RESEARCH ARTICLE

# Malacological survey along the intertidal zone of Las Piñas-Paranaque Critical Habitat and Ecotourism Area

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**ABSTRACT**
**Background:** One of the eight Ramsar sites in the Philippines is the Las Piňas – Parañaque Critical Habitat and Ecotourism Area(LPPCHEA), and it plays a significant role in the East Asian-Australian Flyway as a stopover site. The migratory birds coming from the north of Asia and Alaska feed on the molluscs in this area. However, there is paucity of literature on the species composition of molluscs found in this critical habitat. Baseline information on these organisms is essential as they are subject to the effects of anthropogenic activities close to and in the wetland, which in turn can have an impact on the ecosystem, particularly the birds foraging in this location.
**Methodology:** The Natural Geography of in-Shore areas (NaGISA) protocol was used for the study. Transects were laid in three sampling sites in Freedom Island and Long Island. The sampling sites were GPS-referenced. A cylinder corer was used to collect mudflat soil, with the corer pushed into the sediment. Soil samples were sieved using a 0.5mm stainless mesh sieve pan, leaving shells and larger sand grains. The molluscs were sorted and identified through taxonomic keys. Sampling was done once for each site in November 2012.
**Results and Discussion:** A total of 61 molluscan species belonging to two classes, 14 orders, and 33 molluscan families were identified and recorded. There were 34 species under the Class Gastropoda that belong to 5 orders and 18 families. For Class Bivalvia, there were 27 species belonging to 8 orders and 15 families. Among the molluscs recorded, 10 species were identified as non-indigenous. It is important to monitor molluscan species as anthropogenic activities may affect these organisms, and in turn, affect the wetland's function for migratory birds. The presence of non-indigenous species may be a potential threat to the ecosystem.
**Conclusion:** Baseline information of the molluscan community in the LPPCHEA was provided by the study. These species provide diet to the endemic and migratory birds in the area. There is a need to monitor these molluscs due to the effects of the man-caused activities close to the area. Also, the non-indigenous species should be studied for their potential to be invasive.

**Keywords:** *malacology, LPPCHEA, molluscs, critical habitat, migratory birds*

## Introduction

The Philippines is known to have extensive wetland areas with an estimated total of 1,471,711 hectares. Five major wetland types can be found in the country, the most common of these being intertidal mudflats, sand flats, and mangrove swamps and forests [1]. Eight of the country's wetland areas have been recognized and declared by the Ramsar Convention as wetlands of international importance [2]. The convention provides protection and ensures effective management of these areas as they are significant in the survival of migratory waterfowl and their endemic species [3]. Migratory birds throughout East Asia make their way to these wetlands and become essential wintering grounds. One of these wintering areas is the Las Piñas – Parañaque Critical Habitat and Ecotourism Area (LPPCHEA).

The LPPCHEA is a 175-hectare region of Manila Bay which consists of mudflats and mangroves. Located on the western side of Aguinaldo Highway and bound by the Parañaque and Las Piñas River on the north and south, respectively, it is the first critical habitat established in the Philippines by virtue of Presidential Proclamation 1412 issued in April 2007. A critical habitat is a geographic area that is essential for the conservation of a threatened or endangered species and requires special management and protection [4]. The LPPCHEA as such is a significant component of the East Asian-Australian Flyway. This flyway is used as the flight path direction of millions of migratory birds that breed in northern Asia and Alaska and spend their non-breeding season in South-East Asia and Australasia. The LPPCHEA hosts at least 5,000 heads of migratory birds including the Chinese Egret, an endangered species, and six more threatened species [5]. The Philippine duck, *Anas luzonica*, which is a native threatened species, breeds in this location. It houses a total of 82 bird species, 47 of which are migratory [2]. In terms of mangrove species, there are 11 that can be found in this region [1].

