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SHORT PAPER

A Rare Pelagic Cephalopod *Ocythoe tuberculata* (Octopoda: Argonautoidea): The Record Fecundity for Octopoda and New Data on Morphometry

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Abstract

Two adult female of *Ocythoe tuberculata* were caught in April 2002 (Mantle length, ML=285 mm) and in May 2003 (ML= 335 mm) in Izmir Bay, Aegean Sea the second one being the biggest individual ever found in all oceans as well as it had the highest known fecundity for the entire order Octopoda – around one million. Relations between mantle length (ML) to total weight (TW) was calculated as $TW=0.0061*ML^{2.231}$, and to lower hood length (LHL) was as ML= 18.85*LHL-31.633. For this species relation between mantle length body weight and beak measurements were calculated for the first time using our unpublished and literature data.

Keywords: *Ocythoe tuberculata*, beak, fecundity.

Nadir Rastlanan Bir Pelajik Ahtapot *Ocythoe tuberculata* (Octopoda: Argonautoidea): Ahtapotların Yumurta Verimliliği ve Morfometrisi Üzerine Yeni Kayıtlar

Özet

Ege Denizi'nde *Ocythoe tuberculata'ya* ait Nisan 2002 de Manto boyu ML=285 mm ve Mayıs 2003 de ML=335 mm olan iki adet olgun dişi birey elde edilmiştir. Manto boyu 335 mm olan dişi birey tüm denizlerde ve okyanuslarda bugüne kadar rapor edilen en büyük *O. tuberculata* bireyi olup, aynı zamanda yaklaşık bir milyon yumurta verimliliği ile Octopoda Ordosuna ait tüm türler içerisinde bu güne kadar rapor edilen en yüksek yumurtlama verimliliğine sahip bireydir. *O. tuberculata* için elimizde daha önceden rapor edilmemiş bireyler ile literatürdeki daha önce rapor edilen bireyler de bir araya getirilerek oluşturulan ML ve total ağırlık (TW) ilişkisi ($TW=0,0061*ML^{2,231}$) ve dişlere ait alt diş başlık boyu (LHL) ile manto boyu ilişkisi (ML= 18,85*LHL-31,633) hesaplanarak bu çalışmada ilk kez rapor edilmektedir.

Anahtar Kelimeler: *Ocythoe tuberculata*, alt diş, verimlilik.

Introduction

Ocythoe tuberculata (Rafinesque, 1814) is a representative of a monotypic family Ocythoidae – exotic pelagic octopod family with true swim bladder. It inhabits surface waters from temperate to tropical waters (Roper and Sweeney, 1975; Roper *et al*., 1984) and is one of the few known cephalopods with a true swimbladder allowing it to achieve neutral buoyancy (Packard and Wurtz, 1994). Earlier studies on biology of *O. tuberculata* in the Mediterranean were conducted by Jatta (1896) and Naef (1923).

This species was reported in the stomach contents of some abundant marine predators: sharks, tunas, swordfish, seals and (Clarke, 1986; Bello, 1991, 1996; Lansdell and Young, 2007). It makes important to calculate relation between beak length and octopus length which is absent because of paucity of wild-captured animals. The first evidence of the embryonic development of this species was given by Naef's (1928). However, his study didn't include description the entire consequence of embryonic stages, and in further studies, only embryonic phases of the eggs in the oviduct of *O. tuberculata* were reported (Laptikhovsky and Salman, 2003; Tutman *et al*., 2008). This study, it is aimed to contribute in knowledge of reproductive biology of this rare species as well as eventually to provide a relation between beak and body length (weight) using entire existing data set.

Materials and Methods

Two females of *O. tuberculata* were purchased on the fish wholesale market in İzmir, Aegean Sea. One of them was sampled in 19 April 2002 (Mantle length, ML= 285 mm) and the second one in 05 May 2003 (ML= 335 mm). The samples were fixed in 10% formalin solution. ML was measured to the nearest 1 mm and body weight to the nearest 1 g. After several years of storage, the animals were dissected in the laboratory to investigate their reproductive biology. Gonads were removed and weighed nearest 0.1 g. Ten sub samples from the different parts of gonad (0.015-0.030 mg) and five sub samples from the oviduct (0.3-0.4 mg) were taken separately, weighed and then counted. Then, potential fecundity (PF) was calculated gravimetrically. All fertilized eggs in the oviduct and ovarian oocytes were measured by major axis under micrometric ocular nearest 0.01 mm. Stages of embryonic development were assigned according to Naef (1928). The beaks were removed and measured under the microscope (nearest 0.01 mm) in order to calculate the correlations between the lower hood length (LHL) and mantle length (ML) according Clarke (1986). In addition to these beaks from the samples, one more beak from an animal fixed earlier by Katagan and Kocataş (1990) was measured.

