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ORIGINAL ARTICLE

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Actinostola callosa (Verrill, 1882) (Actinostolidae, Anthozoa), a medusivorous sea anemone and its mass occurrence in the Lurefjord, Norway

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Abstract The seafloor of two Norwegian fjords (Lurefjord and Sognefjord) was studied using a remotely operated vehicle (ROV). Two large sea anemone species, *Actinostola callosa* and *Bolocera tuediae*, are part of the benthic fauna of these fjords. The first species is the most abundant in the Lurefjord north of Bergen. A special linear model to calculate the distances between specimens was constructed using the Geographic Information System data from the ROV. *A. callosa* was found to be medusivorous. Its biomass and high abundance seem to be correlated with a mass occurrence of its important local prey, the coronate medusa *Periphylla periphylla*.

Keywords Cnidaria · Predation · Medusivorous · *Periphylla periphylla* · Norwegian fjords

Introduction

The fauna of several west Norwegian fjords have been studied during recent years with a focus on the Lurefjord which shows a mass occurrence of the deepwater scyphomedusa *Periphylla periphylla* (Fosså 1992; Jarms et al. 1999, 2002; Youngbluth and Båmstedt 2001). Recent studies of archibenthal are rare (e.g. Tyler and Zibrowius 1992). Our studies on the jellyfish *P. periphylla* in the Lurefjord have been based on a remotely operated vehicle (ROV). The ROV "Aglantha" is especially equipped for scientific studies, allowing video recording and environmental monitoring (see Båmstedt and Youngbluth 2000). The dives in the Lurefjord have revealed an abundance of large actinians, with *Actinostola callosa* as the dominant species. The use of the ROV provided in situ information on the appearance and behaviour of these organisms. We report here on the abundance and distribution of *A. callosa* in the Lurefjord, and on its trophic relationship to the jellyfish *P. periphylla*.

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Methods

Biological material and video material were obtained using the ROV "Aglantha" in the deepest part (ca. 440 m) of the Lurefjord (05° 10.00′ N, 60° 41.10′ E) during two cruises with R/V "Håkon Mosby" in August 1999 and October 2000. For quantitative analysis of abundance and distribution patterns, the ROV was run along the bottom at a constant speed and defined distance to the seafloor. A simple geometric model was used to calculate the abundance. The analysis of the ROV transects was made using the Arc View 3.1a program from the computer company ESRI.

One specimen of *Actinostola callosa* was used for feeding experiments in the laboratory over a period of 7 days with live *Periphylla* medusae as prey. The experiment was performed in the dark at 6°C. A conical net with a non-filtering cod-end collected the prey immediately before the experiment. After the experiment, the *Actinostola* specimen was preserved in 4% seawater-formaldehyde solution. It is deposited in the Zoological Museum Hamburg under no. ZMH C 11652.

For morphological examinations, several individuals were collected from the soft bottom of the Lurefjord and preserved. *Actinostola* can be distinguished in the video material by its colour and habit. Both the short inner and the long peripheral tentacles of a collected specimen were cut off, and their characteristic supply of nematocysts was analysed by K. Riemann-Zürneck under a light microscope.

Results

External morphology

The analysis of the cnidome after Riemann-Zürneck (1978) revealed that the Lurefjord population belongs to *Actinostola callosa* (Verrill, 1882).

As there are no records of live specimens of *A. callosa* so far, we give a short description of this anemone as seen on the video. The column of *A. callosa* is yellowish-white and opaque. The pedal disk, if visible, is similar in

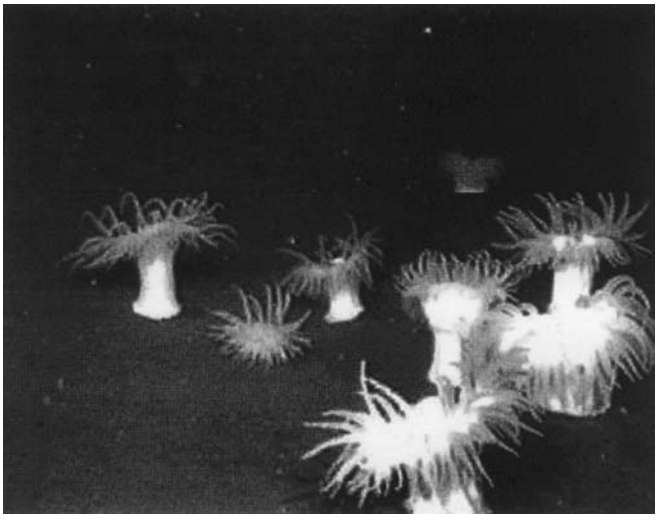

Fig. 1 A group of *Actinostola callosa* on the sea floor of the Lurefjord, western Norway; picture from a video taken by the ROV "Aglantha"

