

## Article

# Filling a Gap: A Population of *Eunicella verrucosa* (Pallas, 1766) (Anthozoa, Alcyonacea) in the Tavolara-Punta Coda Cavallo Marine Protected Area (NE Sardinia, Italy)

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**Abstract:** Among Mediterranean habitat-forming alcyonaceans, the sea fan *Eunicella verrucosa* is known to form dense forests at circalittoral depths, providing seascape complexity and sustaining a rich associated fauna. Its occurrence in the Tavolara–Punta Coda Cavallo Marine Protected Area (NE Sardinia) has never been deeply investigated despite this area being well known from a biocoenotic point of view. This study provides new information on the size of the colonies settled between 35 and 59 m depth on granitic outcrops and represents a contribution to highlighting the hotspot of megabenthic diversity enclosed in the protected area. The presence of 100 colonies was assessed by photographic samplings performed between 2015 and 2020, in a small area characterized by peculiar ecological conditions. The morphometric descriptions and age estimation showed a persistently isolated population probably derived from a stochastic event of settling of larvae presumably coming from the Tuscany Archipelago. A richly associated epibiotic community, composed of 18 species/OTUs, showed how branched bryozoans, particularly *Turbicellepora avicularis*, and the parasitic octocoral *Alcyonium coralloides*, affected the colonies' branches, suggesting a putative anthropogenic impact related to fishing activity. This study indicates that proper protection and management strategies are mandatory for the Marine Protected Area, in order to conserve this unique population and the whole associated benthic assemblage.

**Keywords:** gorgonians; coralligenous assemblages; fishing impact; Mediterranean sea

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## 1. Introduction

The sea fan *Eunicella verrucosa* (Pallas, 1766) is a large, erected gorgonian, profusely branched, white to deep pink in color, with an Atlanto-Mediterranean distribution, ranging from Angola to Ireland, in the East Atlantic Ocean [1,2]. The species settles directly on bedrock, on large boulders and on artificial surfaces in areas with moderate water movement [3]. The depth range for the Mediterranean Sea goes from 26 to 215 m depth with most of the records located below 35 m depth [1,4–9]. The populations of this species provide structural complexity sustaining rich, associated biodiversity and aesthetic value to sublittoral communities [10,11]. The tridimensional morphology of *E. verrucosa* colonies observed in previous studies is complex and variable: the typical architecture is planar, but other growth forms, characterized by a high rate of branch overlapping, result from different environmental conditions, such as spatial constraints, current intensity, feeding ability and predation [12–18].

The growth rate of *E. verrucosa* was recorded as highly variable: demographic studies of different populations suggest values of 0.6–3.5 cm year<sup>−1</sup> for Mediterranean areas and of 1–4.5 cm year<sup>−1</sup> for the English Channel [6,19–22]. The relatively slow growth rate of *E.*

*verrucosa* coupled with its sensitivity to abrasion, mechanical disturbance by anchors, fishing gear and fin-stroke damage by scuba divers [23–26], as well as substratum loss [21,27], makes this species particularly sensitive to anthropogenic impacts and environmental stressors.

Thanks to recent Remotely Operated Vehicle (ROV) surveys [8] and SCUBA dives coupled with citizen science reports, the distribution of *E. verrucosa* on the Mediterranean scale has been recently updated [28]. This large amount of data confirms the occurrence of the species mainly along the coast of the western Mediterranean basin with a peak of records in the Ligurian Sea. In particular, a structured community dominated by this species was identified here in dozens of sites, mainly on sub-horizontal rocks characterized by heavy silting between 30 and 215 m (maximum occurrences 60–90 m) [8]. A lower number of records involve the North African coasts, the Sicily Channel, the North Adriatic Sea and the Aegean Sea. In this scenario, the most impressive gap sees the almost complete absence of the species from the central Tyrrhenian Sea, and in particular, from the Sardinian coast [28].

Very few data are available in the literature regarding NE Sardinia. The oldest records date back to 1990 when Bianchi et al. [29] recorded the species at a site in the Tavolara-Punta Coda Cavallo Marine Protected Area (TPCCMPA). Later, in the same area, field campaigns reported some colonies on the hull of the Klearchos wreck at 77 m depth [30], and another specimen settled on a granitic shoal (Tavolara2) at 55 m depth [31]. Recent surveys assessed the occurrence of this species, in association with large and erect sponge assemblages, on granite reliefs in the Tavolara Channel under 40 m depth [32,33].

