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ZOOPHILIC AND GEOPHILIC FUNGI AS A CAUSE OF SKIN DISEASE IN FARMERS*

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Abstract: The impact of microscopic fungi on the farmers' health seems to be underestimated. In the present article an overview of fungi as pathogens is presented with reference to occupational hygiene in agriculture and related areas. The infection may be transmitted from infected humans, animals, plants or soil. To date, little epidemiological data on fungal skin disease in farmers is available. Epidemiological studies from Poland suggest that mycoses are the most prevalent skin diseases in farmers, and may be present even in over 20% of the population. Working conditions on farms greatly enhance the development of fungal infections. Farmers spend most of their working time in humid conditions, wearing rubber boots for long hours, etc. Another professional groups at higher risk for developing a fungal disease are animal feeders, foresters, grave-diggers and veterinarians as well as employees working in the food industry. Besides infection, fungi may also cause non-invasive forms of skin disease, as *dermato-mycotoxicosis professionalis* or alternariosis. Criteria for classifying a case of mycosis as occupational disease are also discussed.

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Key words: microscopic fungi, antropophilic fungi, zoophilic fungi, geophilic fungi, zoonoses, occupational diseases, skin diseases, mycoses, occupational exposure, risk groups, farmers, veterinarians, foresters, agriculture, veterinary medicine, forestry, food industry.

The impact of pathogenic fungi on the farmers' health seems to be underestimated. Despite much progress in the therapy of fungal infections they still remain a big socioeconomical problem. In this article, an overview of fungi as pathogens with reference to occupational hygiene in agriculture and related areas is presented.

CLASSIFICATION OF PATHOGENIC FUNGI

From the epidemiological point o view, microscopic fungi of importance to human pathology are divided into 3 groups depending on their typical environment. The group of antropophilic fungi comprises species able to grow only on the human body. Infection by these micro-organisms is possible only from another person, either by immediate contact, or through shared items of personal usage, bathrooms, saunas, etc. To the second group belong zoophilic (transmissible from animals) fungi, which typically cause disease in animals but may be also transmitted from sick animals to man. The group of geophilic fungi comprises species, the natural habitat of which is soil and decomposing organic matter. Under certain circumstances fungi of this group may also cause disease in man. In 1996, Weller and Leifert [23] described 2 workers who became infected by fungus *Trichophyton mentagrophytes* from seedlings of the coffee plant *(Coffea arabica)*. This turns attention to yet another possibility of transmitting a fungal infection - through contact with the plant material. These infections could be referred to as "phytophilic". The importance of this phenomenon still remains to be assessed.

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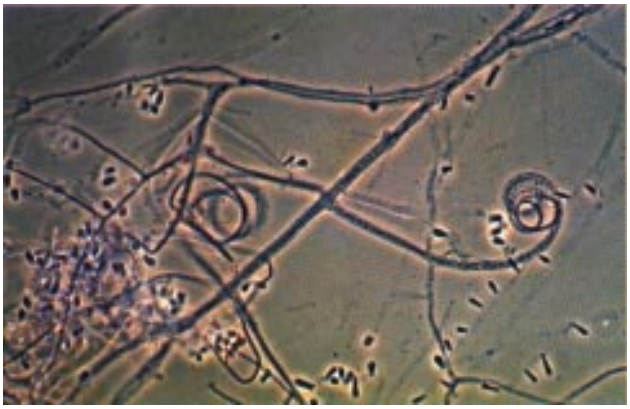

Figure 1. Microscopy of *Trichophyton mentagrophytes*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

Figure 2. Microscopy of *Microsporum canis* showing typical macroconidia. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

EPIDEMIOLOGY OF FUNGAL INFECTION IN FARMERS

To date, little epidemiological data on fungal skin diseases in farmers is available. Nowicki [17], in a group of 184 employees of a state farm in Northern Poland, found tinea pedis (superficial fungal infection of feet) in 45 farmers (24.5%). In the same population, onychomycosis (fungal infection of nail plates) was diagnosed in 10 farmers (5.4%). Although the studied population was not big as for an epidemiological study, based on these data the incidence of tinea pedis in Northern Polish farmers might be assessed from 16.3% to 32.6% and of onychomycosis from 1.1% to 9.7% at confidence level of 99%. Taking even the lowest figures, this show that fungal infections are considerably widespread among farmers.

