Mar Biodiv (2016) 46:85–94
DOI 10.1007/s12526-015-0325-9

SENCKENBERG

ORIGINAL PAPER

Hydroid gardens of *Nemertesia ramosa* (Lamarck, 1816) in the central North Atlantic

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Received: 4 November 2014 / Revised: 26 January 2015 / Accepted: 5 February 2015 / Published online: 18 March 2015

Abstract *Nemertesia ramosa* (Lamarck, 1816) is a large eurybathic hydrozoan species. Its habitat and spatial distribution in the Azores archipelago (central North Atlantic) are described based on 22 new records collected in situ by scuba diving and by observations using a drop-down camera and remote operated vehicles (ROVs) between 2004 and 2011. *N. ramosa* grows on hard substrates in mono and multi-specific assemblages. In the Azores it is well known in the sublittoral at 15–158 m depth in the central group of islands, but historical records exist from seamounts down to bathyal grounds of nearly 1000 m. Scuba diving surveys generally reveal *N. ramosa* as an occasionally occurring and rare species in the infralittoral (1–9 colonies 10^{-3} m^{-2}), although it may also be common and even abundant at some sites. A circalittoral aggregation was assessed in detail exhibiting densities of up to 2.82 colonies m^{-2} on rocky substrate and one order of magnitude lower on mixed bottom (0.25–0.55 colonies m^{-2}). An aggregated spatial distribution is described, with aggregations being considered hydroid gardens (>1–9 10^{-1} m^{-2}). Colonies measured on ROV imagery averaged 23.5 cm in height (STD=4.1). Taller colonies (max=36.7 cm) were registered on rocky outcrops protruding more than 15 cm. *N. ramosa* co-occurred mainly with brown and red algae, bryozoans, polychaetes, and other hydroids. A diverse ichthyofauna was associated to these habitats. Circalittoral communities of *N. ramosa* included hydrozoans, sponges, and fish.

Keywords Benthic ecology · Eurybatic · *Nemertesia ramosa* · Large hydrozoa · Hydroid garden · Azores

Communicated by B. W. Hoeksema

Electronic supplementary material The online version of this article (doi:10.1007/s12526-015-0325-9) contains supplementary material, which is available to authorized users.

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Introduction

The description of the assemblages consisting of sessile invertebrates is crucial for the understanding of benthic ecosystems by providing a baseline for the classification of habitats, which is an integral part of any nature information system (Greene et al. 1999; Connor et al. 2003; Davies et al. 2004). Hydrozoa are cnidarians, usually growing in colonial forms with the polyps connected to a hydrocauli. Sessile hydrozoans can reach considerable densities (Williams 1976), and tall colonies reach a few dozens of centimetres. They have been shown to characterize and dominate certain shelf habitats, standing out as habitat-building macrofauna (Strong et al. 2012; Tempera et al. 2013). As knowledge of circalittoral epibenthic assemblages grew in result of the increasing utilization of remote surveying techniques, these biotopes were assigned to their own habitat classes. Specifically, the EUNIS habitat classification (http://eunis.eea.europa.eu) has integrated the class "Facies with large hydrozoa", whilst CMECS (Madden et al. 2009) integrated "Attached Hydroids" and "Soft Sediment Hydroids" communities.

Nemertesia ramosa (Lamarck, 1816) is a large plumulariid hydroid (Order: Leptothecata). Its distribution ranges from Iceland, the Faeroes and Scotland (Broch 1918), down to South Africa, including the southeast coast of Africa (Millard 1975). The species is eurybathic, with records ranging from sublittoral areas (Picton and Morrow 2010) to depths of

1,182 m off Morocco (Ramil and Vervoort 1992). It is a conspicuous element of animal turf communities on several locations in Britain and Ireland (Porter 2012), but habitats dominated by *N. ramosa* have never been reported in detail.

N. ramosa has been reported from shelf areas at <200 m depth around the islands (Rees and White 1966; Cornelius 1992), as well as from seamount samples collected at bathyal depths (Calder and Vervoort 1998). It was first reported in the Azores from two stations at Faial-Pico Channel during the surveys of Prince Albert 1st of Monaco in the late 1800s (Pictet and Bedot 1900). Cornelius (1992) compiled the existing records in 1989, including a previous collection by Patzner south of Faial Island, and added new observations close to Faial Island obtained by scuba divers from around 30 m depth and by a remote underwater video camera operated at depths of ca. 100 m for which no precise locality data is given. Calder and Vervoort (1998) collected two *N. ramosa* with a remote operated vehicle at 788 and 919 m depth, from seamounts in the Azores region. These records are, however, somewhat questionable as both are small and their hydrocladia are biserial instead of multiserial in arrangement (Calder and Vervoort 1998). Recently, further samples were collected from Faial-Pico Channel by fishing vessels (Moura et al. 2012).

N. ramosa is one of several species belonging to the genus *Nemertesia* that occur in the Azores. Other species include *N. belini*, *N. norvegica*, and at least three cryptic species sharing morphological affinities with *N. antennina* (Moura et al. 2011). *N. ramosa* is a conspicuous hydrozoan, and one of the tallest branching hydroid species in the Azores. Its appearance makes it is macroscopically distinguishable from regional congenerics (see the "Material and methods" section for more details), as well as from other large hydrozoan species such as *Polyplumaria flabellata* (fan-shaped) or *Lytocarpia myriophyllum* (tall feather-like plumes).

