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Mass Mortality Report of Critically Endangered Fan Mussel (*Pinna nobilis*, Linnaeus 1758) from Cunda Island, Ayvalık (Aegean Sea, Turkey)

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ABSTRACT

Fan mussel, *Pinna nobilis* (Linnaeus, 1758), species has been critically endangered in the Mediterranean Sea because of *Haplosporidium pinnae*. Thus, the purpose of this study was to determine the current status of the fan mussel populations at three stations (Patriça Beach, Bıyıklı Beach and Çataltepe Beach) in Cunda Island, Ayvalık, Aegean Sea. Underwater observations were carried out in July 2020. Mass mortality (100%) was observed at all stations during the study. The length of the fan mussel was ranged between 39.8 cm and 79.8 cm and no individuals were small-sized.

INTRODUCTION

The fan mussel *Pinna nobilis* is endemic marine mollusc species in the Mediterranean Sea. It is among the largest bivalve species and can be reach up to 1.2 m (Zavodnik et al., 1991) and common size is between 20 cm and 30 cm (Fischer et al., 1987) which lives up to 45 years

(Rouanet et al., 2015). It lives half buried in the soft bottom seafloor (sea grass meadow, mud sandy mud or gravel bottoms) and anchored by byssus (Tebble, 1966). Fan mussel can be found between 0.5 and 60 m deep (Butler et. al., 1993).

Fan mussel is filter-feeding organisms which provide to improve water quality by filtration activity (Vicente et al., 2002; Natalotto et al., 2015). Moreover its hard-surface supplies potential living habitat to benthic species as annelids, ascidians, bivalves, bryozoans, cnidarians, crustaceans, echinoderms, macroalgae, gastropods, sponges (Acarli et al., 2010). However, the fan mussel populations have been seriously damaged for a long time due to recreational and commercial fishing activities for supplying food, the usage of its shell for decorative purposes, and incidental killing by trawling and anchoring. Consequently, the fan mussel is under strict protection status according to Annex IV of the Habitats Directive (Council Directive 92/43/EEC). Nowadays, *P. nobilis* population had been severely destroyed at the different area by Haplosporidium parasite, *Haplosporidium pinnae* (Vázquez-Luis et al., 2017; Panarese et al., 2019; Lottos et al., 2020; Čižmek et al., 2020).For this reason, the status of the species has been revised from "Vulnerable" to "Critically Endangered" by the Spanish Sectorial Environmental Conference on July 17, 2017, at the national level.

Although many studies have been conducted on growth (Acarli et al., 2011a; Demirci & Acarli, 2019), spat settlement (Acarli et al., 2011b; Kurtay et al., 2018), and gonad development (Acarli et al., 2018) of fan mussel in Turkey. But there is limited study on the determination of *P. nobilis* population (Öndes et al., 2020a; Acarli et al., 2021). The goal of the present study is to determine to the population features such as distribution, mortality rate, density and size structure of fan mussel in the Cunda Island.

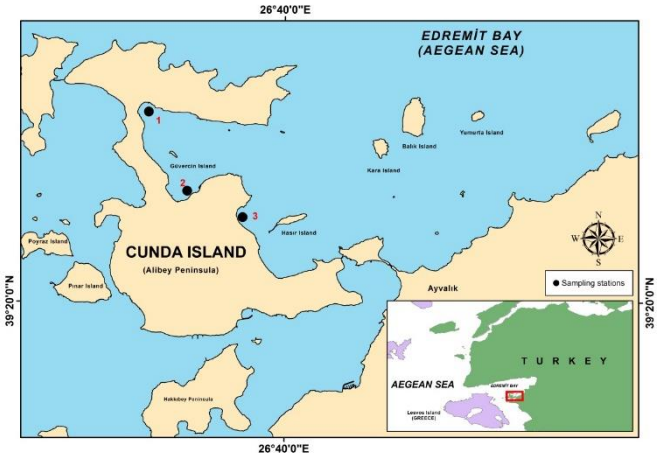

Figure 1. Study area. 1) Patriça beach; 2) Bıyıklı beach; 3) Çataltepe beach.

