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Research Article

Marine endemic species in Tunisia: Biogeography and ecological state in front of anthropogenic activities and climate change
2. Fauna

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Abstract: Historically, most Mediterranean biocenosis has been reconstituted from immigrants from the Atlantic that penetrate through the Strait of Gibraltar after its almost total desiccation during the Messinian crises approximately 5-6 million years ago, and their descendants have become Mediterranean endemic species over time. Currently, Mediterranean Sea is considered as a true hotspot of biodiversity and endemic species compared to other seas and oceans, and Tunisian coasts present a mosaic of bottom types from muddy-sandy to rocky bottoms. This offers diverse habitats and micro-habitats for flora and fauna, mainly for endemic species. Several factors affect biodiversity and endemic species in Tunisian waters, and most often act concurrently, such as climate change, water acidification, urban and industrial discharges, excessive fishing, aquaculture, tourism, and biological invasions. To date, there is neither a complete inventory of endemic marine species nor a study on their status, geographic distribution, and nuisance factors, with the exception of some work on certain groups such as fish. In this work, we have established a non-exhaustive list including more than sixty marine endemic species of fauna which have been observed in Tunisia, with information on their ecological state, their geographical distribution, and the main nuisances which threaten them.

Keywords: fauna endemic species; Tunisia; biogeography; anthropogenic disturbances; climate change

1. Introduction

Historically, the Mediterranean biocenosis comes from successive invasions from the Atlantic after its almost total desiccation during the Messinian crises approximately 5-6 million years ago, and during other following hydroclimatic variations, mainly the salinity crisis (Hsü *et al*., 1977; Krijgsman *et al*., 1999). Thus, animal and vegetal communities have been reconstituted in the Mediterranean mostly from immigrants from the Atlantic that penetrate through the Strait of Gibraltar,

and which have adapted to local conditions over millions of years, and their descendants have become Mediterranean endemic species over time (Boudouresque, 1997; McKenzie, 1999; Hippolyte *et al*., 2021). This is a recent endemism or neo-endemism manifested at the specific level (Hippolyte *et al*., 2021). To ensure correct understanding of this study, the notion of endemism must be clearly defined. According to Morrone (2008), an endemic species is a native vegetal/animal species that is restricted to a particular geographic area. Thus, the endemism by definition stands for a species that's only found in a defined physical-geographical area and not anywhere else in the world. So, two types of endemism can by distinguished; strict endemism (the species is strictly limited to a geographical area), and broad endemism (the species reaches neighboring areas).

Globally, the Mediterranean Sea is considered as a true hotspot of biodiversity (Bianchi & Morri, 2000; Mannino *et al*., 2017), and it presents a very high endemism rates compared to other regions of the world since 20–30% of marine species in the Mediterranean are considered endemic to this sea (Table 1) (Capapé, 1986; Stehmann & Bürkel, 1986; Fischer *et al.*, 1987; Fredj & Maurin, 1987; Bradaï, 2000; Boudouresque, 2004; Ben Rais Lasram *et al*., 2009a, b, 2010a, 2010b; Mannino *et al*., 2017). In Tunisia, Northern coasts present bottoms with a mosaic of biotopes (e.g. rocks, cliffs, loose sediments, islands, and marine banks) (Azouz, 1973). This offers diverse habitats and micro-habitats that are remarkable for the presence of benthic species (Boudouresque, 1997; Ministère des affaires locales et de l'environnement, 2014). Southern coasts have a very extensive continental shelf with a low slope, and are characterized by a large tide, a relatively higher salinity, and are characterized by sandy and sandy-muddy bottoms, favorable to the development of sea vegetation, mainly *Posidonia* meadows (Azouz, 1973). The Eastern coasts are an alternation of rocky bottoms and soft bottoms, and provided with a relatively extensive continental shelf with *Posidonia* meadows and lawns with *Caulerpa* and *Cymodocea* which are quite frequent and in good conditions (Langar *et al*., 2002). In general, the main problems that threaten marine and coastal biodiversity in the Mediterranean and in Tunisian waters, mainly endemic species, remain the habitat loss, the urbanization, the overexploitation of natural resources, the proliferation of alien species, the increasing maritime traffic, the water acidification, and the pollution (Mannino *et al*., 2017). In a climate change context, this has led to the loss of the biodiversity, the growing scarcity of the most sensitive endemic species and the degradation of unique coastal and remarkable habitats (Numa & Troya, 2011). In fact, the progressive water warming of the Mediterranean Sea caused by climate change, induces a flow of subtropical species that penetrate through the Strait of Gibraltar, and especially from the Red Sea since the opening of the Suez Canal in 1869 in what is known as Lessepsian migration (Zenetos *et al*., 2010; Ounifi-Ben Amor*et al.,* 2016).

Table 1: Number and percentage of endemic taxa for a certain number of phylums of the Mediterranean fauna (according to Fredj & Maurin (1987) for pisces, and Fredj (1974) for the other groups, *in* Boudouresque (1997)).

Phylum	Number of species	Number of endemic species	Rate of endemism (%)
Echinodermata	134	32	24
Priapulida	1	0	0
Polychaeta Errantia	371	88	24
Echiurida	6	1	17
Sipuncula	20	4	20
Brachiopoda	15	2	13
Mollusca	401	65	16
Crustacea Decapoda	286	52	18
Pogonophora	1	1	100
Phoronidea	4	0	0
Hemichordata	5	2	40
Pisces	638	117	18

This work is based on the available bibliography. It aims to establish the first list of marine endemic fauna species in Tunisia (macro and mega fauna) and to assess their biogeography and current ecological state in front of anthropogenic activities and climate change. In this study, endemism is defined in relation to the Mediterranean Sea, but only the species present in Tunisia are studied in this work.

2. Species threats and their impacts on coastal Ecosystems

Endemic marine species have not been the subject of specific inventories in Tunisia, and the few reports made were mostly reported accidentally. As a result, the inventory carried out in this work required extensive research in scientific articles, PhD and scientific reports. Thus, the list below is not exhaustive and the endemic species in Tunisia would be significantly more numerous. The verification of the species names and the systematic classification in this work were carried out using the "World Register of Marine Species" website (https://www.marinespecies.org).

2.1. Sponges

2.1.1. Axinella cannabina (Esper, 1794)

- Porifera (Phylum);
- Demospongiae (Class);
- Heteroscleromorpha (Subclass);
- Axinellida (Order);
- Axinellidae (Family);
- *Axinella* (Genus);
- *Axinella cannabina* (Species)

This species is endemic to the Mediterranean (mainly in Southern Mediterranean). It lives in muddy bottoms of the circalittoral stage (up to 50m). It grows slowly, as all *Axinella* species. It was seriously affected by the regular trawling of the bottom (Hattour & Ben Mustapha, 2015).

2.1.2. Petrobiona massiliana Vacelet & Lévi, 1958

- Porifera (Phylum);
- Calcarea (Class);
- Calcaronea (Subclass);
- Baerida (Order);
- Petrobionidae (Family);
- *Petrobiona* (Genus);
- *Petrobiona massiliana* (Species)

It is endemic to the Mediterranean. Distribution sites are rare, in the Western basin and the Adriatic. It lives in dark areas; in caves up to 30m. Threats include scarcity of distribution sites and fishing (Hattour & Ben Mustapha, 2015).

