

## Diversity and Relative Abundance of Crustaceans in Ain Al-Ghazala Lagoon, Libya

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### التنوع والوفرة النسبية للقشريات في بحيرة عين الغزالة، ليبيا

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#### Abstract:

The present study investigates the species diversity and relative abundance of crustaceans in Ain Al-Ghazala Lagoon, a coastal ecosystem located on the northeastern Libyan coast. Sampling was conducted during both summer and winter using sediment sieves, baited traps, and hand-nets. Fourteen species of crustaceans were identified, with *Penaeus semisulcatus* (22%) and *Metapenaeus monoceros* (18%) being the most dominant. Other notable species included *Portunus pelagicus* (15%) and *Callinectes sapidus* (12%). The diversity and abundance patterns observed indicate a well-structured crustacean community influenced by habitat complexity, substrate type, and environmental parameters such as salinity. The presence of commercially and ecologically significant species underscores the lagoon's importance as a biodiversity hotspot. The study highlights the need for conservation and continuous monitoring to sustain the ecological balance of this vulnerable coastal habitat and provides baseline data for future ecological assessments and resource management strategies in Libyan lagoons.

**Keywords:** crustaceans, Biodiversity, abundance, Ain Al-Ghazala Lagoon, Libya.

#### الملخص:

الدراسة الحالية تستقصي التنوع البيولوجي والوفرة النسبية للقشريات في بحيرة عين الغزالة، وهي نظام بيئي ساحلي يقع على الساحل الشمالي الشرقي لليبيا. تم جمع العينات خلال فصلي الصيف والشتاء باستخدام مناخل الرواسب، والمصائد، والشبكات اليدوية. تم تحديد أربعة عشر نوعاً من القشريات، حيث كان *Penaeus semisulcatus* الأكثر هيمنة بنسبة (22%)، *Metapenaeus monoceros* بنسبة (18%)، وشملت الأنواع البارزة الأخرى *Portunus pelagicus* بنسبة (15%) و *Callinectes sapidus* بنسبة (12%). تشير أنماط التنوع والوفرة الملاحظة إلى مجتمع قشريات جيد التنظيم يتأثر بتعقيد الموائل، ونوع الركيزة،

والعوامل البيئية مثل الملوحة. يؤكد وجود أنواع ذات أهمية تجارية وبيئية على أهمية البحيرة كبؤرة للتنوع البيولوجي. تسلط الدراسة الضوء على الحاجة إلى الحفاظ والمراقبة المستمرة للحفاظ على التوازن البيئي لهذا الموئل الساحلي الضعيف، وتوفر بيانات أساسية للتقييمات البيئية المستقبلية واستراتيجيات إدارة الموارد في البحيرات الليبية.

**الكلمات الدالة:** القشريات، التنوع البيولوجي، الوفرة، بحيرة عين الغزالة، ليبيا.

## Introduction

Coastal lagoons represent dynamically active and highly productive ecosystems, forming crucial ecological linkages between terrestrial and marine environments (Okoro et al., 2014). These systems are widely recognized for their significant ecological contributions, including the sustenance of diverse food webs, provision of essential breeding grounds for numerous marine species, and enhancement of overall ecosystem health and productivity (Haddoud & Rawag, 1995). The Mediterranean region, in particular, hosts many such vital ecosystems, which are especially vulnerable to anthropogenic pressures and environmental shifts. Consequently, a comprehensive understanding of the biodiversity within these fragile environments is imperative for effective conservation and sustainable management strategies.

Ain Al-Ghazala Lagoon, situated along the northeastern Libyan coast, exemplifies a critical coastal habitat. This 180-hectare lagoon, with depths ranging from 3.5 to 5 meters, is characterized by distinct physicochemical properties, including elevated electrical conductivity and higher concentrations of various chemical constituents compared to adjacent aquatic bodies (Fitori et al., 2022). These unique environmental conditions position Ain Al-Ghazala as a pivotal site for marine biological research, supporting a rich and specialized biodiversity.

Among the various faunal groups inhabiting coastal lagoons, malacostracan crustaceans hold particular ecological and economic significance. As members of the phylum Arthropoda, this class encompasses a diverse array of species, such as crabs, prawns, and lobsters, which play critical roles in the nitrogen cycle, marine food webs, and local fisheries (Agbali et al., 2014; El-Maremie et al., 2015). Their abundance and widespread distribution also render them valuable indicators of environmental change and ecosystem health. Despite their ecological importance, comprehensive studies explicitly detailing the diversity and relative abundance of malacostracan crustaceans in Libyan coastal lagoons, particularly Ain Al-Ghazala, remain limited. Previous biodiversity assessments of Ain Al-Ghazala have broadly documented crustaceans and other faunal groups, underscoring their contribution to the lagoon's diverse ecosystem (Ali et al., 2025). However, a targeted investigation of this specific group is necessary to elucidate their ecological dynamics and community structure within this unique setting.

