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The Benthic Exotic Species of the Black Sea: Blood Cockle (*Anadara inaequivalvis*, Bruguiere, 1789: Bivalve) and Rapa Whelk (*Rapana thomasiana*, Crosse, 1861: Mollusc)

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Abstract: The Black Sea is in transition from a freshwater to a marine environment and has a very low biodiversity. Therefore, it appears to be particularly vulnerable and easy target for many exotic species. Anthropogenic introductions of exotic species into the Black Sea began in the 19th century, but accelerated during the second half of the century. There are about 36 kinds of introduced species in Black and Azov seas now and some of them had already severe damage to part or whole ecosystem, while some may have limited or neutral impacts. Current status of two exotic benthic species presented here: Rapa Whelk, *Rapana thomasiana* and blood-cockle, *Anadara inaequivalvis*. Most dramatic changes to benthic ecosystem of the Black Sea has taken place after introduction of predatory gastropod Rapa whelk from Far East (Sea of Japan) to the Black Sea in 1940s and has since spread to the Aegean and Adriatic Seas. The second species blood-cockle is a filtering feeding bivalve introduced 20 years ago, but not so well-known since its invasion ability and impact on ecosystem seems to be not very devastating. Particularly rapid distribution and increased biomass of Rapa Whelk caused severe damage to narrow benthic ecosystem. It has direct (predation on bivalves) and indirect (fishing with dredges) negative impacts on the ecosystem. Annual Rapa whelk catches from Turkey and Bulgaria reached totally 13,000 ton year^{-1}. This study presents updated information on spatial distribution, habitats preferences, population structures, ecological and economical impacts of two exotic species; Rapa whelk and blood-cockle.

Key words: Black Sea, exotic species, invasive species Rapa whelk, *R. thomasiana,* blood cockle, *Anadara inaequivalvis*

INTRODUCTION

The Black Sea was characterized until the mid 1980s as a highly productive ecosystem at all trophic levels. However, the system rapidly degraded during early 1990s due to multi-factor actions including pollution, changes in river discharge, over-fishing, eutrophication, climate change and anthropogenic introduction of exotic species. Accidental or intentional introduction of exotic species into the Black Sea started in the 19th century, but the major impacts were observed during the second half of the current century. The Black Sea, with semi-enclosed brackish water environment and its decreased diversity, has been target of opportunistic invasions by temperate and subtropical species (Siganova, 1998). Among nearly 30 exotic species currently occurring in the Black Sea, 6 had significant impact on its ecosystem and fisheries. These are ctenophore *Mnemiopsis leidy*, the molluscs, *Rapana thomasiana*, *Mya arenaria* and *Anadara inaequivalvis*, crustacean, *Rhithopanopeus harrisi* and the fish *Mugil soiuy*, *M. arenaria* and *R. harrisi* have not widely distributed along the Turkish coast.

Rapa whelk or sea snail, *Rapana thomasiana* (syn., *Rapana venosa*, is originated from the Sea of Japan. It was first recorded from the Black Sea in Novorossick Bay in 1946. It is supposed that like most exotic species it was also carried in ballast waters and introduced (Bilecik, 1975; Duzgunes *et al*., 1988). Since, veliger larvae of sea snail has pelagic larval phase, human activities facilitated transportation and spread of the species (Cesari and Mizan, 1993). The biology (biometric parameters, reproduction and food consumption) (Hou, 1990, 1991), salinity tolerance during the early development stages of the growth (Mann *et al*., 1999) and

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distribution (Rinaldi, 1985; Koutsoubas and Voultsiadou-Koukoura, 1990; Harding, 2003) were studies around the world. Distribution (Bilecik, 1975), assessment of stocks during early 1990 (Duzgunes *et al*., 1992; Prodanov *et al*., 1995), prey and predator relationships (Konsulova, 1992; Savini and Anna, 2006), growth rate (Prodanov *et al*., 1995; Sahin *et al*., 2005) and reproductive characteristics were studied in the Black sea (Emiral, 1997, 2003). The carnivorous Rapa whelk has been considered as an important fisheries source but stocks have been exploited by dredging and exported to Far East countries since it is lack domestic consumption in Turkey. The amount of Whelk production by fishing of Turkey and some countries in Black Sea was given in Table 1 (Emiral, 2003).