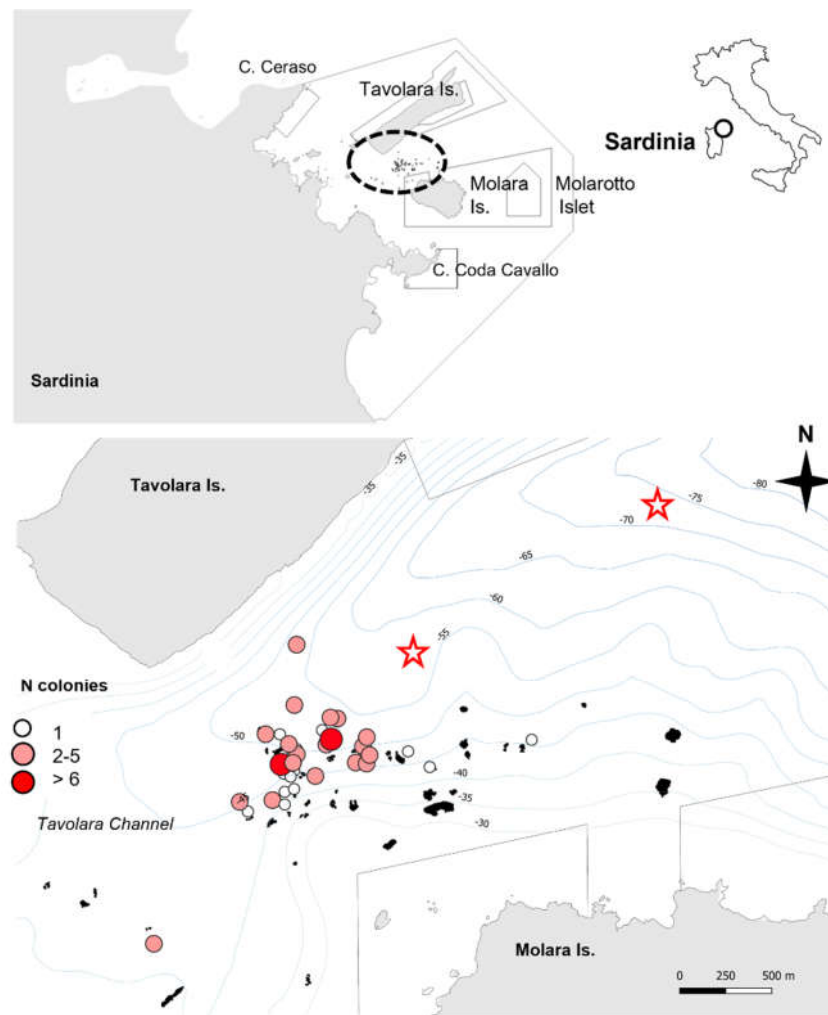
This study aims to quantify the presence of *E. verrucosa* in the TPCCMPA, improve the knowledge of its Mediterranean distribution, and provide a morphometric description of the population. In addition, a study of the opportunistic fauna living on the colonies, used as an indicator of mechanical abrasion also of anthropic origin [34,35], was conducted to evaluate the impact of anthropogenic activities within the MPA.

## 2. Materials and Methods

Between 2015 and 2020, 110 scuba dives were carried out on 77 granite outcrops within the Tavolara Channel at depths between 12 m and 59 m (Figure 1). Each outcrop was georeferenced on a Geographic Information System (GIS) and the coordinates of the sites investigated were registered on the MPA web platform. All the sites where *Eunicella verrucosa* was recorded are listed in Table 1.

All the recorded colonies of *E. verrucosa* were photographed. The multi-zoom photographic approach [36] was used to characterize the site geomorphologies, the benthic assemblages, and in particular, the presence of *E. verrucosa*, and the occurrence of epibionts and damages on the sea fans (Figure 2).

Images were taken using a Sony A6000 camera (24 megapixels, two Inon S2000 strobes, color temperature 5000 K) with Sony 16–50 lens (focal length 19 mm), Nauticam WW1 wet wide lens (130° rectilinear field angle) and a Sea & Sea MDX-A6000 underwater case with a flat porthole. Panoramic renderings of the sites to localize the colonies were obtained with multiple shots subsequently joined and optimized in postproduction using the Photoshop CS6 Merge tool.

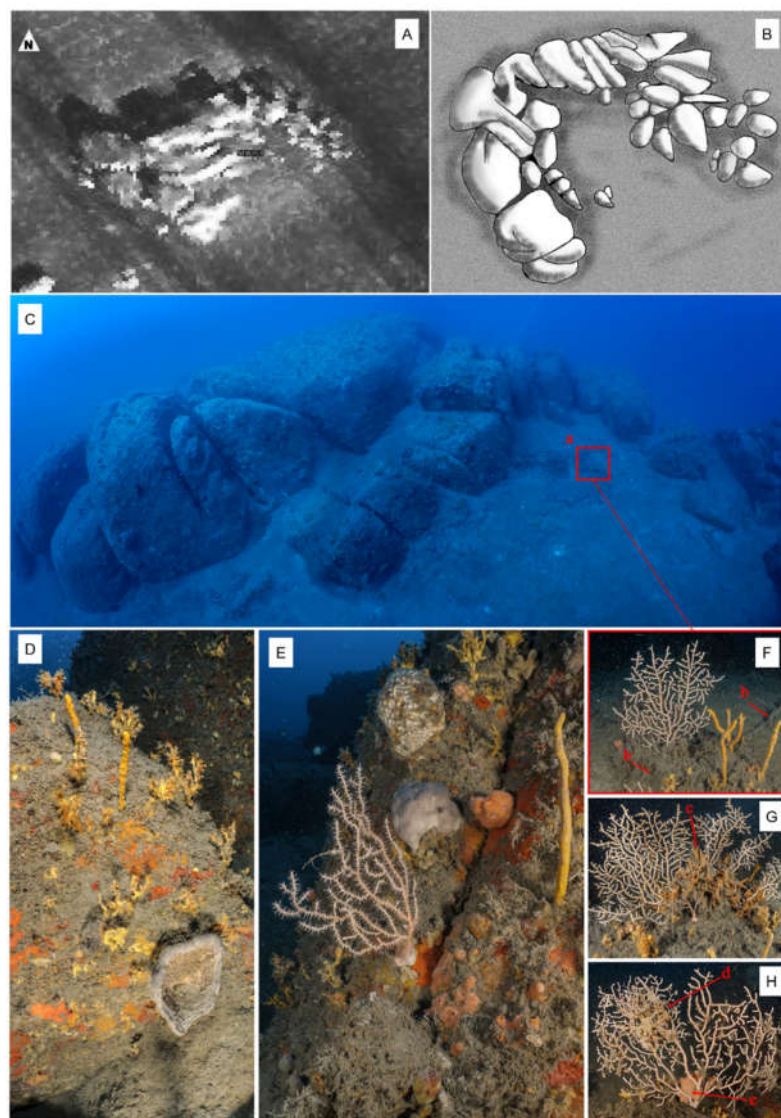


**Figure 1.** Location of the Tavolara–Punta Coda Cavallo Marine Protected Area and investigated sites (black polygons) with the indication of the number of *Eunicella verrucosa* colonies per site. Stars refer to ANDROMEDA [30,31] reports.

