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Distribution Patterns and Associated Communities of Sea Anemones in the South-Western Mediterranean

Rozmieszczenie przestrzenne ukwiałów morskich i gatunków towarzyszących w południowo-zachodniej części Morza Śródziemnego

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Abstract: This study investigates the distribution of sea anemone species along the Mediterranean southwest coast (the region of Oran, Mostaganem, Tlemcen/Ain Temouchent) aiming to understand their role as bioindicators and their contribution to biodiversity. Recognizing that anemone distribution is influenced by associated species, this research also examines the co-occurrence of other flora and fauna. A complete census of cnidarians was conducted, and Correspondence Factor Analysis (CFA) was used to analyze the relationships between three species of anemones (*Anemonia viridis, Anemonia rustica*, and *Actinia equina*) and their locations. The CFA identified five distinct groups in the spatial distribution of the anemones and associated floral and faunal species. Specifically, one group associated *Ulva Lactuca* with sites like Saintrock and Marsa El Hadjadj another linked *A. rustica* to sites like Madagh I and Arzew I; a third group connected *Padina pavonica* and *Cystoseira mediterranea* to locations such as Moscarda and Bider; a fourth associated *Paracentrotus lividus* with La Madrague; and a final group linked *A. viridis* to sites like Arzew II and Sidi Yochaa. Interestingly, the Shannon index (H) revealed variations in species diversity across the study area. The Tlemcen/Ain Temouchent and Mostaganem area exhibited the highest Shannon index values (some exceeding 1.6), indicating greater diversity, but also included sites with the lowest value (0), suggesting localized impacts on biodiversity. This research provides valuable insights into the distribution patterns of these key cnidarian species and their associated communities, contributing to our understanding of coastal ecosystem biodiversity and is likely to be useful for future conservation efforts in the Mediterranean.

Keywords: *Anemonia viridis*, *Anemonia rustica*, western Algeria, Mediterranean coast, ecosystem biodiversity, distribution patterns

Streszczenie: Badania dotyczą rozmieszczenia gatunków ukwiałów oraz współwystępowania innych gatunków flory i fauny wzdłuż południowo-zachodniego wybrzeża Morza Śródziemnego (regiony Oran, Mostaganem, Tlemcen/Ain Temouchent). Przeprowadzono inwentaryzację parzydełkowców, a zależność między trzema gatunkami ukwiałów (*Anemonia viridis*, *Anemonia rustica* i *Actinia equina*) a ich miejscem występowania zbadano za pomocą analizy czynnikowej (Correspondence Factor Analysis, CFA). Zidentyfikowano pięć odrębnych grup w przestrzennym rozmieszczeniu ukwiałów i związanych z nimi gatunków roślin i zwierząt. Występowanie gatunku *Ulva lactuca* skorelowane było w szczególności ze stanowiskami Saintrock i Marsa El Hadjadj, *A. rustica* ze stanowiskami Madagh I i Arzew I, *Padina pavonica* i *Cystoseira mediterranea* z Moscarda i Bider; *Paracentrotus lividus* z La Madrague, a *A. viridis* z Arzew II i Sidi Yochaa. Stwierdzono duże wahania w różnorodności gatunkowej na stanowiskach w trzech badanych regionach. Najwyższa wartość wskaźnika różnorodności Shannona (H) na niektórych stanowiskach w regionie Tlemcen/Ain Temouchent i Mostaganem przekraczała wartość 1,6, natomiast na innych była równa zero, co sugeruje wpływ lokalnych warunków na różnorodność biologiczną. Przeprowadzone badania dostarczają cennych informacji na temat rozmieszczenia kluczowych gatunków parzydełkowców i związanych z nimi innych gatunków flory i fauny. Uzyskane wyniki uzupełniają wiedzę na temat bioróżnorodności ekosystemów przybrzeżnych i mogą być przydatne dla przyszłych działań ochronnych w regionie Morza Śródziemnego.

Słowa kluczowe: *Anemonia viridis*, *Anemonia rustica*, zachodnia Algieria, wybrzeże Morza Śródziemnego, bioróżnorodność ekosystemu, rozmieszczenie przestrzenne

Introduction

Cnidarians, a major group of marine fauna, play a crucial role in marine ecosystems, particularly in the Mediterranean. They contribute to the structuring of habitats, take part in biogeochemical cycles and represent an essential link in marine trophic chains as predators and prey, they participate in marine food chains. Once regarded as mere trophic cul-de-sacs, jellyfish are now recognised as a surprisingly vital link within marine food webs. Owing to advanced techniques—ranging from isotope tracking and gut DNA analysis to animal-borne cameras—research is revealing that numerous oceanic predators consume jellyfish far more frequently than previously assumed. Although low in calorific value, jellyfish represent an accessible, abundant, and rapidly digestible food source, particularly when predators selectively target their more nutrient-rich components. However, this concealed dietary reliance carries a significant risk: the potential for predators to mistake plastic for jellyfish, rendering them increasingly susceptible to the rising prevalence of marine debris (Hays et al. 2018; Rossi et al. 2017), influencing population dynamics. Their symbiotic relationship with algae, such as zooxanthellae, is vital for coral/anemone survival and reef health. What is more, cnidarians are sensitive to environmental changes, making them important indicators of marine health (Kherchouche and Haffersas 2020).