More extensive studies in 1980–1986 were carried out on 6,963 employees of state-owned farms in North-eastern Poland. These studies showed that among examined farmers fungal infections constituted the most frequent skin disease and were found in 378 farmers (5.5%) [6]. Table 1 presents results of calculations made by the author based on the data extracted from the original publication. Unfortunately, in the original study no identification of pathogenic fungi was performed, and only clinical diagnoses were listed, which indirectly indicate the possible causative factor. The shadowed figures in the table show data which, within all probability, pertain to infections at the workplace (mostly those transmitted from animals).

Working conditions on a farm greatly enhance the development of antropophilic fungal infections. Farmers spend most of their working time in humid conditions, they wear rubber boots for long hours, have a continuous contact with organic matter, *etc*. This problem is very interesting from the aspect of occupational hygiene and without doubt deserves introduction of appropriate prophylactic means into daily life. One possibility could be a campaign aimed at informing farmers about fungal diseases, their causes and factors promoting development of the diseases, as well as about protective measures. Compared to most other professions, farmers are to a greater extend endangered by contact to pathogenic fungi present in soil as well as from infected farm animals. Already in 1950s it was noted that zoophilic fungal

Table 1. Fungal infections in a population of farm workers. This table has been compiled based on data extracted from the publication of Chodynicka *et al.* [6]. 6,963 workers were examined, skin diseases were found in 1,476 farmers, fungal infections were diagnosed in 378 farmers.

Type	N	% in the whole examined population	% of all diagnosed skin diseases	% of all fungal infections
Pityriasis versicolor	175	2.5	11.9	46.4
Tinea pedum and tinea manuum	93	1.3		6.3
Yeast infections*	74	1.1	5.0	19.5
Tinea corporis with a deep inflammatory reaction	20	0.3	1.3	5.3
Tinea capitis or tinea barbae with a deep inflammatory reaction	11	0.2	0.7	2.9
Superficial tinea corporis	5	0.1	0.3	1.3
Total	378	5.5	25.5	100

24.6

* mostly intertrigo in milkers and cowshed workers caused by yeasts.

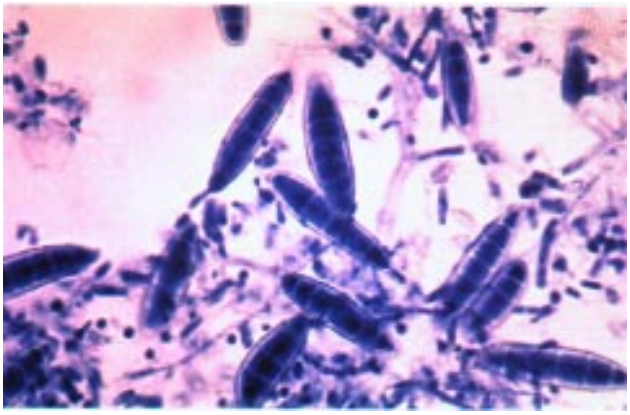

Figure 3. Microscopy of *Microsporum gallinae*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

Figure 5. Microscopy of *Chrysosporium* spp. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

diseases were more prevalent in rural population than in urban inhabitants ([16], p. 292). However, there are also other professional groups where working conditions promote development of these diseases. Czernielewski lists among the professional groups at higher risk of developing a fungal disease, besides farmers, animal feeders, grave-diggers and veterinarians ([7], pp. 255-275).

ZOOPHILIC AND GEOPHILIC FUNGI IN AGRICULTURE

Zoophilic fungi causing skin disease in farmers. Among zoophilic fungi causing skin infection in farmers the following species are listed: *Trichophyton mentagrophytes* var. *mentagrophytes* (Fig. 1), *T. erinacei*, *T. verrucosum*, *T. equinum*, *T. quinckeanum*, *T. simii*, *Microsporum canis* (Fig. 2), *M. persicolor*, *M. equinum*, *M. manum*, *M. gallinae* (Fig. 3) ([8], p. 216; [15], p. 18). According to Rudzki, farmers become infected in their working environment predominantly from cattle, horses and sheep ([18], p. 248). Seidel and Bittighofer also indicate plant production as an activity with higher risk of infection ([19], p. 406). In Germany, Korting and Zienicke described the family of a farmer infected by *Trichophyton verrucosum* from cattle, as well as a veterinarian, who became infected by *Microsporum canis* from a cat which he treated [14].

