

## SUNDER LAL HORA MEMORIAL LECTURE, 1967

### SAPROPHYTIC HABITATS OF CAUSATIVE AGENTS OF HUMAN MYCOSES IN INDIA

by M. J. THIRUMALACHAR, F.N.I., *Hindustan Antibiotics Research Centre, Pimpri, Poona 18*

(Received 1 January 1968)

The importance of the study of fungi inciting human mycoses is becoming recognized in recent years, since the diseases are more frequent, perhaps accentuated by the widespread use of broad spectrum antibiotics, and also recognition of their importance in public health. Medical mycology which was considered to belong to the domain of the medical man is now being taken up by the mycologists also, who up till now were little concerned about these anthropophilic fungi. The subject is gaining importance rapidly and the mycologist and the physician have shared the responsibility of providing a better definition of the disease and correct determination of the causal agent. With the discovery of new antifungal antibiotics like nystatin, griseofulvin, amphotericin B, hamycin and others, the possibilities of curing these diseases have brightened and more attention is focused on the etiology of these diseases with reference to chemotherapy.

Many of the fungi and actinomycetes inciting diseases in man and animals are closely related, and in a few cases the same species can infect both. In such cases animals act as reservoirs of the inoculum and increase the chances of exposure of humans to infection. The border-line between medical mycology and plant mycology often narrows down when we consider some of the fungi like *Cercospora apii* Fres., which is a disease of celery, and was reported by Emmons *et al.* (1957) as inciting infection in a patient in Indonesia. *Helminthosporium tetramera*, a plant pathogen, was reported to incite disease in a dog. The generic names *Pyrenochaeta* and *Leptosphaeria* which were designated to chiefly plant pathogenic fungi are appearing in medical mycology also. Baylet *et al.* (1959) described madura foot in Africa due to *Leptosphaeria senegalensis* and Borelli (1959) reported mycetoma due to *Pyrenochaeta romeroi*. These and other examples serve to show that with increased knowledge of the organisms inciting human mycoses there would be several closely related species, some of which are adapted as plant parasites, and others which can accidentally invade human tissue and cause mycoses. Ciferri carried out inoculation experiments on plants using *Sporotrichum schenkii* which is a human pathogen and stated that he got leaf spot infection.

Fungi and actinomycetes inciting human mycoses were until recently studied with reference to infection in humans, artificial culture to establish their identity, animal experiments to determine their pathogenicity and virulence. It is only recently in the study of epidemiology and investigations on the sources of infection that the natural occurrence of these pathogens was taken up. The fungi which cause systemic mycoses in man are mostly saprophytes growing in soil enriched with humus, decaying vegetable matter and logs of wood. The parasitic cycle in man is only accidental, brought about by chance exposure of man to the spores of these fungi or implantation of the fungus in the human tissue through spines and thorns of plants. In most of the cases the disease is not transmitted from man to man. In the present account some of the data on the saprophytic existence of these pathogens inciting superficial and deep mycoses in humans are given which would emphasize the need for studies of this type with reference to Indian conditions.

From the physician's point of view, the human mycotic infection can be divided into superficial mycoses and deep mycoses. The dermatophytosis, except in few cases, is superficial, the pathogen attacking chiefly the keratinized tissues. *Candida albicans* is primarily a pathogen on mucous membrane. The other mycoses like maduramycoses, chromoblastomycoses, sporotrichoses are primarily cutaneous, subcutaneous or lymphatic, and mostly localized to the extremities of the body. The systemic mycoses, which are most serious, become generalized, attacking viscera and skeletal organs. These include cryptococcosis, histoplasmosis, blastomycosis, etc.

#### *Mycetoma of Feet and other Parts of Body*

Mycetoma of feet is known to occur in India from ancient times, and the name 'padavalmikam' given in Ayurvedic literature denotes the symptoms. Numerous fungi which are not related to each other are the causative agents. The swelling of the feet, deformity with sinuses and exuding fluid with granules are characteristic of the disease. The colour of the granules to some extent gives an indication of the type of pathogen involved, though microscopic examination of the structure of the granules and artificial culture of the organism are needed for confirming their identity.

