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SHORT PAPER

Some Preliminary Data about Reproductive Activity of Female of *Nephrops norvegicus* (Linnaeus, 1758), in the South Adriatic Sea (Montenegro)

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Abstract

This study was conducted to determine the first maturity size of females of Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758). Sampling was carried out by commercial trawl in Montenegrin territorial waters (South Adriatic Sea) between summer 2009 and summer 2011 at the depths of 40-350 m. Carapace length of all collected specimen was ranged from 20 to 58 mm CL. The overall females -males sex ratio was 1.4:1. The proportion of mature females in the catch increased from spring to the summer months. The highest number of berried females (with external eggs) was in October. The size at which 50% of the female population reached maturity was 23.74 mm carapace length (CL).

Keywords: Norway lobster, size at first maturity, Montenegrin territorial waters.

Introduction

Nephrops norvegicus occurs on muddy sea bed on the continental shelves and upper slopes of the Northeast Atlantic and Mediterranean (Fariña and González Herraiz, 2003). In the Adriatic Sea, this species could be found in the entire Adriatic Sea but the highest population density was recorded in the open middle Adriatic and primarily in the deepest parts of Jabuka Pit area (Vrgoč *et al*., 2005).

Despite its high commercial value, the data about this species in the Montenegrin territorial waters are very scarce and focused mainly on its distribution (Merker-Poček, 1972; Kasalica *et al*., 2011). In Montenegro, this species is mainly targeted by bottom trawls and by baited traps but in lesser degree. The Montenegrin trawling fleet is consists of 22 trawlers, of which only 4 exceed 24 m in overall length. As a result of their age (average age is 39.5 years) and the poor state of their equipment, the fishing activities of these vessels are restricted to inshore waters. Most of the trawling activity carries out in the area from Budva to Bar, on muddy and sandy sea beds, at depths ranging between 40 and 250 m. Only a few fishing vessels have the capacity to be active offshore. It is worth noting that there is no fishing activity outside the 12 Nautical Miles limit. This is the main reason why we have very limited information about this species in our waters.

The aim of this study was to obtain some aspects of reproductive activity of Norway lobster for the first time in Montenegrin waters: the size at first sexual maturity (L_{50}) of females, stages of maturity of females as well as sex ratio.

Material and Methods

Individuals of Norway lobster were collected seasonally from summer 2009 to summer 2011 on the Montenegrin shelf and the upper part of the continental slope. Individuals were caught during the bottom trawl survey carried out at a depths ranging between 40 and 350 m. A total of 80 valid hauls were performed, during daylight hours and in stable weather and sea conditions. The trawl survey was conducted in the framework of the National research project "The biological resources, edible and inedible, in the trawl fishery on the Montenegrin coast". Tows were performed on ten sampling stations according to depth stratum (Figure 1). Among ten stations, seven stations were on continental shelf, on depths less than 200 m, where almost the all trawling activity took place in Montenegro. Sampling was conducted by commercial bottom trawler (LOA 21.4 m) equipped with a 40 mm stretched diamond-shaped mesh-size cod-end. The haul duration is fixed at 30 minutes on depths less than 200 m and at 60 minutes at depths more than 200 m.

A total of 744 individualsof *N. norvegicus* were examined on the vessel. Sex was determined and gonad maturity stage of females was assessed. All sampled individuals were sorted according to the sex by checking the external genital organs. Carapace length (CL), which was adopted as the standard length in this investigation, was measured as the distance from the postorbital margin to the mid-dorsal posterior edge of the carapace.

The sex ratio was estimated as the ratio of females to total number of sexed animals. Statistically significant differences in the sex ratio were tested by the chi-square (χ^2) test ($p < 0.05$) (Sokal and Rohlf, 1995). The ovaries, exposed after cutting the carapace, were examined on vessel in the fresh condition and classified into seven stages of development according to their macroscopic characteristics and colour following the MEDITS Codes of sexual maturity for Crustaceans (Bertrand *et al*., 2007) (Table 1). Maturity of samples were estimated using a non-linear regression of the proportion of all developing and mature females over carapace length, weighted by the number of individuals in each length class (Silva, 2009). Berried females, immediatelly after the measurement were returned to sea.