The LPPCHEA, as a stopover site, is a source of food for migratory birds. Mudflats in bays and estuaries are crucial feeding sites along the shorebird migratory route between breeding and wintering grounds [6,7]. This is so because wetlands support a diverse community of organisms, primarily macroinvertebrates. Many wintering birds mostly feed on aquatic invertebrates [8,9]. A study of a Mediterranean coastal wetland showed that the presence of food, such as aquatic macroinvertebrates and vegetation, is an important factor in determining the avian use of these habitats [10]. Macroinvertebrates provide crucial links in the food chain, especially between primary production and detritus of the system to the higher-order consumers such as birds and fish [11]. They can also be used as indicators in assessing the health of wetlands [12,13] as some species are sensitive to alterations in physical, chemical, or biological conditions [14].

Among macroinvertebrates, molluscs provide a major food component for the different waterfowls. Molluscs are one of the most diverse and dominant groups in mangrove and mudflat communities. They have been observed to essentially take part in the structure and function of these systems. Ecologically, many molluscs are highly active scavengers that break down organic matter. They serve as links between primary producers and the higher trophic levels in the food web [15]. There are molluscan species that can be indicators of water quality [16] and show the measure of environmental parameters such as heavy metal content in wetlands [17]. Economically, molluscs provide *in situ* fishery and supply edible species of bivalves and gastropods for local consumption [18].

Despite their importance, molluscs in Philippine wetlands have been scarcely studied. The LPPCHEA, for one, has few information on molluscs and other macroinvertebrates. This paper is the first to identify and provide a listing of molluscan species in the LPPCHEA through a malacological survey. The identification of these organisms can be useful in the development of effective conservation strategies of this critical habitat, as it faces threats of pollution, reclamation for commercial interests, and introduction of alien invasive species.

## Methodology

*Study Area*

Three sampling sites were established along the intertidal zones of the LPPCHEA. The first site was at Freedom Island, the second was between the two islands, and the third was at Long Island (Figures 1 and 2). The sites were thirty meters away from each other. The sampling points are shown in Table 1.

*Sample Collection*

The Natural Geography of in-Shore areas (NaGISA) protocol was used for the study [19]. The sampling sites had 30-meter gaps. The location of each sampling site was GPS-referenced. Environmental parameters such as atmospheric temperature and wind speed, were recorded. Water quality parameters such as total dissolved solids, conductivity, resistivity, and salinity were also recorded.

A transect was laid in each sampling site. Each transect had a length of 100 meters and a sampling point was laid every five meters, hence a total of twenty sampling points. A quadrat was placed in each sampling point. Each quadrat had an area of 2.5 m2 (0.5 m x 0.5 m).

A cylinder corer with a diameter of 15 cm and a depth of 10 cm was used to collect mudflat soil in each quadrat. Such dimensions are specific for taking representative samples of macrofauna from the mudflat substrate. The corer was deployed at the center of the quadrat. To collect mudflat soil, the corer was pushed into the sediment until it reached the 10-cm mark of the corer's depth, then retrieved. Soil samples were initially placed inside standard rice sack (sako) bags to drain the water. Macrophytes and unwanted objects (plastic garbage and other rubbish) were discarded in a black polyethylene bag. The remaining components were sieved using a 0.5mm stainless mesh sieve pan, leaving behind shells and larger sand grains. The molluscs were then put through sorting and initial identification. Twenty core