Blood-cockle *Anadara inaequivalvis* (Syn. *Anadara cornea* Reev, 1841) is another benthic species introduced into the Black Sea accidentally. It's known that from Arcidae family has been fished intensively in the south-east Asian countries (FAO, 2000; Broom, 1985). It's been determined that the species has a great distribution around the world (Lazzari and Rinaldi, 1981; Boonruang and Fanekarn, 1987; Narasimham, 1988). Various bioecological aspects of the blood-cockle and species from genus *Anadara* have been studied around the world; e.g., growth rate and fishing of *Anadara ovalis* on the Virginia seaside in America (Alexander, 1993), egg productivity and larval growth of *Anadara trapezia* in Australia (Cruz, 1984, 1987; Nell *et al*., 1994), growth, mortality and production of the species of *Anadara granosa, Anadara cornea* (*S. inaequivalvis*), *Anadara modifera* and *Anadara senilis* during reproduction season in India, Malaysia and Senegal (Kayombo, 1993; Debenay and Tack, 1994).

The blood-cockle was transferred from Indo-Pacific region into Adriatic and Aegean and Black Sea through ballast waters during late 1970s. It was first time recorded by Russian scientists on the Bulgaria coasts in 1981 and initial data from the Black Sea and its distribution were published after several years (Zolotaryov *et al*., 1987). Scientific name of the species was accepted as *Anadara cornea* after consultation with British Natural Science Museum (Sahin *et al*., 1999). Currently *S. inaequivalvis* seems to be preferred scientific name for the species (CIESM, 2007). Moreover, growth parameters, age composition, population structure and reproduction period along the north-eastern Black Sea coast of Turkey were studied by Sahin (1999, 2006).

Main objectives of the study are to present updated data on spatial distribution, habitats preferences, population structures, ecological and economical impacts of two exotic species in the Black Sea; Rapa whelk (*R. thomasiana*) and blood-cockle (*A. inaequivalvis*).

Table 1: The amount of *R. venosa* production in coast line countries of Black Sea (ton year^{-1})

	Countries				
Years	Turkey	Bulgarian	Ukraine	Georgia	Russia
1994	2607	3000	5	166	2
1995	1198	3120	303	700	7
1996	2447	3260	376	535	1
1997	2020	4900	476	337	440
1998	4000	4300	369	-	46
1999	3638	3800	619	-	45
2000	2150	3800	913	184	182
2001	2650	3353	395	517	224
2002	6241	698	-	504	56
2003	5500	-	-	-	-
2004	14034	-	-	-	-
2005	12600	-	-	-	-

Distribution and habitat fields: Both Rapa whelk and blood-cockle are Indo-Pacific origin (Fig. 1). They, particularly Rapa whelk, have formed important stocks by adapting the brackish water ecosystem of the Black Sea. Their habitat and preferred environmental variables are quite similar (Lazzari and Rinaldi, 1981; Broom, 1985; Narasimham, 1988; Sahin, 1999).

They have also prey-predator relationships. *A. inaequivalvis* generally prefers places where plankton may be abundant near river mouths and also soft substratum where it can burrow itself easily. Preferred substratum is generally composed of clay and sand.

Rapa whelks are quite active carnivorous species performing seasonal migration. They prefer habitats occupied by bivalve and crustacean species known found both in epifauna (*M. galloprovincialis* vb.) and infauna (*A. inaequivalvis*, *V. gallina*, *Donax* sp.). Therefore, they can be found in soft substratum, rocky areas and other places.

Continental shelf along the Black Sea coast is limited to the north-western and northern regions. It is very narrow along the Anatolian cost with limited soft bottom habitats. In this area blood-cockle can be found at depths of 3-60 m and density increases from 5-25 m, while Rapa whelk occur between 1 and 90 m exhibiting seasonal migration; populating shallow waters <15 m during summer and going down deep waters (>15 m) in winter. Studies showed that they are seen to spread along the coast of the Black Sea in different densities (Sahin, 1999). Both species are also found in Marmara, Aegean and Adriatic Seas (Demir, 1977; Lazzari and Rinaldi, 1981) (Fig. 2).