The primary objective of the present study is to assess the species diversity of malacostracan crustaceans in Ain Al-Ghazala Lagoon and, where feasible, to provide data on their relative abundance. This research will not only document the species composition but also offer baseline data essential for future conservation initiatives and the sustainable management of this invaluable Libyan coastal resource, thereby contributing to a more thorough understanding of the lagoon's biodiversity and the ecological roles of these crustaceans.

## Materials and Methods

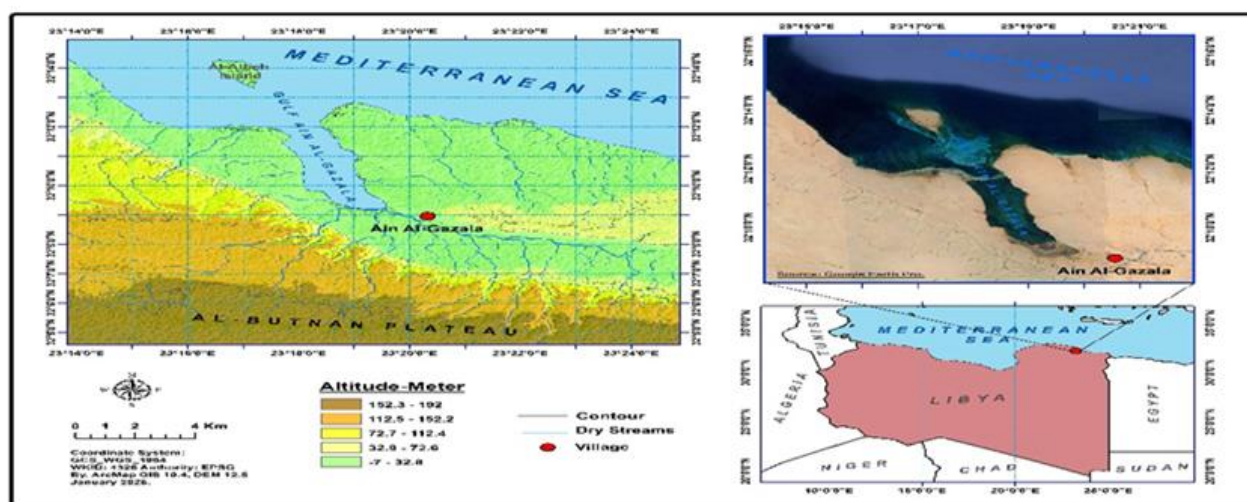
### Study area

Ain Al-Ghazala Lagoon is located along the Mediterranean coast of northeastern Libya, between latitudes 32.05°–32.15° N and longitudes 23.14°–23.26° E. The lagoon's distinctive coastal landscape is characterized by sandy beaches interspersed with rocky shorelines. Covering an area of approximately 180 hectares, the lagoon extends 6 kilometers in length and 1.5 kilometers in width, with water depths ranging from 3.5 to 5 meters. Almarakeb (Ulbah) Island acts as a natural barrier at the lagoon's entrance, lessening

the effects of northern winds and wave activity and preserving the ecological stability of the bay. The surrounding area has a variety of physical features, such as low hills to the south that rise up to 192 meters above sea level, narrow coastal plains, wide sand dunes, and numerous notable bays, the most notable of which is Ain Al-Ghazala Bay (Figure. 1).

### Sampling

Sampling of the Ain Al-Ghazala lagoon was conducted during the summer and winter seasons. Crustacean specimens were collected at multiple locations utilizing three distinct methods: sediment sieves, baited traps, and shallow-water hand-nets. Following collection, specimens were preserved in 70% ethanol and subsequently identified to species level using established taxonomic keys. Relative abundance was determined by expressing the number of individuals of each species as a percentage of the total crustacean catch.