**Table 1.** Investigated sites with the occurrence of *Eunicella verrucosa* within the Tavolara–Punta Coda Cavallo Marine Protected Area and number of specimens in each one. Coordinates of the sites can be consulted upon request to the Marine Protected Area repository.

Site	Depth Range (m)	Outcrop Area (m <sup>2</sup> )	N Colony	N Dives
N1	37–44	428	6	3
N2	39–45	1336	1	1
N24	38–44	1408	1	1
N25	43–54	677	6	2
N27	38–47	1024	14	6
N28	38–47	3343	4	3
N29	42–49	410	2	1
N30	46–50	435	4	1
N32	47–52	371	3	1
N33	50–56	574	2	1
N34	38–45	421	3	1
N37	35–41	736	3	2
N73	36–40	100	1	1
N74	40–45	345	1	1
N75	40–45	595	1	1
N83	48–52	1022	2	1

N95	41	221	2	1
N99	45–50	1253	1	2
N100	38–45	498	1	1
N101	46–52	820	1	1
N102	47–53	264	1	1
N118	47–52	580	3	2
N119	39–44	286	1	1
N120	40–45	331	1	1
N140	42–48	900	4	1
N148	48–54	471	3	1
N150	43–49	165	4	1
N151	38–46	198	3	3
N159	48–59	272	12	1
N160	44–49	760	3	1
N165	44–48	197	3	1
N171	40–44	141	1	1
N180	40–45	92	1	1
N182	40–45	280	1	1



**Figure 2.** Operative workflow for the characterization of the investigated sites by a multi-zoom approach. Preliminary Side Scan Sonar survey (A) graphic reconstruction and (B) final panoramic

photographic rendering (C) of the site. Examples of the ecological context in which *Eunicella verrucosa* settles, mainly composed of large and erect sponges such as *Axinella* spp., *A. polypoides*, *Spongia lamella* (D), *Sarcotragus foetidus* (E) and other encrusting and massive species. Details of damages, (F) as entangled lines (b) and epibionts, (G, H) such as *Turbicellepora avicularis*, (c) *Crella elegans* and (e) other acrophilic species associated to the gorgonian (H) as *Astrospartus mediterraneus* (d).

Using a laser gauge as a reference (wheelbase 25 cm), the height was measured in each colony whereas the fan surface was evaluated for only 63 specimens with a suitable perspective. Photographic processing for measurements was carried out using ImageJ Software (Wayne Rasband and contributors, National Institutes of Health, Bethesda, MD, USA) [37].

As gorgonian colony height is considered a robust parameter leveraged for age estimation in this species [38], this datum was calculated according to the function proposed by Chimienti [39] for Mediterranean populations (Table 2):

$$\text{Age} = e^{\frac{H+18.39}{17.94}} \quad (1)$$

The size and age structure of the population were analysed in terms of size–frequency and distribution parameters (skewness and kurtosis) using Past 4.10 statistic (Øyvind Hammer, Natural History Museum, University of Oslo, Oslo, Norway).

Finally, photographs were analyzed to identify associated epibiont species to the lowest possible taxonomic level: when the identification was not possible, Operational Taxonomic Units (OTUs) were adopted. Species/OTUs were grouped into sessile opportunistic epibionts, predators/mucous feeders and vagile acrophilic species. The occurrence of each epibiont species and the percentage of colony surface covered were calculated (Table 2). Moreover, recent mechanical damages were also recorded as a percentage of the colony's naked skeleton portion. The total damage was estimated as the sum of the percent of naked portion and epibionted ones (Table 2).

**Table 2.** Morphometric parameters, percent portion of surface covered by epibionts, naked skeleton and damage of the specimens of *Eunicella verrucosa* investigated in the present study.

Site	Height (cm)	Surface (cm <sup>2</sup> )	Age (yrs)	Epiosis %	Naked Skeleton %	Damage %	Site	Height (cm)	Surface (cm <sup>2</sup> )	Age (yrs)	Epiosis %	Naked skeleton %	Damage %
N1	41.03	688.07	30.5	5	0	5	N74	22.56		10.5	0	0	0
N1	39.21	823.51	27.4	15	0	15	N75	59.06		85.9	0	0	0
N1	43.27	1028.3	34.7	0	0	0	N83	40.04	610.01	28.8	0	0	0
N1	35.02		21.57	0	0	0	N83	18.17	291.49	8.2	0	0	0
N1	19.49	183.14	8.8	0	0	0	N95	48.59	1873.8	47.1	0	0	0
N1	36.14		23	0	0	0	N95	34.2	588.98	20.6	0	0	0
N2	27.31	490.01	13.8	30	0	30	N99	25.37	397.06	12.4	40	0	40
N24	10.73	26.92	5.3	0	0	0	N100	35.7	713.1	22.5	0	0	0
N25	26.68		13.4	0	0	0	N101	35.72		22.5	0	0	0
N25	29.12		15.4	5	0	5	N102	27.73	230.85	14.2	0	0	0
N25	27.4		13.9	0	0	0	N118	51.03	2344.6	54.2	25	0	25
N25	46.34		41.4	20	0	20	N118	45.04		38.4	0	0	0
N25	48.64		47.2	0	100	100	N118	12.355		5.9	80	0	80
N25	52.3		58.3	40	0	40	N119	18.9	159.4	8.5	0	0	0
N27	20.5	176.32	9.4	0	0	0	N120	10			0	0	0
N27	31.43	423.55	17.5	0	0	0	N140	63.55		111.3	0	0	0
N27	24.04		11.5	65	0	65	N140	55.9	1754.9	71.7	5	0	5
N27	48.3		46.3	10	0	10	N140	36.22		23.1	0	0	0
N27	37.27		24.5	0	0	0	N140	48.7	1222.9	47.4	5	0	5

