farms, the average exposure period was 8 yr with individuals exposed from 5 mo (minimum) to 33 yr (maximum). Fourteen workers (63.6%) work in swine farms for less than 10 yr, 4 (18.2%) at 10–20 yr, 2 (9.1%) at 20–30 yr, and 1 (4.5%) at more than 30 yr. One missing value was recorded.

Among the workers enrolled in this study, the incidence of diagnosed asthma was 8.8%.

In all asthmatic workers who were previously diagnosed with asthma, 57.1% of them reported the first attack after 40 yr of age. With this study, a prevalence of 5% of occupational asthma was detected, which is consistent with other European studies (Bardana 2003; Kogevinas et al. 2009). Moreover, other allergic diseases were detected with higher prevalence, including rhinitis ($n = 16$; 20%) and eczema ($n = 25$; 31.3%). Approximately 72% ($n = 18$) of all workers with eczema considered that this problem was related to their work. A high prevalence of respiratory symptoms in professionals without asthma was also observed, namely, wheezing associated with dyspnea ($n = 5$; 23.8%) and dyspnea after strenuous activities ($n = 9$; 12.3%). Further, 18.75% ($n = 12$) of the workers reported problems with sneezing, runny nose, or nasal stuffiness without the presence of a cold or flu and also without medical diagnosis of rhinitis. In this study 12 workers (15%) displayed chest tightness or wheezing at work, which were directly associated with the environment of the farms (dust, temperature) and their involvement in specific activities in the workplace, namely, the use of detergents and disinfectants, preparation/contact with animals' feed and housing, and direct contact with animals and also with their medication. It is of interest that approximately 26 (32.5%) of all studied workers indicated a significant improvement of their respiratory ability during resting days and holidays, indicating an association of respiratory disturbances with the working activities.

Due to the higher level of fungal contamination in poultry farms, determination of specific IgE in serum was performed only in poultry workers. No significant positive association was found between fungal contamination and sensitization to fungal antigens. Table 2 presents the results of specific serum IgE levels in poultry workers and in a control group of 28 persons. The prevalence of positive specific IgE in poultry workers and controls were 8.5 and 3.5%, respectively, for mixture 2. The prevalence of positive IgE for mixture 4 was 4.2% in poultry workers and 3.5% in the controls. Despite the high number of fungal colonies detected

TABLE 2. Markers of IgE Mediated Hypersensitivity in Poultry Workers and Controls

	Total		<i>p</i>	Women		Men	
	Controls	Poultry workers		Controls	Poultry workers	Controls	Poultry workers
Number of subjects	28	47		19	14	9	33
Positive specific IgE (mix 2)	2	4	.768	0	0	2	4
Positive specific IgE (mix 4)	1	2	.838	0	1	1	1

Note. mix 2: *P. notatum*, *C. herbarum*, *A. fumigatus*, *C. albicans*, *A. alternata*, *H. halodes*. mix 4: *A. fumigatus*, *A. terreus*, *A. niger*, *A. flavus*. *p*, Statistical significance of difference between poultry workers and controls.

in the air, surfaces, and litter (data not shown, except for *Aspergillus* species) in the poultry farms and although there were higher values in poultry workers, no significant difference was noted between poultry workers and controls.

DISCUSSION

Occupational health and safety issues have become a major issue, and all employers should determine whether farm environments have the potential to adversely impact on the health of their workers. Fungi pose potential health risks because of their production of allergens (Shen et al. 1998; Shen and Han 1998; Shen et al. 2001), a wide range of mycotoxins (Hendry and Cole 1993), and inflammatory substances such as beta-D-glucan (Douwes 2005). Several studies have demonstrated the relationship between increased spore counts and fungal antigen levels with the presence of allergic symptoms (Bush and Portnoy 2001). Cultural methods were performed in order to detect the presence of fungi and quantify them. In fact, in the case of a possible fungal occupational exposure through inhalation, conventional methods offer the advantage of enabling identification and quantification only of viable microorganisms and, therefore, the ones causing higher risk for workers' health (Samson et al. 2000).

Among the filamentous fungi, *Aspergillus* species have been strongly linked with exacerbations of asthma and other respiratory allergic diseases (Eduard 2009; Agarwall and Gupta 2011).

