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OCCUPATIONAL ALLERGY TO BIRDS WITHIN THE POPULATION OF POLISH BIRD KEEPERS EMPLOYED IN ZOO GARDENS

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Abstract
Objectives: To evaluate the risk factors for the development of occupational allergy to birds among Polish zoo garden keepers. **Methods:** A total of 200 bird zookeepers employed in the Polish zoo gardens in Łódź, Warsaw, Gdańsk, Chorzów and Płock and exposed occupationally to bird allergens were examined using a questionnaire, skin prick tests (SPTs) to common allergens and bird allergens, spirometry and cytograms of nasal swab. The level of total IgE in serum and serum-specific IgE to parrot, canary, pigeon feathers and serum were also evaluated. **Results:** Eight percent of bird zookeepers were sensitized to at least one of the bird allergens. The most frequent allergens yielding positive SPT results were *D. farinae* — 32 cases (16%), *D. pteronyssinus* — 30 cases (15%) and grass pollens (16.5%). In the studied group, allergen-specific IgE against bird allergens occurred with the following frequency: 87 (43.5%) against canary feathers and/or serum, 80 (40%) against parrot feathers and/or serum and 82 (41%) against pigeon feathers and/or serum. Occupational allergy was diagnosed in 39 (26.5%) cases, occupational rhinitis was present in 22 (15%) cases, occupational asthma in 20 (13.6%) subjects, occupational conjunctivitis in 18 (12.2%) cases, whereas occupational skin diseases in 11 (7.5%) cases. More eosinophils were found in nose swab cytograms among bird zookeepers with occupational airway allergy. **Conclusions:** The findings indicate that occupational allergy to birds is an important health problem among zoo bird keepers in Poland.

Key words:
Allergens, Birds, Allergy, Occupational exposure

INTRODUCTION

Bird allergens are an important cause of occupational allergic diseases [1–4]. Airborne contaminants in birds' cages constitute a complex mixture of aerosolized agents, consisting of organic dust-skin debris, broken feather barbules, insects' remains, aerosolized food particles, birds' excreta, ammonia, and a variety of viable bacteria, as well as airborne gram-negative bacteria and endotoxins [5,6]. Our data published in 2009 shows that subjects working with birds are also exposed to disinfectants and latex allergens (LA) [4]. In the aforementioned study we proved the significant role of family history positive for atopy and occupational contact with parrots either in the development of work-related

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symptoms or work-related respiratory allergic symptoms (questionnaire data) [4].

The aim of the present study was to investigate the frequency of hypersensitivity to bird allergens and to identify the risk factors for the development of occupational allergy and occupational airway allergy among bird keepers in Polish zoo gardens.

MATERIALS AND METHODS

The studied group consisted of 200 persons (109 males and 91 females) employed at zoo gardens located in the metropolitan areas of Łódź, Warszawa, Gdańsk, Chorzów and Płock.

A field study was carried out in 2008 and it comprised a medical examination, a questionnaire survey, SPTs, spirometry, tests for total and specific antibodies in blood and cytology of nasal swab.

The study protocol gained approval of the Regional Biomedical Ethics Committee. All the participants gave their informed consent prior to the study.

The questionnaire, supervised by a physician, was adapted from the instrument developed by the International Union against Tuberculosis and Lung Disease (IUATLD) [9].

The symptoms suggestive of asthma included dyspnoea, wheezing, chest tightness or cough, the symptoms of rhinitis encompassed sneezing, rhinorrhea, mucosal edema and itching, whereas the symptoms of allergic conjunctivitis manifested in the form of redness and edema of eyelids, redness and edema of conjunctivae, lacrimation and itching.

Respiratory, nasal and eye symptoms related to the exposure to specific agents at the workplace and to those outside of it were also noted.

The issues covered by the questionnaire included also job characteristics and description of occupational exposure.

The two categories of smokers and non-smokers were distinguished concerning the smoking habit. The category of smokers encompassed current smokers and ex-smokers. Current smokers were defined as the subjects who reported smoking tobacco at the time of the survey, and ex-smokers as those who had smoked daily in the past and discontinued it at least one month before the survey. The non-smokers category was formed only by the subjects who had never smoked. The subjects who had had a pet in their childhood, or before the onset of the occupational contact with animals, were defined as subjects with previous exposure to animals and/or birds.