MATERIAL AND METHOD

This study was conducted in the coastal waters of Cunda Island that is also called as Alibey Island in July 2020 (Figure 1). It is located in the Ayvalık district of Balıkesir, Turkey, in the Northeastern Aegean Sea. Ayvalık Peninsula, including Cunda Island, was declared as a natural park with the decision of the Council of Ministers dated 21 April 1995, published in the Official Gazette of the Republic of Turkey with No. 22265. Three stations were determined to detect the presence of *P. nobilis* species which are Bıyıklı Beach (39°22'725" N and 26°37'487" E), Patriça Beach (39°25'592" N and 26°38'199"

E), and Çataltepe Beach (39°21'322" N and 26°36'243" E) in the coasts of Cunda Island. The depth and temperature were measured with the Oceanic Geo 2 dive computer.

The present status of the *P. nobilis* population was determined by SCUBA diving equipment. Alive and dead *P. nobilis* individuals were detected by transect and visual census methods. At the same time, an underwater video camera and an underwater camera were used during the study. All images of *P. nobilis* were analyzed to determine total shell lengths. Total shell length for individuals standing upright in the sand was calculated by equation (1) which was proposed by using the unburied length obtained from raw data provided by Acarli et al (2018).

$$a = 0.8061b + 28.61;\ (r^2 = 0.717) \qquad (1)$$

In this equation, *a* is calculated total length, *b* is unburied shell length.

RESULTS

Mass mortality (100%) was observed in Bıyıklı Beach, Patriça Beach and Çataltepe Beach at Cunda Island. A total of 351 fan mussels was recorded at all stations during the study (Table 1). The highest number of individuals was observed at Patriça Beach. Habitat structure were determined as sandy (100%) for Bıyıklı Beach, *Posidonia sp.* (70%), sandy and tragana (30%) (tragana is hard bottom of calcium carbonate) for Patriça Beach and *Posidonia sp.* (70%), rocky (20%), sandy (10%) for Çataltepe Beach (Table 2). While all individuals in Bıyıklı Beach was observed on the sand in a lying position and broken, 221 individuals in Patriça Beach were half buried in the soft bottom seafloor or in a lying position (see videos from URL-1, URL-2, and URL-3). In Çataltepe Beach, a total of 23 individuals was found out but only 3 individuals were determined half buried in the soft bottom seafloor (Figure 2). Length range of fan mussel in Bıyıklı Beach, Patriça Beach and Çataltepe Beach were recorded between 44.6 cm and 60.0 cm, 40.2 cm and 79.8 cm, and 39.8 cm and 65.2 cm, respectively. Temperature was 26°C for Bıyıklı Beach, 27°C for Patriça Beach and 26°C Çataltepe Beach during the study.

Table 1. Mortality rate and shell length values (minimum (min) and maximum (max)) of *Pinna nobilis* individuals measured by the underwater visual census in the Cunda Island

Station	N	Mortality rate (%)	Min-Max (cm)
Bıyıklı Beach	18	100	44.6-60.0
Patriça Beach	310	100	40.2-79.8
Çataltepe Beach	23	100	39.8-65.2

DISCUSSION

Several authors have reported mass mortality caused the main etiological agent the parasite *H. pinnae* in different areas of the Mediterranean Sea coasts in recent years (Carella et al., 2019; Cabanellas-Reboredo et al., 2019; IUCN 2020). In addition, Scarpa et al. (2020) mentioned that a multifactorial disease may be responsible for the mass mortality of *P. nobilis*. Environmental parameters temperature (above 13.5°C) and salinity (36.5-39.7 PSU) were

Table 2. Descriptive information about the stations

Station	N	Surveyed Area (m^2)	Density (ind./100 m^2)	Depth Range (m)	Habitat Structure
Bıyıklı Beach	18	3000	3	2.5-3	Sandy (100%)
Patriça Beach	310	2000	16	2-5	*Posidonia sp*. (70%), sandy + tragana (30%)
Çataltepe Beach	23	2200	1	6-8	*Posidonia sp.* (70%), rocky (20%), sandy (10%)

affected by disease expression of *P. nobilis* (Cabanellas-Reboredo et al., 2019). In the present study, we recorded temperatures between 26°C and 27°C during the underwater observations. However, the temperature was between the same ranges as in Çanakkale Strait where mortality changed from 100% to 9.62% reported by Acarli et al. (2021). Öndes et al. (2020) also declared that 100% mortality was observed in the Aegean Sea, Turkey except for Kıyıkışlacık (75%) and Akarca station (75%). The high-temperature values together with the potential role of currents on parasite expansion might have affected this extremely high mortality rate of *P. nobilis* in the study area. In order to able to say something about mass mortality of *P. nobilis* in the Aegean Sea in Turkey, environmental parameters such as temperature, salinity, current, dissolved oxygen, pH, etc., should be monitored for a long time and also it is necessary to determine the etiological agent.

