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Versatile aquarium for jellyfish: A rearing system for the biomass production of early life stages in flow-through or closed systems

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Interest in the rearing of jellyfish has grown exponentially over recent years due to their indisputable potential in a wide variety of uses and research. Here, we describe the design and operation of an effective modified kreisel aquarium that allows to grow of the early planktonic life stages of jellyfish in both flow-through or closed systems. Thanks to its versatile and innovative approach, the aquarium operates for species with a metagenetic life cycle, and allows the metamorphosis of ephyrae from fertilized eggs for species with a holoplanktonic life cycle, such as *Pelagia noctiluca*. In addition, its configuration allows the mesh screen to be changed *in situ*, adjusting the size of the mesh according to the growth of the jellyfish and the size of the prey offered. An accessory, named the polyp plate, suspends the polyps in a downward or sideways position, facilitating prey capture, strobilae formation and release of ephyrae. The improvements of this modified kreisel reduce the time-involvement for staff in maintenance routines, and it is an important contribution to jellyfish husbandry techniques and biomass production. These improvements especially target to the culture of the blooming and stinging *P. noctiluca*, which has been noted to present a host of challenges to the scientific and aquarist communities.

KEYWORDS

aquaculture, ephyra, kreisel, metaephyra, *Pelagia noctiluca*, polyp, strobilation, tank

Introduction

Jellyfish are considered an important fishery commodity for the food industry (Omori and Nakano, 2001; Dong et al., 2009) and have a high value as raw material in a wide variety of biotechnological applications (Merquiol et al., 2019; D'Ambra and Merquiol, 2022). Although wild jellyfish are exploited as a marine resource for different proposals (Omori and Nakano, 2001; Dong et al., 2009; Elliott et al., 2017), they are considered unpredictable due to the seasonality and spatiotemporal variability of their life cycles (Purcell et al., 2013; Gueroun et al., 2021; Marambio et al., 2021). From this point of view, biomass production through aquaculture activity can offer a permanent stock to supplement the fished biomass, as well as, to assure individuals not contaminated with unknown pollutants and safeguards traceability; a plus when aiming to target premium sectors associated with pharmaceutical, cosmeceutical and biomedical industries.

To raise jellyfish successfully, knowledge on the biology of target species is required including their feeding and reproductive behavior (Fu et al., 2014; Lilley et al., 2014b; Gueroun et al., 2021; Camacho-Pacheco et al., 2022). The majority of the scyphozoan species (Cnidaria: Scyphozoa) have a well-known metagenetic life cycle. Sexually mature jellyfish produce eggs or sperm which fuse to develop a ciliated planulae. Planulae settle to the marine substrate and metamorphose into the scyphistoma or polyp (benthic phase) (Helm, 2018). Through the process of strobilation, the polyps fission perpendicularly (strobilae) to release small ephyrae into the water column (planktonic phase). Ephyrae grow into metaephyrae, juvenile medusae and finally, sexually mature adults that produce eggs and sperm, completing the life cycle (Fuentes et al., 2011; Helm, 2018). Despite being the most common life cycle in scyphozoans, some species, such as the holoplanktonic *Pelagia noctiluca*, lack a benthic phase, and the fertilized eggs metamorphose directly into ephyrae in the water column (Sandrini and Avian, 1983; Canepa et al., 2014).

Aquaculture techniques, employed to produce jellyfish, vary according to the species and life cycle stages (Raskoff et al., 2003; Pierce, 2005; Purcell et al., 2013; Schaadt et al., 2017; Duarte et al., 2021). Polyp colonies are a continuous source of jellyfish through the strobilation process (Helm, 2018; Duarte et al., 2021), hence keeping colonies healthy is strategic for continuous production over time. Their maintenance is easier and much less time-consuming than early planktonic life stages (ephyrae and metaephyrae), which are the most complicated stages in jellyfish aquaculture and consume the majority of staff time (Duarte et al., 2021). However, although polyps are resistant to some anthropogenic stressors in marine habitats (e.g., pesticides, Olguín-Jacobson et al., 2020), to ensure successful breeding in aquaculture, it is important to maintain adequate water quality

and suitable nutrition (Raskoff et al., 2003; Crow et al., 2013; Duarte et al., 2021).

Regarding life support system in jellyfish aquaculture, polyps and jellyfish can be maintained in flow-through or closed systems (Crow et al., 2013). While in a flow-through is the water is constantly replaced with new water from a source such as the ocean, in a closed system, the water needs to be recirculated (Duarte et al., 2021). In the case of a close system, the outflow drain should lead to a sump with proper mechanical and biological filtration, and UV sterilisation (Duarte et al., 2021, e.g., Figure 6). Both systems have advantages and disadvantages, but one of the drawbacks of using a closed system is the time spent on maintenance routines (Crow et al., 2013).