In the Mediterranean, these organisms are subject to numerous anthropogenic pressures. Overfishing, in particular, often results in harmful practices such as bottom trawling, which significantly disrupts benthic ecosystems—key habitats for sea anemones and corals. This degradation contributes to a decline in both biodiversity and habitat complexity. Historical patterns indicate that the primary anthropogenic drivers of biodiversity loss have been overexploitation and habitat destruction. At present, the most significant threats include habitat degradation, fishing pressure, pollution, climate change, eutrophication, and the spread of non-native species—factors that collectively affect a wide range of taxonomic groups (Coll et al. 2010; Holon et al. 2019). Despite their ecological importance, knowledge of the distribution and diversity of cnidarians in certain coastal areas, particularly in North Africa, remains fragmentary (Kherchouche et al. 2024). The Algerian west coast, including the areas of Mostaganem, Oran, Aïn Temouchent and Tlemcen, remains a little-studied area in terms of cnidarian diversity and distribution.

This study aims to highlight the lack of knowledge about the diversity and distribution of cnidarians, and more specifically sea anemones, on the Algerian west coast. Faced with growing anthropogenic pressure and the ecological importance of these organisms, questions arise regarding their conservation and their role in maintaining marine biodiversity in the southern Mediterranean (Yacine et al. 2023). How can we characterise and enhance the diversity of cnidarians, particularly sea anemones, along the western coast of Algeria, in order to contribute to their conservation and the sustainable management of marine ecosystems.

In the context of our research, we are particularly interested in the order Actiniaria, and in particular the sea anemones *Anemonia viridis* (Forskal, 1775) and *A. rustica* (Risso, 1827) and, *Actinia equina* (Schmidt 1971).

Anemonia viridis plays a significant role in defining the thermal range essential for the stability of coral reef ecosystems (Abdelali & Grimes 2024). Its distribution is extensive, spanning the Mediterranean Sea and extending along the Atlantic coastline, including the shores of the English Channel. Recently brought to attention by a Dutch naturalist, *A. viridis* is particularly notable for its well-documented mutualistic relationship with the hermit crab *Pagurus prideaux*. In addition to its ecological interactions, this sea anemone is widely distributed across both the Mediterranean and Atlantic coasts, where it contributes substantially to the structure and dynamics of benthic communities (Manuel 1981). This project aims to identify and protect cnidarians in the southern Mediterranean by conducting a comprehensive species inventory. This will contribute to marine ecosystem conservation and sustainable management.

1. Material and Methods

1.1. Sampling sites and observation methods

Visual observations were made at each site to locate and identify the various anemone species present. Anemone samples were collected by snorkelling or scuba diving using a SCUBA by Cressi equipment devices. A unique code was assigned to each specimen, corresponding to the first letter of the species. Anemones were counted on site by diving using a quadrat randomly placed 10 samples from a transect at least 100 meters long for each site.

All observations and sampling were recorded using underwater video captured with an HDL action video camera video observations were digitally recorded on tape and enriched, in post-processing, with ancillary data. This made it possible to record the latitude, longitude, depth, temperature and oxygen concentration of each specimen observed or collected. Where conditions permitted, the size of organisms was estimated in situ using a graduated tape measure.

This spatial scale covers a study area encompassing almost the entire Algerian west coast (Fig. 1), including all the marine ecosystems of this region, and different types of coastal habitat (beaches, islets). The study area was divided into four regions to account for spatial heterogeneity in coastal environments and simplify data analysis. These regions likely differ in environmental factors like wave exposure, substrate type, and influence from human activities or river inputs.

Where the geographical coordinates of the beach and/or the specific sampling locality were not given, we used the local name of the town given in the document as the main reference (Table 1).

The anemones collected and their associated fauna and flora, from four different region some 31 coastal sites (Table 1) were identified according to their distinctive morpho-anatomical characteristics on site (*in situ*), before being validated in the laboratory through identification tests such as anemone morphology and pattern analysis, as well as detection of GFP (Green Fluorescent Protein) using UV lamps (Moya et al. 2012) To confirm the identification of the species observed, we used specialist literature including Ganot et al. (2011).

