Review Article

Mycoses of implantation in Latin America: an overview of epidemiology, clinical manifestations, diagnosis and treatment

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Implantation or subcutaneous mycoses are a frequent health problem in Latin American countries and other tropical and subtropical areas. Although such infections rarely cause disseminated or invasive disease, they have an important impact on public health, and timely diagnosis and appropriate treatment remain important. Although some implantation mycoses are found in immunocompromised persons, the immunocompetent population is the principal target in Latin America. Most etiologic agents are found in soil, vegetation, and decaying matter in tropical, subtropical, and humid environments and infection is commonly the result of penetrating injury. Infections primarily occur (1) among low socioeconomic groups, (2) among those living in rural areas or involved in farming, hunting, or other outdoor activities, and (3) particularly among adult men. This review focuses on the epidemiology of the most clinically significant implantation mycoses in Latin America, i.e., sporotrichosis, eumycetoma, chromoblastomycosis, subcutaneous phaeohyphomycosis, subcutaneous zygomycosis, and lacaziosis. Main epidemiologic findings, clinical manifestations, diagnosis, and treatment options are also discussed.

Keywords subcutaneous mycoses, endemic mycoses, posaconazole, itraconazole

Introduction

Implantation mycoses include a heterogeneous group of fungal diseases that develop at the site of transcutaneous trauma. They are also known as ‘subcutaneous mycoses’, but some of them (sporotrichosis and mycetoma) may also involve muscles, fascia, cartilage and bones, beyond the skin and the subcutaneous tissues. These infections are a frequent health problem in Latin American countries and other tropical and subtropical areas [1]. Although such infections rarely cause disseminated or invasive disease, they have an important impact on public health, may be difficult to control, and often recur [2,3]. The objective of this paper was to review the epidemiology of the most clinically significant implantation mycoses in Latin America, i.e., sporotrichosis, eumycetoma, chromoblastomycosis, subcutaneous phaeohyphomycosis, subcutaneous zygomycosis, and lacaziosis. An overview of these implantation mycoses with respect to the populations typically affected, main clinical manifestations, and suggestions for diagnosis and treatment is presented in Table 1. Data particularly supporting the potential use of some newer antifungal agents in the treatment of some of these infections are presented in Table 2.

Sporotrichosis

Sporotrichosis is caused by Sporothrix schenckii, a thermally dimorphic fungus that grows optimally in the presence of...
Lymphocutaneous:
Itraconazole 200 mg/d po for 2–4 wk after lesions resolve, usually for total of 3–6 mo
Nonresponders:
Itraconazole 200 mg po bid, terbinafine 500 mg po bid, SSKI
Culture:
Intradermal sporotrichin 40-50 drops tid, fluconazole 400-800 mg/d po (only in patients who cannot tolerate other agents)
Surgery and antifungal therapy with skin test (in endemic areas); tube and latex particle agglutination (not widely available) [8,29,89]; Montenegro skin test to distinguish from cutaneous leishmaniasis [90]
Options for other clinical presentations:
Surgery effective in early stages; itraconazole (50–100 mg/d), terbinafine (500 mg/d) plus posaconazole (400 mg po bid) in patients with disease refractory to itraconazole or who are intolerant of itraconazole [26,30,94]