DISCUSSION

Several authors have reported mass mortality caused the main etiological agent the parasite *H. pinnae* in different areas of the Mediterranean Sea coasts in recent years (Carella et al., 2019; Cabanellas-Reboredo et al., 2019; IUCN 2020). In addition, Scarpa et al. (2020) mentioned that a multifactorial disease may be responsible for the mass mortality of *P. nobilis*. Environmental parameters temperature (above 13.5°C) and salinity (36.5-39.7 PSU) were affected by disease expression of *P. nobilis* (Cabanellas-Reboredo et al., 2019). In the present study, we recorded temperatures between 26°C and 27°C during the underwater observations. However, the temperature was between the same ranges as in Çanakkale Strait where mortality changed from 100% to 9.62% reported by Acarli et al. (2021). Öndes et al. (2020) also declared that 100% mortality was observed in the Aegean Sea, Turkey except for Kıyıkışlacık (75%) and Akarca station (75%). The high-temperature values together with the potential role of currents on parasite expansion might have affected this extremely high mortality rate of *P. nobilis* in the study area. In order to able to say something about mass mortality of *P. nobilis* in the Aegean Sea in Turkey, environmental parameters such as temperature, salinity, current, dissolved oxygen, pH, etc., should be monitored for a long time

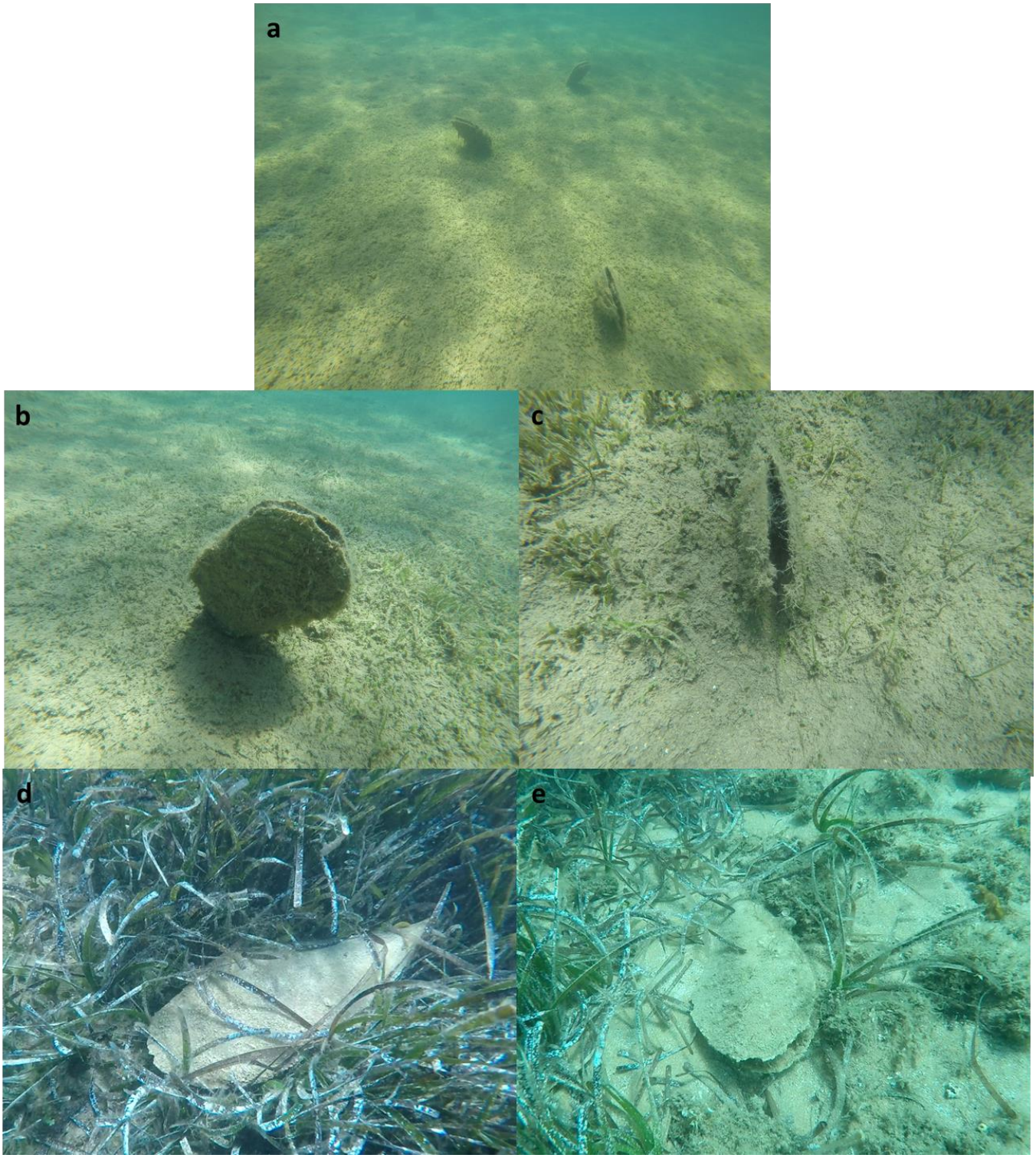

Figure 2. Underwater photography of *Pinna nobilis.* a) general view; b) and c) half buried in the soft bottom seafloor; d) and e) lying position on seafloor.

and also it is necessary to determine the etiological agent.

In this study, the total shell lengths of *P. nobilis* at all stations (mass mortality 100%) were recorded between 39.8 cm and 79.8 cm, although small sized shells were not observed during the observations. Despite scanning has been started from the coastal zones, individuals were observed between 2 m and 8 m depth. There were no shells of young individuals that

occurred and this might be evidence for a problem in the population such as larval adhesion difficulties or reproduction anomalies before the disease reached the location. Davenport et al. (2011) reported that adult individuals of *P. nobilis* could negatively be affected on spat settlement because of their filter-feeding characteristics and thus, they