Samples collected by classical methods, like dredging, usually yield more than one colony, suggesting the existence of *N. ramosa* aggregations. In situ observations have previously reported aggregations of several colonies (e.g. Cornelius 1992), but no further details were given.

This paper provides 22 new records for the species, including several locations with a large number of *N. ramosa* colonies. Details of a deep circalittoral aggregation of *N. ramosa* is provided, along with a list of co-occurring species.

Material and methods

The Azores is an archipelago in the northeast Atlantic composed of nine islands situated at latitudes ranging between 37°N and 40°N (Santos et al. 1995). The islands spread across an extent of 617 km and are surrounded by narrow shelves and a rich submarine topography dominated by over 400 seamount-like features (Morato et al. 2008) and, more distally, abyssal plains extending to depths exceeding 5,000 m.

Surveys conducted by scuba diving, drop-down camera, and remote operated vehicles (ROVs) in the Azores archipelago between 2004 and 2011 were analyzed to investigate the habitat and distribution of *N. ramosa*. Densities of *N. ramosa* and co-occurring organisms were estimated using the SACFOR scale for species with sizes >15 cm (Hiscock 1996). Abundances recorded from ROV *SP* where estimated using the ROV field of view (Porteiro et al. 2013), as detailed below.

Identification of *N. ramosa* was based on phenotypic characters, using: i) the long, sparse, and irregularly branched main stems; ii) whorled three-dimensional side branches in groups of six angled upward; and iii) the close correspondence with the descriptions and illustrations of *N. ramosa* from (Ramil and Vervoort 1992; Porter 2012). Other phenotypic characters considered where (i) the species large size, (ii) its prominent branching, and (iii) the yellowish colouration. The two latter characters generally distinguish it from the *N.* aff. *antennina* group of species. Colonies were hand-collected during scuba dives and kept in the reference collection of the Dept. of Oceanography and Fisheries of the University of the Azores (COLETA).

Scuba dives between 15–40 m performed in the scope of projects MARÉ, OGAMP, and MARMAC recorded *N. ramosa* on coastal areas around the islands of Faial, São Miguel, and Santa Maria. Dives were geo-referenced using (i) a hand-held GPS deployed on the support boat or (ii) "transit marks" and site proxies as described in the scuba diving survey protocol of Holt and Sanderson (2001).

Underwater surveys were performed with a drop-down camera between 30–60 m comprising a Tritech MD4000 video camera mounted on a metal frame and suspended from M/V *Jonas* using a cable containing coaxial and LED light control elements. Approximate camera position was obtained from a hand-held GPS on deck (±50 m accuracy).

Several locations around Faial Island and Faial-Pico channel were also surveyed with a VideoRay Explorer Mini-ROV between 30–60 m, operating from the R/L *Águas Vivas* in 2004. The video survey was georeferenced using a hand-held GPS on deck (±80 m accuracy).

The ROV *SP* (*SeaBotix LBV300S-6*; IMAR-DOP/UAz), was operated between 80–255 m from the R/L *Águas Vivas*. The ROV was equipped with a colour camera (570 line/02 Lux, 4:3), with four lights installed externally on the four front corners (480 Lumen each) and a scaling two-point laser system (5 cm apart) that was used to estimate sizes. ROV *SP* was positioned with a Subsea Micron Nav USBL (Ultra Short Baseline) unit fitted onto the vehicle in the responder mode. The navigational data were manually filtered for outliers and smoothed with a moving average, to remove false loops. The moving average allowed adjusting the resulting dive track, which was aided by visualizing the ROV behaviour on the recorded video. Finally, the track was splined to obtain coordinates for every second.

The surveyed area was estimated by multiplying the distance travelled on the seafloor (x, y) with the average field of view. With a tilt range of 270° and panning achieved by moving the ROV itself, the camera orientation can change during the dive while the seafloor and its features are being explored. The average field of view was obtained by measuring the image width when the scaling lasers were projected on the seafloor. Measurements of video stills were repeated each 5 s of the dive, with the image analysis software *ImageJ* (1.46r). As the field of view can vary considerably, an average value was estimated for each transect as well as the surveyed area (total average field of view 1.96, SD=0.4; see information on transects below).

The video was annotated for the presence of *N. ramosa* and other large megafauna (>10 cm), with the Customizable Observation Video Image Recorder - COVER (v0.7.2, Ifremer; Carré 2010). The seafloor geomorphology was classified in four categories: "Gravel and Sand", "Sand-Dominated Mixed", "Rock-Dominated Mixed", and "Hard Bottom". "Sand-Dominated Mixed" comprises unconsolidated sediments, i.e. gravel and sand, covering >50 % of seafloor (not taken into account if they consist of only a very thin layer). "Rock-Dominated Mixed" comprises areas with hard substrate (i.e. rocky bottom, boulders, cobbles, and pebbles; Wentworth 1922) representing >50 % of seafloor coverage. Hard bottom are areas of consolidated ground only.