Identification was based mainly on the 1987 FAO Species Identification Sheets for Fisheries, as well as more recent scientific studies such as Grimes et al. (2004), Kallouche (2008), and Gofas et al. (2011). As part of our methodology, we used a 100 m linear transect with transect strips on each beach for benthic flora and fauna. This method allows for observation of biodiversity variations across the coastal zones of our stations.

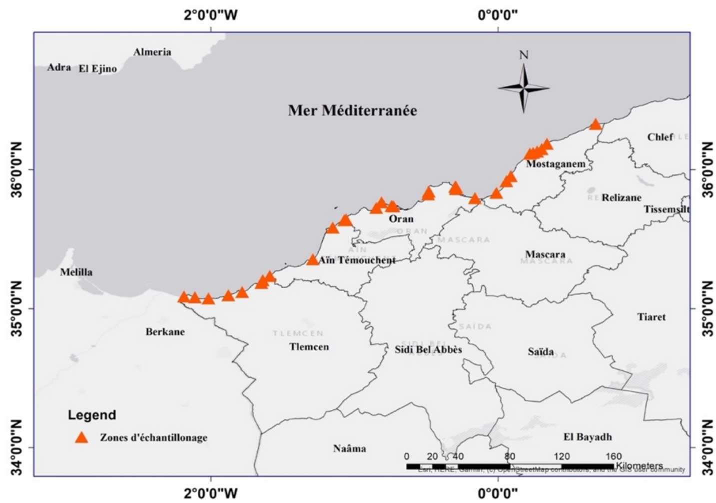

Figure 1. Location of sampling sites along Algeria's west coast – the Alboran Sea. (Soltani 2024)

1.2. Ecological indices

The current state of species diversity (flora and fauna) in the target area was assessed using the Shannon index (H', H_{max}) and Pielou's equitability index (J) where $J = H/ H_{max}$ for the major units identified.

The overall species composition at each sampling site was assessed using the species richness index (*S*), which is generally defined as the total number of species present (*S* = total number of species), including sea anemones and associated flora and fauna. For the calculation PAST Paleontological Statistics Software Package for Education and Data Analysis was used. This indicator combines richness and regularity, making it possible to determine the variety of the benthic populations throughout the study area (Hereu et al. 2004; Fourcassié 2006; Trigui et al. 2009).

2. Results

An inventory of anemones in western Algeria in January 2024 revealed 3 species, all of the same order: *A. viridis*, *A.rustica* and *Actinia equina*. They belong to 1 order (Actiniaria), 1 family (Actiniidae) and are divided into 2 genera. According to our observations, sea anemones are mainly found on rocky substrata (around 55% of records) in western Algeria. They are distributed in open areas, such as vertical walls, and sheltered, isolated areas, such as rocky crevices, caves and under rocks. Specimens were identified on the basis of their diagnostic morphological characteristics. A total of 3 anemone species were identified, distributed over 31 sites.

2.1. Complete inventory of anemone species and associated flora and fauna on Algeria's west coast

Anemone research along the Algerian west coast revealed *A. rustica* as the most common species, followed by *A. viridis*. *Cystoseira mediterranea* (Sauvageau, 1912) dominated the flora, while *Paracentrotus lividus* was the most prevalent animal. AZ III, AZ II, and MH exhibited the highest biodiversity, with *A. rustica* and *Cystoseira mediterranea* frequently coexisting. *Paracentrotus lividus* preferred areas with abundant *Cystoseira mediterranea*.

2.2. Comparison of cnidarian distribution and abundance between surveyed sites in each region

Anemonia rustica appears to be more broadly distributed across the studied sites (Oran area) than *A. viridis* (Fig. 2). While both species show fluctuations in density across sites, *A. rustica* maintains relatively higher densities at several locations, indicating potentially more favourable conditions

