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Distribution and life strategy of the deep-sea crab *Paromola cuvieri* (Risso, 1816) (Brachyura, Homolidae) in the central Mediterranean Sea over twenty-five years

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ABSTRACT

The present study represents a new contribution to the knowledge on the distribution and life strategy of *P. cuvieri* in the central Mediterranean. During 71 experimental bottom trawl surveys carried out in the Northern Ionian Sea from October 1994 to July 2019 a total of 457 specimens was sampled from 91 to 1118 m in depth. The highest frequency of occurrence and density was observed in the 600–800 m depth range. The relationship between carapace length and depth was statistically significant showing a significant decrease in size with depth. The length-frequency distribution was unimodal for both sexes and there was a low number of small individuals. The most represented size classes for both sexes were between 50 and 130 mm Carapace Length (CL), with males significantly larger than females. The sex ratio by size showed an increase of males with increasing length. Of the sampled females, 50 were in ovigerous condition and 92 females were non ovigerous. *P. cuvieri* appears to have continuous reproduction throughout the year, with ovigerous females observed in all seasons, with the highest abundance in spring and winter and between 400 and 800 m of depth. The fecundity ranged between 138165 and 374453 eggs with a mean value of 217237 eggs. The eggs show a spherical shape and their mean size increased with maturity stage. Egg development appears to not be completely synchronous, and two patterns can be observed simultaneously. The relationships between CL/brood size and weight/brood size were highly significant. The relationships between width and hand-length of both chelae and Carapace Width (CW) for both sexes were highly significant. Time-series data showed a scanty abundance of *P. cuvieri* in the studied area with no trend over the period 1995–2019 with no significant trend over. Its preferential distribution on the middle slope was confirmed. Time-series data (1995-2019) showed a scanty abundance of *P. cuvieri* in the studied area with no signficant trend. Its preferential distribution on the middle slope was confirmed.

1. Introduction

Decapod crustaceans constitute one of the most abundant groups of megabenthic invertebrates on the continental slope of the Mediterranean and a very important fraction of demersal communities (Abelló et al., 1988; Maynou and Cartes, 2000; Colloca et al., 2003; Company et al., 2004; Fanelli et al., 2007), resulting the dominant faunistic category in the megafauna sampled by trawl on the middle slope of the Mediterranean (Fernandez-Arcaya et al., 2019). Although decapod crustacean assemblages have been intensively studied in this basin (Abelló et al., 1988, 2002; Cartes, 1993a; Cartes and Sardà, 1993; Maynou et al., 1996; Maynou and Cartes, 2000; Company et al., 2004; Politou et al., 2005; Ungaro et al., 2005; Fanelli et al., 2007; García Munõz et al., 2008; Follesa et al., 2009; Tecchio et al., 2013), few data have been published from the central Mediterranean area (e.g. Pipitone and Tumbiolo, 1993; D'Onghia et al., 1998, 2004; Company et al., 2004; Politou et al., 2005, 2008; Tecchio et al., 2011).

Despite the increasing interest in the study of these invertebrates, in relation to their functional role as a key taxonomic group coupling lower and higher trophic levels (Cartes, 1998; Fanelli et al., 2007; Relini and Orsi Relini, 2019; Ricci et al., 2022), many aspects of the biology of some of species, especially that with no or low commercial value, remain almost unknown.

For example, the ecology of *Paromola cuvieri* (Risso, 1816) is still

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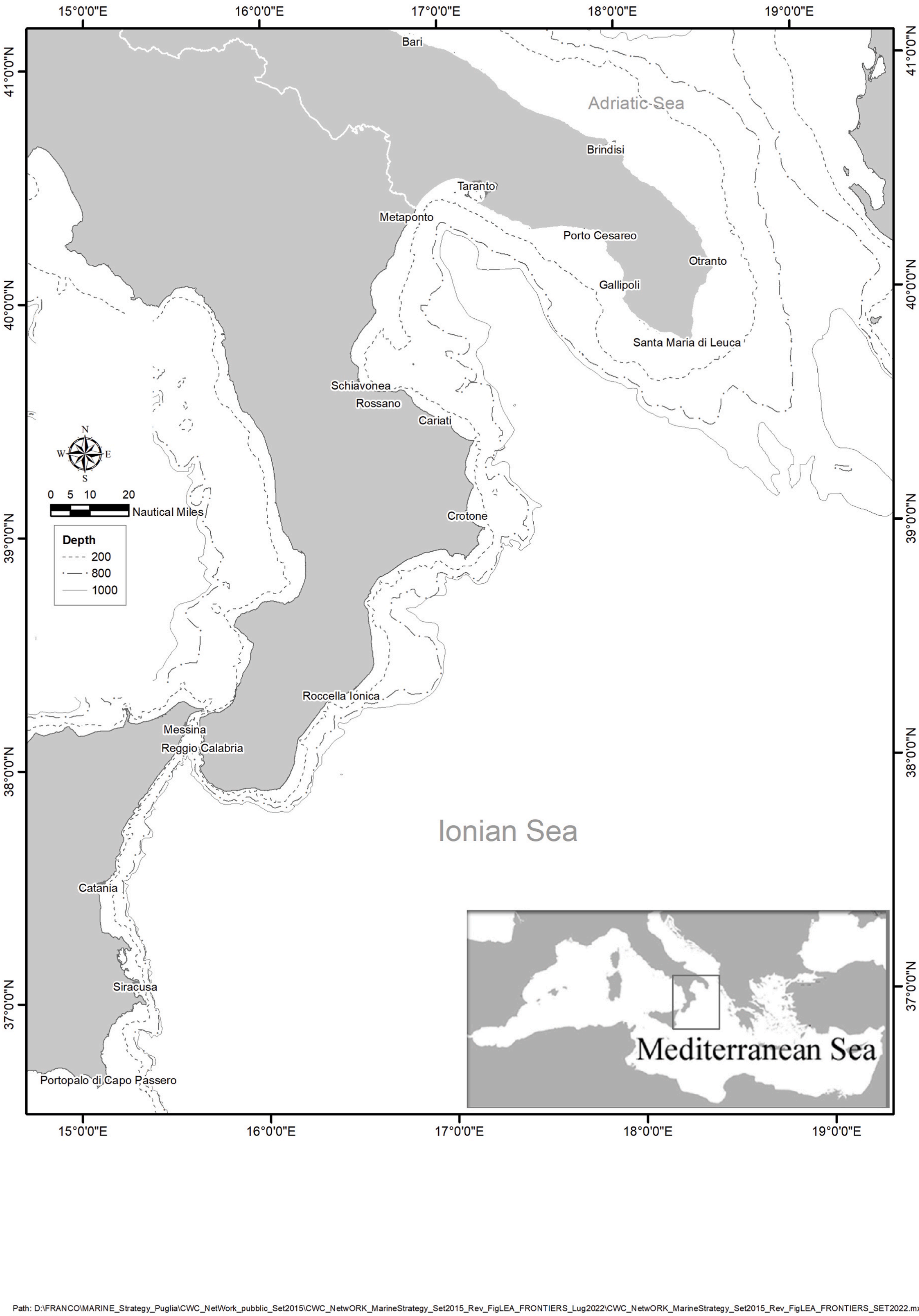

Fig. 1. Map of the investigated area.