Skin prick tests (SPTs) were applied to the forearm. They consisted of the standard, commercially available common allergens including tree and grass pollens, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Acarus siro*, *Thyrophagus putrescentiae*, *Lepidoglyphus destructor*, feathers mixture, parrot feathers, canary feathers, molds in general, molds series I* (*Alternaria tenuis*, *Botrytis cinerea*, *Cladosporium herbarum*, *Curvularia lunata*, *Helminthosporium halodes*, *Fusarium moniliforme)* and molds series I** *(Aspergillus fumigatus*, *Mucor mucedo*, *Penicillium notatum*, *Pullularia pullulans*, *Rhizopus nigricans*, *Serpula lacrymans),* cat and dog allergens (Allergopharma, Reinbek, Germany). The negative control solution was a commercially available allergen diluent, while the positive control was a 1 mg/ml histamine dihydrochloride solution (Allergopharma). The largest wheal diameter was assessed after 15 min. A wheal diameter of ≥ 3 mm and equal to or greater than half of that formed by histamine was defined as the positive one and indicated sensitization. The subjects were asked to avoid antihistamines or antidepressants for at least 72 h prior to testing.

Blood samples were then taken from all participants and the total serum IgE was evaluated. The total IgE level > 100 kU/l was considered as elevated.

Specific IgE antibodies to canary, pigeon, parrot feathers and serum were measured by the immunoenzymatic method (Allergopharma, Germany) — canary feathers (e009); parrot feathers (e010); pigeon feathers (e011);

pigeon serum (e013); canary serum (e014); parrot serum (e016). Specific IgE levels > 0.35 kU/l were regarded as positive: class 1 ≥ 0.35 kU/l < 0.7 kU/l low; class 2 ≥ 0.7 < 3.5 kU/l mild; class 3 ≥ 3.5 < 17.5 kU/l elevated; class 4 ≥ 17.5 < 50 kU/l high; class 5 ≥ 50 kU/l very high.
Spirometry was performed in all the subjects. Additionally, a nose swab was taken using the traditional approach, and cytograms from nose swabs were evaluated after coloring them with the MGG (May-Grunwald-Giemsa) method.

Definitions

Nasal symptoms and/or symptoms from the low respiratory tract formed the category defined as respiratory symptoms [7].
Allergic sensitization to birds was recognized when at least one positive result of SPTs or allergen-specific serum IgE (asIgE) to bird allergens (at least in the 1st class) occurred [7,8].
Occupational allergy was defined as work-related allergy symptoms coexistent with the presence of allergic sensitization [9].
Occupational bird allergic rhinitis was specified as work-related specific symptoms and the presence of allergic sensitization [9].
Occupational bird allergic asthma was characterized as occurrence of work-related specific symptoms along with the presence of allergic sensitization.

Statistical analysis

Continuous variables were expressed as mean values ± standard deviations (SD), while nominal variables as numbers and percentages. Odds ratio (OR) with 95% confidence interval was calculated for all the risk factors examined, and separately for the following outcomes: work-related allergic symptoms, work-related sensitization to bird allergens, occupational allergy to birds, occupational airway allergy to birds using EPI INFO software (CDC, Atlanta, GA, USA). Factors found to be significant in the univariate analysis were included into the multivariate logisitic regression model (Statistica 99) to predict each of the different outcomes. The p value below 0.05 was adopted as the reference for the selection of significant risk factors.

RESULTS

Study population characteristics

The mean age of the investigated group was 43.27±13.59 years, whereas the mean duration of exposure to occupational allergens lasted 16.23±12.08 years (min. 3 months; max. 50 years) (Table 1). Most of the subjects participating in the study, namely 122 workers (61%), had a history positive for smoking (Table 1). Family history positive for atopy was reported by 58 persons (29%). A current contact with an animal at home was recorded in 137 cases (68.5%) — 45 workers (22.5%) confirmed the contact with a cat, 102 (51%) with a dog, 23 (11.5%) with a parrot, 16 (8%) with a canary and 16 subjects (8%) with other birds (duck, goose, hen, pigeon and birds of prey), respectively. All questionnaire responses concerning exposure to animals and birds at present and in the past are shown in Table 1. In total, 131 workers (65.5%) informed about the previous contact with an animal mentioned in the questionnaire. In particular: 55 subjects (27.5%) reported having contact with a cat, 96 (48%) with a dog, 39 (19.5%) with a parrot, 19 (9.5%) with a canary and 30 workers (15%) with other birds. 148 workers (74%) used latex gloves in the workplace, and 139 workers (69.5%) were occupationally exposed to disinfectants while cleaning the cages (Table 1).