Table 1. GPS locations of sampling sites

Studied Sites	Latitude	Longitude
Oran Area		
Kristel (KR)	35.82345475898434	-0.48832230856552333
Ain Defla (AD)	35.843171951716265	-0.4835318012000072
Arzew III (AZ III)	35.87851386661312	-0.29952083447435907
Arzew II (AZ II)	35.875159269563106	-0.2932335853593883
Arzew I (AZ I)	35.860982993539025	-0.29527360538721614
Marsa el hadjaj (MH)	35.796661245282564	-0.16248063075331534
Trouville (TV)	35.73947858634728	-0.7419377895940164
Saintrock (SR)	35.73721900350312	-0.7289258136393907
Bousfer (BS)	35.72652092426649	-0.8486664744221223
La Madrage (MB. B)	35.76572405181129	-0.8127725460503944
Madagh I (Mgh I)	35.64235293018755	-1.0588785154627136
Madagh II (Mgh II)	35.63766925823337	-1.070636642381495
Mostaganem Area		
Mosta hadjadj (MH I)	36.14978926818785,	0.3022158004716402
Mosta Hadjadj (MH II)	36.12239312972771	0.2432837686972861
Bousquette (BQ)	36.188085065084294	0.3382801400376184
Clovis (CV)	36.13074403147582	0.2707440070256391
Cap ivi (CI)	36.11628436742277	0.220689334217207
Salamandre (SLM)	35.917268434556966	-0.057005929801786114
Stidia (ST)	35.834545135643395	-0.013149565522551459
Tlemcen + Ain Temouchent Area		
Bouzedjar (BZ)	35.583722308178814,	-1.151205639976244
Ourdania (OD)	35.23633760814518,	-1.5899598563057316
Sidi djeloul (SD)	35.35599786759426,	-1.2907538435713963
Sidi majdoub (SM)	35.954036887695565,	0.08820659331506378
Ghazaouat (G. OA)	35.09639072304736,	-1.87807333421809
Agla (AG)	35.205205828203226,	-1.6388362219826842
Bider (BD)	35.08235329864345,	-2.1109697588729532
OuledBoughalem (OB)	36.33019281221835,	0.678026311828916
Honaine tafsout (HT)	35.18574049482439,	-1.6490818371903595
Mascadra (MD)	35.087798582435184,	-2.1872753706763284
Ouled Aide (OA)	35.074026128785334,	-2.0165960251112396
Sidi youchaa (SY)	35.1206049515242,	-1.7824882490964544

for this species overall in the studied area. The absence of both *A. rustica* and *A. viridis* from TV/SR suggests this location might have environmental characteristics that are unsuitable for both species. *Actinia equina* is a rare occurrence in the studied area, observed at only two sites and in very low numbers. This indicates that the conditions in most of the surveyed locations are not conducive to its survival or establishment.

Unlike the previous dataset (Oran area), the Mostaganem data shows a much more distinct difference in distribution patterns between the two species (Fig. 3).

A. viridis exhibits a strong site preference in the Mostaganem area, contrasting with the more dispersed distribution seen in the Oran data. The overall abundance of both species is notably lower at most sites in Mostaganem compared to some of the higher density locations in the Oran

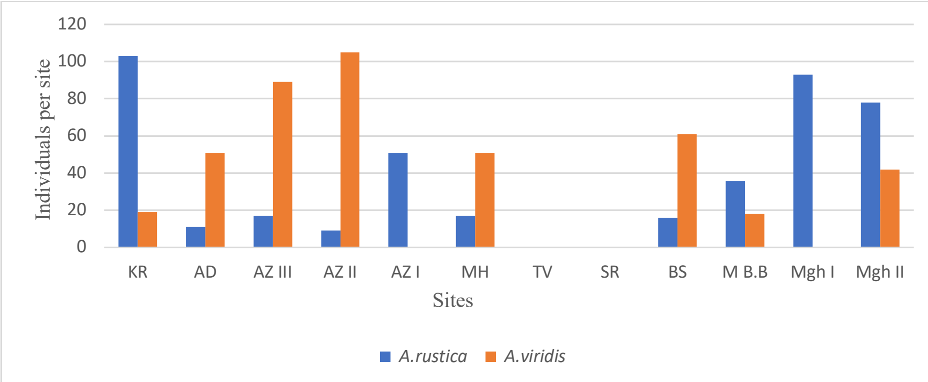

Figure 2. Comparison of the numbers of two cnidarian species at different sites in the Oran area. For full names of the sites see Table 1

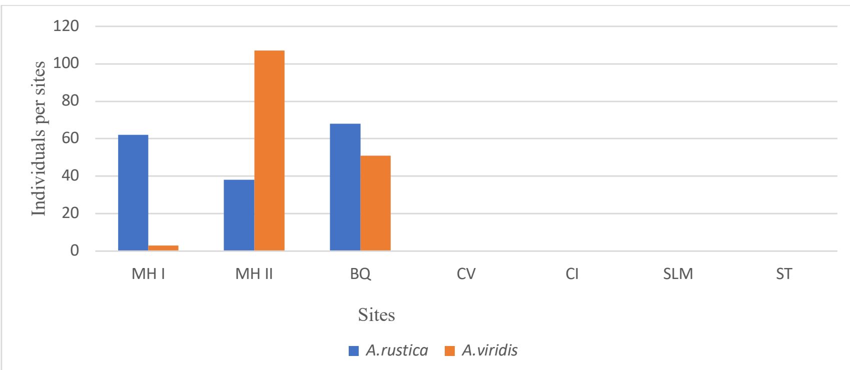

Figure 3. Comparison of the numbers of two cnidarian species at different sites in the Mostaganem area. For full names of the sites see Table 1

area. There is a clear separation in habitat use in Mostaganem: *A. rustica* is present in moderate numbers across several sites, while *A. viridis* is highly concentrated in just one.

