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Biodiversity of Macroinvertebrates in the Intertidal Zones of the Garmmat Ali, Basrah, Southern Iraq

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Abstract

The study aimed to assess the biodiversity of invertebrates in the study area by identifying species, determining their abundance and spatial and temporal distribution, and analyzing the effects of environmental factors on community structure in two site of Garmmat Ali. The Environmental parameters recorded in the two study areas were expressed as mean ± SD, minimum and maximum values, in the Al-Masahab area, the temperature avarge lwas 24.5 ± 7.50°C, 17.0 °C and 32. 0 °C respectively, salinity was 7.36 ± 3.77 g/L, 3,59 and 11.13 g/L respectively, pH was 7.51 ± 0.41, 7.10 and 7.92 respectively, while dissolved oxygen was 8.90 ± 1.10 mg/L, 7.80 and 10.00 mg/ L. respectively. While, in the Garammat Ali area, the avarge of temperature was 22.81 ± 8.22°C , and minimum and maximum values between 14.59 – 31.03 °C respectively, salinity avarge was 8.50 ± 4.20 g/L, minimum 4.30 g/L. and maximum 12.70 g /L. , pH avarge was 7.30 ± 0.81, with minimum and maximum values 6.49 and 8.11 respectively, and dissolved oxygen avarge was 8.61 ± 1.40 mg/L, with minimum value 7.21 mg/L and maximum 10.01 mg/L. Macroinvertebrate samples were collected from the intertidal zone at Al-Masahab and Garmmat Ali between November, 2025 and August, 2026, with 3–5 replicates collected during low tide. At Al-Masahab, 16 species were recorded, representing Phylum Arthropod, subphylum crustacean, Mollusca, Annelida, Brachiopoda, and the Insects, with a total of 5,694 individuals. Subphylum Crustaceans were the most abundant group, comprising 5,160 individuals, followed by Annelida (316), Mollusca (138), Insect (30) and Brachiopoda (50). At Garmmat Ali, 14 species were recorded across three major phyla, with a total of 6,603 individuals. Subphylum Crustaceans were also the dominant group, accounting for 5,960 individuals, followed by Annelida (408) and Mollusca (235). The Shannon-Wiener index (H) was 1.80 at Al-Masahab and 1.66 at Garmmat Ali, while the Dominance index (D) was 0.21 and 0.23, respectively. Pielou's Evenness index (J) was 0.38 at Al-Masahab and 0.37 at Garmmat Ali.

Keywords: Biodiversity, macroinvertebrates, intertidal zones, Garmmat Ali.

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Introduction

The study of biodiversity is particularly important in areas experiencing a decline or disappearance of certain marine invertebrate species, as such loss serves as an early indicator of environmental changes within the aquatic ecosystem (Abroguena *et al.*, 2021). Species loss results from a combination of natural and anthropogenic factors, including habitat degradation, alterations to the seabed, pollution, climate change, rising temperatures, and coastal urbanization (Nazeer *et al.*, 2021).

Biodiversity indices focus on assessing species richness and abundance relative to the total number of individuals, as well as examining evenness and distribution patterns to determine whether a few species dominate the community (Ji *et al.*, 2024). Biodiversity analysis is a fundamental component for understanding the structure of ecological communities, as it provides quantitative tools to evaluate species richness, relative distribution, and similarity between ecological sites (Chao and Jost, 2015). Consequently, ecological indices serve as vital indicators in environmental studies; they help interpret biodiversity patterns and identify factors governing invertebrate distribution, while also playing a crucial role in the early detection of impacts caused by pollution, climate change, and various human activities (Ray *et al.*, 2026).

Intertidal zones are among the most diverse and complex coastal environments; situated at the interface between land and sea, they are directly influenced by tidal cycles and characterized by sharp environmental gradients involving temperature, salinity, humidity, and dissolved oxygen levels (Rubin *et al.*, 2024; Bae *et al.*, 2026). Benthic invertebrate communities are characterized by high species diversity, comprising various groups such as Annelida, Mollusca, Crustacea, and Echinodermata (Miri *et al.*, 2023).

The study by Beanland (1940) was among the first globally to examine invertebrate communities in sandy and muddy substrates at the Dyfi Estuary in western Wales; it observed that invertebrates were distributed systematically based on the specific substrate and sediment types they preferred. Rengaiyan *et al.* (2017) studied polychaete communities associated with substrates along the coastal waters of the southeastern Arabian Sea, recording 71 species across 16 families and noting a strong correlation between worm species distribution and sediment characteristics. Abe *et al.* (2019) investigated polychaetes in Tokyo Bay, Japan, finding that most burrowing species were distributed in exposed environments outside the bay, while only two burrowing species preferred sandy and muddy sediments. Schenone and Thrush (2020) focused on the burrowing bivalve Macomona liliana and the tube-dwelling mud worm Macroclymenella stewartensis; their results showed that areas where the two species co-occurred produced distinct non-linear effects on oxygen fluxes and organic matter decomposition rates. Chen *et al.* (2022) examined the role of abiotic factors in the distribution of crab burrows within a tidal salt marsh, linking burrow density to several environmental variables, including mean sediment grain size, water content, organic matter, salinity, and elevation above sea level.

Examined the burrowing structure of Perinereis aibuhitensis worms in relation to size and season. Asha *et al.* (2023) compared the polychaete community structure in the soft bottoms of the Vembanad Estuary (southwest India) with historical data. Behera *et al.* (2023) investigated the influence of water quality and sediment characteristics on benthic invertebrate community structure along the Paradip coast in northeastern India. Additionally, the seasonal relationship between benthic invertebrate distribution and environmental factors near the Xiaoqing River estuary in China was studied; 84 species were recorded, and a non-linear relationship was found between biological community indices and environmental factors (Liu *et al.*, 2023). Rubin *et al.* (2024) monitored the response of benthic invertebrates to the restoration of tidal marshes in the Nisqually River Delta (Washington State, USA) within one year of dike removal, observing a roughly 15-fold proliferation in the invertebrate community at certain restored sites.

In the Indian region, Prajapat *et al.* (2025) tracked the burrowing patterns of the crustacean Sphaeroma annandale in the hard, muddy intertidal substrate, revealing a complex network of interconnected burrows. Chauvel *et al.* (2025) investigated the influence of sediment grain size, bed morphology, and submerged dune dynamics on the distribution of benthic communities in the eastern English Channel. Al-Khayat *et al.* (2026) studied the spatial and seasonal variations of benthic invertebrate communities in Khor Al-Adaid, Qatar; they found that the winter invertebrate community was associated with higher oxygen and chlorophyll levels, whereas the summer community was linked to elevated temperatures and salinity.

Several local studies have also been conducted; the works of Ahmed (1975) and Al-Dabbagh and Daoud (1985) stand as early, seminal studies addressing the phylum Mollusca in the Arabian Gulf and the Shatt al-Arab. Following the re-flooding of the marshes, the return of aquatic invertebrate communities-specifically mollusks, crustaceans, and aquatic insects was documented, and these groups were recognized as key indicators of the marsh ecosystem's recovery (Richardson *et al.*, 2005). Research also examined the abundance and distribution of macro-invertebrates in the restored southern marshes-specifically Hawizeh Marsh, Hammar Marsh, and Suq Al-Shuyukh-recording 78 invertebrate species, including aquatic insects, mollusks, crustaceans, and annelids (Ali *et al.*, 2007). Al-Khafaji *et al.* (2018) examined the abundance and distribution of invertebrates in the intertidal zone of the Shatt al-Arab (Basra) and their relationship with associated benthic aquatic plant communities across four seasons. Additionally, Mohammed *et al.* (2020) studied the invertebrate community.

Materials And Methods

Study Areas

Two sites were selected in Basrah Governorate: Al-Masahab and Garmmat Ali. Both are located within tidal zones, so that influenced by tidal hydrological dynamics. These conditions provide diverse habitats for aquatic organisms—particularly benthic invertebrates-making it a suitable location for studying the diversity, density, and spatial

distribution of invertebrates, as well as their relationship with benthic environmental characteristics and organic matter.

The second site (Garmmt Ali) is located near the University of Basrah colleges, College of Engineering. This area is characterized by its connection to the Shatt al-Arab aquatic system and its proximity to waterways and channels linked to the Garmmat Ali River. This aquatic environment offers a gradient of environmental characteristics across the riverbed and banks, making it suitable for studying aquatic communities and macro-invertebrates associated with littoral and semi-riverine environments.

