



Fungal Diversity Associated with *Posidonia oceanica* in Libya:

A Comparative Review of Eastern and Western Coastal Records

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Abstract

We compared the cultured fungal taxa reported from *Posidonia oceanica* on the eastern and western coasts of Libya, using the published records of two surveys that differed in sampling and isolation procedures. Only 5 of the 19 taxa recorded overall (the name-based union of both coasts' lists) were reported from both regions, giving a Jaccard similarity of 26.3% and a corresponding Jaccard dissimilarity of 73.7%; this value describes name-based turnover between the two lists and should not be read as a formal beta-diversity turnover component unless a specific partitioning method is applied. Rhizomes supported the highest number of recorded taxa in the eastern dataset, whereas roots and rhizomes were tied for the highest richness in the western dataset. The difference between the coastal lists may reflect some combination of geography, tissue type, sampling effort and isolation method — particularly the contrast between wrack incubation and direct plating of surface-sterilised fresh tissue — although these factors cannot be disentangled from the available published data. Because both source studies relied primarily on morphological identification and used non-equivalent sampling designs, these results are best read as a preliminary comparison of cultured records rather than a standardised estimate of regional mycobiota diversity, pointing to a clear need for coordinated, molecularly supported surveys across North Africa.

Keyword : North Africa; *Posidonia oceanica*; marine fungi; beta diversity; Libya

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INTRODUCTION

Knowledge of the *Posidonia oceanica* mycobiota across the Mediterranean remains patchy, and what does exist is concentrated in the northern basin. Most culture-based work has come out of Italy [1], while Mediterranean-wide molecular surveys [2] consistently recover taxa such as *Posidoniomyces atricolor* (Pleosporales) alongside various Hyphomycetes. Records from North Africa, by contrast, sit scattered across journals and unpublished theses, with no coordinated regional assessment bringing them together until now.

In Egypt, review papers have underscored the ecological importance of *Posidonia oceanica*, yet dedicated fungal surveys remain scarce [3–5]. Tunisia has coastal biodiversity studies, but few yield culture-based marine mycobiota lists [6,7]. Recent Algerian work has characterised halotolerant and halophilic fungi from inland saline habitats rather than from *P. oceanica* itself [8]. Along the Moroccan Mediterranean coast, surveys of *P. oceanica*-associated marine fungi are similarly scarce. Based on the literature retrieved for this review, we found no dedicated culture-based study specifically targeting the mycobiota of *P. oceanica* tissue outside Libya.

Libya holds the most active and recent record of such work, with Ghenghish [9], Al-Masri & Kafu [10], and Benzayed et al. [11] documenting fungi from the marine environment, including from *Posidonia oceanica*. This points to a broader pattern: where general marine fungal diversity has received some attention, the seagrass niche itself remains largely unstudied across North Africa. Even within Libya, only two survey studies have been published; together they reveal marked site-level variability and several taxon records newly reported for the sampled Libyan coast, while leaving the unculturable fraction of the community entirely uncharacterised. For Egypt, Tunisia and Algeria — where *P. oceanica* is also extensive — we found no dedicated seagrass-associated fungal

surveys in the literature retrieved for this review, leaving a substantial geographic gap across the southern Mediterranean.

Closing this gap matters both for understanding the ecological role of fungi in North African seagrass ecosystems and for situating regional findings within the wider global picture of *P. oceanica* mycobiota. To date, and based on the literature retrieved for this review, the only published data we could locate on *P. oceanica* mycobiota in North Africa come from the two Libyan survey studies compared here. Both studies reported fungal taxa from the leaves, rhizomes and, in the western study, roots of *P. oceanica*, sampled respectively from the eastern and western coasts of Libya, and in both cases the cultured isolates were dominated by Ascomycota. The complete taxa lists and a full site-by-site comparison are presented in Tables 1–3 and Figure 1.

DATA SOURCES AND STUDY AREAS

Fungal records for eastern Libya were obtained from landed *P. oceanica* wrack, incubated in sterile humid chambers [10]. Records for western Libya came from fresh seagrass tissue, including roots, collected by diving at 5–12 m depth, with surface sterilisation followed by direct plating [11]. This methodological contrast — passive wrack incubation versus active surface-sterilised plating of live tissue — is revisited below as a factor that may substantially influence part of the observed turnover between the two coasts, alongside other unresolved factors noted below.