ingested their planktonic larvae. A similar situation at Patriça Beach might occur. It is known that *P. nobilis* population have threatened by human activities such as habitat degradation and loss, recreational and commercial fishing, ornamental harvesting, boat anchoring, and coastal construction (Vicente & Moreteau, 1991; Richardson et al., 2004; Centoducati et al., 2007; Deudero et al., 2015). Prado et al. (2014) indicated that the absence of small sizes in the *P. nobilis* population comes from the presence of human activities that might be damage *P. nobilis* and its habitat. No dead shells were found between 0 m and 2 m in the study area. The spawning period of *P. nobilis* was the summer months, mainly in July (Acarli et al., 2018) and its spat attachment was observed in August (Acarli et al., 2011b). During the study, coastal tourism practices, including swimming and snorkelling activity was intensively observed in the coastal areas of Cunda Island. It is showed that its habitat and newly settled individuals may have been destroyed because of human activities. As a result, before observing mass mortality, the population of *P. nobilis* in Cunda Island had been exposed to a variety of human impacts.

CONCLUSION

Öndeş et al. (2020) mention that there were few alive individuals in 3 different stations in the Aegean Sea. According to the finding of Öndeş et al. (2020), we think that the resistant individuals in the impact areas or healthy populations can newly be found in the Aegean Sea with help of the local people mainly fisherman and diving clubs. Determining healthy populations, which is reproducing and recruitment ability, and recovery populations are very important to devise an action plan. Furthermore, it is recommended that establishing a new marine protected area is compulsory for ensuring the sustainability of this species where alive individuals have occurred. In addition, conservation programs and restoration programs should be implemented for the successful management of *P. nobilis* population along the coasts of Turkey.

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Compliance with Ethical Standards

Authors' Contributions

DA and SA carried out underwater observations. AÖ helped in the field. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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