The size at which 50 % of the females reached maturity was estimated using a logistic equation (1):

$$p_i = 1/\left(1+\exp\left[-\left(a+b*CL\right)\right]\right) \rightarrow \ln\left[p_i/\left(1-p_i\right)\right] = a+b*CL \quad (1)$$

Where $p_i$is the percentage of mature specimens in the size interval *i*; CL is the carapace length (mm), and *a* and *b* are the constants (Echeverria, 1987).The size at which 50% of the females reaches sexual maturity was obtained from the ratio between the parameters calculated in CL = − (a/b) (Oh and Hartnoll, 1999).

Results

During the survey,theNorway lobsterwas foundonlyontwo sampling stations(number13and 15) which are located at depths of330 to350m, although it wasrecorded at thelower depths, about 170m, but in a verysmall number(oneortwoindividuals).

Total of 744 individuals of *Nephrops norvegicus* were examined, out of which 431 were females (58%) and 313 were males (42%). The carapace length of all individuals ranged from 20 to 58 mm, with a mean of 33.9 mm ± 6.9. The carapace length of females ranged from 20 to 52 mm, while at males the range was wider, from 22 to 58 mm. The mean value of the females' carapace length (31.8 mm ± 5.2) was smaller than the mean value of the males' carapace length (36.6 mm ± 7.7).The overall sex ratio was calculated

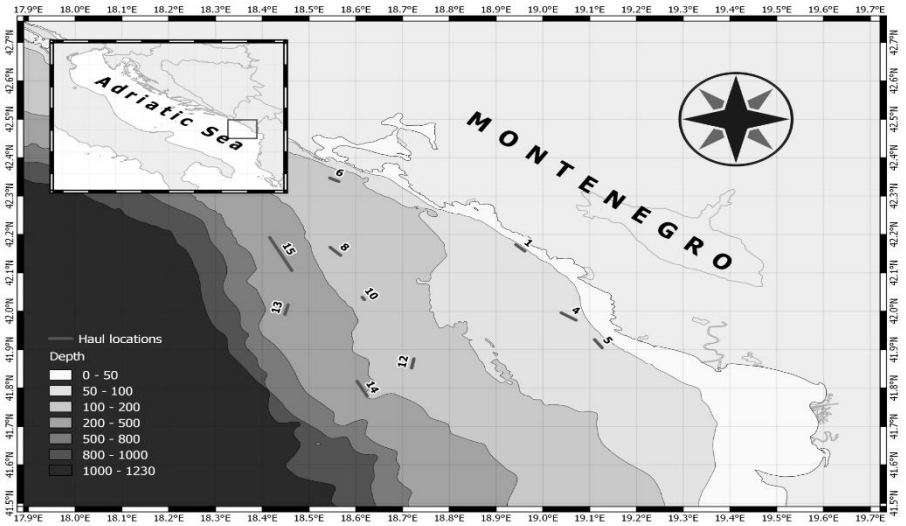

Figure 1. Map of the investigated area with sampling stations.

Table 1. MEDITS Codes of sexual maturity for Crustaceans – *Nephrops norvegicus*

Colouring of Fresh Ovary	Maturation State	Stage
Whitish or translucent	Immature = virgin	1
Cream	Virgin developing	2a
Cream	Recovering	2b
Light green	Maturing or almost mature	2c
Dark gray	Mature	2d
Uncolored	Resting adult	2e
	Berried	3

as 1.4 females:males. This ratio was found significantly different from the expected value of 1:1 (χ^2=20.66, P<0.05). Sex ratio is showed seasonal variations (Table 2). Proportion of females was only lower in autumn period. Females dominated at smaller length classes, in length class 36 mm CL sex ratio was almost equal and at greater lengths males were dominant sex. At lengths greater than 48 mm CL almost all individuals were male.

The size at first maturity, estimated using the formula provided by Echeverria (1987), was 25.7 mm CL, while the values of $L_{25\%}$ and $L_{75\%}$ were 23.4 mm and 28.1 mm, respectively (Figure 2). Mature females with light green ovaries (2c stage) were predominant in spring while females with dark green ovaries were predominant in summer. In autumn there was a maximum of berried females. In October almost all sample (89%) was consisted of that mature females. The smallest berried female measured 29 mm carapace length, and the largest 52 mm carapace e length.