In our study, *Aspergillus* and *Penicillium* genera were the most frequently isolated from the analyzed settings. From the 165 indoor

environmental samples analyzed, 12 *Aspergillus* groups were found in poultry and 9 in swine farms. The same was observed by Gigli et al. (2005), who evaluate the presence of fungi in the air of two distinct types of broiler houses. Their research compared conventional (natural) air ventilation and positive tunnel ventilation and it was found that *Aspergillus* was the most common genus in both treatments.

Our study showed high *Aspergillus* CFU counts in several air samples (ranging 0 to >2000 CFU/m³). According to the American Industrial Hygiene Association (1996), the presence of the species *Stachybotrys chartarum*, *Aspergillus versicolor*, *Aspergillus flavus*, *Aspergillus fumigatus*, and *Fusarium moniliforme* in different settings requires the implementation of corrective measures.

Regarding these specific settings, Brazilian regulations limit the presence of fungi in the air inside the poultry houses to 750 CFU/m³ (Gigli et al. 2005). The obtained results showed that considering all fungal species, 22 air samples from poultry farms and 3 from swine farms were out of this limit (data not shown). When looking only for *Aspergillus* counting, three of these air samples—all from poultry farms—exceeded that limit (*A. flavus* and *A. versicolor*, ranging from 960 to >2000 CFU/m³). According to a Kasprzyk review (2008) about aeromycology, the concentrations of airborne fungi in these settings may vary from 2.5×10^1 to 4.9×10^6 CFU/m³. Our results do not exceed the highest values, but we obtained samples with no fungal growth, in opposition to what was described. In opposition to what was found by Nichita and Tirziu (2008), the most frequent isolated *Aspergillus* species were,

besides *A. flavus*, *A. versicolor* and not *A. fumigatus*.

In a study performed by Cormier et al. (2000) about the airborne microbial contents in two types of swine confinement buildings in Quebec, there were found, as in the present study, the same fungal genera and *Aspergillus* as one of the most prevalent ones.

Higher fungal contamination is probably a result of the higher animal density and more tightly closed houses, conditions that promote microorganism multiplication. Nevertheless, those are not the only possible sources of contamination, and animal feed and/or animal litter are also enrolled as possible sources. In a study performed by Magnoli et al. (1998), the mycological examination of 180 samples of poultry feed indicated the presence of 9 groups of *Aspergillus* and 3 species of *Eurotium*. *Aspergillus* belonging to the flavi section showed the highest frequency in the poultry feeds analyzed in their study. Astoreca et al. (2011), also in a survey in poultry feed samples, found that 62% of the *A. flavus* isolates detected were aflatoxin producers.

Despite animal feeds not being analyzed in our study, several isolates belonging to the *Aspergillus flavus* complex were isolated from the indoor air (in five samples), surfaces (in six samples), and litter (in one sample) of the poultry farms analyzed. *Aspergillus flavus* was also isolated in swine farms (two and three samples from air and surfaces, respectively). In 4 of the air samples analyzed, the *A. flavus* load was higher than 1000 CFU/m³. Furthermore, *A. flavus* load reached 12,500 CFU/g in 1 poultry farm's litter and $>1 \times 10^{-2}$ CFU/m² in 3 surfaces, raising the problem of possible workers' exposure to micotoxins.

As occurred in our study, in a study performed by Pinello and colleagues (1977), the same fungal species were isolated from both litter and air. In their study, the mean total fungal counts in shavings or wood chips from broiler and layer houses ranged between 10² and 10⁸ CFU/g. The higher value obtained in our work was 10⁶ CFU/g, with *Aspergillus* species reaching 5×10^5 CFU/g (*A. versicolor* found in a poultry farm's litter composed of shavings

and rice hulls). According to Dennis and Gee (1973), the biodiversity of litter mycoflora depends on material choice, litter aging, and handling techniques. In turkey farms of central Iowa, an increased number of *Aspergillus* conidia was correlated with higher counts of molds in bedding, suggesting that the fungal species arose from the litter or that the environmental conditions were favorable to fungal growth and sporulation (Debey et al. 1995).

Among the very few studies in occupational exposure in these settings, one (Skórska et al. 1998) reported a higher prevalence of work-related nasal symptoms in farmers (6.5%) than in healthy urban dwellers (0%), while another (Rylander et al. 1990) found similar rates of nasal irritation (22–25%) among pig and dairy farmers and greenhouse workers.