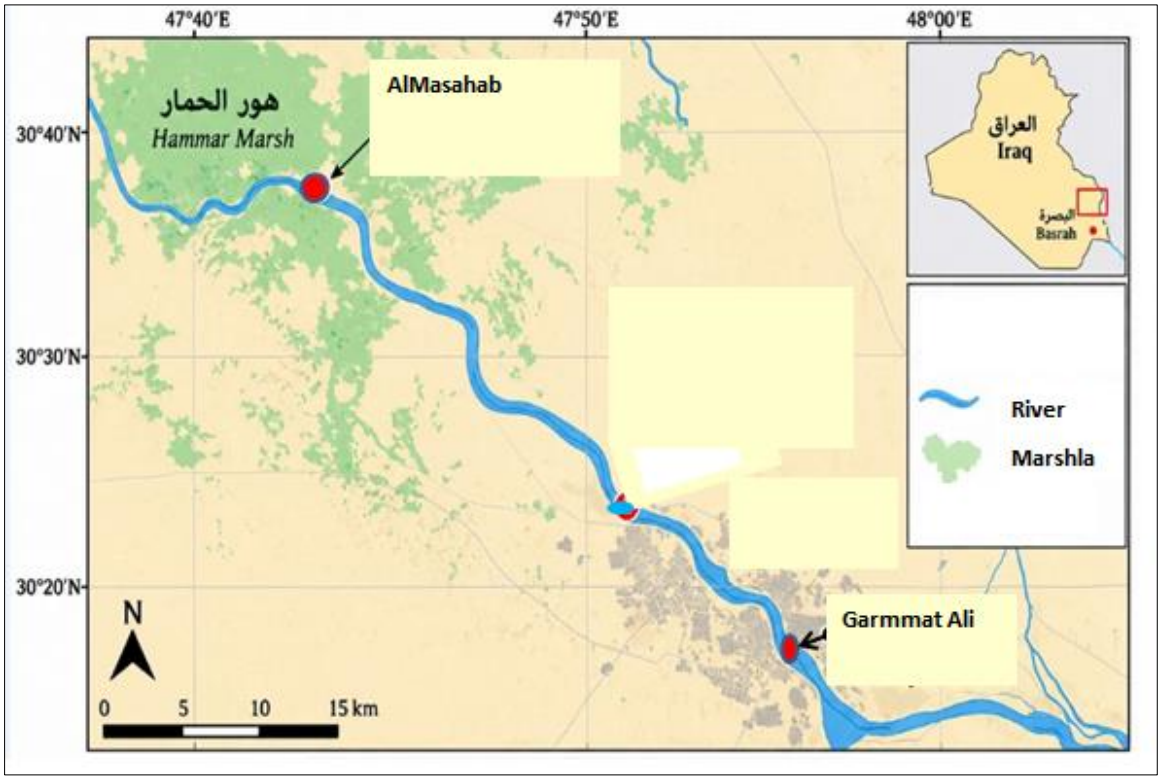


Figure 1: Map of study sites in Al-Masahab and Garmmat Ali during the study period.

Collection of Invertebrates samples

Invertebrate samples were collected from intertidal zone between December 1, 2025, and August 26, 2026, with 3–5 replicates taken during low tide. A random sampling method using fixed-area quadrats (100×100 cm) was employed for the intertidal zone; the quadrat was placed on the substrate surface, and the sediment within it was removed using a hand shovel to a depth of 10–20 cm. For invertebrates inhabiting the permanently submerged zone-areas not exposed during low tide-samples were collected using a benthic dredge. This metal tool (measuring 30 × 30 × 60 cm) was deployed onto the seabed and hauled toward the shore. After washing away the mud, the invertebrates were isolated using sieves of various mesh sizes and preserved in 70% alcohol pending laboratory examination and identification.

Measurement of Environmental Factors

Environmental factors in the study areas were measured concurrently with the collection of benthic organism samples. These measurements included water temperature (°C) using a digital thermometer, salinity (g/L) using a digital salinometer, pH, and dissolved oxygen (mg/L) using a dissolved oxygen meter.

Estimation of Biodiversity Indices

Biodiversity indices were estimated based on quantitative invertebrate data collected from various study sites. Following sample collection, sorting of benthic organisms, and identification to the lowest possible taxonomic level (species or genus), the number of individuals per species in each sample was recorded. The data were entered into specific tables and subsequently used to calculate the following biodiversity indices:

Shannon–Wiener Diversity Index (H′)

According to Shannon (1948) and Shannon and Weaver (1949), this index was used to estimate the overall diversity of the invertebrate community, reflecting species richness and the distribution of individuals among species. It was calculated using the following equation: $H' = - \Sigma\ pi \ln pi$

Where: H′ = Shannon Index Pi = Proportion of individuals of species, i to the total number of individuals in the sample (ni/N), ni = Number of individuals of a single species; N = Total number of individuals.

Dominance Index (D)

The following equation was used to determine the dominance Index (Magurran, 2004) $D = \Sigma\ (ni/N)^2$ where: D = Dominance Index, ni = Number of individuals of a single species

N = Total number of individuals

Pielou's Evenness Index (J)

According to Pielou (1966) and Jaccard (1912) this index was used to assess the uniformity of individual distribution among different species and was calculated using the following equation: $J' = H' / \ln(S)$ Where: H′ = Shannon Index, S = Number of species.

Results

Environmental Factors

The Environmental parameters recorded in the two study areas were expressed as mean ± SD, minimum and maximum values, in the Al-Masahab area, the temperature avarge lwas 24.5 ± 7.50°C, 17.0 °C and 32.0°C respectively, salinity was 7.36 ± 3.77 g/L, 3,59 and 11.13 g/L respectively, pH was 7.51 ± 0.41, 7.10 and 7.92 respectively, while dissolved oxygen was 8.90 ± 1.10 mg/L, 7.80 and 10.00 mg/L. respectively. While, in the Garammat Ali area, the avarge of temperature was 22.81 ± 8.22°C, and minimum and maximum values between 14.59 – 31.03 °C respectively, salinity avarge was 8.50 ± 4.20 g/L, minimum 4.30 g/L and maximum 12.70 g/L., pH avarge was 7.30 ± 0.81, with

minimum and maximum values 6.49 and 8.11 respectively, and dissolved oxygen avarge was 8.61 ± 1.40 mg/L, with minimum value 7.21 mg/L and maximum 10.01 mg/L

Table 1: Environmental factors recorded in al Masahab and Garammat Ali

Factors	Al-Masahab		Garmmat Ali	
	Avarge ± SD	Ranged	Avarge ± SD	Ranged
Temparture (C)	24.5 ± 7.50	17.0 – 32.0	22.81 + 8.22	14.59 – 31.03
Salinity (ppt)	7.36 ± 3.77	3.59 – 11.13	8.50 + 4.20	4.30 – 12.70
pH	7.51 ± 0.41	7.10-7.92	7.30 + 0.81	6.49-8.11
DO (mg/l)	8.90 ± 1.10	7.80 -10.00	8.61 + 1.40	7.21-10.01

Invertebrate community composition in Al-Masahab

The results indicated that the invertebrate community composition in the intertidal zones varied relatively across the studied areas and seasons regarding species richness, density, and relative abundance. In the Al-masahab the phyla present Arthropoda, Mollusca, Annelida, Brachiopoda and Subphylum Insects. These comprised 16 species distributed across the five phyla and sub phyla: For sub phyla crustacean: *Sesarma boulengeri*, *Elamenopsis kempi*, *Amphibalanus amphitrite*, *Sphaeroma annandalei*, *Parhyale basrensis*, *Platorchestia monodi* and for sub phylum Insects: *Anax parthenope*, *Ischnura evansi*. Phylum Mollusca: *Melanoides tuberculata*, *Melanopsis nodosa, Corbicula fluminea, Mytilus edulis*. For Annelida: *Tubifex tubifex, Pristinella idrensis, Pristinella longiseta*. For phylum Brachiopoda *Lingula anatina*.

The total number of individuals recorded was 5,694. The subphylum Crustacea accounted for the largest share, with 5,160 individuals distributed across the seasons as follows: 2,106 in autumn, 799 in winter, 1,174 in spring, and 1,081 in summer. The subphylum Insecta totaled 30 individuals: 26 in autumn, 2 in winter, and 2 in spring, with no individuals recorded in summer.

The total count for the phylum Mollusca was 138 individuals, distributed as 91 in autumn, 22 in winter, 19 in spring, and 7 in summer. The phylum Annelida totaled 316 individuals, distributed as 152, 93, 56, and 15 in autumn, winter, spring, and summer, respectively. The phylum Brachiopoda totaled 50 individuals, with 48 recorded in autumn and 2 in winter, while none were recorded in spring or summer (Figure 2).

The total number of individuals recorded was 2,423 in autumn, 917 in winter, 1,251 in spring, and 1,103 in summer. In autumn, the species *P. monodi* was the most abundant (720 individuals), while I. evansi was the least abundant. In winter, the crustacean *A. amphiteratie* recorded the highest count (319 individuals), while the species C. fluminea and I. evansi recorded the lowest (2 individuals each). In spring, *P. monodi* was again the most abundant (428 individuals), while *I. evansi* was the least abundant (2 individuals).

During the summer season, the highest and lowest counts were recorded for the species P. *monodi* and *I. evansi*, with 428 and 2 individuals, respectively (Figure 3). Figure (4) illustrates the relative abundance (%) of the species; the highest relative abundance was 27.2% for P. monodi, while the lowest was 0.17% for *I. evansi.*

The total annual density of the invertebrate community was 1,898 individuals/m². The subphylum Crustacean exhibited the highest density at 1,720 individuals/m², whereas the phylum Mollusca recorded a density of 46 individuals/m² and the phylum Annelida recorded 105 individuals/m². Densities for the subphylum Hexapoda (insects) and the phylum Brachiopoda were 102 individuals/m² and 16 individuals/m², respectively. Among the species, *P. monodi* showed the highest density (27.22 individuals/m²), while *I. evansi* and *M. nodosa* showed the lowest density (0.17 individuals/m² each) (Figure 5).