Geophilic fungi causing skin disease in farmers. The soil fungi of greatest importance to human pathology are: *Microsporum gypseum* (Fig. 4, 6), *M. fulvum*, *Sporothrix schenckii*. Moreover, fungi from genera *Acremonium*, *Fusarium* and *Aspergillus* are cultured occasionally from

Figure 4. Microscopy of *Microsporum gypseum*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

Figure 6. Colony of *Microsporum gypseum*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

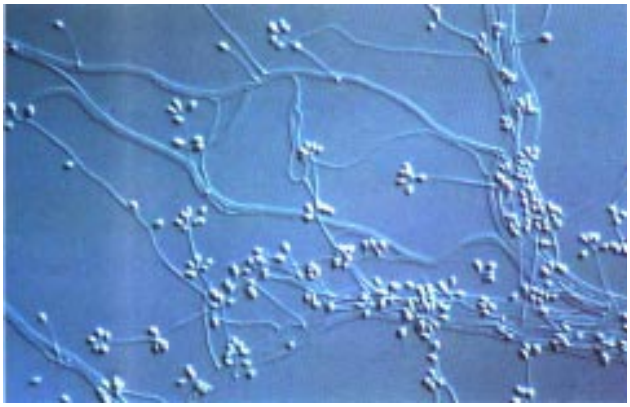

Figure 7. Microscopy of *Sporothrix schenckii*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

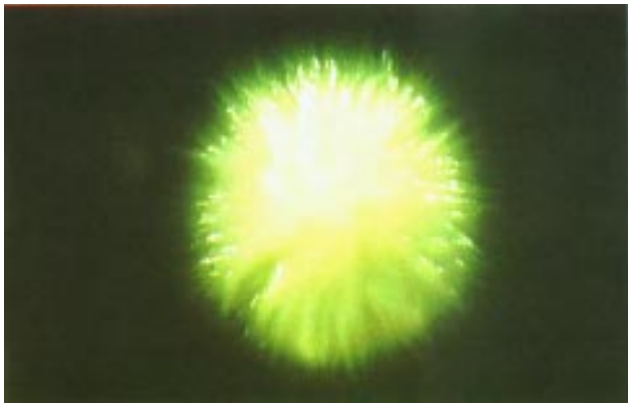

Figure 9. Colony of *Sporothrix schenckii*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

infected nail plates. Baran and Walów described a case of fungal infection of skin and nail plates caused by *Chrysosporium keratinophilum* (Fig. 5), a fungus present in cultivated soil [2]. The course of the disease in the described person was very relevant. The patient was employed at the melioration of arable fields and several times underwent successful medical treatment. Every time after returning back to work a reinfection by *Chrysosporium keratinophilum* appeared. In another study, 49 species of keratinophilic (i.e. having affinity to human skin) fungi were identified in soil samples collected from cultivated gardens [21]. Perionychia (infection of tissues surrounding nails) is considered a typical form of fungal infection in gardeners, which is related to immediate contact to contaminated soil and to microtraumas ([19], p. 197). The most typical pathogen in such cases is *Microsporum gypseum*. Sporotrichosis is a disease caused by the fungus *Sporothrix schenckii* (Fig. 7, 8, 9) and presents another example of a geophilic infection. Professional groups at risk from sporotrichosis are gardeners, florists and foresters ([15, p. 102).

An outbreak of lymphocutaneous sporotrichosis among workers producing sphagnum moss topiaries was described [12]. The authors reported results of a cohort study of all 65 employees which was carried out after diagnosing the disease. The study revealed that the risk of sporotrichosis increased significantly with the duration of working with sphagnum moss and with having less gardening experience, whereas wearing gloves had a protective influence. Blastomycosis caused by a geophilic fungus *Blastomyces dermatitidis* (Fig. 10) is generally considered a tropical disease which, with exception of infected immigrants, is absent in Europe ([15], p. 124). However, Chodorowska and Lecewicz-Toruń described a Polish carpenter suffering from cutaneous blastomycosis. He had never been abroad and became infected most probably in the Old Town of Lublin in Poland when injured by a piece of old wood while exploring underground passages which had not been used since medieval times [5]. There is also probability of transmission of the blastomycosis from dogs, cats and horses ([3], pp. 236-256), therefore blastomycosis may be considered as a geophilic and a zoophilic disease.