<table>
<thead>
<tr>
<th>Disease</th>
<th>Population typically affected</th>
<th>Main clinical manifestations</th>
<th>Suggestions for diagnosis</th>
<th>Treatment</th>
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</thead>
<tbody>
<tr>
<td>Sporotrichosis</td>
<td>Lymphocutaneous: immunocompetent persons engaged in agriculture, gardening, mining, or other outdoor activities; zoonotic spread from infected domestic cats or scratches from digging animals such as armadillos; variable sex and age distribution</td>
<td>Lymphocutaneous: chronic subcutaneous nodular lesion arising at site of minor skin trauma and spreading proximally along lymphatic channels</td>
<td>Culture: intradermal sporotrichin skin test (in endemic areas); tube and latent particle agglutination (not widely available) [8,29,89]; Montenegro skin test to distinguish from cutaneous leishmaniasis [90]</td>
<td>Itraconazole 200 mg/d po for 2–4 wk after lesions resolve, usually for total of 3–6 mo</td>
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<tr>
<td>Eumycetoma</td>
<td>Men aged 20–40 who work as herders, farmers, or other field laborers [26]; increasingly in travelers to tropical endemic areas [3]</td>
<td>Local chronic, progressive, multifrustulous, suppurative, tumoral lesions discharging grains. Infection involves cutaneous and subcutaneous tissues, fascia, and eventually muscle and bone [29]</td>
<td>Observation of grain color and texture; deep surgical biopsies containing grains that can be cultured or fixed for histopathology: immunodiffusion, ELISA, PCR with DNA sequencing; MRI or CT to determine bone involvement [2,3,26,46,93]</td>
<td>Surgery and antifungal therapy with itraconazole (400 mg po) or ketoconazole (400-800 mg/d po), often given for 7–12 mo; posaconazole (400 mg po bid) in patients with disease refractory to itraconazole or who are intolerant of itraconazole [26,30,94]</td>
</tr>
<tr>
<td>Chromoblastomycosis</td>
<td>Usually in men aged 30–50 who work as farm laborers, lumberjacks, or sellers of farm products; affected persons usually poor, without adequate protective footwear and clothing [37,42]</td>
<td>Slowly progressive disorder usually limited to the skin and subcutaneous layer in which initial erythematous papular lesions may gradually evolve to display varying morphologies, such as nodular, tumoral (cauliflower-like), plaque, verrucous, and cicatricial lesions; affects feet and legs most frequently; may transform into squamous cell carcinoma [3,42]</td>
<td>Microscopic finding of muriform cells (sclerotic bodies) is the hallmark of this disease. Examination of scrapings or vinyl adhesive tape preparations, wet mount, histology, culture [37,95–98]</td>
<td>Surgery effective in early stages; itraconazole (100–400 mg/d), terbinafine (250–500 mg/d), terbinafine (500 mg/d) plus itraconazole (50–100 mg/d); combination therapy (itraconazole with terbinafine or 5-flucytosine) for severe cases, posaconazole (400 mg po bid) in patients with disease refractory to itraconazole or who are intolerant of itraconazole; cryotherapy [3,37–41,94,99]</td>
</tr>
<tr>
<td>Phaeohyphomycosis</td>
<td>Occurs sporadically, often in older men who work in farming, carpentry, or other occupations that expose them to plant materials; usually occurs in both immunocompetent and in immunocompromised persons [48,50]</td>
<td>Chronic localized infection of deep dermis and subcutaneous tissues; single asymptomatic mass or nodule at trauma site gradually evolving to form painless cystic abscesses; erythematous plaques possibly also present; lesion usually remaining localized with overlying skin staying intact Most common sites of infection: feet, legs, hands, arms, head [48,49]</td>
<td>Microscopic examination of biopsy material from cyst, with hematoyxin-eosin or Fontana-Masson staining; culture; PCR [2,95,96,100]</td>
<td>Complete surgical excision; itraconazole (100-600 mg/d), amphothericin B (0.5–1 mg/kg/d), often for several months; immunosuppressant doses reduced if feasible [48,49,5,163] Posaconazole for patients with disease refractory to other agents</td>
</tr>
<tr>
<td>Subcutaneous zygomycosis</td>
<td>Infections usually caused by Entomophthorales, Basidiobolus ranarum, and Conidiobolus coronatus; usually in immunocompetent persons;</td>
<td>Basidiobolomyces: usually has chronic progressive clinical course; hard nodules that spread, often over thighs and buttocks, eventually</td>
<td>Histology: Wide sparse septated, thin-walled hyphae with right-angle branching, Splendore-Hoepli phenomenon present with</td>
<td>No standard treatment defined for entomophthoromyces (basidiobolomyces or conidiobolomyces)</td>
</tr>
</tbody>
</table>
Conidiobolomycosis: begins with swelling of inferior nasal turbinates and extends to facial and subcutaneous tissues and paranasal sinuses; eventually, subcutaneous nodules attach to underlying tissues, causing facial disfigurement [68,77,78].

Lacaziosis

Men aged 21–40 who live in tropical rain forests and work as farmers, miners, hunters, and rubber workers [3,83].

Very slow evolution over many years; small papules or pustules that evolve into keloid-like lesions, which gradually increase in size; pinna of the ear most commonly affected; original lesion followed by involvement of other areas by subsequent abrasion/autoinoculation; nodule distribution follows lymphatic system [3,29,101].

