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# THE REMEDIA LIFE INTEGRATED MULTITROPHIC AQUACULTURE SYSTEM AS A POWERFUL SPONGE BIOMASS SUPPLY

## *IL SISTEMA DI ACQUACOLTURA MULTITROFICA INTEGRATA REMEDIA LIFE COME FONTE DI BIOMASSA DI SPUGNE*

**Abstract -** *The present study was undertaken to assess the survival and the growth rate of the sponges* Aplysina aerophoba *(Nardo, 1833),* Geodia cydonium *(Linnaeus, 1767),* Hymeniacidon perlevis *(Montagu, 1814) and* Ircinia variabilis *(Schmidt, 1862) within an integrated multitrophic aquaculture system (IMTA) to highlight their suitability for a circular blue economy. Donor sponges were cut into explants and arranged in net bags to monthly monitor their rearing performance in terms of survival and volumetric growth rates. All sponge species showed a high survival ratio not lower than 95%. Similarly, most species showed values of more than 7% monthly volume increase (with values up to 16% for* A. aerophoba*) and final volumes more than 150% of the initial (*A. aerophoba *reaching 400%). These results make these sponge species reliable candidates for co-culturing in IMTA systems and a possible solution to the biomass supply problem.*

***Key-words:*** *Porifera, aquaculture, growth rate, survival, Mediterranean Sea*

**Introduction -** The polyculture of fish with other organisms at different levels of the food web (Integrated Multi-Trophic Aquaculture, IMTA) is an eco-friendly alternative that has received increasing attention and promises considerable economic potential. Among the co-cultured organisms Porifera, or sponges, show an extensive potential, both for their bioremediation skills and for the marketable by-product biomasses due to the discovery of bioactive compounds for applications in different fields (e.g. pharmaceutical, nutraceutical, environmental) (Aguilo-Arce *et al*., 2023 and references therein). As bioremediator organisms, different sponge species showed high efficiency in removing organic particles between 0.1–50 μm (e.g. Riisgård and Larsen, 1995), which can positively affect the quality of the surrounding water. However, obtaining the needed biomass for their use involves a considerable challenge as different species' natural populations cannot supply this market. In this sense, sponge rearing has been proposed as a sustainable alternative. Thus, in this work four sponge species were reared near fish cages in an IMTA system and tested in terms of survival and growth rates in order to evaluate their suitability for rearing and as biomass suppliers.

**Materials and methods** - The REMEDIA Life IMTA system, ongoing in the "Maricoltura del Mar Grande" aquaculture plant, consists of floating fish cages to which an innovative set of bioremediator organisms such as sponges, polychaetes, bivalves and macroalgae have been associated (Giangrande *et al.,* 2020). In order to assess sponge rearing suitability in such conditions, four species were tested: *Aplysina aerophoba* (Nardo, 1833), *Geodia cydonium* (Linnaeus, 1767), *Hymeniacidon perlevis* (Montagu, 1814) and *Ircinia variabilis* (Schmidt, 1862) (Fig. 1). Donor sponges were cut into explants and arranged in net bags. At least 40 sponge individuals were monitored each month for one year, to evaluate the rearing performance in terms of survival (visually assessed, $(N_{final}/N_{initial})\times100$) and volumetric growth (V, mL) (by water displacement, $(V_{month}/V_{initial})\times100$) rates. Temporal volumetric changes were statistically confirmed by means of Mann-Kendall Trend test.


Fig. 1 – The sponge species selected for rearing in the REMEDIA Life IMTA system: *A. aerophoba* (A), *I. variabilis* (B), *H. perlevis* (C) and *G. cydonium* (D).
*Le specie di poriferi selezionate per l'allevamento nel sistema IMTA REMEDIA Life:* A. aerophoba *(A),* I. variabilis *(B),* H. perlevis *(C) e* G. cydonium *(D).*

**Results** – All four sponge species showed a high survival rate, with values ranging from 95,8% for *H. perlevis* to 100% for *G. cydonium* (Fig. 2), recording the highest mortality rates during the first few months after their positioning in the system. Explants showed a rapid recovery from their cutting, regenerating the surface in just few weeks. Similarly, regarding sponge growth, with the exception of *H. perlevis* that maintained its volume constant, all species showed positive growth rates, increasing their volume by 7.8% for *G. cydonium*, 8.9% for *I. variabilis* and an impressive 16.5% for *A. aerophoba* on average each rearing month (Fig. 1).

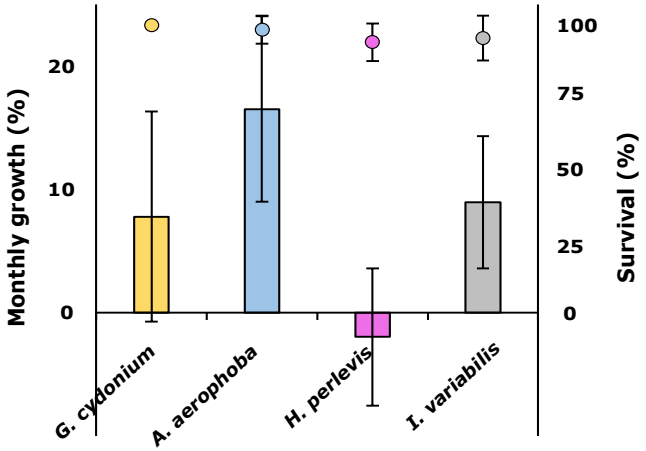


Fig. 2 – Rearing performance of selected sponge species in terms of monthly growth rate (bars) and survival (dots) (± SE) (N =40).
*Prestazioni di allevamento delle specie selezionate in termini di tasso di crescita mensile (colonne) e sopravvivenza (punti) (± ES).*

These positive monthly growths result in more than 150, 200 and 400% final volume of *G. cydonium*, *I. variabilis* and *A. aerophoba* explants, respectively, in a twelve-month period, showing a significant increasing trend for the latter two ($p=0.005$ and $p<0.001$, respectively). For *H. perlevis*, the high water temperature recorded in summer affected negatively to sponge explant growth, with neither a positive nor negative significant trend ($p=0.375$).

**Conclusions** – Overall, all sponge species tested promise excellent results in IMTA systems, with high survival and growth rates. The survival values of *I. variabilis* obtained in this study are higher than those published by van Treeck *et al*. (2003) for the same time period tested (one year). Likewise, together with *A. aerophoba,* both species present higher survival values, while *H. perlevis* and *G. cydonium* show values comparable to cultured sponges of the same subclass (Bierwirth *et al*., 2022). Regarding the Monthly Growth Rate, the values for *I. variabilis* are similar to those obtained by Ledda *et al*. (2014). However, for the rest of the species, comparisons are difficult due to the different methodologies used to monitor growth (*G. cydonium* in weight, Müller *et al.* 1999) or the lack of literature on *in situ* sponge farming, which highlights the importance of the present research in order to improve efficiency in this type of aquaculture systems. Overall, the high survival ratio of explants, the final increase of up to 300% additional biomass (for *A. aerophoba*) and high growth rates of most reared species, together with their efficient filtering activities (e.g. Ledda *et al*., 2014; Longo *et al.,* 2016), make these sponge species ideal candidates for co-culture in IMTA systems.

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