Distribution of the Mediterranean ribbed limpet 
*Patella ferruginea* Gmelin, 1791 along the Ligurian 
coast and implications for conservation actions

FERRANTI MARIA PAOLA
DIStAV, Department for Earth, Environment and Life 
Sciences, University of Genoa – Corso Europa 26 – 
16132 Genoa

MONTEGGIA DAVIDE
DIStAV, Department for Earth, Environment and Life 
Sciences, University of Genoa – Corso Europa 26 – 
16132 Genoa

ASNAGHI VALENTINA
DIStAV, Department for Earth, Environment and Life 
Sciences, University of Genoa – Corso Europa 26 – 
16132 Genoa

DAGNINO ALESSANDRO
ARPaL, Regional Agency for the Environmental Protection 
Liguria – Via Bombrini 8 – 16149 Genoa

GAINO FEDERICO
ARPaL, Regional Agency for the Environmental Protection 
Liguria – Via Bombrini 8 – 16149 Genoa

MORETTO PAOLO
ARPaL, Regional Agency for the Environmental Protection 
Liguria – Via Bombrini 8 – 16149 Genoa

PARODI VERONICA
ARPaL, Regional Agency for the Environmental Protection 
Liguria – Via Bombrini 8 – 16149 Genoa

TIXI LUCA
Outdoor Portofino – Via Duca degli Abruzzi 62 – 16034 
Portofino (Genova)

CAPPANERA VALENTINA
Portofino Marine Protected 
Area – Viale Rainusso 1 – 
16038 S. Margherita Ligure 
(Ge)

VALERANI CLAUDIO
Cinque Terre Marine 
Protected Area – Via Discovolo snc – 19017 
Riomaggiore (Spezia)

BAVA SIMONE
Bergeggi Marine Protected
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Distribution of the Mediterranean ribbed limpet, *Patella ferruginea* Gmelin, 1791, along the Ligurian coast and the potential of these findings for conservation actions

Maria Paola FERRANTI1, Davide MONTEGGIA1, Valentina ASNAGHI1, Alessandro DAGNINO2, Federico GAINO3, Paolo MORETTO4, Veronica PARODI2, Luca TIXI2, Valentina CAPPANERA4, Claudio VALERANI5, Simone BAVA6 and Mariachiara CHIANTORE1

1 DiSTAV, Department for Earth, Environment and Life Sciences, University of Genoa, Corso Europa 26, 16132 Genoa, Italy
2 ARPAL, Regional Agency for the Environmental Protection Liguria, Via Bombonri 8, 16149 Genoa, Italy
3 Outdoor Portofino, Via Duca degli Abruzzi 62, 16034 Portofino (Ge), Italy
4 Portofino Marine Protected Area, Viale Rainusso 1, 16038 S. Margherita Ligure (Ge), Italy
5 Cinque Terre Marine Protected Area, Via Discovolo snc, 19017 Riomaggiore (Sp), Italy
6 Bergeggi Marine Protected Area, Via A. De Mari 28d, 17028 Bergeggi (Sv), Italy

Corresponding author: mariapaola.ferranti@edu.unige.it

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**Abstract**

*Patella ferruginea* is a limpet endemic to the Western Mediterranean Sea. It is presently considered the most threatened marine macroinvertebrate in the region and has been included in several international conservation directives. Its populations were widespread throughout the Western Mediterranean in the late Pleistocene period, and remained broadly distributed until the 19th century. Presently this species is confined into small populations in a few restricted areas due to human harvesting for food and baits, construction of coastal infrastructures and the effects of seawater pollution. In particular, the species is reported as presently disappeared from the whole of the Italian continental coast and measures are in progress to reintroduce the species through translocation and reproduction in controlled conditions along the Ligurian coasts of the Northwestern Mediterranean.

Recent surveys implemented in the framework of the present work along the Ligurian coasts, to assess the most suitable sites for reintroduction, resulted in the discovery of 32 specimens of this endemic limpet, which previously was thought to have vanished from the area. These findings shed new light on the ability of species to naturally disperse, the relevance of the measures set in place to restore presently rarefied populations and may provide information to aid in the selection and management of sites within the Natura 2000 Ecological network.