**Figure 1:** location of Ain Al-Ghazala Lagoon on the northeastern coast of the Mediterranean Sea in Libya

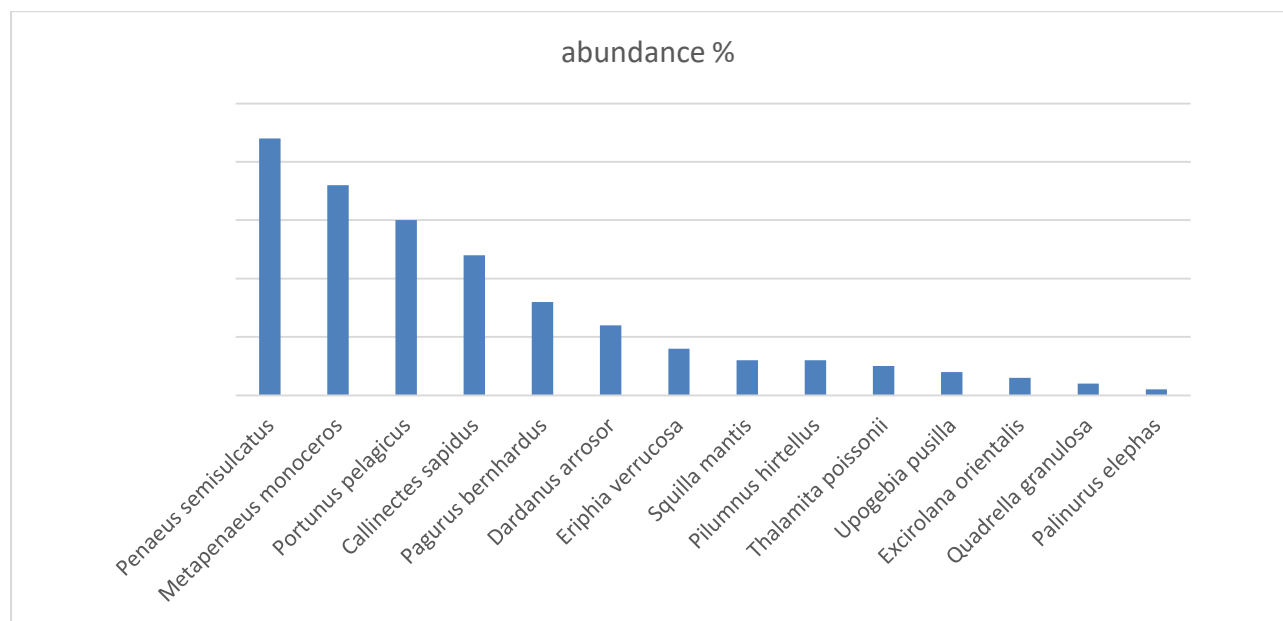
### Results

A total of 14 crustacean species were identified within the Ain Al-Ghazala lagoon. The dominant species observed were *Penaeus semisulcatus*, accounting for 22%, and *Metapenaeus monoceros*, at 18%. Following these were *Portunus pelagicus* at 15% and *Callinectes sapidus* at 12%. Other notable species included *Pagurus bernhardus* at 8% and *Dardanus arrosor* at 6%. The remaining species, encompassing various crabs, shrimp, and an isopod, exhibited lower relative abundances, all less than 5% (Table 1, Figure2).

**Table 1:** Relative abundance of crustacean species recorded in Ain Al-Ghazala lagoon

No.	Species Name	Relative Abundance (%)
1	<i>Penaeus semisulcatus</i>	22
2	<i>Metapenaeus monoceros</i>	18
3	<i>Portunus pelagicus</i>	15
4	<i>Callinectes sapidus</i>	12

No.	Species Name	Relative Abundance (%)
5	<i>Pagurus bernhardus</i>	8
6	<i>Dardanus arrosor</i>	6
7	<i>Eriphia verrucosa</i>	4
8	<i>Pilumnus hirtellus</i>	3
9	<i>Squilla mantis</i>	3
10	<i>Thalamita poissionii</i>	2.5
11	<i>Upogebia pusilla</i>	2
12	<i>Excirolana orientalis</i>	1.5
13	<i>Quadrella granulosa</i>	1
14	<i>Palinurus elephas</i>	0.5



**Figure 2:** Relative Abundance of Crustacean Species in Ain Al-Ghazala Lagoon

## Discussion

Ain Al-Ghazala Lagoon exhibits a relatively high level of biodiversity, as evidenced by the identification of 14 crustacean species in this study. *Penaeus semisulcatus* was the most prevalent species, constituting 22% of the total abundance, followed by *Metapenaeus monoceros* (18%). Both *P. semisulcatus* and *M. monoceros* are penaeid prawn species found in the Mediterranean Sea, particularly in its eastern and southeastern regions. These species have experienced notable population declines in recent decades and are now less common compared to other penaeid shrimps. Historically, they held commercial significance, but their populations have drastically decreased over the past 20 years, largely attributed to environmental changes such as the restriction of the Nile flow (Wadie & Razek, 1985). Consequently, smaller penaeid species now dominate prawn catches in the southeast Mediterranean. Recent surveys indicate their presence in Iskenderun Bay (NE Mediterranean), though they are not dominant (Can et al., 2004; Kumlu