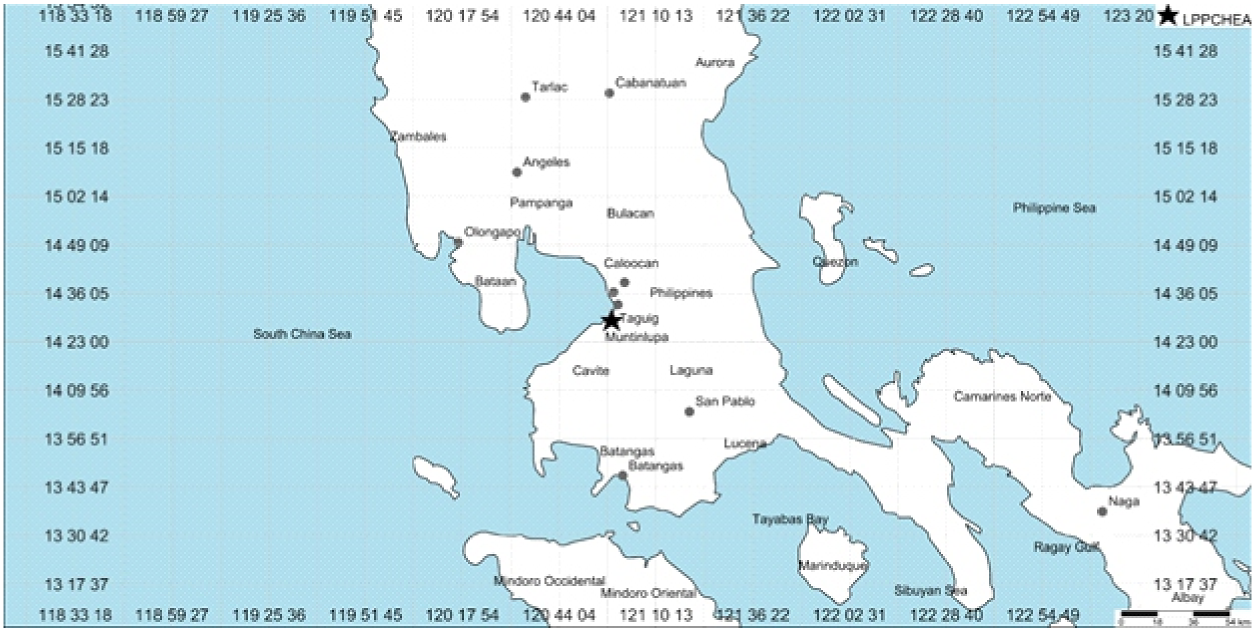


**Figure 1.** *Location of the study site LPPCHEA, represented by the star. Map generated through SimpleMappr.*

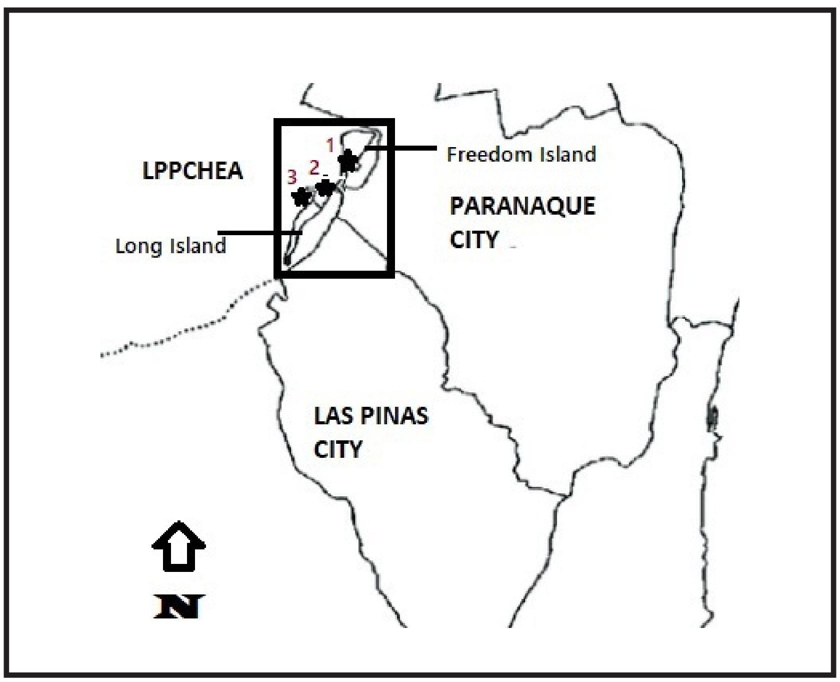


**Figure 2.** *Location of sampling sites in LPPCHEA.*

samples were collected per site. Sampling was done once for each site in November 2012, with three replicates per site.

*Molluscan Identification*

Molluscs were sorted and photo-documented using a point and shoot camera (Olympus TG-820) and Leica ES2 steromicroscope. Specimens were identified using taxonomic keys and other printed and electronic references [21-25].