In the Tlemcen and Ain Temouchent area *A. viridis* exhibits a relatively widespread distribution, being present at most sites, except OB and SM (Fig. 4). While its abundance varies, its consistent presence suggests a broader tolerance for the range of environmental conditions present in the Tlemcen and Ain Temouchent area. Some locations appear to be more favourable than others, supporting larger populations.

A. rustica exhibits a notably restricted distribution and was not recorded at any of the three sites: HT, OB, and SM.

2.3. Species richness and species diversity at the studied sites Oran, Mostaganem, Tlemcen and Ain Temouchent

2.3.1. Species richness (S)

The Oran zone has an average species richness, ranging from 2 to 7 species (Fig. 5). With a maximum of six species and a minimum of one species in CI, the Mostaganem shows a relatively modest species richness (Fig.5).

2.3.2. Shannon Index of species diversity

The Shannon index, a measure of species diversity (*A. viridis*, *A. rustica*, *Actinia equina*, *Ulva lactuca*, *Padina pavonica*, *Cystoseira mediterranea*, *Paracentrotus lividus*), varies across the examined locations. The Oran region shows the greatest variability in diversity, spanning from relatively low

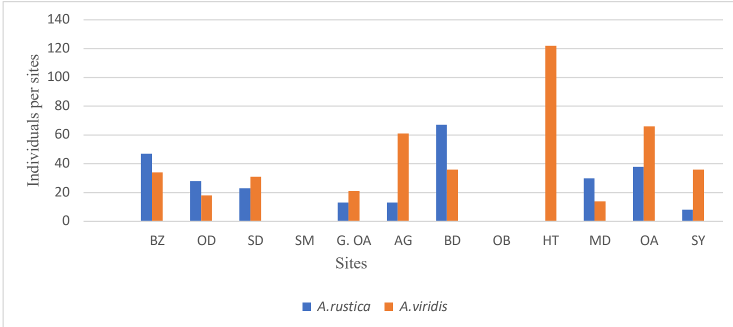

Figure 4. Comparison of the abundance of two cnidarian species across various sites in the Tlemcen and Aïn Témouchent region. For full names of the sites see Table 1

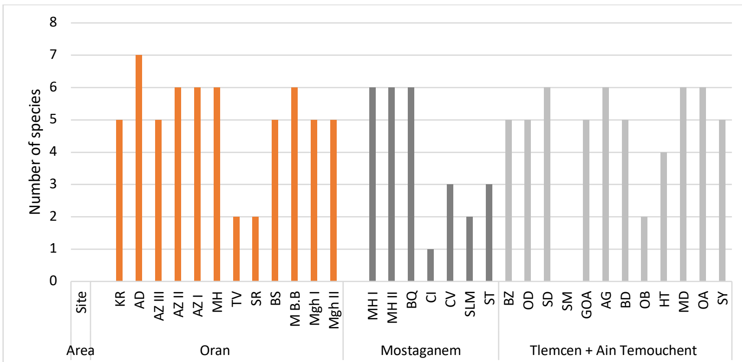

Figure 5. Species richness (S) for different stations in the three areas of study

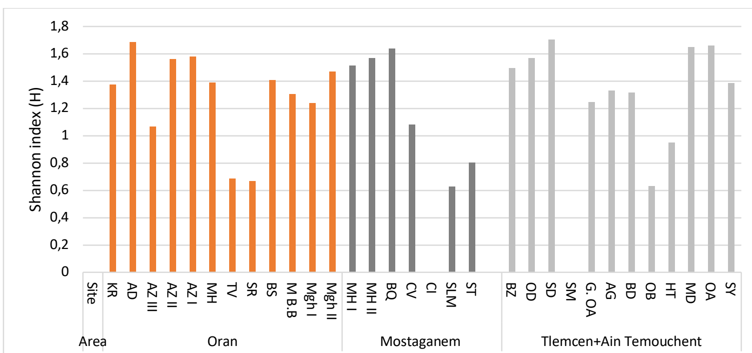

Figure 6. Shannon's diversity index (H) for different stations in the three areas of study. For full names of the sites see Table 1

to quite high values. This suggests a heterogeneous environment with some locations supporting a rich mix of species and others being less hospitable (Fig. 6).

The Mostaganem region demonstrates a more limited range of diversity compared to Oran. While some sites show moderate diversity, the overall range is narrower, and the presence of a zero value indicates at least one site lacking diversity. The Tlemcen/Ain Temouchent region, in turn, is characterised by generally higher diversity values compared to the other two regions.

2.3.3. Piélou's equitability index (J)

Pielou's J values are generally high across the Oran area, indicating a relatively even distribution of species among the sampled sites (Fig. 7). This suggests that no single species overwhelmingly dominates most locations.