Among the primitive group, actinomycosis incited by *Actinomyces israelii* (Harz.) Kruse, a non-acid-fast anaerobe, is known from several parts of the country. Previously confused with *A. bovis* Harz. it has been reported by Gokhale *et al.* (1959) from Poona, Andleigh (1951), Banerjee (1958) and others. The sulphur granules which are exuded out may get reseeded in the soil and none have traced the source of inoculum in soil on account of difficulties of growing the organism. *Nocardia asteroides* (Eppinger) Blanchard, *N. brasiliensis* (Lindberg) Castellani and Chalmers have been

reported by several workers in India (Banerjee and Basu 1961; Sanyal and Basu 1964; Klokke 1964; Mohapatra 1966). *Streptomyces madurae* (Vincent) Mackinnon and Artag. produces pale-yellowish to pink granules associated with mycetoma of foot. Seven such cases incited by one of the three species mentioned above have been investigated by us. The identity of the causal organism was determined by histopathology and growth of the organism in culture. It is well known that these species of *Nocardia* and *Streptomyces madurae* are common soil inhabitants and can be isolated by burying glass rods dipped in paraffin. All the seven cases of patients investigated had histories of working in the field or walking barefooted and had trauma due to thorn prick or injury due to nails.

The black grain mycetoma due to higher fungi is of more serious nature since treatment is difficult and in most cases the leg of the patient is amputated. Madura foot incited by *Madurella mycetomi* (Leveran) Braumpt was recognized as far back as 1860 by Carter in India and the disease complex goes under the name maduramycoses, though several other fungi are known to be causative agents. *Madurella mycetomi* develops black granules and infection often results in considerable swelling, formation of multiple sinuses and deformity of the leg. The fungus and the disease are widespread and known in several parts of the world. A second species, *Madurella grisea* Mackinnon, Ferrada and Montemayer, so far is known only from America. The two show differences in the structure of the grain, temperature requirements and utilization of sugars such as sucrose and lactose. A single case of *M. grisea* was isolated from a patient in Poona who is a farmer and had the history of thorn injury which resulted in the initiation of infection. Of the several etiological agents of mycetoma caused by fungi, only *Allescheria boydii* Shear has repeatedly been isolated from soil up till now and none of the species of *Madurella* or others. During the course of isolation of soil fungi, two isolates of *Madurella mycetomi* were obtained by the author, which produced deeper, brownish pigment than normal ones in Sabouraud's agar and had more aleuriospores. *M. mycetomi* produces aleuriospores on soil agar under certain conditions. This is the first report of *M. mycetomi* being isolated from soil, which shows that it is a soil inhabitant in restricted areas, developing sclerotia, which is seen on lactose agar at 37 °C and aleuriospores.

Other incitants of maduramycoses with black granules are *Phialophora jeanselmi* Emmons, *Cephalosporium madurae* Thirum., Padhye and Sukapure, *C. infestans* Thirum. and Gaind. The first one belongs to the group of Dematiaceae, similar to *Cladosporium*, which is a ubiquitous fungus on decomposing vegetable matter. Three cases of mycetoma of foot were in a place in Bombay where the persons were living in marshy area on which they walked barefeet every day. The two *Cephalosporium* species inciting mycetoma of foot have been reported for the first time from India (Padhye *et al.* 1962; Gaind *et al.*

1962). *Cephalosporium* species are mostly soil fungi and a detailed account of the Indian species has been given by Sukapure and Thirumalachar (1966).

*Allescheria boydii* with its conidial stage *Monosporium apiospermum* Sacc. is the chief incitant of maduramycoses in the U.S. and is characterized by white granules. The fungus has been isolated several times in soil in India. Pawar *et al.* (1963) reported it from the Bandra area in the brackish marshes and Padhye and Thirumalachar (*in press*) reported 16 different isolates from soil samples collected in several places in Maharashtra. Of these, 13 isolates produced both *Monosporium apiospermum* conidial stage and the *Allescheria* perithecial stage on Sabouraud's agar after 16 days' incubation, while the other three produced the perfect stage only after growing them on corn meal agar of Emmons (1944), the incubation period being three weeks. Even a detailed search among the numerous patients, coming to O.P.D. from the areas where *Allescheria boydii* was isolated, failed to show any case of mycetoma due to this fungus. Mohapatra (1966) records that out of 19 cases of mycetoma studied in Delhi area, 17 were *Madurella mycetomi*, one was due to *Phialophora jeanselmi* and the other probably *Monosporium apiospermum*. No other records of mycetoma due to *Monosporium apiospermum* or its perfect stage *Allescheria boydii* are known from India, though the fungus is well distributed in Indian soils.