Because this review compiles and compares published records rather than reporting original sampling, the literature underlying the North African and Mediterranean context discussed above was retrieved through targeted searches of Google Scholar, PubMed and regional repositories (including AJBAS, ajol.info and AlQalam/AJMAS), using combinations of the terms “*Posidonia oceanica*”, “marine fungi”, “seagrass mycobiota”, “Libya”, “Egypt”, “Tunisia”, “Algeria” and “Morocco”, covering publications up to September 2026. Studies were included if they reported culturable or molecularly detected fungi specifically associated with *P. oceanica* tissue; broader seagrass, coastal-sediment or unrelated marine-fungus surveys were noted for context but not treated as evidence of a dedicated *P. oceanica* mycobiota record. This was not a formal systematic review (e.g., following PRISMA guidelines), and the absence of retrieved studies for a given country should be read as an absence from this search rather than a confirmed absence of published work.

Two further caveats apply to the comparisons that follow. First, because the two source studies differed in sampling design, sample size, tissue representation and isolation protocol, the tissue-level percentages reported below describe the published taxon records and should not be interpreted as standardised estimates of true fungal richness. Second, the 19-taxon union used throughout was calculated from the names as reported in the source studies; because *Aspergillus* was identified only to genus in the eastern study but to species level in the western study, this union is a name-based count that may over- or under-estimate true taxonomic turnover, and is treated as such throughout this review.

Table 1. Fungal taxa isolated from rhizomes (Rh) and leaves (L) of *P. oceanica*, eastern Libya (Al-Masri & Kafu, 2021) [10]. Class names follow the original study's informal, non-equivalent spore-form groupings (see Table 3 note for the current phylum/class reclassification).

Fungal taxon	Class	Rhizomes	Leaves
<i>Halosphaeria sp.</i>	Ascomycetes	+	–
<i>Halothia posidoniae</i>	Ascomycetes	+	–
<i>Leptosphaeria sp.</i>	Ascomycetes	+	–
<i>Lulworthia sp.</i>	Ascomycetes	+	+
<i>Pleospora pelagica</i>	Ascomycetes	+	–
<i>Pontoporeia biturbinata</i>	Ascomycetes	+	–
<i>Alternaria sp.</i>	Hyphomycetes	+	+
<i>Aspergillus sp.</i>	Hyphomycetes	+	+
<i>Cladosporium sp.</i>	Hyphomycetes	+	+
<i>Fusarium sp.</i>	Hyphomycetes	–	+
<i>Penicillium sp.</i>	Hyphomycetes	+	+
<i>Camarosporium roumegueri</i>	Coelomycetes	+	–

Table 2. Fungal taxa isolated from roots (R), rhizomes (Rh) and leaves (L) of *P. oceanica*, western Libya (Benzayed et al., 2026) [11].

Fungal taxon	Roots	Rhizomes	Leaves
<i>Alternaria sp.</i>	–	+	+
<i>Aspergillus fumigatus</i>	+	+	–
<i>Aspergillus niger</i>	+	+	–
<i>Chaetomium sp.</i>	–	–	+
<i>Fusarium sp.</i>	+	+	–
<i>Cladosporium sp.</i>	–	–	+
<i>Humicola sp.</i>	+	–	–
<i>Halothia posidoniae</i>	–	+	–
<i>Mucor sp.</i>	+	–	–
<i>Penicillium sp.</i>	–	+	–
<i>Rhizopus sp.</i>	+	–	–
<i>Scopulariopsis sp.</i>	+	+	+

Table 3. Unified comparison of fungal taxa recorded on *P. oceanica* from the eastern and western coasts of Libya, reclassified according to current fungal taxonomy and grouped by current fungal class. E = eastern (Rh, L); W = western (R, Rh, L). * indicates genus-level overlap only (*Aspergillus** spp. identified to species in the western study but to genus only in the eastern study).