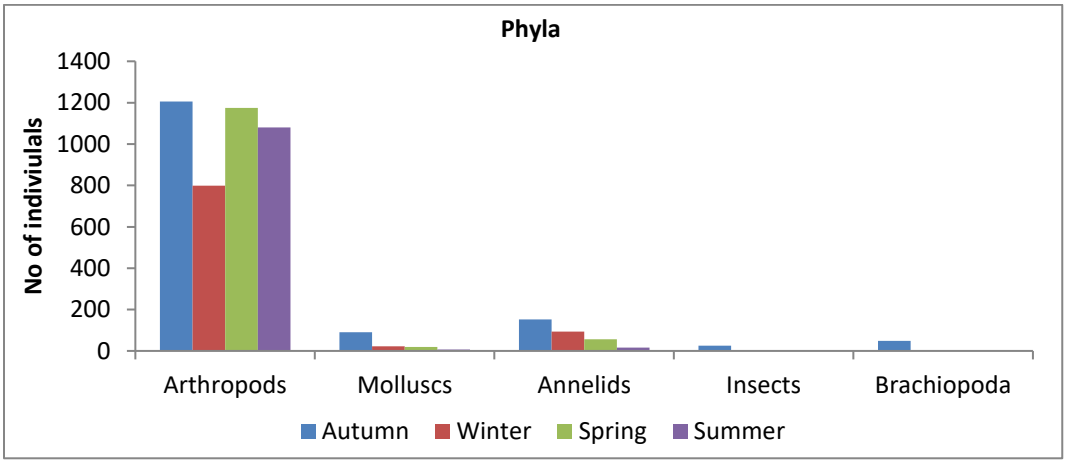


Figure 2: Seasonal variations in the abundance of various invertebrate phyla in the intertidal Al-Masahab area.

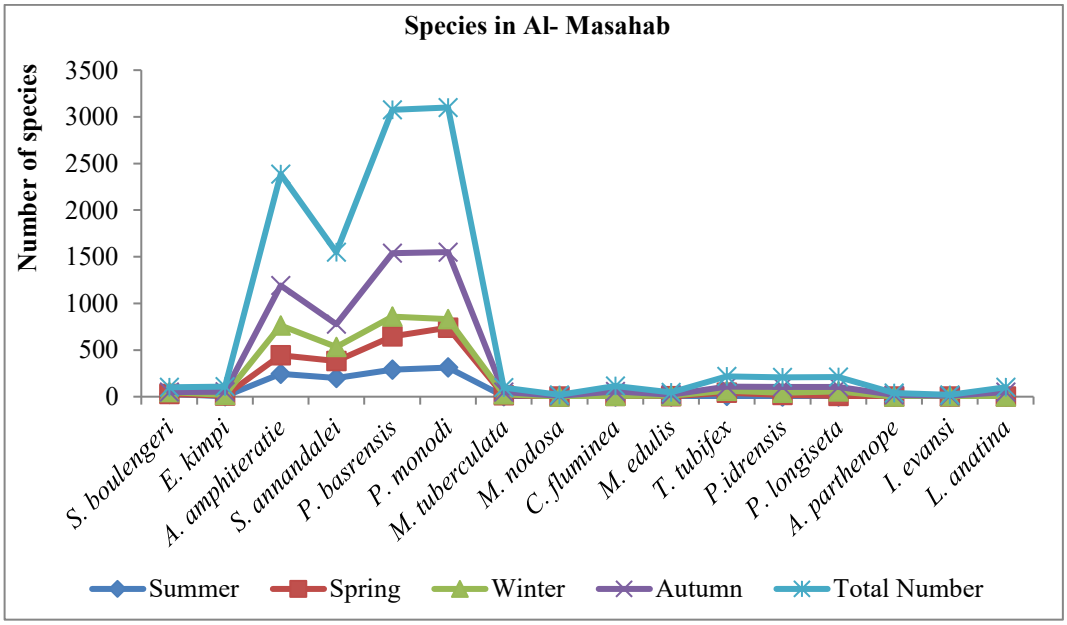


Figure 3: Seasonal changes in the number of invertebrate species in the intertidal of Al- Masahab area

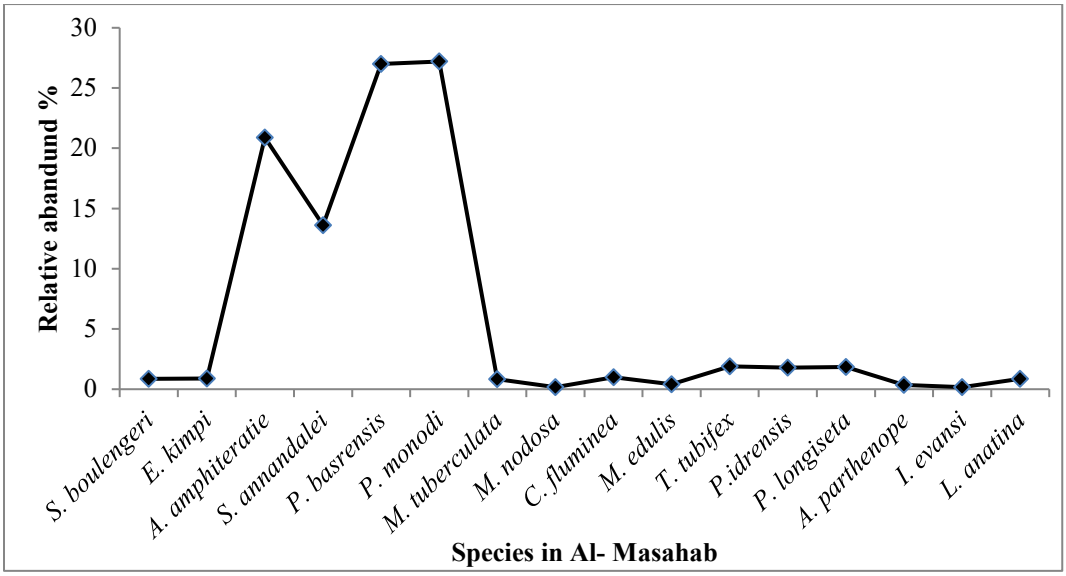


Figure 4: Relative abundance (%) of the intertidal invertebrate community in the Al-Masahab area.

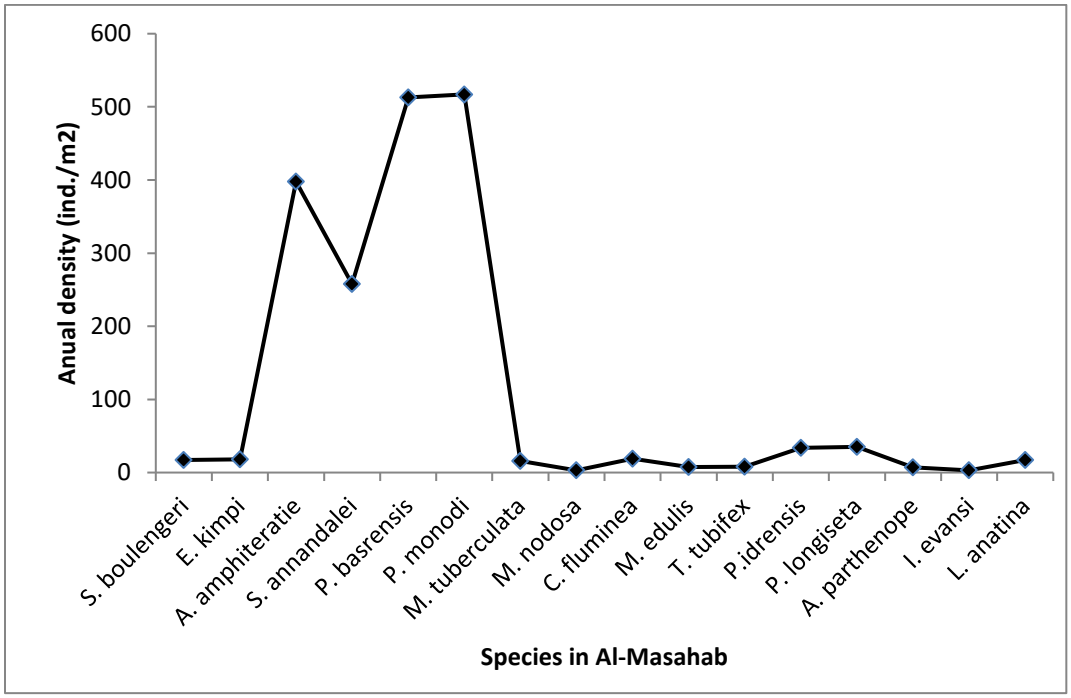


Figure 5: Species density (individuals/m²/year) of invertebrates in the intertidal of Al- Masahab area.