Population structure: Mean length of Rapa whelk population in the eastern Black Sea was reported as 57.08±0.432 mm and maximum length was 87 mm. The length-weight relation was calculated as $W = 0.00009 \times L^{3.145}$. According to Bhattacharya method,

Fig. 1: *R. thomasiana* (A1-A2) and *A. inaequivalvis* (B)

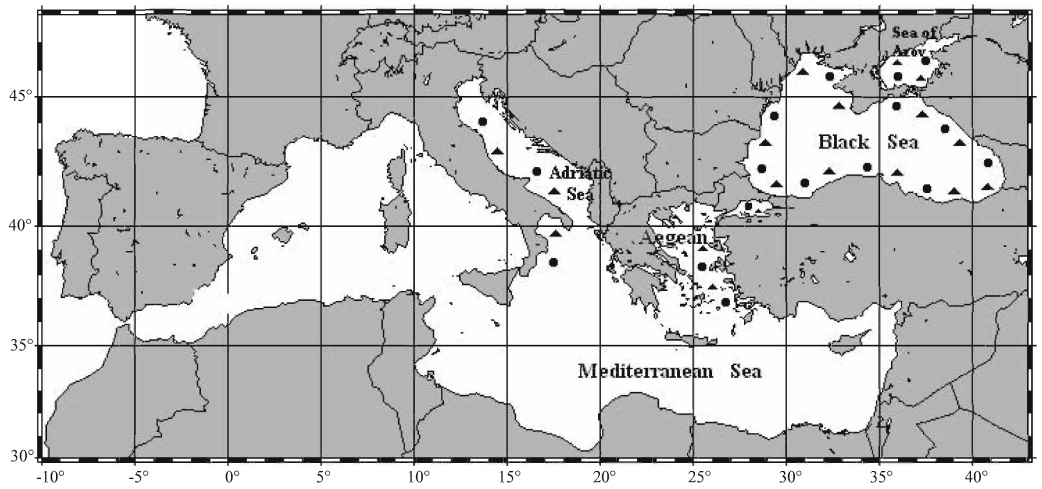

Fig. 2: Distribution of *A. inaequivalvis* (▲) and *R. thomasiana* (•)

age classes ranged between 0 and 5 years, while growth parameters were estimated as L_∞ = 103.97 mm, k = 0.345, t_0 = -0.310 and W_∞ = 213.52 g. Sex ratio (male to female) was 1:1.6 and the smallest matured individual was 32 mm. Spawning in Rapa whelk stock in the Black Sea takes place between June and July and recruitment starts in September (Emiral, 1997, 2003; Sahin *et al*., 2005).

Mean length and weight values of blood-cockle in the eastern Black Sea region were reported as 39.28±0.261 mm and 24.84±0.372 g, respectively. Maximum measured length was 85 mm found at around 15 m on the coast of Giresun. The equation of length-weight relation was calculated as $W = 0.0002 \times L^{3.058}$. The oldest individual was found to be 7 years old. The growth parameters have been estimated as L_∞ = 89.30 mm, k = 0.238, t_0= -0.454 and W_∞ = 166.47 g. Histological studies indicated that the ratio of male to female was almost equal (1.04:1). The size at first maturity was assessed as 20 mm and reproductive period lasts from June to September, while recruitment starts in August (Sahin, 1999; Sahin *et al*., 2006).

DISCUSSION

Carnivorous Rapa whelk was one of most remarkable introductions into Black Sea ecosystem, while bivalve blood-cockle was also significant, but not as effective as

the former (Duzgunes *et al*., 1992; Prodanov and Konsulova, 1995; Emiral, 1997; Sahin, 1999). Both species have found almost ideal living conditions in the Black Sea in terms of abiotic and biotic parameters.