Table 1
List of cruises, with relative date, number and depth of occurrence of *Paromola cuvieri* caught in the Northern Northern Ionian Sea.

Project	Year	Number of specimens	Depth range (m)
RED SHRIMPS	1994–1995	9	567–643
GRUND	1994–2008	73	116–738
MEDITS	1995–2019	226	91–767
DISCARD	1995–2000	54	462–673
DEEP FISHERIES	1996–1998	71	462–676
DIREMARE	1999–2000	9	513–782
RESHIO	2001	2	642–676
RIME	2003	7	771–1115
GAVIS	2006	4	477–1118
CORAL FISH	2009	2	525

little known although it is widely spread in different habitats, from muddy bottoms as characteristic species of bathyal muds (Pérès and Picard, 1964), to cold-water coral communities, seamount, deep-sea hydrothermal vents, and deep-sea sponge aggregations (Biscoito, 1997; Stora et al., 1999; Cartes and Carrassón, 2004; Follesa et al., 2009; Freiwald et al., 2009; Capezzuto et al., 2010, 2012; Maiorano et al., 2010; Sabatini et al., 2011; Braga-Henriques et al., 2012; Muñoz et al., 2012; Triay-Portella et al., 2014).

The box crab *Paromola cuvieri* (Risso, 1816) is a deep-water homolid decapod crustacean mainly distributed on the upper slope (Holthuis, 1981; Manning and Holthuis, 1981) in the Eastern Atlantic and in the Mediterranean Sea (d'Udekem d'Acoz, 1999), although it has been collected from 10 m (Doflein, 1904) down to 1230 m (Tecchio et al., 2011). The presence of *P. cuvieri* has been reported along the Italian coasts, apart from the Adriatic Sea (Froglia, 1995), where it has been only recorded in the southern Adriatic Sea, on both Italian and Croatian side (Ungaro et al., 2000; Isajlovic et al., 2009). The box crab has been recorded in the Ionian Sea at depths between 91 and 1118 m (Capezzuto et al., 2010; Maiorano et al., 2010).

Despite to its relative abundance in some Atlantic or Mediterranean areas (Rihan et al., 2006; Castro et al., 2014), and its potentially commercial interest, this deep-sea crab is not a target species in any world fishery. The catches are generally discarded or handled as by-catch in some artisanal fisheries of the Eastern Atlantic and south-western Mediterranean along the African coast (Thurston, 1987; Blasdale et al., 2006; Castro et al., 2014). Thus, most of studies on *P. cuvieri* are limited to its geographic and bathymetric distribution and it still results a fewer known species in the assemblages of the continental slope of the Mediterranean. In this basin some aspects of its size, reproduction, feeding behavior, and associated epibionts have been studied in the Ligurian Sea (Mori, 1980, 1986; Mori and Mancori, 1990) many years ago, while a marked scavenging trophic habit and a relatively slow growth have been reported in the western Mediterranean by Cartes (1993b, 1998) and Company and Sardà (2000). More recently, information on its occurrence and behavior has been collected in the Northern Ionian Sea (Capezzuto et al., 2012).

The aim of this study is to provide new contributions to the knowledge on the distribution and life strategy of *P. cuvieri* in the central Mediterranean.

2. Materials and methods

2.1. Sampling

Samples were collected during 71 experimental bottom trawl surveys carried out in the Northern Ionian Sea (Fig. 1) from October 1994 to July 2019 as part of ten study projects. In these surveys a total of 457 specimens was sampled from 91 to 1118 m in depth (Table 1). The large number of considered projects together with a long-term period investigated, is due to the scanty abundance and/or availability of the species in the study area. However, the greatest number of individuals was collected during the MEDITS project (e.g. Bertrand et al., 2002; Spedicato et al., 2019).

2.2. Data collection

For each specimen of *P. cuvieri* the following data were recorded in the laboratory:

- Carapace length, CL, was measured from the post-orbital socket to the posterior-median edge of the cephalothorax, to the nearest millimeter.
- Body weight was taken to the nearest 0.1 g.
- Sex was determined according to the abdomen morphology.
- Ovigerous condition was determined according to the presence of eggs among pleopods.

For a subsample of individuals other measurements of the body were recorded according to Triay-Portella et al. (2014):

- carapace width (CW) (maximum transverse diameter, excluding spines);
- width of right/left chela (R/LCHW) (maximum diameter of the propodus at level of its jointure with the dactyl);
- right/left hand-length (R/LCHL) (propodus + dactyl);

For a subsample of 15 ovigerous females the following data were recorded:

- Four stages of egg development were considered on ovigerous females according to Triay-Portella et al. (2014): (I) eggs undivided and fully filled with yolk; (II) eggs with a free region of yolk visible; (III) embryos with slightly pigmented eyes, growing as crescents; (d) embryos with visible pigmented structures, enlarging eyes, segmented appendages and abdomen appearing.
- Egg number was counted under a stereomicroscope.
- Egg size, to the nearest 0.01 mm, was measured for each stage of egg development. The major and minor axes of eggs were measured under a stereomicroscope using a micrometer lens.

2.3. Data processing

Using the number of the individuals for each haul swept area, the density index (N/km^2) by depth was computed and the depth range of the highest concentration of *P. cuvieri* was defined. The swept area was estimated according to the wing spread of the net (horizontal opening) and the speed of the vessel (Pauly, 1983).

The frequency of occurrence (Foc) was also estimated by depth range as the ratio between the number of hauls with positive catches and the number of total hauls carried out.

Change in density with depth was statistically tested by means of regression analysis.

Sex ratio by length was computed for the population sampled throughout the research period.