Another subcutaneous mycosis resembling madura foot is chromoblastomycosis. It is characterized by verrucous ulcerated and crusted lesions, which may be cauliflower-like and often presenting considerable deformation of the leg. Several fungi are known to incite this disease, and it was considered quite rare in India. Rajam *et al.* (1958) reported *Phialophora dermatitidis* (Kano) Emmons from Punjab, Meenakshi *et al.* (1966) reported *Phialophora pedrosi* (Braumpt) Emmons from Kerala. Mohapatra *et al.* (*in press*) reported *Cladosporium carrionii* Trejos which was known previously in Australia, inciting infection in a patient in Punjab. Gokhale, Padhye and Thirumalachar studied a case of mycetoma of foot incited by *Cladosporium carrionii* in a patient in Poona. All these fungi, though not isolated from soil so far, are saprophytes and soil inhabitants. *Cladosporium*, *Hormodendrum* and *Phialophora* are closely related genera and form the chief components of organisms associated with decaying vegetable matter. In this connection mention may be made of *Cladosporium werneckii* Horta which produced black patches on the palms and often on the face, brought about by the infection of the epidermis. This fungus is widespread, and several isolations of this have been reported by Pawar and Thirumalachar (1965) from marine soil. The fungus produces yeast phase readily in culture.

Sporotrichosis is a chronic, subcutaneous, lymphatic mycosis which often becomes generalized. The disease is incited by *Sporotrichum schenckii* (Hektn. and Perkins) Matruchot which is a dimorphic fungus with mycelial

and conidial stages at room temperature, and yeast phase at 37 °C on high glucose media. Panja and Dey (1947), Dey (1959), Ghosh (1948a, b) and others have reported the disease from India, most of them from Assam. One of the haemorrhagic diseases among the Armed Forces stationed in Assam was investigated by Lt.-Col. K. N. Rao, who had maintained the inciting pathogen in mice by repeated inoculation of blood from the diseased to healthy mice. The disease symptoms were produced within a month. *Sporotrichum schenkii* has been isolated from the blood sample and identification confirmed by mycological examination, cultural studies, animal inoculation and the finding of the asteroid body in the artificially infected mice (Rao *et al. in press*). *S. schenkii* is a saprophyte on decaying material. In the gold mines of Witwatersrand, South Africa, where 3,000 cases of sporotrichosis were reported within four years, the fungus *Sporotrichum schenkii* was found growing abundantly on the timbers, and the disease was controlled effectively by treating the wooden rafters with fungicides. Beurmann and Gougerot (1911) isolated the fungus from growing plants of *Equisetum* and beech, and this only indicated their wide distribution as saprophytes.

The creeping granuloma incited by *Basidiobolus haptosporus* Drechsl. and other phycomycetous fungi are getting more attention in recent years as potential human pathogens. *B. haptosporus* was reported by Emmons *et al.* (1957) in Indonesia under the name *B. ranarum* and has been reported by Wilson from Kampala, Uganda, Nigeria and other places. In India, a case was reported by Mukherjee from Bombay. The fungus has been isolated in all cases and found to be identical with the saprophyte occurring in nature. Since artificial infection has not proved successful with many of these pathogens it is difficult to test the infectivity of an isolate from soil. *B. haptosporus* is a common member of the intestinal flora of frog, and its isolation from wide habitats like plant detritus, etc., has been reported by Srinivasan and Thirumalachar (1965). Srinivasan and Thirumalachar (1968) also showed that Greer and Friedman's (1966) concept, that only the pathogenic strains can grow at 37 °C which is the human body temperature, is incorrect, since all the isolates can grow at 37 °C.

Rhinosporidiosis is a disease chiefly of India and Ceylon and occasionally in other parts of the world. It is a disease of the mucous membrane, producing granulomatous polyps, mostly in the mucosa of the nose, nasopharynx, lachrymal sac of the eye and occasionally in other parts of the body also (Rajam *et al.* 1955). India has the highest incidence of the disease in the world. The disease is incited by *Rhinosporidium seeberi* (Wernicke) Seeber. In the last fifty years the work on this important pathogen is so meagre that some of the investigators have even doubted whether it is a fungus at all. Some of the preliminary studies carried out by the author has indicated close parallelism between the chytrid group *Synchytrium* and *Rhinosporidium*.