Results

Morphometry

Morphometric data of the female individuals with ML of 285 and 335 mm from this study were combined with the data on 16 individuals of *O. tuberculata* reported in previous studies (Sanchez, 1980; Clarke, 1986; Corsini and Lefkaditou, 1995; Cardoso and Paredes, 1998; Lefkaditou and Kallianiotis, 2006; Tutman *et al*., 2008) and their morphometric and weight measurements (Table 1, Figure 1). Growth in weight was characterized by negative allometry in respect to the ML (Figure 1). The correlations between the lower hood length (LHL) and mantle length (ML) was ML= 18.85*LHL-31.633 (r=0.81; N=15).

Fecundity and Spawning Pattern

The ovary of the smaller mature female (ML= 285 mm) weighed 215.9 g and represented 5.4% of the body weight. It contained about 584,583±119,116 oocytes. Oocyte size in the gonad varied between 0.1 and 3.7 mm with oocytes of 0.5-0.7 mm predominating (Figure 2). The oviduct contained about 176,862±19,247 mature eggs of 2.2-2.6 mm. It was 434.2 g (10.9% BW) in weight. Thus the PF of this individual was about 761,445. The eggs in the proximal section of the oviduct were freshly fertilized, whereas and those in the distal section were at the stage VI according to Naef (1928). The gonad of the second individual (ML 335 mm), was 83.3 g (1.6 %BW) in weight, and contained 967,530 ± 286,333 oocytes. Oocyte size varied between 0.1 and 3.1 mm and with oocytes of 0.4-0.6 mm predominating as in the previous animal. The oviduct of the same individual, contained 207,974 ± 45,916 eggs, and weighed 569.6 g (11.3 % BW). The calculated PF was around 1,175,000. Eggs in the oviduct were between 2.4 and 2.6 mm. When the oocytes in the gonads were examined according to the phases of maturity, fully mature oocytes were oval in shape but the immature ones were pointed in one end (Figure 3B, C). The eggs in the oviduct were free of follicles and transparent with oval in shape (Figure 3A).

Apart from the freshly fertilized eggs in the proximal cavity of the oviduct, the ones in the distal cavity of the oviduct were at phase XII, according to Naef (1928) (Figure 4). Egg weights in the oviducts of both females were between 0.00211 and 0.00307 g.

Discussion

The oviduct of the individual reported by Naef (1923) from Western Mediterranean contained 100,000 eggs and was recorded as the highest number of eggs in the oviduct of an individual of this species so far. Since Naef (1923) didn't give the egg count in the gonad, there is no information for PF of the subject individual. The PF for one of the largest individuals (310 mm) reported by Roper and Sweeney (1975) was estimated as 104,000. Laptikhovsky and Salman (2003) reported 28,000 eggs in the oviduct of an individual with 170 mm ML (PF was around 200,000). Tutman *et al.* (2008) reported egg counts in the oviducts of two individuals with 178mm and 202mm ML as 21,000 and 25,000 respectively and their PF estimates were 178,000 and 220,000. Number of eggs in the oviducts and PFs of the females reported in this study were much higher than ever found in this species, likely because of larger size.

In this study, the reason of estimated average PF's high STD values was that the subsamples which were taken from different parts of the gonad, oocyte diameters varied. Also, because the size distribution of the oviduct eggs is less than size distribution of the gonad oocytes it is the reason low STD values (Fig 2). When the gonads egg diameter distributions were examined every diameter of egg and maturity stage was present (Figure 2). Rocha *et al*. (2001) describe this condition as asynchronous gonad structure. Because *O. tuberculata* lay egg batches continuously during most of its adult life as other pelagic octopuses do, as Rocha *et al.* (2001) and Laptikhovsky and Salman (2003) has reported, this species should be considered as a "continous spawner" Additionally, the specimen, which has 335 mm ML and smaller gonadal weight, has a greater PF value than those of

