For the last ten years in China, the fur-processing industry has developed rapidly, especially in the northeastern part of China. The components of fur dust are very complex. There might be a correlation between fur dust and respiratory disease, mainly inflammation and allergic diseases\(^1\text{-}^3\). We conducted an investigation of respiratory symptoms, chest X-ray examinations, and analysis of antibodies to fungi in 138 fur-processing workers and 40 control workers. An industrial hygiene survey and environmental mycological studies were also conducted. We also discussed possible causes of respiratory impairments in this fur-processing factory.

**Material and Methods**

**Subjects.** The fur-processing factory studied was founded in 1990 and located in Jinzhou city Liaoning province, in the northeastern part of China. Its products were mainly fur and leather clothes, caps and cushions. Goat furs as primary raw materials were imported from Australia and then processed in the following steps: preparing, carding, wearing, sewing and tailoring. This factory was private owned.

A total of 138 workers were investigated in this study in May 1999. The three criteria for subject-selection were (1) exposure to fur dust; (2) no other exposure to toxicants; (3) absence of asthma, tuberculosis or heart disease. Among them, 27 male smoking workers were 32.6 yr old on average and the average work duration was 3.1 yr, and 16 male non-smokers were 31.6 yr old on average and average work duration was 5.1 yr. 95 female workers (non-smoking) were 30.6 yr old and the average work duration was 4.0 yr. Another 40 workers with similar labor intensity and no exposure to dust or toxicants in an appliance assembling factory were selected as controls. 12 male smokers were 31.8 yr old on average; 8 male non-smokers 32.3 yr old on average; and 20 females (non-smoker) 30.1 yr old on average.

**Environmental surveys of dust concentration, free silica content and environmental mycological study.** The total dust concentration was measured by area sampling, and
2–4 locations for each fur processing workshop were selected for sampling. Four samples were collected during the entire 8-h shift, and sampling was continued for 2 d in each location. Air sampling pumps were utilized. The arithmetic means of dust concentrations in all workshops were calculated as the time-weighted average (TWAs) according to the data obtained in the surveys. The gravimetric method was carried out to analyze the silica content. Out-plate culture (90 mm) was adopted to inspect the fungus conditions in all workshops. The culture plates used for sampling atmospheric molds contained Sabouraud’s agar medium for 2–4 days. Five plates were exposed for 5 min in the workers’ breathing zone (1–1.5 m high) for each processing workshop. Their fungus colonies were counted after being incubated at 25–28°C for 7 d. Species of isolated fungi were identified according to morphology under the microscope.

Respiratory symptom investigation and chest X-ray examination. Data on respiratory symptoms and smoking habits were collected by means of a self-administered Chinese version of the British Medical Research Council (BMRC) Standardized Questionnaire. Additional questions about work-related symptoms, fever and occupational history were included. Questions on Cough and Phlegm are as followings. Cough: ① Do you usually cough first thing in the morning (on getting up) in the winter? and/or ② Do you usually cough during the day-or at night-in the winter? ③ Do you usually cough like this on most days (or nights) for as much as three months each year? Phlegm: ① Do you usually bring up any phlegm from your chest first thing in the morning (on getting up) in the winter? and/or ② Do you usually bring up any phlegm from your chest during the day-or at night-in the winter? ③ Do you usually bring up any phlegm from your chest like this on most days (or nights) for as much as three months each year? Subjects were considered to have chronic respiratory symptoms if they had a cough or phlegm production on most days or nights for as much as 3 months each year (chronic cough or chronic phlegm). Dyspnea (shortness of breath) is defined as if they answered yes to one of the following three questions. ④ Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? ⑤ Do you get shortness of breath walking with other people of your own age on level ground? ⑥ Do you have to stop for breath when walking at your own pace on level ground? Chest tightness or fever was considered to be positive if they answered yes to each of the following questions: “Do you get chest tightness if you are exposed to fur dust?” or “Have you ever had fever after you were exposed to fur dust?” Chest X-ray films were taken for those with at least 3 respiratory symptoms. The quality of the films was according to the diagnostic standards of X-ray films of pneumoconiosis. Chest X-ray films were examined by a radiologist. The films with spotted or patchy shadows or mediate or severe enhanced lung marking were considered to be abnormal.

IgG to Fungi by ELISA (Enzyme-linked immunosorbent assay). 5 ml sera of 138 exposed workers and 40 control workers were prepared and stored at –20°C. 6 mg mycelia of fungi were homogenized completely into carbonate buffer solution (PH 9.6) by ultrasonic treatment. The supernatant after centrifugation at 40,000 g for 10 min was taken as the ELISA antigen solution. 100 μl of antigen solution per well was added and preserved at 4°C for 24 h for antigen coating. The plates were washed 3 times with phosphate-buffered saline (PBS). The 100 μl of 1: 100 dilutions of serum was put into the antigen-coated well and cultured for 1 h at room temperature. After washing 3 times, 100 μl sheep anti-human IgG-HPR was added, then incubated at 37°C for 45 min. After being washed 3 times, to each well was added 100 μl TMB (H2O2/3,3',5,5'-tetramethyl -phenylamine ), and left at 25°C for 15 min. The enzymatic reaction was stopped by 50 μl 2M sulphuric acid and the absorbances read at 450 nm with a spectrophotometer (Bio rad-450).