The length-weight power equation $W = a\ CL^b$ was used to estimate the relationship between the body weight (W, g) of the crab and its carapace length (CL, mm) for each sex and for all individuals, where a is the y-intercept and b the allometric coefficient (or slope). The length-frequency distributions (10 mm size class) of the whole sampled population, females and males, were performed for the investigated period. Statistical differences in size between females and males were determined using the Kolmogorov–Smirnov non-parametric Z-test performed with Past 4.03 (Hammer et al., 2001). The change in carapace length with depth was statistically tested by means of linear regression. The size distributions of ovigerous females and non ovigerous females by depth and by season were calculated for the investigated period.

The relationships between carapace length and brood size and body

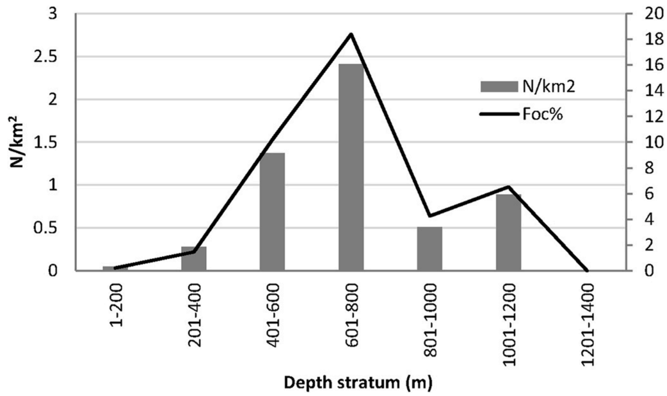

Fig. 2. Density (N/km^2) and frequency of occurrence (Foc%) of *Paromola cuvieri* by depth stratum in the Northern Ionian Sea.

weight and brood size were evaluated by regression analysis (King and Butler, 1985; Company and Sardà, 1997).

The carapace length, the length and width of both chelae were plotted against the CW for both males and females in order to investigate the relationship between these dimensions and increasing body size (Attrill et al., 1991; Triay-Portella et al., 2014).

To evaluate any potential change over 25 years, the long time series (1995–2019) available for the MEDITS data was used to explore abundance and bathymetric distribution of *P. cuvieri* in the Northern Ionian Sea. The abundance was expressed as density index (N/km^2) and its changes over time tested using the Spearman non-parametric correlation. Changes in the bathymetric distribution of *P. cuvieri* over the study period 1995–2019 were examined quantitatively by estimating the Centre Of Gravity (COG; Daget, 1976). Before the analysis, the bathymetric range of species occurrence during the MEDITS experimental trawl surveys was divided into eight strata of 100 m (from 0 to 800 m) and COG was calculated as follows:

$$COG = (x1+2x2+3x3+ \ldots +nxn) / \Sigma xi$$

where xi represents the calculated mean abundance values of *P. cuvieri* present in the *i*-th stratum. The Spearman non-parametric test was applied in order to evaluate the significance of the temporal variability of the COG.

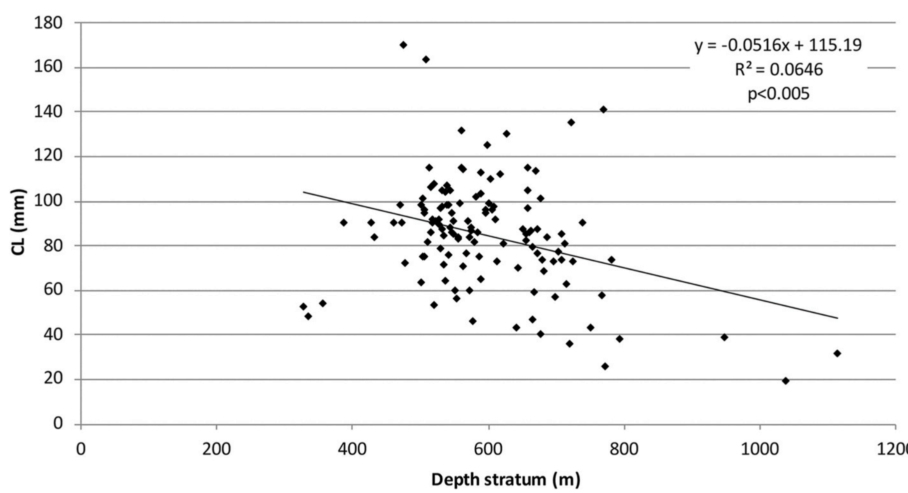

Fig. 3. Relationship between mean carapace length (mm) and depth for males and females of *Paromola cuvieri* in the Northern Ionian Sea.

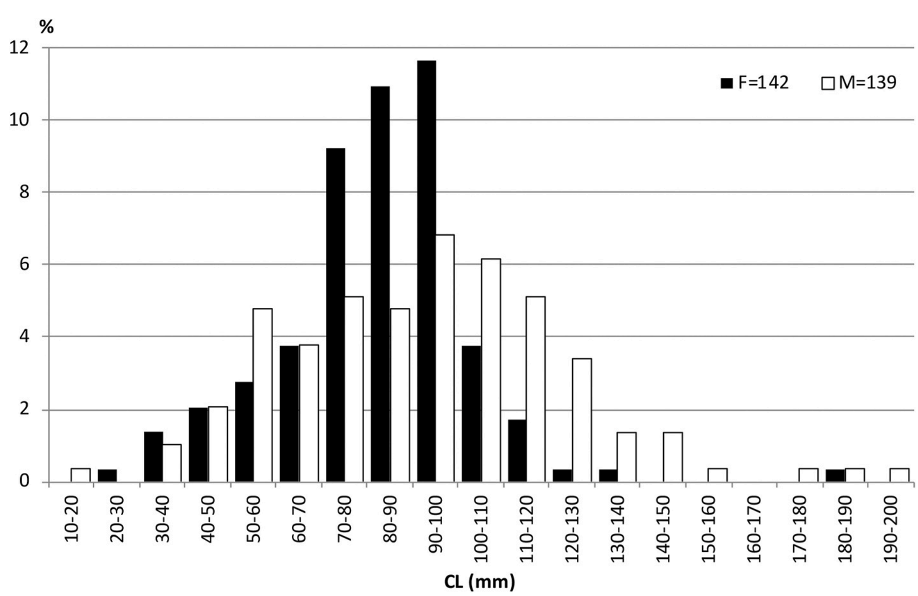

Fig. 4. Length-frequency distributions of *Paromola cuvieri* sampled in the Northern Ionian Sea.