Blood-cockle prefers a substratum structure to hide itself easily and so, it increases its survival and filter feeding. Therefore, they became dense near coasts and river mounts. It is known that *Anadara* sp. can survive in very shallow waters and even when sea water withdraws in tide (Seed, 1975; Morton, 1980; Broom, 1982; Boonruang and Fanekarn, 1987). However, they can be hardly found waters less than 3 m depths in the Black Sea. This is mainly because the substratum in shallow waters of the Black Sea is mostly consisted of gravels and coarse sand particles. The studies indicate that growth performance seems to better in the Black Sea than in other coastal waters and oceans (Sahin, 1999; Sahin *et al*., 1999). For example, lack of competition for space and food is among the major factors for better growth in the Black Sea. The species forms quite dense stocks in particular places where there is no any fishing activity yet. Blood-cockle is not consumed in Turkey, but many people consume it in other counties and future demands may trigger blood-cockle fishing in the Black Sea and it can be a new fisheries resource for coastal communities.

The distribution of Rapa whelk in the Black Sea starts almost from coast line and goes up to 90 m depths. Most dense schools can be found around 30 m, where their major food organisms, bivalves occur (Rinaldi, 1985; Koutsoubas and Koukoura-Koukoura, 1990; Konsulova, 1992; Duzgunes *et al*., 1992; Cesari and Mizan, 1993; Harding, 2003). The species seems to have no substratum preference. It is present on rocky, sandy, clay and similar habitats, due to either continuously searching for food or feeding on existing prey. By doing vertical migration it only goes to certain depths in winter when the seasonal water temperature may drop down 7-9°C (Rinaldi, 1985; Koutsoubas and Koukoura-Koukoura, 1990; Duzgunes *et al*., 1992). In spite of lack of reliable data on age structure of the Black Sea population, according to size distribution and maximum sizes of individuals caught, it is possible to assess that growth performance seems to slower than that of original stocks in Pacific Ocean and Japan Sea (Emiral, 1997). Rapa whelk, which was found in 1962 in Turkish coast first time has formed important commercial stock. It is not consumed in domestic marker, but as a result of demands from the Far Eastern countries, commercial fishing started in 1985. At the beginning mean size of catch was 65 mm; it has decreased to 57 mm since then (Duzgunes *et al*., 1992; Emiral, 1997; Sahin *et al*., 2005). It has been providing important income source particularly for small scale coastal fishermen. Since, the continental shelf of the southeastern Black Sea is very narrow and both its benthic fauna and flora have been affected to a serious extent, fishing for Rapa whelk with dredge has been forbidden and also size (length) limitation has been imposed by considering the first size of maturity. In spite of these limitations, mean size in stocks has continued to decline. This might be due to multiple factors including excessive reproduction and recruitment, lack of natural predators, limited food sources and competition for food. From the ecologically point of view there is no doubt that *R. thomasiana* caused considerable deleterious effects and should be controlled or managed properly. Therefore, recently studies have concentrated on alternative fishing methods and management strategies.

Although, both species can also be considered alternative aquaculture species, it is difficult to expect any development particularly for Rapa whelk due to its feeding habit. Unfortunately, the species is a top predator on the benthic ecosystem of the Black Sea and it is an important disadvantage for the simple food web since there are no any predators, which will form natural balance in the system. This situation affects not only benthic but also pelagic organisms depending benthic to in important extent. Considering the blood-cockle as a candidate for aquaculture its main limitations are the market, suitable site for culture and again natural food source.

Rapa whelk is still accidentally transported and introduced into coastal waters around the world. Recently, it has been introduced and colonized in the Chesapeake Bay Region (USA) (Harding, 2003). Therefore, it has been classified as invader species (Harding, 2003; Mann *et al*., 2006). Althoug, basic studies on these species have been performed in the Black Sea, their distribution and population characteristics haven't been stated in FAO (2000) reports and publications.

CONCLUSION

Currently, the Black Sea ecosystem is accommodating around 30 exotic species from temperate and subtropical waters. These species and their impacts can be classified as benthic and pelagic. These species have been introduced on different times and into different locations. Particularly six of them easily adapted new environment and acted as invaders, had significant impacts not only ecosystem but also regional fisheries. Introduction, distribution and impacts of two molluscs species, Rapa whelk and blood-cockle, are evaluated in this study. Rapa whelk had a major impact on benthic habitats through heavy predation on limited bivalve stocks, while blood-cockle competes with other bivalve species for space and food. Since, adult Rapa whelks have no predator in the Black Sea, over-population controlled through fishing and

source limitations, particularly scaring food sources. There are indications of food limitation for Rapa whelk and decline in mean size. Therefore, particularly Rapa whelk should be closely monitored and developed ecosystem based management plans.