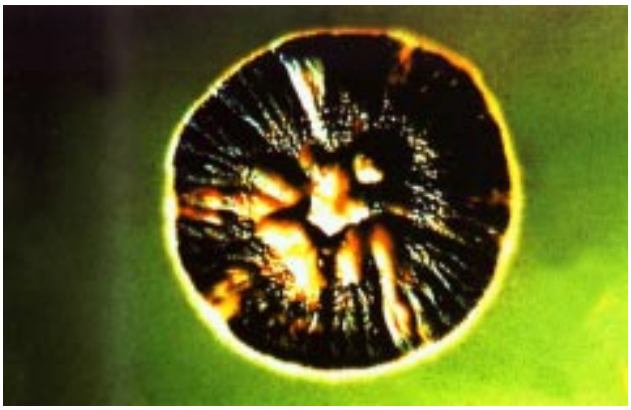

Figure 8. Colony of *Sporothrix schenckii*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

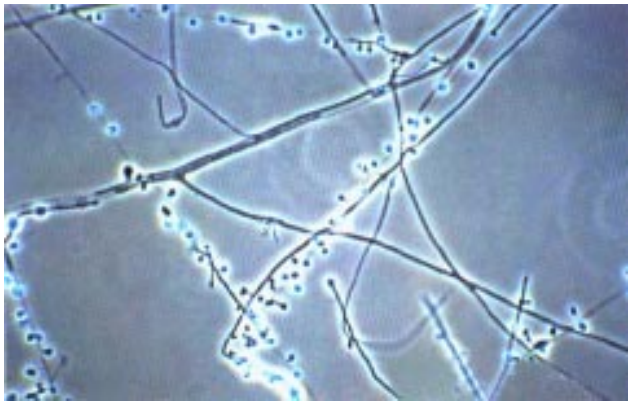

Figure 10. Microscopy of *Blastomyces dermatitidis* growing at room temperature. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

Infection caused by yeast-like fungi. Among pathogenic yeast-like fungi the most common cause of human infection is *Candida albicans* (Fig. 11, 12). This microorganism is extensively widespread in the environment; especially high concentrations of the fungus were found in manured soil [13]. Under physiological conditions fungi of the genus *Candida* are comensals of the mouth, gastrointestinal tract and vagina, and occasionally found also on healthy skin ([15], page 58). Superficial *Candida* infections are very common, therefore attempts to prove the relationship between occupational exposure and disease are rather condemned to failure. On the other hand, however, the importance of occupational factors promoting the infection must be stressed, among them wet hand working, working in high temperature, and handling material with a high sugar content. In this context, professions at risk include workers in the food industry, sugar factories, personnel of baths, laundries and kitchens, as well as milkers and workers employed in cowsheds ([1], p. 229; [19], p. 196). According to Rudzki, interdigital candidosis, although it cannot be classified as a zoophilic disease, in milkers may be regarded as occupational dermatosis ([18], page 248).

Toxic and immunotoxic reactions in skin caused by fungi. In addition to infection - the most common pathological process caused by fungi - other forms of disease may be observed where there is no invasion and multiplication of microorganisms in the host's tissues. In the disease referred to as *dermato-mycotoxicosis professionalis* the damage to skin is caused by toxins produced by fungi present in the outer environment ([10], page 68). Professional dermato-mycotoxicosis may be caused by toxins produced by fungi of the genera *Stachybotrys* and *Fusarium*, which are abundant in spoiled grain and hay. Fungi of the genus *Stachybotrys* present in spoiled animal food (hay) produce stachybotryotoxin, which causes irritation of the skin and mucosae; ingestion of bigger amounts of this toxin may cause damage to internal organs ([4], p. 369). Fungi of the genus *Fusarium* produce cyclic trichotecenic compounds, characterised by a strong irritating action on the skin ([4], pp. 376-377). Ubiquitous filamentous fungus *Alternaria alternata* may provoke development of a granuloma in skin, referred to as alternariosis ([15], page 110).

Mycoses in farmers as a socio-economic problem. The impact of fungi on farmers' health seems to be underestimated. Mycoses, besides unpleasant skin changes, may lead to secondary allergization, and may promote invasion of bacteria and viruses into the human body. In the case of untreated onychomycosis (fungal nail infection), the nail plate of toes becomes thick and causes chronic pain while walking, which causes an unconscious false positioning of feet in order to minimalise discomfort. This may lead to orthopedical problems after a certain time.

