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Fecundity and egg volume in Norway lobster (*Nephrops norvegicus*) from different depths in the northern Tyrrhenian Sea*

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SUMMARY: The relationships between fecundity and egg volume of Norway lobster (*Nephrops norvegicus*) inhabiting three different depth ranges (200-300, 350-450, and 500-550 m) in the North Tyrrhenian Sea (western Mediterranean) were compared. Fecundity was not dependent on depth and egg volume did not vary with female size. The egg volume of females collected in the shallowest areas (200-450 m) was instead significantly larger than that collected in deeper waters (500-550 m). Possible explanations for this fact are examined.

Key words: fecundity, egg volume, depth, *Nephrops norvegicus*, western Mediterranean.

INTRODUCTION

The Norway lobster, *Nephrops norvegicus* (L.), is a marine boreal species, inhabiting the Mediterranean Sea and the continental shelves of the north-eastern Atlantic Ocean, occurring at depths of from 15 to more than 800 m (Farmer, 1975). It is a synchronous spawner that produces a single batch of large eggs (1-1.3 mm diameter) that are released after a long, well-defined breeding season of six to ten months, depending on the latitude and habitat type (Farmer, 1975; Sardà, 1995; Mori *et al.*, 1998a). Many papers on the biology of this species have included data on the number of eggs produced as a function of size (Farmer, 1975; Sardà, 1995) or locality (Thomas, 1964; Abelló and Sardá, 1982; Orsi Relini *et al.*, 1998). However, none have addressed the question of just how fecundity and egg size can vary as a consequence of depth.

The present study was then performed to assess intraspecific variability of egg volume and fecundity with depth of capture for Norway lobster from the northern Tyrrhenian Sea (western Mediterranean). The relationship between egg volume and female size was also investigated.

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MATERIAL AND METHODS

Study area

The study area extended over the southern Tuscan Archipelago, between the islands of Elba and Giannutri (northern Tyrrhenian Sea, western

Mediterranean). A wide depression in the central part of the area named "Central Basin" characterises the bottom morphology. It becomes gradually deeper southward down to 600 m depth between the islands of Montecristo and Giannutri. This huge amphitheatre-like depression is limited eastward by a wide continental shelf, northward by the shelf of the Elba Island and Piombino channel, and westward by the Elba ridge (Sardà, 1998). In this area *N. norvegicus* inhabits depths of between 135 and 635 m, but its greatest abundance is located from 300 to 500 m depth (Biagi *et al.,* 1989).

Sampling and laboratory work

Samples of ovigerous female Norway lobster were obtained in September 1995, from commercial catches at three different depth ranges (Fig. 1) in the northern Tyrrhenian Sea (area A, 200-300 m; B, 350-450 m; C, 500-550 m). The ovigerous females, separated by depth of capture, were immediately preserved in 7% buffered saline formalin.

In the laboratory, each individual was measured with callipers to the nearest 0.5 mm carapace length (CL, from the posterior edge of an eye socket to the distal edge of the carapace) and the eggs were staged under a binocular microscope. Only females with newly spawned eggs or early blastulae were considered in this study. Both stages have identical volume (Gilbert, 1994). A total of 102 ovigerous females were then selected, and precisely 35 individuals were collected in area A, 34 in B, and 33 in C.

Prior to estimation of egg number, a subsample of ten eggs was removed by each female from the three different depth ranges and measured to the nearest 0.01 mm using a binocular microscope with a calibrated eyepiece. Egg volumes were calculated using the formula for the volume of an ellipsoid, since most eggs have this shape:

$$V = \pi LW^2/6$$

where V, L and W are egg volume, length and width respectively.

The external eggs were totally counted, but if their number was greater than 1000 the egg masses were dried at 60°C for 24 h and weighed to the nearest 0.1 mg. Two subsamples of about 500 eggs were then weighed and counted. Fecundity was then estimated by multiplying the mean sample by a proportional factor calculated by dividing the total weight of the egg mass by the average of the two estimates of individual egg weight. All the counting of the eggs was performed within a month of their collection.