REFERENCES

Alexander, R.R., 1993. Correlation of shape and habit with sediment grain size for selected species of the bivalve *Anadara*, Lethaia, 16: 153-162. DOI: 10.1111/j.1502-3931.1993.tb01807. http://www3.interscience.wiley.com/journal/119294992/abstract.

Bilecik, N., 1975. The distribution of rapana *Thomasiana thomasiana* stick on the ture littoral of the black sea extending from igne ada to Calti Burnu. Rapp. Comm. Int. Mer. Medit., 23 (2): 169-171.

Boonruang, P. and V. Fanekarn, 1987. Distribution density, biomass and population bionics of *Anadara granosa* (L) in relation of environmental factors at sabum bay on the east coast of Pahukent Island. Thai Fish. Gaz., 36: 461-468.

Broom, M.J., 1982. Size selection, consumtion rate and growth of the gastrapods *Natica magolosa* (Lamarck) and *Thais carinifera* (Lamarck) preying on the bivalve *Anadara granosa* (L.). J. Exp. Mar. Biol. Ecol., 56: 213-233. http://dx.doi.org/10.1016/0022-0981(81)90191-X.

Broom, M.J., 1985. The biology and culture of marine bivalve molluscs of the genus Anadara. ICLARM, International Center far Living Aquatic Resources Management, Manila, Philippines. ICLARM Studies and Reviews 12, Contribution No. 263: 37. ISBN: 971-1022-21-4.

Cesari, P. and L. Mizan, 1993. Osservazioni Su *Rapana venosa* (Valenciennes, 1846) in Cattivita (Gastropoda, Muricidae, Thaidinae). BollettIno Museo di Storia Naturalea, 42: 9-21.

CIESM, 2007. Exotic Species Atlas, Vol. 3. http://www.ciesm.org/atlas/appendix3.html.

Cruz, R.A., 1984. Some Aspect of the Reproduction of *Anadara tuberculosa* (Plecypoda: Arcidae) From Punta Morales, Punterenas. Costa Rica Revista de Biologia Trop., 32: 45-50.

Cruz, R.A., 1987. The reproductive Cycle of the Mangrove Cockle *Anadara grandis* (Bivalvia: Arcidae) in Costa Rica, Brenesia, 27: 1-8. http://orton.catie.ac.cr/cgi-bin/wxis.exe/?IsisScript=OET.xis&method=post andformato=2&cantidad=1andexpresion=mfn=007129.

Debenay, J. and D.L. Tack, 1994. Environmental Condition, Growth of *Anadara senilis* (Linneus, 1758) in A Segal Lagoon. J. Mollusca Stud., 60: 113-121. DOI: 10.1093/mollus/60.2.11.

Demir, M., 1977. On the presence of Arca (*Scapharca*) *Amygdalum philippi,* 1845 (Mollusca: Bivalvia) In: The Harbour of Izmir, Istanbul Univ. Fen. Fak. Mec., B, 42: 197-202. http://journals.tubitak.gov.tr/zoology/issues/zoo-03-27-2/zoo-27-2-5-0205-1.pdf.

Duzgunes, E., H. Karacam and K. Seyhan, 1988. A study on the growth parameters and meat yield of Rapa Whelk (*Rapana venosa*, Val., 1846). J. Fish. Aquatic. Sci., 5: 19-20 (in Turkish).

Duzgunes, E., S. Unal and M. Feyzioglu, 1992. Assessment of Rapa whelk, *Rapana thomasiana* Gross, 1861, Stocks along the eastern Black Sea coast of Turkey. Project Report (DEBAG 143/6), Faculty of Marine Sciences, Karadeniz Technical University, Trabzon, Turkey (in Turkish). DEBAG 143/6.

Emiral, H., 1997. Egg Mass and Larval Development of Rapa whelk, *Rapana thomasiana* Gross 1861, from the eastern Black Sea coast of Turkey. MSc thesis, Graduate School of Natural and Applied Sciences, Karadeniz Technical University, Trabzon, Turkey (in Turkish). http://tez2.yok.gov.tr/fmi/xsl/tez/listevedetay_liste.xsl?-db=TezVT&-lay=web_arama&-max=20&-token.error=liste.xsl&AdSoyad=Hacer Emiral&-find=&-token.d=1.