Direct microscopy of tissue smear from lesion, examination of vinyl adhesive tape preparation; cannot be cultured. Serologic tests: have high sensitivity but lack specificity because of antigenic cross-reactivity with Paracoccidioides [3,97].

Wide surgical excision, electrodessication in early stage of disease, cryosurgery; clofazimine (300 mg/d until clinical improvement, then 100 mg/d for ≥2 y) Amphotericin B, 5-fluorocytosine, and azoles usually ineffective, but patient with disseminated disease undergoing treatment with itraconazole (200 mg/d) [3,84,86].

Sporotrichosis

Inhabitants and others whose occupational involvement involves cat care have been reported from 1997–1999 in this region was 98 cases per 100,000 persons, with a mean incidence of 156 cases in children aged <15 years [17]. Higher socioeconomic status in this region was associated with a lower incidence of infection [17]. Patients with AIDS or other causes of immunodeficiency such as chronic alcoholism and diabetes are at risk for developing cutaneous sporotrichosis [11–15]. Although sporotrichosis has been reported throughout the world, endemic areas are usually considered to be Latin America, South Africa, India, and Japan (Table 3). There is no uniform prevalence of disease by age or sex; sporotrichosis generally occurs sporadically in outdoor activities.
Table 2 Data supporting potential use of newer antifungals voriconazole, posaconazole, and the echinocandins in the treatment of subcutaneous mycoses.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Supporting data</th>
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<tbody>
<tr>
<td><strong>Voriconazole</strong></td>
<td><strong>Chromoblastomycosis:</strong> potent in vitro activity against Cladophialaphora carrionii (MIC\text{mean} = 0.125 μg/ml), Fonsecaea pedrosoi (G\text{mean} MIC = 0.08 μg/ml), and Phialophora verrucosa (G\text{mean} MIC = 0.12 μg/ml) [100,101]; resolved refractory chromoblastomycosis caused by F. pedrosoi in 43-year-old man with diabetes [104]</td>
</tr>
<tr>
<td><strong>Sporotrichosis</strong></td>
<td>moderate/low in vitro activity against Sporothrix spp. (G\text{mean} MIC = 1.9–13.2 μg/ml) [105–107]</td>
</tr>
<tr>
<td><strong>Phaeohyphomycosis/eumycetoma</strong></td>
<td>in vitro activity against Exophiala jeaneselmei (G\text{mean} MIC = 0.6 μg/ml), Exophiala dermatitidis (G\text{mean} MIC = 0.02 μg/ml), Alternaria alternata (G\text{mean} MIC = 0.63 μg/ml) [103], Scedosporium apiospermum (MIC\text{mean} = 0.125 μg/ml) [108], and Madurella mycetomatis (G\text{mean} MIC = 0.05 μg/ml) [103]; successfully treated cutaneous S. apiospermum infections [109,110]</td>
</tr>
<tr>
<td><strong>Posaconazole</strong></td>
<td><strong>Chromoblastomycosis:</strong> approved to treat refractory chromoblastomycosis in Europe [94]; in vitro activity against Phialophora spp. (G\text{mean} MIC = 0.4 μg/ml) [109]; successfully treated 5 of 6 patients with refractory chromoblastomycosis caused by F. pedrosoi [112]</td>
</tr>
<tr>
<td><strong>Sporotrichosis:</strong></td>
<td>in vitro activity against Sporothrix spp. greater than that of intraconazole, voriconazole, amphotericin B, caspofungin, and anidulafungin (G\text{mean} MIC = 0.7–1.59 μg/ml) [105,111]</td>
</tr>
<tr>
<td><strong>Phaeohyphomycosis:</strong></td>
<td>successfully treated a patient with chronic disease caused by Alternaria spp. that was refractory to voriconazole, amphotericin B, and caspofungin [113]; also effective in a mouse model of disseminated disease caused by E. dermatitidis [114]; successfully treated disseminated respiratory infections caused by Ramichloridium mackensi [115], and Espinifera [116]</td>
</tr>
<tr>
<td><strong>Eumycetoma</strong></td>
<td>approved to treat refractory eumycetoma in Europe [94]; potent in vitro activity against E. jeaneselmei and E. oligosperma (MIC\text{mean} = 0.031 μg/ml for both species) [117]; in vitro activity against S. apiospermum (MIC range = 0.5–2 μg/ml) [118]; successfully treated 5 of 6 patients with refractory eumycetoma caused by M. grisea, M. mycetomatis, and S. apiospermum [112]</td>
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<tr>
<td><strong>Zygomycosis</strong></td>
<td>in vitro activity against clinical species of Zygomycetes greater than that of intraconazole, voriconazole, and flucanazole [119,120]; successfully treated refractory subcutaneous zygomycosis caused by Rhizopus oryzae [121,122]; also successful as salvage therapy in disseminated zygomycosis [123]</td>
</tr>
<tr>
<td><strong>Echinocandins</strong></td>
<td><strong>Chromoblastomycosis:</strong> micafungin has some in vitro activity (MIC = 2 μg/ml) [123] and caspofungin has potent in vitro activity (G\text{mean} MIC = 0.13 μg/ml) [124] against F. pedrosoi</td>
</tr>
<tr>
<td><strong>Sporotrichosis</strong></td>
<td>moderate in vitro activity against S. schenckii. (Caspofungin and anidulafungin G\text{mean} MIC = 5.4 and 3.9 μg/ml, respectively) [111]</td>
</tr>
<tr>
<td><strong>Phaeohyphomycosis</strong></td>
<td>caspofungin has potent in vitro activity against Alternaria spp. (MIC range ≥ 0.12 μg/ml); micafungin has moderate in vitro activity against E. dermatitidis (MIC range = 1.0–&gt; 8 μg/ml) [118]</td>
</tr>
<tr>
<td><strong>Eumycetoma</strong></td>
<td>in vitro activity against E. jeaneselmei and E. oligosperma (caspofungin and anidulafungin MIC\text{mean} = 4 and 0.5 μg/ml, respectively, for both species [117]; caspofungin G\text{mean} MIC = 1.10 μg/ml against E. jeaneselmei) [124]; micafungin has moderate in vitro activity against Exophiala spp. (MIC = 0.25–2 μg/ml) [123]; caspofungin has potent in vitro activity against S. apiospermum (G\text{mean} MIC = 0.38 μg/ml) [124]; anidulafungin and caspofungin show moderate activity against S. apiospermum (MIC range = 1–4 μg/ml and 0.25–4 μg/ml, respectively), and micafungin shows in vitro activity against S. apiospermum (MIC range = &gt;8 μg/ml) [119]</td>
</tr>
<tr>
<td><strong>Zygomycosis</strong></td>
<td>caspofungin and micafungin showed poor in vitro activity against clinical Zygomycetes [120,123,125]</td>
</tr>
</tbody>
</table>