Fungal taxon	E-Rh	E-L	W-R	W-Rh	W-L	Shared
Sordariomycetes (Ascomycota)						
<i>Halosphaeria</i> sp.	+	–	–	–	–	No
<i>Lulworthia</i> sp.	+	+	–	–	–	No
<i>Fusarium</i> sp.	–	+	+	+	–	Yes
<i>Chaetomium</i> sp.	–	–	–	–	+	No
<i>Humicola</i> sp.	–	–	+	–	–	No
<i>Scopulariopsis</i> sp.	–	–	+	+	+	No
Dothideomycetes (Ascomycota)						
<i>Halothia posidoniae</i>	+	–	–	+	–	Yes
<i>Leptosphaeria</i> sp.	+	–	–	–	–	No
<i>Pleospora pelagica</i>	+	–	–	–	–	No
<i>Pontoporeia biturbinata</i>	+	–	–	–	–	No
<i>Camarosporium rouseae</i>	+	–	–	–	–	No
<i>Alternaria</i> sp.	+	+	–	+	+	Yes
<i>Cladosporium</i> sp.	+	+	–	–	+	Yes
Eurotiomycetes (Ascomycota)						
<i>Aspergillus</i> sp.*	+	+	–	–	–	Genus-level overlap only
<i>Penicillium</i> sp.	+	+	–	+	–	Yes
<i>Aspergillus fumigatus</i> *	–	–	+	+	–	No
<i>Aspergillus niger</i> *	–	–	+	+	–	No
Mucoromycetes (Mucoromycota)						
<i>Mucor</i> sp.	–	–	+	–	–	No
<i>Rhizopus</i> sp.	–	–	+	–	–	No

Note: The reclassification presented in Table 3 is a nomenclatural/taxonomic review carried out by the author of this paper against current fungal classification schemes, not a result of molecular re-identification of the original isolates. Table 3 updates the taxa from the older, informal spore-form groupings used in Table 1 (Ascomycetes, Hyphomycetes and Coelomycetes) to the current phylum/class-level taxonomic classification already used in Table 2 (Dothideomycetes, Eurotiomycetes, Sordariomycetes, Mucoromycetes). Ascomycetes is the outdated class-level name for what is now the phylum Ascomycota (split into Dothideomycetes, Eurotiomycetes, Sordariomycetes, etc.); Hyphomycetes and Coelomycetes are not taxonomic ranks at all but spore-form categories cutting across these unrelated modern classes. It should be noted that identification in both underlying studies was morphological and culture-based rather than molecular; the difference between Tables 1 and 2 lies solely in which taxonomic nomenclature — the older informal spore-form groups versus the current phylum/class system — was applied to name the isolates. Classification follows the general

framework of Wijayawardene et al. [12], the genus-level revisions of Houbraken et al. [13] (*Aspergillus*/*Penicillium*) and Crous et al. [14] (*Fusarium*), and the marine-fungus-specific placements of Suetrong et al. [15], Jones et al. [16], Wanasinghe et al. [17] and Kohlmeyer [18]/Index Fungorum–WoRMS [19]. Two genus names have also been corrected to their accepted spelling: *Leptosphaeria* (not “*Leptosporia*”) and *Pontoporeia biturbinata* (not “*Pontoporia biturbionta*”).