Problem description

Depending on the life cycle stage, individuals are grown in a variety of culture vessels or aquariums in a flow-through or closed systems (Widmer et al., 2005; Purcell et al., 2013; Duarte et al., 2021, e.g., Figure 5). The best-known type of aquarium in jellyfish rearing is the kreisel tank (Greve, 1968). The kreisel is a circular aquarium with a flat back and front that contains an inlet and an outlet water chamber separated by a screen. The water inlet is generally provided by a spray bar with holes creating a circular flow that moves jellyfish away from the screen (Purcell et al., 2013, e.g., Figure 13.3). The separation of the chambers along with the water inlet allows jellyfish to swim freely without danger of being sucked down the drain (Purcell et al., 2013; Duarte et al., 2021). Despite their wide use in jellyfish aquaculture, usually, kreisel aquariums are not used as early stage grow-out tanks (Duarte et al., 2021, e.g., Figure 4). Ephyrae and metaephyrae, which are small and thin (Straehler-Pohl and Jarms, 2010; Straehler-Pohl et al., 2011), can easily be retained in the mesh screen due to the suction produced by the drain. Under this premise and to ensure their safety, they are often cultured successfully in vessels such as flasks, dishes or balls glass and plastic jars (Widmer et al., 2005; Crow et al., 2013), as well as, in larger tanks without water outlet (Duarte et al., 2021). All of these rearing systems require daily water changes to ensure its quality (Duarte et al., 2021). However, from the perspective of biomass production and scalability of jellyfish cultures, the time spent on recurrent water changes, involving the pipetting of each ephyra one by one at discrete time intervals, is unfeasible.

With the aim of reducing the time required for maintenance routines, and exploring new technologies to scale jellyfish cultures and biomass production, we present a versatile modified kreisel aquarium that allows safe cultivation early jellyfish life stages in both flow-through and closed systems. Our prototype aquarium is an important contribution to jellyfish husbandry techniques, especially for *P. noctiluca*, a species whose culture represents a challenge for the scientific and

aquarist community due to the lack of polyp stage in its life cycle (Ramondenc et al., 2019; Ballesteros et al., 2022). Additionally, due to its versatility and accessories, this system can be used for polyps, strobilae, eggs, planulae and grow-out ephyrae and metaephyrae tanks.

Aquarium design

Tank configuration

The aquarium (350 mm x 350 mm x 150 mm) comprises an 8 L main PVC and methacrylate circular tank (main chamber) with a rectangular upper frame on top, through which the water inlet and jellyfish are introduced (Figures 1A–C, 2A, B). A second chamber (drainage chamber) adjoins the main chamber, separated by a long, narrow interchangeable mesh screen (Figures 1B, D, 2C). The mesh screen allows the water to enter from the main chamber to the drainage chamber (Figure 2D). An air duct ($Q_{\text{air}} = 11.5 \text{ l/h}$), placed in the bottom-center of the mesh screen (Figures 1A, B), introduces air into the first tank, creating a flow of bubbles which

covers almost the entire mesh screen to prevent small ephyrae and metaephyrae from approaching (Figures 2E, F). The air bubbles, push the animals into the main chamber.

The interchangeable mesh screen (150, 250, 350 and 500 μm and 1 mm) (Figures 1B, D, 2D) allows the changing of different sizes of mesh screen throughout the growth of the early jellyfish stages *in situ* without removing individuals from the tank.

Polyp plate

An accessory, named the polyp plate (Figures 1A, E, 3A, B, E), can be easily placed to keep polyps suspended in the water column in a downward or sideways position, facilitating prey capture, strobilae formation and release of ephyrae (Figures 3C, D). The strobilation process can be induced in the tank. In jellyfish aquaculture, different methods are used to trigger the strobilation process (e.g., addition of chemicals or the up- or down-regulation of water temperature or salinity, Kuniyoshi et al., 2012; Treible and Condon, 2019). In this case, and in order to keep the desired chemical concentrations in a