Table 1. Some biological and morphometric parameters belonging to *O. tuberculata* individuals

ML (mm)	BW (g)	ST	GW (g)	OW (g)	GN	OWN	PF	UCL (mm)	UHL (mm)	LCL (mm)	LHL (mm)	Locality	Source
-	-	V	-	-	-	100000	100000	-	-	-	-	Mediterranean	Naef, 1923
115	-	-	-	-	-	-	-	-	-	-	-	Blannes, Western Mediterranean	Morales, 1958
230	-	-	-	-	-	-	-	-	-	-	-	Castellon, Western Mediterranean	
310	-	-	-	-	-	-	104000	-	-	-	-	Southern Australia	Roper & Sweeney, 1975
290	2794	-	-	-	-	-	-	36.6	21.7	21.6	14.6	Western Mediterranean	Sanchez, 1980
210	1740											Western Mediterranean	Biagi, 1980
95	-	-	-	-	-	-	-	-	-	13.0	7.6	California, Pacific Ocean	Clarke 1986
This sample was dissected later study by Laptikhovsky & Salman, (2003)													Katagan & Kocataş, 1990
20	-	-	-	-	-	-	-	-	-	4.3	2.7	South Africa	Smale *et al*., 1993
185	765	-	-	-	-	-	-	-	15.6	17.5	11.4	Aegean Sea, Mediterranean	Corsini & Lefkaditou, 1995
260	4300	-	-	-	-	-	-	40.2	22.9	29.8	18.9		
290	3250	-	-	-	-	-	-	-	-	-	-		
66	-	I	-	-	-	-	-	12.4	7.3	10.2	5.2	Peru, Pacific Ocean	Cardosa & Paredes, 1998
105	-	V	-	-	-	-	-	-	-	-	-		
170	1458	V	73.15	78.13	170000	28000	198000	29.0*	18.4*	22.6*	11.8*	Aegean Sea, Mediterranean	Laptikhovsky & Salman 2003
210	1032	IV	36	-	-	-	-	-	16.1	-	10.6	Aegean Sea Mediterranean	Lefkaditou & Kallianiotis, 2006
249	2212	IV	261	-	-	-	-	33.2	16.3	-	14.6		
305	3387	V	388	-	-	-	-	34.2	21.4	-	15.4		
245	2700	V	329	-	-	-	-	-	-	-	-		
190	1500	-	-	-	-	-	60000	-	-	-	-	Sea of Japan, Pacific Ocean	Honma *et al*., 2007
188	708	-	-	-	-	-	-	-	-	-	-	North-East Atlantic	Caballero *et al*., 2009
245	1929	-	-	-	-	-	-	-	-	-	-		
77	172	I	-	-	-	-	-	18.47	10.22	14.04	7.28	Adriatic Sea, Mediterraean	Tutman *et al*., 2008
178	1006	V	35.81	-	157000	21000	178000	26.23	15.91	20.11	11.74		
202	1458	V	125,5	-	173000	25000	220000	27.77	17.25	21.26	12.35		
285	4000	V	215	434	584583	176862	761445	36.0	20.9	32.6	15.6	Aegean Sea, Mediterranean	Present Study
335	5060	V	83	569	967530	207974	1175504	37.9	23.2	34.7B	19.8		

*reported for the first time in this study.

(ML:Mantle length; BW:Body weight; ST:Gonad Stage; GW:Gonad weight; OW:Oviduct weight; GN:Gonad egg number; OWN:Oviduct egg number; PF:Potential fecundity; UCL:Upper crest length; UHL:Upper Hood length; LCL:Lower Crest length; LHL:Lower hood length).

