PSM
Microbiology

Research Article 2025 | Volume 10 | Issue 1 | 1-10

Open Access

Article Information

Received: October 4, 2024

Accepted: November 4, 2024

Published: February 6, 2025

Keywords
Fungi,
Yeast,
Sand,
Beach,
Pig,
Filamentous fungi.

Authors' Contribution
LE designed and performed the experiments. LE and FB wrote and revised the paper.

How to cite
Echevarría, L., Bello, F., 2025. Variety of Filamentous Fungi and Yeast Species Found on the White Sands of Crystal Beach in the Bahamas: Swimming with the Pigs. PSM Microbiol., 10(1): 1-10.

***Correspondence**
Lourdes Echevarría
Email:
lourdes_echevarría@pucpr.edu

Variety of Filamentous Fungi and Yeast Species Found on the White Sands of Crystal Beach in the Bahamas: Swimming with the Pigs

Lourdes Echevarría[1]*, Francisco Bello[2]

[1]Biology Department, Pontifical Catholic University of Puerto Rico 2250 Boulevard Luis A. Ferré Aguayo suite 570 Ponce, Puerto Rico 00717– 9997.
[2]Science and Technology Department, Ana G. Méndez University of Puerto Rico, P.O. Box 21345. San Juan, P.R. 00928-1345.

Abstract:

Research on filamentous fungi in sand in tropical ecosystems is very limited. Every year many tourists visit the beach, especially in summer. Therefore, we want to continue learning about the variety of species of fungi and yeasts that live in the sand on the beach. Especially this beach that has pigs that swim with the people. The quality of the sand was analyzed. The following culture media were used: SDA, RBA, Mycosel and HardyCHROM™ Candida. One gram of sand was weighed in triplicate and spread over the different media. The samples with the SDA, RBA and Mycosel media were incubated at 25 °C for 7 to 14 days. As for the samples with HardyCHROM™ Candida, they were incubated at 35 °C for 48 hours. The colonies were isolated and counted. Macroscopic and microscopic analysis was used. Four genus were identified: *Aspergillus sp., Penicillium sp., Candida sp.,* and *Curvularia* sp. The isolated yeast species were: *Candida albicans, C. tropicalis, C. parapsilosis, C. krusei* and *C. glabrata*. The filamentous fungal species were: *Penicillium sp.*, *Aspergillus sp., A. flavus, A. parasiticus* and *A. glaucus*. The *Candida* genus was the most isolated. The average number of fungal and yeast colonies was 24 CFU/g. The quality of the sand was classified as average quality. Most of the isolates are fungi or yeasts of clinical interest. Many of these identified species are pathogenic, causing respiratory and skin diseases. Other species cause skin infections, respiratory allergies and risk of infection in immunosuppressed people. It is recommended to take measures to prevent these fungi from continuing to develop and thus avoid contamination of the sand.

Scan QR code to visit this journal.

INTRODUCTION

Fungal species that inhabit sand and sea water have been identified as dangerous to human health. For this reason, it is extremely important to know the quantity, species and genus that inhabit there. The number of medical consultations related to various fungal infections on the skin can increase to 25%. It has been documented that this is due to the fact that in places with hot conditions (tropics), in the summer season, which are mostly the months of June and July, favorable conditions such as temperature and humidity meet, which favor the growth of these fungi and yeasts (Van den Nest *et al*., 2021; Salmon and Fuller, 2013). Crystal Beach in the Bahamas, in addition to having white sand and crystal-clear waters, is characterized by the visit of many tourists annually. This is because they have pigs living there. Pigs have become a tourist attraction, so they live with people. Those animals have captured the attention of many tourists, to have a unique experience in the world (Hanes, 2023).

The islands are a meeting point in the months of June, July and August for those tourists who want to enjoy the sun, the beach and take photos in the water and sand with the pigs. Tourism accounts for more than 60% of the island's economy (Basquiat, 2018). These animals feed on fruits. Once they enter the water, they usually leave their excrement in the water and sand (Figure 1).

Fig. 1. Pigs at the Crystal beach, Bahamas.