Invertebrate Composition in the Garmmat Ali

A total of 14 invertebrate species were recorded in the Garmmat Ali area, distributed across three major phyla. Arthropoda phylum includeds subphylum Crustacean *Elamenopsis kempi*, *Amphibalanus amphitrite*, *Sphaeroma annandalei*, *Parhyale basrensis*, and *Platorchestia monody*. The Mollusca phylum included four species:

Melanoides tuberculata, *Neritina violacea*, *Corbicula fluminea*, and *Mytilus* edulis. The Annelida phylum included five species: *Tubifex tubifex*, *Namalycastis indica*, *Pristina longiseta*, *Limnodrilus hoffmeisteri*, and *Pristina proboscidea*.

The total number of individuals was 6,603. The Crustacean group accounted for the largest share, with 5,960 individuals distributed across the seasons as follows: 2,702 in autumn, 1,858 in winter, 1,889 in spring, and 511 in summer. The total count for the Mollusca group was 235 individuals, distributed as 44 in autumn, 83 in winter, 103 in spring, and 5 in summer. The Annelida group totaled 408 individuals, distributed as 165, 123, 87, and 33 individuals across autumn, winter, spring, and summer, respectively (Figure 6).

Figure (7) illustrates the seasonal species counts: the totals were 2,911 individuals in autumn, 2,064 in winter, 1,079 in spring, and 549 in summer. The species A. amphitrite achieved the highest dominance in most seasons, with counts of 780, 690, and 527 individuals in autumn, winter, and spring, respectively, meanwhile, S. annandalei was the most abundant species in summer, with 287 individuals. The least abundant species were *C. fluminea* in autumn and winter (4 and 3 individuals, respectively) and *P. longiseta* in spring (1 individual); in autumn, the least abundant species were *M. edulis* and *P. longiseta*, with one individual each. Figure (8) shows the relative abundance (%) of the species; the highest relative abundance was 33.57% for A. amphitrite, while the lowest relative abundance was 0.09% for both *E. kempi* and *N. violacea*.

The total annual density of the invertebrate community reached 2,201 individuals/m². The subphylum Crustacea recorded the highest density at 1,986 individuals/m², while the phylum Mollusca showed a density of 78 individuals/m², and the phylum Annelida recorded 136 individuals/m² (Figure 9).

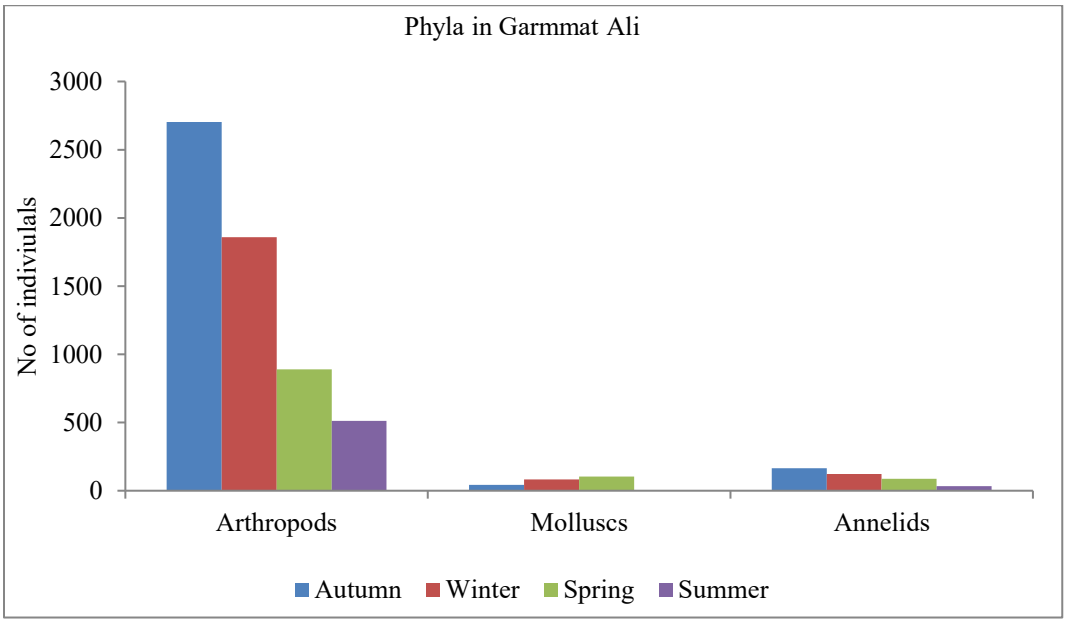


Figure 6: Number of invertebrates by phylum, distributed across the different seasons in the study areas.

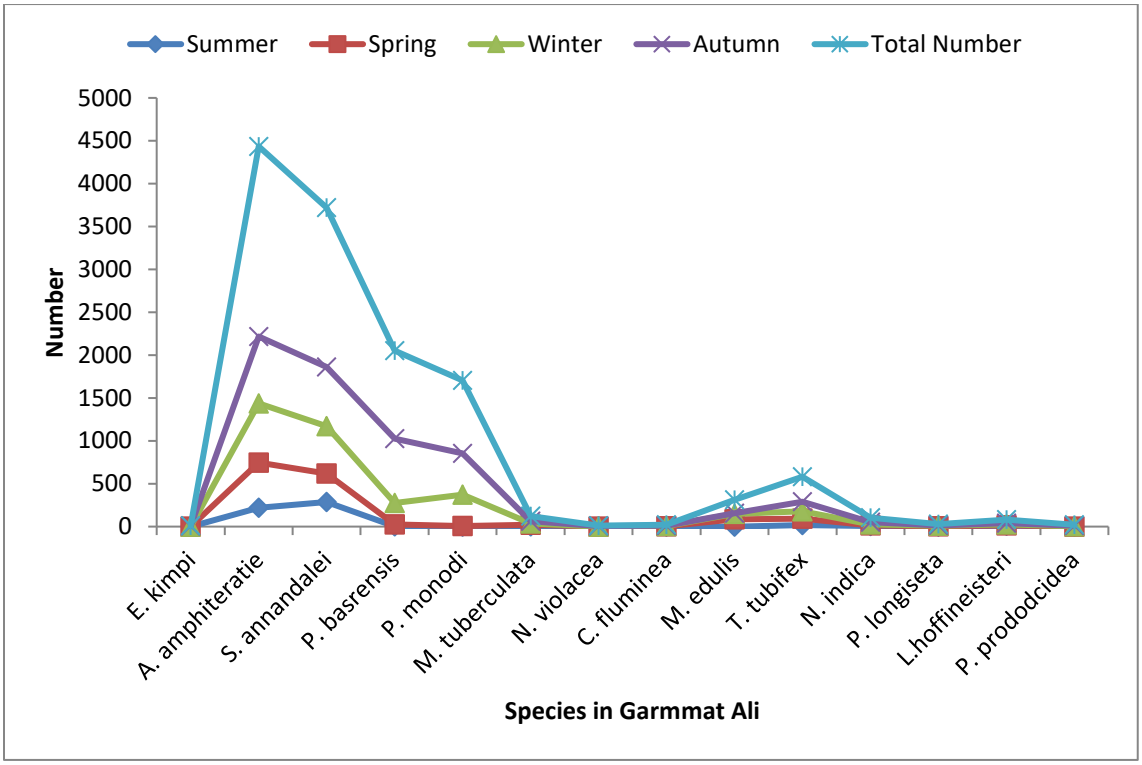


Figure 7: Seasonal changes in invertebrate species in the inter tidal of Garmmat Ali area.

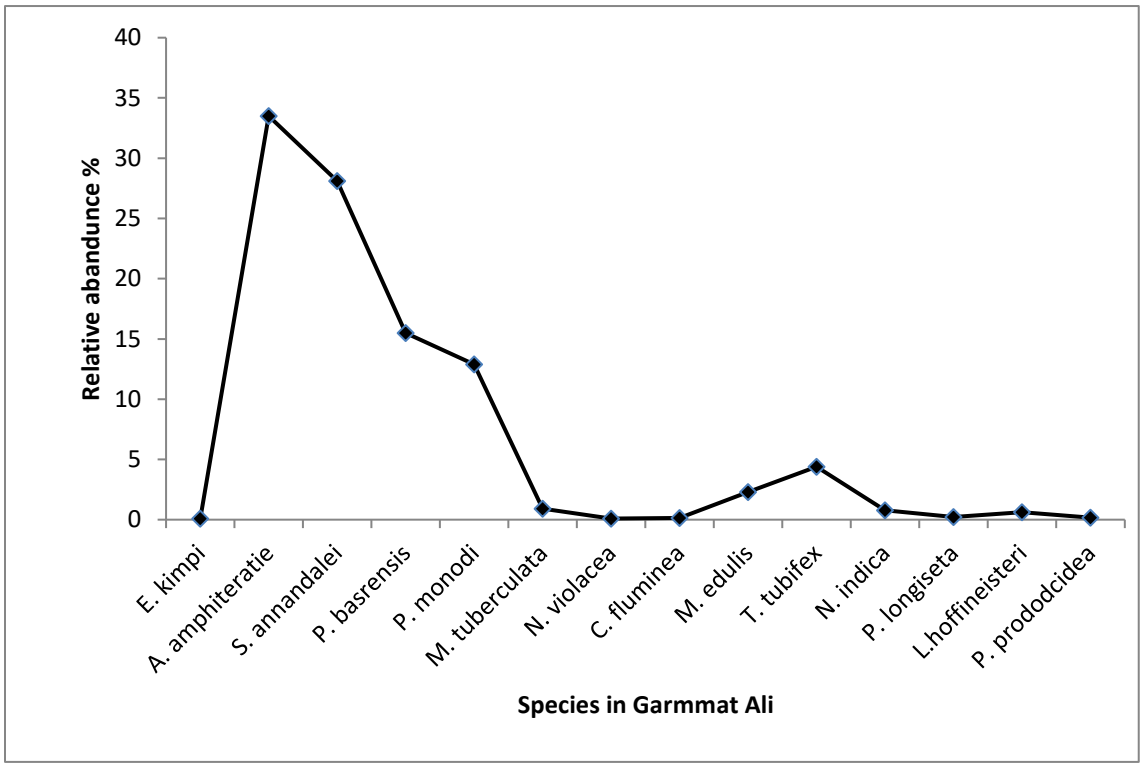


Figure 8: Relative abundance (%) of the intertidal invertebrate community in the Garmmat Ali area.