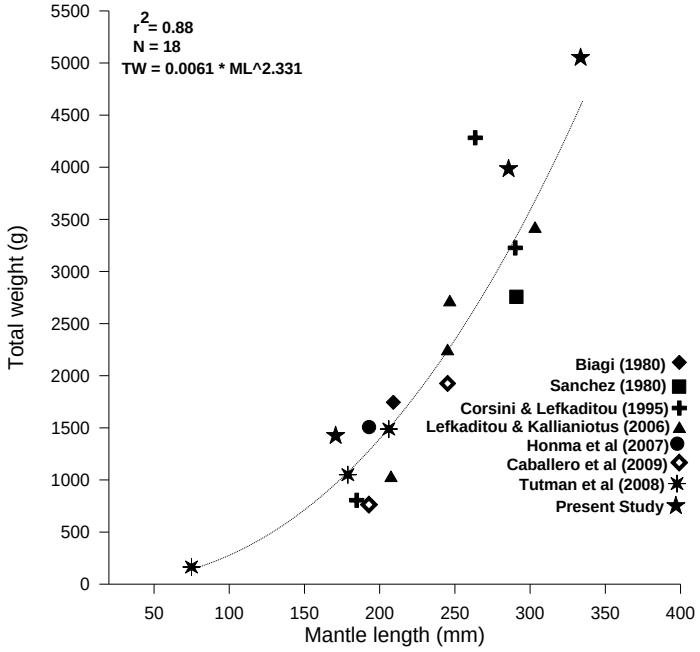

Figure 1. Relation between the mantle length and weight of *O. tuberculata*.

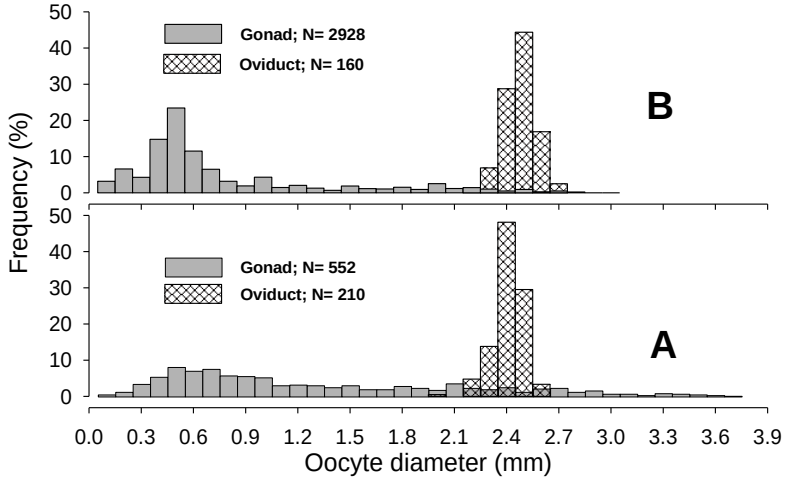

Figure 2. The size frequency distribution of eggs located in *O. tuberculata*, gonad and oviduct (A: 295 mm ML sized individual; B 335 mm ML sized individual; N Number of oocyte).

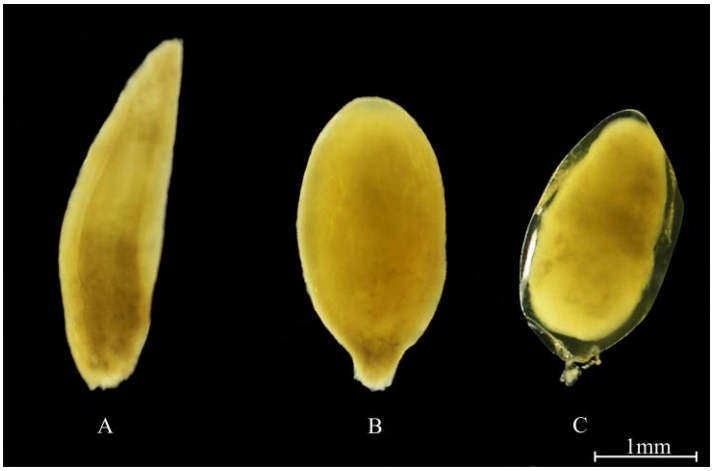

Figure 3. Vitellogenic eggs partaking in *O. tuberculata* (A, B) and fertilized egg passed to oviduct (C).