Mycosis as an occupational disease. The criteria for classifying mycosis as occupational disease are very debatable. In Poland, according to the Farmers' Social Insurance Act [22], a disease is regarded occupational if the causative factor is present in the working environment. Therefore, for establishing the diagnosis, isolation of the causative fungus from a workplace is of crucial importance. According to Chorążak, occupational mycosis could be diagnosed only in the case of isolating the same strain of pathogenic fungus both from the farmer and from sick animals with which he had contact (cited after Rudzki [18]). This requirement is often very difficult to fulfil, because the efficacy of identifying a fungus from the

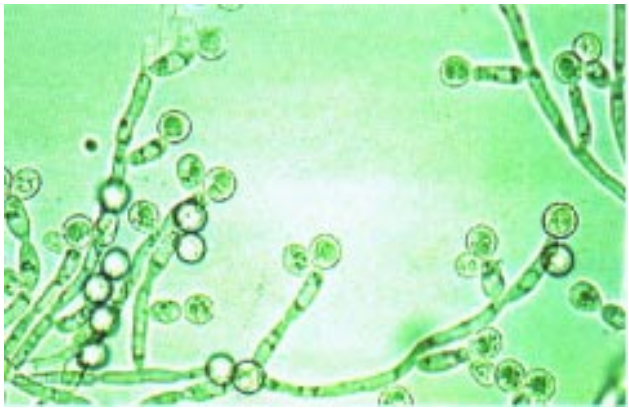

Figure 11. Microscopy of *Candida albicans* growing on corn meal agar. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

Figure 12. Colony of *Candida albicans*. Courtesy of Dr. Michael R. McGinnis, Medical Mycology Research Center, The University of Texas Medical Branch at Galveston, Texas, USA (http://fungusweb.utmb.edu).

farmer depends on previous treatment. In most cases, the patient undergoes treatment by a general practitioner before being referred to a specialist. After a treatment, either microscopic examination and culture may remain false negative. Even "self-treatment" of fungal infection with e.g. cosmetic creams causes a drastic decrease in the effectiveness of further laboratory diagnosis [20]. In the case of zoophilic species, the next step should be the investigation of sick animals in co-operation with veterinarians. Also, this is possible only if the animals were not treated previously. In the case of geophilic fungi, a mycological examination of soil would be necessary, whereas confirming or excluding the presence of a given species, even in a farm of only several hectares, seems technically impossible. Recurrence of disease after returning to work is also a not a very useful criterion as recurrence may result from a non-compliance of the farmer to prophylactic advice. Therefore, in many cases, experts must rely on fragmentary data, as e.g. presence of a zoophilic infection in farmer and certification from a veterinarian that in the preceding period a fungal infection in cattle was found. On the other hand, according to some researchers, candidosis in milkers may be considered occupational, despite the fact that *Candida* is widespread in the environment.

Another difficulty is giving an opinion about the time of work inability. In modern medicine there is a wide range of effective antimycotic drugs; however, in some patients the time of treatment may exceed several months. There is also still a possibility that in some farmers available drugs may prove ineffective for a successful treatment ([11], p. 80; [20]). Poor compliance by patients during therapy may also be caused by high cost of treatment as well as unwillingness to follow advice regarding treatment and avoiding reinfections. An incurable mycosis may be diagnosed only in case of no effect or multiple recurrences despite repeated treatment, properly planned and carried out. The process of planning appropriate treatment may be well subjected to quality control. In contrast to this, the quality of treatment may be very difficult to assess in the absence of compulsory treatment and lack of appropriate inpatient therapy wards. Occupational mycoses are nowadays significantly less often diagnosed compared to the past. According to Grzegorczyk, the definition of occupational mycosis may be fulfilled now only in very selected cases of fungal skin diseases, mostly in farmers and veterinarians ([11], p. 80).

Closing remarks. Compared to other professional groups, farmers are more exposed to pathogenic fungi. This is caused by constant exposure to sources of infection as well as by specific working conditions (humid environment, changing atmospheric conditions, rubber boots, etc.). Fungi may exert their pathogenic action either through invasion (infection) of tissues, or as a source of toxic or allergizing substances. After fulfilling certain criteria, mycosis may be acknowledged as an occupational disease, although proving of the relationship between the occupational exposure and the development of the disease may be difficult.

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