**Keywords:** *Patella ferruginea*; distribution; Ligurian Sea; conservation.

**Introduction**

The Mediterranean ribbed limpet, *Patella ferruginea* Gmelin, 1791, is an endemic species of the Western Mediterranean Sea, presently considered the most threatened marine macroinvertebrate in the region (Ramos, 1998). It is included in the list of the strictly protected species in Annex IV of the CEE Habitat Directive 92/43. It is also recognized as an endangered or threatened species through international conventions including the Berna Convention-Annex II and the Barcelona Convention-Annex II. Finally, the status of *P. ferruginea* is recognized by individual countries, and as such, it has been categorized in the Spanish Catalog of Endangered Species as “in danger of extinction”, is protected by law in France through the decree of 26 November 1992 and under the Italian Marine Strategy framework (D.lgs. n. 190, 13th October 2010) if was recently proposed that *P. ferruginea* be a target species used to define the “Good Environmental Status” of a specific location.

*P. ferruginea* populations were widespread throughout the Western Mediterranean in the late Pleistocene (Tyrrenian period) era and primarily maintained this range until the 19th century (Laborel-Deguen & Laborel, 1991a). Presently, they are confined into small populations in few restricted areas (Doneddu & Manunza, 1992; Guerra-Garcia et al., 2004; Bava, 2009; Espinosa et al., 2009; Table 1) due to human harvesting for food and baits, construction of coastal infrastructures and seawater pollution. The species is easily accessible to humans since it generally resides in the high mid-littoral zone, but can also be found in the supra-littoral (Paracuellos et al.,...
Table 1. Density of *P. ferruginea* in localities along the Mediterranean coast in which the species persists. *only adults (>30 mm) were identified.

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
<th>Mean density</th>
<th>Assessment method</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>National Park of Al Hoceima (Cala Iris Islet)</td>
<td>0.23 ind/m</td>
<td>Whole stretch of coast</td>
<td>Bazairi et al., 2004</td>
</tr>
<tr>
<td>Algeria</td>
<td>Rachgoun Island</td>
<td>3–10 ind/m²</td>
<td>Transects (20 m)</td>
<td>Taibi et al., 2013</td>
</tr>
<tr>
<td>Algeria</td>
<td>Habibas Islands</td>
<td>4.8 ind/m</td>
<td>12 Transsects (10 m)</td>
<td>Espinosa, 2009</td>
</tr>
<tr>
<td>Tunisia</td>
<td>Zembra &amp; Zembretta Islands</td>
<td>0.1–8.5 ind/m</td>
<td>30 Transsects (10 m)</td>
<td>Zarrouk et al., 2016</td>
</tr>
<tr>
<td>Tunisia</td>
<td>North-East Tunisian coast</td>
<td>0.025–4.5 ind/m²</td>
<td>Stretches of different length</td>
<td>Tlig-Zouari et al., 2010</td>
</tr>
<tr>
<td>Spain (North Africa)</td>
<td>Ceuta</td>
<td>2.34 ind/m</td>
<td>170 Transects (10 m)</td>
<td>Rivera-Ingraham et al., 2011</td>
</tr>
<tr>
<td>Spain</td>
<td>Alboran Island</td>
<td>0.42 ind/m</td>
<td>Whole stretch of coast</td>
<td>CMA-JA 2014</td>
</tr>
<tr>
<td>Spain (North Africa)</td>
<td>Melilla</td>
<td>2.8 ind/m*</td>
<td>Whole stretch of coast</td>
<td>Guallart et al., 2013</td>
</tr>
<tr>
<td>Spain (North Africa)</td>
<td>Chafarinas Islands</td>
<td>4.82 ind/m*</td>
<td>Whole stretch of coast</td>
<td>Guallart &amp; Templado, 2016</td>
</tr>
<tr>
<td>Spain (North Africa)</td>
<td>Peñón de Vélez de la Gomera</td>
<td>0.13 ind/m*</td>
<td>Whole stretch of coast</td>
<td>Orozco et al., 2013</td>
</tr>
<tr>
<td>Spain</td>
<td>Algeciras Bay</td>
<td>0.07 ind/m</td>
<td>Whole stretch of coast</td>
<td>Espinosa et al., 2005</td>
</tr>
<tr>
<td>France</td>
<td>Marine Park of Scandola and surroundings (Corsica)</td>
<td>0.79 ind/m</td>
<td>146 Transects (10m)</td>
<td>Laborel-Deguen and Laborel 1991a</td>
</tr>
<tr>
<td>France</td>
<td>Cap Corse/Bastia harbour (Corsica)</td>
<td>0.2 ind/m²</td>
<td>-</td>
<td>Vela et al., 2007</td>
</tr>
<tr>
<td>Italy</td>
<td>Maddalena Archipelago (Sardinia)</td>
<td>0.028 ind/m</td>
<td>73 Sectors (425m)</td>
<td>Cosua et al., 2006</td>
</tr>
<tr>
<td>Italy</td>
<td>Ceraso Cape (Sardinia)</td>
<td>0.12 ind/m</td>
<td>Stretches of different length</td>
<td>Cristo and Caronni 2008</td>
</tr>
<tr>
<td>Italy</td>
<td>Gulf of Olbia (Sardinia)</td>
<td>0.023 ind/m</td>
<td>Whole stretch of coast</td>
<td>Cristo et al., 2007</td>
</tr>
<tr>
<td>Italy</td>
<td>Sinis Peninsula MPA (Sardinia)</td>
<td>0.02 ind/m</td>
<td>Stretches of different length</td>
<td>Coppa et al., 2012</td>
</tr>
<tr>
<td>Italy</td>
<td>Ligurian coasts</td>
<td>0.005 ind/m*</td>
<td>Stretches of different length</td>
<td>Present study</td>
</tr>
</tbody>
</table>