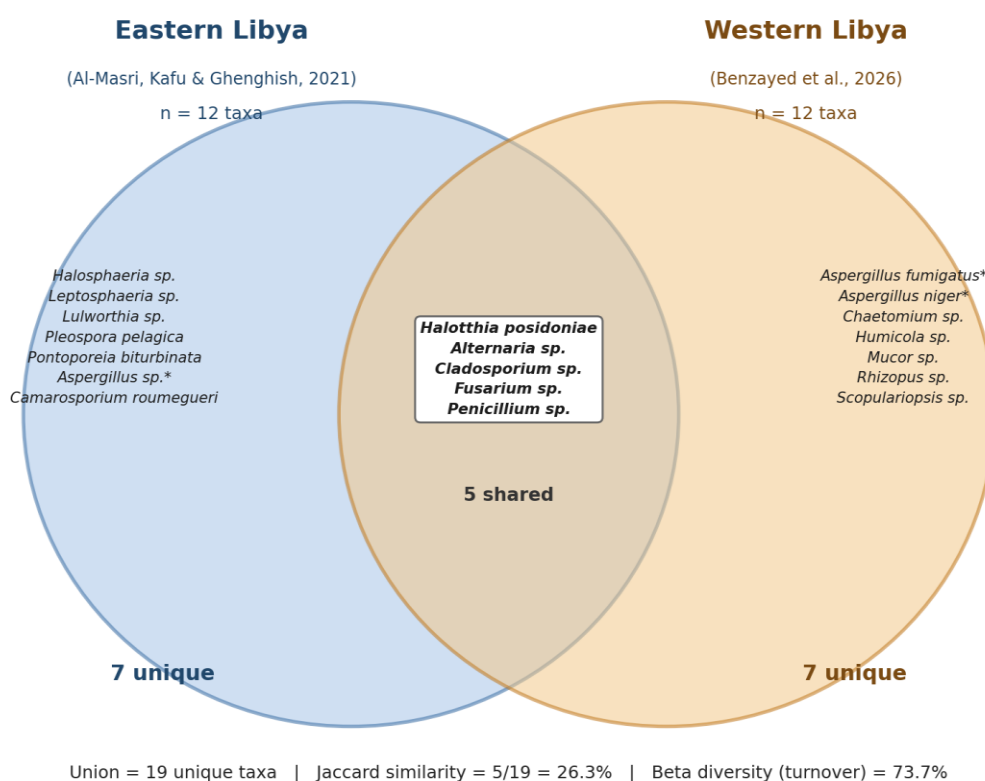


Figure 1. Venn diagram of the name-based comparison of fungal taxa recorded on *P. oceanica* from eastern vs. western Libya, resolving the overlap visually: 7 taxa unique to the east, 7 unique to the west, 5 shared (union = 19; Jaccard = 26.3%). * = genus-level overlap only (*Aspergillus**).

RESULTS AND DISCUSSION

Descriptive statistical analysis

Richness by site and tissue type. Eastern Libya yielded 12 reported taxa (6 Ascomycetes, 5 Hyphomycetes, 1 Coelomycete, under the old morphology-based scheme); rhizomes carried 11/12 taxa (91.7%) and leaves 6/12 (50.0%), so rhizomes supported the highest number of recorded taxa at this site. Western Libya also yielded 12 reported taxa across two phyla (Ascomycota 10 taxa, 83.3%; Mucoromycota 2 taxa, 16.7%); roots carried 7/12 (58.3%), rhizomes 7/12 (58.3%) and leaves 4/12 (33.3%), so roots and rhizomes were tied for the highest recorded richness at this site. As neither source study reports sample sizes, replicate numbers or isolation effort per tissue, these percentages describe the published taxon records rather than standardised estimates of true fungal richness (see caveats above).

Combined richness and overlap. The union of both taxa lists is 19 unique fungal taxa. Five taxa were recorded, by identical name, on both coasts — *Halothia posidoniae*, *Alternaria* sp., *Cladosporium* sp., *Fusarium* sp. and *Penicillium* sp. — giving a Jaccard similarity index of $5/19 = 26.3\%$ and a corresponding Jaccard dissimilarity of 73.7% ($1 - 0.263$); this value should not be interpreted as a formal turnover component of beta-diversity unless a specific partitioning method is applied. Seven taxa were unique to the eastern coast (*Halosphaeria* sp., *Leptosphaeria* sp., *Lulworthia* sp., *Pleospora pelagica*, *Pontoporeia biturbinata*, *Aspergillus* sp., *Camarosporium roumegueri*) and seven were unique to the western coast (*Aspergillus fumigatus*, *Aspergillus niger*, *Chaetomium* sp., *Humicola* sp., *Mucor* sp., *Rhizopus* sp., *Scopulariopsis* sp.). Treating the genus *Aspergillus* as a single overlapping unit rather than as separate species-level records raises the shared count to 6/18 (33.3%).