Most of the sites in Mostaganem—namely SLM, CL, ST, MH I, MH II, and BQ—exhibit very high evenness, approaching a near-perfect balance. These locations likely offer stable and diverse environmental conditions that support a well-distributed community of species. One site, however, stands out for its noticeably lower evenness: CI. At this site, a high abundance of *Cystoseira mediterranea* was recorded.

Compared to Oran, Tlemcen and Ain Temouchent show a similar general trend of good evenness. Compared to Mostaganem, Tlemcen and Ain Temouchent show more variability in evenness. Mostaganem was characterised by consistently high evenness across almost all sites, indicating more homogenous conditions.

2.5. Correspondence factor analysis (CFA)

The first two axes of the CFA together explain 61% of the total variance in the data (37% + 24% respectively; Fig. 8). This indicates that these two axes capture the majority of the information contained in our dataset and are therefore the most relevant for interpretation.

The CFA also identified five distinct groups in the spatial distribution of the anemones and associated floral and faunal species.

Group 01: This group includes *Ulva lactuca* and the MH II, KR, TV, CV, OB, BZ, ST and SM sites. The green alga is often found in nutrient-rich or disturbed environments. These sites might be subject to higher nutrient levels due to runoff or agriculture pollution, or experience more physical disturbance (e.g., wave action).

Group 02: This group includes the Mgh I, AZ I, BQ, MH I sites with *A. rustica.*

These sites may share common characteristics, such as the presence of a port or an industrial zone, which favour the growth of this particular species.

Group 03: This group includes *Padina pavonica* and *Cystoseira mediterranea* at the BD, BS and SM, Mgh II, AD, MH II, SD, MS, G.OA sites.

These algae often prefer different habitats. *Padina* thrives in more exposed, rocky areas while *Cystoseira* prefers calmer, more sheltered waters and is sensitive to pollution. Its presence in this group could indicate relatively good water quality at these sites The presence of both species within this group suggests a potential mix of habitats within these sites or a broader environmental tolerance of these species.

Group 04: This group includes the association of *Paracentrotus lividus* with the MB.B site.

This association suggests the MB.B site provides suitable habitat for this sea urchin species, such as rocky substrates for grazing.

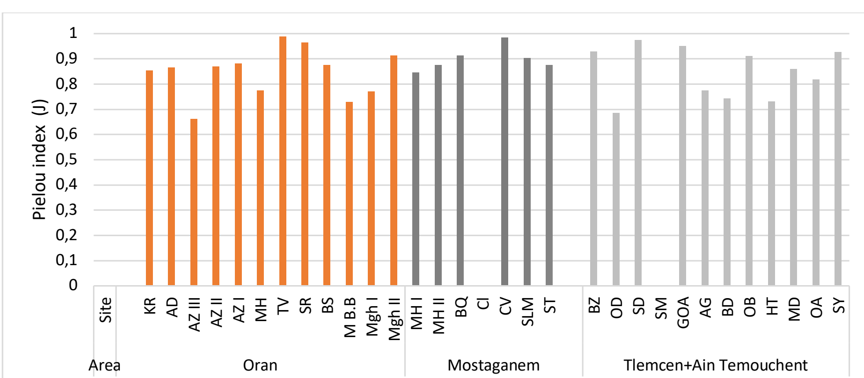

Figure 7. Pielou's equitability index (J) for different stations in the three areas of study. For full names of the sites see Table 1

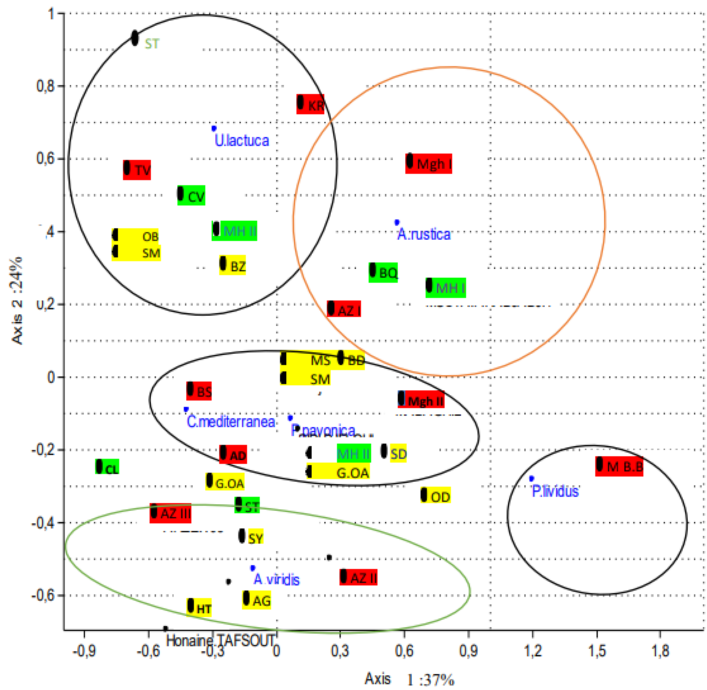

Figure 8. Correspondence Factor Analysis (CFA) illustrating the spatial distribution of sea anemones and their associated floral and faunal communities along the south-western Mediterranean coast. Colour codes: Red – Oran, Green – Mostaganem, Yellow – Tlemcen/Aïn Témouchent

Group 05: This final group includes AZII, AZ III, SY, AG, ST and HT, all characterised by the presence of *A. viridis*. The clustering may be attributed to the geographical positioning of these sites in the far western region of Algeria.