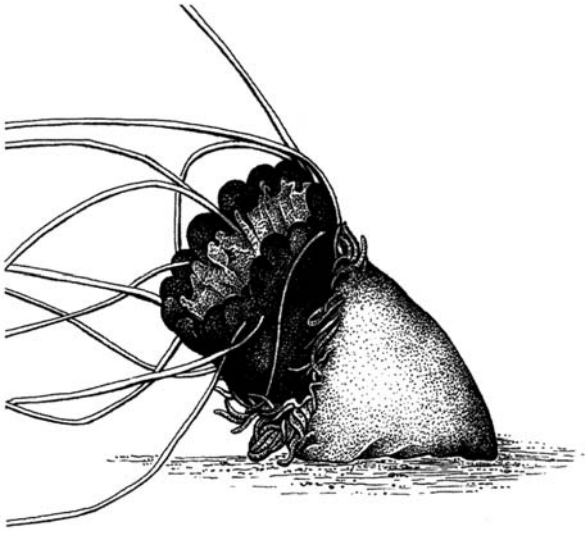

Fig. 2 A specimen of *A. callosa* devouring a big *Periphylla periphylla* on the sea floor of the Lurefjord, western Norway; drawing from a video image taken by the ROV "Aglantha"

diameter to the column, and has the same colour. The marginal part of the column bearing the tentacular crown is widely extended and about twice the diameter of the column. Most specimens have their tentacles extended and held arched outwards. The fully expanded tentacles are as long as the column. From the video, we counted about 90–100 tentacles in large specimens, arranged in four circles. In the middle of the flat oral disc, the lips and upper part of the actinopharynx are bright yellow. We found this actinian species living on soft bottom (Fig. 1). The collected live specimen was 14 cm across and 18 cm high when relaxed in a bucket at 6°C half an hour after collection. This size was constant during the time of cultivation as long as the animal remained undisturbed. The measurements of the collected specimen gave us a scale to estimate the density of the big actinians. The preserved specimen is 10 cm high and has a weight of 427 g.

Abundance of *Actinostola*

On all cruises (February, August, October, December), we found only large *A. callosa* on the seafloor. They were abundant on all transects analysed. Out of 24 transects, 18 provided sufficient information on travelled distance, and had a stable altitude and non-overlapping route to pass the criterion for quantification. From these data, we calculated that the individuals were an average distance of 4.9±3.2 m apart, corresponding to a density of 5.3±3.5 individuals per 100 m^2. However, clusters of up to seven specimens were common along the transects, with individuals usually 30–100 cm from each other (Fig. 1). Among such assemblages, single specimens were scattered at different distances from each other. Frequently, around the actinians but at a safe distance, there were several shrimps.

Trophic relationships

During our ROV dives we observed several severely damaged medusae of *Periphylla periphylla* that appeared to have been partly devoured. One *Actinostola* had a medusa half inside its actinopharynx (Fig. 2). Several *Actinostola* were also observed with the typical *Periphylla* pigment around the mouth. The specimen mentioned above was observed for half an hour while gradually engulfing its prey. An in situ experiment was performed in order to test the ability of *Actinostola* to ingest big *Periphylla.* A medusa of about 15 cm in diameter was caught with the collecting device of the ROV and was placed near to the tentacles of the anemone. The tentacles of *Actinostola* stuck immediately to the medusa and pulled it to the mouth opening by shortening the tentacles. Although the diameter of the medusa was even larger than that of the anemone, *Actinostola* began to engulf the medusa while widening its mouth considerably. After 40 min, the medusa was more than half ingested. The same experiment was repeated with the collected *Actinostola* (14 cm diameter) and a *Periphylla* of 6 cm diameter. The latter was totally ingested within 4 hours.