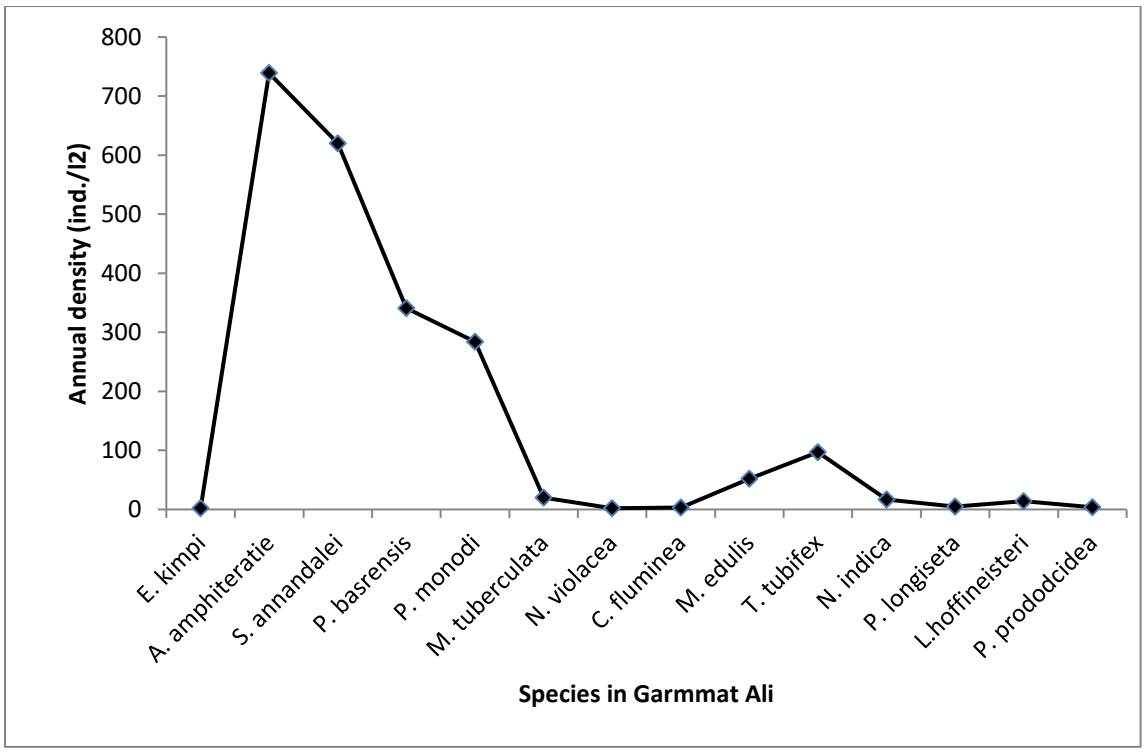


Figure 9: Species density (individuals/m²/year) of invertebrates in the inter tidal of Garmmat Ali area

Invertebrate diversity indices

The Shannon-Wiener index (H) value was 1.80 in the Al-Masahab area and 1.66 in Garmmat Ali. Regarding the Dominance index (D), values were 0.21 in Al-Masahab and 0.23 in Garmmat Ali. As for Pielou's Evenness index (J), the value recorded was 0.38 in Al-Masahab and 0.37 in Garmmat Ali. The Jaccard index value between the Al-Masahab area and Garmmat Ali was 0.50, indicating a moderate degree of similarity in the invertebrate community composition between the two areas (Figure 10).

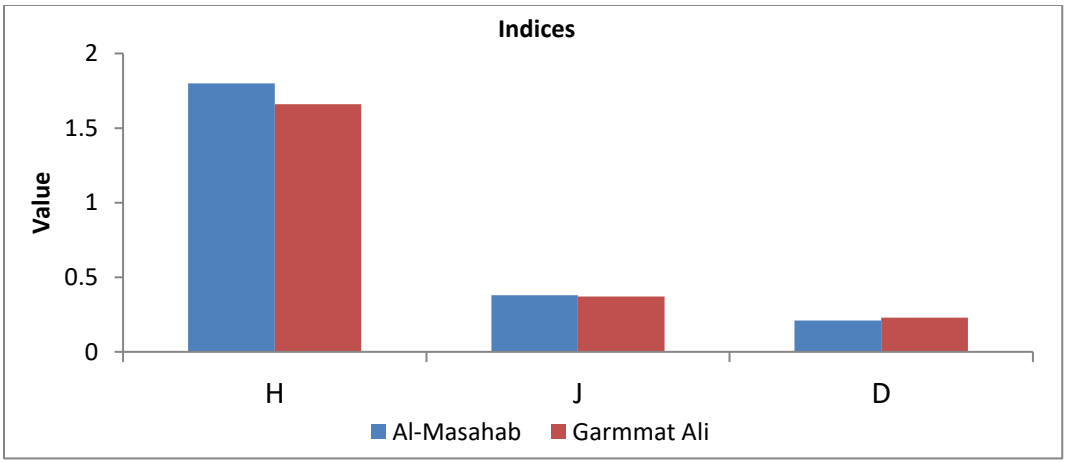


Figure 10: Diversity indices for Shannon-Wiener index (H), Pielous Evenness index (J) and Dominance index (D) for two stations in Al- Masahab and Garmmat Ali, Southern Iraq.

Discussion

Environmental factors

The intertidal zone is characterized by marked fluctuations in environmental conditions (Gao and Song, 2022; Manokaran *et al.*, 2022). The distribution, abundance, and diversity of invertebrates are influenced by various environmental factors, owing to differences in their ability to adapt to changes in habitat conditions (Ahmed and Kareem, 2020). Factors such as temperature, salinity, pH, and dissolved oxygen affect physiological processes, as well as rates of growth, reproduction, and survival (Mohammed *et al.*, 2017; Imamsyah *et al.*, 2020; Aghajari-Khazaei *et al.*, 2021). Additionally, pH, the nature of the substrate, grain size, and organic matter content determine environmental suitability for different species regarding the availability of food, shelter, and attachment sites. This variation in environmental factors leads to the disappearance of sensitive species and an increase in the abundance of more tolerant ones (Abdul-Sahib *et al.*, 2019; Verberk *et al.*, 2020).

Invertebrate community composition

The study results revealed a clear trend of increasing crustacean abundance alongside a decline in insect and mollusca populations in certain intertidal zones. This variation is attributed to the ability of these animal groups to adapt to the prevailing environmental conditions of the study area (Al-Adhub and Hamzah, 1987; Abdullah *et al.*, 2016; Saoud, 2005). Crustaceans are among the most successful groups in aquatic and semi-aquatic environments, possessing structural and physiological adaptations that enable them to withstand fluctuations in salinity, temperature, and dissolved oxygen levels, in addition to their capacity to utilize diverse food sources and habitats (Al-Mamoori *et al.*, 2015; Jabbar *et al.*, 2021).

The high abundance of crustaceans may also be linked to the availability of suitable habitats specifically, clay and sandy sediments rich in organic matter, as well as crevices, burrows, and areas offering protection from predation and water currents (Al-varez-Cabri *et al.*, 2011; Wilbur *et al.*, 2024). Furthermore, some crustaceans exhibit high mobility, allowing them to move between zones in response to changing water levels and tides, thereby granting them greater ecological flexibility compared to other groups (Yasser *et al.*, 2021; Prajapt *et al.*, 2025).

The lower abundance of insects can be attributed to the fact that most insect species are primarily associated with freshwater environments or terrestrial areas adjacent to water bodies. In contrast, the intertidal zone is a dynamic environment subject to periodic submersion and exposure; these fluctuations impact the insects' ability to settle, feed, and reproduce, consequently, their abundance tends to be lower in sites dominated by marine influence or those subject to prolonged submersion (Ahmed, 2021; Abed *et al.*, 2023).