2003; Guerra-García et al., 2004; Casu et al., 2006), and the low mid-littoral (Casu et al., 2004). Espinosa et al. (2014) and Luque et al. (2018) provided an exhaustive review of its recent overall Mediterranean distribution. Today, populations of different size are reported along the coasts of Maghreb (Fguiri et al., 2007; Tlig-Zouari et al., 2010; Bazairi et al., 2012; Taibi et al., 2013, among others), in the Strait of Gibraltar (Espinosa et al., 2009), along Alboran Island (Paracuellos et al., 2003) and in the south of Spain (Espinosa et al., 2005; Moreno & Arroyo, 2008; Guallart & Templado, 2012; CMA-JA, 2014). Conspicuous populations of some thousands of specimens are presently found along the North African coasts, such as those identified in Ceuta (Rivera-Ingraham et al., 2011), Melilla (Guallart et al., 2013), the Chafarinas Islands (Guallart & Templado, 2016), Cala Iris Islet, National Park of Al Hoceima, Morocco (Bazairi et al., 2004), Peñón de Vélez de la Gomera (Orozco et al., 2013), the Habibas Islands (Espinosa, 2009; Boumaza & Semroud, 2001), and Zembra Island (Espinosa & Bazairi, 2009; Zarrouk et al., 2016). An overview of the reported densities of *P. ferruginea* in different localities along the Mediterranean coasts is provided in Table 1.

In France, the species is considered extinct along the continental coasts but has been reported to be present in Corsica, within and surrounding the Marine Park of Scandola (Galéria region) at Cap Corse, and in the Strait of Bonifacio (Laborel-Deguen & Laborel, 1991a; Laborel-Deguen et al., 1993; Blacher et al., 1998; Pascal, 2002; Vela et al., 2007). In Italy, the species is predominantly restricted to some archipelagos and particularly some areas of Sardinia. Its presence has been reported in the Egadi Archipelago, the Sicily Channel, and in the Island of Lampedusa (Scotti & Chemello, 2000). In the Sardinia coasts (Porcheddu & Milella, 1991) quite dense populations have been recorded inside the Maddalena Archipelago (Cosua et al., 2006), the Ceraso Cape (Cristo & Caronni, 2008), the Gulf of Olbia (Cristo et al., 2007) as well as in the Sinis Peninsula Marine Protected Area (MPA) (Coppa et al., 2012). In each of these localities, populations of the species sum up to some
hundred specimens.