Table 2
Parameters of CL–W (W = a CL^b) for females, males and all crabs of *Paromola cuvieri*. N, number of specimens, a, intercept; b, allometric coefficient; r^2, determination coefficient.

N	Sex	A	B	r^2	p
79	F	0.0005	3.002	0.93	<0.001
72	M	0.0004	3.165	0.95	<0.001
151	P	0.0002	3.078	0.94	<0.001

r^2 coefficient determination; a and b parameters of length-weight relationship; N sample size; M male; F female; P pooled sex.

3. Results

Paromola cuvieri was found between 91 and 1118 m of depth, with the highest frequency of occurrence and density in the 600–800 m depth range (Fig. 2). Although the species was caught in all investigated bathymetric strata, low percentages of occurrence were generally observed, showing the scanty abundance or accessibility of the species in the study area.

The relationship between carapace length and depth was statistically significant ($p < 0.005$) showing a significant decrease in size with depth (Fig. 3). A total of 281 individuals of *P. cuvieri* were collected with size range between 19 and 200 mm CL (Fig. 4). In particular, females (n = 142) ranged from 26 to 180 mm CL and males (n = 139) ranged from 19 to 200 mm CL, even if the most represented size classes for both sexes were between 50 and 130 mm CL, with males significantly larger than females (Kolmogorov–Smirnov non-parametric test D = 0.301; $p < 0.001$).

The results of the weight-length relationship indicated a slightly positive allometric growth for both males and females and for all individuals (Table 2).

The sex ratio by size, for the entire dataset, showed an increase of males with increasing length (Fig. 5). In fact, excluding the size classes in which only one individual per sex was observed and therefore considering the size range of 30–150 mm CL, the increase in males with length was highly significant ($p < 0.01$) (Fig. 6).

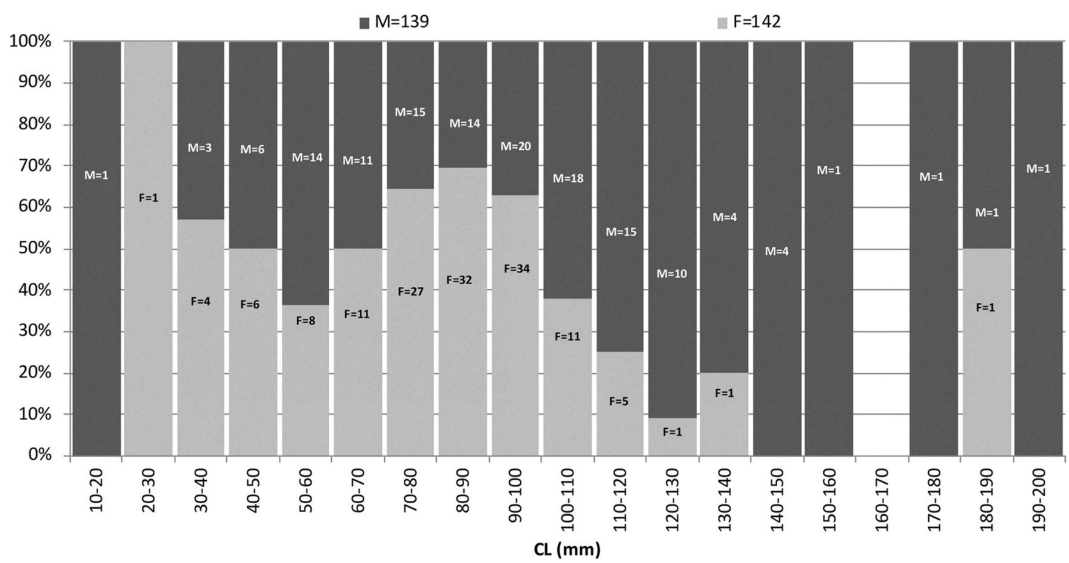

Fig. 5. Sex ratio by carapace length of *Paromola cuvieri* sampled in the Northern Northern Ionian Sea. The number of individuals is indicated for each size class.

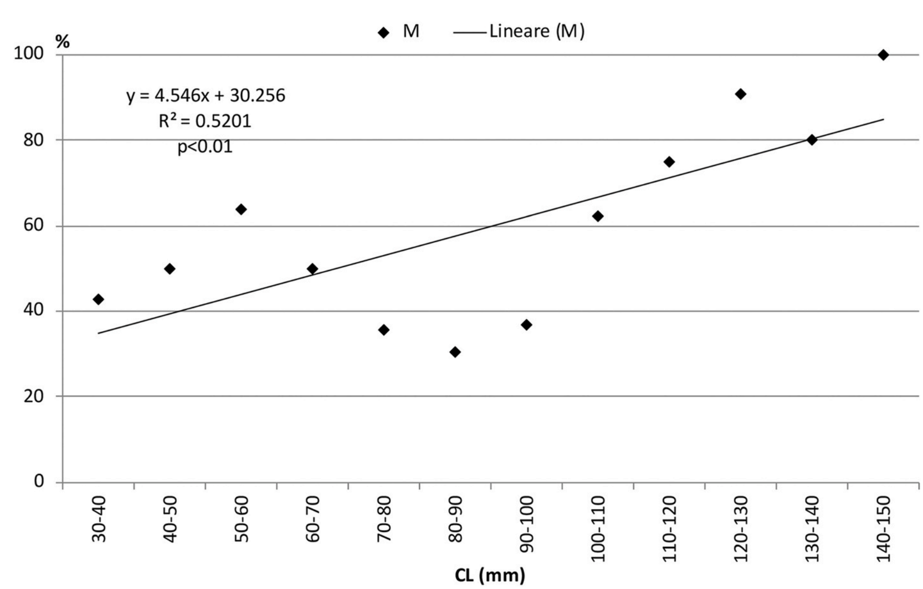

Fig. 6. Relationship between percentage of males and Carapace Length (CL) of *Paromola cuvieri* sampled in the Northern Ionian Sea, considering only the size classes in which more than one individual per sex was observed (30–150 mm).