N27	34.45	1985.9	20.9	15	0	15	N148	33.31	722.6	19.5	0	0	0
N27	24.93	490.38	12.1	10	0	10	N148	46.43	1302.1	41.6	5	0	5
N27	39.55	823.07	28.0	5	0	5	N148	36.8	821.99	23.9	5	0	5
N27	34.5	595.65	20.9	0	0	0	N150	39.02	492.64	27.1	5	0	5
N27	20		9.1	30	5	35	N150	26.4		13.1	0	0	0
N27	55.64		70.6	15	0	15	N150	28.2		14.6	20	0	20
N27	16.86		7.6	0	0	0	N150	19.95		9.1	0	0	0
N27	40.7		29.9	20	0	20	N151	41.16	1318.0	30.7	0	0	0
N27	40.7	267.05	29.9	15	0	15	N151	49.86	982.98	50.6	10	10	20
N28	41.53	220.39	31.4	0	0	0	N151	36.59	691.24	23.6	0	0	0
N28	48.32	382.91	46.3	0	0	0	N159	29.67	539.54	15.9	5	0	5
N28	40.65	1219.6	29.8	0	0	0	N159	43.78	668.55	35.7	0	0	0
N28	34.67	811.27	21.1	0	0	0	N159	38.33	492.06	26.1	0	0	0
N29	36.14		23.0	0	0	0	N159	37.72	733.66	25.2	0	0	0
N29	34.46		20.9	5	0	5	N159	18.24	169.71	8.2	0	0	0
N30	66.32	1375.7	130.5	0	0	0	N159	32.6	765.03	18.8	0	0	0
N30	53.49	1688.0	62.4	20	5	25	N159	34.21	693.07	20.6	0	0	0
N30	19.32		8.7	85	0	85	N159	46.09	1832.4	40.8	30	0	30
N30	36.13	932.27	23.0	0	0	0	N159	37.02	49.97	24.2	0	0	0
N32	15.11		6.9	50	0	50	N159	23.59		11.2	0	0	0
N32	55.13	1261.8	68.6	20	5	25	N159	37.58	1325.2	25.0	10	0	10
N32	50.98	1085.5	54.0	0	0	0	N159	48.11	1326.8	45.8	5	0	5
N33	25.76		12.7	0	0	0	N160	35.54	720.5	22.2	0	0	0
N33	26.31	233.29	13.1	0	0	0	N160	43.31	495.95	34.7	0	0	0
N34	32.34	528.52	18.5	50	40	90	N160	43.42	863.23	35.0	0	0	0
N34	32.04	338.25	18.2	5	0	5	N165	56.75	1796.2	75.3	5	0	5
N34	55.65	1892.9	70.6	15	0	15	N165	40.96	703.3	30.4	0	0	0
N37	16.85		7.6	5	0	5	N165	35.5		22	0	0	0
N37	18.22		8.2	0	0	0	N171	43.93		36.0	5	5	10
N37	14.61		6.7	0	50	50	N180	26.42	385.42	13.2	5	0	5
N73	19.8	299.26	9.0	50	0	50	N182	31.48	599.32	17.6	5	0	5

### 3. Results

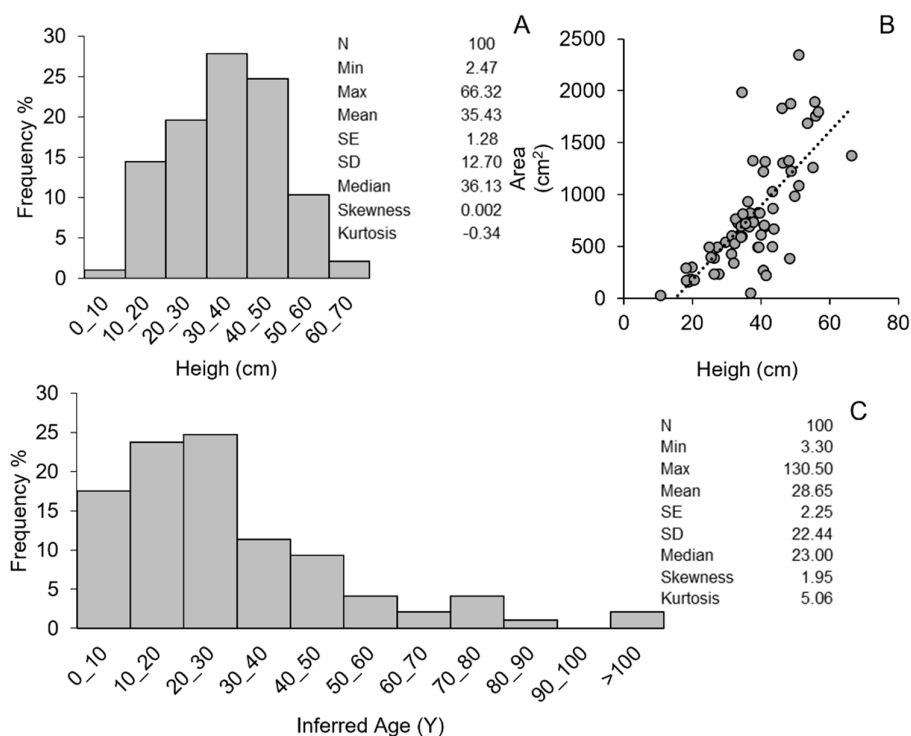
#### 3.1. Distribution and Occurrence

The population of *Eunicella verrucosa* of Tavolara MPA is composed of light pinkish-colonies settled on granitic outcrops arising from the detritic bottom and surroundings in the centre of the Tavolara Channel (Figure 1). These outcrops (Figure 2A–C) were characterised by a high level of sedimentation, scarce development of the crustose coralline algae and by the widespread presence of the brown algae *Carpomitra costata*, and to a lesser extent, *Ericaria zosteroides*. The animal community was mainly composed of large, erect sponges, particularly *Axinella* spp. and several species of *Keratosia* (*Dysidea* spp., *Sarcotragus foetidus*, *Spongia lamella* and *S. officinalis*) (Figure 2D–E). Together with *E. verrucosa*, *Paramuricea clavata* was also relatively abundant.