2.1.3. Sarcotragus pipetta (Schmidt, 1868)

- Porifera (Phylum);
- Demospongiae (Class);
- Keratosa (Subclass);
- Dictyoceratida (Order);
- Irciniidae (Family);
- *Hircinia* (Genus);

- *Hircinia (Euricinia)* (Subgenus);
- *Hircinia (Euricinia) pipetta* (Species)

This massive sponge is endemic to the Mediterranean and is present in particular in El Bibane (Southern Tunisia) and in Italy, it was reported as *Hircinia pipetta* Schmidt, 1868 (Hattour & Ben Mustapha, 2015). According to Vacelet (1959), this species cannot be separated from *Ircinia fasciculata* Pallas, since the main difference is thought to be the presence of osculiferous papillae in the species described by Topsent (1894; 1928). However, Pulitzer-Finali & Pranzato (1980) support the existence of two different species. It is a Mediterranean endemic species. It lives on rocky bottoms, up to 35m depth. As described by Rützler (1976), horny sponges (*Spongia*, *Hippospongia*, *Ircinia* and *Sarcotragus*) constitute "an ecological niche particularly suited to harboring interstitial fauna". For *I. fasciculata*, the author counted 825 individuals of the macro-benthic endofauna per kg of sponge, and as such sponges must benefit from certain measures ensuring their sustainability as an inseparable part of the marine habitat.

2.1.4. *Hippospongia communis* (Lamarck, 1814)

- Porifera (Phylum);
- Demospongiae (Class);
- Keratosa (Subclass);
- Dictyoceratida (Order);
- Spongiidae (Family);
- *Hippospongia* (Genus);
- *Hippospongia communis* (Species)

It lives in the *Posidonia* meadow, the lawn in *Caulerpa prolifera*, detrital bottoms, but also on rock, coralligenous seabeds and sandy mud bottoms (Soufi-Kéchaou, 2004; Soufi-Kéchaou *et al.*, 2005; Ramos-Esplá *et al.*, 2011). Within the framework of the project "Protection of Marine and Coastal Resources of the Gulf of Gabès" financed by the International Bank for Reconstruction and Development, surveys were taken during 2009-2010 by several methods (diving, dredging, coring and trawling). The species was collected between 29 and 47m depth, on various bottoms (dead matte of *Posidonia*, coastal detritus with *Synascidia* and/or Echinoderms). The maximum length was 330mm. It has been reported in the deeper Boughrara area with *Pinna nobilis* and *Spongia zimocca*. On the other hand, *H. communis* has not been observed in the Boughrara lagoon. It is a good indicator of the impact of the trawl. In addition, the species represents the habitat of a high number of organisms (Ascidians, Crustaceans, Polychaetes, and Cnidarians). It is a Mediterranean endemic species (Hattour & Ben Mustapha, 2015). It is a common species in the Gulf of Gabès between 1 and 200m depth (Ramos-Esplá *et al.*, 2011). The species is threatened by silting, trolling, and uncontrolled harvesting.

2.1.5. *Calyx nicaeensis* (Risso, 1826)

- Porifera (Phylum);
- Demospongiae (Class);
- Heteroscleromorpha (Subclass);
- Haplosclerida (Order);
- Phloeodictyidae (Family);
- *Calyx* (Genus);
- *Calyx nicaeensis* (Species)

This Mediterranean endemic species lives in the *Posidonia* meadows at about 1m depth, but it has been observed on a detrital coastal bottom of Synascidia and *Echinoderma* at more than 40m depth (Ramos-Esplá *et al.*, 2011). It has been reported in the Gulf of Gabès; however, it seems very rare. A single specimen was captured in July 2009 in the Southeastern sector of Kerkennah between 40–41m depth. It is threatened by siltation and trawl fishing (Hattour & Ben Mustapha, 2015).

2.2 Briozoans

2.2.1. *Electra posidoniae* Gautier, 1954

- Bryozoa (Phylum);
- Gymnolaemata (Class);
- Cheilostomatida (Order);

- Membraniporina (Suborder);
- Membraniporoidea (Superfamily);
- Electridae (Family);
- *Electra* (Genus);
- *Electra posidoniae* (Species)

This species lives associated with the leaves of *Posidonia oceanica* and *Cymodocea nodosa* where it forms stolonial and encrusting colonies (De Gaillande, 1970). Normally, it grows well in dense seagrass beds, between 5 and 15m depth. The species is annual due to its epiphytism on the leaves of *Posidonia* and *Cymodocea* (Pérès et Picard, 1964). As is the case with *Asterina panceri*, *E. posidoniae* also grows in *Posidonia* meadows, and to a lesser extent in *Cymodocea* lawns. Any threat to these meadows and their degradation will pose a risk to the populations of this species, particularly the silting up and the development of epiphytes. It is a Mediterranean endemic species (Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). In the Gulf of Gabès, it has been reported by De Gaillande (1970). It is abundant in areas/sectors where the meadows are in good status with well developed leaves (South of Kerkennah, East of Djerba, and Kneiss).

2.2.2. *Bryobifallax disjuncta* (Canu & Bassler, 1930)

- Bryozoa (Phylum);
- Gymnolaemata (Class);
- Cheilostomatida (Order);
- Flustrina (Suborder);
- Microporoidea (Superfamily);
- Onychocellidae (Family);
- *Rectonychocella* (Genus);
- *Rectonychocelladisjuncta* (Species)

According to Canu & Bassler (1930) and Boudouresque (1997), this species (described as *Rectonychocella disjuncta* Canu & Bassler, 1930) is present in Tunisia. It has been also observed in different regions of the Mediterranean, notably in Tripoli (Lebanon) with low densities (Harmelin *et al.*, 2016).

2.3. Ascidians

2.3.1. *Halocynthia papillosa (Linnaeus, 1767)*

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Stolidobranchia (Order);
- Pyuridae (Family);
- *Halocynthia* (Genus);
- *Halocynthia papillosa* (Species)

This species is very sensitive to siltation and organic pollution (bio-indicator), specific to the coralligenous, present in the coastal detrital, between 35 and 80m depth (Chebbi, 2010). It rarely occurs on the rhizomes of *Posidonia* dislodged and on the valves of *Pinctada radiata* in the mud, between 5 and 13m depth (Ben Mustapha *et al.*, 1999). It is a Mediterranean endemic species, which stretches also to the Atlantic, from Portugal to the Canary Islands (Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). Considered rare in the Gulf of Gabès, it is threatened by siltation, organic pollution, trawling, and scavenging (Ben Mustapha *et al.*, 1999; Ramos-Esplá *et al.*, 2011).

2.3.2. *Microcosmus sabatieri* Roule, 1885

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Stolidobranchia (Order);
- Pyuridae (Family);
- *Microcosmus* (Genus);
- *Microcosmus sabatieri* (Species)

The species colonizes infra and circalittoral rocky bottoms, *Posidonia* meadows, coastal detrital, silted detrital and offshore detrital, terrigenous muds; between 1 and 265m depth (Chebbi, 2010). Currently, the genus *Microcosmus* includes the species *M. nudistigma*, *M. polymorphus*, *M. sabatieri,* and *M. vulgaris* (Ramos-Esplá *et al.*, 2011). It is a Mediterranean endemic species which extends to Portugal (Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). It is reported in the Gulf

of Gabès, and it is threatened by chemical pollution, Trawling, and collection by divers (Ramos-Esplá *et al.*, 2011).