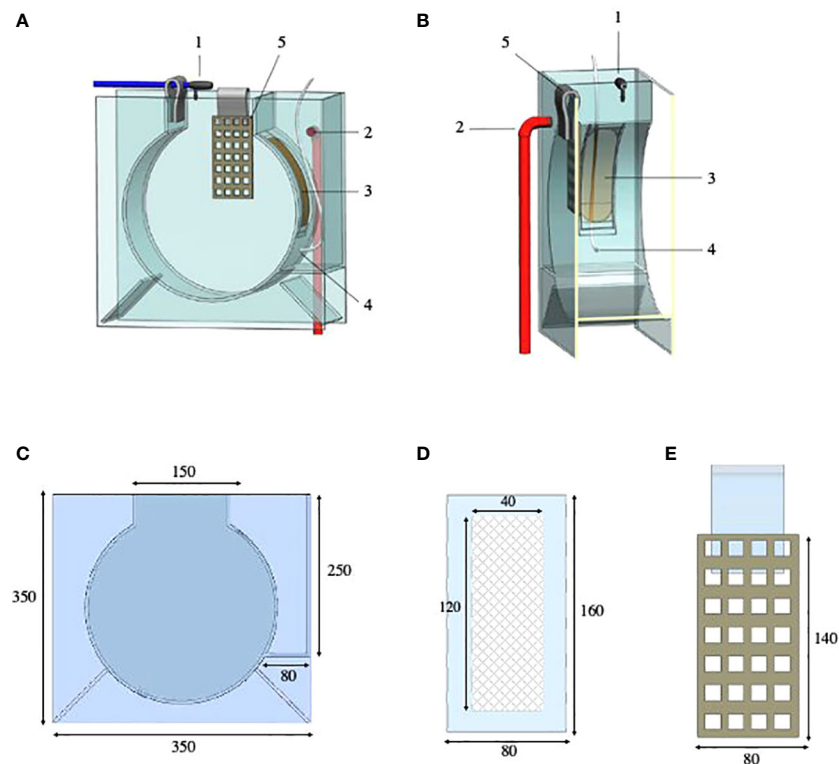


FIGURE 1

Schematic representation of the aquarium and accessories for the growth of the early stages of jellyfish: (A) Frontal view. (B) Transverse modified section. (C) Aquarium measures (mm). (D) Interchangeable mesh screen measures (mm). (E) Polyp plate measures (mm). Aquarium configuration: 1, water inlet in the main chamber (blue pipe, $\text{Ø ext.}=8 \text{ mm}$); 2, water outlet in the drainage chamber (red pipe, $\text{Ø ext.}=20 \text{ mm}$); 3, interchangeable mesh screen (150, 250, 350 and 500 μm and 1 mm); 4, air inlet in the main chamber (white tube, $\text{Ø ext.}=5 \text{ mm}$); 5, polyp plate (square grid, 20x20 mm). Polyp plate dimensions can be varied as desired. Schematic representation by Carlos Mengod.