Discussion

Our study revealed a diverse assemblage of anemones along the Algerian west coast, with varying spatial distributions and abundance patterns across different regions. The number of observed anemone species represents 12.5% of all species of Mediterranean (Gueroun et al. 2022) These species have been previously documented in the northern Mediterranean. However, compared to earlier research conducted in the southern Mediterranean (Seguin 1973; Dallot et al. 1988; Daly Yahia et al. 2003; Touzri et al. 2010; Touzri et al. 2012). Sea anemones in the southern Mediterranean exhibit a greater degree of ecological flexibility than previously assumed, with certain species demonstrating resilience to rising sea temperatures, while others are becoming increasingly restricted to specific, cooler microhabitats. This finding contrasts with earlier studies that suggested more general, less species-specific trends in marine diversity.

A. rustica demonstrated a relatively consistent presence across most sites, suggesting its adaptability to a range of environmental conditions (Ounissi et al. 2016). High densities were observed at (KR), (Mgh I), and (Mgh II), potentially due to favourable substrate, food availability, and reduced human disturbance (Kallouche et al. 2014). Conversely, its absence from (TV) and (SR) could be attributed to specific local factors like pollution, habitat degradation, or competition from other species. It is important to note that the benthic stages of these organisms are influenced by various environmental factors, including temperature, food availability, light exposure, salinity, and lunar cycles, as well as potential interactions between these factors (Dong et al. 2015). Particularly noteworthy is the positive association between the anemone *A. rustica* and the seaweed *C. mediterranea*, which is frequently present in large numbers. Furthermore, it appears that the sea urchin

P. lividus prefers fertile areas of *C. mediterranea*. This study is not only an inventory of species, but it also highlights the ecological relationships between them. *A. viridis* exhibited a more uneven distribution, with high densities concentrated in (AZ II), (AD), and (MH). This suggests greater sensitivity to environmental variations compared to *A. rustica*. The absence from (AZ I), (Mgh I), and TV/SR might be linked to specific habitat requirements, such as water temperature, depth, or substrate type (Belmokhtar 2012).

A. equina was the least abundant species, recorded only at AD and AZ I. This rarity may indicate specific habitat preferences or limited dispersal capabilities. Spatial distribution patterns of *A. rustica* in the Mostaganem region, displayed a relatively uniform distribution across the three sites MH I, MH II and BQ, suggesting that these locations provide suitable conditions for this species (Leopold & Kouyoumjian 2006). In contrast, *A. viridis* exhibited a strong dominance at the BQ site, implying that this location likely offers more favourable environmental conditions, such as specific temperature, light, or substrate characteristics (Boutiba 2015). In the Tlemcen and Ain Temouchent region, *A. rustica* again showed a relatively uniform distribution, although with variations in abundance. BZ and Mgh II appeared to support the largest populations. *A. viridis* demonstrated a more heterogeneous distribution, with a marked dominance at OB. Its notable absence from several localities, including Mgh II, BZ, and BD, suggests that these locations may not meet its specific habitat requirements (Bouras et al. 2017).

The quantitative indices: Shannon diversity, Pielou's equitability, and species richness—further support this interpretation. Sites exhibiting higher species richness and more balanced community structures, particularly in the Oran and Tlemcen/Ain Temouchent regions, are likely to possess greater habitat complexity, enhanced ecological stability, and lower levels of disturbance. In contrast, sites characterised by low diversity and uneven species distributions may indicate ecological simplification, potentially resulting from stressors such as nutrient enrichment, urbanisation, or physical degradation.

The Shannon index, used to measure biodiversity, shows significant variability between the regions studied (Oran, Mostaganem and Tlemcen/Ain Temouchent), indicating different levels of specific diversity. This variation could be attributed to various factors: the more intense industrial activity in Mostaganem and Oran, which is likely to have a negative impact on biodiversity through pollution and destruction of habitats, and the particular geographical characteristics of the Tlemcen/Ain Temouchent region, in especially its considerable depth (potentially linked to altitude, topography or geology), which may favour a greater diversity of habitats—and therefore species (Kallouche 2008). The division of the study area into these three parts makes it possible to take better account of these distinct influences, which should be studied in greater detail by quantifying industrial activity and accurately characterising geographical features, while also considering other potential factors such as climate, soil type or land use.