2.3.3. *Microcosmus vulgaris* Heller, 1877

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Stolidobranchia (Order);
- Pyuridae (Family);
- *Microcosmus* (Genus);
- *Microcosmus vulgaris* (Species)

This species lives in circalittoral rocky bottoms, coastal detrital, silted detrital and offshore detrital, terrigenous muds; between 10 and 380m depth (Chebbi, 2010; Ramos-Esplá *et al.*, 2011). It is endemic to the Mediterranean with a distribution deeper than *M. sabatieri* (Hattour & Ben Mustapha, 2015). It was reported in the Gulf of Gabès. Trawling represents its main threat (Ben Mustapha *et al.*, 1999; Ramos-Esplá *et al.*, 2011).

2.3.4. *Pseudodistoma obscurum* Pérès, 1959

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Aplousobranchia (Order);
- Pseudodistomidae (Family);
- *Pseudodistoma* (Genus);
- *Pseudodistoma obscurum* (Species)

It lives on hard bottoms (littoral rock, coralligenous, rhizomes of *Posidonia*, coastal detrital), between 0 and 40m depth (Ramos-Esplà, 1991). It is endemic to the Mediterranean (Chebbi, 2010; Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). It has been reported in the Gulf of Gabés by Ben Mustapha *et al.* (1999) and has been observed later by Ramos-Esplá *et al.* (2011). The main threats are Troll fishing, siltation, and habitat degradation (*Posidonia* meadows, coralligenous). It is the conservation of the *Posidonia* meadows that allows the development of *P. obscurum* since this is its preferred habitat.

2.3.5. *Eudistoma tridentatum* (Heiden, 1893)

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Aplousobranchia (Order);
- Polycitoridae (Family);
- *Eudistoma* (Genus);
- *Eudistoma tridentatum* (Species)

Eudistoma tridentatum is a Mediterranean endemic species of limited distribution. It is present mainly in the Western basin of the Mediterranean. In Tunisia, it has been observed in the North, in the archipelagos of Galite and Zembra (Chebbi, 2010). It has also been observed in Sfax and Kerkenna (Ramos-Esplá *et al.*, 2011).

2.3.6. *Eudistoma plumbeum* (Della Valle, 1877)

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Aplousobranchia (Order);
- Polycitoridae (Family);
- *Eudistoma* (Genus);
- *Eudistoma plumbeum* (Species)

As *Eudistoma tridentatum*, *E. plumbeum* is also a Mediterranean endemic species of limited distribution (Chebbi, 2010). It is present mainly in the Western basin of the Mediterranean. In Tunisia, it has been observed in the North, in the archipelagos of Galite and Zembra. It has also been observed in Sfax and Kerkenna (Ramos-Esplá *et al.*, 2011).

2.3.7. *Eudistoma mucosum* (Drasche, 1883)

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Aplousobranchia (Order);
- Polycitoridae (Family);
- *Eudistoma* (Genus);
- *Eudistoma mucosum* (Species)

As *Eudistoma tridentatum*, it is a Mediterranean endemic species of limited

distribution (Chebbi, 2010). It is present mainly in the Western basin of the Mediterranean. In Tunisia, it has been observed in the North, in the archipelagos of Galite and Zembra. It has also been observed in Sfax and Kerkenna (Ramos-Esplá *et al.*, 2011).

2.3.8. Aplidium conicum (Olivi, 1792)

- Chordata (Phylum);
- Tunicata (Subphylum);
- Ascidiacea (Class);
- Aplousobranchia (Order);
- Polyclinidae (Family);
- *Aplidium* (Genus);
- *Aplidium conicum* (Species)

It is a Mediterranean endemic species observed at 3-100m depth under the name *Amaroucium picardi*. It lives in photophilic algae in calm mode, sciaphilic algae in calm mode, *Posidonia* meadows/rhizomes, *Caulerpa prolifera* bottoms, coastal detrital and coastal terrigenous bottoms. Its distribution in the Mediterranean is large, it has been observed in Balearic Islands, Ceuta (Morocco), Girona, Tabarka Islands and Bay of Alicante (Spain), France, Italy, Tunisia (Kerkennah) (Ramos-Esplá *et al.*, 2011), Egypt, and ex Yugoslavia (Chebbi, 2010).

2.4. Cnidarians

2.4.1. Corallium rubrum (Linnaeus, 1758)

- Cnidaria (Phylum);
- Anthozoa (Class);
- Octocorallia (Subclass);
- Alcyonacea (Order);
- Scleraxonia (Suborder);
- Coralliidae (Family);
- *Corallium* (Genus);
- *Corallium rubrum* (Species)

This species is endemic to the Mediterranean, it was found mainly in the Western part and in the Adriatic. It is rare in the Eastern part (Aegean Sea). The colony is rigid and red, and the branches extend in all directions (Jaziri, 2017). This species of red corals lives on rocky substrates, slightly exposed to light, at shallow depth, and in caves up to 400m below sea level (Jaziri*et al*., 2016; Jaziri, 2017; Ghanem, 2018). Polyps of *C*. *rubrum* capture plankton preys with their tenticules and stingent cells (nematocystes) (Mojetta & Ghisotti, 1996). The species is mainly exploited in Algeria, France, Italy, Morocco, and Tunisia (North) by the jewelry industry. Its overexploitation caused locally disappearance of the species at shallow depths. Destructive fishing techniques have also contributed to its scarcity (Jaziri*et al*., 2016; Ghanem, 2018). Although the species is currently collected in Tunisia mainly by scuba diving and the deep colonies remain out of the reach of divers, the species suffers from diseases causing significant mortality (Jaziri, 2017; Ghanem, 2018).

2.4.2. Cladocora caespitosa (Linnaeus, 1767)

- Cnidaria (Phylum);
- Anthozoa (Class);
- Hexacorallia (Subclass);
- Scleractinia (Order);
- Scleractinia incertae sedis (Family);
- *Cladocora* (Genus);
- *Cladocora caespitosa* (Species)

It is a Mediterranean endemic species (Hattour & Ben Mustapha, 2015). However, in the prospected areas between 20 and 25m depth on the dead matte of *Posidonia*, both South-West of Kerkennah and West of Djerba, only the remains of dead colonies were observed as a testimony of the presence of this important species. It is recorded on *Posidonia oceanica* beds, *Cymodocea nodosa* and/or *Caulerpa prolifera* lawns, coastal detritus and silted detrital; between 11 and 80m depth (Ben Mustapha *et al.*, 1999, 2004). De Gaillande (1970) and Ramos-Esplá *et al.* (2011) reported *Cladocora coespitosa* as an accompanying species with no specific ecological significance. The presence of another species of *Cladocora* (*C. debilis*) sampled by the dredge in the South-East of Kerkennah, between 17 and 18m depth,

should be noted. As a Mediterranean species, reported from Southern Portugal and Agadir (Morocco), in the Gulf of Gabès, it seems to be common in bottoms spared from bottom trawling such as the South-East of Kerkennah at –14m; and in Kneiss, between 6–7m depth. It is threatened mainly by silting and Troll fishing.

2.4.3. Eunicella singularis (Esper, 1791)

- Cnidaria (Phylum);
- Anthozoa (Class);
- Octocorallia (Subclass);
- Alcyonacea (Order);
- Holaxonia (Suborder);
- Gorgoniidae (Family);
- *Eunicella* (Genus);
- *Eunicella singularis* (Species)

It colonizes coastal detritus, between 35 and 100m depth (Ben Mustapha *et al.*, 2004). It is an endemic species of the Mediterranean, mainly in the Western basin and the Adriatic (Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). It is much localized in the Gulf of Gabès, and considered uncommon in the coastal detritus (35–100m depth), while for Ben Mustapha *et al.* (2004), it is common in Fora Mostafa (Djerba-Tunisia), on thalli of maerl (40–55m). It is threatened mainly by silting and Troll fishing.