Colonies (Figure 2F–H) were recorded in 34 of the 77 investigated sites, in an area of approximately 30 ha (Table 1, Figure 1). All the colonies (100) were found between a depth of 35 and 59 m; about one-third of the colonies were settled near the areas where the detritic sediment borders the rocks, whereas the remaining specimens were mainly observed on the sloping flanks of the outcrops and less frequently on their top.

Generally, the colonies were isolated or spread, without the formation of a true forest (*sensu* Chimienti [28]). The highest number of colonies were found at sites N159 (12 colonies) and N27 (14 colonies), exactly in the middle of the channel (Figure 1).

The colony size of the 100 recorded specimens ranged from 10 to 66.3 cm in height, with the size class 30–40 cm being dominant. Size–frequency distribution was symmetric and leptokurtic (Figure 3A). The fan surface measured for 63 colonies ranged from 27 to 2350 cm<sup>2</sup> and was linearly related to height ( $n = 63$ ;  $r = 0.73$ ;  $p < 0.001$ ) (Figure 3B).

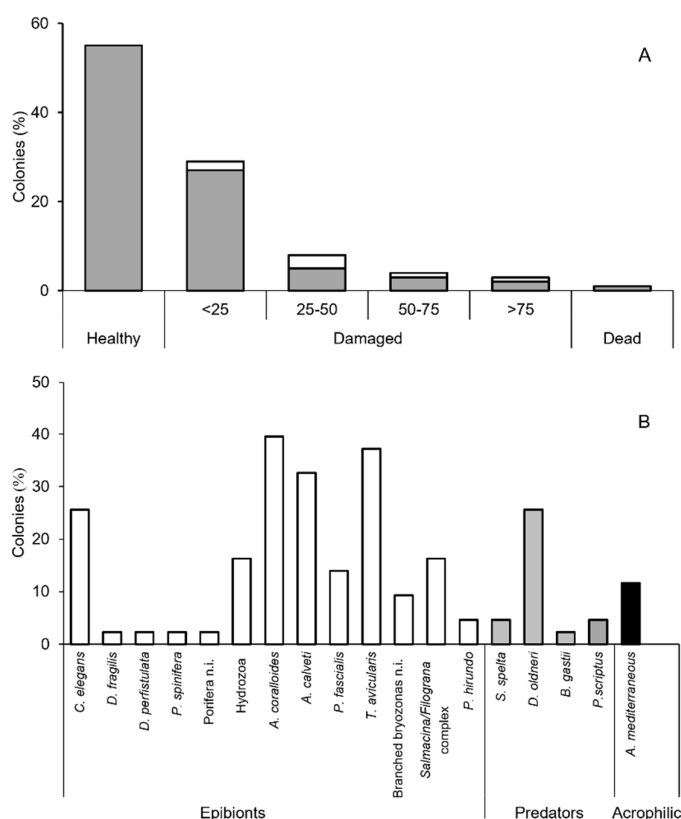


**Figure 3.** Morphometric description of *Eunicella verrucosa* colonies at the Tavolara MPA. (A) size–frequency distribution of the colony heights; (B) correlation between height and fan area; (C) age–frequency distribution, inferred from height of colonies according to [39].

According to the equation proposed by [39], the age estimation ranges were from 3 to 130 years, with a distribution showing a mode in the 30–50-year-old class, showing a highly skewed and leptokurtic distribution, with a long tail toward large age classes (Figure 3C).

### 3.2. Epibiosis and Damages

A total of 55% of the observed colonies did not show epibionts or direct damages, whereas the remaining was affected at different levels and in different portions of the colony (base, fan surface, apexes) (Table 2, Figure 4A); no relationship between damages and colony height was observed (on average, healthy colonies were  $33.99 \pm 1.74$  cm height, whereas damaged ones measured  $37.22 \pm 1.93$  cm). Damaged specimens were randomly located across the investigated sites.