Hypersensitivity to bird allergens

The outcomes of SPTs are presented in Table 2. A total of 32.5% (65) of the subjects revealed at least one positive SPT response to common allergens. In the total study population, the most frequent allergens yielding

Table 1. Study population characteristics

Analyzed parameter	Subjects (N = 200) n (%)
Age (mean±SD) (years)	43.27±13.59
Sex ratio: men/women	109:91 (54.5:45.5)
Duration of work with birds (mean±SD) (years)	16.23±12.08 (min. 3 months; max. 50 years)
≤ 5	40 (20.0)
6 ≤ 10	33 (19.5)
≥11	121 (60.5)
Smoking status	
current smoker	71 (35.5)
ex-smoker	51 (25.5)
non-smoker	78 (39.0)
Family history of atopy	58 (29.0)
Contact with animals and/or birds	137 (68.5)
cat	45 (22.5)
dog	102 (51.0)
parrot	23 (11.5)
canary	16 (8.0)
other birds	16 (8.0)
Contact with animals and/or birds in the past	131 (65.5)
cat	55 (27.5)
dog	96 (48.0)
parrot	39 (19.5)
canary	19 (9.5)
other birds (duck, goose, hen, pigeon and birds of prey)	30 (15.0)
Using latex gloves in the workplace	148 (74.0)
Using disinfectants in the workplace	139 (69.5)

positive SPT results included: *D. farinae* — 32 cases (16%), *D. pteronyssinus* — 30 cases (15%) and grass pollens (16.5%). Eight percent of bird zoo keepers were sensitized to at least one of the bird allergens, most frequently to canary feathers — 9 cases (4.5%), parrot feathers — 7 cases (3.5%), and 7 cases (3.5%) to the mix of bird feathers.

The results of allergen-specific serum IgE are presented in Table 3. A total of 72% of all participants had at least one allergen-specific IgE to bird allergens. Allergen-specific IgE against particular factors was detected in the respective cases, namely against canary feathers in 58 cases (29%), against parrot feathers — in 50 cases (25%), against pigeon feathers — in 41 cases (20.5%), against

Table 2. The results of SPTs to common and bird allergens and evaluation of the total IgE level

SPTs to	Whole group (N = 200) n (%)
Common inhalant allergens	65 (32.5)
Dermatophagoides pteronyssimus	32 (16.0)
Dermatophagoides farinae	30 (15.0)
Molds in general	13 (6.5)
Mold series I*	10 (5.0)
Mold series II**	8 (4.0)
Grass pollens	33 (16.5)
Trees pollens	29 (14.5)
Trees pollens I#	25 (12.5)
Trees pollens II##	25 (12.5)
Weeds	27 (13.5)
Lepidoglyphus destructor	24 (12.0)
Acarus siro	18 (9.0)
Tyrophagus putrescentiae	19 (9.5)
Cereal	6 (3.0)
Bird allergens	16 (8.0)
Parrot feathers	7 (3.5)
Canary feathers	9 (4.5)
Feathers mixture	7 (3.5)
Total IgE level (kU/l) (mean±SD) (min., max.)	120.15±205.64 (2.8; 1 000)
IgE > 100 kU/l	53 (26.5)

* *Alternaria tenuis*, *Botrytis cinerea*, *Cladosporium herbarum*, *Culvularia lunata*, *Helminthosporium*, *Fusarium moniliforme*.
** *Aspergillus fumigatus*, *Mucor mucedo*, *Penicillium notatum*, *Pullularia pullulans*, *Rhizopus nigricans*, *Serpula lacrimans*.
# Alder, hazel, poplar, elm, willow.
Birch, beech, oak, plane tree.