G\text{mean} geometric mean; MIC, minimum inhibitory concentration.

Sporotrichosis has been found in the central region of Mexico, with the highest incidences during the cold and dry seasons. However, its overall incidence has been decreasing, probably because of a general improvement in nutrition and living conditions [10].

Sporotrichosis has also been reported in Uruguay and Venezuela [10]. In Uruguay, 80.5% of cases have been attributed to armadillo hunting, especially around the Easter holidays [10]. In contrast, the first isolation of S. schenckii in Venezuela was reported in 2007 and was from an environmental source [25].

Eumycetoma

Mycetoma is a chronic granulomatous infection caused by fungi (eumycetoma) and bacteria (actinomycetoma) [26]. Agents of mycetoma are classified according to their biologic characteristics and grain aspects (color, size, hardness, shape) [27]. There are at least two dozen species of fungi-causing eumycetoma throughout the world, but the most prevalent causative specie (approximately 70% of reported cases) is Madurella mycetomatis, which is associated with black-grain mycetomas [27,28]. Scedosporium apiospermum, responsible for approximately 10% of reported eumycetoma cases, produces white grains in tissues (Fig. 2) [27]. Other etiologic agents include Madurella grisea, Acremonium falciforme, A. kiliense, A. recifei, Cylindrocarpon cyanescens, C. destructans, Exophiala jeaneselmei, Scytalidium dimidiatum, Aspergillus nidulans, Neotestudina rosatti, Leptosphaeria senegalensis, Pyrenochaeta romeroi, and Phialophora verrucosa [1,26,27,29]. Eumycetoma generally occurs in a 5:1 ratio of men to women and in adults aged 20–40 years [26,29]. The disease is most commonly seen in herders, farmers, and other field laborers [26].