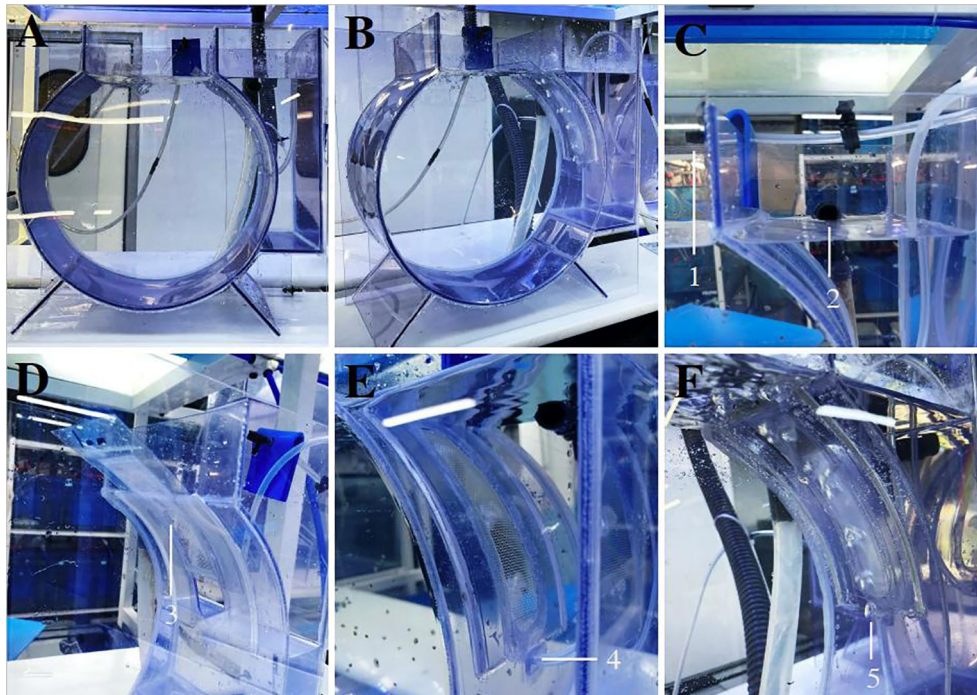


FIGURE 2
 Aquarium for the growth out of the early jellyfish life stages: (A, B) Frontal view. (C) Drainage chamber. (D) Interchangeable mesh screen (150, 250, 350 and 500 μm and 1 mm). (E) Air inlet in the main chamber. (F) Air bubbles covering the interchangeable mesh screen. Aquarium configuration: 1, water inlet; 2, water outlet; 3, interchangeable mesh screen; 4, air inlet; 5, air bubbles.

closed system, water entry to the system can be stopped with stopcocks.

Biomass production in a flow-through system

In order to increase biomass, the aquariums are placed in series in metal galvanized shelves in a temperature-controlled chamber (Figure 4). The water inlet is supplied with seawater that has been pretreated in a distribution system, obtained from a facility that provides access to high-quality seawater (e.g., Aquaria and Experimental Chambers of the Institute of Marine Science (ICM-CSIC)). The water is pretreated by mechanical (decantation and filtration with artificial polymers) and chemical (activated carbon) processes, as well as UV sterilized to remove unwanted organisms. For greater safety in case of any specific climatic event (e.g., storm), a filter system comprising filter cartridges of 20, 10 and 1 μm – the 1 μm filter cartridge can be replaced by a 5 μm cartridge – is placed before the water enters the sump (Figure 4A). For ease of emptying, there is a screw cap at the bottom (Figure 4B).

From the sump, water is pumped through the pipes to each aquarium individually, and the inlet flow can be regulated by individual stopcocks (Figure 4A). Like the water inlet, the air

inlet comes from the general system for each aquarium (Figure 4A). The air bubble flow can also be controlled with stopcocks. Lastly, the excess water stored in the drainage chamber flows into laboratory sewers through the system's drain pipes (Figure 4B). Before being returned to the sea, the water is once again pretreated at the facility through mechanical and biological filtrations, pH control and UV sterilization.

Finally, and proving its versatility, this system has been successfully used for metagenetic species such as *Aurelia* sp. or *Rhizostoma pulmo* (Table 1), as well as for the breeding of the holoplanktonic jellyfish *P. noctiluca* in a flow-through system (Table 2). For *P. noctiluca* culture, fertilized eggs were transferred from sexually mature jellyfish to the aquariums. After three (22°C) or four days (18°C) the first ephyrae were observed in the tank, and they were grown until they reach the juvenile stage in flow-through aquariums (Figure 4). The conditions for its culture from fertilized eggs to metaephyrae in a flow-through system are given in Table 2.

Discussion

Jellyfish early life stages are commonly cultured in receptacles (e.g., balls glass and plastic jars) which involve recurring water