The ecological preferences exhibited by each species are particularly informative. *A. rustica*'s widespread presence and adaptability suggest that it functions as a resilient species, capable of tolerating a broad range of environmental conditions, including those influenced by anthropogenic activity. In contrast, *A. viridis*, with its more selective distribution, appears to serve as a sensitive ecological indicator, likely responding to subtle variations in temperature, substrate type, or water quality. The very limited presence of *A. equina* may indicate either a high degree of habitat specificity or increasing environmental pressures that are restricting its distribution—potentially serving as an early warning sign of local ecological stress. While *A. rustica* appears more tolerant of the varying environmental conditions present at certain locations, its absence or low abundance at several other sites may reflect the lack of essential resources or the presence of unfavourable conditions for its establishment.

Notably, the Correspondence Factor Analysis (CFA) results enhance our understanding by clustering sites and species into distinct ecological assemblages, thereby revealing patterns that can inform site-specific conservation strategies. For example, the clear grouping of species associated with nutrient-rich or disturbed environments (Group 01), in contrast to those linked with more pristine conditions—such as *Cystoseira mediterranea* in Group 03—provides a valuable framework for environmental monitoring and targeted habitat protection.

Taken as a whole, these findings reinforce the view that preserving sea anemone diversity is not merely an end in itself, but a means of safeguarding broader ecological functions and biodiversity patterns. As keystone and indicator species, cnidarians embody the delicate balance of Mediterranean coastal ecosystems. Their presence—or absence—provides critical insight into the health, resilience, and trajectory of marine habitats facing increasing pressures from climate change, pollution, and anthropogenic activity.

In answering the central research question, this study demonstrates that characterising cnidarian diversity is not only feasible but also both urgent and actionable. The insights gained here lay a foundation for long-term monitoring programmes, guide the designation of marine protected areas, and inform policy decisions related to coastal development and resource management. Furthermore, they contribute to filling critical biogeographic knowledge gaps in a region that is often overlooked in global marine biodiversity assessments.

Ultimately, this research highlights that conserving marine biodiversity in the southern Mediterranean necessitates an integrated approach—one that combines rigorous field data, sound ecological theory, and effective conservation frameworks. By focusing on key species such as *A. viridis* and *A. rustica*, the study demonstrates that even modest biodiversity assessments can yield valuable insights into broader environmental dynamics and inform targeted ecological stewardship.

The results indicate that several regions have been poorly studied or not studied at all. Although inventory efforts have increased in recent years—over 50% of which have focused on biodiversity—the status of biodiversity within this group of species remains uncertain. Substantial effort is still required to enhance the analysis of occurrence patterns and to identify new species, particularly in the context of an environmental landscape that is continuously evolving under the influence of human activity.

Conclusion

This study highlights and confirms the distinct spatial distribution of *A. rustica* and *A. viridis* on the west Algerian coast (Rodriguez 2007). Our results demonstrate the importance of considering the complex interactions between these anemones and their environment to understand their stress responses (Hoepner et al. 2019; Wu et al. 2022). The ubiquitous presence and abundance of *A. rustica* suggest a key role of the species in the ecosystem, while the variations observed in *A. viridis* underline its sensitivity to environmental conditions (Ventura et al. 2016). Therefore, these organisms seem to be promising indicators for environmental monitoring. Their potential use in monitoring networks could enable early detection of environmental changes and thus contribute to better management of marine ecosystems (Gómez et al. 2023).

The study found that the Tlemcen and Ain Temouchent region has the highest biodiversity among the three areas examined, likely due to favourable environmental conditions and less human interference. Oran shows moderate biodiversity, while Mostaganem has the lowest, potentially as a result of environmental factors and higher human impact. The Tlemcen and Ain Temouchent region requires urgent conservation efforts, while Oran and Mostaganem need restoration and sustainable management practices to enhance biodiversity

Future research should focus on identifying the specific pollutants to which these anemones are sensitive; determining their levels of tolerance to xenobiotics; studying the physiological mechanisms explaining the differences in response between *A. rustica* and *A. viridis* (Morais et al. 2020). The results of these studies will enable us to refine the use of anemones as bioindicators and optimize conservation strategies for the Algerian coastline. In conclusion, this study broadens our understanding of the ecology of *A. rustica* and *A. viridis*. It opens the way to new research prospects and applications for the monitoring and preservation of marine ecosystems in Algeria and beyond.

The CFA highlights interesting associations between marine species and observation sites. Further analysis of these results, taking into account the environmental characteristics of the sites, will enhance our understanding of the factors influencing the distribution of these species.

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