Identifying some articles analyzing fungi in sand in various countries, we can observe the different isolated species. We start with a tropical country such as Puerto Rico. In the study, Echevarría (2017) showed that the dry season was the season of greatest growth of fungal species. 129 species were identified, most of them pathogens. Regarding the quality of the sand, it was classified as average quality. Another investigation by Echevarría (2019a), fungi were isolated in the sand of three beaches in the Caribbean; Puerto Rico, Barbados and Saint Martin respectively. The sand quality analysis resulted in being of average quality. The species isolated in this study were: *A. niger*, *R. stolonifer*, and *P. wasksmanii*. Echevarría and Iqbal (2021) managed to identify, in the sand of the pyramids of Egypt, the following species: *Aspergillus*, *Penicillium*, *Rhizopus*, *Candida*, *Alternaria* and *Hortea*. In this study, the sand quality was classified as average quality. Both the geographical location and the distribution of these fungi are variable. As shown by INSA (National Institute of Health Dr. Ricardo Jorge, Portugal), filamentous fungi are the largest group of pathogenic and allergic fungi for humans. Among the most frequently mentioned are the species of *Penicillium* sp., *A. fumigatus*, *A. niger*, *Aspergillus* sp., *Cladosporium* sp., *Paecylomices* sp., *Curvularia* sp., *Fusarium* sp., *Mucor* sp., *Geotrichum* sp., *Acremonium* sp. (Daoud and Gulati, 2023; Van den Nest *et al.,* 2021; Merad *et al.,* 2021; White *et al.,* 2021; Iturrieta *et al.,* 2020; Brandão *et al.,* 2007). As an important fact, yeasts are an important part of the biodiversity of different tropical ecosystems. They are characterized by being unicellular and microscopic, and are distributed throughout the world. One of their main functions is the recycling of plant and animal remains. They can be found in marine environments, such as lagoons, estuaries, and are related to the geographical and hydrological conditions of the ecosystem. Yeasts can be found in these environments due to the large amount of nutrients accumulated, either naturally or through human pollution (Caetano *et al.,* 2023; Sharma and Chakrabarti, 2023; Segal-Kischinevzky *et al.,* 2022; García and Giraudo,

2014). The main Candida species common to humans include: *Candida albicans*, *C. glabrata*, *C. tropicalis*, *C. parapsilosis*, *C. Krusei*, *Meyerozyma guilliermondii* (anamorph *Candida guilliermondii*) and *C. dubliniensis* (Govrins and Lass-Flörl, 2024; Duggan and Usher, 2023; Soliman, 2023; Dos Santos and Ishida, 2023; Branco *et al.,* 2023; Richardson, 2022; Jamiu *et al.,* 2021; Hassan *et al.,* 2021; Gomez-Gaviria and Mora-Montes, 2020; Chowdhary *et al.,* 2017; Lockehart *et al., 2*017). Solo-Gabriele, (2016), in their study isolated fungi from samples of marine environments (seawater, sand) and compared them with the isolates from clinical samples. They evaluated the fungal species that were found in the three samples. Some species mentioned in this study were; *Candida*, *Microsporum*, *Trichophyton*, *Aspergillus*, *Fusarium*, *Mucor*, *Penicillium* and *Alternaria*. These species were found in common in clinical samples, sand samples and seawater samples. Therefore, this study shows us that there is convincing scientific evidence that beaches, through their sand and water, contribute significantly to the pathogen load to which beach users are exposed. The objectives of this research are to isolate filamentous fungi and yeasts from the dry sand of Crystal Beach in the Bahamas. To document what species and genus of filamentous fungi and yeasts were found in the beach sand. To work on the identification of the species, several taxonomic keys were used. Use of the microscope and different specific selective culture media to grow environmental fungi and yeasts. On the other hand, to know the average number of colonies (CFU) of fungi and yeasts from sample isolations. In order to identify the quality of the sand on this beach. To know the fungi and yeasts found in the sand and to perform an analysis of which ones are pathogenic to humans.

MATERIALS AND METHODS

The samples were taken on July 5, 2023, at Crystal Beach on the island of Bahamas. A well-known beach that receives thousands of visitors in summer to bathe with the pigs in the sea (Figure 2).