Statistical analysis. Differences in proportion of respiratory symptoms and prevalence of anti-fungal antibodies were examined by chi-square test. Differences in OD450 values for specific antibodies were examined by Student’s t-test. P<0.05 was regarded as the level of significance.

Results

The dust concentrations in the fur processing workshops ranged from 1.8 to 6.7 mg/m3, which were below the national health limit (10 mg/m3). The concentrations of dust in the carding, sewing and tailoring workshops were 6.7, 4.6 and 4.3 mg/m3 respectively. Most dust contained less than 2.0% silica. Only 6 workers in preparing workshops were exposed to dust containing...
The data on isolated fungi in the fur processing factory compared with the data in the appliance assembling factory are shown in Table 1. The numbers of fungi in the fur processing workshops were 629–3,681 cfu/m^3 (colony forming unit/m^3). The numbers of fungi in the environments of the appliance assembling factory were lower (63–503 cfu/m^3).

The details of distribution of atmospheric fungi in various fur processing workshops are shown in Table 2. A total of 728 fungal colonies were isolated from all the fur processing workshops, and the fungal spectrum for all workshops was almost the same. The proportions of Cladosporium, Penicillium and Alternaria in all the colonies were 260/728 (35.7%), 227/728 (31.2%) and 134/728 (18.4%), respectively. Meanwhile Aspergillum and yeast were also detected in most of the workshops, but very few (only 6.3% and 2.2% respectively). The leading strain in the environment of the appliance assembling factory was Penicillium (39.4%). Cladosporium was detected in only 12.1% of the colonies.

The prevalences of respiratory symptoms (chronic cough, chronic phlegm, chest tightness, dyspnea) and fever in exposed groups were higher than those in the control groups. The prevalences of respiratory symptoms of exposed female workers were higher (Table 3). 37.9% of exposed female workers complained of chronic cough, and about 10.5% suffered from dyspnea. Chest tightness...
was experienced by 22.1% of them, and the prevalences of chronic phlegm and fever were 28.4% and 4.2%, respectively. The prevalence of chronic cough in exposed female groups was significantly higher than in female control groups (P<0.05). A total of 30 exposed workers with at least 3 types of symptoms were examined by chest X-ray. Seven X-rays were abnormal. Among them, one had a patchy shadow; there were 6 with disordered lung marking, and 2 with fractured lung marking.

Levels of antibodies to fungi (Cladosporium and Alternaria) are shown in Table 4 as mean absorbance in an ELISA test (OD_{450 nm}). The OD_{450 nm} values for antibodies in 138 fur processing workers were significantly higher than those for control workers, and there were seven workers with abnormal chest X-rays and 30 workers who often suffered from at least 3 respiratory symptoms also had significantly higher OD_{450 nm} values.

Based on the OD_{450 nm} values for 40 control workers, 95 percent confidence intervals of OD_{450nm} values of anti-fungi antibodies were calculated and upper-limits were established as the cut off values. The cut off values of specific antibodies to fungi were 0.644 for Cladosporium and 0.778 for Alternaria, respectively. The positive rates of antibodies to fungi in fur processing workers were significantly higher than those of control group (P<0.01). Seven workers with abnormal X-rays and thirty workers who often suffered from at least 3 respiratory symptoms also had a significantly higher proportion of positive antibodies (P<0.01, Table 4).

Discussion

Fur dust with complex components could cause respiratory diseases such as chronic bronchitis, exogenous allergic alveolitis (EAA), bronchial asthma and organic dust toxic syndrome (ODTS), but the etiologic agents remain unclear. The main inhalation causative agents might be fur dust itself, bacteria, endotoxin, and fungi. Fungal spores, mycelium and metabolic products were all allergenic substances. It was reported that there were 10 species of fungi leading to EAA or bronchial asthma, such as Aspergillus fumigatus causing EAA and bronchial asthma, Alternaria inducing woodworker’s lung, and so on. In this fur-processing factory, the dust concentrations in fur processing workshops ranged from 1.8 to 6.7 mg/m³, which were below the national health limit (10 mg/m³) and most dust contained less than 2.0% silica, but the amounts of fungi in half of workshops were up to 2,000 cfu/m³. And our findings of specific antibodies to fungi indicated that the fur processing workers were exposed to fungi. The prevalences of respiratory symptoms (chronic cough, chronic phlegm, dyspnea, chest tightness, fever) in exposed workers were higher than those in control workers. The prevalence of fever in exposed female workers was 4.2%. Seven X-ray films were abnormal such as with patchy shadows. Based on our preliminary study, we consider that fungi might be one of the main etiologic agents causing the respiratory diseases in the fur-processing workers.

References