As for the decline in mollusk populations, this may be linked to changes in sediment characteristics-particularly grain size, organic matter content, moisture, and salinity. Benthic organisms vary in their tolerance to environmental conditions, and changes in

sediment composition or a reduction in suitable food availability can lead to a decrease in their population density (Al-Abbad *et al*., 2015; Al-Abbad, 2022). Furthermore, some species may be more closely associated with soft, organic-rich sediments; consequently, variations in the nature of the sabstrate across stations can lead to distinct differences in their abundance (Gao and Song, 2020).

The fact that the Al-Masahab area exhibited the highest taxonomic richness indicates that its environmental conditions were more favorable for sustaining a greater number of taxonomic groups compared to the Garrmat Ali area (Ali *et al*., 2021). This higher richness in Al-Masahab is likely linked to microhabitat diversity, sediment characteristic variations, and the availability of food resources and refugee factors known to influence benthic community composition (Abdullah, 2024). A studies by Al- Abbad (2014) and Al-Khafaji *et al*. (2018) in the Shatt al-Arab demonstrated that invertebrate richness was associated with vegetation characteristics and recorded significant differences in species counts across study sites.

In contrast, the Garmmat Ali area recorded a less diverse composition, taxonomically, invertebrate communities in intertidal environments do not remain static throughout the year; rather, they fluctuate in response to seasonal variations in temperature, salinity, dissolved oxygen, and pH, as well as changes in sediment properties, vegetation cover, and food availability (Souza and Gianuca, 1995; Mahamed and Abood, 2017).

According to Souza and Gianuca (1995), Autumn represents a transitional phase from high summer temperatures to the milder conditions of winter, providing relatively favorable environmental conditions for various invertebrates particularly those adversely affected by high summer heat. A study on the snails *M. nodosa* and *M. costata* in the Shatt al-Arab showed higher densities during autumn and spring compared to summer and winter; researchers attributed this to the suitability of moderate temperatures for the distribution of these species (Naser *et al*., 2024). This supports the likelihood of increased activity among certain invertebrate community components during autumn, driven by improved thermal conditions relative to summer (Al-Dabbagh and Daoud, 1985; Al-Baghdadi, 2024).

The higher number of taxa and species in Al-Masahab during autumn can be attributed to the availability of more diverse habitats or more favorable benthic conditions; conversely, the lower number of Garammat Ali render the community more dependent on a limited number of species capable of tolerating environmental fluctuations (Ali and Salman, 1987; Hossain *et al*., 2009). Recent studies , confirm distinct seasonal variations in the density of certain invertebrates; for instance, the polychaete worm *Namalycastis indica* exhibited peak density in spring and minimum density in summer, coinciding with marked seasonal changes in temperature, salinity, and oxygen levels (Khalaf, 2023; Al-Baghdadi *et al*., 2025).

Water temperatures drop significantly during winter, leading to reduced metabolic rates, activity, and feeding among certain invertebrates. Studies conducted in Shatt Al-Arab and Shatt Al-Basra have demonstrated clear seasonal variations in aquatic

organisms; for example, a study on the intertidal invertebrate community in Shatt Al-Arab recorded water temperatures ranging from 11.1°C to 32.4°C throughout the year, reflecting the substantial seasonal thermal fluctuations experienced by these aquatic communities (Al-Khafaji, 2015).

Furthermore, a decline in winter density does not necessarily imply the disappearance of species from the area; some species may persist in low numbers due to reduced activity or diminished reproductive and feeding rates (Atee, 2008). This pattern is clearly evident in seasonal studies of aquatic organisms in Shatt Al-Basra, where zooplankton studies recorded the lowest densities at certain stations during winter, followed by a significant rise in density during spring and summer, alongside varying responses among different taxonomic groups (Al-Asadi, 2019; Abbas, 2022). Summers in southern Iraq are characterized by high temperatures, a factor that can impose environmental stress on sensitive species particularly when combined with salinity fluctuations and reduced dissolved oxygen levels (Mohamed and Abood, 2017). In intertidal zones, this impact is intensified by the exposure of sediments and shallow waters to heat during low tide. Studies in the Shatt al-Arab have recorded temperatures reaching 33.1°C (Al-Khafaji, 2015).

Summer heat and salinity stress are expected to reduce the abundance of sensitive species while increasing the relative proportion of highly tolerant ones. Local findings regarding *N. indica* support this; despite the species' known tolerance to environmental fluctuations, its lowest density 32 individuals/m² was recorded during the summer. This suggests that elevated summer temperatures and salinity may limit certain physiological processes or prompt individuals to migrate to more suitable habitats (Al-Baghdadi *et al.*, 2023).

However, summer does not necessarily lead to a decline in all invertebrate assemblages; some species may actually benefit from higher temperatures, increased productivity, and greater food availability (Zhang *et al.*, 2021). Consequently, results should be interpreted based on species identity rather than species richness alone.

The study results revealed variations in biodiversity index values across the studied intertidal zones-specifically the Shannon–Wiener index (H′), Pielou's evenness index (J′), and Simpson's dominance index (D), these differences are attributed to variations in environmental conditions and the physicochemical characteristics of the sites (Sorenson, 1948).

The Shannon–Wiener index reflects both species richness and the distribution of individuals among species; thus, a high H′ value generally indicates a greater number of species with a more balanced distribution of individuals, whereas a low value may be associated with reduced species richness or the dominance of a limited number of species, consequently, differences in H′ values across study sites may reflect variations in the composition of the invertebrate community rather than merely differences in the total number of individuals (Hashim and Al-Taee, 2015; Ji *et al.*, 2024).

Sediment characteristics play a significant role in explaining these variations; sandy or fine-grained muddy sediments create distinct environments regarding stability, aeration, and organic matter retention, thereby influencing their capacity to support benthic species (Chelchowski *et al*., 2022; Zhang *et al*., 2023 a). While high organic content can provide a vital food source for certain benthic organisms, excessive levels may be linked to increased decomposition, oxygen consumption, and altered sediment conditions-factors that can lead to a proliferation of tolerant species and a decline in the diversity of sensitive species (Zhang *et al*., 2023 b; Lukhabi *et al*., 2024).

References:

Abbas, M.F. (2022). An ecological study of Rotifera of the Southern Shatt Al-Arab River, Basrah, Iraq. Iraqi Journal of Aquaculture, 18(2): 1–16.

Abdullah, A.D.; Karim, O.F.A.; Masih, I.; Popescu, I and Van der, Z. (2016). Anthropogenic and tidal influences on salinity levels of the Shatt Al-Arab River, Basrah, Iraq. International Journal of River Basin Management, 14(3): 357-366.

Abdullah, S.S. (2024). Tide phenomenon in the Shatt Al-Arab River, South of Iraq. Arabian Gulf Journal, 42(4–3): 231–235.

Abdul-Sahib, I.M.; Salman, S.D. and Ali, M.H. (2019). Oxygen consumption and energy budget of the barnacle Balanus amphitrite amphitrite (Darwin, 1854) in an estuarine ecosystem, Basrah-Iraq. Mesopotamian Journal of Marine Sciences, 34(2): 126–141.

Abe, H.; Takeuchi, T.; Taru, M.; Sato-Okoshi, W. and Okoshi, K. (2019) Habitat availability determines distribution patterns of spionid polychaetes (Annelida: Spionidae) around Tokyo Bay. Marine Biodiversity Records, 12: 7.

Abed, H.B.; Al-Abbad, M.Y. and Al-Qarooni, I.H. (2023). The effect of some environmental factors on the abundance and distribution of annelid worms from Shatt Al-Arab, Basra, southern Iraq. Iraqi Journal of Aquaculture, 19(1): 15–32.

Abrogueña, J.B.R.; Joydas, T.V.; Pappathy, M.; Cali, N.A.; Alcaria, J. and Shoeb, M. (2021). Structure and composition of the macrobenthic community associated to shallow mangrove-seagrass habitat along the southern Red Sea coast, Saudi Arabia. Egyptian Journal of Aquatic Research, 47(1): 61–66.

Aghajari Khazaei, S.; Safaie, M.; Valinassab, T.; Noorinezhad, M. and Mortazavi, M. (2021) Assessing the diversity of macroinvertebrates communities and their relationship with environmental factors in the Persian Gulf and the Gulf of Oman. Iranian Journal of Fisheries Sciences, 20(6): 1704–1726.

Ahmed, H.K. (2021). Aquatic insects: A review study for some biological and environmental aspects in Shatt Al-Arab and Southern Marshes of Iraq. Iraqi Journal of Aquaculture, 18(2): 63–76.

Ahmed, H.K. and Kareem, D.K. (2020). Effect of some environmental factors on the density of Odonata naiads in the temporary ponds of Basrah Province, South Iraq. Journal of Basrah Researches (Sciences), 46(1): 110–121.

Ahmed, M.M .(1975). Systematic study on the mollusca from Arabian Gulf and Shatt Al-Arab. Center for Arab Gulf studies, Basrah Univ. Iraq, p. 87.

Ajeel, S.G. and Abbas, M. (2012). Diversity of Cladocera of the Shatt Al-Arab River, Southern Iraq. Mesopotamian Journal of Marine Sciences, 27(2): 126–139.