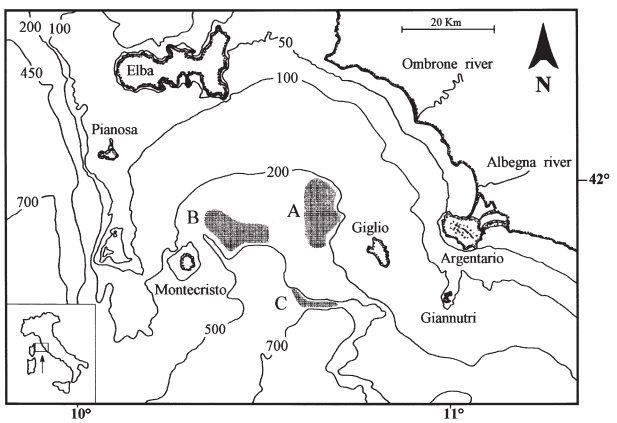

FIG. 1. – Chart showing the areas of the northern Tyrrhenian Sea (western Mediterranean), where samples of ovigerous female *Nephrops norvegicus* were collected (area A, 200-300 m; area B, 350-450 m; area C, 500-550 m).

Statistical analysis

Data analyses followed standard methods described by Sokal and Rohlf (1981). The homoscedasticity of the data was tested by means of the Bartlett's test. The parameter values of the fecundity-female size relationship were estimated by least-square regression (Model I). Slopes and intercepts of different regression equations were compared with each other employing ANCOVA.

RESULTS

Fecundity/depth

The number of eggs per brood (fecundity) in relation to the carapace length of the females from the three different depth ranges is shown in Figure 2. The ANCOVA yielded that the fecundity was not dependent on depth (slopes $F = 0.811$, $P>0.05$; intercepts $F = 0.775$, $P>0.05$).

Egg volume/female size

Egg volume data collected from different depths (Table 1) were analysed to verify whether egg volume varied with female size. Mean egg volume was independent of Norway lobster size in all areas (A, r = -0.046; B, r = 0.027 and C, r = -0.072, not significant). By pooling the values obtained in the three

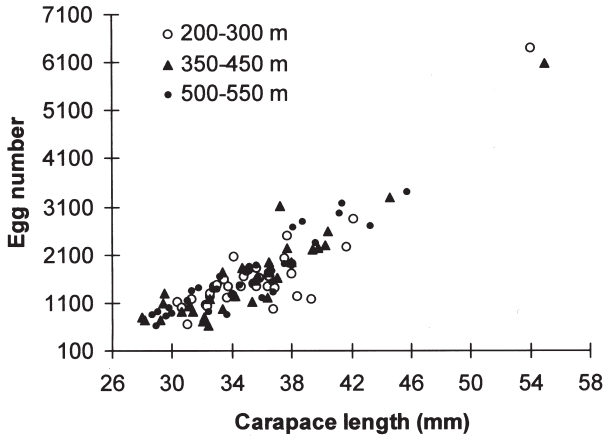

FIG. 2. – Relationship between carapace length and number of newly spawned eggs of female *Nephrops norvegicus* from three different depths.

TABLE 1. – Mean volume of newly spawned egg (with standard deviation in parentheses) of female *Nephrops norvegicus* from three different depth ranges.

Depth ranges	Number ovigerous females	size range CL (mm)	Number examined eggs	Mean egg volume (mm^3)
200-300 m	13	30-54	130	1.553 (0.385)
350-450 m	15	28-55	150	1.569 (0.192)
500-550 m	16	29-46	160	1.409 (0.230)

TABLE 2. – Comparisons (Games and Howell method) among samples of mean egg volume of females from three different depth ranges: A (200-300 m); B (350-450 m); C (500-550m).*: $P<0.05$; ns: not significant.

Comparison among depth	Diff.	Q	P- level ($Q_{0.05\,(3,\infty)} = 3.314$)
C vs. A	0.144	3.752	*
C vs. B	0.160	6.670	*
A vs. B	0.016	0.429	ns

