Plasticity of the Scleractinian Body Plan: Functional Morphology and Trophic Specialization of Mycedium elephantotus (Pallas, 1766)

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SUMMARY

Morphological, histological and behavioral features indicate that Mycedium elephantotus, a zooxanthellate scleractinian species without tentacles, is well adapted for utilizing suspended organic matter for nutrition. The colonies are composed of vertically growing fan-like plates and can reach diameters of more than 1 m in depths below 20 m. The external body surface is coated with a mucus layer (cuticle) which enables the acquisition and accumulation of suspended organic material. The mucus-entangled particles pass to the mouth openings by gravitational transport assisted by water movement.

In experiments the corals were able to discriminate between suspended food and mineral particles. Both types of particles were rapidly entangled in fine mucus nets or filaments. Mineral particles were never ingested and instead tumbled down the inclined skeletal plates. In contrast, food particles were actively incorporated when the mucus filaments accidentally touched the stomodaea during the downward gliding.

The food-enriched mucus filaments were either transported by ciliary activity into the coelenteron or were stuck into the body cavities by decreasing pressure in the coelenteron caused by contraction of longitudinal, mesenterial muscles. The discriminative reactions to mineral or food particles are probably based on the release of different types of mucus.

Nematocysts are infrequent in the oral epidermis, indicating that the capture of living prey plays a subordinate role in nutrition. The mesenterial filaments, in contrast, are densely packed with large nematocysts. Storage products were piled up within the tissues of gastral pockets.

The adaptations of Mycedium elephantotus for using suspended food particles may explain the particularly high abundance of this species between ca. 20 and 40 m depth on a steeply inclined fore-reef slope in the Gulf of Aqaba (Red Sea).

The evidence indicating the importance of heterotrophic fueling to M. elephantotus is supported by carbonate production rates which are, in contrast to that of many other zooxanthellate scleractinian species, almost constant at depths between 5 and 40 m and which are uneffected by varying light regimes over the year, suggesting that the reduced phototrophic contribution by the zooxanthellae is compensated by mucus suspension feeding.

1 INTRODUCTION

Recent subtropical and tropical photic reefs grow through deposition of limestone produced by a variety of organisms, of which colonial, zooxanthellate scleractinian species play an outstanding role not only as carbonate producers and frame-work builders, but also as bafflers and binders.

Coral calcification and reef growth is controlled by numerous ecological factors, of which the trophic ones are the most basic.

The synthesis of scleractinian tissues as well as the production of the skeletons uses metabolic energy which is provided by different trophic sources (Schlichter, 1983). Corals have up to four independent possibilities for energy supply:

1) They use living and/or dead particulate organic material (POM) either as macrophages or microphages (Yonge, 1930; Lewis & Price, 1975; Lewis, 1977; Porter, 1976; Sorokin, 1993; Sebens, 1997).

3) Zooxanthellate species profit from their endocyto-
symbiotic algae (zooxanthellae = unicellular algae of the
genus Symbiodinium) (Schlichter, et al. 1983; Muscatine &
Weis, 1992; Spencer Davis, 1992), whereby the pho-
totropic production of the zooxanthellae depends on the
availability of light and mineral nutrients.

4) Finally, the skeletons of a multitude of scleractinian
species are colonized by endolithic algae, the photoassimilates
of which, like those of the zooxanthellae, are used by the

Each of these four nutritional sources contribute to a
different degree to the energetic demands of the symbiotic
system. Depending on the availability of the trophic re-
sources in different habitats, different species compensate
the shortage of one resource by specializing on using
another. Such specialized species settle "trophic niches"
which are out of the reach of less well-adapted species.
The specific morphology of scleractinian colonies in com-
bination with qualities of the living tissues relates to their
ecological distribution. The species-specific qualities have
been discussed for decades in relation to environmental
conditions such as depth-related factors (including the
light regime), temperature, water motion and the inclina-
tion and quality of the substrate (Köhlmann, 1983). The
shape of the colonies has also been discussed in the context
of sediment rejection and of food supply (Yonge 1930;
Vaughan & Wells, 1943; Hubbard & Pocock, 1972,
Lewis & Price, 1975, 1976; Schuhmacher, 1979; Lasker
1980; Logan, 1988; Sebens & Johnson, 1991; Abelos et
al. 1993; Helmuth & Sebens, 1993; Stafford-Smith, 1993;
Sebens, 1997).