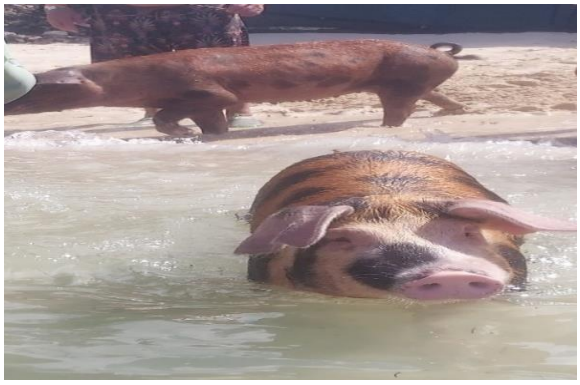

Fig. 2. Pigs in sea water and sand.

The samples were taken once the activity was concluded (Interacting with the pigs in the water and sand of the beach). Sand samples were taken in the dry area of the beach. The beach was divided into three equidistant points from the front of the beach shore. Approximately 100 grams of sand was taken, using a sterilized bag spatula (Echevarría, 2022). The depth of taking the sample was approximately 2 inches (Frenkel *et al.,* 2022) deep from the area where the wave ends, and the dry area bathers are located (Figure 3).

Fig. 3. Sampling location at Crystal Beach Bahamas.

One (1) gram of the sand sample was weighed (Echevarría, 2019a). It was carefully poured by spreading it throughout the agar in the plates containing each of the culture media, in triplicate. The culture media used were Sabouraud dextrose agar (SDA), Rose Bengal agar (RBA), Mycosel agar and HardyCHROM™ Candida (García *et al.,* 1998). The incubation temperature was 25°C for a period of 7 to 14 days, in the case of RBA, SDA and Mycosel media (Echevarría, 2022). The HardyCHROM™ Candida culture medium is incubated at 35°C for 48 hours (Hardy Diagnostics, 2022). Positive and negative controls were performed. For the positive control of filamentous fungi, plates containing the culture media (SDA, RBA and Mycosel) were inoculated with the fungus *A. fumigatus*. The objective of the positive control is to demonstrate that the medium has the capacity to grow the fungal species in the sample. The same process is applied to the HardyCHROM™ Candida, with the difference that it was inoculated with the yeast *Candida albicans*. On the other hand, we have the negative control. This was done by taking a plate of each culture medium, without inoculating. The objective is to ensure that the culture medium is free of microorganisms (sterile). These controls are incubated at the same temperature and time as the samples of each culture medium. Once the time has passed, it is verified if there was growth in the controls. The positive controls should obtain growth and the negative controls should not have growth. The colony forming units (CFU) of each sample was counted. Since the samples are in triplicate, the average of each sample in the different culture media is calculated. The species that grew in the different media were then isolated by transferring them to tubes with the same culture medium (Cavalcante *et al.,* 2021; Meyer *et al.,* 2021; Black, 2020; Scharmann *et al.,* 2020). To perform the calculation, the average of each culture medium was used using the colony forming units (CFU). Then, the general average of all fungi and yeasts is taken (Forbes, 2009). Depending on the total number (average) of colonies, the quality of the sand is determined. We used Table 1 as a reference to determine the quality of beach sand and the maximum values recommended by the Ricardo Jorge National Health Institute (INSA) (Brandão *et al.,* 2011) and the National Health Institute of Portugal (Pereira *et al.,* 2013). Microscopic and macroscopic studies were carried out to identify the genus and species of filamentous fungi. For the macroscopic study, the color and appearance of the surface and back of each fungi sample were identified. Likewise, for the microscopic study, the samples were placed on a slide together with the Lactophenol reagent. The Nikon Eclipse Ci microscope was used to observe them. The species identified in the microscope were compared with of taxonomic keys. The HardyCHROM™ Candida samples were identified by the color change of the sample in the culture medium (Cavalcante *et al.,* 2021; Mulet *et al.,* 2020; Tapia and Correa, 2015; Scharmann *et al.,* 2020).