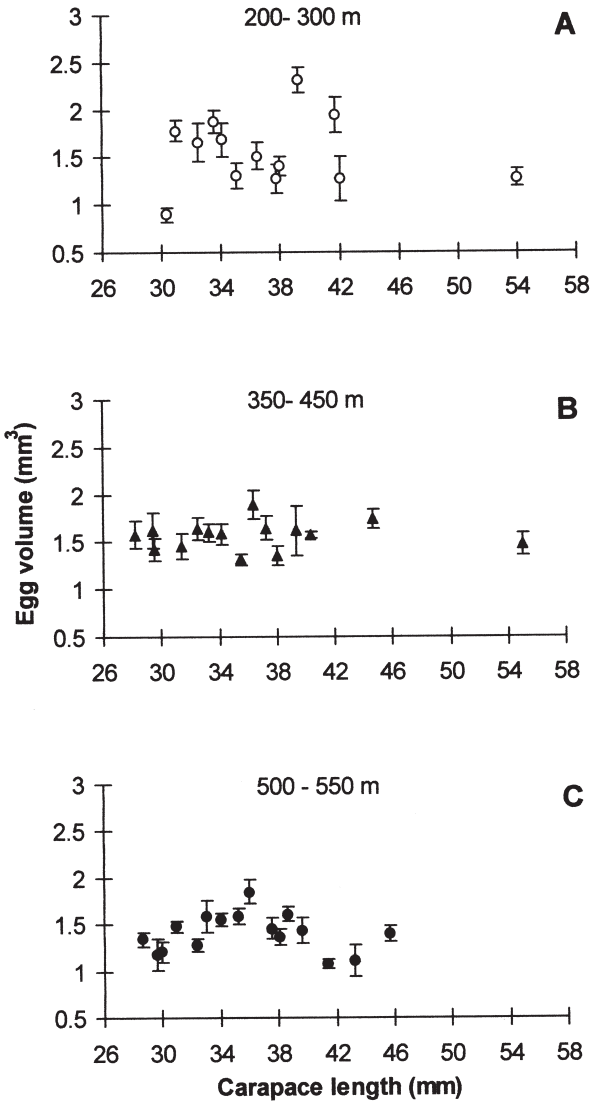

FIG. 3. – Relationship between carapace length and volume (mean ± SD) of newly spawned eggs of female *Nephrops norvegicus* from three different depths.

areas, the regression analyses yielded that egg volume did not vary with female size (r=0.004, df= 43; not significant).

Egg volume/depth

Mean egg volumes from female Norway lobsters taken from three different depth ranges are presented in Figure 3. The mean egg volume decreased from females collected in the shallowest areas A and B to the deeper area C (Table 2). As the variances of the egg volume from the three different depth ranges were heterogeneous ($\chi^2 = 85.08$, $P<0.05$), a test of equality of means (Games and Howell method, in Sokal and Rohlf, 1981) was carried out. It yielded that the mean egg volume from area C differed significantly from areas A and B, which did not differ significantly from each other (Table 2).

DISCUSSION

The results of this study support the view that Norway lobsters from the shallowest areas A and B (200-300 and 350-450 m) and the deeper area C (500-550 m) of the northern Tyrrhenian Sea should be treated as a single spawning population, given that their fecundities were similar. Further, it has been shown that individual egg volume did not decline significantly with female size. Instead, the

egg volume was found to differ between depths. This implies that the egg number-weight relationship seen at one depth cannot be used for predicting egg numbers for populations from other depths. Therefore, the egg dry weight/uneyed egg number relationship estimated by Mori e*t al*. (1998b) for *N. norvegicus* from 200 to 450 m depth off the northern Tyrrhenian Sea may only be used for predicting egg number for females inhabiting this depth range.

Thomas (1964) found that the mean diameter of the eggs differed between localities. However, such a pattern is comprehensible for populations inhabiting far away localities, as investigated by Thomas, and not nearby localities like those examined in this work. According to Raven (1961), the size of the eggs produced by a species is under genetic control, but it is also in part phenotypically determined. Therefore, site differences in terms of temperature, population structure, food availability and the actual nature of the environment may all be causative factors for the egg size. Unfortunately, the general hydrology and water mass circulation of the northern Tyrrhenian Sea is poorly known (Sardà, 1998). Temperature below 180 m depth is almost constant throughout the year at about 13.5°C (Aliverti *et al.,* 1968), so this does not seem to be a causative factor for the observed differences in the egg size of Norway lobster. Also, the population structure does not seem to be a causative factor, since the mean size and sex ratio of *N. norvegicus* in area C are not significantly different from those in the other two areas throughout the year, but only in some months (data in progress). On the other hand, it is possible that there is a different food availability in the three areas. Actually, in the Mediterranean, *N. norvegicus* is both an euriphagous and non-selective species, consuming a great variety of crustaceans, fish and molluscs, and an active predator or scavenger (Lagardère, 1977; Gual-Frau and Gallardo-Cabello, 1988; Sardà and Valladares, 1990; Mytilineou *et al*., 1992; Cristo and Cartes, 1998). In specimens collected at 150 m depth in the Catalan Sea, Gual-Frau and Gallardo-Cabello (1988) found a greater active feeding and higher diet diversity index than those caught at 300 m. In the Mediterranean, the diet of the Norway lobster does not differ geographically or seasonally (Cristo and Cartes, 1998). Thus, it is possible that the deeper area C has less food available than the shallower areas A and B. It is known from the literature that the condition of food available to mature females may directly influence reproductive characteristics such as fecundity and egg size in various organisms (Kaplan, 1987; Qian and Chia, 1991; Chester, 1996). However, further investigations performed over more years and sampling of ovigerous female *N. norvegicus* from different depth ranges and areas are required to enhance the accuracy of knowledge about this aspect.

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