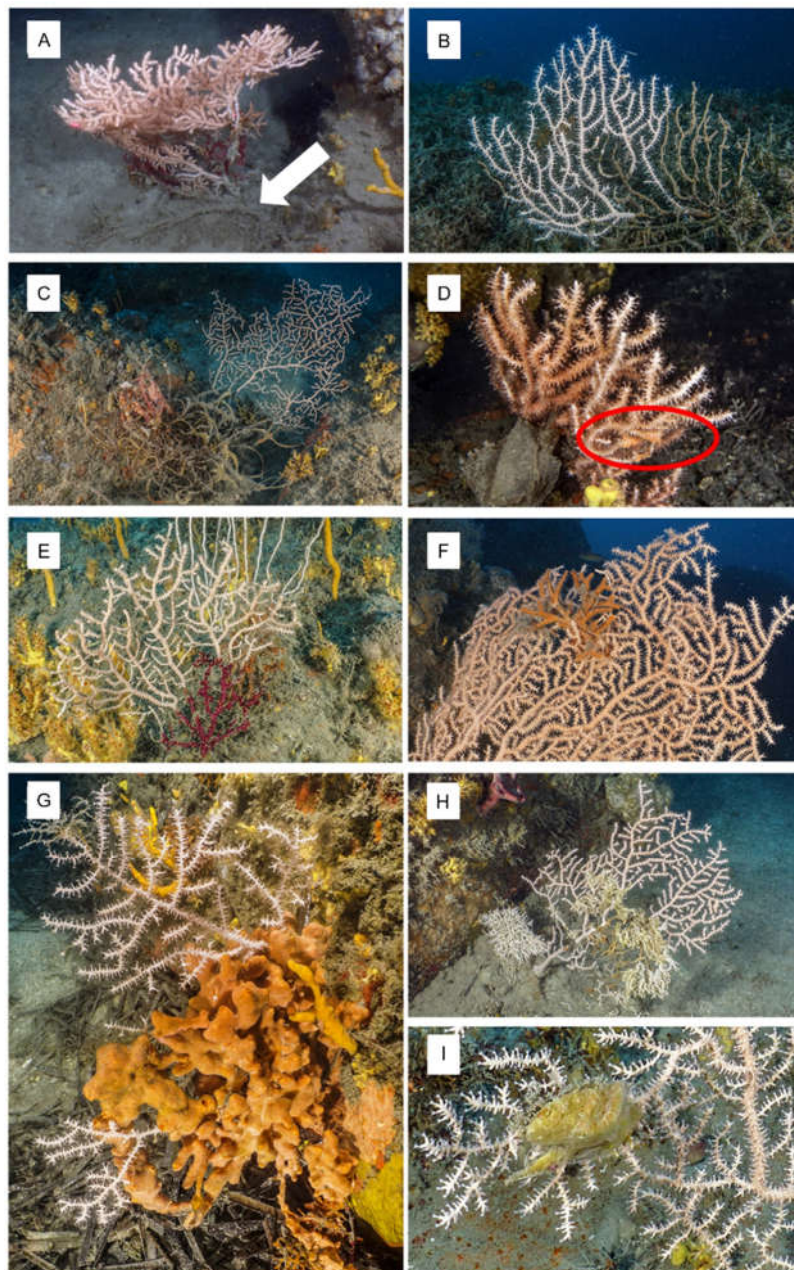


**Figure 4.** Health state of the studied *Eunicella verrucosa* population. (A) percentage of healthy and damaged colonies, according to the percentage of affected surface. White bars, percentage of colonies characterized by naked skeleton; grey bars, percentage of surface covered by epibionts. (B) percentage of colonies hosting associated species/OTUs.

Only one colony was observed as dead, at site N25 (Figure 5A). Seven colonies showed parts of branches deprived of coenenchyme with an exposed naked skeleton without epibiosis (Figure 5B). In total, 43 colonies hosted epibionts; 29% of these were covered for less than 25% of the total surface, 8% were affected between 25–50%, 4% showed 50–75% of the surface covered and 3% for more than 75% (Figure 4A). Two colonies were recorded entangled by an abandoned nylon line (N151-2 and N159-7) (Figure 5C) and one colony was enveloped by plastic debris (N27-12). This colony was also found spawning on 10 November 2019 (Figure 5D).

In total, 18 species/OTUs were found associated with the colonies (Figure 4B). The most common taxon was the parasitic octocoral *Alcyonium coralloides*, recorded on 39.5% of the damaged colonies (Figure 5E). Overall, branched bryozoans were settled on 67% of the suffering colonies: the most common one was *Turbicellepora avicularis*, present on 37.2% of the colonies (Figure 5F), followed by *Adeonella calveti* and *Pentapora fascialis* (32.6 and 14%, respectively) (Figure 5G). Sponges, particularly *Crella elegans* (25.6%) (Figure 5G), were responsible for the epibiosis on 30% of the colonies. The serpulids of the *Salmacina/Filograna* complex (Figure 5H) and the bivalve *Pteria hirundo* (Figure 5I) were found on 11.6% and 5% of the colonies, respectively.