Emiral, H., 2003. Bio-ecology of the whelk Rapana thomasiana Crosse, 1861 in the Eastern Black Sea region, Ph.D. thesis, Graduate School of Natural and Applied Sciences, Karadeniz Technical University, Trabzon, Turkey (in Turkish). http://tez2.yok.gov.tr/fmi/xsl/tez/listevedetay_liste.xsl?-db=TezVT&-lay=web_arama&-max=20&-token.error=liste.xsl&AdSoyad=HacerEmiral&-find=&-token.d=1.

FAO, 2000. Yearbook of Scientific Catches and Landings, 1994 Rome, 74 p. ftp://ftp.fao.org/fi/stat/summary/a-0a.pdf

Harding, J.M., 2003. Predation by blue crabs, *Callinectes sapidus*, on rapa Whelks, *Rapana venosa*: Possible natural controls for an invasive species. J. Exp. Mar. Biol. Ecol., 297: 161-177. DOI: 10.1016/j.jembe.2003.07.005.

Hou, S.M., J.M. Cheng, L. Hou, Q.Y. Wang and G.H. Li, 1990. Morphology of Reproductive systems of *Rapana venosa* (Valenciennes) Gastropoda. Acta Zoologica Sinica 36, 4: 398-405.

Hou, L., J.M. Cheng, S.T. Hou, G.H. Li and Q.Y. Wang, 1991. Morphology of the Digestive system of *Rapana venosa* (Valenciennes) Gastropoda. Acta Zoologica Sinica, 37, 1: 7-14.

Kayombo, N.A., 1993. Substrate grain-size analysis in cultured and natural population of Edible Ark Clam *Anadara antiquate* (Linneus, 1758) on the Tanzanian Coast. World Aquac., 24: 68-79.

Koutsoubas, D. and E. Voultsiadou-Koukoura, 1990. The occurrence *Rapana venosa* (Valenciennes, 1846) (Gastropoda, Thaidide) in the Aegean Sea, Boll, Malacol., 26: 2001-2004. http://www.sim-online.it/Pubblicazioni/Conchiglie/db/a26.htm

Konsulova, H.T., 1992. Mussel *Mytilus galloprovincialis* L. (Bivalvia) Natural Resources Along Northern Bulgarian Black Sea Coast in Relation to *Rapana thomasiana* Grosse (Gastropod) Distribution, Proceedings of Institute of Oceanology, Vol. 1, Varna. http://www.io-bas.bg/Oceanology_ Volume_ 1.html.

Lazzari and Rinaldi, 1981. Casi estremi di polimorfismo in Scapharca inaequivalvis (Brug.). Bollettino Malacologico, 17, 5-6. 115-117. http://www.sim-online.it/Pubblicazioni/Conchiglie/db/a17.htm.

Mann, R., J.M. Harding and S.L. Haywood, 1999. *Rapana venosa* in the Chesapeake Bay: Current Status and Prospects for Range Extension Based on Salinity Tolerance of Early Life History Stage. National Shellfisheries Association, J. Shellfish Res.,18, No: 1. www.vims.edu/mollusc/research/ merapven.html.

Mann, R., J.M. Harding and E. Westcortt, 2006. Occurrence of Imposex and Seasonal Patterns of Gametogenesis in the Invading Veined Rapa Whelk *Rapana venosa* from Chesapeake Bay, USA, Marine Ecology Progress Series, 310: 129-138. Inter-Research. www.int-res.com.

Morton, B., 1980. Some Aspects of the Biology and Functional Morpology (including the Presence of A Ligamental Lithodesma) of *Montacutona compacta* and *M. olivacea* (Bivalvia: Leotonacea) Associated With Coelenterates in Hong Kong. J. Zool., 192: 431-455.

Narasimham, K.A., 1988. Biology of the Blood Clam, *Anadara rehombea* (Born) in Kakinada Bay. J. Mar. Biol. Assoc. India, 30: 134-135. http://www.mbai.org.in/journal.html.