2.4.4. Leptogorgia sarmentosa (Esper, 1789)

- Cnidaria (Phylum);
- Anthozoa (Class);
- Octocorallia (Subclass);
- Alcyonacea (Order);
- Holaxonia (Suborder);
- Gorgoniidae (Family);
- *Leptogorgia* (Genus);
- *Leptogorgia sarmentosa* (Species)

It lives in the coastal detritus, between 35 and 100m depth. It is a Mediterranean endemic species (Ramos-Esplá *et al.*, 2011). Much localized in the Gulf of Gabès, it is considered uncommon in the coastal detritus (35–100m depth). Siltation and Trawl fishing are the main threats (Hattour & Ben Mustapha, 2015).

2.5. Polychaeta annelids

2.5.1. *Unanereis zghali* Ben Amor, 1980

- Annelida (Phylum);
- Polychaeta (Class);
- Errantia (Subclass);
- Phyllodocida (Order);
- Nereidiformia (Suborder);
- Nereididae (Family);
- Nereidinae (Subfamily);
- *Unanereis* (Genus);
- *Unanereis zghali* (Species)

This Meditarranean endemic species exists in Tunisia (Boudouresque, 1997). It has been observed in the Zembra Islands off Cap Bon region (Ben Amor, 1980).

2.6. Arthropods

2.6.1. *Pachylasma giganteum* (Philippi, 1836)

- Arthropoda (Phylum);
- Crustacea (Subphylum);
- Multicrustacea (Superclass);
- Thecostraca (Class);
- Cirripedia (Subclass);
- Thoracica (Infraclass);
- Thoracicacalcarea (Superorder);
- Balanomorpha (Order);
- Chthamaloidea (Superfamily);
- Pachylasmatidae (Family);
- Pachylasmatinae (Subfamily);
- *Pachylasma* (Genus);
- *Pachylasma giganteum* (Species)

It is a Mediterranean endemic species, known only in Sicily (Straits of Messina, Italy). Nevetheless, Darwin (1854) has also reported it from the shores of Great Britain and the Northern United States, with a larger average size than in Sicily. It is a small crustacean that lives in hard substrates at relatively great depths. It is rare and threatened by its restricted geographical distribution (Di Geronimo & Fredj, 1987). Hattour & Ben Mustapha

(2015) reported its presence in Tunisia, but they did not specify where it was observed.

2.7. Echinoderms

2.7.1. Asterina pancerii (Gasco, 1876)

- Echinodermata (Phylum);
- Asterozoa (Subphylum);
- Asteroidea (Class);
- Valvatacea (Superorder);
- Valvatida (Order);
- Asterinidae (Family);
- *Asterina* (Genus);
- *Asterina pancerii* (Species)

It is a Mediterranean endemic species observed in Italy, Spain, France, Greece, and Libya (Ramos-Esplá *et al.*, 2011). In Tunisia, Hattour & Ben Mustapha (2015) have reprted it in the Gulf of Gabès. It is a tiny starfish (10–20mm) that is red or green with white spots (Ramos-Esplá *et al.*, 2011). It is a small starfish living in the depth *Posidonia* meadows. The species is hermaphroditic, but does not self-breed, and reproduction occurs in the spring. Once abundant, it now appears to be in decline due to trawling in the *Posidonia* meadows leading to its recession. Thus, the species continues to decline along with *Posidonia* meadows, and its protection is therefore linked to them.

2.7.2. Ocnus syracusanus (Grube, 1840)

- Echinodermata (Phylum);
- Echinozoa (Subphylum);
- Holothuroidea (Class);
- Actinopoda (Subclass);
- Dendrochirotida (Order)
- Cucumariidae (Family);
- *Ocnus* (Genus);
- *Ocnus syracusanus* (Species)

This Mediterranean endemic species has been observed in the Gulf of Gabès (Ben Mustapha *et al.*, 1999; Ramos-Esplá *et al*., 2011; Hattour & Ben Mustapha, 2015). It lives in *Posidonia* meadows and detrital bottoms, from the surface up to 100m. In the Gulf of Gabès, it has been found on the seabed of *Posidonia*, on coarse and silted sediment, muddy sand, mud, silted coastal detrital, between 5 and 30m depth (Ben Mustapha *et al.*, 1999). Outside of Kerkennah, it was captured East of Djerba and El Bibane (Ben Mustapha *et al.*, 1999).

2.8. Mollusks

2.8.1. Pinna nobilis Linnaeus, 1758

- Mollusca (Phylum);
- Bivalvia (Class);
- Autobranchia (Subclass);
- Pteriomorphia (Infraclass);
- Ostreida (Order);
- Pinnoidea (Superfamily);
- Pinnidae (Family);
- *Pinna* (Genus);
- *Pinna nobilis* (Species)

It is a Mediterranean endemic species. Its length can reach 1m (Ramos-Esplá *et al.*, 2011). It lives half-buried in the infralittoral and sometimes even in the circalittoral, on soft bottoms, among the *Posidonia* meadows. It is a planktophagous filter feeder. Its reproduction is little known, except that the eggs are released in open water. Until the 19th century, the species was exploited in the Mediterranean for human consumption, the manufacture of silk from its byssus and buttons or jewelry from the mother-of-pearl of its shell (Peyran, 2021). Since then, the pressures on its populations have increased, in particular because of anthropogenic activities (anchoring of boats, pollution, reduction and fragmentation of its habitat). These pressures have contributed to the decline of *P. nobilis* populations (Öndes *et al*., 2020). To compensate for this decline, protection measures were undertaken and allowed the species to recover, sometimes even in highly anthropized habitats, such as ports and lagoons. Unfortunately, since October 2016, *P. nobilis* has suffered high mortality rates attributed to a parasitic protozoan, *Haplosporidium pinnae*, accidentally introduced into the Mediterranean in ballast waters it seems, and which mainly affects the digestive glands of the animal (Catanese *et al*.,

2018). In Tunisia, *P. nobilis* is present in all the coasts, mainly in shallow waters, including lagoons as those of Bizerte, Ghar El Melh, Boughrara and El-Biban, the Monastir Bay, the Islands of Kerkennah and Djerba, etc. (Rabaoui *et al*., 2009; 2010; Zakhama-Sraieb *et al*., 2011). The Tunisian populations have also suffered high mortalities which affected between 80% and 100% of its populations in the Mediterranean Sea (Jacquesson, 2020).

2.8.2. Patella ferruginea Gmelin, 1791

- Mollusca (Phylum);
- Gastropoda (Class);
- Patellogastropoda (Subclass);
- Patelloidea (Superfamily);
- Patellidae (Family);
- *Patella* (Genus);
- *Patella ferruginea* (Species)

This species is endemic to the Mediterranean, quite rare in the mediolittoral and infralittoral zones (Frenkiel, 1975; Ouannes-Ghorbel *et al*., 2009; Hattour & Ben Mustapha, 2015; Kallouche, 2018). *Patella ferruginea* is found in Western Mediterranean, on rock bands, solitary, periodically deviating from its location for trophic reasons. The breeding season is very short, two months at most, in late summer and autumn (Frenkiel, 1975; Hattour & Ben Mustapha, 2015).