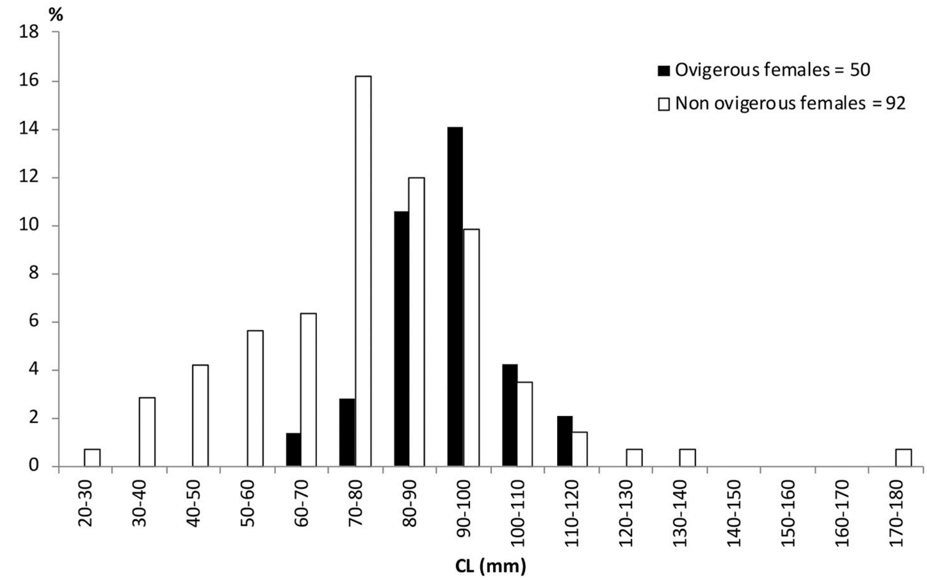

Fig. 7. Length-frequency distributions by ovigerous condition of females of *Paromola cuvieri* sampled in the Northern Ionian Sea.

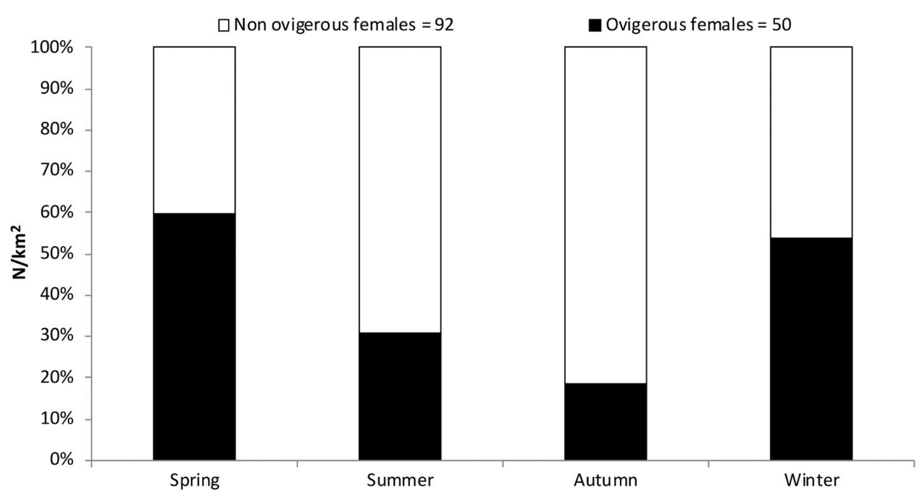

Fig. 8. Density (N/km^2) of females of *Paromola cuvieri* by season and ovigerous condition in the Northern Ionian Sea.

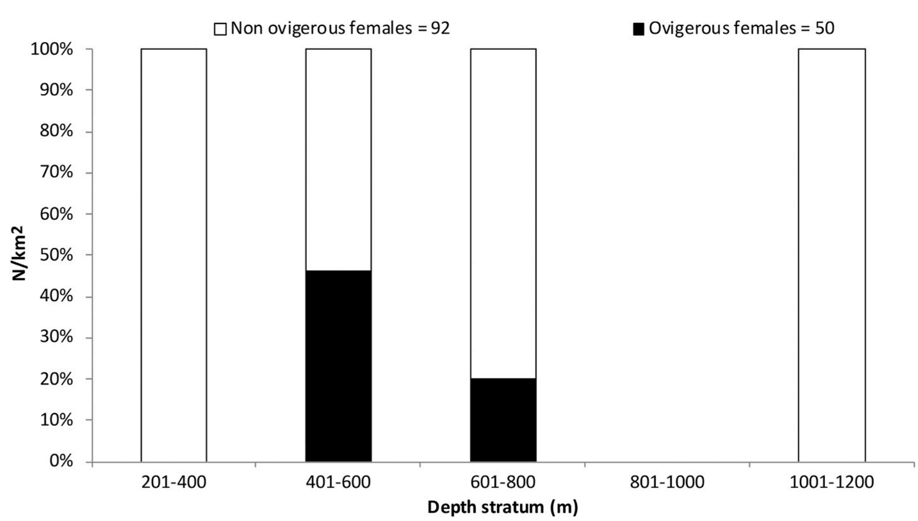

Fig. 9. Density (N/km^2) of females of *Paromola cuvieri* by depth and ovigerous condition in the Northern Ionian Sea.

Table 3
Egg weight (g), Mean diameter and Brood size of eggs (mm) with standard deviation (s.d.) and Average values for different egg development stages of 15 samples of *Paromola cuvieri* in the Northern Ionian Sea.

CL (mm)	Weight (g)	Egg weight (g)	Egg stage	Mean diameter ± s.d. (mm)	Brood size
98	591.2	74.79	1	0.688 ± 0.70	323422
83	276	26.14	1	0.643 ± 0.65	138165
85	357	53.00	1	0.683 ± 0.69	245781
92	436.2	64.29	1	0.658 ± 0.66	211368
92	546.2	41.06	1	0.694 ± 0.71	167448
Average				**0.673 ± 0.022**	**217237**
73	257.3	30.45	1/2	0.705	170998
89	443.3	74.24	1/2	0.659	257892
82	412.8	85.97	1/2	0.666	227615
111	778.4	79.94	1/2	0.744	374453
83	375.2	56.88	1/2	0.663	230799
97	472.2	60.57	1/2	0.664	259583
Average				**0.684 ± 0.034**	**253557**
89	536.6	53.75	2	0.758	281351
61	129.4	20.65	2	0.750	135160
91	474	47.24	2	0.740	156424
Average				**0.749 ± 0.009**	**190978**
73	284.8	36.95	2/3	0.770	156498

Fig. 10. Eggs in stage 1, undivided and fully filled with yolk (a), eggs in stage 2 with a free region of yolk visible (b).

Of the sampled females, 50 were in ovigerous condition and 92 females were non ovigerous. Females in the non ovigerous condition ranged from 26 to 180 mm CL, while ovigerous were distributed between 61 and 111 cm CL (Fig. 7).

The ovigerous females were observed in all seasons, with the highest abundance in spring and winter (Fig. 8). The highest density of non ovigerous females was observed in autumn.