et al., 1999), with *M. stebbingi* currently being the most prevalent penaeid prawn. While *P. semisulcatus* and *M. monoceros* remain prevalent along the eastern Mediterranean coasts of Egypt and Turkey, their numbers are low compared to other penaeid species and historical levels (Sharawy et al., 2017). These shrimps exhibit marked seasonal fluctuations in abundance and biological traits, including protein and carotenoid content, which typically peak in spring and summer (Yanar et al., 2004; Yanar & Celik, 2006). Although *M. monoceros* is now infrequently caught in some areas, *P. semisulcatus* attains larger sizes and is more commonly observed in deeper waters during spawning (Kumlu et al., 1999).

Other significant species included swimming crabs such as *Portunus pelagicus* (15%) and *Callinectes sapidus* (12%). These species are ecologically important and frequently dominate productive estuarine and lagoonal habitats. Their presence reflects a healthy trophic structure and adequate prey availability, demonstrating their adaptability as omnivores in dynamic environments. Both *P. pelagicus* and *C. sapidus* are ecologically and commercially significant crab species found in estuaries and lagoons. Their omnivorous diet, adaptability, and tendency to dominate their environments signify healthy ecosystems with sufficient prey resources.

Blue crabs (*Callinectes sapidus*) and flower crabs (*Portunus pelagicus*) have successfully established colonies in numerous Mediterranean lagoons and estuaries, including Bizerte Lagoon (Tunisia), Bardawil Lagoon (Egypt), and Mellah Lagoon (Algeria). They often become dominant or co-dominant species in these settings. *C. sapidus* is a particularly noteworthy invasive species, having colonized various estuarine and lagoonal habitats due to its broad tolerance for temperature and salinity (Schubart et al., 2022; Razek et al., 2016; Kara & Chaoui, 2021). The consistent presence of juveniles and ovigerous females in these regions indicates successful reproduction and long-term establishment of both species (Gil-Fernández et al., 2023).

Both *P. pelagicus* and *C. sapidus* are omnivores, effectively adapted to variable and dynamic environments. They thrive in productive estuarine and lagoonal settings due to their ability to consume a diverse range of prey and detritus (Rifi et al., 2023). *C. sapidus* is particularly well-adapted to brackish and fluctuating conditions, with optimal performance recorded at 18.5 psu. The nursery grounds within these lagoons contribute to the recruitment and abundance of these crab populations, thereby enhancing their stability (Gil-Fernández et al., 2023). Significant populations of hermit crabs, including *Pagurus bernhardus* (8%) and *Dardanus arrosor* (6%), were also observed. Their presence suggests the existence of intricate benthic habitats with an adequate supply of gastropod shells and cover, both essential for these species' survival. Empty snail shells are crucial for hermit crabs, providing vital, portable protection for their delicate abdomens. This essential requirement directly impacts hermit crab populations, as the availability and size of suitable shells are critical. Larger species are particularly vulnerable if appropriate shells are scarce or already occupied. Complex underwater habitats with a diverse range of suitable shells support higher densities and diversity of hermit crabs.

A hermit crab's shell selection is influenced by several factors: competition and coexistence, where multiple species may share resources, partition microhabitats, or even utilize alternative shelters like sponges when preferred shells are scarce; prior experience, which often leads them to prefer shell types they have previously inhabited; and shell diversity and size, as larger crabs require larger shells, and limited availability can restrict their growth and population numbers (Rodrigues et al., 2002; Kellogg, 1976; McLean, 1983; Colón-Piñeiro et al., 2021; Sandford, 1995).

The abundance of other species, such as *Eriphia verrucosa*, *Upogebia pusilla*, and *Squilla mantis*, was very low (less than 5%). Regarding Ain Al-Ghazala Lagoon specifically, the analysis of key environmental variables (inferred through electrical conductivity and total dissolved solids), and pH reveals a water body with distinct physicochemical characteristics that directly influence biodiversity. The elevated levels of electrical conductivity and total dissolved solids indicate a relatively high salinity, reflecting the lagoon's limited tidal exchange and marine influence. The alkaline pH suggests a relatively



stable aquatic environment, which is essential for the survival of sensitive marine organisms. Additionally, the concentrations of nutrients such as nitrate, nitrite, phosphate, sulfate, calcium, and magnesium were notably high, promoting a fertile environment that can support increased biological productivity. While these conditions may provide a favorable habitat for certain euryhaline and nutrient tolerant species, the excessive nutrient load raises concerns about potential eutrophication, which can lead to algal blooms, oxygen depletion, and consequently, negative impacts on aquatic biodiversity especially among sensitive species. Thus, the relationship between these environmental parameters and biodiversity in Ain Al-Ghazala is critically dependent on maintaining a delicate balance. Continuous monitoring and responsible management are essential to safeguard the lagoon's ecological integrity, particularly in light of planned aquaculture development initiatives in the region. (Fitori et al.,2022).