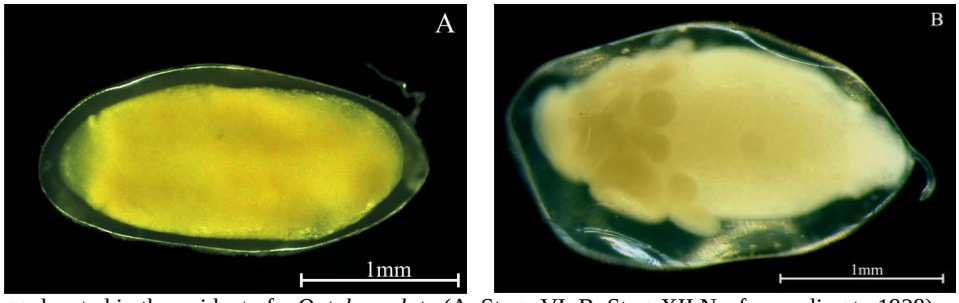

Figure 4. Eggs located in the oviduct of a *O. tuberculata* (A: Stage VI; B: StageXII Naef according to 1928)

specimens which have heavier gonadal weight. The reason of calculated higher PF value can be explained as the ratio of small-sized oocytes in gonad is higher than that of the other specimen reported in this study (Figure 2). Actually, the largest specimen with its fecundity around one million was a record breaker among entire order Octopoda. By now the highest fecundities among octopods were recorded in *Octopus vulgaris* 634,445 oocytes (Otero *et al*., 2007) and about 700,000 in *Octopus cyanea* (Van Heukelem, 1983).

In this study the diameters of the mature eggs (between 2.2 and 2.7mm) was similar to that described by Laptikhovsky and Salman (2003) and Tutman *et al*. (2008) for east Mediterranean specimens and much larger than reported from Western Mediterranean (2 mm) by Naef (1923) and from Australian waters (1.75 mm) by Roper and Sweeney (1975).

Naef (1928) investigated the embryonic phases of *O. tuberculata* in only one individual and he reported that in extremely long oviduct which act as a uterus, the eggs are lined up in successive stage, but the progress is not continuous but stepwise, probably due to the mechanisms of fertilization so absolutely complete series could not be obtained even under more favorable conditions. However, to find out the batch fecundity it is necessary to count separately series of stages of embryonic development in the oviduct. Laptikhovsky and Salman (2003) and Tutman *et al*. (2008) reported the embryonic phases of the eggs in the oviduct as V and VI according to Naef (1928). Embryonic phases of this study changes between VI and XII. Although Lefkaditou and Kallianiotis (2006) did not report phases of the eggs in the oviduct in their study, it is obvious from their results that phases of the eggs in their study has been the furthest of all phases reported so far. Since some breakages were experienced while opening the fixed oviduct, a timeline of embryonic development could not be revealed completely. In order to prevent such difficulties in the future, sampled fresh oviducts should be unfolded and dissected before preservation.

As Tutman *et al*. (2008) also stated, adult females were observed on the northern coastal line of Mediterranean between late spring and early autumn, and this latitudinal spawning immigration probably was due to the warming up of waters. In Lefkaditou and Kallianiotis's studies (2006) and this study, the capture time and stages of gonad development phases supported the suggestion of Tutman *et al*. (2008). In addition, Caballero-Alfonso *et al*. (2009) reported that two individuals of *O. tuberculata* were sampled in North-east Atlantic in the summer of 2006 simultaneously to the abnormal increase in water temperature. Therefore we may conclude that limits of the species range of pantropical *Ocythoe tuberculata* are closely related to surface temperatures and fluctuate respectively even in such a narrow in latitudinal aspect water body as the Mediterranean Sea.

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References

Bello, G. 1991. Role of cephalopods in the diet of the swordfish, *Xiphias gladius*, from the eastern Mediterranean Sea. Bulletin of Marine Science, 49: 312-324.

Bello, G. 1996. Teuthophagus predators as collectors of oceanic cephalopods: the case of the Adriatic Sea. Bolletino Malacologico, 32: 71-78.

Biagi, V. 1980. Sul rinvenimento e la cattura di un esemplare vivente di *Ocythoe tuberculata* (RAF.) femmina (Cephalopoda-Octopoda) nelle acque del canale di Piombino. Bolletino Malacologico, 16: 41-52.

Caballero-Alfonso, A., Ganzedo-Lopez, U., Diez-Diez, G. and Castro, J.J. 2009. New record of *Ocythoe tuberculata* (Cephalopoda:Ocythoidae) in the North-east Atlantic related to sea warming. JMBA2 Biodiversity Records – no: 6153.

Cardoso, F. and Paredes, C. 1998. Family Ocythoidae (Cephalopoda:Octopoda) in Peru. Revista Peruana de Biologia, 5:1-9

Clarke, M.R. 1986. A handbook for the identification of cephalopod beaks. Clarendon Press, Oxford, 286 pp.