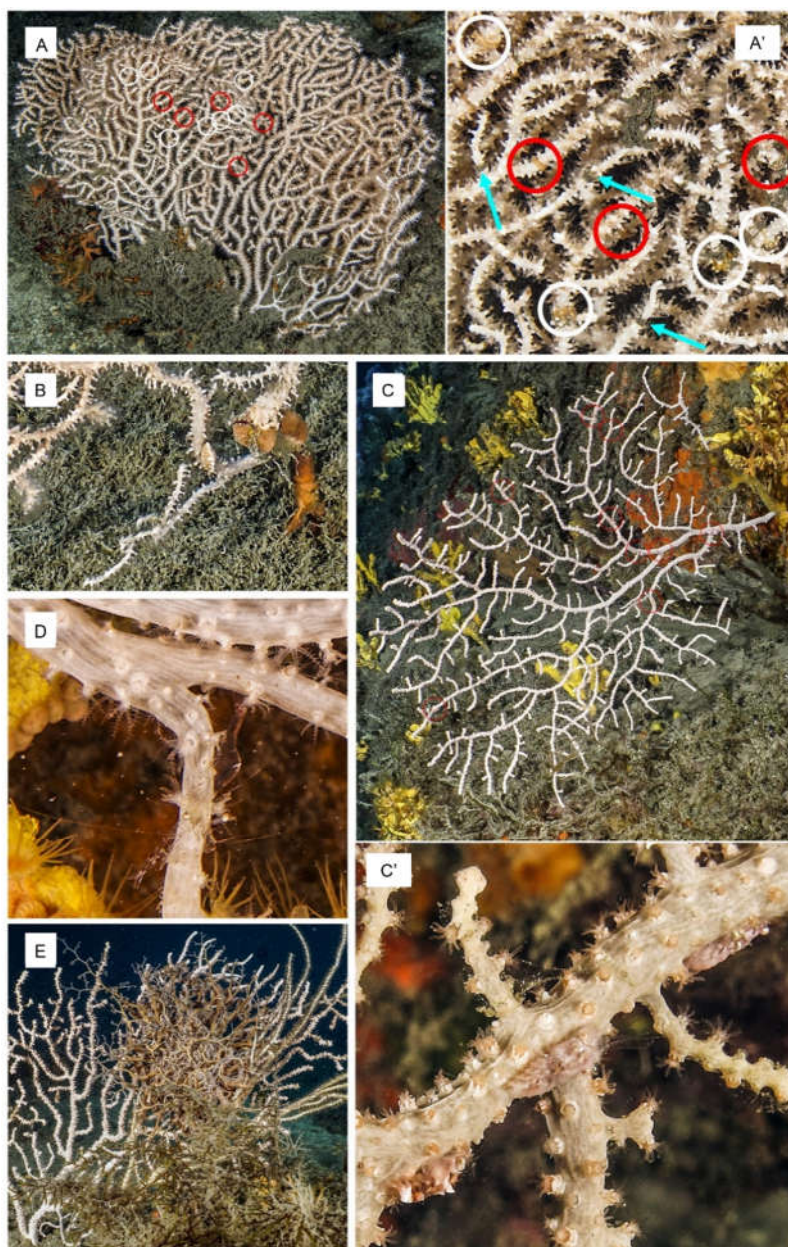




**Figure 5.** Examples of mechanical damages and epibiosis affecting *E. verrucosa*. (A) dead colony (white arrow); (B) a colony with a huge portion deprived by coenenchyme; (C) colonies entangled with an abandoned line and plastic debris (D) Red circle refers to spawning polyps; (E–H) main epibionts affecting *E. verrucosa*: the parasitic octocoral *Alcyonium coralloides* (E) the bryozoans *Turbicellepora avicularis*, (F) *Adeonella calveti*, with the sponge *Crella elegans*, (G) the *Salmacina/Filograna* complex (H) and (I) the bivalve *Pteria hirundo*.

Three predators, the nudibranch *Duvaucelia odhneri*, the ovulid *Simnia spelta* and the decapod *Balssia gasti* were observed (Figure 6A–C). The most represented was *D. odhneri*, recorded on eleven colonies, in four cases together with their eggs (Figure 6A,A'). Three specimens of *S. spelta* were recorded on two colonies (Figure 6B). One colony (N182-1) hosted ten specimens of *B. gasti* (Figure 6C,C'). Moreover, two specimens of the decapod *Periclimenes scriptus* were recorded on two colonies at site N27 (Figure 6D). Five colonies hosted the large acrophilic ophiuroid, *Astrospartus mediterraneus* (Figure 6E).





**Figure 6.** Associated vagile fauna with *Eunicella verrucosa*. The three predators, the nudibranch *Duvaucelia odhneri* (red circles) (A) together with its eggs (white circles) and damaged zones (blue arrows), (A') the ovulid *Simnia spelta* (red arrow), (B) and the decapod *Balssia gastii*, (C,C') the decapod *Periclimenes scriptus*, (D) the large acrophilic ophiuroid and (E) *Astrospartus mediterraneus*.

#### 4. Discussion

##### 4.1. Distribution of *Eunicella verrucosa* and Population Singularity

Although recently the Sardinian coasts have been widely explored through a series of ROV surveys [40–44], no colonies of *Eunicella verrucosa* have been recorded. This evidence agrees with the recent map of the species distribution at the Mediterranean basin scale published by Chimienti [28], which includes data from original investigations, scientific literature and citizen observations validated by photographs.

The record of a persistent population settled in the Tavolara area for at least several decades, is, in this light, a peculiar feature of this zone. Its occurrence in the TPCCMPA was already observed in some previous investigations [29–33].

Here, the *E. verrucosa* colonies settle within sponge-dominated assemblages present on granitic outcrops under a high sedimentation rate in the Tavolara Channel, where the development of crustose coralline algae is limited. A similar assemblage including *E. verrucosa* together with *Axinella polypoides* and massive sponges was described on silted rocks of various lithology at 40–70 m depth in many sites along all Ligurian Sea [8,28].

Our observations indicate that the *E. verrucosa* population is composed of scattered colonies without formation of true forests; in fact, the recorded 100 colonies were grouped on 34 rocky outcrops reaching a total area of about 2 ha. Nevertheless, the size structure of the population seems equilibrated, with a symmetric size–frequency distribution and the modal class of the distribution, 30–40 cm, completely overlapped with that recorded by Chimienti [28] for the denser forests of Sanremo (Ligurian Sea). The estimated age structure reflects previous data obtained in the Marseille region. The data recorded for Sanremo population was younger (11–15 years), with a modal class in the range of 26–30 cm and a tail of old colonies reaching a maximal estimated age of about 71–75 years [28]. It is probable that sexual reproduction is only possible in a cluster of outcrops very close to the central of the channel. The maximal settling distance for this center was about 1.2 km for colonies recorded during this study and about 2 km for the colonies settled on the Klearchos wreck [30]. These data agree with the behavior of the lecithotrophic larvae of *E. verrucosa* showing a dispersion ability around the parent colonies <1 km [5,19,21,45].

The occurrence of several, well-developed colonies on the hull of the Klearchos wreck, sunk on 20 July 1979 [30], is a useful opportunity to validate the age estimation of the population. Although no reference scale is present in the available images, recorded in September 2011, the age of the wreck is in accordance with the modal class of the age distribution recorded during our survey.

The overall rarity of this species in Sardinia is difficult to argue, in the light of the wide occurrence of all the other shallow-water and mesophotic species of alcyonaceans [40–44].

The map of distribution proposed by Chimienti [28] suggests that the predominant Mediterranean water circulation explains the gradual colonization of the western Mediterranean Sea by *E. verrucosa* from the Atlantic Ocean. The presence of this coral in both the Balearic Sea and the Strait of Sicily may be explained by some common environmental and oceanographic features of these two areas. Both are characterized by an intense geostrophic circulation of water masses and a complex seafloor topography, that, due to the presence of islands and seamounts, generates mesoscale eddies and convergent fronts [46–51]. In the Balearic Sea, the colonisation is driven by the ascending Atlantic Water (AW, surface water of Atlantic origin), which, bordering the western coast of Corse, where populations were recorded, see [28], enters the Ligurian Sea, reaching the Tuscany Archipelago. In this area, coral larvae can be spread by the Lyon Gyre [52].