In the subgenus *Woroninella* particularly, the primary nucleus of the sorus is one of the largest among fungi. By free nuclear division, numerous nuclei are produced and, with each division, the sizes of the nuclei are correspondingly reduced. The free nuclear division is followed by delimitation of wall. Each of these cells is uninucleate at first, and later becomes multinucleate and thus becomes sporangia later by rounding off the contents. The same type of development is seen to some extent in the formation of endospores. Vanbreuseghem *et al.* (1955) have identified, within the endospores, spore bodies which the previous investigators have identified as proteinaceous sphaerules. For appearance these very closely resemble the early germination stage of the sporangia of the summer spores of *Synchytrium*. Due to lack of viable fresh material, germination studies could not be carried out.

In determining the mycotic nature or any further relationship of *Rhinosporidium*, investigators have chiefly attempted to grow the fungus in artificial culture and only reported failure. The success of growing the fungus in culture is considered as the only fruitful line of work. It may be pointed out that the large group of *Synchytrium*, many of which like the potato wart show verrucose growth, have never been grown in artificial culture. Even the powdery mildews so common in the field, whose spores germinate so readily in water, have not been grown on artificial culture. Some day this will be done.

Rhinosporidiosis in Maharashtra is endemic in villages like Mancher, where the workers dive into the river to collect sand for purposes of construction of buildings; Emmons *et al.* (1964) quote the same situation where rhinosporidiosis was observed in persons diving in water for collecting sand and none in those that carried it further. At Kakinada, a place in South India, Dr. Jain reported that a large number of people bathing in one of the holy tanks contracted rhinosporidiosis. All these indicated some extraneous source of infection and *R. seeberi* having some habitat in water. The saprophytic existence of *R. seeberi* when discovered would present a most interesting data.

Candidiasis is incited by several species of *Candida*, of which *C. albicans* (Robin) Berkhout is the most important one. It is ubiquitous and causes various types of infections, from mere skin infection and paronychia to pulmonary candidiasis and systemic candidiasis involving dissemination in visceral organs. With the large-scale use of broad spectrum antibacterial antibiotics the problem of candidiasis has become a major one. Use of antitubercular drugs like streptomycin, INH and PAS eliminate *Mycobacterium tuberculosis* but, on the damaged regions of the lung, *Candida albicans* and some of the other opportunistic fungi like *Aspergillus niger* *Mucor* sp. get established and protect *M. tuberculosis* against the anti-tubercular drugs. Screening of a large number of tuberculous patients at the

Aundh Chest Hospital, Poona, by Shende *et al.* (1965) showed the high incidence of pulmonary candidiasis in patients receiving antitubercular drugs for long periods. Vulvovaginitis due to *C. albicans* is a common gynaecological manifestation, which is also responsible for oral thrush in the newborn. The large-scale use of oral contraceptives of the steroidal hormone type has accentuated monilial vaginitis. *C. albicans* is ubiquitously present as a saprophyte. Predisposition to infection are factors like diabetes, obesity and other conditions lowering body resistance.

*Cryptococcosis* is another yeast-like organism causing systemic mycoses such as subacute or chronic meningitis which is sometimes fatal. Few cases have been reported from India because, in the diagnosis, fungi are overlooked. Padhye and Thirumalachar (1961) reported two cases of cryptococcal meningitis in Poona. The disease has been recorded from several places in India, particularly in Calcutta by Malik. The fungus is in some way associated with the excreta of pigeons, as shown by Emmons (1955). Excreta from the roosting sites of pigeons in upper floors of buildings contain abundant number of blastospores. The fungus has also been isolated from soil, fruit juice and several other sources. Padhye and Thirumalachar isolated *C. neoformans* from pigeon droppings collected on old roof tops and proved the virulence of isolates by inoculation in mice. Mohapatra failed to isolate any *C. neoformans* in Delhi area from the pigeon droppings.

Histoplasmosis is a rare disease in India, though it has all the potentialities of building up. According to Randhawa *et al.* (1961) there are only two positive cases reported in India where the causal organism *H. capsulatum* was isolated. Lal and Mohapatra (1964) made a detailed study of a case of histoplasmosis inciting ulcer in the oral cavity. *H. capsulatum* has been reported from several countries, and Ajello (1956, 1959) has developed the method of isolating it from the soil. The soil suspension is inoculated intraperitoneally in mice and, after three weeks, the mouse is sacrificed, and the liver and spleen are plated on blood agar containing cyclohexamide and chloramphenicol. At an incubation temperature of 37 °C the yeast phase colonies of *H. capsulatum* begin to grow, indicating the presence of *H. capsulatum* in the soil sample. Work of Emmons (1949, 1953, 1954, 1958) has confirmed the saprophytic nature of *H. capsulatum* and its association with particular habitats. The chicken yard and caves infested with bats have been shown to harbour *H. capsulatum*. The soil with the droppings of chickens and bats is a source of inoculum. Soil beneath trees which shelter sterling also showed presence of *H. capsulatum* (Emmons 1961).