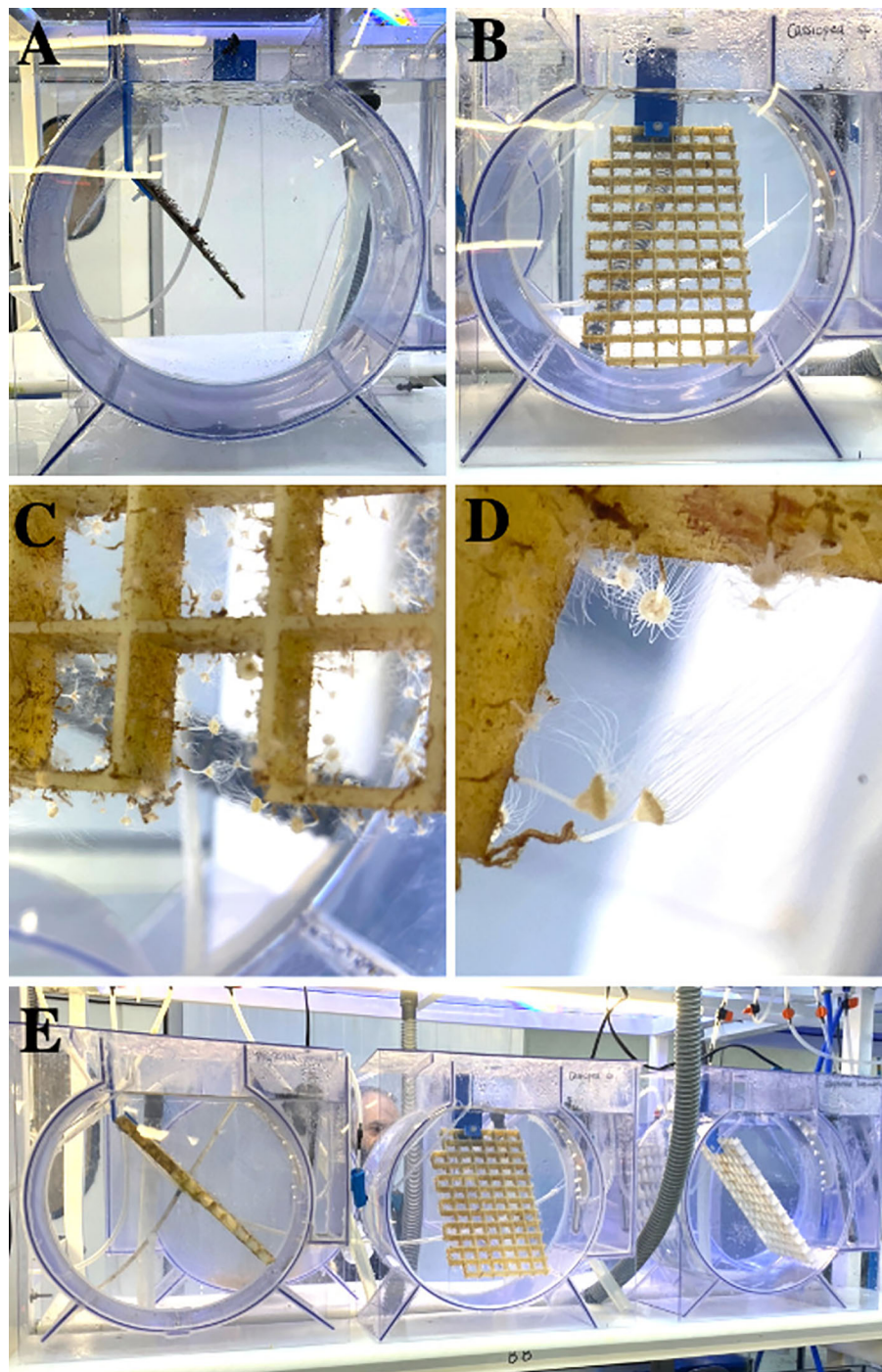


FIGURE 3

Polyp plates in flow-through aquarium: **(A)** Polyp plate of *Aurelia* spp. **(B)** Grid polyp plate of *Cassiopea* spp. **(C)** Suspended polyps in a downward or sideways position, enhancing prey capture, strobilae formation and release of ephyrae. **(D)** Tentacles of *Cassiopea* spp. polyps fully extended. **(E)** Polyp plates with *Phyllorhiza punctata* (left), *Cassiopea* spp. (middle) and *Cotylorhiza tuberculata* (right) species. Notes: The *Cassiopea* spp. polyp plates can be placed in rectangular tanks; The use of grid plates prevents the massive growth of algae; Multiple polyp plates can be placed in the same aquarium.