The density of *N. ramosa* (colonies m^{-2}) was estimated for several transects developed during one ROV dive (11CF_RSP018), and colony size was measured whenever possible. Dive sections were considered transects every time the ROV was transiting close to the seafloor with a good visibility and covering a minimum of 5 m2. Twenty transects were considered for analysis, including areas before and after the colonies were observed (Fig. 2). Surveyed areas by each transect varied between 5.3–38.2 m2 (average 16.8 m2, STD=6.2), 00:30-01:17 min:s (average 00:48) and an average distance of 8.9 m (STD=3.9).Colonies growing at seafloor level, or on outcrops protruding <15 cm from the seafloor, were compared with colonies growing on rocky outcrops protruding >15 cm from seafloor to evaluate possible differences in colony heights. The Wilcoxon–Mann–Whitney two-sample rank-sum test (two-tailed, $p<0.05$) was used to test for differences in this parameter. The probability of *N. ramosa* having an equal abundance on different bottom types was tested with Kruskal-Wallis using transects T5-T17 (the first and last transect where the species was observed; see the "Results" section). Subsequently, the abundance of *N. ramosa* between different bottom types were evaluated using *t*-tests. All statistical analyses were performed using Statistica 10.0 software (StatSoft Inc., Tulsa, OK, USA). The coefficient of dispersion was calculated as CD=s2 μ^{-1}, where s is the standard deviation and μ the observed average (Bliss 1958), to ascertain the type of distribution: random (CD=1), uniform (CD<<1), or aggregated (CD>>1).

Results

We report 22 new records of *Nemertesia ramosa* on different locations around Faial island and in the Faial-Pico channel as illustrated in Fig. 1. New records were compiled with a list of previous records after Cornelius (1992), and are provided in Table 1. This raises the total amount of records of *N. ramosa* to 31, ranging in depth mostly from the infralittoral (15 m) to the deep circalittoral (158 m).

During infralittoral scuba diving surveys, *N. ramosa* was observed around Faial Island and Faial-Pico Channel at three sites, at 15–36 m depth. Occurrences on the three locations were considered as occasional and rare.

The drop-down camera recorded a mono-specific facies of *N. ramosa* in the Faial-Pico Channel, east of the Espalamaca headland at 50–60 m depth (Table 1; Fig. 2). The seafloor was dominated by rocky outcrops mixed with gravelly sand. Colonies were recorded as soon as the DDC reached the bottom, during 11:15 min:s, until the DDC transect reached an area of continuous unconsolidated sediment. A total of 302 colonies were counted, being abundant on every rocky outcrop in the area (i.e., 1–9 colonies m^{-2}). *N. ramosa* was also encountered in high densities on a communications cable lying on the seafloor.

The Mini-ROV recorded *N. ramosa* at 16 sites, at 30–60 m depth (Table 1; Fig. 2). Densities varied from occasional, where several colonies were observed, to rare, where only isolated or very few colonies were identified on the seabed.

Density estimates on infralittoral areas collected by scuba diving, drop-down-camera, and mini-ROV reveal mostly occasional species with colonies ranging between 1–9 10^{-3} m^{-2} (40 %), but also rare species in some locations (30 %) (Fig. 3). In the remaining 30 % of the sites *N. ramosa* was frequent, common or even abundant, reaching densities of 1–9 m^{-2}.

The infralittoral conspicuous biota occurring together with *N. ramosa* on rocky areas recorded during 16 Mini-ROV dives at 30–60 m depth included nearly 100 taxa (Tables 1, 2 in ESM). The most abundant sessile species were the brown algae *Halopteris filicina, Dictyota* spp., and *Zonaria tournefortii,* Delesseriacea red algae, and encrusting Corallinacea; several sponges, particularly *Clathrina lacunosa*, the bryozoan *Smittina cervicornis*, the polychaethes *Hermodice carunculata*, and *Sabella spallanzanii*. Several Hydrozoa also occurred frequently in the same location as *N. ramosa*, particularly *Aglaophenia* spp. and *Sertularella*

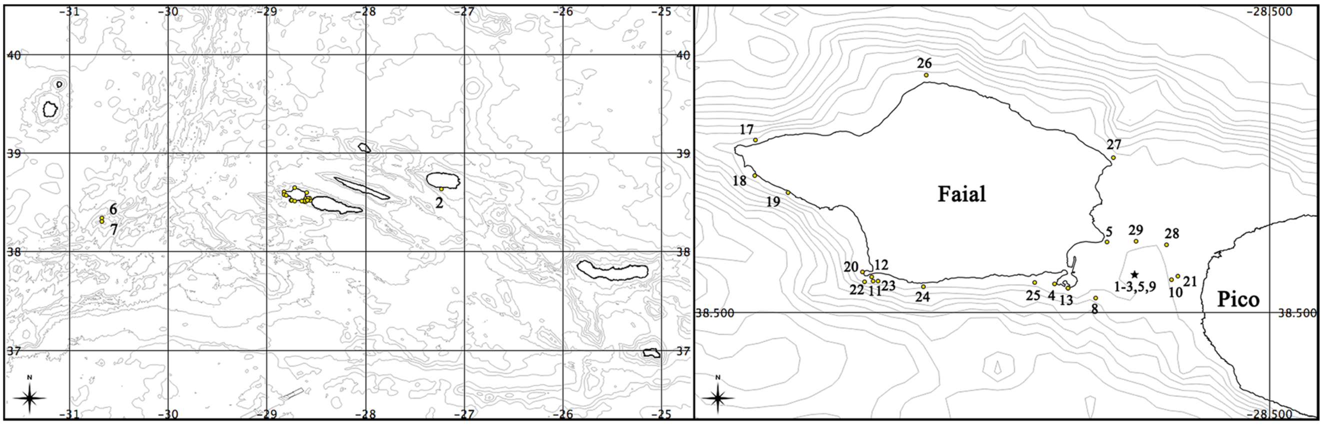

Fig. 1 Locations of *Nemertesia ramosa* records in the Azores Archipelago. Locations of historical samples are based on site descriptions and are not necessarily accurate, except for 8 and 13–31. The asterisk indicates the approximate locality for samples labelled as "Faial-Pico Channel" 1–3, 5, and 9. Bathymetric contours are spaced at 500 m depth intervals in the left figure, and 100 m in the right figure