*Aspergillus fumigatus* Fres., *A. niger* Van Tiegh and *A. flavus* Link are saprophytes widely distributed in nature on decaying vegetable matter. *A. fumigatus* has pathogenic potentialities and incites pulmonary infections, and in most of the cases it is a secondary invader. Aspergillosis can be a

major disease under certain conditions. *A. niger* is also an opportunistic fungus overlying infection by tuberculosis. Both *A. niger* and *A. flavus* are associated with otomycosis of the ear. The fungus grows on the cerumen, epithelial scales and detritus, causing irritation, erosion of the tympanic membrane. Impairment of hearing and irritation is of common occurrence. The saprophytic nature of these two *Aspergillus* species is well known. Another instance where these fungi can be of serious nature is in the case of orbital aspergillosis. The fungal infection of the eye follows widespread use of tetracyclines and corticosteroids in the treatment of trachoma.

Another opportunistic fungus which can incite deep mycoses is *Emmonsia ciferina* (Thirumalachar *et al.* 1965). This fungus is a saprophyte growing on damp surfaces during the rainy season. The mycelium can break into arthrospores as in the case of *Coccidioides immitis*, but the cells are more rounded. When either the arthrospores or the conidia are inoculated in mice, or are made to be inhaled, the spores form large acaiospores which are large and thick-walled. Emmons and Jellison (1960) first described these spores in rodents, and Batista *et al.* (1963) in Brazil reported *E. brasiliensis* as pathogenic in man. In the course of investigations of opportunistic fungi forming superimposed infection in tuberculosis patients in Poona, Misra *et al.* (1966) reported the occurrence of *E. ciferina*.

Dermatophytoses include those superficial fungi which infect keratinized tissues like skin, hair and nails. They incite numerous clinical types such as *Tinea pedis* or athlete's foot, *Tinea corporis* or ring-worm of the glabrous skin, *Tinea barbae* or the barber's itch, *Tinea cruris* or dhobi's itch, *Tinea capitis* or ring-worm of the scalp, onychomycosis or infection of the nails and other symptoms. Numerous species belonging to three genera, viz. *Trichophyton*, *Microsporum* and *Epidermophyton*, are included in the causative agents. Etiological aspects of dermatophytes have been reported by several workers in India among whom mention may be made of Behl and Sharma (1957), Kalra *et al.* (1964), and Kandhari and Sethi (1964) from Delhi, Banerjee *et al.* (1959), Ghosh (1948b) from Calcutta, Dasgupta and Shome (1957), Gupta and Shome (1959), Dasgupta *et al.* (1960) from Lucknow, Desai and Bhatt (1961) from Bombay, Gokhale *et al.* (1959), Padhye *et al.* (*in press*) from Poona, Kurup and Ananthanarayan (1961), Klokke and Durairaj (1967) from Kerala, Vasu (1966) from Andhra Pradesh.

In the present paper the main attention is focused on the saprophytic habitat of these dermatophytes. Attempts have been made to isolate these fungi from soil and other habitats. It is well known that dermatophytes have been isolated from floors of showers, locker rooms, towels, etc. In a recent paper Padhye *et al.* (*in press*) summarized the work carried out over a six-year period, where over 1,441 patients were studied critically by isolating the pathogen and noting effects of environmental conditions, etc. Places like



Remand Home Orphanage, police headquarters, municipal schools, etc., offered good material. *Tinea capitis* causing scalp infection became epidemic in children in Remand Home Orphanage. Poor hygienic conditions and malnutrition were some of the predisposing factors. With the exception of *Microsporium gypseum* and *Trichophyton mentagrophytes* which are isolated from soil, the other dermatophytes may be occurring on fragments of keratinaceous material like skin and hairs and on contact with human skin and favourable conditions cause infection.

*Microsporium gypseum* and the keratinophilic fungus *Keratinomyces ajelloi* Vanbreus. are most frequently isolated from soil. Dey and Kokoti (1955) isolated *M. gypseum* in an animal house in Assam. Randhawa *et al.* (1959) Padhye (1961), Mohapatra and Gugnani (1964) isolated it from soil using the hair baiting technique of Vanbreuseghem (1952).