2.8.3. Patella nigra da Costa, 1771

- Mollusca (Phylum);
- Gastropoda (Class);
- Patellogastropoda (Subclass);
- Patelloidea (Superfamily);
- Patellidae (Family);
- *Patella* (Genus);
- *Patella nigra* (Species)

This endemic species lives permanently at the Intertidal stage on the beaten and lit rocks where it constitutes dense populations. It is favored by its organization which allows it to withstand both wave shocks and desiccation (Kallouche, 2018). In Tunisia, it was observed in la Galite and Zembra islands. It has also observed in North Morocco and Algeria (Kallouche, 2018).

2.8.4. Dendropoma cristatum (Biondi-Giunti, 1859)

- Mollusca (Phylum);
- Gastropoda (Class);
- Caenogastropoda (Subclass);
- Littorinimorpha (Order);
- Vermetoidea (Superfamily);
- Vermetidae (Family);
- *Dendropoma* (Genus);
- *Dendropoma cristatum* (Species)

It is a Mediterranean endemic species described as *Dendropoma petraeum* (Monterosato, 1884) (Commission européenne, 2022), particularly in the warm waters of the coasts of North Africa, the Eastern Mediterranean, Southern Spain, Sicily, Malta, Corsica and Tunisia (Ingénierie de l'Hydraulique, de l'Equipement et de l'Environnement, 2016). Some isolated populations are limited in the Atlantic at the level of the Strait of Gibraltar (Hattour & Ben Mustapha, 2015). Species contributing to the formation of calcareous reef of biological origin, the sidewalks and ledges with Vermets are the product of the close association between a calcareous Corallinacea algae, a certain number of epilithic and endolithic forms (e.g *foraminifera*) and a Gastropod Vermetidae like *Dendropoma petraeum* often referred to in the literature as *Vermetus cristatus*. The species is not rare, its protection comes from the fact that to get it, divers have to break the limestone drop offs on which it lives, thus destroying all the neighboring species (Hattour & Ben Mustapha, 2015).

2.8.5. Steromphala nivosa (A. Adams, 1853)

- Mollusca (Phylum);
- Gastropoda (Class);
- Vetigastropoda (Subclass);
- Trochida (Order);

- Trochoidea (Superfamily);
- Trochidae (Family);
- Cantharidinae (Subfamily);
- *Gibbula* (Genus);
- *Gibbula nivosa* (Species)

This species is endemic to the Malta area. It was recorded as *Gibbula nivosa* A. Adams, 1853 (Hattour & Ben Mustapha, 2015). Other species of *Gibbula* are present in the Mediterranean, but with different pigmentations from those of *G. nivosa*. It lives exclusively under the tidal zone in shallow water of *Posidonia* meadows or hidden under rocks. It is a nocturnal species (collections are made between midnight and early morning) (Hattour & Ben Mustapha, 2015).

2.8.6. Spondylus gaederopus Linnaeus, 1758

- Mollusca (Phylum);
- Bivalvia (Class);
- Autobranchia (Subclass);
- Pteriomorphia (Infraclass);
- Pectinida (Order);
- Pectinoidea (Superfamily);
- Spondylidae (Family);
- *Spondylus* (Genus);
- *Spondylus gaederopus* (Species)

This species colonizes the mattes of *Posidonia*, the coastal detrital, between 10 and 80m depth (Ben Mustapha *et al.*, 1999), also on rock and small boulders. It is endemic to the Mediterranean, its distribution has reached Southern Portugal (Ramos-Esplá *et al.*, 2011; Hattour & Ben Mustapha, 2015). During surveys carried out in the Gulf of Gabès, some very eroded upper valves were collected by the large Trawl West of Djerba between 14 and 21m depth, on the dead matte of *Posidonia* and bottom of *Fulvia fragilis*. Moreover, Ben Mustapha *et al.* (1999) found it dead (empty shells) and very rare in a muddy sediment covering the dead mattes of *Posidonia*, with *Caulerpa prolifera* or on the rhizomes of a regressing seabeds. Empty *Spondylus* shells in Western Djerba were also observed (Ben Mustapha *et al.*, 1999).

2.8.7. Steromphala umbilicaris (Linnaeus, 1758)

- Mollusca (Phylum);
- Gastropoda (Class);
- Vetigastropoda (Subclass);
- Trochida (Order);
- Trochoidea (Superfamily);
- Trochidae (Family);
- Cantharidinae (Subfamily);
- *Steromphala* (Genus);
- *Steromphala umbilicaris* (Species)

This Mediterranean endemic species was observed in the Gulf of Gabès (Tunisia), at 1m depth in seaweeds of Sidi Yussef, Kerkennah (Boudouresque, 1997). It is frequently confused with other Trochidae, and it has been often decribed as *Gibbula umbilicaris* (Affenzeller *et al.*, 2017).

2.8.8. Gibbula ardens (Salis Marschlins, 1793)

- Mollusca (Phylum);
- Gastropoda (Class);
- Vetigastropoda (Subclass);
- Trochida (Order);
- Trochoidea (Superfamily);
- Trochidae (Family);
- Cantharidinae (Subfamily);
- *Gibbula* (Genus);
- *Gibbula ardens* (Species)

This Mediterranean endemic species was observed in Tunisia (Boudouresque, 1997). Aloui-Béjaoui & Afli (2012) and Cheour *et al.* (2014) have observed it in the port area and around the Kerkennah islands (Tunisia). It is frequently confused with other Mollusc Trochidae, and it has been often decribed as *Gibbula barbata* (Affenzeller *et al.*, 2017).

2.8.9. Jujubinus unidentatus (Philippi, 1844)

- Mollusca (Phylum);
- Gastropoda (Class);
- Vetigastropoda (Subclass);
- Trochida (Order);
- Trochoidea (Superfamily);
- Trochidae (Family);

- Cantharidinae (Subfamily);
- *Jujubinus* (Genus);
- *Jujubinus unidentatus* (Species)

This Mediterranean endemic species has been observed in the upper infralittoral at 1m depth, in *Posidonia* meadow of the Gulf of Gabès, mainly in Kerkennah and Djerba Islands (Boudouresque, 1997).

2.8.10. Columbella rustica (Linnaeus, 1758)

- Mollusca (Phylum);
- Gastropoda (Class);
- Caenogastropoda (Subclass);
- Neogastropoda (Order);
- Buccinoidea (Superfamily);
- Columbellidae (Family);
- *Columbella* (Genus);
- *Columbella rustica* (Species)

This Mediterranean endemic species was observed in Tunisia, along the Tunisian Eastern coasts and in the Gulf of Gabès, mainly around the Kerkennah Islands (Boudouresque, 1997; Ouannes-Ghorbel *et al*., 2009; Torchia *et al*., 2016).

2.9. Pisces

Ben Rais Lassram (2009) studied the ichthyological diversity in the Mediterannean and focused on endemic fishes in the Mediterranean and in Tunisia. A synthesis of the results of this study and other studies published before and thereafter (Capapé, 1986; Stehmann & Bürkel, 1986; Fredj & Maurin, 1987; Fischer *et al.*, 1987; Ben Rais Lasram *et al*., 2009a, b, 2010a, 2010b; Ramos-Esplá *et al.*, 2011) was elaborate in this work. According to Bradaï (2000) and Bradaï *et al.* (2012), 23 endemic fish species were identified in Tunisia, which represent 18% of the total ichthyological fauna.