## Results

The study yielded 61 molluscan species belonging to two classes, 14 orders, and 33 molluscan families.

There were 34 recorded species under the Class Gastropoda . These species belonged to 5 orders and 18 families. Of all the gastropods, Order Neogastropoda had the most species with 16, followed by Littorinimorpha with

**Table 1.** *Sampling points at Las Piñas-Parañaque Critical Habitat and Ecotourism Area.*

| Sampling point | Coordinates |
|---|---|
| 1 | N 14˚29.6'; E 120˚58.8' |
| 2 | N 14˚29.6'; E 120˚58.8' |
| 3 | N 14˚29.6'; E 120˚58.8' |

6 species, Caenogastropoda with 5 species, Trochida with 4 species, and Heterostropha with 3. Family Nasariidae had the most number of species with 4, followed by Cerithiidae, Buccinidae, Naticidae, and Trochidae with 3 species each. The different gastropod species are shown in Table 2.

For Class Bivalvia, 27 species were identified. These species belonged to 8 orders and 15 families. Among the bivalves, Order Venerida had the most number of species, with 11 being identified. It is followed by Arcoida with 4, Mytilida and Ostreida both with 3, Carditida and Pectinida with 2, and Cardiida and Myoida with 1. The family with the most species was Veneridae with 6, followed by Arcidae with 4 species, then Mytilidae with 3 species. The bivalve species identified were summarized in Table 3.

The occurrence of the different groups across the sites in Freedom and Long Islands is shown in Tables 4 and 5.

Among the molluscs recorded, 13 species were identified as non-indigenous (Table 6).

## Discussion

A significant result of the research is that it provides the first documentation of molluscs in the LPPCHEA. Molluscan biodiversity in this area is not well studied. Although the data may not be representative of the current malacofauna of the LLPCHEA due to its year of data collection, this listing establishes the baseline information of species in the area. These species, apart from playing essential roles in the ecosystems in the LPPCHEA, are recipients of the impact of the environmental problems being faced by the wetland as well. The LPPCHEA is an urban ecosystem, and it is vulnerable to threats caused by anthropogenic activities such as urbanization and pollution. A listing can provide basis for unique conservation considerations for management plans that are being drawn up for this critical habitat.

The LPPCHEA is composed of mudflats and mangroves, and these two types of wetlands are associated with each other [26]. They are habitats that are considered to be structurally complex and as such, can support higher diversity of benthic organisms. This is because complex structures can provide more settlement areas, with more nutrients being made available [27]. Studies in Asia show this rich biodiversity in wetlands: in the wetlands of Raigad district, Maharashtra, India, 24 species of molluscs (9 bivalves, 15 gastropods) were identified [28]; in the upper Gulf of Thailand, 47 species (31 gastropods, 16 bivalves) were observed [15]; in Cengkrok Beach-Trenggalek, Indonesia, there were 13 species (11 gastropods, 2 bivalves) reported [29], and in Catanduanes Island, Luzon, Philippines, 57 species (27 gastropods, 30 bivalves) were found [30].

Molluscs provide an invaluable resource of food for birds in mudflats and mangrove areas. In the meta-analysis conducted by Van Leeuwen [31], an analysis of freshly collected droppings from the field showed that aquatic macroinvertebrates were indeed present in the droppings, and are viable. The occurrence of the invertebrates in the droppings was described "as often as plant seeds." Except for the database in Japan [32], there is poor documentation of specific dietary preferences of migratory birds or predator-prey interactions among birds and molluscs.

Among the molluscs collected, several species have been cited to be environmentally important. *Anadara antiquata* has been used in East Africa in studying the prevalence of microplastics [33]. *Tegillarca granulosa* has been used to study the effects of ocean acidification on its fitness [34]. *Crassostrea iredalei* and *Katylesia hiantina* have been used in studies involving heavy metal concentration in their habitat [35, 36]. In general, bivalves have been able to protect estuaries and coastal systems from developing phytoplankton blooms due to nitrogen being deposited in the waters by anthropogenic activities [37]. Moreover, they can prevent sedimentation from soil erosion and reduce the turbidity of the waters [38].