The saprophytic existence of these dermatophytes, coupled with their keratolytic character, has enabled several investigators to gain knowledge about the life-cycles of these organisms. The first break-through came from the work of Stockdale (1961) who described the perfect stage of *M. gypseum* and showed it to be *Nannizzia incurvata*, a member of the Gymnascaceae. Now the genera *Nannizzia* and *Arthroderma* encompass the ascigerous stages of dermatophytes where they are known. The discovery of the perfect stage of *Blastomyces dermatitidis* by McDonough and Lewis (1967) and of *Histoplasma capsulatum* by Ajello and Cheng (1967), both of which turned out to be members of Gymnascaceae, has highlighted the importance of this group in medical mycology. More attention will be paid in coming years to the saprophytic states of these pathogenic fungi both by pure mycologists and the medical men.

#### REFERENCES

- Ajello, L. (1956). Soil as a natural reservoir for human pathogenic fungi. *Science*, **123**, 876-878.
- (1959). *Histoplasma capsulatum*. Soil studies. *Proc. 50th Intern. Bot. Congr. Montreal, Recent Adv. Bot.*, **1**, 317-322.
- Ajello, L., and Shu-Lan Cheng (1967). Sexual reproduction in *Histoplasma capsulatum*. *Mycologia*, **59**, 689-697.
- Andleigh, H. S. (1951). Two rare cases of fungus infection of the skin in Rajasthan, actinomycosis and rhinosporidiosis. *Indian med. Gaz.*, **86**, 100-103.
- Banerjee, A. K., and Basu, N. (1961). Sulfamethoxypyrazine in mycoses due to *Nocardia asteroides* infection. *Bull. Calcutta Sch. trop. Med. Hyg.*, **9**, 67.
- Banerjee, A. K., Rao, A., and Chakraborty, A. N. (1959). Dermatmycoses: a clinical, mycological and therapeutic study. *Symp. on Fungus Diseases in India*, 181-189.
- Banerjee, B. N. (1958). Primary actinomycosis of the skin in tropics. *Indian J. Derm.*, **3**, 8-13.
- Baylet, J., Camain, R., and Segretain, G. (1959). Identification des agents des maduramycoses du Senegal et de la Mauritanie. *Bull. Soc. Path. exot.*, **52**, 448-477.
- Behl, P. N., and Sharma, M. D. (1957). Incidence of mycotic infections in Delhi. *Indian J. Derm.*, **3**, 5-7.
- Beurmann, L., and Gougerot, H. (1911). *Archs Parasitol.*, **15**, 5-109.