Ovigerous females were observed only between 400 and 800 m of depth, with the highest density between 400 and 600 m (Fig. 9). At lower or greater depths all the specimens sampled were non ovigerous females.

For a subsample of 15 ovigerous females the brood size and egg sizes of each egg development stage are reported in Table 3.

The eggs development seems not to be completely synchronous, because in 10 of the 15 sampled eggs two stages of egg development were observed simultaneously. In fact, 4 development stages of eggs were observed, stage 1 in five females, stage 1/2 in six females, stage 2 in three females and stage 2/3 in one female. No single stage 3 and stage 4 were observed. The number of external eggs carried by female in stage 1 varied from 138165 (CL = 83 mm) to 323422 (CL = 98 mm), in stage 1/2 from 170998 (CL = 73 mm) to 374453 (CL = 111 mm), in stage 2 from 135160 (CL = 61 mm) to 281351 (CL = 89 mm) and in stage 2/3 the only sampled female carried 156498 eggs (Table 3). Considering that only females of *P. cuvieri* with eggs in the first developmental stage have to be considered for the fecundity estimates due to the egg losses caused by parasites during embryonic development (Mori, 1986), the fecundity ranged between 138165 and 374453 eggs with a mean value of 217237 eggs (Table 3).

The eggs show a spherical shape and their mean size increased from the mean diameter of stage 1 (0.673 mm) to the mean diameter of stage 2/3 (0.770 mm) (Table 3) (Fig. 10).

Considerable changes in brood size were shown in relation to carapace length and individual weight. The relationships between CL/brood size and weight/brood size were highly significant ($p < 0.001$) (Fig. 11).

The relationships between width and hand-length of both chelae and CW for both sexes were highly significant (Fig. 12).

Finally, considering the MEDITS data collected over 25 years (1995–2019), low abundance indices (N/km^2) were observed throughout the study period, and they were fluctuating with no significant trend over time (Fig. 13). Apart from few years, *P. cuvieri* occurred on a narrow depth range, mostly located on the middle slope. The COG values resulted between 366 and 682 m, generally deeper than 500 m in depth, with no significant trend over the study period (Fig. 14).

4. Discussion

P. cuvieri was mostly caught between 600 and 800 m in the Northern Ionian Sea and therefore slightly deeper than in the Ligurian Sea (400–700 m) (Mori, 1986) and in the Canary Islands (400–700 m) (Castro et al., 2014; Triay-Portella et al., 2014), but somewhat comparable to the depth range of distribution observed in the Catalan Sea by Cartes (1993a), where the species was more abundant between 550 and 750 m. The maximum depth of occurrence in the study area (1118 m) was comparable to that found in the south-eastern Sardinian waters, equal to 1212 m (Follesa et al., 2009) and in the Catalan Sea, equal to 1165 m (Cartes, 1993a), and slightly deeper than that of 906 m reported in the Canary Islands by Castro et al. (2014).

The sea-bottom structure generally affects the distribution pattern of the geryonid crabs, and probably also that of *P. cuvieri* and other brachyuran crabs (Hastie, 1995; Castro et al., 2010, 2014). Therefore, the scanty abundance or accessibility observed for this species in the central Mediterranean could be due to its preference to live on intermixed bathyal mud and emerging rocky substrates (Pérès, 1985) that are difficult to sample with bottom trawls (Cartes, 1993a). With this regard, *P. cuvieri* has been collected in complex and heterogeneous habitats in the central Mediterranean, such as cold-water coral habitats and

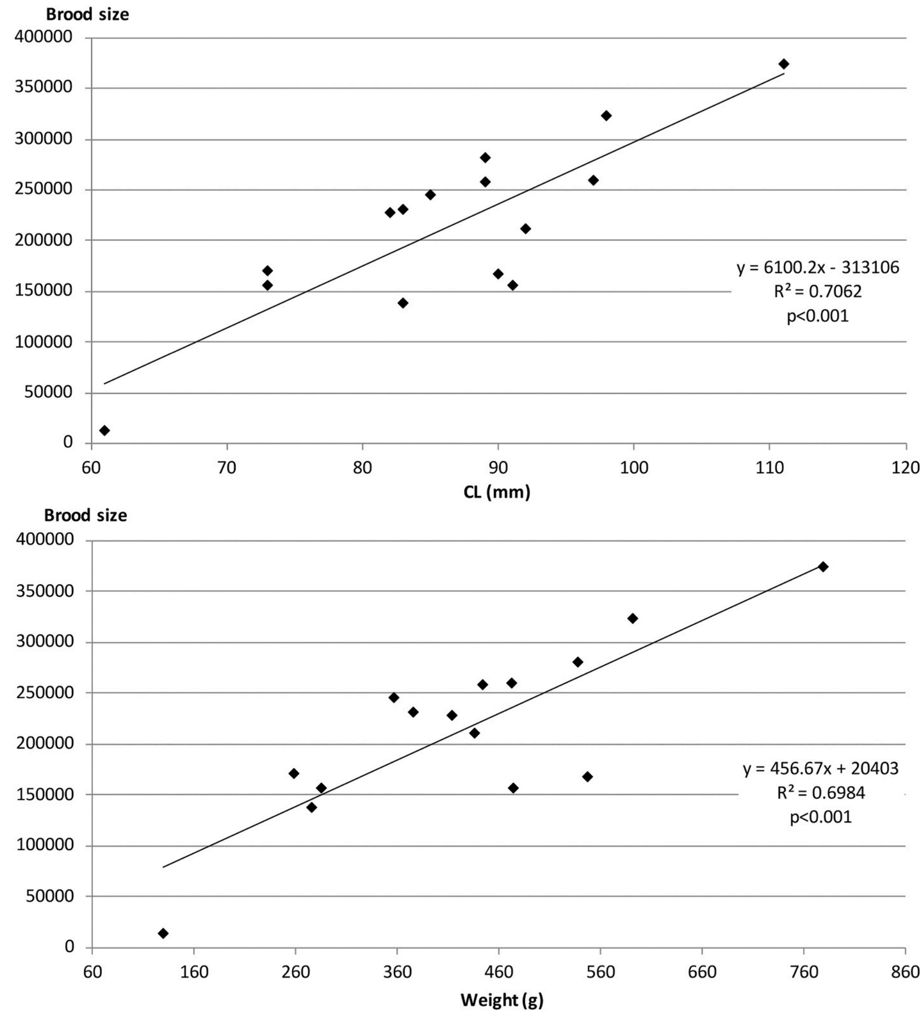

Fig. 11. Relationships between Brood size/Carapace Length and Brood size/Weight computed for females of *Paromola cuvieri* in the Northern Ionian Sea.

canyons (Freiwald et al., 2009; Capezzuto et al., 2012; D'Onghia et al., 2015).