Table 3. The results of asIgE to bird allergens

asIgE in serum	Whole group (N = 200) n (%)
Specific IgE level to bird allergens	144 (72.0)
Presence of asIgE to	
canary feathers (e009)	58 (29.0)
parrot feathers (e010)	50 (25.0)
pigeon feathers (e011)	41 (20.5)

Table 3. The results of asIgE to bird allergens — cont.

asIgE in serum	Whole group (N = 200) n (%)
pigeon serum (e013)	60 (30.0)
canary serum (e014)	49 (24.5)
parrot serum (e016)	49 (24.5)
canary feathers and/or serum	87 (43.5)
parrot feathers and/or serum	80 (40.0)
pigeon feathers and/or serum	82 (41.0)

pigeon serum — in 60 cases (30%), against canary serum — in 49 cases (24.5%), and against parrot serum — in 49 cases (24.5%).

We found that 16 persons were positive both for SPTs and/or asIgE to bird allergens, and 13 of them showed both SPTs and asIgE tests results positive for the same bird allergen (Table 4).

Symptoms reported by workers

All symptoms reported within the group of bird zookeepers in the questionnaire are presented in Table 5.

The following symptoms were recorded in the respective numbers of cases: rhinitis in 62 subjects (42.2%), conjunctivitis in 42 cases (28.6%), lower airways symptoms (dyspnoea, wheezing, chest tightness or cough)

Table 4. Combination of results in a group of persons (N = 16) with positive SPTs and asIgE results to birds allergens

Initials of persons	SPT to bird allergens	SPT to parrot feathers	SPT to canary feathers	asIgE to bird allergens	asIgE e009	asIgE e010	asIgE e011	asIgE e013	asIgE e014	asIgE e016
A.K.	+	–	+	+	–	1.7	–	1.3	1.6	–
K.F	+	+	–	+	1.4	–	2.0	2.0	1.1	–
B.K	+	+	+	+	1.7	2.1	2.1	–	1.9	–
E.J.	+	–	–	+	1.7	2.1	2.1	–	1.9	–
S.S.	+	+	+	+	4.2	–	3.2	4.5	4.3	4.2
W.D.	+	–	–	+	–	–	1.6	–	1.5	–
J.G.	+	–	+	+	–	–	–	–	–	2.7
K.S.	+	–	+	+	1.1	–	–	–	–	–
Sz.B.	+	+	–	+	2.0	–	–	–	2.0	–
K.R.	+	+	–	+	–	–	2.1	–	1.5	–
T.B.	+	+	–	–	–	–	–	–	–	–
J.P.	+	–	+	+	–	–	–	2.5	–	–
A.B.	+	–	+	+	–	–	1.1	2.1	2.5	1.0
W.H.	+	+	–	+	1.6	–	–	–	1.6	1.5
M.Ś.	+	–	+	–	–	–	–	–	–	–
M.A.	+	–	+	–	–	–	–	–	–	–

+ Positive. – Negative.

Table 5. Symptoms reported by all bird zookeepers on the basis of the questionnaire

Question	Whole group (N = 200) n (%)	Persons with allergy to bird allergens (asIgE and/or SPT positive) (N = 147) n (%)	Persons without allergy to bird allergens (asIgE and SPT negative) (N = 53) n (%)
Clinical symptoms generally			
symptoms from the lower part of the respiratory tract	51 (25.5)	36 (24.5)	15 (28.3)
at least one symptom from the respiratory tract	99 (49.5)	70 (47.6)	29 (54.7)
dyspnoea	25 (12.5)	20 (13.6)	5 (9.4)
cough	43 (21.5)	31 (21.1)	12 (22.6)
nasal symptoms	84 (42.0)	62 (42.2)	22 (41.5)
eye symptoms	57 (28.5)	42 (28.6)	15 (28.3)
skin symptoms	32 (16.0)	21 (14.3)	11 (20.8)
Clinical symptoms connected with the workplace			
symptoms from the lower part of the respiratory tract	28 (14.0)	20 (13.6)	8 (15.1)
at least one symptom from the respiratory tract	40 (20.0)	29 (19.7)	11 (20.8)
dyspnoea	14 (7.0)	11 (7.5)	3 (5.7)
cough	20 (10.0)	15 (10.2)	5 (9.4)
nasal symptoms	33 (16.5)	22 (15.0)	11 (20.8)
eye symptoms	27 (13.5)	18 (12.2)	9 (17.0)
skin symptoms	12 (6.0)	11 (7.5)	1 (1.9)
allergy symptoms in the workplace	58 (29.0)	39 (26.5)	19 (35.8)

in 36 cases (24.5%). In total, 39 patients (26.5%) were diagnosed with an occupational allergy. Occupational rhinitis was found in 22 (15%) cases, occupational asthma was reported among 20 (13.6%) subjects, occupational conjunctivitis was reported in 18 (12.2%) cases, occupational skin diseases were diagnosed in 11 (7.5%) cases (Table 5).