Molluscs in the LPPCHEA might be affected by critical threats that are observed in Manila Bay. These threats include pollution, habitat degradation, and climate change [39,40]. These have been observed in Southwestern Australia and

**Table 2.** *Gastropod families and identified species collected from three sampling sites in LPPCHEA.*

| Order | Family | Common name | Identified species |
|---|---|---|---|
| Heterostropha | Acteonidae | barrel bubble shells | *Pupa alveola* |
| | Architectonicidae | sundial shells | *Architectonica perspectiva*<br>*Pseudotorinia gemmulata* |
| Caenogastropoda | Cerithiidae | ceriths, cerithiids | *Cerithium coralium*<br>*Cerithium gloriosum*<br>*Rhinoclavis longicaudata* |
| | Epitoniidae | wentletraps | *Trigonostoma crenifera* |
| | Turritellidae | turret shells | *Turritella terebra* |
| Neogastropoda | Buccinidae | Whelks | *Cantharus wrightae*<br>*Euthria bednalli*<br>*Pollia wagneri* |
| | Conidae | cone shells | *Conus cocceus* |
| | Costellariidae | miter shells | *Vexillum semisculptum*<br>*Vexillum weberi* |
| | Mitridae | miter shells | *Mitra avenacea*<br>*Mitra nadayaoi*<br>*Scabricola limata* |
| | Muricidae | murex or rock snails | *Thais javanica* |
| | Nassariidae | dog whelks | *Nassarius livescens*<br>*Nassarius margaritiferus*<br>*Nassarius pullus*<br>*Nassarius thachi* |
| | Volutidae | Volutes | *Calliotectum tibiaeforme*<br>*Nanomelon viperinus* |
| Littorinimorpha | Cypraeidae | Cowries | *Leporicypraea mappa mappa f. panerythra* |
| | Naticidae | moon shells | *Globularia fluctuata*<br>*Natica atypha*<br>*Natica pluvialis* |
| | Ranellidae | triton shells | *Cymatium mundum* |
| | Strombidae | Conchs | *Doxander entropi* |
| Trochida | Liotiidae | Liotia | *Liotinaria scalaroides* |
| | Trochidae | top shells | *Calthalotia strigata*<br>*Monilea callifera*<br>*Monodonta canalifera* |

China and they have negative impacts on mollusc diversity [41,42]. Resource availability is a critical factor for migratory waterfowls because it sets the schedule of migration and determines the amount of time spent at stop-over sites [43].

Other anthropogenic disturbances such as agricultural wastes, chemical fertilizers, and household wastes can result in a decrease in molluscs and other invertebrate species in wetlands. An emerging problem which warrants further study is the introduction of alien invasive species in LPPCHEA. Invasive species threaten native species since they have no natural predators in the area of introduction; they can reproduce fast and outnumber the native species. Later on, they can alter the habitat of the native species and eventually drive out the native species in the area. This will result in a drastic change in the community structure. The survey has identified 10 non-indigenous species. These species can be potentially invasive and must be religiously monitored. An invasive mollusc, *Mytella charruana*, has already established populations in parts of Manila Bay [44] that are close to the LPPCHEA.


**Figure 3.** *Some identified gastropod species from LPPCHEA: (A) Architectonica perspectiva, (B) Polia wagneri, (C) Cymatium mundum, (D) Nassarius liviscens, (E) ; Calthalotia strigata, (F) Natica pluvialis.*