RESULTS

Both the negative and positive controls for each sample obtained the expected results. The positive controls of fungi and yeasts showed growth of colonies of *A. fumigatus* and *Candida albicans* in their respective culture media. The negative controls of each medium did not obtain growth. From the isolated samples, four (4) genus of fungi were identified. This genus was *Aspergillus, Penicillium, Candida* and *Curvularia*. Of the species of filamentous fungi and yeasts found are: *Aspergillus flavus*, *Aspergillus parasiticus, Aspergillus glaucus, Aspergillus sp., Penicillium sp., Curvularia*, *Candida parapsilosis, C. tropicalis, C. krusei, C. albicans* and *C. glabrata*. In figure 4 you can see the average (CFU) of the samples of fungi and yeasts. The average number of filamentous fungal colonies for each medium was: 3 CFU/g in RBA, 29 CFU/g in SDA and 43 CFU/g in Mycosel. The average number of yeast colonies (*Candida*) was: 22 CFU in HardyCHROM™ Candida. The *Candida* genus was the most abundant species. The overall average (CFU) of fungi and yeasts in the sand samples was 24 CFU/g. With this data,

it indicates that the quality of the sand at Crystal Beach, according to the parameters in Table 1, is classified as average quality (>CFU/g=5). This is compatible with other studies conducted on other beaches with tropical conditions and in the months of June and July.

Table 1. Values recommended by the National Institute of Saúde Ricardo Jorge and the National Health Institute on Portugal (Pereira *et al.,* 2013).

Values to Determine the Quality of Sands		
> MVA poor quality	> MRV average quality	≤ MAV good quality
cfu / g = 85	cfu / g = 5	cfu / g = 5

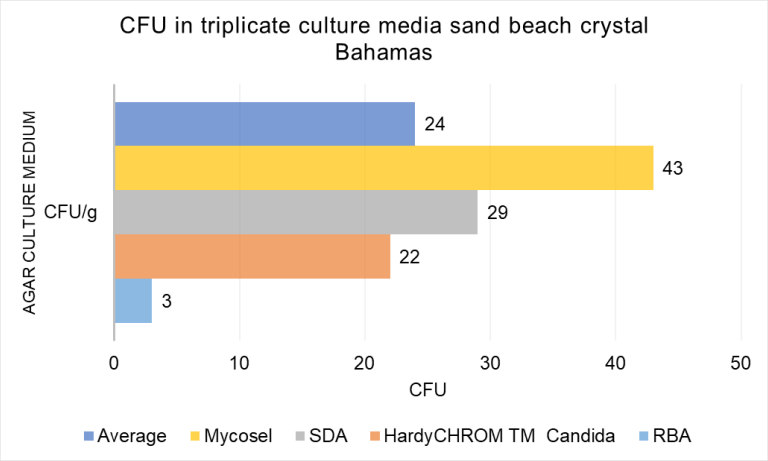

Fig. 4. Yeast and molds isolated from sand samples.

DISCUSSION

The species of fungi and yeasts isolated in this study coincide with the results of other investigations (Echevarría, 2017; Echevarría, 2019a; Echevarría, 2019b; Echevarría and Iqbal, 2021; Echevarría, 2022; De Araújo Pinto *et al.,* 2018). Solo-Gabriele et al. (2016) confirm that sand can be a host for fungi and yeasts, which can use it as a vehicle to pass or transmit various diseases. The variety of species identified in this research uses direct contact with the air, contact with sand and seawater as a transmission route. Table 2 shows the fungi found in this research, showing their level of pathogenicity. Many of the species mentioned here have been found in patient samples and may cause asthma (Behera and Das, 2023; Walker and Robicheau, 2021; Echevarría and Iqbal, 2021; Hu *et al.,* 2017; Echevarría, 2017; St-Germain and Summerbell, 2011). Research indicates that it is necessary to continue performing and documenting these analyses, since in recent years there has been a notable increase in cases of candidiasis, with *Candida albicans* being the main agent (Govrins and Lass-Flörl, 2024; Behera and Das, 2023; Duggan and Usher, 2023; Soliman, 2023; Branco *et al*., 2023; Richardson, 2022; Jamiu *et al*., 2021; Walker and Robicheau, 2021; Hassan *et al*., 2021; Van den Nest *et al*., 2021; Gomez-Gaviria and Mora-Montes, 2020; Chowdhary *et al*., 2017; Lockehart *et al*., 2017).

Table 2. Summary of fungal species found and their pathogenicity.