Univariate analysis showed that none of the parameters analyzed in Table 6 is a risk factor of sensitization to bird allergens in the analyzed group (N = 200).

Statistical analysis revealed that people who had occupational contact with birds from 6 and 10 years more often complained of work-related allergy symptoms in the workplace OR = 4.59 (95% CI: 1.06–27.46) (Table 7). This observation was not confirmed by multivariate logistic regression analysis (p = 0.0825, OR = 2.03, 95% CI: 0.9–4.56).

Univariate analysis did not confirm that any of the examined risk factors (Table 8) was significantly associated with an occupational respiratory system allergy in the analyzed group.

Table 6. Risk factors of sensitization to bird allergens using univariate analysis in the whole group (N = 200)

Analyzed parameter	Subject sensitized to bird allergens (N = 147) n (%)	Subject not sensitized to bird allergens (N = 53) n (%)	OR (95% CI)
Male	83 (56.5)	26 (49.1)	1.35 (0.68–2.65)
Female	64 (43.5)	27 (50.9)	0.74 (0.38–1.46)
Duration of work with birds (years)			
< 5	28 (19.0)	12 (22.6)	0.8 (0.36–1.90)
6–10	32 (21.8)	7 (13.2)	1.83 (0.72–5.25)
> 11	87 (59.2)	34 (64.2)	0.81 (0.40–1.62)
Current smokers	51 (34.7)	20 (37.7)	0.88 (0.44–1.79)
Family history of atopy	41 (27.9)	17 (32.0)	0.82 (0.40–1.74)
Animals at home	105 (71.4)	32 (60.4)	1.64 (0.80–3.31)
Birds at home	25 (17.0)	7 (13.2)	1.35 (0.52–3.94)
Occupational exposure to			
parrot	71 (48.3)	28 (52.8)	0.83 (0.42–1.64)
canary	56 (38.1)	23 (43.4)	0.80 (0.41–1.60)
pigeon	65 (44.2)	27 (50.9)	0.76 (0.39–1.50)
other birds (duck, goose, hen and birds of prey)	70 (47.6)	30 (56.6)	0.70 (0.35–1.37)
other animals	92 (62.6)	26 (49.1)	1.74 (0.88–3.44)
Positive SPT to common allergens	46 (31.3)	19 (35.8)	0.82 (0.40–1.68)
Total IgE level > 100 kU/l	42 (28.6)	11 (20.8)	1.53 (0.69–3.60)

Table 7. Risk factors of occupational allergy using univariate analysis in the whole group (N = 200)

Analyzed parameter	Subject with occupational allergy (N = 39) n (%)	Subject without occupational allergy (N = 34) n (%)	OR (95% CI)
Male	18 (46.2)	18 (52.9)	0.76 (0.27–2.11)
Female	21 (53.8)	16 (47.1)	1.31 (0.47–3.65)
Duration of work with birds (years)			
< 5	7 (17.9)	8 (23.5)	0.71 (0.19–2.59)
6–10	12 (30.8)	3 (8.8)	4.59 (1.06–27.46)*
> 11	20 (51.3)	23 (63.6)	0.50 (0.17–1.44)
Current smokers	12 (30.8)	20 (58.8)	1.78 (0.60–5.32)
Family history of atopy	17 (43.6)	12 (35.3)	1.42 (0.50–4.08)
Animals at home	28 (71.8)	10 (29.4)	1.07 (0.35–3.31)

Table 7. Risk factors of occupational allergy using univariate analysis in the whole group (N = 200) — cont.