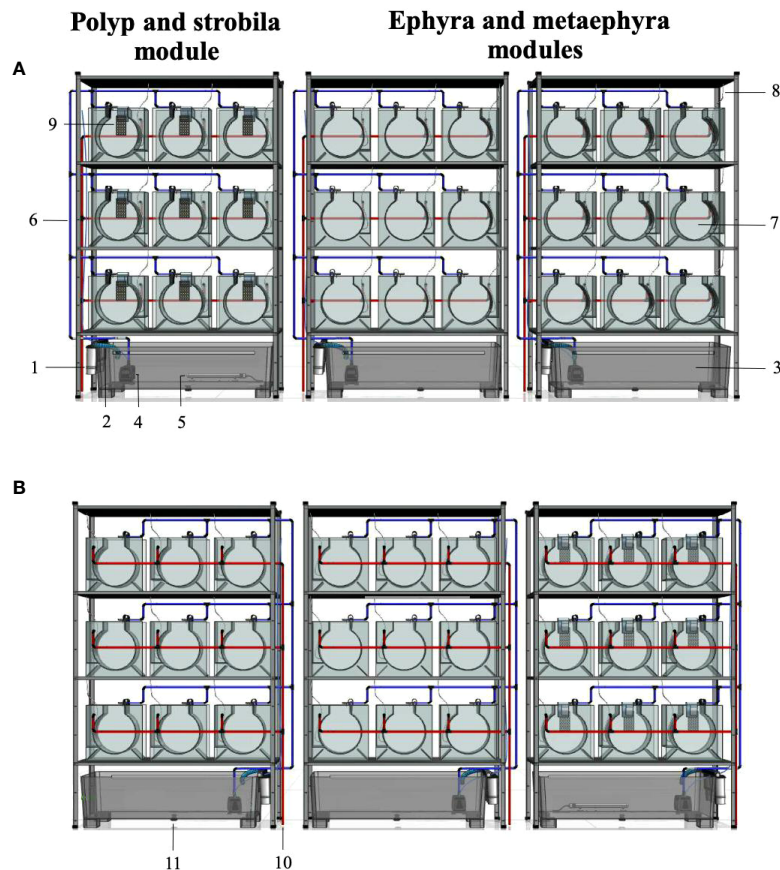


FIGURE 4

Schematic representation of a flow-through system of jellyfish biomass production for metagenetic and holoplanktonic species. (A) Frontal view. (B) Posterior view. System configuration: 1, filter system composed of filter cartridges; 2, water inlet towards the sump; 3, sump; 4, water pump; 5, heater; 6, individual water inlet to each kreisel (blue pipe); 7, kreisel; 8, individual air inlet to each kreisel; 9, polyp plate; 10, water drainage (red pipe); 11, screw cap for emptying the sump. Notes: Polyp plates with strobilae can be easily moved to the ephyra and metaephyra modules during the strobilation process; Fertilized eggs of *Pelagia noctiluca* can be metamorphosed into the ephyra and metaephyra modules.

changes as well as more staff time on maintenance routines (Duarte et al., 2021). In the recent review of jellyfish husbandry by Duarte et al. (2021), different types of ephyrae grow-out tanks have been proposed. However, of all of them, only the rectangular and V-shaped bottom aquariums allow growth in flow-through (Duarte et al., 2021, Figure 4 and Table 1). Here, we present a modified kreisel for rearing of the early planktonic stages of jellyfish in both flow-through and closed systems. The aquariums have been manufactured for an 8 L water capacity, but larger volumes can be mass-produced keeping the same configuration (Figure 1).

Collecting newly released ephyrae from polyp tanks represents a large investment of time for research staff and aquarists, who must chase ephyrae around the polyp tank to transfer them to new aquariums (Schaadt et al., 2017). To optimize jellyfish aquaculture techniques, polyp and ephyrae aquariums have been connected to each other in order to sweep ephyrae after release from the polyp towards ephyrae catch

aquariums in a flow-through. An example of an ephyrae catch tank was proposed by Schaadt et al. (2017) for *Aurelia* spp. The system was composed of a small plastic vessel with a large parabolic arc-shaped mesh screen to one side of the tank followed by a hole allowing water drainage. Similar designs can be consulted in Raskoff et al. (2003) and Duarte et al. (2021) for any scyphozoan with a metagenetic life cycle. Here, the easily removable polyp plates allow movement between tanks (Figures 1A, 3A, B), and they can be returned to the polyp module once the strobilation process is finished (Figure 4). The suspension of the polyp plate in the kreisel allows the scyphistome to reside in a position where the tentacles are suspended downward or sideways as in the wild, improving prey capture, strobilae formation and release of ephyrae (Figures 3C, D) (Brewer, 1976). In addition, it also prevents the polyp from being covered by debris. However, for the rearing of *Cassiopea* spp., a benthic jellyfish, the use of the current kreisel design is not recommended, but to benefit from the

TABLE 1 Culture conditions for polyps, ephyrae and metaephyrae of some metagenetic species in flow-through system.