Al Adhub, A.HY. and Hamzah, H.A. (1987). Caridina babaulti basrensis sub sp. Nov. from the Shatt Al-Arab Region, Iraq (Decapoda: caridea, Atyidae). Crustceana, 52 (3): 225-228.

Al Dabbagh, K.Y. and Daoud, Y.T. (1985). The ecology of three gastropod mollusks from Shatt Al-Arab –Iraq-. Journal of Biological Sciences Research, 16: 155-168.

Al-Abbad, M.Y. (2022). Addition of four new records of Naidid (Oligochaeta) to the Iraqi fauna. Mesopotamian Journal of Marine Sciences, 29(2): 137–144.

Al-Abbad, M.Y.; Salman, S.D. and Al-Qarooni, I.H. (2015). Biodiversity of the macroinvertebrates in the Southern Iraqi Marshes, with a special reference to Oligochaeta. Journal of Biodiversity and Environmental Sciences, 7 (1): 61–71.

Al-Abbad, M.Y.M. (2014). Addition of four new records of Naidid (Oligochaeta) to the Iraqi fauna, Mesopot. J. Mar. Sci., 29(2): 137 – 144.

Al-Asadi, S.A.R. (2019). General assessment of Shatt Al- Arab River- Iraq. Int. J. water, 13(4):360-375.

Al-Baghdadi, N.M.; Galo,A.M.; Ahmed,M.H. and Al—Khafaji, K.K. (2025). Study of benthic macrofauna and organic pollution indices in southern part of Shatt Al-Basrah Canal, Basrah, Iraq. Egyptian Journal of Aquatic Biology and Fisheries, 29(2): 1723–1743.

Al-Baghdadi, N.M. et al. (2024). Monitoring environmental changes in the Shatt Al-Arab River using the Organic Pollution Index (OPI) and two species of benthic invertebrates Melanoides tuberculata and Neritina violacea. Egyptian Journal of Aquatic Biology and Fisheries.

Al-Baghdadi, N.M.; Sultan, E.N. and Abdullah, A.A.M. (2023). Effect of some environmental factors on the presence and density of the snail Melanoides tuberculata (Müller, 1774) in the tidal region of Shatt Al-Arab, Iraq, Basrah. Iraqi Journal of Aquaculture, 20(1): 41–60.

Ali A.H. ; Aziz, N.M. and Hamza, H.A. (2007). Abundance, occurrence, seasonal changes and species composition of Macroinvertebrates in the restored Iraqi southern marshes. Marsh Bulletin, 2(1): 80-95.

Ali, M.H. and Salman, S.D. (1987). Growth and production of the Amphipod Parhyale basrensis (Talitridae) in the Shatt Al-Arab region. Mar Ecol. Prog. Ser., 40: 231-238.

Ali, M.H.; Salman, S.D.; Al-Taei, S.A. and Ahmed, H.K. (2021). The abundance and distribution of invertebrates and relation to macrophyte communities in intertidal zone of Shatt Al-Arab River, Basrah, Iraq. Oceanography and Fisheries Open Access Journal, 13(4): 1–12.

Al-Khafaji, K. (2015). The diversity, abundance and distribution of macroinvertebrates community in the intertidal zone of the Shatt-Al-Arab, South-Iraq. University of Thi-Qar Journal of Science, 5(2): 54–66.

Al-Khafaji, K.K.; Hreeb, K.K.; Okash, A.N. and Alsheraa, A. (2018). The abundance and distribution of invertebrates and relation to macrophyte communities in intertidal zone of Shatt Al-Arab River, Basrah, Iraq. Oceanography and Fisheries Open Access Journal, 6(2): 1–7.

Al-Khayat, F.A.; Shet, P.; Nanajkar, M.; Boopathy, N.S.; Vethamony, P. and Al-Khayat, J.A. (2026). Macrofauna community structure in extreme temperature and hypersaline waters: Khor Al-Adaid, Arabian Gulf. Aquatic Ecology, 60: 61.

Almamoori, A.; Abd Al-Rezzaq, A.J.; Yass, M.J. and Salman, J.M. (2015). Morphological and molecular study of new record species of barnacle Amphibalanus amphitrite (Darwin, 1854) in Babylon Province, Iraq. Advances in Natural and Applied Sciences, 9(12): 116–120.

Alvarez-Cabria M. ; Barquı´n, J. and Juanes, J.A. (2011). Macroinvertebrate community dynamics in a temperate European Atlantic river. Do they conform to general ecological theory. Hydrobiologia, 658: 277–291.

Asha, C.V.; Retina, C.I.; Nandan, S.B. and Suson, P.S. (2023). Community structure and ecology of soft bottom polychaetes in Vembanad estuary. Regional Studies in Marine Science, 67: 103213.

Atee, R.A. (2008). The diversity of Mollusca in four water systems in southern Iraq. Basrah Research Journal, 3(34): 28- 34.

Bae, S.; Yi, C.H.; Yang, D.; Jo, N.; Kim, J.M. and Kim, H.S. (2026). Macrobenthic community structure and associated carbon stocks in tidal flats of South Korea. Diversity, 18(5): 254.

Beanland, F.L. (1940). Sand and mud communities in the Dovey Estuary. Journal of the Marine Biological Association of the United Kingdom, 24(2): 589–611.

Behera, R.; Mishra, S.; Sharma, S.D.; Mahapatro, D.; Pati, S.S.; Raut, D.; Mallick, N. and Murugesan, K. (2023). Influence of water quality and sediment nature on macrobenthic community structure along Paradeep. Regional Studies in Marine Science, 62: 102970.

Chao, A. and Jost, L. (2015). Estimating diversity and entropy profiles via discovery rates of new species. Methods in Ecology and Evolution, 6(8): 873–882.

Chauvel, N.; Dufresne, T.; Le Bot, S.; Weill, P.; Raoux, A. and Pezy, J.P. (2025). Sediment grain size and bed form morphology and dynamics shape benthic community heterogeneity in submarine dune fields. Scientific Reports, 15: 40693.

Chelchowski, M.; Balazy, P.; Grzelak, K.; Grzelak, L.; Kędra, M.; Legeżyńska, J. and Kukliński, P. (2022). Vertical zonation of benthic invertebrates in the intertidal zone of Antarctica (Admiralty Bay, King George Island). Antarctic Science, 34(1): 29–44.

Chen, X. ; Zhou, Z. ; He, Q.; Zhang, H.; Bouma, T. ; Gong, Z. ; Towend, I and Zhang, C. (2022) Role of abiotic drivers on crab burrow distribution in a saltmarsh wetland. Frontiers in Marine Science, 9: 1040308.

Clements, J.C. and Hunt, H.L. (2023). Infaunal invertebrate community relationships to water column and sediment abiotic conditions. Marine Biology. 171 (3).

Gao, X. and Song, J. (2020). Organic matter in intertidal sediments: Sources, compositions, and biogeochemical significance. Marine Pollution Bulletin, 150: 110743.

Hashim, N.N. and Al-Taee, M.M. (2015). Biodiversity of benthic macroinvertebrates in Al-Razzaza lake at Karbala. International Journal of Advanced Research, 3(1): 423-427.

He, W.; Fang, J.; Zhang, Y.; Yan, Y.; Zhang, Z.; Huang, J. et al. (2022). Factors affecting burrow architecture of the polychaete Perinereis aibuhitensis. Frontiers in Marine Science, 9: 893539.

Hossain, M.B.; Das, N.G. and Sharmeen, R. (2009). Seasonal and spatial distribution macrozoobenthos of the Meghna river estuarine bed. Int. J. Sustainable Agric. Tech., 5: 11-16.

Imamsyah, A.; Arthana, I.W. and Astarini, I.A. (2020). The influence of physicochemical environment on the distribution and abundance of mangrove gastropods in Ngurah Rai Forest Park Bali, Indonesia. Biodiversitas, 21(7): 3178–3188.

Jabbar, I.M.A.; Najem, S.M. and Sultan, E.N. (2021). Some phenotypic characteristics of Eriocheir hepuensis Dai, 1991 from Shatt Al-Arab. Iraqi Journal of Aquaculture, 18(2): 77–89.

Jaccard, P. (1912). The distribution of the flora in the alpine zone. New Phytologist, 11(2): 37–50.

Ji, Y.; Song, B.; Xu, J.; Jiang, S.; Chen, L. and Li, B. (2024) Distribution and influencing factors of macrobenthos on three seagrass beds in the intertidal zone of Shandong province, China. Frontiers in Marine Science, 11: 1349131.

Khalaf, R.Z. (2023). Diversity of macrobenthic invertebrates at three stations from the middle part of Shatt Al-Arab River. GSC Advanced Research and Reviews, 15(3): 8–21.

Liu, L.; Li, A.; Zhu, L.; Xue, S.; Li, J.; Zhang, C. et al. (2023). The application of the generalized additive model to represent macrobenthos near Xiaoqing Estuary, Laizhou Bay. Biology, 12(8): 1146.

Lukhabi, D.K.; Mensah, P.K.; Asare, N.K.; Akwetey, M.F.A. and Faseyi, C.A. (2024) . Benthic macroinvertebrates as indicators of water quality: a case study of estuarine ecosystems along the coast of Ghana. Heliyon, 10(6): e28018.