Analyzed parameter	Subject with occupational allergy (N = 39) n (%)	Subject without occupational allergy (N = 34) n (%)	OR (95% CI)
Birds at home	7 (17.9)	4 (11.8)	1.64 (0.37–8.39)
Occupational exposure to:			
parrot	26 (66.7)	15 (55.9)	2.53 (0.89–7.30)
canary	17 (43.6)	12 (35.3)	1.42 (0.50–4.08)
pigeon	19 (48.7)	14 (41.2)	1.36 (0.49–3.81)
other birds (duck, goose, hen and birds of prey)	21 (53.8)	18 (52.9)	1.04 (0.37–2.88)
Positive SPT to common allergens	20 (51.3)	12 (35.3)	1.93 (0.68–5.58)
Total IgE level > 100k U/l	15 (38.5)	7 (20.6)	2.41 (0.76–8.15)

* $p < 0.05$.

Table 8. Risk factors of occupational respiratory tract allergy using univariate analysis in the whole group (N = 200)

Analyzed parameter	Subjects with occupational airway allergy (asthma and/or allergic rhinitis) (N = 29) n (%)	Subjects without occupational airway allergy (N = 42) n (%)	OR (95% CI)
Male	12 (41.4)	22 (52.4)	0.64 (0.22–1.85)
Female	17 (58.6)	20 (47.6)	1.56 (0.54–4.53)
Duration of work with birds (years)			
< 5	5 (17.2)	10 (23.8)	0.67 (0.16–2.50)
6–10	8 (27.6)	5 (11.9)	2.82 (0.70–12.28)
> 11	16 (55.2)	27 (64.3)	0.68 (0.23–2.01)
Current smokers	9 (31.0)	15 (35.7)	0.81 (0.26–2.47)
Family history of atopy	13 (44.8)	12 (28.6)	2.03 (0.67–6.14)
Animals at home	20 (69.0)	23 (54.8)	1.84 (0.61–5.67)
Birds at home	6 (20.7)	5 (11.9)	1.93 (0.43–8.91)
Occupational exposure to			
parrot	17 (58.6)	20 (47.6)	1.56 (0.54–4.53)
canary	10 (34.5)	17 (40.5)	0.77 (0.26–2.29)
pigeon	13 (44.8)	20 (47.6)	0.89 (0.31–2.56)
other birds (duck, goose, hen and birds of prey)	13 (44.8)	23 (54.8)	0.67 (0.23–1.93)
Positive SPT to common allergens	13 (44.8)	14 (33.3)	1.63 (0.55–4.79)
Total IgE level > 100 kU/l	12 (41.4)	8 (19.0)	3.00 (0.91–10.10)

Table 9. Results of spirometry among 200 bird zookeepers

Group	EVC (%) (mean±SD)	FEV1 (%) (mean±SD)	FVC (%) (mean±SD)	PEF (%) (mean±SD)	FEV1/FVC (%) (mean±SD)
Whole group (N = 200) (min., max.)	93.13±14.25 (58; 141)	99.81±12.91 (46; 142)	97.82±12.74 (61; 140)	95.63±17.71 (35; 145)	106.34±9.83 (75; 165)
Subjects with occupational airway allergy (N = 29) (min., max.)	101.1±17.06 (79; 141)	100.83±12.27 (84; 128)	99.31±14.58 (77; 127)	98±12.91 (78; 133)	106.24±8.24 (81; 117)

EVC — Expiratory Vital Capacity.
FEV1 — Forced Expiratory Volume in 1 sec.
PEF — Peak Expiratory Flow.

Table 10. Results of cytograms from nose swabs in 200 bird zookeepers

Group	Na (%)	Ne (%)	Eo (%)	Ba (%)	Li (%)	Mo (%)
Whole group (N = 200) (min.; max.)	39.21±24.16 (1; 94)	59.84±24.39 (6; 98)	1.15±5.69 (0; 66)	0	0	0.11±0.33 (0; 2)
Subjects with occupational airway allergy (N = 29) (min.; max.)	43.59±27.91 (6; 34)	53.72±29.38 (6; 94)	3.27±12.92 (0; 66)	0	0	0.10±0.31 (0; 1)

Na — epithelial cells , Ne — neutrophils , Eo — eosinophils , Ba — basophils , Li — lymphocytes , Mo — monocytes.

The results of spirometry were similar in both examined groups, as shown in Table 9.

More eosinophils were found in cytograms from nose swabs of bird zookeepers with an occupational airway respiratory allergy (Table 10).

DISCUSSION

Allergen exposure may occur from contact with bird feathers, serum or droppings. Bird droppings may contain excreted serum protein antigens, they may also include bacterial endotoxin and other biological non-specific substances [10,11]. Feathers have been known as a source of allergens since 1920 [12].