Minimum landing size for this species in the Montenegro is 100 mm of total length. This is not identical to value prescribed by EU regulation. According to Council Regulation (EC) No. 1967/2006 minimum size for *N. norvegicus* is 70 mm total length or 20 mm carapace length. In our case, we did not have individuals below MLS in total catch. Proportion of female juvenile individuals below the length at sexual maturity was 9.6%.

Discussion

The Norway lobster is one of the most important commercial crustaceans in Europe. In the Adriatic Sea, *N. norvegicus* ranks first of all crustacean species exploited in terms of value, and second in terms of weight, with a decreasing trend in catches since 1993 (Vrgoč*et al.*, 2004). The western Adriatic Sea trawling grounds have been classified as fully exploited to over exploited with respect to *Nephrops* (Sardà, 1998). Due to old and obsolete Montenegro trawl fleet, as well as their activity in shallow waters (< 200 m) catch of this species is not high in Montenegro waters.According to the present study the individuals of Norway lobster were caught mainly in upper continental slope, between 330 and 350 m, in the Montenegrin territorial waters (south Adriatic Sea). Maximum carapace length for females and males was 52 mm and 58 mm CL, respectively. Along the Turkish coast of the Aegean Sea, Aydin and Aydin (2011) reported smaller maximum length of 42.3 mm CL for females and 49.4 mm CL for males. Our findings are in line with Bianchini (1998) who reported maximum length for females of 51 mm CL but different from data collected during investigations conducted in a framework of DemMon 2003 project (Vrgoč *et al.*, 2005) where females reached 71 mm CL as well as 68 mm CL in Swedish west coast (Ulmestrand and Eggert, 2001). The results obtained show that, on average, males were larger than females which is in accordance with data found in other

Table 2. Sex ratio according to season in total sample (2009–2011)

Season	Sex ratio (F: M)	χ^2	p
Spring	1,8 : 1	7.682	<0.05
Summer	1,2 : 1	1.83	NS
Autumn	1 : 1,2	0.156	NS
Winter	1,9 : 1	10.24	<0.05

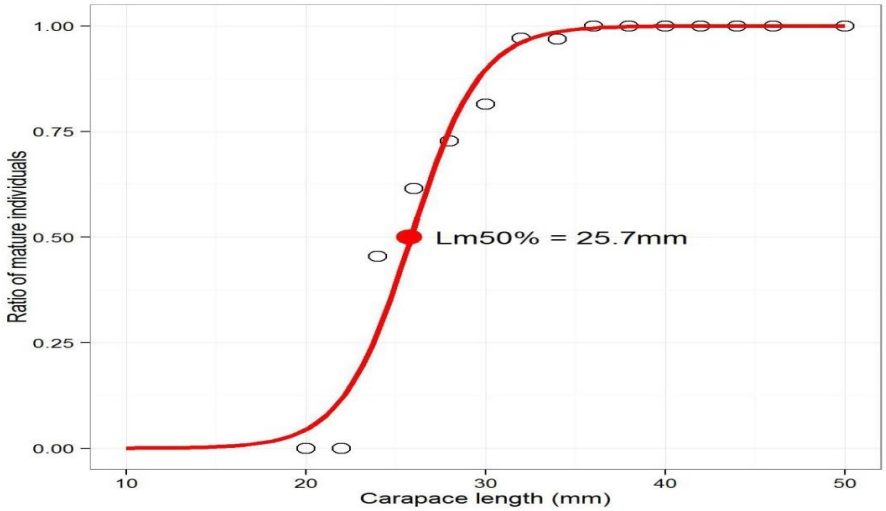

Figure 2. Length of first maturity of Nephrops norvegicus females**.**

Mediterranean areas.

The mean value of the carapace length of all individuals was 33.9 mm CL. In our study, the mean CL measurement of the caught individuals was larger than in some studies carried out in other Mediterranean areas. Mean CL for specimen collected during the investigations conducted in Croatia waters (central and south Adriatic) in framework of PHARE 2005 project was 26.3 mm CL which is in line with Aydin and Aydin (2011) data (28.5 mm CL) reported for the international waters of the middle Aegean Sea. These variations could be due to sample size, methodology of sampling or environmental conditions as well as differing states of exploitation (Sarda, 1998).