- Borelli, D. (1959). *Pyrenochaeta romeroi* n. sp. *Rev. Derm. Venezolana*, **1**, 1-3.
- Dasgupta, S. N., and Shome, S. K. (1959). Studies on medical mycology. I. On the occurrence of mycotic diseases in Lucknow. *Mycopath. Mycol. appl.*, **10**, 177-186.
- Dasgupta, S. N., Shome, S. K., and Majumdar, S. S. (1960). Medical mycology in India. *Mycopath. Mycol. appl.*, **13**, 339-376.
- Desai, S. C., and Bhatt, M. L. A. (1961). Dermatomycoses in Bombay. A study of incidence clinical features, incriminating species of dermatophytes and their epidermicity. *Indian J. med. Sci.*, **49**, 662-671.
- Dey, N. C. (1959). Solitary sporotrichosis granuloma. *Bull. Calcutta Sch. trop. Med. Hyg.*, **7**, 39.
- Dey, N. C., and Kakoti, L. M. (1955). *Microsporium gypseum* in India. *J. Indian med. Ass.*, **25**, 160-164.
- Emmons, C. W. (1944). *Alescheria boydii* and *Monosporium apiospermum*. *Mycologia*, **36**, 188-193.
- (1949). Isolation of *Histoplasma capsulatum* from soil. *Publ. Hlth. Rep. Wash.*, **64**, 842-846.
- (1953). The natural occurrence in animals and soil of fungi which cause diseases in man. *Proc. 7th Intern. Bot. Congr. Stockholm*. Almquist and Wickell. **1**, 416-418.
- (1954). The significance of saprophytes in the epidemiology of the mycoses. *Trans. N.Y. Acad. Sci.*, **17**, 157-166.
- (1955). The Isolation of *Cryptococcus neoformans* from Pigeon Droppings. Therapy of Fungus Diseases, Ed. T. H. Sternberg and V. D. Newcomer. Little Brown Co., Boston, 302-307.
- (1958). Association of bats with histoplasmosis. *Publ. Hlth. Rep. Wash.*, **73**, 590-595.
- (1961). Isolation of *Histoplasma capsulatum* from soil in Washington. *Publ. Hlth. Rep. Wash.*, **64**, 892-896.
- Emmons, C. W., Binford, C. H., and Utz, J. P. (1964). Medical Mycology. Lea & Febiger, U.S.A., 380 pp.
- Emmons, C. W., and Jellison, W. L. (1960). *Emmonsia crescens* n. sp. and Adiaspiromycosis (Haplomycosis) in mammals. *Ann. N.Y. Acad. Sci.*, **89**, 91-101.
- Emmons, C. W., Lie-Kian-Joe, Njo-Injo-Tjoe-Eng, Pohan, A., Kertopati, S., and Van der Meulen, A. (1957). *Basidiobolus* and *Cercospora* from human infections. *Mycologia*, **49**, 1-10.
- Gaind, M. L., Padhye, A. A., and Thirumalachar, M. J. (1962). Madura foot in India caused by *Cephalosporium infestans* n. sp. *Sabouraudia*, **1**, 230-233.
- Ghosh, L. M. (1948a). An unusual case of sporotrichosis. *Indian med. Gaz.*, **67**, 570.
- (1948b). An analysis of 50,000 skin cases seen in the Outpatient Department of the School of Tropical Medicine, Calcutta, during the years from 1942 to 1946. *Indian med. Gaz.*, **83**, 493-501.
- Gokhale, B. B., Padhye, A. A., and Thirumalachar, M. J. (1959). Incidence of dermatophytes in patients examined at Sassoon Hospital, Poona. *Symp. on Fungus Diseases in India*, 100-107.
- Greer, D. L., and Friedman, L. (1966). On the genus *Basidiobolus* with reclassification of the species pathogenic to man. *Sabouraudia*, **4**, 231-241.
- Gupta, R. N., and Shome, S. K. (1959). Dermatophytes in Uttar Pradesh. *Indian J. med. Ass.*, **33**, 39-42.
- Kalra, S. L., Mohapatra, L. N., and Gugnani, H. C. (1964). Etiology of dermatophytes in Delhi. *Indian J. med. Res.*, **52**, 553-558.
- Kandhari, K. C., and Sethi, K. K. (1964). Dermatophytes in Delhi area. *Indian J. med. Ass.*, **42**, 324-326.
- Klokke, A. H. (1964). Mycetoma in North India due to *Nocardia brasiliensis*. *Trop. geogr. med.*, **1**, 170-171.
- Klokke, A. H., and Durairaj, P. (1967). The causal agents of superficial mycoses isolated in rural area in South India. *Sabouraudia*, **5**, 153-158.
- Kurup, P. V., and Ananthanarayan, R. (1961). A preliminary study of 148 cases of dermatophytosis. *Indian Practnr.*, **14**, 33-41.