Manokaran, S.; Joydas, T.V. and Khan, A. (2022). Physico-chemical factors regulating marine benthos structure and function. In: Ecology and Biodiversity of Benthos, pp. 209–250.

Miri, M.; Seyfabadi, J.; Ghodrati Shojaei, M.; Rahimian, H. and Valipour, M. (2023). Polychaete diversity and functional trait composition in subtropical mangrove ecosystems. Diversity, 15(9): 998.

Mohamed, A.M. and Abood, A.N. (2017). Ecological Health Assessment of the Shatt Al-Arab River, Iraq. Journal of Agriculture and Veterinary Science, 10 (10): 1-8.

Mohammed, H.H.; Ahmed, H.K.; Al-Taei, S.A. and Ali, M.H. (2020). Macro-invertebrates response to acute salinity changes in the Shatt Al-Arab River system, Southern Iraq. Iraqi Journal of Aquaculture, 17(1): 61–78.

Naser, M.D.; Yasser, A.; Abdul-Sahib, I. and Auda, N. (2024). An annotated checklist of the Amphipoda (Crustacea) of the Iraqi coast, north-western Persian-Arabian Gulf. Journal of Fauna Biodiversity, 1(1): 1–7.

Nazeer, Z.; Khan, S.A.; Manikandan, K.; Manokaran, S.; Hsu, H.H.; Joydas, T.V. and Lyla, P.S. (2021). Macrofaunal assemblage in the intertidal area of Saudi Arabian Gulf Coast. Regional Studies in Marine Science, 47: 101954.

Pielou, E.C. (1966). The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 13: 131–144.

Prajapat, D.; Jadeja, F. and Vachhrajani, K.D. (2025). Boring pattern of isopods in the intertidal hard mud substratum of Gulf of Khambhat, with two new records from Gujarat coast. Marine Ecology. https://doi.org/10.1111/maec. 70024.

Ray, H.; Paul, A.; Pal, S.; Das, N.; Borah, P. and Mandal, S. (2026). Distribution and abundance of key bioindicator gastropod species of the Sundarban mangrove ecosystem, India. Ecological Research, 41(1): e70025.

Rengaiyan, P.; De, K. and Ingole, B. (2017) Polychaete assemblage driven by substrate composition along the coastal waters of the South-eastern Arabian Sea. Regional Studies in Marine Science, 16: 208–215.

Richardson, C.J.; Reiss, P.; Hussain, N.A.; Alwash, A.J. and Pool, D.J. (2005). The restoration potential of the Mesopotamian Marshes of Iraq. Science, 307(5713): 1307–1311.

Rubin, S.P.; Davis, M.J.; Grossman, E.E.; Woo, I.; De La Cruz, S.E.W.; Nakai, G. and Takekawa, J.Y. (2024). Benthic macroinvertebrate response to estuarine emergent marsh restoration across a delta-wide environmental gradient. Frontiers in Ecology and Evolution, 12: 1356679.

Saoud, K.D. (2005). Distribution and abundance of some crustacean in the Shatt Al- Arab River. Marine Mesopotamica, 21(1):131 – 147 (in Arabic).

Schenone, S. and Thrush, S.F. (2020) Unraveling ecosystem functioning in intertidal soft sediments: the role of density-driven interactions. Scientific Reports, 10: 11909.

Shannon, C.E. (1948). A mathematical theory of communication. Bell System Technical Journal, 27(3): 379–423.

Shannon, C.E. and Weaver, W. (1949). The mathematical theory of communication. University of Illinois Press.

Sørensen, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Biologiske Skrifter, 5: 1–34.

Souza, J.R.B. and Gianuca, N.M. (1995) Zonation and seasonal variation of the intertidal macrofauna on a sandy beach of Paraná State, Brazil. Scientia Marina, 59(2): 103–111. https://doi.org/10.3989/scimar.1995.59n2103.

Verberk, W.C.E.P.; van Kleef, H.H.; Durance, I.; Vaughan, I.P. and Ormerod, S.J. (2020). Oxygen is a better predictor of macroinvertebrate richness than temperature -a systematic review. Environmental Research Letters, 15.

Wilbur, L.; Küpper, F.C. and Louca, V. (2024) Analyzing species diversity in rocky intertidal communities over multiple spatial scales among understudied Eastern Pacific ecoregions. Diversity, 16(8): 498.

Yasser, A.G.; Naser, M.D. and Ghazi, A.H. (2021). A new record of blue crab Portunus segnis (Forskal, 1775) from the Iraqi coast. Bulletin of the Basrah Natural History Museum, 7(1): 8–14.

Zhang, P.; Yongo, E.; Liu, F.; Pan, S.; Sun, A.; Zhou, L. et al. (2023 a). Effects of substrate on burrowing behavior, feeding physiology, and energy budget of undulated surf clam Paphia undulata. Journal of Oceanology and Limnology, 41: 1795–1808.

Zhang, Y.; Wan, H.; Zhao, Y.; Ding, J.; Zhu, Z.; Zhang, H. and Liu, Z. (2023b). Macrobenthic functional group analysis of ecological health of the intertidal artificial oyster reefs in the Yangtze Estuary, China. Frontiers in Marine Science, 9: 1059353.

Zhang, Y.; Zhao, C. and Liu, J. (2021). Use of benthic macroinvertebrates as environmental indicators in coastal ecosystems: A review. Ecological Indicators, 127: 107765.

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التنوع الحيوي للافقاريات الكبيرة في مناطق المد والجزر لكرمة علي، البصرة، جنوب العراق

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المستخلص

هدفت الدراسة إلى تقييم التنوع البيولوجي للافقاريات في منطقة الدراسة، وذلك من خلال تحديد الأنواع، وتقدير وفرتها وتوزيعها المكاني والزماني، وتحليل تأثيرات العوامل البيئية على بنية المجتمع الأحيائي في موقعين بمنطقة كرمة علي .تم التعبير عن العوامل البيئية المسجلة في منطقتي الدراسة بالمعدل ± الانحراف المعياري، بالإضافة إلى القيمتين الاقل والاعلى. ففي منطقة المسحب، بلغ معدل درجة الحرارة 24.5 ± 7.50 °م وباقل واعلى قيمة كانت 17.0 و32.0 °م على التوالي، وبلغ معدل الملوحة 7.36 ± 3.77 غم/ لتر وباقل واعلى قيمة تراوحت بين 3.59 و11.13 غم/لتر، بينما بلغ معدل الاس الهيدروجيني 7.51 + 0.41 باقل واعلى قيمة تراوحت بين 7.10 و7.92على التوالي، في حين بلغ معدل تركيز الأكسجين المذاب 8.90 ± 1.10 مغم/لترباقل واعلى قيمة تراوحت بين 7.80 و10.00 مغم/لتر. أما في منطقة كرامة علي، فقد بلغ معدل درجة الحرارة 22.81 ± 8.22 °م واقل واعلى قيمة تراوحت بين 14.59 و31.03 °م على التوالي، وبلغ معدل الملوحة 8.50 ± 4.20 غم/لتر وباقل واعلى قيمة تراوحت بين 4.30 و12.70 غم/لترعلى التوالي، وبلغ معدل الاس الهيدروجيني 7.30 + 0.81 وباقل قيمة 6.49 واعلى قيمة 8.11 ، بينما بلغ معدل تركيز الأكسجين المذاب 8.61 ± 1.40 مغم/لتر باقل قيمة كانت 7.21 ملغم / لتر واعلى قيمة 10.01 ملغم / لتر. جمعت عينات من اللافقاريات الكبيرة من منطقة المد والجزر في كل من المسحب وكرمة علي، حيث أُخذت 3-5 عينات مكررة خلال فترة الجزر. ففي منطقة المسحب، سجلت 16 نوعاً تنتمي إلى شعبة مفصليات الأرجل والرخويات والديدان الحلقية،وعضديات الأرجل، بإجمالي عدد بلغ 5,694 فرداً. وكانت تحت شعبة القشريات هي المجموعة الأكثر وفرة إذ ضمت 5,160 فرداً، تلتها الديدان الحلقية (316 فرداً)، ثم الرخويات (138 فرداً)، وعضديات الأرجل (50 فرداً) والحشرات 30 فردا . أما في منطقة كرمة علي، فقد سجلت 14 نوعاً تتبع ثلاث شعب رئيسة، بإجمالي عدد بلغ 6,603 أفراد، وكانت تحت شعبة القشريات هي المجموعة السائدة بواقع 5,960 فرداً، تلتها الديدان الحلقية 408 فرد ثم الرخويات 235 فرداً. وبلغت قيمة مؤشر "شانون-وينر 1.80 في المسحب و1.66 في كرمة علي، في حين بلغت قيمة مؤشر السيادة 0.21 و0.23 على التوالي. كما بلغ مؤشر بيلو للتساوي (J) وبلغ 0.38 في المسحب و0.37 في كرمة علي.

الكلمات المفتاحية: التنوع البيولوجي، اللافقاريات الكبيرة، مناطق المد والجزر، كرمة علي.

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