The most frequent allergens yielding positive SPT results within the total studied population were *D. farina* — 32 cases (16%), *D. pteronyssinus* — 30 cases (15%) and grass pollens (16.5%). There are many articles proving that feather mites compose a major source of clinically-relevant allergens for pigeon breeders [13–16].

Eight percent of 200 bird zookeepers were sensitized to at least one of the bird allergens, most frequently to canary feathers — 9 cases (4.5%), parrot feathers — 7 cases (3.5%), and 7 cases (3.5%) to a mix of bird feathers. In our earlier work, published in 2002, 45 (66.1%) subjects out of the group of 68 examined zoo animal keepers revealed positive skin reaction to any inhalant allergen, while 12 (17.6%) workers within the same cohort — only to feather allergens [16]. In the examined group, allergen-specific IgE against canary feathers was detected in 58 cases (29%), against parrot feathers — in 50 cases (25%), against pigeon feathers — in 41 cases (20.5%), against pigeon serum — in 60 cases (30%), against canary serum — in 49 cases (24.5%), against

parrot serum — in 49 cases (24.5%). Additionally, we found that 16 persons had both positive SPT and asIgE to bird allergens. Both SPT and asIgE were positive to the same bird allergen in 13 cases.

Some data obtained from the general population indicates that positive results in intracutaneous and SPTs with feather allergens may occur in 20–60% of patients suspected of allergy to feathers [17–18]. In the study published by Kilpio et al. [19], 24 patients (19%) out of 269 adult subjects with suspected allergic cutaneous or respiratory symptoms and 14% of the patients with a positive reaction to any inhalant allergen (177 subjects) reacted to commercial feather extracts.

Occupational allergy was diagnosed in 39 (26.5%) cases. Occupational rhinitis was found in 22 (15%) cases, occupational asthma was reported among 20 (13.6%) subjects, occupational conjunctivitis was reported in 18 (12.2%) cases, while occupational skin diseases were diagnosed in 11 (7.5%) cases. In the research carried out in the United Kingdom during 1999–2000, the estimated incidence rate of asthma attributable to birds amounted to 23.9/1000/year [20]. In another study, up to 17.4% of poultry farmers reported symptoms of asthma [2]. Rees et al. [21] after the examination of 134 poultry workers found that significantly more poultry workers, comparing to the control group, complained of respiratory, ocular, nasal and dermal symptoms, resulting from exposure to irritating agents at work. Poultry workers included in that study reported symptoms consistent with asthma which occurred with rising frequency of 3%, 4% and 13% for the corresponding increasing exposure: low, medium and high, respectively. Unexpectedly, univariate analysis did not reveal a significant association between occupational contact with birds and sensitization to bird allergens or with an occupational respiratory system allergy in the analyzed group. Similarly, the present study did not confirm a higher frequency of work-related allergic symptoms at the workplace within the group of people with occupational exposure to bird allergens during the period ranging from 6 to 10 years. The obtained results appeared to be somewhat disappointing. In our study 68.5% of all participants reported a current contact with an animal at home, including birds in some cases, so that fact may partly explain why the authors did not find the occupational contact with bird to be a statistically significant variable in the final analysis. Perhaps the data would be different if the authors analyzed more precisely the character of occupational exposure — specific job, the intensity of exposure to bird allergens, and the frequency of use of personal protective equipment. At present, we can only suppose that, similarly as in laboratory animal allergy, many personal and exposure variables may participate in the development of sensitization and occupational allergy [22] and that further research in this area will bring new insight into bird exposures and allergic responses.

The higher number of eosinophils was found in cytograms from nose swab of bird zookeepers with occupational airway respiratory allergy. During the allergic inflammation process they are attracted to the airways, then they migrate through the vascular endothelium to airway epithelium and release eosinophilic toxic products, lipid mediators, oxygen free radicals and cytokines [23]. In the authors' opinion, the subjects who suffer from an occupational allergy involving airways seem to have a greater deal of airway inflammation. We also think that a linear association between the level of sensitization and the cell count analyzed in the cytograms from nose swab does not exist — this hypothesis deserves further investigations.

CONCLUSIONS

The findings indicate that occupational allergy to birds is an important health problem among zoo bird keepers in Poland.

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