The bathymetric distribution of the hermatypic
zooxanthellate scleractinian species Mycedium elephantotus
on reefs in the Gulf of Aqaba (Red Sea), although not
unique, is exceptional for a symbiotic species. At 20 m
depth M. elephantotus makes up to 36% of the living coral
cover. M. elephantotus still accounts for 25% of the living
coral coverage at 40 m depth; in 10 m the portion drops
down to 2.5% (Kührau, 1998). In contrast, the coverage
consisting of colonies of Acropora variabilis decreased from
28% in 3-5 m to 9% in 10 m and 2% in 20 m.

Carbonate production rates of M. elephantotus, in
contrast to those of other species, are only slightly affected
by depth-related factors and seasons, i.e. the energetic
supply for tissue and skeleton production seems to be
optimal over the whole year at all depths (Schlichter et al.,

The depth distribution and the almost constant carbo-
rate production rates of M. elephantotus point towards
trophic adaptations which improve heterotrophic supply,
thus compensating the reduced phototropic support of the
zooxanthellae, the productivity of which, in general, de-
clines in dependence on depth and season.

Suspended material, including bacteria and nano-
flagellates is present in the sea in high amounts, but the
particles are strongly diluted (Sorokin, 1993). That means
this trophic resource can only be used by such organisms
possessing mechanisms which allow them to effectively
catch and accumulate these particles. Furthermore, such
organisms must actually be able to digest the incorporated
food stuffs.

The present paper deals with the acquisition, accumu-
lation and incorporation of suspended organic material by
M. elephantotus. which intensifies heterotrophic energy
supply.

2 MATERIAL AND METHODS

Study Site: colonial fragments (ca. 25-35 cm) of
Mycedium elephantotus (Pallas) were collected on a fring-
ing reef off the Marine Science Station in Aqaba (Jordan,
Red Sea; 29°30'N; 34°58'E) in depths from 2 m to 55 m.
The fragments were transferred in light-proof containers
to the laboratory and maintained in natural running sea
water at irradiance intensities equal to those at the sites of
collection.

Histological Preservation: small skeletal pieces were
cut off and preserved either in Trump's fixative (McDowell
& Trump, 1976) or in a fixative according to Cloney &
Florey (1968).

Transmission Microscopy (LM = light microscopy;
TEM = transmission electron microscopy): the samples

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The morphology of Mycedium elephantotus

Fig. 1. A colony (ca. 1 m in diameter) of the zooxanthellate scleractinian Mycedium elephantotus on a steeply
inclined fore-reef slope in the Gulf of Aqaba, Red Sea (29°30'N) in 25 m depth. Colonies are composed of
fan-like plates growing mainly vertically oriented.

Fig. 2. A young colony of Mycedium elephantotus. Sediments accumulate in the protected basal part of the whorl-
forming skeleton (ca. 15 cm in diameter).

Figs. 3, 4. The influence of water movement on skeletal features of Mycedium elephantotus. Fig. 3. Detail of a colony
growing in a sheltered habitat. Fig. 4. Detail of a colony exposed to turbulent water. Diameter of the
corallites 8-10 mm.

Fig. 5. Part of a bare skeleton (after sodium hypochlorite treatment) of Mycedium elephantotus. Corallites
laterally adjacent to each other form horizontal terraces. The costae of corallites one above the other fuse,
forming crests and grooves in a vertical direction. Diameter of corallites 8-10 mm.

Fig. 6. A close-up of non-tentacled polyps of Mycedium elephantotus. The oral discs are fenced by tissue
duplications. Diameters of the corallites 8-10 mm.