Interpretation. *Halothia posidoniae* is the only obligate marine species recorded at both sites and is the strongest indicator of a shared, seagrass-specific mycobiota; the remaining four shared taxa (*Alternaria*, *Cladosporium*, *Fusarium*, *Penicillium*) are common facultative marine/terrestrial genera frequently reported as contaminant-tolerant colonisers of decaying plant material, so their recurrence may reflect ubiquity rather than a genuine regional signal. The cultured isolates were dominated by Ascomycota at both sites (the eastern record included several ascomycete genera, including *Halosphaeria*, *Leptosphaeria*, *Lulworthia* and *Pleospora*; the western record comprised 83.3% Ascomycota), which fits the broader Mediterranean literature. The high turnover ($\approx 74\%$) between two sites within a single country is nonetheless striking. This turnover may be substantially influenced by the different isolation protocols used — wrack incubation in humid chambers versus direct plating of surface-sterilised, depth-collected fresh tissue, which are known to bias toward different fungal guilds (sporulating marine Ascomycetes versus fast-growing terrestrial/opportunistic moulds) — although the relative contributions of methodology, geography, season, habitat condition and sampling effort cannot be separated from the available published data.

Distinguishing obligate marine fungi from facultative marine/terrestrial taxa clarifies this pattern further. Following the classical marine-mycology framework [15,16,18], the assemblage recovered here includes several recognised obligate marine Ascomycetes — *Halothia posidoniae*, *Lulworthia* sp., *Halosphaeria* sp. and *Pontoporeia biturbinata* — organisms restricted to marine and estuarine substrates that typically fruit only on plant material submerged or stranded in seawater. Of these, only *Halothia posidoniae* was recovered from both coasts; *Lulworthia* sp., *Halosphaeria* sp. and *Pontoporeia biturbinata* were each confined to the eastern wrack samples, consistent with their being genuine marine specialists whose detection depends on the passive, humidity-driven fruiting that wrack incubation favours. *Aspergillus*, *Penicillium*, *Fusarium*, *Alternaria* and *Cladosporium*, by contrast, are facultative marine or opportunistic terrestrial genera with a near-cosmopolitan distribution on decaying organic matter in general rather than on *P. oceanica* specifically; their recovery from both coasts, irrespective of isolation method, is therefore better read as reflecting ubiquity than a shared, seagrass-specific core mycobiota. Benzayed et al. [11] treated *Humicola* sp. as an obligate marine taxon in the western dataset; however, its ecological status is not uniformly resolved across the marine-mycology literature [15,16], and this record should therefore be treated cautiously until supported by molecular and ecological evidence.

A further caveat concerns the identification method itself. Both underlying studies [10,11] relied exclusively on phenotypic and morphological criteria — colony morphology, growth

rate and spore/conidial morphology under light microscopy — without molecular characterisation such as ITS or TEF1 sequencing. This matters most for genera such as *Fusarium* and *Penicillium*, whose morphological species boundaries are now known to be unreliable: many nominal morphospecies in these genera correspond to several phylogenetically distinct members of species complexes that cannot be separated without DNA sequence data [13,14]. The taxa listed here as *Fusarium* sp. and *Penicillium* sp. should therefore be read as morphology-based working identifications rather than confirmed species-level records, and the true extent of overlap or turnover between the two coasts may change once molecular data become available.

Regional context and implications

Set against the broader Mediterranean literature, current knowledge of *Posidonia oceanica* fungi remains heavily weighted toward the north, where culture- and molecular-based approaches already exist for Italy, France, the eastern Mediterranean and the wider basin [1,2,20–22,24]. These studies also indicate that fungal assemblages respond to disturbance such as boat anchoring [21] and differ between alive and dead matte [23], while culture-based work off Elba Island (Italy) recovered marine-specialist Lulworthiales, including the newly introduced genus *Paralulworthia*, from *P. oceanica* [25], which gives context for the *Lulworthia* records from eastern Libya. North Africa, by contrast, is represented only by the two Libyan culture-based studies compared here, with no equivalent data yet published from Egypt, Tunisia, Algeria or Morocco. This disparity points to an urgent need for coordinated regional surveys to establish whether the southern Mediterranean harbours a distinct *P. oceanica* mycobiota or shares the same dominant taxa, and argues for standardised sampling depth, tissue type and isolation protocol before any such regional comparison can be considered reliable, as done in recent studies that applied the same descriptors across sites and sampling years [22] and combined microscopy, culturing and pyrosequencing across several localities [24].