Worldwide, the prevalence rates of eumycetoma and actinomycetoma are similar, but eumycetomas are more common in Africa and Asia (especially India), whereas actinomycetomas are more common in Latin America [30]. The mycoses generally prevail in the ‘mycetoma belt’, which
Chromoblastomycosis

Chromoblastomycosis, or chromomycosis, is a chronic cutaneous and subcutaneous mycotic infection developing at the site of a previous transcutaneous trauma [37–39]. The disease is characterized by the development of verru- cose plaques, scaly lesions, and the presence of muriform cells (sclerotic bodies; Fig. 3) [37,38–40]. Several dematiaceous fungi are involved with the disease etiology, most commonly Fonsecaea pedrosoi and Cladorhizomphala carrionii [38,39]. More than 70% of cases are indigenous to tropical and subtropical climates [37]. F. pedrosoi is found in humid tropical zones or in wet areas within torrid zones, whereas C. carrionii is usually the predominant pathogen in dry or semidesert regions [29,37]. Less-frequent causative pathogens include P. verrucosa, Rhinocladiella aquaspersa, E. dermatitidis and F. monophora [38,40]. E. jeanselmei and E. spinifera also have been found forming muriform cells in typical chromoblastomycosis lesions and are therefore also considered etiologic agents of chromoblastomycosis [38,39].

Chromoblastomycosis-causing fungi are found worldwide in soil and decaying plant materials, including wood [7]. Table 4 shows details of transcutaneous traumas leading to cases of chromoblastomycosis in 32 Brazilian patients; most cases of implantation trauma (18/32) were caused by plant material. Chromoblastomycosis is considered an occupational disease, occurring in farm laborers, lumberjacks, or vendors of farm products [37,38,41]. Affected persons are usually poor and lack adequate protective footwear and clothing. Chromoblastomycosis rarely occurs before adolescence with most patients being 30-
50-year-old men, with male-to-female ratios of 5:1 and 9:1 reported [37,42].

Although the highest reported prevalence rates of chromoblastomycosis are in Madagascar, South Africa, Brazil, and Costa Rica, the disease has also been reported in other Latin American countries, the United States, Asia, some European countries, and other parts of Africa [37]. In Latin America, the infection also occurs in Mexico, Venezuela, the Dominican Republic, Cuba, Colombia, and Brazil, with a small number of cases being reported in Puerto Rico, Peru, Ecuador, and Argentina [29,43].

In Brazil, the mean annual numbers of cases of chromoblastomycosis reported were 6.4 (71 cases/11 years) for Paraná (South Region), 5.9 (325 cases/55 years) for Pará (North Region), 4.3 (13 cases/3 years) for Maranhão (Northeast Region), and 2.6 (73 cases/28 years) for Rio Grande do Sul (South Region) [1]. Of the 78 causative agents identified in a retrospective study of 325 cases reported in Pará from 1942–1997, 77 were F. pedrosoi [42]. This fungus was also the causative organism in 9 of 13 patients treated in Maranhão between 1988 and 1991 [44].

A potentially important source of infection in the Amazon Region of Maranhão is the harvesting and processing of the Babassu coconut, whose shells may be colonized by F. pedrosoi [45].

After mycetoma and sporotrichosis, chromoblastomycosis is the third most frequent type of cutaneous mycosis in Mexico [7]. It is mostly found in the states of Chiapas, Oaxaca, Veracruz, Guerrero, and Tabasco, all of which have a tropical or subtropical climate [37]. At the General Hospital of Mexico, in Mexico City, of 51 infections treated over 17 years, 48 (90%) were caused by F. pedrosoi, and most patients came from warm, humid rural areas along the Gulf of Mexico or the Pacific Ocean [46].

In the semiarid states of Venezuela, the most prevalent causative organism is C. carrionii, especially in men who care for goats [29]. From 1992–2004, 22 children and adolescents (aged 2–19 years) living in the semiarid zone of Falcón state were diagnosed with chromoblastomycosis caused by C. carrionii [47]. However, in more humid states, including Táchira, Trujillo, Mérida, and Miranda, most cases were caused by F. pedrosoi [29].
In Ecuador and especially in rural areas of Colombia, the majority (≥95%) of cases of chromoblastomycosis were caused by *F. pedrosoi* [29]. Similarly, in Cuba, in the Dominican Republic, and throughout Central America, more than 80% of infections were caused by *F. pedrosoi* and occurred in men living in rural areas [29].