On the other hand, from the Sicily Channel, the species has colonised the Tyrrhenian coast without going beyond the Gulf of Naples. Therefore, the species appears absent in the central Tyrrhenian Sea and the population of Tavolara MPA could be the unique description for the entire sub-basin. In this situation, it is plausible that the occurrence of this species at Tavolara could result from a stochastic event of settling of larvae presumably coming from the Tuscany Archipelago. Genetic studies on this isolated population might help to clarify its origin and connectivity with other coastal forests.

#### 4.2. Predators and Acrophilic Epibionts

The study of the associated community provides some data about the specialized predators of *E. verrucosa*. The tritoniid nudibranch *Duvaucelia odhneri* lives its entire life cycle on the same host colony, exploiting seven different gorgonian species [53], including *E. verrucosa*, as also confirmed in this investigation with the discovery of individuals and eggs on the same colony.

The ovulid *Simnia spelta* shows a similar life strategy, being associated with at least four gorgonian species, *Eunicella cavolini*, *E. singularis*, *L. sarmentosa*, and, in our case, *E.*

*verrucosa*. *S. spelta* feeds on the coenenchyme and polyps of the host and also lays ovarian capsules on the branches, causing necrosis of the underlying tissue [54].

During this study, we observed one colony of *E. verrucosa* hosting a group of the palaemonid shrimp *Balssia gasti*. The species has always been observed associated with octocorals, although the nature of the association is still to be elucidated. However, a predatory strategy was hypothesized due to the homocromic camouflage of this species in agreement with the color of the coenenchyme of the hosts [55–58]. In the Tavolara area, *B. gasti* was already observed on *Paramuricea clavata* and *E. cavolini* [59]. Finally, two specimens of the decapod *Periclimenes scriptus*, known as mucus-feeder of octocorals [56], were recorded. In the Tavolara area, this species was observed mainly associated with *P. clavata*, living on the granitic outcrops of the Tavolara Channel [60].

Regarding acrophilic species, the frequent occurrence of the basket star *Astrospartus mediterraneus* is remarkable. This species, generally recorded as colonizing deep habitats, [61] is becoming more and more abundant in relatively shallow waters in recent years [62]. *A. mediterraneus* is one of the few species that have changed its bathymetric distribution moving towards the surface. This is unusual; in fact, in relation to water temperature increasing, numerous shallow-water species changed their bathymetric distribution, reaching deeper levels [63].

#### 4.3. Epibiosis and Health Status of the Population

Out of 100 colonies, 45 showed damages of various entities, from small portions of naked skeleton to completely dead colonies (Figures 5 and 6). The main stressors able to influence the coenenchyme integrity of structuring anthozoans are thermal stress and mechanical injuries, mainly due to fishing activity [34,35,64–66].

Diseases due to heating phenomena with consequent necrosis of coenenchyme are widely documented in the TPCCAMPA for *Paramuricea clavata* and *Eunicella cavolini*, but not at depths exceeding 35–40 m, where the process of necrosis starts from the apical portions of the colonies [67]. Based on this evidence, thermal stress has a negligible influence on the damages described in this study. In fact, the population of *E. verrucosa* mainly lives below the depth where these phenomena are usually documented. Moreover, the degenerative processes due to thermal anomalies are evident as a naked portion of the apical branches. This kind of damage was only sporadically recorded in our study. The direct observation of lost lines entangled in the colonies suggests, at least partially, an anthropic involvement. Physical contact with fishing gear scrapes the gorgonian coenenchyme, favoring the development of epibionts. Epibionts substantially modify the host–environment interactions (e.g., transference of energy or matter), eventually reducing their fitness [68]. Large masses of epibionts lead to a burdening of the colonies and greater mechanical stress, increasing their resistance to water movement [26,34,35,69–71].

The most common epibionts observed in this study were *Alcyonium coralloides*, bryozoans (*Turbicellepora avicularis*, *Adeonella calveti* and *Pentapora fascialis*) and the demosponge *Crella elegans* (Figures 4B and 5).

*A. coralloides* is one of the first colonizers of the skeletal portions deprived of coenenchyme and can subsequently continue its expansion to the detriment of the coral to fully occupy its skeleton. On the Tavolara specimens, *A. coralloides* always settled in the basal or central portions of the fan and never on the apical parts. It is generally accepted that the high occurrence of this epibiont may be correlated, in frequented sites, to anthropogenic damages [72], supporting its use as a bioindicator of stress in coralligenous assemblages [26,34,73,74]. Similar considerations are also true for erect bryozoans, such as *T. avicularis* [75].

Many Mediterranean localities endure impacts by anthropogenic pressure due to demersal fishing activities that pauperize three-dimensional benthic ecosystems, such as coral forests [10,26,35,40,69,76–81]. In the Medes Islands (Catalan Sea), between 10% and 33% of the colonies in unprotected populations were partially colonized by epibionts, most likely following tissue injury, whereas only from 4% to 10% of the populations in a

marine protected area was affected [76], suggesting that fishing activities directly cause severe damage expressed as epibiosis coverage. Our data indicate an epibiosis at least four times higher for the Tavolara's *E. verrucosa* population.

The communities occurring on the granite outcrops have traditionally been considered of low quality due to the absence of the typical coralligenous features such as the thick coralline algal concretion [82]. This underestimation serves to classify the Tavolara Channel in the C-zone of MPA (Partial Reserve), allowing artisanal and recreational fishing activities, which, in turn, probably increased the pressure on the benthic communities. Recently, however, it was stated that the communities settled in this particular habitat are not impoverished facies of the coralligenous assemblage, but a peculiar community composed of erect sponge and habitat-forming anthozoans [33]. An adjustment of the management guidelines of the MPA is required in light of the re-evaluation of this habitat.

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