Corsini, M. and Lefkaditou, E. 1995. Occurrence of *Ocythoe tuberculata* (Cephalopoda: Ocythoidea) in Greek waters. Bolletino Malacologico, 30: 304-310.

Honma, Y., Ushiki, T., Takeda, M. and Nakamura, Y. 2007. Notes on the histology of ovarian eggs of the

epipelagic Octopus *Ocythoe tuberculata* caught off Naoetsu Port, Niigata Prefecture, Sea of Japan. Venus, 65:345-353.

Jatta, G. 1896. Cefalopodi viventi nel Golfo di Napoli (Systematica). Fauna und Flora des Golfes von Neapel, 23:1-264.

Katagan, T. and Kocatas, A. 1990 Note préliminaire sur les Cephalopodes des eaux Turques. CIESM Workshop Monoghraphs, 32: 242 pp.

Lansdell, M. and Young, J. 2007. Pelagic cephalopods from eastern Australia: species composition, horizontal and vertical distribution determined from the diets of pelagic fishes. Reviews in Fish Biology and Fisheries, 17: 125-138. doi: 10.1007/s11160-006-9024-8

Laptikhovsky, V.V. and Salman, A. 2003. On reproductive strategirs of the epipelagic octopods of the superfamily Argonautidea (Cephalopoda: Octopoda). Marine Biology, 142: 321-326.

Laptikhovsky, V., Pereira, J., Salman, A., Arkhipov, A. and Costa, A. 2009. habitat-depence in reproductive strategies of cephalopods and pelagophile fish in the Mediterranean Sea. Bolletino Malacologico, 45: 95-102.

Lefkaditou, E. and Kallianiotis, A. 2006. New findings of female *Ocythoe tuberculata* in the Northeastern Mediterranean. CIAC Symposium, Cephalopod Life Cycles POSTER

Morales, E. 1958. Cefalopodos de Cataluna I. Investigacion Pesquera,Tom. XI:3-32

Naef, A. 1923. Die Cephalopoden (Systematik). Fauna e Flora del Golfo di Napoli, Monograph, 35(1): 1-863.

Naef, A. 1928. Die Cephalopoden (Embryologie). Fauna e Flora del Golfo di Napoli, Monograph, 35(2): 1-357.

Otero, J., González, A.F., Sieiro, M.P. and Guerra, A. 2007. Reproductive cycle and energy allocation of *Octopus vulgaris* in Galician waters, NE Atlantic. Fisheries Research, 85: 122-129. doi: 10.1016/j.fishres.2007.01.007

Packard, A. and Würtz, M. 1994. An octopus, Ocythoe, with a swimbladder and triple jets. Philosophical Transactions of the Royal Society London B, 344: 261-275. doi: 10.1098/rstb.1994.0065

Rocha, F., Guerra, A. and Gonzales, A.F. 2001. A review of reproductive strategies in cephalopods. Biological Review, 76: 291-304. doi: 10.1017/S1464793101005681

Roper, C.F.E. and Sweeney, M.J. 1975. The pelagic octopod *Ocythoe tuberculata* Rafinesque,1814. Bulletin of American Malacological Union, 21-28.

Roper, C.F.E., Sweeney, M.J. and Nauen, C. 1984. Cephalopods of the world. FAO Species catalogue, No.125. Rome,

Sanchez, P. 1980. Nueva cita de *Ocythoe tuberculata* (Raf., 1814) (Cephalopoa: Ocythoidae) en las costas Catalanas. Investigacion Pesquera, 44: 111-117.

Smale, M.J., Clarke, M.R., Klages, N.T.W. and Roeleveld, M.A.C. 1993. Octopod beak identification-Resolution at a regional level (Cephalopoda, Octopoda: Southern Africa). South African Journal of Marine Science, 13: 269-293. doi: 10.2989/025776193784287338

Tutman, P., Sifner, S.K., Dulcic, J., Pallaoro, A., Gavrilovic, A., Dujakovic, J.J. and Glamuzina, B. 2008. A note on the distribution and biology of *Ocythoe tuberculata* (Cephalopoda: Ocythoidae) in the Adriatic Sea. Vie et Milieu, 58: 215-221.

Van Heukelem, W.F. 1983. *Octopus cyanea*. In: P.R. Boyle (Ed.), Cephalopoda lifecycles, Academic Press, London: 267-276.