A smaller-deeper distribution was observed for both sexes; in fact, the length of sampled individuals decreased with depth in agreement with observations from the Central east Atlantic (Triay-Portella et al., 2014).

The size range of *Paramola cuvieri* found during this study was wider than those previously reported for the Mediterranean Sea (Company and Sardà, 2000), Central east Atlantic (Castro et al., 2014; Triay-Portella et al., 2014) and Irish Sea (Rihan et al., 2006). The length-frequency distribution was unimodal for both sexes and there was a low number of small individuals as observed in the Canary Islands (Castro et al., 2014; Triay-Portella et al., 2014). Males were significantly larger than females reaching a maximum size equal to 200 mm CL, which is larger than that found in other Mediterranean areas (Mori, 1986; Ungaro et al., 2000). A significant increase of males with length was observed as reported by Triay-Portella et al. (2014) in the Canary Islands where males were significantly dominant in larger size classes.

The sex ratio found in the present study (1:1) was in accordance with what is reported by Mori (1986) in the Ligurian Sea, while differed from the observations made in Canary Islands (CE Atlantic) where the sex ratio was in favor of females (Triay-Portella et al., 2014). However, in situ observation collected by MEMO lander in the Santa Maria di Leuca cold-water coral community recorded higher numbers of females than males (Capezzuto et al., 2012).

The weight-length relationship indicated a slightly positive allometric growth for both males and females unlike what was observed in the Central east Atlantic where the growth was allometrically negative (Triay-Portella et al., 2014), but similar to that reported in the north-western Mediterranean for males (Company and Sardà, 2000). Indeed, the relative growth (in terms of size-weight relationship) in decapod crustaceans is considered a morphological parameter reflecting the species' life habit, with weight increasing significantly more than size in species strictly adapted to the benthic habit such as the brachyuran crabs (Company and Sardà, 2000).

P. cuvieri showed spawning activity during all seasons, even if with slightly higher numbers in spring and winter. This result is similar to that recorded by Mori (1986) that found the highest number of females carrying eggs during April and May. On the contrary, a higher number of ovigerous females was observed especially in summer by Lo Bianco (1909) in the Gulf of Naples, by Monod (1956) in the West Africa, by Zariquiey (1968) in the Iberian Peninsula and by Triay-Portella et al. (2014) in the Canary Islands (all year round, with the highest activity during summer). The presence of ovigerous females in all seasons suggests that *P. cuvieri* has continuous reproduction throughout the year, as observed also by Mori (1986) in the Ligurian Sea.

The fecundity estimate from the present work is equal to that estimated by Mori (1986) and similar to that estimates by Triay-Portella et al. (2014) for the same species and to those found for other deep-sea crabs (Melville-Smith, 1987; Tuset et al., 2011). In addition, also the positive correlation observed between female size and weight and number of eggs was observed in Canary Islands (Triay-Portella et al.,

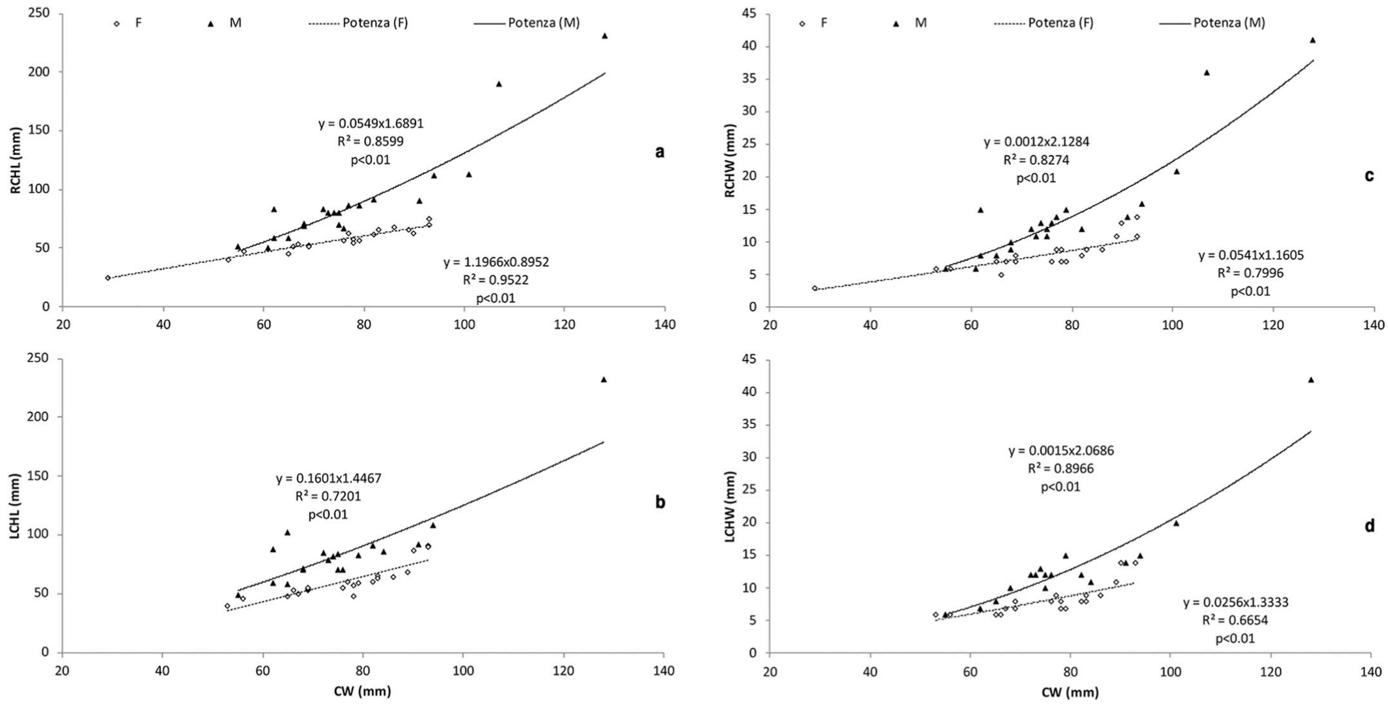

Fig. 12. Right (a) and left (b) chela length (R/LCHL) and chela width (R/LCHW) (d and c) plotted against carapace width (CW).