Scyphozoan species	T (°C) ⁺	Salinity ⁺	Bubble flow	Mesh size			Number of feedings times, amounts and food offered ⁺		
				P	E	ME	P	E	ME
<i>Aurelia</i> spp.	13–25	36–37	2 bubbles/second	350 µm	350 µm	1 mm	(x1) 50000 rotifers/100 ml seawater	(x2) 50000 rotifers/100 ml seawater	(x1) 50000 rotifers/100 ml seawater, (x2) 14000 <i>Artemia</i> sp./100 ml seawater
<i>Cotylorhiza tuberculata</i> [*]	13–25	36–37	2 bubbles/second	350 µm	350 µm	1 mm	(x1) 50000 rotifers/100 ml seawater	(x2) 50000 rotifers/100 ml seawater	(x1) 50000 rotifers/100 ml seawater, (x2) 14000 <i>Artemia</i> sp./100 ml seawater
<i>Phyllorhiza punctata</i> [*]	13–25	36–37	2 bubbles/second	350 µm	350 µm	1 mm	(x1) 50000 rotifers/100 ml seawater	(x2) 50000 rotifers/100 ml seawater	(x1) 50000 rotifers/100 ml seawater, (x2) 14000 <i>Artemia</i> sp./100 ml seawater
<i>Rhizostoma pulmo</i>	13–25	36–37	2 bubbles/second	350 µm	350 µm	1 mm	(x1) 50000 rotifers/100 ml seawater	(x2) 50000 rotifers/100 ml seawater	(x1) 50000 rotifers/100 ml seawater, (x2) 14000 <i>Artemia</i> sp./100 ml seawater
<i>Sanderia malayensis</i>	13–25	36–37	2 bubbles/second	350 µm	350 µm	1 mm	(x1) 50000 rotifers/100 ml seawater	(x2) 50000 rotifers/100 ml seawater	(x1) 50000 rotifers/100 ml seawater, (x2) 14000 <i>Artemia</i> sp./100 ml seawater

P, polyp stage; E, ephyra stage; ME, metaephyra stage.

^{*}Species with zooxanthellae. IED strip with photosynthetic spectrum (4500K and 80W). All life cycle stages require light.

⁺Additional temperature and salinity ranges and food offered can be consulted in Purcell et al. (2013) and Duarte et al. (2021).

An interval of at least 4 hours between feeding times is suggested. Amounts of food for a number of 150 individuals. Jellyfish can also be feed ad libitum.






improvements in polyp suspension (Figures 3C–E), the polyp plates can be placed in flow-through rectangular tanks. Those specifically interested in the culture of *Cassiopea* spp. should consult the system proposed by Pierce (2005).

The rearing of *P. noctiluca* is a challenge for the scientific and aquarist community (Ramondenc et al., 2019; Ballesteros et al., 2022). Lilley et al. (2014a) proposed a system composed of 5 to 15 L receptacles with motorized PVC paddles rotating to keep animals in suspension with recurrent water changes (Ramondenc et al., 2019, Figure 1A). According to Ramondenc et al. (2019), this system caused stress to the individuals and was not suitable for the farming of any jellyfish. Years later, Ramondenc et al. (2019) improved the rearing techniques for *P. noctiluca* and cultivated the individuals in a closed system kreisel aquarium, avoiding collision of the individuals with the vessel walls (Ramondenc et al., 2019, Figure 1B). The authors highlighted the difficulty of adjusting prey concentration to feed individuals *ad libitum* and avoiding the accumulation of debris from unassimilated food. The technical improvement of this aquarium (Figure 1) has allowed to provide large amounts of food or *ad libitum* thanks to the continuous renewal of new seawater (Tables 1, 2). In addition, for the first time to our knowledge, *P. noctiluca* to be safely maintained during their early life stages in a flow-through system (Table 2). The design of the screen mesh (Figures 1B, D), has allowed fertilized eggs metamorphose into ephyrae in the aquarium directly (Figure 4) without staff having to move the transparent ephyrae between receptacles as in Purcell et al. (2013), Lilley et al. (2014a), Ramondenc et al. (2019); Ballesteros et al. (2021) and Ballesteros et al. (2022). In disagreement with Purcell et al. (2013) and Duarte et al. (2021), we do not recommend the ephyrae grow-out of *P. noctiluca* in a flow-through system using conventional kreisels or rectangular tanks due to their risk of being retained on the mesh screen. Although our aquarium design has been

used for different scyphomedusae (Table 1), specifically, we highlight the successful rearing of *P. noctiluca* from fertilized eggs to metaephyrae in flow-through, an important improvement and contribution to the rearing techniques of this scyphozoan (Table 2).