In the North Tyrrhenian Sea, *P. ferruginea* is scantily distributed and records are episodic. Appelius (1869), Terreni (1981), Porcheddu & Milella (1991) record its presence in the Montecristo, Gorgona and Capraia Islands (Tuscan Archipelago). Records of its presence along continental Italian coasts are very scarce and relatively old, as they were published several decades ago. Terreni (1981) reported its presence along the continental seashore, near Livorno. Near the Promontory of Piombino, a few dozen specimens were recorded by Biagi & Poli (1986), along several hundred meters of coastline, while Curini-Galletti (1979) reported one specimen in Castiglione della Pescaia (Grosseto). Along the Ligurian coast (North Ligurian Sea), the species has been presently reported as missing by Espinosa et al. (2014), although the presence of the species in the prehistoric era is supported by records of *P. ferruginea* shells in the Arene Candide cave (Ghisotti, 1997). Although no *P. ferruginea* shells are present in the north Italian Natural History Museum collections, *Patella* spp. Harvesting for human consumption in the 19th century has been reported as a cultural tradition in the area (Parona, 1898; Zolezzi, 1940). The most recent information concerning the presence of *P. ferruginea* in the Ligurian coast dates back to a personal communication by Leonardo Tunesi (Porcheddu & Milella, 1991) who recorded a single specimen along the Portofino Promontory (before the Portofino MPA was established). Consequently, *P. ferruginea* is presently considered absent or sporadic and is no longer able to establish stable populations in the area.

This species has received a large degree of interest in the last decade and actions have been implemented in order to restock endangered populations and re-establish populations where they are presently extinct. For example, in Spain, between 2002 and 2017, 28 technical and scientific projects were founded for increasing knowledge of *P. ferruginea* and planning its conservation along the Spanish coasts (MMAMRM, 2008; Luque et al., 2018). In France, the Accord RAMOGE (http://www.ramoge.org) was implemented to foster collection of *P. ferruginea* records along the Ligurian Sea coastline. Also, in Italy, interest in this species has increased over the last few years. Within the framework of the Italian Marine Strategy guidelines. These included: Punta Mesco (the second A Zone of Cinque Terre MPA), Portovenere (La Spezia), and Celle Ligure (Genoa). In addition, three randomly situated findings occurred in the Portofino MPA (C Zone), in Pontetto (around 10 km from Genoa port) and in the Cinque Terre MPA (C Zone, Manarola).

### Results

Surveys along the Ligurian coast detected a total of 32 specimens of *P. ferruginea*. Each specimen was recorded and measured (Table 2). The maximum diameter of the shell of all specimens ranged between 30 mm and 68 mm (53.67 mm ± 11.24, avg. ± st. dev.). The distribution of the species was extremely scattered with large variability. The largest number of specimens were recorded within Cinque Terre MPA, in which 25 limpets (16 in Punta Mesco and 9 in Capo Montenero) were found along approximately 1000 m of monitored coast. In the other sites, very few individuals (1 or 2 in Celle Ligure, Pontetto, Portofino and Portovenere) were recorded for a total of 6 specimens over 4750 m of linear coast investigated (Fig. 1).

### Discussion and Conclusions

*P. ferruginea* cannot be considered completely absent from the Ligurian coast, as previously reported (Espinosa et al., 2014). In fact, the present study not only confirmed the presence of the species in the Portofino MPA area, as reported by Porcheddu & Milella (1991), but also reported the presence of over 30 individuals scattered along other stretches of the Ligurian coast. Throughout the survey, small specimens (<30mm) were not found. This is
probably due to the difficulties associated with detecting small sized specimens, which are sometimes camouflaged on their substrate (Guallart et al., 2017). Apparently, a relative hotspot for the species in Liguria is the Cinque Terre MPA, where only the A Zone has been investigated so far. Here, specimens were present at moderate densities (0.025 ind/m²), a phenomenon that could be linked to the proximity of this area to the Tuscan archipelago and coast, where the presence of the species has been reported by several authors (Appelius, 1869; Curini-Galletti, 1979; Terreni, 1981; Biagi & Poli, 1986; Porcheddu & Milella, 1991). It could further indicate the regular arrival of larvae from this population. It could also be related to the substrate morphology mostly sandstone in the area. However, *P. ferruginea* was observed by many authors living on substrates of different nature (granite, sandstones, carbonate rock, rhyolite, adesite, dacite, limestones) as has been summarized by Luque et al. (2018). In the light of these findings, Luque et al. (2018) hypothesized that other factors, such as wave exposure, acclivity, texture, microbial biofilm and human accessibility, rather than the mineralogy of the rocks, affect the distribution of this species.