Nell, J.A., W.A. Connor and M.P. Heasman, 1994. Hatchery production for the Venerid Clam *Katelysia rhytiphora* (Lamy) and Sydney Cockle *Anadara trabezia* (Deshayes). Aquaculture, 119: 149-156. DOI: 10.1016/0044-8486 (94)90171-6.

Prodanov, K., T. Konsulova and V. Todorova, 1995. Growth Rate of *Rapana thomasiana* (Gastropoda) Along Bulgarian Black Sea Coast, XXXIV Congress of CIESM Rapp. Comm. Int. Mer. Medit., 34, Malta.

Prodanov, K. and T. Konsulova, 1995. *Rapana thomasiana* Stock Assessment and Catch Projection along Bulgarian Black Sea Coast. XXXIV Congress of CIESM Rapp. Comm. Int. Mer. Medit., 34, Malta.

Rinaldi, E., 1985. *Rapana venosa* (Valenciennes) Spiaggiata in Notevole Quantita Sulla Spiaggia di Rimini (FO) Bollettino Malacologico, 21: 10-12. http://www.sim-online.it/Pubblicazioni/Conchiglie/db/a21.htm.

Savini, D. and O.A. Anna, 2006. Consumption Rate and Prey Preference of the Invasive Gastropod *Rapana venosa* in the Northern Adriatic Sea. Helgol. Mar. Res., 60: 153-159. DOI: 10.1007/s10152-006-0029-4.

Siganova, T.A., 1998. Invasion of the Black Sea by Ctenophore *Mnemiopsis leidy* and Recent Changes in Pelagic Community Structure. Fish. Océanogr., 7 (3-4): 305-310. http://www3.interscience.wiley.com/journal/119132538/abstract.

Seed, R., 1975. Reproduction in *Mytilus* (Mollusca: Bivalvia) in European waters. In: Bonaduce, G. and G.C. Carrada, (Eds.) 1975. Eighth European Marine Biology Symposium Sorrento (Naples) 1973. Sorrento, Italy, Pubblicazioni della Stazione Zoologica di Napoli 39, Supplement 1, pp: 727. http://www.promare.at/embs40/embs-history.htm#Anchor-45410.

Sahin, C., E. Duzgunes, C. Mutlu, M. Aydin and H. Emiral, 1999. Determination of the Growth Parameters of the *Anadar cornea* R. 1844 Population by the Bhattacharya Method in the Eastern Black Sea. Tr. J. Zool., 23: 99-105. http://journals.tubitak.gov.tr/zoology/issues/zoo-99-23-1/zoo-23-1-13-98036.pdf.

Sahin, C., 1999. A Study on the Population Structure and Gonadal Development of *Anadara cornea* (Reev, 1844) in the Eastern Black Sea, Ph.D. Thesis, Graduate School of Natural and Applied Sciences, Karadeniz Technical University, Trabzon, pp: 102. (in Turkish). http://tez2.yok.gov.tr/fmi/xsl/tez/listevedetay_liste.xsl?-db=TezVT&-lay=web_arama&-max=20&-token.error=liste.xsl&AdSoyad=Cemalettin %C5%9Eahin&-find= &-token.d=1.

Sahin, C., E. Duzgunes, S. Engin, C. Mutlu and N. HacImurtazaoglu, 2005. Determining of Age and Growth Parameters of *Rapana thomasiana* in the South Eastern Black Sea. Turk. J. Aquatic. Life, 4: 34-38 (in Turkish). http://www.akuademi.net/USG/USG2005/CK/ck07.pdf.

Sahin, C., E. Duzgunes and I. Okumus, 2006. Seasonal Variations in Condition Index and Gonadal Development of the Introduced Blood Cockle *Anadara inaequivalvis* (Bruguiere, 1789) in the Southeastern Black Sea Coast. Turk. J. Fish. Aquatic. Sci., 6: 153-161. http://www.trjfas.org/pdf/issue_6_2/155_163.pdf.

Zolotaryov, V.N. and P.N. Zolotaryov, 1987. A New Bivalve species (*Cunearca cornea*) in the Black Sea, Dogladi Akademis, Nauk, 2: 501-504.