Overall, the patterns of relative abundance indicate a well-organized crustacean community likely influenced by various ecological elements, including habitat heterogeneity, salinity gradients, substrate type, and anthropogenic activity. These findings underscore the ecological significance of Ain Al-Ghazala Lagoon as a thriving and diverse marine ecosystem, hosting both economically and ecologically important crustacean species. Consequently, implementing conservation efforts and ongoing monitoring is recommended to maintain the biological balance and biodiversity of this vital coastal system. Ain Al-Ghazala Lagoon is a diverse and ecologically rich marine habitat that plays a crucial role in the local economy and environment. The lagoon's distinctive water chemistry characterized by elevated concentrations of various chemical components supports a wide array of marine organisms, including fish, crustaceans, algae, and mollusks that are both ecologically and economically important. Its biological richness underscores the lagoon's significance as a valuable marine resource, despite the challenges posed by invasive species (Ali et al., 2025). Crustaceans are a fundamental component of the food web in Ain Al-Ghazala Lagoon, serving as a primary food source for significant species such as *Diplodus vulgaris* and *Sepia orbignyana*. Their abundance and presence underscore their ecological importance in supporting the lagoon's biodiversity and sustaining its marine life (Ali et al.,2025).

Ain Al-Ghazala Lagoon represents a vital marine ecosystem, supporting rich biodiversity and playing a crucial role in maintaining ecological balance and sustaining local economic activities. Local communities significantly rely on the lagoon for essential activities such as irrigation, transportation, fishing, cooking, and washing. Despite its importance, the lagoon faces challenges from anthropogenic activities. The presence of invasive species like *Pterois miles* and *Lagocephalus sceleratus* raises environmental concerns due to their potential impact on native species. The study indicates a pressing need for further research into human activities contributing to water quality degradation, and it is imperative to prevent the disposal of waste and urban products in these ecologically sensitive areas. Furthermore, activities such as agriculture and potential industrial growth could pose threats to the lagoon's water quality and biodiversity. To address these challenges, effective conservation strategies are urgently required to protect the lagoon's biodiversity and mitigate the risks posed by invasive species. Ain Al-Ghazala is recognized as a Marine Protected Area (MPA), a fundamental tool for marine environmental conservation and sustainable development. The lagoon's distinctive water chemistry and rich biodiversity underscore its potential for sustainable aquaculture development. With the ongoing development of a fish breeding facility and an aquaculture complex, large-scale capacity building for the national aquaculture sector is crucial in the near future (Ali et al.,2025).

Although the lagoon is generally unpolluted, continuous preservation measures are necessary to maintain its ecological integrity. The study emphasizes the significance of ongoing research and effective management strategies to safeguard the lagoon's unique environmental attributes, coupled with awareness of its ecological role, to ensure its long-term health and the continued availability of its resources for future generations. The Ain Al-Ghazala Marine Reserve is essential for marine environmental conservation and sustainable development. It supports biodiversity by protecting rare and endangered species (Salem et al.,2024; Fitori& Saied,2024).

To ensure the sustainable environmental management of Ain Al-Ghazala Lagoon, comprehensive conservation strategies must be developed and implemented. These strategies should focus on mitigating the impact of invasive species and improving water quality through the identification and reduction of pollution sources. Furthermore, the complete prohibition of waste disposal is crucial, alongside the promotion of sustainable aquaculture practices coupled with local capacity building. Reinforcing the lagoon's status as a Marine Protected Area, minimizing the negative effects of agriculture and industrial growth, and fostering environmental awareness and community participation, in addition to continuous research and monitoring, are all essential steps to guarantee the lagoon's long-term health. The study concludes by emphasizing the ecological importance and remarkable diversity of malacostraca crustaceans in Ain Al-Ghazala Lagoon. The presence of species with both economic and ecological value underscores the lagoon's role as a vital marine ecosystem. Species distribution and abundance are shaped by environmental conditions and the presence of invasive species. Preserving the lagoon's biodiversity and ecological balance requires continuous monitoring and effective conservation measures.

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