Species of fungi pathogenic to humans		
Species	**Pathogenicity**	**References**
Aspergillus flavus	Opportunistic pathogen that causes invasive aspergillosis.	(Shittu *et al*., 2022)
Aspergillus parasiticus	Recognized as major contaminants of organic and nonorganic items, produces the polyketide mycotoxin aflatoxin, one of the most mutagenic and carcinogenic natural compounds described to date.	(Shabeer *et al*., 2022)
Aspergillus glaucus	Is known for producing a variety of secondary metabolites, including mycotoxins. They can have detrimental effects on human health. Aflatoxins, for example, are potent carcinogens and can cause liver cancer.	(Qiu *et al*., 2020)
Aspergillus sp.	It can cause a significant group of superficial and cutaneous mycoses, including distal lateral subungual onychomycosis, proximal subungual onychomycosis, cutaneous aspergillosis and otomycosis.	(Merad *et al*., 2021; White *et al.*, 2021)
Penicillium sp.	A very important genus of fungi due to its widespread presence in the environment and the role of many species in food spoilage and the production of mycotoxins.	(Toghnueo and Boyom, 2020)
Curvularia sp.	This pathogen is found mainly in plants. We can also identify it in clinical cases such as sinusitis and keratitis. To date, it is the cause of fungal keratitis.	(Daoud and Gulati, 2023; Iturrieta *et al*., 2020)
Candida albicans	Opportunistic pathogen in humans, causes candidiasis.	(Richardson, 2022)
C. tropicalis	This species is the most virulent and is resistant to antifungals.	(Dos Santos and Ishida, 2023)
C. krusei	This species has the characteristic of being resistant to different medicines. It causes very dangerous infections in patients with compromised immune systems.	(Jamiu *et al*., 2021; Gomez-Gaviria and Mora-Montes, 2020)
C. glabrata	This yeast causes candidiasis. It is a difficult disease to treat because it is resistant to antifungal therapies for most mycoses.	(Hassan *et al*., 2021; Duggan and Usher, 2023)
C. parapsilosis	It causes invasive candidiasis infection, especially in people with weak immune systems.	(Branco *et al*., 2023; Govrins and Lass-Flörl, 2024)
Penicillium sp.	This fungus is responsible for causing food spoilage by creating mycotoxins. It is widely found in all ecosystems.	(Toghnueo and Boyom, 2020)
Yeast	Is used to cause fermentation and leaving, some yeast are mild to dangerous pathogens of humans, especially on patients with weakened immune systems.	(Caetano *et al*., 2023; Sharma and Chakrabarti, 2023)

Other studies have shown that 8% of *C. tropicalis* and between 3% and 6% of *C. glabrata* and *C. Krusei* show greater resistance to the imidazole fluconazole (Dawoud *et al*., 2024; Barantsevich and Barantsevich, 2022; Hassan *et al*., 2021; Jamui *et al*., 2021; Mendoza, 2005). Further research is needed to be able to work with environmental assessment plans in countries that have this beautiful natural resource. Therefore, it is important that people who go on vacation to the beach consider being aware of the fungi that inhabit the sand and their possible impact on health. Several articles indicate that we need to continue researching and documenting the findings of each investigation. The possibility of considering the implementation of sand quality programs on beaches in each country should be evaluated. With the purpose of protecting the public health of beach users, even more so on beaches with a high level of tourism like this one, and the ecosystem.

CONCLUSION

1. The genus *Aspergillus* and *Candida* are the fastest growing in the samples.

2. Five species of *Candida* were identified in the samples: *C. tropicalis, C. albicans, C. parapsilosis, C. kruse, C. glabrata.*

3. The species of filamentous fungi found were; *Aspergillus glaucus, Aspergillus parasiticus, Aspergillus flavus, Aspergillus sp., Penicillium sp.,* and *Curvularia* sp.

4. Sand samples are classified as average quality, 24 CFU/g (>CFU/g=5).

5. Many of the fungi identified in this research use direct contact and air as a vehicle of transmission.

6. The isolates found in this investigation are mostly pathogenic to humans. We must continue to document the findings from all beaches to create a profile and monitor growth and species so that consideration can be given to implementing sand quality procedures on all beaches with high levels of tourists.