sp., as well as scleractinian corals such as *Antipathella* spp. and *Caryophyllia* sp. The infralittoral ichthyofauna was diverse (Table 2, ESM), with the labrids *Coris julis* and *Bodianus scrofa* as the most frequently observed species followed by *Boops boops*. *Mullus surmulentus, Scorpaena scrofa, Diplodus sargus,* and *Muraena helena* were also frequently observed in the area. In the drop-down camera survey fewer species were identified, with *Zonaria tournefortii, Caryophillia* sp. and a purple encrusting sponge as the only sessile invertebrates identified from imagery. The fish species most frequently observed were *Serranus atricauda* and the micronectivorous *Anthias anthias* and *Thalassoma pavo*.

Exploratory dives in the circalittoral with ROV *SP* on the southern sector of the Faial-Pico Channel yielded records of two facies with *N. ramosa* at 118–158 m depth (see Table 1 and Table 3 in ESM for more details).

On dive 11CF_RSP018 a total of 62 colonies were identified in eight transects (T5, T7-11, T13, and T17) (Table 3 in ESM; Figs. 2 and 4), comprising a surveyed area of 109 m^2. A strong tidal current was reflected on the colonies, as seen in Fig. 2i. Colony height averaged 23.5 cm (STD=4.1). The seafloor was composed of a mixture of outcrops of consolidated sedimentary rock and unconsolidated sediment covered by bioclastic material (e.g. made by bryozoans). The rocky layer showed several crevices, protruding from the seafloor level up to ca. 40 cm in some locations. Small and medium boulders occurred throughout, appearing to be broken sections of the rocky underground. The sedimentary origin of the hard substrate and heavy colonization by encrusting sponges and other fauna gave it a very rough appearance. The "Sand-dominated mixed" area was composed mostly of small boulders, pebbles, shells, and other bioclasts, alternated with gravel.

Hydroids growing on rocky outcrops protruding more than 15 cm from the surrounding seafloor averaged 25.3 cm height (min., 16.2; max., 36.7 cm; STD=5.1; N=11). Colonies growing near the seafloor averaged 22.2 cm height (18.7–26.7 cm; STD=2.5; N=15). The difference between colonies at both locations is marginally significant (Mann–Whitney U=126, p=0.0257; two-tailed test). Before crossing the area colonized by *N. ramosa*, the ROV *SP* traversed ca. 40 m over a seabed composed of unconsolidated sediment, pebbles, and small boulders. The area traversed after the hydroid aggregation was identical, suggesting that *N. ramosa* colonies occurred in a rocky area surrounded by unconsolidated sediment and smaller rocks.

Densities of *N. ramosa* were different according to the geological setting of each transect ($p<0.05$; Kruskal-Wallis). The largest density was recorded on a small area of (strictly) rocky bottom, with an average density of 2.82 m^{-2} (min.: 2.6, max.:3.1; corresponding to Abundant in the SACFOR scale). In areas of mixed seafloor types, *N. ramosa* were common, with densities of 0.25 m^{-2} for sand-dominated mixed and 0.55 m^{-2} for rock-dominated mixed substrates (Fig. 5). The differences were actually not significant (T-test; p=0.12), except for the rocky area ($p<0.05$). The coefficient of dispersion CD=1.45 implies an aggregated spatial distribution that could be described by a negative binomial distribution (Bliss 1958). However the small sample size hampered further investigations (Heip 1976). In general, many of the colonies observed (but not all), were close to other conspecific colonies, forming small patches on the rocks, being often closer than each other's height. In the occasions the ROV approached the seabed, several colonies were observed growing in close proximity (i.e., < 5 cm in some cases; Fig. 2).

On dive 11CF_RSP023, five colonies were identified in a step-like large outcrop. The step 'face' was ca. 2 m tall, protruding from unconsolidated sediment, and hosted a great diversity of sessile invertebrate fauna. A small area of the outcrop was inspected by the ROV, with the transect developed perpendicularly to the outcrop (step). *N. ramosa*, including large colonies, were observed mostly on the edge of the

Table 1 *Nemertesia ramosa* records in the Azores archipelago ordered by depth and grouped by depth class: Infralittoral (0–80 m), Circalittoral (80–200 m), Bathyal (>200 m); Record refers to the historical sequence of records, with previous records compiled after Cornelius (1992). Indication of location, Lat/Lon (latitude and longitude), accuracy, depth (m), date (yyyy-mm-dd), survey type, notes on sample and material, density in SACFOR and source of data (>15 cm); * indicates location not exact; N/A indicates that information not available