Biomass relation between *Actinostola* and *Periphylla*

As stated above, the abundance of *Actinostola* is 5.3±3.5 specimens per 100 m^2. The biomass of a wet specimen with squeezed-out gastrovascular system is about 500 g. The total biomass of *Actinostola* thus amounts to at least 2,000 g per 100 m^2. Youngbluth and Båmstedt (2001) reported an abundance of big *Periphylla* medusae (coronal diameter 6–16 cm) of 2.5 specimens per m^2 water column from 0–400 m depth (measured by net hauls). They estimated that about 10% of all medusae are this big

size. An abundance of eight big medusae per m^2 was counted by ROV observations.

The average biomass of a big medusa is 373 g. The total biomass per 100 m^2 thus amounts to about 100 kg (calculated from haul examination) or about 300 kg (from ROV counting).

Discussion

There are only a few video records of large anemones in deepwater habitats, for example from European waters by Howson and Davies (1991) and Tyler and Zibrowius (1992). Our ROV results indicate that there is a remarkably high density of *Actinostola callosa* on the bottom in the deepest part of the Lurefjord. Vader (1970) reported that *A. callosa*, besides *Bolocera tuediae* (Johnston) and *Hormathia nodosa* (Fabricius), is one of the characteristic anthozoan species of the epifauna of the muddy bottoms in the deeper basins of the Norwegian fjords. With a shrimp-trawl in the Korsfjord, he collected up to 140 specimens per haul. Unfortunately, towing times were not mentioned so that densities cannot be calculated. Size data for *Actinostola* are not available. But, within Vader's collection, 10–28% of the *Bolocera* specimens had a weight of more than 200 g; the heaviest was 540 g and two specimens were 480 g each. Our specimen of *Actinostola*, at 427 g, belongs to the same size class as the large *Bolocera*. This specimen was collected under video control out of a group of nearly equal-sized animals, and we found that more than 90% of the individuals were of that size. So we can conclude that, in the Lurefjord, the *Actinostola* population is not only very dense, but that individuals are also remarkably large. That corresponds to the findings of Riemann-Zürneck (1978): within the genus *Actinostola*, the species of the *callosa*-group are the biggest. Dredge samples of different actinian species from the south-west Atlantic, treated by Riemann-Zürneck and deposited in the Zoological Museum of Hamburg, mostly show only a single specimen, rarely two or a few more much smaller individuals. Thus, the abundance of *Actinostola* in the Lurefjord can be regarded as exceptionally high.

Only a small number of anemone species have been documented as medusivorous. Amongst those are *Sargatiogeton laceratus* predating upon the semaeostomean *Aurelia aurita* (Berryman 1984), and *Entacmea medusivora* described from the jellyfish lake in Palau feeding on the rhizostomean *Mastigias papua* (Fautin and Fitt 1991). Recently, Schwanitz (personal communication) saw *Urticina felina* swallowing *Chrysaora hysoscella* off Helgoland in the German Bight. All these records are from shallow waters. Whereas *Entacmea* seems to predate exclusively upon medusae, *Sargatiogeton* and *Urticina* are known to have a more diverse diet. *Actinostola callosa* is the first deepwater anemone now established as feeding on a coronate medusa. Further investigations of the food web of that particular Norwegian fjord will show whether *Periphylla* is the only prey of *Actinostola*.

The method used to study the softbottom benthos proved to be suitable and effective. The great variability of the data is due to the patchy distribution of the actinians and not to methodical deficiencies. In deepwater, about five specimens per 100 m^2 seems to be a very high density for large animals such as these anemones. Due to the species' long lifespan, the *Periphylla* population does not show any significant seasonality in the Lurefjord, and all stages could be found throughout the year. We also found large specimens of *Actinostola* at different times of the year, which leads to the question of whether the high abundance of *Actinostola* may be related to the mass occurrence of *Periphylla* (Fosså 1992) in the same fjord. The biomass of *Periphylla* (calculated by Youngbluth and Båmstedt 2001) is about 100 times larger than the biomass of *Actinostola* (our calculation). From these findings, a predator prey relationship seems to be possible. Our in situ observations support this assumption, suggesting that the mass occurrence of *Periphylla periphylla* might be causing the high population density of *A. callosa* in the Lurefjord.

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