2.9.1. Raja (Raja) asterias Delaroche, 1809

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Elasmobranchii (Class);
- Neoselachii (Subclass);
- Batoidea (Infraclass);
- Rajiformes (Order);
- Rajidae (Family);
- *Raja* (Genus);
- *Raja asterias* (Species)

It is a Mediterranean endemic species, known in both basins of this sea and in the Adriatic. On the East Atlantic coasts, it is reported in Southern Portugal and Northern Morocco (Fischer *et al.*, 1987). This species is predominantly Mediterranean, it expanded until the 1990s Westwards from Gibraltar, off the Tunisian-Algerian border and in the gulfs of Tunis, Hammamet and Gabès (Vinciguerra, 1884; Le Danois, 1925; Lubet & Azouz, 1969; Capapé, 1989). Since then, the species has become increasingly rare, and is currently no longer observed in the South of Tunisia (Enajjar *et al*., 2023).

2.9.2. Raja radula Delaroche, 1809

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Elasmobranchii (Class);
- Neoselachii (Subclass);
- Batoidea (Infraclass);
- Rajiformes (Order);
- Rajidae (Family);
- *Raja* (Genus);
- *Raja radula* (Species)

It is an endemic species, known in the two basins of the Mediterranean, and in the Adriatic. In the Atlantic, it has been accurately reported in Northern Morocco. However, Capapé (1989) considers it as a Mediterranean endemic species. In Tunisia, it has been observed along the entire coasts (Le Danois, 1925; Lubet & Azouz, 1969; Enajjar *et al*., 2023).

2.9.3. Raja polystigma Regan, 1923

- Chordata (Phylum);

- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Elasmobranchii (Class);
- Neoselachii (Subclass);
- Batoidea (Infraclass);
- Rajiformes (Order);
- Rajidae (Family);
- *Raja* (Genus);
- *Raja polystigma* (Species)

It is a Mediterranean endemic species, known in its Western and Eastern basins and in the Adriatic. In the Eastern basin, its presence is practically limited to the Tunisian, Libyan and Greek coasts. In Tunisia, it is reported along the entire coasts (Bradaï, 2000; Enajjar *et al*., 2023).

2.9.4. Leucoraja melitensis (Clark, 1926)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Elasmobranchii (Class);
- Neoselachii (Subclass);
- Batoidea (Infraclass);
- Rajiformes (Order);
- Rajidae (Family);
- *Raja* (Genus);
- *Leucoraja melitensis* (Species)

It is a Mediterranean endemic species, known both in the Western and the Eastern basins. It is recorded several times along the Tunisian, Libyan and Maltese coasts. But, it is rare in Algeria, and only one capture has been reported from Southern Italy (Bradaï, 2000; Enajjar *et al*., 2023).

2.9.5. Salaria basilisca (Valenciennes, 1836)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Blennioidei (Suborder);
- Blenniidae (Family);
- Salariinae (Subfamily);
- *Salaria* (Genus);
- *Salaria basilisca* (Species)

It is a Mediterranean endemic species, reported in the Eastern and Western basins of this sea and in the Adriatic. However, records of this species are apparently following isolated captures (Bradai, 2000). In Tunisia, it is recorded in the center of the country under the synonym *Blennius basiliscus* (Pruvot, 1921). It has also been reported in the center and the South (Gulf of Gabès) (Gharred *et al*., 1998; Bradaï, 2000).

2.9.6. Microlipophrys dalmatinus (Steindachner & Kolombatovic, 1883)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Blennioidei (Suborder);
- Blenniidae (Family);
- Salariinae (Subfamily);
- *Lipophrys* (Genus);
- *Lipophrys dalmatinus* (Species)

It is a Mediterranean endemic species, reported in the Eastern and Western basins of this sea and in the Adriatic. However, it is mentioned in the Mediterranean following isolated captures. It should be noted that it has been observed in the Eastern Mediterranean. In Tunisia, this species has been reported from Mahdia, La Goulette, and Bizerte for the first time (Gharred *et al*., 1998; Bradaï, 2000; Bradaï *et al*., 2004).

2.9.7. Aidablennius sphinx (Valenciennes, 1836*)*

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Blennioidei (Suborder),

- Blenniidae (Family);
- Salariinae (Subfamily);
- *Aidablennius* (Genus);
- *Aidablennius sphynx* (Species)

It was reported in the Eastern and Western basins of the Mediterranean, and in the Adriatic and black Seas, and it is considered endemic to the Mediterranean (Fredj & Maurin, 1987). The species occurs also in the Atlantic coasts of Morocco (Zander, 1986). It is not then a strict endemic (Bradaï, 2000; Bradaï *et al*., 2004). It is recorded in Northern and central of Tunisia (Gharred *et al*., 1998; Gharred, 1999).

2.9.8. Echiodon dentatus (Cuvier, 1829)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Ophidiiformes (Order);
- Carapidae (Family);
- Carapinae (Subfamily);
- *Echiodon* (Genus);
- *Echiodon dentatus* (Species)

It is a Mediterranean endemic species, reported in the Eastern and Western basins of this sea and in the Adriatic and black Seas (Fredj & Maurin, 1987). However, according to Trott & Olney (1986), its distribution would extend from Gibraltar to Greek and Libyan waters. In 1996, it has been recorded in the Eastern Levantine basin. On the Eastern Atlantic coasts, a mention in Moroccan waters has been reported. For Tunisia, only one record from 100 years ago is known on Northern and central coasts (Le Danois, 1925*in* Bradaï, 2000).

2.9.9. Aphanius fasciatus (Valenciennes, 1821)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Cyprinodontiformes (Order);
- Cyprinodontidae (Family);
- Cyprinodontinae (Subfamily);
- *Aphanius* (Genus);
- *Aphanius fasciatus* (Species)

It is a Mediterranean endemic species, living in the two basins of this sea and in the Adriatic. However, it is absent from the Western basin of Morocco, Western Algerian, Spanish and French coasts. Corsica and the Northern Adriatic represent the Northern distribution limits of the species. In Tunisia, *Aphanius fasciatus* has been reported in the North (Northern lagoon of Tunis or "Lac de Tunis"), in the center (Khénis) and in the South (Sfax and Sidi Mansour), where Bradaï (2000) observed it in abundance in a few centimeters of water, and previously in the Skhira and in the oasis of Chénini, the only oasis whose irrigation canals are connected to the sea by the Wadi Gabès. But its abundance is decreasing probably because of pollution.

2.9.10. Trisopterus capelanus (Lacepède, 1800)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Gadiformes (Order);
- Gadidae (Family);
- *Trisopterus* (Genus);
- *Trisopterus minutus* (Species);
- *Trisopterus capelanus* (Subspecies)

This species, with a cold-affinity, is endemic to the Mediterranean, and is present in its Western and Eastern basins and in the Adriatic. On the South shore, *T. capelanus* is present in Algeria, in the North of Tunisia and on the coasts of Eastern Mediterranean countries. In Tunisia, it has been reported in the Gulf of Gabès and in the Northern coasts (Le Danois, 1925; Lubet & Azouz, 1969; Bradaï, 2000).

2.9.11 Gobius geniporus Valenciennes, 1837

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order)
- Gobioidei (Suborder);
- Gobiidae (Family);
- Gobiinae (Subfamily);
- *Gobius* (Genus);
- *Gobius geniporus* (Species)

This species is endemic to the Mediterranean. It is recorded in the Eastern basin as well as in the Western basin and in the Adriatic. On the North shore, it is mentioned in the Aegean Sea, Adriatic Sea, Tyrrhenian Sea, around Sicily and in Corso-Liguro-Provençal Sea. Thereafter, it has been reported in Eastern Levantine (Bradaï, 2000). In Tunisia, it has been mentioned in the region of the Gulf of Gabès (Bradai *et al*., 2004).