ACKNOWLEDGMENTS

This research was carried out in the microbiology laboratory of Pontifical Catholic University of Puerto Rico - Arecibo.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Barantsevich, N., Barantsevich, E., 2022. Diagnosis and treatment of invasive Candidiasis. Antibiotics (Basel), 11(6): 718.

Basquiat, A., 2018. La famosa “La isla de los cerdos” de las Bahamas no es precisamente el paraíso para estos animales. *La Vanguardia*. [Accessed in July 2018]. Available in:

https://www.lavanguardia.com/cribeo/fauna/20180725/47426817242/la-famosa-la-isla-de-los-cerdos-de-las-bahamas-no-es-precisamente-el-paraiso-para-estos-animales.html

Behera, A.D., Das, S., 2023. Ecological insights and potential application of marine filamentous fungi in environmental restoration. Rev. Environ. Sci. Biotechnol. 22: 281–318.

Black, W.D., 2020. A comparison of several media types and basic techniques used to assess outdoor airborne fungi in Melbourne, Australia. PLoS One, 15: 12.

Branco, J., Miranda, I.M., Rodrigues, A.G., 2023. *Candida parapsilosis* virulence and antifungal resistance mechanisms: A comprehensive review of key determinants. J. Fungi (Basel), 9(1): 80.

Brandão, J., Rosado, C., Silva, C., Almeida, C., Carrola, C., *et al*., (Eds). 2007. *Monitorizacao da Qualidade das Areias em Zonas Balneareas. Lisbon*. Instituto Nacional de Sáude Doutor Ricardo Jorge. http://hdl.handle.net/10400.18/231

Brandão, J., *et al*. (Eds.). 2011. *Monitorização da qualidade das areias em zonas balneares –Época Balnear de 2010*. Instituto Nacional de Saúde Dr. Ricardo Jorge. DOI:10.13140/RG.2.2.13957.35049

Caetano, C.F., Gaspar, C., Martínez-de-Oliveira, J., Palmeira-de-Oliveira, A., Rolo, J., 2023. The role of yeasts in human health: A review. Life,13(4): 924.

Cavalcante, J.A.G., Guerra, F.Q.S., Silva-Rocha, W.P., 2021. Characterization of biodiversity of filamentous fungi in the soil

of public spaces in João Pessoa, Northeast of Brazil. Res. Soc. Develop., 10(16): 1-12.

Chowdhary, A., Sharma, X., Meis, J.F., 2017. *Candida auris*: a rapidly emerging cause of hospital-acquired multidrug resistant fungal infections globally. PLoS Pathog., 13.

Daoud, N., Gulati, N., 2023. Curvularia lung infection mimics malignancy. Heliyon, 9(5).

Dawoud, A.M., Saied, S.A., Torayah, M.M., et al., 2024. Antifungal susceptibility and virulence determinants profile of candida species isolated from patients with candidemia. Sci. Rep.,14: 11597.

De Araújo Pinto, I. M. de A. P. M., Cavillcánti, M. A., de Oliveira Passavante, J. Z. de O. P. Z., 2018. Hongos filamentosos aislados desde el suelo y el agua en la playa de Boa Viagem (Recife, Brasil). Boletín Micológico, 7.

Dos Santos, M.M., Ishida, K., 2023. We need to talk about Candida tropicalis: Virulence factors and survival mechanisms. Med Mycol., 61(8): myad075. doi: 10.1093/mmy/myad075.

Duggan, S., Usher, J., 2023. *Candida glabrata*: A powerhouse of resistance. PLoS Pathog.,19(10).

Echevarría, L., 2017. Diversidad de hongos filamentosos en la arena de las playas: en la Costa Norte de Puerto Rico. Editorial Académica Española,188.

Echevarría, L., 2019a. Preliminary study to identify filamentous fungi in sands of three beaches of the Caribbean. PSM Microl., 4(1): 1-6.

Echevarria, L., 2019b. Molecular identification of filamentous fungi diversity in North Coast Beaches Sands of Puerto Rico. Int. J. Mol. Microbiol., 2(3): 51-61.

Echevarría, L., Iqbal, M.N., 2021. Identification of Fungi and Yeasts from the Sands of the Pyramids of Giza, in Cairo, Egypt. PSM Biol. Res., 6(1): 13-18.