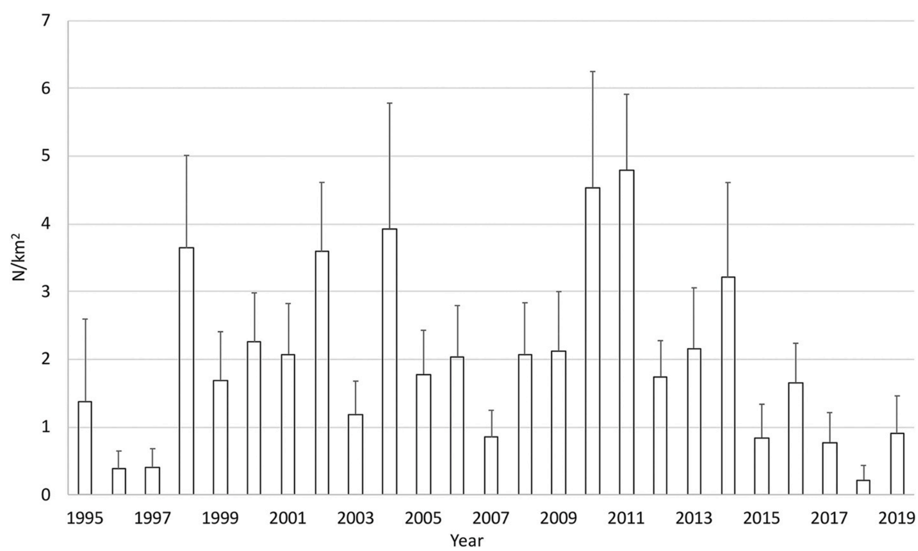

Fig. 13. Time series of abundance index (N/km^2), with indication of standard deviation, of *Paromola cuvieri* sampled during MEDITS experimental trawl surveys carried out in the Northern Ionian Sea from 1995 to 2019.

2014) and in other brachyurans (Erdman and Blake, 1988; Arshad et al., 2006; Tuset et al., 2011). According to these authors, in the present work a large size of eggs and an increase of it from the first development stage to the next was observed. The large egg size can increase the larval survival, considering the migration that the species could make from depth to the surface to complete its larval development (Erdman et al., 1991; Triay-Portella et al., 2014).

P. cuvieri showed a marked sexual dimorphism, regarding the size in length and weight of both chelae, that in males is longer and heavier than in females, as already reported for this species in the Mediterranean (Mori 1986) and for many other brachyuran crabs (e.g., Hartnoll 1974, 1978). Hartnoll (1982) explained this sexual dimorphism in terms of the greater role played by adult males in courtship, display and combat. In addition, Attrill et al. (1991) observed that male needs a large chela to place the female in the position for mating and also to protect it during its moults.

Time-series data from MEDITS experimental surveys showed a scanty abundance of *P. cuvieri* in the Northern Ionian Sea with no trend over the period 1995–2019. The COG detected over time confirmed its preferential distribution on the middle slope of the study area where *P. cuvieri* were already reported as a characteristic benthic species of the mesobathyal assemblages (Maiorano et al., 2022).

Although there are still aspects to deepen, this study provides relevant information for this deep-sea predator and scavenger crustacean species that may be used for its assessment and for a sustainable fishing, even though its vulnerability and IUCN Red List status has not yet been evaluated. Indeed, the box crab *Paromola cuvieri* is not a target species in any world fishery and generally discarded. However, it resulted quietly

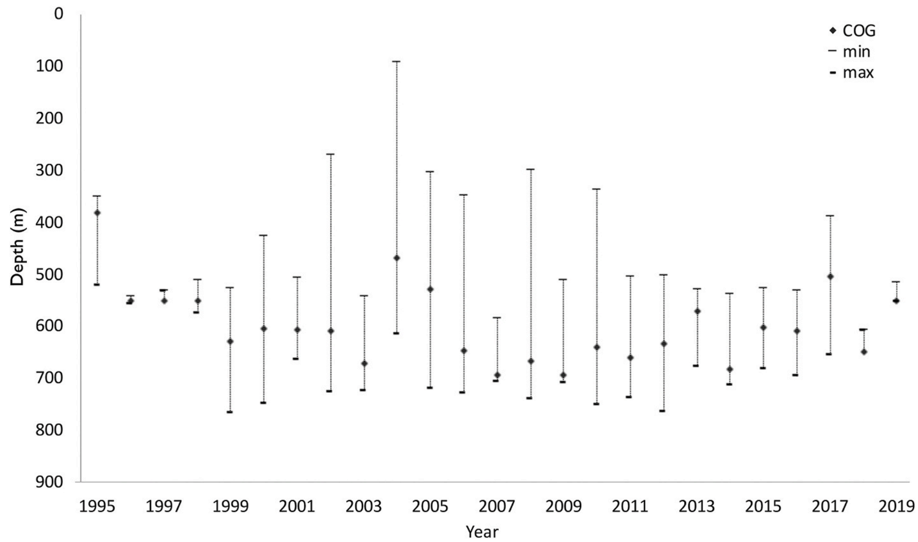

Fig. 14. Time evolution of the center of gravity (COG), with minimum (min) and maximum (max) depth of occurrence of *Paromola cuvieri* sampled during MEDITS experimental trawl surveys carried out in the Northern Ionian Sea from 1995 to 2019.

abundant in the by-catch of some Mediterranean deep-sea fisheries targeting crustacean resources where it was increasingly commercialized together with other decapod crustaceans such as *Pasipahea* spp., *Plesionika* spp. and *Geryon longipes* (Castriota et al., 2004). In the southern Tyrrhenian Sea (Northern Sicily) it is quite appreciated by fishermen, although not usually sold in the local markets (Castriota and Carrassón, 2004). Despite its large size, wide distribution and relative abundance, it is surprising that *P. cuvieri* is not targeted by commercial fisheries and is discarded. Small quantities are landed as by catch in some artisanal fisheries also off Marocco, Mauritania, Namibia and NE Spain (Castro et al., 2014). In the latter area, according to FAO Fisheries Statistics, 4.86 tonnes were recorded during 2020, 93% from Mediterranean and 7% from Eastern Central Atlantic (Quigley, 2022). A report of a course of a demersal gill-netting survey in deep water of Scotland dating back to 1986 remarked that "it is not thought that this species would have any commercial prospects although it is edible with a strong and distinctive flavor" (Quigley, 2022).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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