Record	Depth class	Location	Lat, long	Accuracy	Depth (m)	Date	Survey	Sample/material	Density	Source
2	Infralittoral	Terceira Island, Monte Brazil	N/A	–	20	–	?	–	–	Rees and White 1966
4	Infralittoral	SE Corner of Monte da Guia at entrance to rift*	38.5165000, -28.6317000	+–50 m	ca. 30	1989-07-28	Collection	Two 7.5 cm colonies, young, simply-pinnate, fertile; plus one infertile, 2.5 cm; DOPH; coll R. & A.M. Patzner	–	Cornelius 1992
10	Infralittoral	Baixa do Norte*	38.5205500, -28.5613000	+–50 m	20–35	?	Scuba dive	Imagery, Survey code: xbno1ef	O	*Present study*
11	Infralittoral	Baixa de Castelo Branco*	38.5195500, -28.7491500	+–50 m	27–36	?	Scuba dive	Imagery, Survey code: fbcb1f	R	*Present study*
12	Infralittoral	Morro de Castelo Branco*	38.5223333, -28.7500833	+–50 m	15–36	?	Scuba dive	Imagery, Survey code: fmcb1de	R	*Present study*
13	Infralittoral	Outside Caldeirinhas	38.5150579, -28.6264373	+–50 m	30–50	2004-06-28	Mini-ROV	Imagery, Dive 3, seq. 11	O	*Present study*
14	Infralittoral	Outside Caldeirinhas	38.5150583, -28.6264361	+–50 m	30–50	2004-06-28	Mini-ROV	Imagery, Dive 3, seq. 14	O	*Present study*
15	Infralittoral	Outside Caldeirinhas	38.5150584, -28.6264362	+–50 m	30–50	2004-06-28	Mini-ROV	Imagery, Dive 3, seq. 15	C	*Present study*
16	Infralittoral	Capelinhos	38.5150595, -28.6264332	+–50 m	30–50	2004-06-29	Mini-ROV	Imagery, Dive 4, seq. 18	R	*Present study*
17	Infralittoral	Praia do Norte	38.608434, -28.823073	+–50 m	30–50	2004-06-29	Mini-ROV	Imagery, Dive 5, seq. 22	C	*Present study*
18	Infralittoral	Farol do Vale Formoso	38.586100, -28.823594	+–50 m	30–50	2004-06-29	Mini-ROV	Imagery, Dive 6, seq. 24	O	*Present study*
19	Infralittoral	Igreja do Capelo	38.575467, -28.802418	+–50 m	30–50	2004-06-29	Mini-ROV	Imagery, Dive 7, seq. 26	O	*Present study*
20	Infralittoral	Morro de Castelo Branco (W)	38.5237201, -28.75559	+–50 m	30–50	2004-06-29	Mini-ROV	Imagery, Dive 8, seq. 28	R	*Present study*
21	Infralittoral	S of Madalena Islets	38.5229079, -28.5573247	+–50 m	30–50	2004-06-30	Mini-ROV	Imagery, Dive 11, seq. 37	O	*Present study*
22	Infralittoral	S do Morro de Castelo Branco	38.5190715, -28.7542575	+–50 m	30–50	2004-07-01	Mini-ROV	Imagery, Dive 13, seq. 47	F	*Present study*
23	Infralittoral	SE do Morro de Castelo Branco	38.5194832, -28.7461297	+–50 m	30–50	2004-07-01	Mini-ROV	Imagery, Dive 14, seq. 49	F	*Present study*
24	Infralittoral	S do Aeroporto	38.512549, -28.7176125	+–50 m	30–50	2004-07-01	Mini-ROV	Imagery, Dive 15, seq. 51	R	*Present study*
25	Infralittoral	SE of Ponta Furada	38.5153276, -28.6472613	+–50 m	40–60	2004-07-01	Mini-ROV	Imagery, Dive 16, seq. 53	F	*Present study*
26	Infralittoral	Cedros	38.649396, -28.715586	+–50 m	30–50	2004-07-02	Mini-ROV	Imagery, Dive 23, seq. 73	O	*Present study*
27	Infralittoral	Ponta da Ribeirinha	38.597273, -28.598012	+–50 m	30–50	2004-07-02	Mini-ROV	Imagery, Dive 26, seq. 87	R	*Present study*

Table 1 (continued)

Record	Depth class	Location	Lat, long	Accuracy	Depth (m)	Date	Survey	Sample/material	Density	Source
28	Infralittoral	Baixa do Norte	38.5425167, -28.56475	+−50 m	30–50	2004-08-10	Mini-ROV	Imagery, Dive 29, seq. 99	O	*Present study*
29	Infralittoral	Crista (E da Espalamaca)	38.5444444, -28.5836111	start position	50–60	2005-09-14	DDC	Imagery, DDC20, 05DD_DSA007	A	*Present study*
1	Circalittoral	Faial-Pico Channel	N/A	–	98–130	–	?	"*Antennularia ramosa*" Taken from two stations at Pico-Faial Channel	–	Pictet and Bedot 1900
3	Circalittoral	South of Faial, off Castelo Branco	N/A	–	ca. 100	1980-10-01	?	One 12 cm colony; DOPH cool., H.R. Martins	–	Cornelius 1992
5	Circalittoral	Faial-Pico Channel, off Espalamaca	N/A	–	ca. 100	1989-07-29	Remote TV	Many colonies; via R. Nash; det. PFSC	N/A	Cornelius 1992
8	Circalittoral	Faial-Pico Channel	38.5090167, -28.6090667		150 m	–	Submersible Lula	dive #133, sample DBUA1119.01;DBUA 1119.01; JN714563	N/A	Moura et al. 2012
9	Circalittoral	Faial-Pico Channel	N/A	–	–	–	Fisherman collection.	DOP C2112; JN714562	–	Moura et al. 2012
30	Circalittoral	Faial-Pico Channel	38.4995833, -28.5790500	?	154-158	2011-06-27	ROV SP	Imagery, Dive 11CF_RSP018; 62 colonies, X cm max, max density 3.1 m2	C	*Present study*
31	Circalittoral	Faial-Pico Channel	38.4956683, -28.5600709	?	118	2011-06-28	ROV SP	Imagery, 11CF_RSP023	C	*Present study*
6	Bathyal	Mid-Atlantic Ridge Seamount	38.3416667, -30.6716667		919	1994-05-17	Submersible Nautile	DIVA 1, Dive DV 10-5	–	Calder and Vervoort 1998
7	Bathyal	Seamount	38.3091667, -30.6691667		788	1994-05-19	Submersible Nautile	DIVA 1, Dive DV 11-5	–	Calder and Vervoort 1998