**Table 3.** *Bivalve families and identified species collected from three sampling sites in LPPCHEA.*

| Order | Family | Common name | Identified species |
|---|---|---|---|
| Arcoida | Arcidae | ark shells | *Anadara antiquata*<br>*Anadara vellicata*<br>*Arca navicularis*<br>*Tegillarca granosa* |
| Cardiida | Psammobiidae | sunset clams, sanguins | *Gari elongata* |
| Carditida | Carditidae | Carditas | *Cardites bicolor* |
| | Crassatellidae | Cockles | *Crassatella* sp. |
| Lucinida | Lucinidae | Hatchet shells | *Fimbria* sp. |
| Myoida | Hyatellidae | Pacific geoduck clam | *Panopea generosa* |
| Mytilida | Mytilidae | sea mussels | *Hormomya mutabilis*<br>*Mytilus* sp.<br>*Perna veridis* |
| Ostreida | Gryphaeidae | honeycomb oysters | *Hyotissa sinensis* |
| | Ostreidae | Oysters | *Crassostrea iredalei*<br>*Ostrea palmipes* |
| Pectinida | Plicatulidae | kitten paw clams | *Plicatula gibossa* |
| Venerida | Chamidae | jewel box shells | *Chama gryphoides* |
| | Donacidae | donax clams | *Donax erythraeensis* |
| | Mactridae | trough shells | *Mactra pura* |
| | Tellinidae | Tellins | *Tellina alternata*<br>*Tellina modesta* |
| | Veneridae | venus clams | *Anomalocardia squamosa*<br>*Dosinia (Phacosoma) troscheli*<br>*Katelysia hiantina*<br>*Paphia (Neotapes) textile*<br>*Periglypta (Tigammona) chemnitzii*<br>*Placamen calophylla* |

Table 4. *Gastropod occurrence in LPPCHEA sampling sites 1, 2, and 3.*

| Family | Scientific name | 1 | 2 | 3 |
|---|---|---|---|---|
| Acteonidae | *Pupa alveola* | + | - | - |
| Architectonicidae | *Architectonica perspectiva* | + | - | - |
| | *Pseudotorinia gemmulata* | + | - | - |
| Buccinidae | *Cantharus wrightae* | + | + | + |
| | *Euthria bednalli* | + | + | + |
| | *Pollia wagneri* | + | + | - |
| Cerithiidae | *Cerithium coralium* | + | + | + |
| | *Cerithium gloriosum* | - | - | + |
| | *Rhinoclavis longicaudata* | + | - | - |
| Conidae | *Conus cocceus* | + | - | - |
| Cypraeidae | *Leporicypraea mappa mappa f. panerythra* | + | - | - |
| Costellariidae | *Vexillum semisculptum* | + | + | - |
| | *Vexillum weberi* | + | - | - |
| Epitoniidae | *Trigonostoma crenifera* | + | - | - |
| Liotiidae | *Liotinaria scalaroides* | + | - | - |
| Mitridae | *Mitra avenacea* | + | - | - |
| | *Mitra nadayaoi* | + | + | + |
| | *Scabricola limata* | + | - | - |
| Muricidae | *Thais javanica* | + | + | - |
| Nassaridae | *Nassarius livescens* | + | + | - |
| | *Nassarius margaritiferus* | + | + | - |
| | *Nassarius pullus* | - | - | + |
| | *Nassarius thachi* | + | - | + |
| Naticidae | *Globularia fluctuata* | + | - | - |
| | *Natica atypha* | - | + | + |
| | *Natica pluvialis* | + | - | + |
| Ranellidae | *Cymatium mundum* | - | + | - |
| Strombidae | *Doxander entropi* | - | + | - |
| Trochidae | *Calthalotia strigata* | + | - | - |
| | *Monilea callifera* | - | - | + |
| | *Monodonta canalifera* | + | - | - |
| Turritellidae | *Turritella terebra* | - | + | - |
| Volutidae | *Calliotectum tibiaeforme* | - | + | - |
| | *Nanomelon viperinus* | + | - | + |