Echevarría, L., 2022. Inventory of Filamentous Fungi and Yeasts Found in the Sea Water and Sand of the Beach of Pier in Arecibo Puerto Rico. PSM Microbiol., 7(1): 4-11.

Forbes, B.A. (Ed.). (2009). *Diagnóstico microbiológico*. Ed. Médica Panamericana.

Frenkel, M., Serhan, H., Blum, S.E., Fleker, M., Sionov, E., Amit, S., Gazit, Z., Gefen-Halevi, S., Segal, E., 2022. What Is Hiding in the Israeli Mediterranean Seawater and Beach Sand. J. Fungi., 8(9): 950.

García, P., García, R., Hernández, J.M., Marin, P., Tallero, E., Mira, J., 1998. Identificación de levaduras de interés clínico en el medio de cultivo CHROMagar *Candida.* Rev. Iberoam. Micol., 15: 131-135.

García, V., Giraudo, M.R., 2014. Habitantes microscópicos de los Glaciares Levaduras. Desde la Patagonia Difundiendo Saberes., 11(17): 10-15.

Gómez-Gaviria, M., Mora-Montes, H.M., 2020. Current aspects in the biology, pathogeny, and treatment of *Candida krusei*, a neglected fungal pathogen. Infect. Drug. Resist., 13: 1673-1689.

Govrins, M., Lass-Flörl., 2024. *Candida parapsilosis* complex in the clinical setting. Nat. Rev. Microbiol., 22(1): 46-59.

Hanes S., 2023. When the pigs swim…and Bahamas tourists dive in with them. *The Christian Science Monitor.* [Accessed in January 2023]. Available in:

https://www.csmonitor.com/Environment/2023/0131/When-pigs-swim-and-Bahama tourists-dive-in-with-them

Hassan, Y., Chew, S.Y., Than, L.T.L., 2021. *Candida glabrata*: Pathogenicity and resistance mechanisms for adaptation and survival. J. Fungi (Basel) 7(8): 667.

Hardy Diagnostics., 2022. HardyCHROM™ *Candida auris* chromogenic media [Accessed in October 2022]. Available in: https://youtu.be/uuRjAyRBB18?si=Tr4DEYTs4HPuasCp

Hu, X., Qin, L., Roberts, D.P., Lakshman, D.K., Gong, Y., Maul, J.E., Xie, L., Yu, C., Li, Y., Hu, L., Liao, X., Liao, X., 2017. Characterization of mechanisms underlying degradation of sclerotia of *Sclerotinia sclerotiorum* by *Aspergillus aculeatus* Asp-4 using a combined qRT-PCR and proteomic approach. BMC Genomics., 18(1): 674.

Iturrieta-González, I., Gené, J., Wiederhold, N., García, D., 2020. Three new Curvularia species from clinical and environmental sources. MycoKeys, 68: 1-21.

Jamiu, A.T., Albertyn J., Sebolai, O.M., Pohl, C.H., 2021. Update on *Candida krusei*, a potential multidrug-resistant pathogen. Med. Mycol., 59(1): 14-30.

Lockhart, S.R., Etienne, K.A., Vallabhaneni, S., Farooqi, J., Chowdhary, A., Govender, N.P., et al., 2017. Simultaneus emergence of multidrug- resistant *Candida auris* on 3 continents confirmed by whole- genome sequencing and epidemiological analyses. Clinic. Infect. Dst., 64: 134-140.

Mendoza, M., 2005. Importancia de la identificación de levaduras. Rev. Soc. Ven. Microbiol., *25*(1): 103-117.

Merad, Y., Derrar, H., Belmokhtar, Z., Belkacemi, M., 2021. *Aspergillus* genus and its various human superficial and cutaneous features. Pathog., 10(6): 643.

Meyer, V., Cairns, T., Barthel, L., King, R., Kunz, P., Schmideder, S., Müller, H., Briesen, H., Dinius, A., Krull, R., 2021. Understanding and controlling filamentous growth of fungal cell factories: novel tools and opportunities for targeted morphology engineering. Fungal Biol. Biotechnol., 8(1): 8.