Furthermore, many occupational health and safety risks are shared between different tasks and often these tasks will have their own additional risks (Fragar et al. 2001). There are many different types of work that are regularly carried out by the same agricultural worker. These tasks may include preparing feed, animal feeding, cleaning buildings, harvesting, moving animals, performing veterinary treatments, maintenance, and other husbandry tasks (Fragar et al. 2001; Reed et al. 2006)

According to Fairs et al. (2010), *Aspergillus* sensitization is linked with asthma severity. The relationship between *Aspergillus fumigatus* sensitization and sputum culture is not clear. The effect of colonization on airway inflammation and lung function in asthma is largely unknown. Their study demonstrates that a focused approach increases sensitivity of detection of *A. fumigatus* in sputum, and is associated with *A. fumigatus*–IgE sensitization. In patients with moderate to severe asthma, *A. fumigatus*–IgE-sensitized patients exhibit elevated neutrophilic airway inflammation and reduced lung function.

Despite the high number of fungal colonies (namely from *Aspergillus* spp.) detected in the air, surfaces, and litter of the poultry farms and swine farms, there was no positive association ($p > .05$) between fungal contamination and sensitization to fungal antigens. As described

in other studies (Radon et al. 2002; Siebert et al. 2001; Thygesen et al. 2011), our results suggest the “healthy work effect” due to the fact that the atopy status affects the selection of occupation, with less workers with previous allergies employed in poultry farms than should be expected. Despite the recognition of selection biases arising from the healthy worker effect in occupational mortality studies, the possibility of similar effects in occupational cohort studies on respiratory symptoms is not well known. Two mechanisms are responsible for the healthy worker effect in respiratory cohort studies. One is health-based selection of workers into employment (healthy hire effect), and the other is health-based differential losses to follow-up (healthy worker survivor effect) (Radon et al. 2002).

In the present study, the prevalence of asthma was evaluated as 8.75%, which is in agreement with data described in literature for the prevalence of asthma in general population. It is important to emphasize the importance of regular medical follow-up in order to monitor the symptoms especially in this population, highly exposed to triggering agents such as fungi and dust (Radon et al. 2001; Dusser et al. 2007). The occurrence of asthma attacks in the previous year of this study indicates cases of an active asthma. This fact, in association with a lack of instituted pharmacological therapy in those persons, demonstrates some devaluation of the disease itself and its symptoms. It also shows the labor activities’ influence on workers’ health. Four of the workers reported their first asthma attack as occurring at older than 40 yr of age, which suggests the influence of the working activities in the disease development. A 5% prevalence of occupational asthma was detected, which is consistent with others European studies (Bardana 2003; Kogevinas et al. 2009). In professionals without asthma, a high prevalence of respiratory symptoms directly related with different activities was observed, since those are especially aggravated during the course of those activities. The high prevalence of wheezing associated with dyspnea and dyspnea after strenuous activities in professionals without asthma suggests

an underdiagnosed respiratory problem (Radon et al. 2001). Therefore, these facts support the hypothesis that some activities developed by the workers of these settings may have a negative influence in the development of respiratory diseases.

Protective devices, although available, are not usually used by the poultry farm and swine farm workers. Thus, it is important their awareness for the effect of these activities on its health, in order to promote a better individual and collective behavior regarding their protection (Linaker and Smedle 2002; Dusser et al. 2007).

CONCLUSIONS

Considering the strong association between fungal sensitization and severity of asthma and that *Aspergillus* species are one of the most important fungal agents inducing human sensitization, this study contributes to the knowledge that *Aspergillus* is prevalence and widely distributed in Portuguese poultry and swine farms. The high fungal load detected in the analyzed samples, namely, *Aspergillus* species, suggests a possible occupational health problem and raises the need for preventive and protective measures to avoid exposure in both occupational settings. Molecular identification of *Aspergillus* isolates and susceptibility to antifungal drugs will be performed in further studies in order to understand the molecular epidemiology and antifungal resistance of *Aspergillus* isolates. Taken together, these data and data regarding the evaluation of mycotoxin exposure, obtained by the use of specific biomarkers, will also help to understand how and which *Aspergillus* species affects the health of workers at these locations.

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