2.9.12. Zosterisessor ophiocephalus (Pallas, 1814)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Gobioidei (Suborder);
- Gobiidae (Family);
- Gobiinae (Subfamily);
- *Zosterisessor* (Genus);
- *ophiocephalus* (Species)

It is a Mediterranean endemic species with warm-affinity. Its mention in this sea was made following isolated captures. It has been reported on all Tunisian coasts (under the name *Gobius ophiocephalus*), and also in the lake of Ichkeul (Bradaï, 2000; Bradai *et al*., 2004).

2.9.13. Pomatoschistus tortonesei Miller, 1969

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Gobioidei (Suborder);
- Gobiidae (Family);
- Gobiinae (Subfamily);
- *Pomatoschistus* (Genus);
- *Pomatoschistus tortonesei* (Species)

This species is endemic to the Mediterranean, it is known in its two basins. However, it is only mentioned following two isolated captures in Western Sicily (Marsala) and in the lagoon of Farwah (Western Libya) (Bradaï, 2000; Mejri *et al*., 2009a, b). It was observed for the first time in Tunisia, in the lagoons of Ghar El Melh, Tunis and El Bibène (Bradaï, 2000; Mejri *et al*., 2009a, b).

2.9.14. Zebrus zebrus (Risso, 1827)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Gobioidei (Suborder);
- Gobiidae (Family);
- Gobiinae (Subfamily);
- *Zebrus* (Genus);
- *Zebrus zebrus* (Species)

It is endemic to the Mediterranean, it is known in its two basins and in the Adriatic. It has been reported only on the Northern shore of the Mediterranean following isolated captures. It is generally occasional there. However, it was observed later in Southwestern Spain and in Eastern Levantine (Bradaï, 2000). In Tunisia, it was fished in Salakta, Sfax and in the lagoons of Bizerte and El Bibène (Bradaï, 2000; Mejri *et al*., 2009a, b).

2.9.15. Symphodus rostratus (Bloch, 1791)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Labroidei (Suborder);
- Labridae (Family);
- *Symphodus* (Genus);
- *Symphodus rostratus* (Species)

It is a Mediterranean endemic species. It is known in the two basins of the Mediterranean, in the Adriatic and in the Black Sea. This species is recorded also in the the Gulf of Gabès (Bradaï, 2000).

2.9.16. Symphodus ocellatus (Linnaeus, 1758) (Symphodus (Crenilabrus) ocellatus Forsskal, 1775)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Labroidei (Suborder);
- Labridae (Family);
- *Symphodus* (Genus);
- *Symphodus ocellatus* (Species)

This warm-affinity species is endemic to the Mediterranean. It has been observed in the Eastern and Western basins, in the Adriatic and in the Black Sea. It has been reported also in the Gulf of Gabès and in the North of Tunisia (Lubet & Azouz, 1969; Bradaï, 2000; Bradaï *et al*., 2004; Torchia *et al*., 2016).

2.9.17. Symphodus doderleini Jordan, 1890

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Labroidei (Suborder);
- Labridae (Family);
- *Symphodus* (Genus);
- *Symphodus doderleini* (Species)

This species, warm-affinity, is endemic to the Mediterranean. It is known in the Western basin (except the Gulf of Lion), in the Eastern basin, and in the Adriatic (Bradaï, 2000). In Tunisia, it is reported in the Gulf of Gabès (Ben Othmen, 1973; Bradaï, 2000).

2.9.18. Hyporthodus haifensis (Ben-Tuvia, 1953)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Percoidei (Suborder);
- Serranidae (Family);
- Epinephelinae (Subfamily);
- *Epinephelus* (Genus);
- *Hyporthodushaifensis* (Species)

This is a Mediterranean endemic species, known on the coasts of Palestine, Lebanon and Morocco (recorded as *Epinephelus haifensis)*. In June 1998, it was observed in Zarzis coming from Libya. Then in July of the same year, a specimen was observed in Sfax whose provenance is unknown. In July 2000, six specimens were caught by longliners from Zarzis (Bradaï, 2000; Bradaï *et al*., 2004).

2.9.19. Solea egyptiaca Chabanaud, 1927

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Pleuronectiformes (Order);
- Soleidae (Family);
- *Solea* (Genus);
- *Solea aegyptiaca* (Species)

This species is endemic to the Mediterranean. It is known in its Eastern basin and in the Adriatic. However, it is

present in the Eastern Mediterranean, from the East coast of Tunisia to the East countries. It has been reported in the Languedoc lagoons (France). This species seems to have crossed the Suez Canal in 1899 and currently lives in the Red Sea (Khalifa *et al*., 2019). It has long been considered a subspecies of *Solea vulgaris*. Genetic studies have shown that these are two valid species. It is often confused with *S. vulgaris* which is similar in morphology and color to *S. aegyptiaca*. In Tunisia, it was mentioned in the South-East of Tunisia, in the Gulf of Tunis and in the Lake of Ichkeul and, consequently, in the marine area of Bizerte because it reproduces at sea and comes to feed in the lake (Bradaï, 2000; Khalifa *et al*., 2019).

2.9.20. Synapturichthys kleinii (Risso, 1827)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Pleuronectiformes (Order);
- Soleidae (Family);
- *Solea* (Genus);
- *Synapturichthys kleinii* (Species)

This species is endemic to the Mediterranean. It is known in the Western and Eastern basins, and in the Adriatic. It has been recorded also near the Atlantic. It is therefore an Atlanto-Mediterranean species with a warm-affinity. Its distribution in the Mediterranean should be extended to the Eastern Levantine where it has been recorded (Bradaï, 2000). On the East Atlantic coasts, it is known mainly along West Africa. It has been reported in Tunisia, in the Gulf of Gabès where it has been regularly observed (Bradaï, 2000; Bouain *et al*., 2018).

2.9.21. Diplodus sargus (Linnaeus, 1758)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Percoidei (Suborder);
- Sparidae (Family);
- *Diplodus* (Genus);
- *Diplodus sargus* (Species)

It is a Mediterranean endemic species, known in the two basins of the Mediterranean and in the Adriatic. It has also been observed in the Black Sea. This species is found in Southern Tunisia (Le Danois, 1925; Bradaï *et al*., 2004), in the center (Le Danois, 1925) and the North (Lubet & Azouz, 1969; Bradaï *et al*., 2004).

2.9.22. Tripterygion tripteronotum (Risso, 1810)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Perciformes (Order);
- Blennioidei (Suborder);
- Tripterygiidae (Family);
- Tripterygiinae (Subfamily);
- *Tripterygion* (Genus);
- *Tripterygion tripteronotum* (Species)

This pecies is endemic to the Mediterranean, known in both basins, in the Adriatic and in the Black Sea. It has also been observed in the Eastern Levantine (Bradaï, 2000). It was observed for the first time in Tunisia, on the Eastern coasts (Gharred, 1999; Bradaï, 2000).

2.9.23. Dasyatis tortonesei Capapé, 1975

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Elasmobranchii (Class);
- Neoselachii (Subclass);
- Batoidea (Infraclass);
- Myliobatiformes (Order);
- Dasyatidae (Family);
- *Dasyatis* (Genus);

- *Dasyatis tortonesei* (Species)

This Mediterranean endemic species exists in Tunisia. It lives along the Tunisian littoral in *Posidonia* meadows and seagrass beds, and in sandy/sandy-muddy bottoms up 100m depth. It is frequently observed in wadis mouths and in the Gulf of Gabès (Capapé, 1978; Bradaï, 2000; Saadaoui *et al*., 2016; Enajjar *et al*., 2023).