Mulet, B.J.V., Salvador, G.C., Tormo, P.N., Gimeno, C.C., 2020. Evaluation of a novel chromogenic medium for *Candida spp*. identification and comparison with CHROMagar™ Candida for the detection of *Candida auris* in surveillance samples. Diagn. Microbiol. Infect. Dis., 98(4).

Pereira, E., Figueira, C., Aguiar, N., Vasconcelos, R., Vasconcelos, S., Calado, G., Brandão, J., Prada, S., 2013. Microbiological and mycological beach sand quality in a volcanic environment: Madeira archipelago, Portugal. Sci Total Environ. 461-462: 469-79. doi: 10.1016/j.scitotenv.2013.05.025.

Qiu, W., Li, J., Wei, Y., Fan, F., Jiang, J., Liu, M., Han, X., Tian, C., Zhang, S., Zhuo, R., 2020. Genome sequencing of *Aspergillus glaucus* 'CCHA' provides insights into salt-stress adaptation. Peer J., 8.

Richardson, J.P., 2022. *Candida albicans*: A major fungal pathogen of humans. Pathog., 11(4): 459.

Salmon, N., Fuller, C., 2013. Fungal skin infections: current approaches to management. Prescriber, 24(9): 31-37.

Segal-Kischinevzky, C., Romero-Aguilar, L., Alcaraz, L.D., López-Ortiz, G., Martínez-Castillo, B., Torres-Ramírez, N., Sandoval, G., González, J., 2022. Yeasts inhabit extreme environments and their biotechnological applications. Microorgan., 10(4): 794.

Scharmann, U., Kirchhoff, L., Chapot, V.L.S., Dziobaka, J., Verhasselt, H.L., Stauf, R.,

Buer, J., Steinmann, J., Rath, P.M., 2020. Comparison of four commercially available chromogenic media to identify *Candida albicans* and other medically relevant *Candida* species. Mycoses, 63(8): 823-831.

Shabeer, S., Asad, S., Jamal, A., Ali, A., 2022. Aflatoxin contamination, its impact and management strategies: An updated review. Toxins (Basel), 14(5): 307.

Sharma, M., Chakrabarti, A., 2023. Candidiasis and other emerging yeasts. Curr. Fungal Infect. Rep., 17(1): 15-24.

Shittu, O.B., Iwaloye, O.F., Oloyede, A.R., Oni, E.O., Ajibola, A.T., Arowosegbe, A.O., Oluwasanya, G.O., 2022. Water safety, antifungal-resistant aflatoxigenic aspergillus flavus and other pathogenic fungi in community hand-dug wells. J. Appl. Microbiol., 133(2): 673–682.

Soliman, S.S.M., 2023. Editorial: Candida spp.-transmission, pathogenesis, host-pathogen interaction, prevention, and treatment. Front. Microbiol., 14.

Solo-Gabriele, H.M., Harwood, V.J., Kay, D., et al., 2016. Beach sand and the potential for infectious disease transmission: observations and recommendations. J. Mar. Biol. Assoc. U. K., 96(1): 101–120.

St-Germain, G., Summerbell, R.C., 2011. Identifying Fungi: A Clinical Laboratory Handbook (2nd ed.). Belmont: Star Publishing Company.

Tapia, C., Correa, N., 2015. *Candida parapsilosis* complex. Revista chilena de infectología, 32(5):569-570. https://dx.doi.org/10.4067/S0716-10182015000600012

Toghueo, R.M.K., Boyom, F.F., 2020. Endophytic *Penicillium* species and their agricultural, biotechnological, and pharmaceutical applications. 3 Biotech. 10(3):107. doi: 10.1007/s13205-020-2081-1.

Van den Nest, M., Wagner, G., Riesenhuber, M., Dolle, C., Presterl, E., Gartlehner, G., Moertl, D., Willinger, B., 2021. Filamentous fungal infections in a tertiary care setting: Epidemiology and clinical outcome. J. Fungi (Basel), 7(1):40.

Walker, A.K., Robicheau, B.M., 2021. Fungal diversity and community structure from coastal and barrier island beaches in the United States Gulf of Mexico. Sci. Rep., 11(1): 3889.

White, J.K., Nielsen, J.L., Poulsen, J.S., Madsen, A.M., 2021. Antifungal resistance in isolates of *Aspergillus* from a pig farm. Atmosph., 12(7): 826.