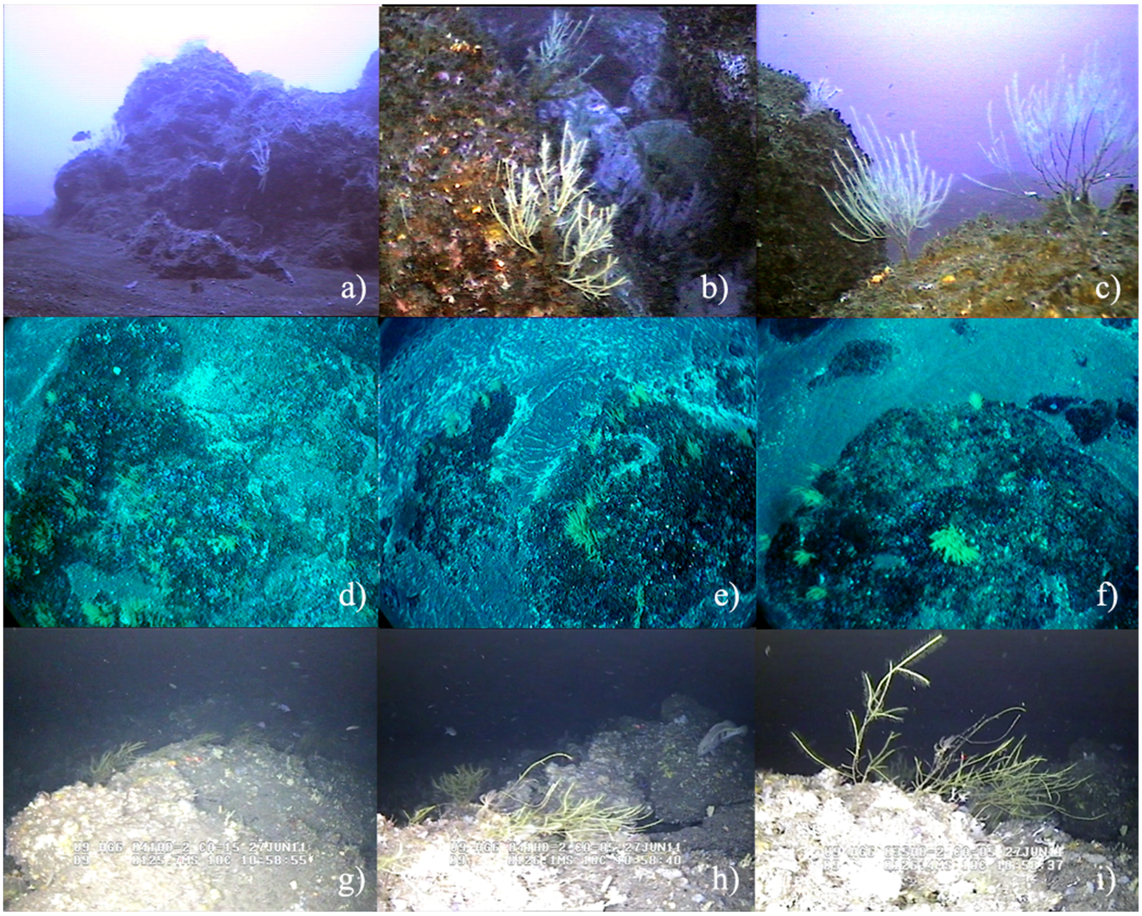

Fig. 2 *Nemertesia ramosa* from infralittoral and circalittoral depths in the Azores Archipelago. **a–c** small number of colonies recorded by Mini-ROV (**a** sample 5, **b** sample 16, **c** sample 29); **d–f** large number of colonies on hard substrate recorded by drop-down camera (DDC20); **g–i** circalittoral aggregation recorded by ROV *SP*, showing colonies on the edge of rocky outcrops, *Anthias anthias* and *Serranus atricauda* (**g–h** transect 9), and close-up view of tall colonies with an epibiont crinoidea (**i**); see Table 1 for sample numbers and information

outcrop, but also on the vertical wall. Colony size and density were not estimated. Two fishing lines were observed in the vicinity.

In both locations several co-occurring species were identified with the ROV *SP*. These were mostly sponges, such as

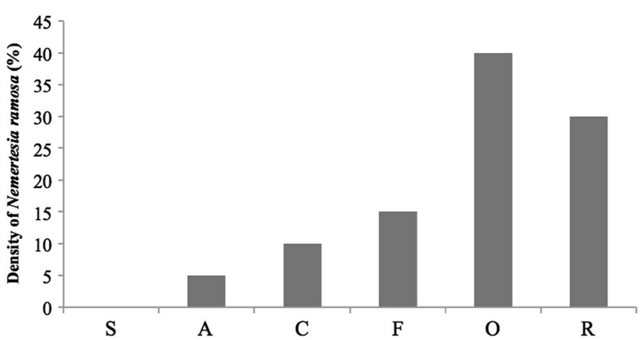

Fig. 3 Density estimates of *Nemertesia ramosa* using the SACFOR scale, on 20 infralittoral surveys from SCUBA diving (3), drop-down camera (1), and Mini-ROV (16) in the Azores Archipelago (see Table 1 for more details)