**Subcutaneous phaeohyphomycosis**

Subcutaneous phaeohyphomycosis is included in the spectrum of diseases caused by melanin-pigmented black fungi. The most frequently reported type of subcutaneous phaeohyphomycosis is a chronic localized infection of the deep dermis and subcutaneous tissues [48]. It is usually the result of traumatic implantation of fungi into subcutaneous tissue and has an unknown incubation period [48]. Phaeohyphomycosis is caused by dematiaceous fungi that can be found in decaying wood and plants [49], most commonly by *E. jeaneselmei*, *E. moniliae*, *E. spinifera*, *Phialophora* (*Phaeoacleromium*) spp., *Bipolaris* spp., and *Exophiala* (*Wangiella*) dermatitidis [46,50–53], and less commonly by *Veronaea botryose* [54], *Exserohilum rostratum* [55], *Colletotrichum crassipes* [56], and *Phoma cava* [57]. Infections occur sporadically, often in older adult men who work as farmers, carpenters, or other occupations that expose them to plant materials [50]. Most phaeohyphomycosis infections occur in immunocompetent persons but with the rising number of iatrogenically immunosuppressed persons, infections have been increasingly reported in immunocompetent persons, but the causative organisms often could not be identified because specimens had been fixed in formalin [58,59]. In other cases, etiologic agents included *E. spinifera* [60], *Cyphellophora pluriseptata* [61], and *B. hawaiiensis* [62]. Case reports of phaeohyphomycosis in Brazil have also involved solid organ transplant recipients and other immunocompromised persons, with infections caused by *E. jeaneselmei* [63,64], *Phaeoacremonium parasiticum* [53], *Cladophialophora* spp. [65], *C. crassipes* [56], and *P. cava* [57].

In El Salvador, one case of phaeohyphomycosis was reported in a 6-year-old immunocompetent boy with extensive lesions caused by *E. spinifera* [67]. At a hospital in Medellin, Colombia, infections due to *Exophiala* spp. and unidentified dematiaceous moulds were reported in five renal transplant recipients, representing a prevalence of subcutaneous phaeohyphomycosis in these patients of 0.34% [67].

**Subcutaneous zygomycosis**

Subcutaneous zygomycosis, or entomophthoromycosis, is usually caused by members of the order Entomophthorales, especially *Basidiobolus ranarum* (formerly *B. haptosporus*) and *Conidiobolus coronatus* [68]. Species of the Entomophthorales are distributed worldwide but are endemic in tropical areas, with most infections occurring in countries situated between 15° north and 15° south latitudes [68,69]. *Basidiobolus* and *Conidiobolus* spp. are most commonly found in tropical climates [68]. *Basidiobolus* spp. are associated with decaying vegetation, insects, wood lice, and the feces of many animals. *Conidiobolus* spp. are found in soils and plant detritus, especially in warm, wet climates [68].

Infections caused by the Entomophthorales usually occur in immunocompetent persons, in contrast to rare cases of subcutaneous infection caused by members of the order Mucorales, which often affect immunosuppressed persons [70]. Conidiobolomycosis usually occurs in men engaged in agricultural and other types of outdoor work, with an 8:1 ratio of infected men to women [70]. Basidiobolomycosis usually occurs in children under age 10 and is more common in boys [70].

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Table 4  Details of subcutaneous traumas leading to chromoblastomycosis in 32 Brazilian patients.

<table>
<thead>
<tr>
<th>Type of trauma</th>
<th>Number of cases</th>
</tr>
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<tbody>
<tr>
<td>Plant</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>9</td>
</tr>
<tr>
<td>Straw</td>
<td>2</td>
</tr>
<tr>
<td>Grass</td>
<td>2</td>
</tr>
<tr>
<td>Thorn</td>
<td>2</td>
</tr>
<tr>
<td>Palm tree</td>
<td>1</td>
</tr>
<tr>
<td>Bamboo</td>
<td>1</td>
</tr>
<tr>
<td>Spiny seed</td>
<td>1</td>
</tr>
<tr>
<td>Animal</td>
<td></td>
</tr>
<tr>
<td>Insect sting</td>
<td>2</td>
</tr>
<tr>
<td>Buck rear</td>
<td>1</td>
</tr>
<tr>
<td>Cock spine</td>
<td>1</td>
</tr>
<tr>
<td>Caterpillar</td>
<td>1</td>
</tr>
<tr>
<td>Agricultural tool</td>
<td></td>
</tr>
<tr>
<td>Hoe</td>
<td>2</td>
</tr>
<tr>
<td>Axe</td>
<td>1</td>
</tr>
<tr>
<td>Knife</td>
<td>1</td>
</tr>
<tr>
<td>Mill</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>2</td>
</tr>
<tr>
<td>Brick</td>
<td>1</td>
</tr>
<tr>
<td>Shoes</td>
<td>1</td>
</tr>
</tbody>
</table>