The sex ratio is in favor of females. Concerning the seasons, the sex ratio changes through the seasons and is also in favor of females except in autumn when they are berried. For that season, the sex ratio was about 1:1.2, which is not significantly different from the expected value of 1:1 (χ^2=0.156, P=0.693). A seasonal fluctuation in the sex ratio of commercial catches suggests that females do not emerge from their burrows when berried. During this period females are less active and spend most of the time hiding in their burrows (Chapman, 1980). Figueiredo and Thomas (1967) reported the sex ratio varies seasonally because of the lower availability of berried females as compared with no berried females and males and Rice and Chapman (1971) as well as Farmer (1975) stated that fluctuations in the sex ratio have usually been attributed to inhibition of burrow emergence by berried females. The percentage of females in the catch is lowest during the period between spawning and hatching which is not in accordance with our results. Concerning that females mainly predominated in all seasons during the sampling period, except in Autumn, we can agree with Aguzzi *et al.* (2007) conclusions who suggest that feeding, burrow emergence, and endogenous locomotion rhythms are not inhibited in berried females so they constitute important part of commercial catch as well as non-berried females and males.

The prevalence of females with mature ovaries in spring and summer months is in agreement with the reproductive period reported for the Adriatic and Mediterranean. Orsi Relini *et al.* (1998) and Lampri *et al*. (2015) stated that the proportion of females with the mature ovaries was highest in June and July in Adriatic and in Central Aegean Sea, respectively, which is in accordance with our study. Berried females were mostly found in October as Orsi Relini *et al*. (1998) reported for the Adriatic while Bianchini *et al.* (1998) reported presence of berried females in summer and autumn in almost equal proportions in the Central Mediterranean Sea (Strait of Sicily). These authors used Farmer's (1974) maturity scale, where females with stage 3 (pale-green ovaries) correspond to 2c stage defined by the MEDITS scale and females with stage 4 (dark-green ovaries) correspond to 2d stage defined by the MEDITS scale.

The size at sexual maturity of *N. norvegicus* (25.7 mm CL) is smaller than the size (30 mm CL) reported for the Algarve, Catalan and Adriatic Seas, for the Ligurian and Tyrrhenian Seas (32 mm CL) and for the Alboran Sea (36 mm CL) (Orsi Relini *et al*., 1998). Minimum size for the ovigerous female was 29 mm CL which is bigger compared to the smallest ovigerous female (< 27 mm CL) found in the previous mentioned seas. These differences might be ascribed to geographical differences, as well as to the different estimation methods applied. Our result was comparable to those reported by Froglia and Gramitto (1979) in Pomo/Jabuka pit area (25.9 mm CL), Marano *et al*. (1998) in the SW Adriatic (25 mm CL), Ungaro *et al*. (1999) in Southern Adriatic Sea (27.5 mm CL) as well as Fariña and Gonzáles Herraiz (2003) for West Galicia and North Portugal (26 mm CL).

According to Jewett *et al*. (1985) size at first sexual maturity of crustaceans is required for the determination of a minimum commercial exploitation size. MLS for this species in the Montenegro is 10 cm of total length. This is not identical to value prescribed by EU regulation. According to that regulation MLS for *N. norvegicus* is 7 cm total length or 2 cm carapace length. Proportion of female individuals below length of first maturity was 9.55% while no one individual was below MLS in total catch. According to Vrgoč *et al.* (2005) this proportion can depend on season and fishing area. The same authors claimed that Norway lobster population in the Adriatic Sea is in typical overexploitation state and according to results of MEDITS expedition, trends in biomass indices of *N. norvegicus* in territorial sea of the Republic Croatia show significant negative trends. This unfavorable situation is not recorded for the population of *N. norvegicus* in Montenegrin territorial waters

Conclusions

Despite the significant number of studies on Norway lobster, little is known regarding the biology as well as reproductive activity of *Nephrops norvegicus* along the Montenegrin coast. The present results indicate that the reproductive pattern of Norway lobster from Montenegrin territorial waters follow the general scheme reported for the species.

The sustained exploitation of any marine living population requires some management procedures. From this study we can conclude that stocks of *N. norvegicus* in Montenegrin waters are unexplored and many research must be taken in order to estimate its level of exploitation and the state of stocks.

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