Haliclona implexa, *Auletta sessilis, Axinella vasonuda,* cf. *Pseudotrachya histrix*, *Petrosia* sp. (*N*=1), and several encrusting species. Other hydrozoans include *Polyplumaria flabellata*, *Lytocarpia myriophyllum*, some observations of *Aglaophenia* sp., cf. *Sertularella gayi*, and several other small-sized, undetermined species. Alcyonacean corals included *Alcyonium* sp. and *Viminella flagellum*. Several unidentified bryozoans were present, comprising a great portion of the bioclastic material. An unidentified crinoid was observed perched on the colonies tall branches (Fig. 2i).

The ichthyofauna at dive 11CF_RSP018 was characterized by several schools of *Callanthias ruber* (*N*>50) and *Anthias anthias* (*N*=20–30). Several *Lappanella fasciata* and *Serranus atricauda* were observed (*N*<5), also *Conger conger* (*N*=1), *Pontinus kuhlii* (*N*=1), *Scorpaena scrofa* (*N*=3), and *Scorpaena* sp. (*N*=2) were seen in the vicinity of the hydroids. *Serranus atricauda* was observed chasing *Callanthias ruber* on one occasion, an agonistic behaviour with possible predatory purposes. On the gravel and sandy bottom, an *Aulopus filamentosus* was observed. At

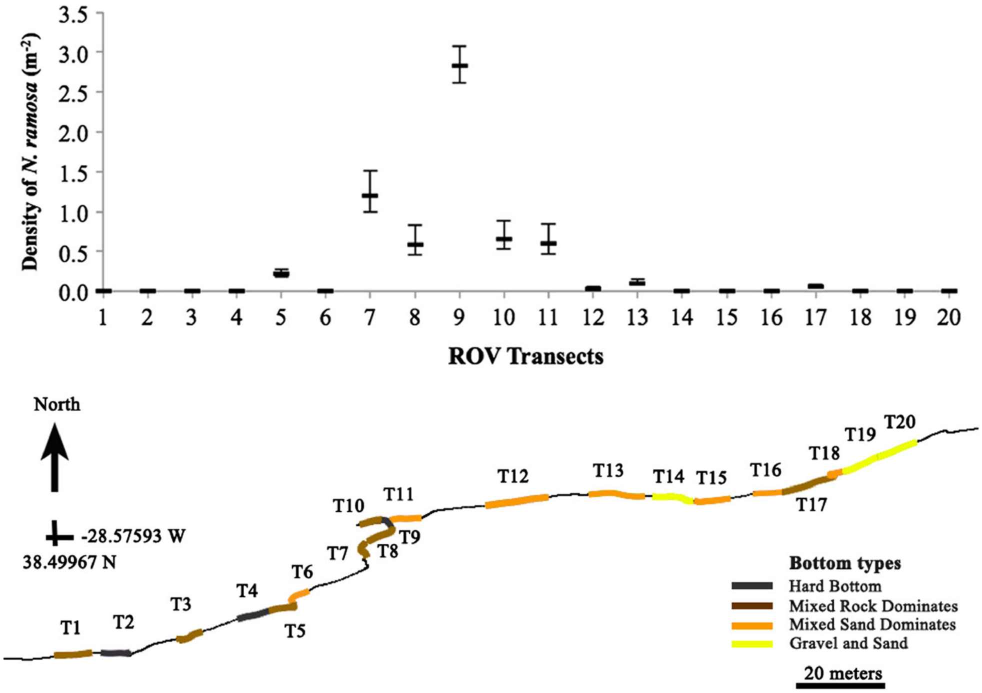

Fig. 4 Density of *Nemertesia ramosa* colonies (m^{-2}) in 20 transects conducted with the remotely operated vehicle (ROV *SP*) in the Faial-Pico Channel. The ROV track below illustrates the different bottom types

dive 11CF_RSP023 *S. atricauda* and *Anthias anthias* where the most frequently observed species.

Discussion

Nemertesia ramosa colonies show an aggregated spatial distribution in the Azores, occurring mainly in low densities throughout infralittoral and circalittoral rocky bottoms. Aggregated distribution is a common distribution pattern of many sessile marine invertebrates (Underwood and Chapman 1996), often resulting from a compromise between energy uptake and the necessity for proximity for reproductive purposes (Heip 1975). *Nemertesia* species release short-lived planulae, like many deep-water hydroids (Henry et al. 2008), which represent the only mobile stage of these species (Hughes 1977). Williams (1976) found that settled larvae form aggregated clusters between neighbouring individuals. Close proximity is required to achieve routine cross-fertilisation, and once planulae are released, long-distance dispersal away from the natal conspecific colonies should be highly limited (Williams 1976). Similar spatial dispersion patterns in deep-water coral ecosystems were also associated to philopatric larval settlement of planuae releasing species, such as with *Eudendrium* hydroids (Henry et al. 2013).