Most cases in Latin America have been reported in Brazil, but infections have also been described in Costa Rica, Colombia, and Puerto Rico (Fig. 5) [68,70]. In Brazil, the majority of cases were found in the coastal areas of the Northeast Region [69]. B. ranarum infections have been documented in children living in the Northeast Region [71–73] and in a 43-year-old male farmer from the Southeast Region [74]. Case reports of C. coronatus infections were reported in adults living in the Northeast and Central-West Regions [69,70,76], whereas an infection due to Mucor hiemalis was noted in a 78-year-old male gardener with diabetes (residence unknown) [77] and another case due to Rhizopus oryzae was described in a 61-year-old man with diabetes from the South Region [78].

Lacaziosis

Lacaziosis, or lobomycosis, is caused by Lacazia loboi (formerly called both Loboa loboi and Paracoccidioides loboi), a fungal pathogen that affects humans and dolphins [79,80]. This fungus has never been isolated in cultures. In most cases, the agent is probably introduced directly into the dermis through a penetrating entry, such as an insect bite or thorn prick [3]. Although the natural reservoir of L. loboi is unknown, its likely habitat is somewhere in the rural environment, with soil and vegetation likely sources of infection [3]. Lacaziosis usually occurs in inhabitants of tropical, humid, or subtropical forests with elevations greater than 200 meters, an average temperature of 24°C, and more than 200 cm of annual rainfall [3].

Nearly all cases of lacaziosis have been reported in Latin America, but isolated cases have also been seen in Europe, the United States, and Canada, usually in persons with a history of travel to Latin America or contact with dolphins [3,81,82]. Lacaziosis generally affects men aged 21–40 who work as farmers, miners, hunters, or as rubber workers [3,83].

Within Latin America, the great majority of cases of lacaziosis have been reported in the Amazon rain forest (Brazil, Ecuador, Colombia, Venezuela, French Guyana, Guyana, and Suriname), but cases have also been described in Peru, Bolivia, Mexico, Costa Rica, and Panama (Fig. 6) [3,84]. In an analysis of 304 reported cases published in 1993, 58% were from Brazil, 13% from Colombia, and 10% from Suriname [83]. In Brazil as reported in 1989, 21% of all known cases worldwide were found in the Cayabi Indians in the state of Mato Grosso (Amazon Region), of which two with long-standing lacaziosis developed squamous cell carcinoma in old scar lesions [85]. Extensively disseminated lacaziosis was reported in an 86-year-old woman with a 55-year disease history, who was a former rubber collector in the state of Acre (Amazon Region) in Brazil [86]. Recurrent lacaziosis lesions have been documented in a patient with human immunodeficiency virus (HIV) infection, suggesting that HIV infection may increase a person’s susceptibility to lacaziosis [87].
1992, a high prevalence (8.5%) of lacaziosis was seen among the Amerindians who live near the Colombian-Venezuelan border [88].

Conclusion

Implantation mycoses, also known as subcutaneous mycoses, are a persistent health problem in Latin American countries, yet are often neglected. Because these infections do not require compulsory notification, data related to their incidence and prevalence may be scarce and fragmentary. Although some implantation fungal diseases are found in immunocompromised persons, the immunocompetent population is the principal target in Latin America. The majority of causative organisms are found in soil, vegetation, and decaying matter in tropical, subtropical, and humid environments, and infection is usually the result of penetrating injury, as well as other avenues. Infections especially occur in low socioeconomic groups; in those living in rural areas or involved in farming, hunting, or other outdoor activities; and particularly in adult men. Although subcutaneous mycoses rarely cause disseminated or invasive disease, especially among immunocompetent hosts, their impact on public health is high, and timely diagnosis and appropriate treatment remain important.

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