CONCLUSION

The published culture-based records from eastern and western Libya show limited name-based overlap on *Posidonia oceanica*: 5 of the 19 reported taxa were shared, corresponding to a Jaccard similarity of 26.3% and a Jaccard dissimilarity of 73.7%. Rhizomes had the highest recorded richness in the eastern dataset and were tied with roots in the western dataset. However, differences in sampling design, tissue representation, isolation protocol and taxonomic resolution prevent the relative effects of geography and methodology from being separated with the available data. The single shared obligate marine species, *Halothia posidoniae*, together with the four shared facultative genera, should therefore be regarded as a preliminary candidate list of recurrent cultured taxa for further testing — a working candidate core based on repeated culture records, not a molecularly validated core microbiome. Future studies in North Africa should combine standardised, multi-site culturing with ITS- and, where appropriate, TEF1-based sequencing or metabarcoding/environmental DNA (eDNA) approaches, so that both the cultured and unculturable fractions of the *P. oceanica* mycobiota can be evaluated on a standardised, region-wide footing.

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Author Contributions

T.A.E. conceived the review, compiled and reclassified the taxonomic data, performed the comparative and descriptive statistical analysis, prepared the tables and figure, and wrote and approved the final manuscript.

Conflict of Interest

The author declares no conflict of interest.

Work Ethics

This article is a literature-based review; it does not involve new sampling of living organisms, human participants, or animal subjects, and therefore did not require ethics committee approval. Primary data discussed herein were previously published and are cited accordingly [10,11].

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التنوع الفطري المرتبط بعشب البحر *Posidonia oceanica* في ليبيا: مراجعة مقارنة للسجلات الساحلية الشرقية والغربية

ملخص

أجرينا مقارنة بين الأصناف الفطرية (التي أمكن استنباتها مخبرياً) المسجلة والمرتبطة بعشب البحر *Posidonia oceanica* على السواحل الشرقية والغربية لليبيّا، وذلك بالاعتماد على السجلات المنشورة لدراستين مسحيتين اختلفتا في إجراءات أخذ العينات والعزل. وقد سُجِّلَت 5 أصناف فقط – من أصل 19 صنفاً إجمالاً (وهو مجموع الأصناف الفريدة في قائمتي الساحلين معاً) – في كلتا المنطقتين؛ مما يعطي معامل تشابه "جاكارد" (Jaccard) بنسبة 26.3% ومعامل اختلاف (عدم تشابه) بنسبة 73.7%. وتُعبّر هذه القيمة عن معدل التغير في قائمة الأنواع بين المنطقتين، ولا ينبغي تفسيرها على أنها مكوّن رسمي لتغيّر "التنوع الحيوي بيتا" (noverdiversity tur-beta) ما لم تُطوَّق طريقة محددة لتقسيم التنوع. أظهرت البيانات الخاصة بالمنطقة الشرقية أن الجذامير (rhizomes) كانت الموطن الأكبر عدد من الأصناف المسجلة، في حين تساوت الجذور والجذامير في تسجيل أعلى درجات الثراء النوعي في بيانات المنطقة الغربية. قد يعكس الاختلاف بين قائمتي الساحلين مزيجاً من العوامل الجغرافية، ونوع الأنسجة، وجهد أخذ العينات، وطريقة العزل – ولا سيما التباين بين تقنية تحضين البقايا النباتية المنجرفة (wrack incubation) والزراعة المباشرة للأنسجة الطازجة المعقمة سطحياً – رغم أنه لا يمكن فصل تأثير هذه العوامل عن بعضها البعض بناءً على البيانات المنشورة المتاحة. ونظراً لأن كلتا الدراستين اعتمدتا بشكل أساسي على التصنيف المورفولوجي (الشكلي) واستخدمتا تصميمات غير متكافئة لأخذ العينات، فإن هذه النتائج تُعد مقارنة أولية للسجلات المستتبّة وليست تقديراً معيارياً لتنوع الفطريات (الميكوبيوتا) الإقليمي؛ مما يشير بوضوح إلى الحاجة إلى إجراء مسوحات منسقة ومدعومة بالتحليلات الجزيئية في جميع أنحاء شمال أفريقيا.

الكلمات المفتاحية: شمال أفريقيا؛ *Posidonia oceanica*؛ فطريات بحرية؛ تنوع بيتا (beta diversity)؛ ليبيا.