Jellyfish grow faster during the early stages of their planktonic life cycle (Widmer et al., 2005; Lilley et al., 2014a; Ramondenc et al., 2019), when the gastric system, prey capture structures and cnidome develop rapidly (Straehler-Pohl et al., 2011; Holst, 2012), increasing the possibility of eating larger amounts of food and capturing larger prey (Ballesteros et al., 2021). Like rearing vessels or aquariums, food regimens also influence the proper development of the gastric system and the growth and survival rates in jellyfish aquaculture (Widmer et al., 2005; Lilley et al., 2014a; Miranda et al., 2016; Ramondenc et al., 2019). Overall, enriched *Artemia* spp. nauplii and *Brachiouneus* spp. (rotifers) are frequently used for husbandry (Raskoff et al., 2003; Purcell et al., 2013; Crow et al., 2013; Duarte et al., 2021) but some researchers have highlighted the importance of prey size for proper rearing, particularly during the polyp and early planktonic life cycle stages (Widmer et al., 2005; Purcell et al., 2013; Miranda et al., 2016; Ballesteros et al., 2022). In our system, the interchangeable mesh screen (Figures 1B, D, 2D) allows adaptation of the size of the mesh to the size of the prey in the aquarium. For example, if the prey offered is *Brachionus plicatilis* ($\approx 100 - 200 \mu\text{m}$) – an ideal size range for capture and ingestion by polyps (Raskoff et al., 2003) and ephyrae such as *Phyllorhiza punctata* (Miranda et al., 2016) and *P. noctiluca* (Ballesteros et al., 2022) – a mesh screen of 350 µm can be selected (Tables 1, 2). When *Artemia* sp. ($\approx 400 \mu\text{m}$) (Raskoff et al., 2003) is included for feeding larger individuals during the metaephyrae stage, the previous mesh screen (350 µm) can be changed for a 1 mm screen (Tables 1, 2). In this way, not only is the permanence of the feed in the tank in a flow-through

TABLE 2 Culture conditions for *Pelagia noctiluca* early life stages in flow-through system.

Life cycle stage*		T (°C) ⁺	Salinity ⁺	Bubble flow	Mesh size	Number of feedings times, amounts and food offered ⁺
Fertilized eggs to planulae		13–24	36–37	2 bubbles/second	250 µm	No food required
Ephyra, stage 1		13–24	36–37	2 bubbles/second	350 µm	(x3) 50000 rotifers/100 ml seawater
Ephyra, stage 2		13–24	36–37	2 bubbles/second	350 µm	(x3) 50000 rotifers/100 ml seawater
Metaephyra, stage 3		13–24	36–37	2 bubbles/second	1 mm	(x2) 50000 rotifers/100 ml seawater, (x1) 14000 <i>Artemia</i> spp./100 ml seawater
Metaephyra, stage 4		13–24	36–37	2 bubbles/second	1 mm	(x2) 50000 rotifers/100 ml seawater, (x1) 14000 <i>Artemia</i> spp./100 ml seawater

* Morphological and cnidome descriptions to identify each life stage can be consulted in Ballesteros et al. (2021).

⁺ Additional temperature and salinity ranges and food offered can be consulted in Purcell et al. (2013) and Duarte et al. (2021).

An interval of at least 4 hours between feeding times is suggested. Amounts of food for a number of 150 individuals. Jellyfish can also be feed ad libitum.

system improved, but it also allows the passage and drainage of debris, avoiding the mesh screen to become clogged. The air inlet moves the individuals inside the tank without any damage (Figures 5E, F), since the air bubbles are safe for individuals with a total body diameter less than 30 mm as reported by Raskoff et al. (2003). It is important to transfer juvenile medusae to their appropriate aquariums (Purcell et al., 2013; Duarte et al., 2021) to avoid any possible damage.

Despite the advantages of the mesh screen change, screens still collect debris quickly in any system and they should be scrubbed and cleaned regularly (Raskoff et al., 2003). When screens become clogged, organisms are more likely to stick to them, and inadequate drainage can even lead to overflow involving the total loss of jellyfish. Here, the mesh screen can be replaced *in situ* without stressing the jellyfish on a regular basis, allowing better cleaning and disinfection of the removable mesh screen and improving water quality, a critical requirement during the husbandry of early jellyfish stages (Raskoff et al., 2003; Duarte et al., 2021).

In summary, the improvements in this modified kreisel have made it possible to optimize the time invested by staff in rearing the early life-cycle stages of jellyfish with a metagenetic life cycle, such as *R. pulmo*, and species with a holoplanktonic life cycle such as *P. noctiluca*. Its configuration and accessories offer the aquarium a versatile and innovative approach in the field of jellyfish rearing techniques, allowing the use of the same aquarium for the maintenance of fertilized eggs, planulae, polyps, strobilae, ephyrae and metaephyrae in both flow-through and closed systems to safeguard the water quality.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

AB and J-MG conceived and designed the aquarium prototype. PS manufactured the aquariums. AB wrote and edited the original manuscript. PS, EJ, and J-MG revised the manuscript and contributed to its improvement. All authors agreed to the published version of the manuscript.

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Conflict of interest

AB and J-MG are intellectual authors of the utility model (Industrial Property number: U202132533) solicited by the Spanish National Research Council (CSIC).

The remaining authors declare that the research was conducted in the absence of any commercial or financial

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