Another potential driver to be considered in order to understand the distribution of these specimens refers to the protection level of the coastline. So far, most prospections have been performed in the A Zones of MPAs, but we cannot exclude the presence of this species in areas characterized by lower protection levels, or even in non-protected areas. Level of protection is likely not the only safeguard for the species. Additionally, low accessibility to the coast could theoretically prevent threats to the species (Coppa et al., 2012; Espinosa et al., 2014). For these reasons, future surveys are now planned not only in the B and C Zones of Ligurian MPAs, but also in other areas of low accessibility to humans because of military use, acclivity or long distance from beach areas. Additional support is expected by citizen science, through the launch of sight recordings (*e.g.* through the RAMOGE Agreement).

Present findings will not only contribute to increasing knowledge about the present distribution of the species but will also have implications for the implementation of conservation and restoration measures, such as those envisaged within the RE-LIFE project. In fact, these findings accomplish three major objectives. (i) They corroborate the presence of a local population, although it is highly reduced in numbers, and probably depends on the arrival of larvae from other nearby more abundantly populated areas. Consequently, (ii) the findings strengthen the need for implementing protection plans within the framework of the EU Habitat Directive (Council Direc-

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Table 2. Data from surveys performed by Genoa University and Regional Agencies for the Environmental Protection, Liguria (ARPAL) in 2017-2019. Size refers to the maximum diameter of the shell.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of specimens</th>
<th>min Size (mm)</th>
<th>max Size (mm)</th>
<th>Avg size ± SD (mm)</th>
<th>Total coast length investigated (m)</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bergeggi MPA</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1100</td>
<td>Dolomite/Limestone</td>
</tr>
<tr>
<td>Celle Ligure</td>
<td>1</td>
<td>-</td>
<td>65</td>
<td>58.5 ± 7.31</td>
<td>750 (250x3)</td>
<td>Conglomerate</td>
</tr>
<tr>
<td>Pontetto</td>
<td>1</td>
<td>-</td>
<td>30</td>
<td>Casual finding</td>
<td>1400</td>
<td>Limestone</td>
</tr>
<tr>
<td>Cinque Terre MPA (A Zone: Cala dell'Oro)</td>
<td>1</td>
<td>-</td>
<td>30</td>
<td>Casual finding</td>
<td>50</td>
<td>Conglomerate</td>
</tr>
<tr>
<td>Cinque Terre MPA (C Zone: Punta del Faro/ Cala Olivetta)</td>
<td>1</td>
<td>-</td>
<td>50</td>
<td>Casual finding</td>
<td>750 (250x3)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Cinque Terre MPA (A Zone: Punta Mesco)</td>
<td>16</td>
<td>45</td>
<td>68</td>
<td>58.5 ± 7.31</td>
<td>750 (250x3)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Cinque Terre MPA (C Zone: Manarola)</td>
<td>1</td>
<td>-</td>
<td>48</td>
<td>Casual finding</td>
<td>270</td>
<td>Concrete (port pier)</td>
</tr>
<tr>
<td>Cinque Terre MPA (A Zone: Capo Montenero)</td>
<td>9</td>
<td>38</td>
<td>65.4</td>
<td>53.4 ± 10.4</td>
<td>750 (250x3)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Portovenere</td>
<td>2</td>
<td>32</td>
<td>45</td>
<td>38.5 ± 9.2</td>
<td>750 (250x3)</td>
<td>Limestone</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>30</td>
<td>68</td>
<td>53.67 ± 11.24</td>
<td>5770</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 1:** Distribution map of *P. ferruginea* along the Ligurian coast. Symbols refer to ranges of abundance.
tive 92/43/EEC) and the EU Natura 2000 ecological network. Further, (iii) they provide valuable information to direct site selection for the implantation of juveniles for repopulation. Thus, allowing conservation efforts to assess the effects of protection levels and substrate features, as planned in the framework of the RE-LIFE project.

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