- Lal, H. B., and Mohapatra, L. N. (1964). Histoplasmosis in India (case report). *Mycopath. Mycol. appl.*, **22**, 65-72.
- McDonough, E. S., and Lewis, A. L. (1967). *Blastomyces dermatitidis*. Production of sexual stage. *Science*, **156**, 3374.
- Meenakshi, L. V., Balakrishnan, P., Kannankutty, M., and Ananthanarayan, R. (1966). Chromoblastomycosis—a short review with report of a case. *Indian Practnr.*, **19**, 449-452.
- Misra, S. P., Shende, G. Y., Yerwadekar, S. N., Padhye, A. A., and Thirumalachar, M. J. (1966). *Allescheria boydii* and *Emmonsia ciferriana* isolated from patients with chronic pulmonary infections. *Hindustan Antibiot. Bull.*, **9**, 99-103.
- Mohapatra, L. N. (1966). Indian Council of Medical Research Yearly Report.
- Mohapatra, L. N., Grueber, H. L. E., and Sood (*in press*). Chromoblastomycosis in India.
- Mohapatra, L. N., and Gujnani, H. C. (1964). Studies on the strains of *Microsporium gypseum* isolated from soil. *Mycopath. Mycol. appl.*, **22**, 175-181.
- Padhye, A. A. (1961). *Microsporium gypseum* from Soil in Poona. Prof. Agharkar Commem. Vol. Prakash Press, Poona, 117-119.
- Padhye, A. A., and Thirumalachar, M. J. (1961). *Cryptococcus neoformans* from patients in Poona. *Curr. Sci.*, **30**, 180.
- (*in press*). Distribution of *Allescheria boydii* in soil in Maharashtra.
- Padhye, A. A., Sukapure, R. S., and Thirumalachar, M. J. (1962). *Cephalosporium madurae* n. sp. cause of madura foot in India. *Mycopath. Mycol. appl.*, **16**, 315-322.
- Padhye, A. A., Thirumalachar, M. J., and Gokhale, B. B. (*in press*). Dermatophytoses in Poona, India. Observation on the incidence, clinical features, environmental factors and causal agents studied during 1956-63 at Sassoon Hospital, Poona. *Mycopath. Mycol. appl.*
- Panja, G., and Dey, N. C. (1947). Sporotrichosis of skin in India. *Indian med. Gaz.*, **82**, 200-202.
- Pawar, V. H., and Thirumalachar, M. J. (1965). *Cladosporium werneckii* isolated from marine habit. *Hindustan Antibiot. Bull.*, **8**, 19-20.
- Pawar, V. H., Padhye, A. A., and Thirumalachar, M. J. (1963). Isolation of *Monosporium apiospermum* from marine soil in Bombay. *Hindustan Antibiot. Bull.*, **6**, 50-53.
- Rajam, R. V., Kandhari, K. C., and Thirumalachar, M. J. (1958). Chromoblastomycosis caused by a rare yeast-like dematiaceous fungus. *Mycopath. Mycol. appl.*, **9**, 5-19.
- Rajam, R. V., Viswanathan, G. S., Rao, A. R., Rangiah, P. N., and Anguli, V. C. (1955). Rhinosporidiosis—a study with report of a fatal case of systemic dissemination. *Indian J. Surg.*, **17**, 1-30.
- Randhawa, H. S., Nath, A., and Viswanathan, R. (1959). Isolation of *Microsporium gypseum* (Bodin) Guiart and Grigorkis from soil in Delhi. *Sci. Cult.*, **25**, 326-327.
- Randhawa, H. S., Sandhu, R. S., and Viswanathan, R. (1961). Medical mycology in India. A review of work done since 1910. *Indian J. Chest Dis.*, **3**, 33-49.
- Rao, K. N., Thirumalachar, M. J., and Padhye, A. A. (*in press*).
- Sanyal, M., and Basu, N. (1964). On the etiology of mycetoma cases. *Bull. Calcutta Sch. trop. Med. Hyg.*, **12**, 115-118.
- Shende, H. Y., Gogte, M. C., Padhye, A. A., and Thirumalachar, M. J. (1965). Hamycin in the treatment of pulmonary candidiasis complicating tuberculosis. *Hindustan Antibiot. Bull.*, **8**, 51-58.
- Srinivasan, M. C., and Thirumalachar, M. J. (1965). *Basidiobolus* species pathogenic for man. *Sabouraudia*, **4**, 32-34.
- (1968). On the identity of human pathogenic *Basidiobolus*. *Hindustan Antibiot. Bull.*, **10**, 190-193.
- Stockdale, P. M. (1961). *Nannizzia incurvata* gen et sp. nov., a perfect state of *Microsporium gypseum* (Bodin) Guiart and Grikias. *Sabouraudia*, **1**, 41-48.
- Sukapure, R. S., and Thirumalachar, M. J. (1966). Conspectus of species of *Cephalosporium* with particular reference to Indian species. *Mycologia*, **58**, 351-361.
- Thirumalachar, M. J., Padhye, A. A., and Srinivasan, M. C. (1965). *Emmonsia ciferriana*, a new species from India. *Mycopath. Mycol. appl.*, **26**, 323-332.

- Vanbreuseghem, R. (1952). Technique biologique pour l'isolement des dermatophytes du sol. *Ann. Soc. belge. Med. trop.*, **32**, 173-178.
- Vanbreuseghem, R., Thys, A., and Henrot, L. (1955). Troisième cas Congolais de rhinosporidiose. *Ann. Soc. Belge Med. Trop.*, **35**, 225-228.
- Vasu, D. R. (1966). Studies in medical mycology. Part I. Incidence of dermatophytes in Warangal (A.P.), India. *Indian J. med. Res.*, **54**, 468-474.