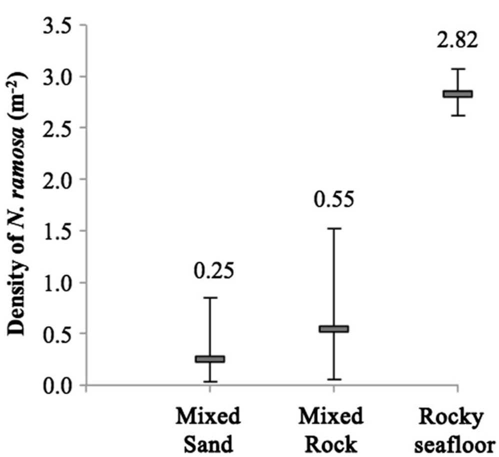

Fig. 5 Average density of *Nemertesia ramosa* colonies (m^{-2}) on different substrate types estimated in circalittoral depths of the Faial-Pico Channel using 20 transects performed by ROV *SP*

The preference of *N. ramosa* for rocky bottom shown in this work agrees with previous observations from the coasts of Britain and Ireland (Porter 2012). In addition, it was seen that colonies growing on outcrops and boulders protruding more than 15 cm from the surrounding seafloor were taller than colonies growing in smaller rocky outcrops. It is known that roughness of the substrate increases turbulent transport, which combined with reduced flow close to the seabed (Frechette et al. 1989) may drive benthic suspension feeders to settle and develop in more protruding locales.

A diverse number of deep-water coral taxa aggregations are now termed “coral gardens” (a classification derived originally from the resemblance of gorgonian-dominated habitats to “trees” in the cold-water environment, Andrews et al. 2002; OSPAR 2008). Consequently, the term hydroid gardens can be applied to aggregations of large hydrozoa. Like corals, hydroids also form three-dimensional habitats (Porter 2012;

Tempera et al. 2013), and support associated species (Hughes 1986). Recent studies proposed that such classification should be applied only to areas where the density of coral colonies is ten times higher than a defined threshold value (Bullimore et al. 2013). *N. ramosa* was considered a rare and occasional species (1–9 10^{-3} m^{-2}), which can be used as a threshold value for the species in the Azores. However, based on the imagery analysed in this study and the circalittoral community studied in detail, we propose that colony densities of 1–9 m^{-2} or higher should be considered hydroid gardens of *N. ramosa*.

Patchy and aggregated communities are more sensitive to anthropogenic impacts such as physical disturbance from dredge deposits, fishing or anchoring activities (Thrush et al. 1998) since localized impacts may affect entire gene pools (Sommer 1992). Large hydroids (here considered colonies >15 cm height) are more sensitive to physical disturbance than small hydroid species that are often reported growing on marine litter or other substrate available (Harms 1990; Gomes-Pereira et al. 2012). In turn, in comparison to corals, hydroids have faster growth rates and shorter life spans (Hughes 1986), than have been reported for scleractinians or stylasterid hydrocorals corals (Andrews et al. 2002). These aspects, as well as reproductive strategies should be addressed in future works, as these might translate into different susceptibilities to human impact and the subsequent need of conservation measures.

Further records of *N. ramosa* are expected from other island shelves, slopes, and seamounts. Recent studies have revealed a great diversity of hydroids in deep-water coral habitats (Henry et al. 2008). As these habitats extend throughout Atlantic seamounts and are being increasingly studied (Tempera et al. 2012, 2013), knowledge on their diversity and on eurybatic hydroid species is expected to increase. The hydroid gardens reported here were used by a diverse ichthyofauna, and epibiont species have been previously recorded, such as *Aglaophenia tubulifera* off Faial Island (Cornelius 1992). However, a quantification of the importance of *N. ramosa* as a habitat-building species remains unaddressed. The ecological processes related to its settlement require further research. Improved sampling methodologies should be utilized to provide more data on the spatial distribution of this species and the extent of communities dominated by large hydrozoans.

Acknowledgments We acknowledge: Ricardo Serrão Santos, Filipe Porteiro, and Telmo Morato (IMAR-DOP/UAz) for their coordination and support throughout the projects mentioned below; Jorge Fontes, Frederico Cardigos, Vanessa Santos, Jaen Nieto Amat, Ricardo Delgado, and Pedro Frade for their collaboration in the scuba-diving surveys; David Abecasis and Manuela Ramos for their help in the ROV and drop-down camera surveys; Renato Bettencourt for his proficiency in piloting ROV *SP*; the crews of RV *Arquipélago* and RL *Águas Vivas* for their competence during the surveys; the dedicated editorial work by B. W. Hoeksema and detailed revisions from Lea-Anne Henry and one anonymous referee that contributed to improve this manuscript. Data collection and analysis was supported by projects MARÉ (Life-Nature B4-3200/98/509), MAROV (PDCTM/P/MAR/15249/1999), MAYA (AdI/POSI/2003), OGAMP (INTERREG IIIb - MAC/4.2/A2 2001), MARMAC (INTERREG IIIb - 03/MAC/4.2/A2 2004), CORALFISH (FP7 ENV/2007/1/21314 4), CORAZON (FCT/PTDC/MAR/72169/2006) and MeshAtlantic (AA-10/1218525/BF). Frederico Dias as coordinator of Project M@rbis (EMEPC). IMAR-DOP/UAz is Research and Development Unit no. 531 funded by the Portuguese Foundation for Science and Technology (FCT) through pluriannual and programmatic funding schemes (OE, FEDER, POCI2001, FSE) and by the Azores Directorate for Science and Technology (DRCT). JNGP was supported by the doctoral grant from the Regional Directorate for Science, Technology and Communications (DRCTC) of the Regional Government of the Azores (M3.1.2/F/062/2011). Fernando Tempera was supported by a post-doc grant from the Portuguese Foundation for Science and Technology (ref. SFRH/BPD/79801/2011).

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