Table 5. *Bivalve occurrence in LPPCHEA sampling sites 1, 2, and 3.*

| Family | Scientific name | 1 | 2 | 3 |
|---|---|---|---|---|
| Arcidae | *Anadara antiquata* | + | + | + |
| | *Anadara trapezia* | + | - | + |
| | *Anadara vellicate* | + | + | + |
| | *Arca navicularis* | + | + | - |
| | *Tegillarca granosa* | + | + | + |
| Carditidae | *Cardites bicolor* | + | - | - |
| Crassatellidae | *Crassatella* sp. | + | + | + |
| Chamidae | *Chama gryphoides* | + | + | + |
| Donacidae | *Donax erythraeensis* | - | - | + |
| Lucinidae | *Fimbria* sp. | + | + | + |
| Gryphaeidae | *Hyotissa sinensis* | + | + | - |
| Hyatellidae | *Panopea generosa* | - | + | + |
| Lucinidae | *Fimbria sp.* | + | + | - |
| Mactridae | *Mactra pura* | + | - | + |
| | *Mactra sp.* | + | + | + |
| Mytilidae | *Hormomya mutabilis* | - | + | + |
| | *Mytilus* sp. | + | + | + |
| | *Perna viridis* | + | + | + |
| Ostereidae | *Crassostrea iredalei* | + | - | - |
| | *Ostrea palmipes* | + | - | + |
| Plicatulidae | *Plicatula gibbose* | + | - | + |
| Psammobiidae | *Gari elongata* | + | + | + |
| Tellinidae | *Tellina alternata* | - | + | - |
| | *Tellina modesta* | + | + | + |
| Veneridae | *Anomalocardia squamosa* | + | + | + |
| | *Dosinia (Phacosoma) troscheli* | - | + | + |
| | *Katylesia hinatina* | + | + | + |
| | *Paphia (Neotapes) textile* | - | + | + |
| | *Periglypta (Tigammona) chemnitzii* | + | - | - |
| | *Placamen calophylla* | - | + | + |


**Figure 4.** *Some identified bivalve species from LPPCHEA: (A) Anadara antiquata, (B) Arca navicularis, (C) Cardites bicolor, (D) Donax erythraeensis, (E) Tellina modesta, (F) Periglypta (Tigammona) chemnitzii.*

**Table 6.** *Non-indigenous species and their native distribution areas.*

| Species | Distribution |
|---|---|
| *Chama gryphoides* | Mediterranean Sea: Greece. |
| *Crassatella* sp. | Western Atlantic, Western Indian Ocean: Qatar, Persian Gulf, Western Central Atlantic. |
| *Donax erythraeensis* | Red Sea |
| *Panopea generosa* | Eastern Pacific: From Alaska to Baja California. Subtropical to temperate. |
| *Mactra pura* | Australia |
| *Mytilus* sp. | temperate and boreal regions of both Northern and Southern Hemispheres |
| *Tellina alternata* | Western Central Atlantic: USA. |
| *Tellina modesta* | Northeast Pacific: Alaska, Canada, Baja California Sur. |
| *Conus cocceus* | Eastern Indian Ocean: Australia. |
| *Natica atypha* | Japan, Madagascar |
| *Calthalotia strigata* | Western Australia |
| *Caliotectum tibiaeform* | Arafura Sea, Australia, Japan, Taiwan |
| *Nanomelon viperinus* | Western Atlantic. |

In conclusion, the study has provided a list of 33 molluscan families that were found in the intertidal regions of the LPPCHEA. These families constitute 18 from class Gastropoda (34 species) and 15 from class Bivalvia (27 species). These molluscs are part of the diet of migratory birds as the LPPCHEA is a major staging site for both migratory and native avian species.

**Table 7.** *Environmental parameters taken at sites 1, 2, and 3.*

| Site | Atmospheric temperature (degrees Celsius) | Wind speed (m/sec) |
|---|---|---|
| 1 | 27.8 | 0.6-2.0 |
| 2 | 27.6 | 0.6-1.5 |
| 3 | 28.5 | 1.6-2.4 |

**Table 8.** *Water quality parameters taken at sites 1, 2, and 3.*

| Site | Salinity (ppt) | Total dissolved solids (ppt) | Conductivity (mS/cm) | Resistivity (Ω) |
|---|---|---|---|---|
| 1 | 40.73 | 32.08 | 43.5 | 12.29 |
| 2 | 46.6 | 36.51 | 49.22 | 10.88 |
| 3 | 46.21 | 36.21 | 48.97 | 10.96 |

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