2.9.24. Zu cristatus (Bonelli, 1819)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Lampriformes (Order);
- Trachipteridae (Family);
- *Zu* (Genus);
- *Zu cristatus* (Species)

This species has been observed in Tunisia under the name *Trachypterus cristatus*. It is an Atlanto-Mediterranean endemic species with warm affinity. It is frequently observed in the North of Tunisia (Postel, 1955; Baradaï *et al.*, 2004, 2012; Bradai & El Ouaer, 2012).

2.9.25. Trachipterus trachypterus (Gmelin, 1789)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Pisces (Superclass);
- Actinopterygii (Class);
- Lampriformes (Order);
- Trachipteridae (Family);
- *Trachipterus* (Genus);
- *Trachipterus trachypterus* (Species)

This species has been observed in Tunisia under the name *Trachypterus taenia*. It is an Atlanto-Mediterranean endemic species, frequently observed in *the Gulf of Gabès (Postel, 1955).*

2.10. Aves

2.10.1. Larus audouinii Payraudeau, 1826

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Infraphylum);
- Tetrapoda (Megaclass);
- Reptilia (Superclass);
- Aves (Class);
- Charadriiformes (Order);
- Laridae (Family);
- *Larus* (Genus);
- *Larus audouinii* (Species)

The Audouin's gull *Larus audouinii* is a Mediterranean endemic species. It is present mainly in the western part of the Mediterranean basin, particularly in Spain where 82% of the global population, estimated at 19,000 pairs in 1998, is present (Abdulla, 2008; Tranchant *et al*., 2008; UNEP/MAP-RAC/SPA, 2009).

In Tunisia, the *Larus audouinii* only seems to breed in significant numbers on the Galite archipelago (Northern Tunisia), which is therefore of extreme importance in terms of conservation of the species at the national level (Tranchant *et al*., 2008). Discards generated by trawling constitute the main source of food for this species and several other seabirds. They are therefore threatened by interactions with trawlers (Belda & Sánchez, 2001; UNEP/MAP-RAC/SPA, 2009; Benmessaoud *et al*., 2018).

2.10.2. Ichthyaetus melanocephalus (Temminck, 1820)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Infraphylum);
- Tetrapoda (Megaclass);
- Reptilia (Superclass);
- Aves (Class);
- Charadriiformes (Order);
- Laridae (Family);
- *Larus* (Genus);
- *Ichthyaetus melanocephalus* (Species)

The Mediterranean endemic gull *Ichthyaetus melanocephalus* is present in the Mediterranean and in Tunisia, and was reported as Larus *melanocephalus* (UNEP/MAP-RAC/SPA, 2009). As *Larus*

audouinii, it is threatened by interactions with trawlers (Belda & Sánchez, 2001; Cooper *et al*., 2003; Benmessaoud *et al*., 2018).

2.10.3. Puffinus yelkouan (Acerbi, 1827)

- Chordata (Phylum);
- Vertebrata (Subphylum);
- Gnathostomata (Superclass);
- Tetrapoda (Superclass);
- Aves (Class);
- Procellariiformes (Order);
- Procellariidae (Family);
- *Puffinus* (Genus);
- *Puffinus yelkouan* (Species)

It is a Mediterranean endemic species with two clearly defined subspecies: *Puffinus y. mauritanicus* breeding in the Balearic Islands, and *Puffinus y. Yelkouan* in the Tyrrhenian, Adriatic, and Aegean seas (Bourgeois & Vidal, 2008). It is a strictly pelagic species that breeds on islands and rocky islets. Nocturnal, it nests in burrows, crevices or under rocks. Its existence in Tunisia is unlikely (UNEP/MAP-RAC/SPA, 2009).

3. Conclusions

Extinction of vegetal/animal species is not a new phenomenon. Naturally, species go extinct all the time due to the limited duration of their biological existence. Scientists estimate that at least 99.9% of all species of plants and animals, terrestrial and aquatic that lived on the Earth since the appearance of life are now extinct (Ceballos *et al*., 2010). Nevetheless, in parallel to these continuous natural extinctions, the Earth has historically experienced five great waves of extinction of species since the appearance of life on Earth (Hughes *et al*., 1997). Currently, we are witnessing the 6th great wave of species extinction, which differs from the previous ones on two essential points; (1) it is due to polluting human activities, and (2) it is relatively too rapid. Indeed, the five previous great waves of extinction extend each over millions of years, even hundreds of millions of years, and have caused each the extinction of 75-96% of species. However, the current wave is counted in decades/years only, and although it has until now caused the extinction of only 20-25% of species so far, it is considered more devastating because it is too rapid (Ceballos *et al*., 2010).

In Tunisia, studies on endemic marine species are rare and fragmentary. To date, there is no complete inventory of endemic marine species in Tunisia, and even less on their status, geographic distribution and nuisance factors. Endemic species have an important role in the ecosystem and are an invaluable heritage wealth. In this work, we have inventoried on the basis of the available bibliography 60 fauna endemic species in Tunisia, distibuted into 25 pisces, 10 mollusks, 8 ascidians, 5 sponges, 4 cnidarians, 3 aves, 2 bryozoans and only one species for each group of polychaetes, arthropods and echinoderms. Therefore, the list of endemic species given in this work is not exhaustive, and certainly the number is significantly higher. Moreover, establishing a more exhaustive list of endemic species requires several marine prospecting surveys with appropriate observation means. This was carried out for only certain commercial interest groups; the other groups are little studied. This means that this list cannot reflect either the exact number of endemic species in each group or their status; e.g., endemic fish are more represented in the list, because they have been relatively more studied with more frequent and more intense sampling efforts. On the other hand, the species listed in this inventory were reported in different periods, ranging from several decades to recently, and some species not observed for a few decades may have disappeared or become very rare or have been the subject of systematic identification errors. Although this is a non-exhaustive inventory of endemic marine fauna species in Tunisia, this work presents a first list of the main species that

can be continually revised and updated, in particular with future studies.

Several factors affect biodiversity and endemic species in Tunisian waters, and most often act concurrently. These include climate change, water acidification, urban and industrial discharges, excessive fishing, aquaculture, tourism, and biological invasions (Krakimel, 2003; Lootvoet*et al*., 2010; Ounifi-Ben Amor *et al.*, 2016). In Tunisia, economic activities (tourism, industry, trade, port activities, etc.) and urban agglomerations are concentrated in the coastal zone, and the pollutants generated by these coastal activities end up, sooner or later, diversifying into the sea.

Among the means/instruments of conserving marine species and ecosystems, the creation of marine and coastal protected areas (MCPA) is considered among the most effective. Tunisia has made great efforts in this direction and has created 12 MCPAs, 4 of which are ongoing. However, with biological invasions these MCPAs can become concentration areas for invasive species such as blue crabs *Portunus segnis* (Forskål, 1775) and *Callinectes sapidus* Rathbun, 1896 which are caught outside these MCPAs and marketed. It is therefore necessary to study the impact of invasive species on the ecosystem and native species in these MCPAs and to find ways to limit their invasion, such as allowing certain types of selective and non-destructive fishing in these protected areas that target only the invasive species.

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