VIE ET MILIEU - LIFE AND ENVIRONMENT, 2022, 72 (3-4): 191-198. https://doi.org/10.57890/VIEMILIEU/2022.72.3/4:191-198

AQUARIOLOGY IN BANYULS-SUR-MER, A LEGACY FROM HENRI DE LACAZE-DUTHIERS: AN ESSENTIAL TOOL FOR RESEARCH AND MEDIATION IN MARINE SCIENCES

V. LOUIS[1,2], J. LOUBET[3], L. BESSEAU[*1]*

[1] *Sorbonne Université, CNRS, Biologie Intégrative des Organismes Marins, BIOM, F-66650, Banyuls-sur-Mer, France*
[2] *Sorbonne Université, CNRS, Laboratoire d'Ecogéochimie des Ecosystèmes Benthiques, LECOB, F-66650, Banyuls-sur-Mer, France*
[3] *Sorbonne Université, OOB, FR3724, Service Mutualisé d'Aquariologie (SMA) – Pôle Aquarium Public (POP), F-66650, Banyuls-sur-Mer, France*
Corresponding author: besseau@obs-banyuls.fr

HENRI DE LACAZE-DUTHIERS
AQUARIUM
HISTORY OF AQUARIOLOGY
BANYULS-SUR-MER
SCIENTIFIC EXPERIMENTATION
SCIENTIFIC MEDIATION
RESEARCH AQUARIUM

ABSTRACT. – The Laboratoire Arago in Banyuls-sur-Mer (France) was founded in 1882 by Professor Henri de Lacaze-Duthiers, one of the most famous French zoologists of the 19th century. Professor at the Sorbonne (University of Paris), he was noted for his wide knowledge of the French coastal marine fauna. In 1885, he initiated the construction of a public Aquarium, one of the first in France, which was attached to the Laboratoire Arago. This Aquarium quickly became not only a place where any eminent scientist or simple curious visitor could observe the Mediterranean diversity, but also a tool for experimentation in controlled environmental conditions made possible by the arrival of electricity in Banyuls in 1888. Nowadays the aquarium is a tool still used as a research medium, for experiments addressing hot issues in the context of global change and the impact of pollution in the marine environment. Since 2017, by associating in the same department the Research Aquarium Centre and the public Aquarium of the Biodiversarium, the Laboratoire Arago, now known as Observatoire Océanologique of Banyuls, offers quality facilities for scientific experimentation and an essential place for scientific mediation, where all audiences are sensitized to the preservation of the marine environment and its biodiversity.

INTRODUCTION: FROM THE INVENTION OF THE AQUARIUM TO AQUARIOLOGY

Knowledge in biology was first acquired by observing wild organisms in their habitat. Thus, naturalists first focused on the description of terrestrial life. The observation of aquatic life indeed requires observations made under water, which is far from being trivial. However, the observation of wild aquatic animals kept in captivity dates back to the period of domestication, *i.e.* around 10,000 BC (Huyge 1994). Then, the Romans used fishponds for the observation and conservation of aquatic animals, marine animals in particular, at the beginning of the urban society in 3000 BC (Schmölcke & Nikulina 2008). First trials of pisciculture have been done with freshwater fishes in India and China in 1500 BC (Yue & Liang 1995). The first "Dorade de la Chine" was imported in Europe during 17th century and met with great success in France during 18th century, notably at the Royal court of Louis XIV who was a fish lover (Chéruel 1856). At the beginning of the 19th century, there was no parlour ornament so elegant, nor so diverting, as a clear glass globe filled with goldfish (Matthews 2016).

The aquarium[1], and by this term we refer to a tank whose glass walls allow the observation of aquatic organisms, has been developed in 1832 by Jeanne Villepreux-Power (1794-1871), a French pioneering 19th century scientist in the field of marine biology (Gage 1883). Jeanne Villepreux-Power was a self-taught naturalist and conducted research on cephalopods biology. By inventing the aquarium, Villepreux-Power was able to conduct research experiments by optimizing the observation of organisms she studied. By the use of her invention, Villepreux-Power precisely described the morphology and biology of cephalopods, especially of the pelagic greater argonaut (*Argonauta argo*) (Villepreux-Power 1856). Her observations led to the conclusion that the shell of the female argonaut is made by the animal forming a "nacelle" that allows itself to stay in the pelagic environment and in which she lays its eggs. The question of the acquisition or the internal production of that shell by the argonaut was still pending and debated (Boletzky & Centelles 1978). This remarkable behavior has long been considered like the parasitism of another species. Thanks to her observations in aquarium, Villepreux-Power highlighted, in particular, that it was the behavior of solely the females. The first aquarium was therefore created for scientific needs.

Few years later, in 1850 and 1852 respectively, two English scientists, the chemist Robert Warington in freshwater (Warington 1850) and the naturalist Philip Henry Gosse in sea water (Gosse 1854), created an aquarium

[1] In this paper, Aquarium with a capital "A" refers to the building and aquarium with a lower-case "a" is the tank.

ecologically stable (Lorenzi 2009). Until then, aquatic organisms were presented in large vials of formalin in cabinets of curiosities, but from then on, the aquarium was no longer just a tool for scientific research and observation, but it became the medium for the aquatic biodiversity to be presented to the general public, through exhibitions of living aquatic organisms. The first permanent public Aquarium in Europe was built in 1853 to Regent's Park, in London (Brettingham Sowerby 1857). During a few years, others public Aquariums successfully offered the possibility to discover the aquatic world, then unknown to the public at that time.

HENRI DE LACAZE-DUTHIERS SETTLED AQUARIOLOGY IN BANYULS

Henri de Lacaze-Duthiers was an eminent naturalist of the second half of the 19th century. Following the spirit of his professor, the zoologist Henri Milne-Edwards (1800-1885), he was one of the first scientists to carry out field work to study alive organisms and their interactions with their environment (Jessus 2022). Through his work, he promoted an empirical and inductive approach to biological research, without *a priori*, allowing the construction of a theory on the basis of what is observed (Carrau 2022). During a trip to the Spanish island of Menorca, Henri de Lacaze-Duthiers developed a particular interest in marine life, and more particularly in the biology of marine invertebrates such as mollusks and the precious coral *Corallium rubrum* (Jessus 2022). During this period, Henri de Lacaze-Duthiers quickly focused his studies on the whole life cycle of marine organisms, whereas at that time most studies focused on the adult phase. Henri de Lacaze-Duthiers was also convinced of the usefulness of an aquarium, in order to describe more precisely the organisms he was studying at any stage of their life cycle (Fig. 1).

After having promoted the construction of the marine station in Roscoff in 1873 and the Laboratoire Arago in Banyuls-sur-Mer in 1882, Henri de Lacaze-Duthiers, now Professor at the Sorbonne (University of Paris), initiated the project of a public Aquarium in Banyuls-sur-Mer in 1885, the public Aquarium of the Laboratoire Arago (Prouho 1886). The Aquarium was thus created in gratitude to the municipality of Banyuls, which offered the land where the Laboratoire Arago has been established. The Aquarium quickly became a place where scientists, naturalists or just curious met, and, above all, where everyone could come, discover and appreciate the marine Mediterranean biodiversity (Fig. 2). Moreover, thanks to the Aquarium attached to the marine station, Pr. H. de Lacaze-Duthiers offered the scientific community valuable tools to collect, breed, observe and understand the Mediterranean marine biodiversity and he also offered the general public a medium for the transfer of this scientific knowledge.

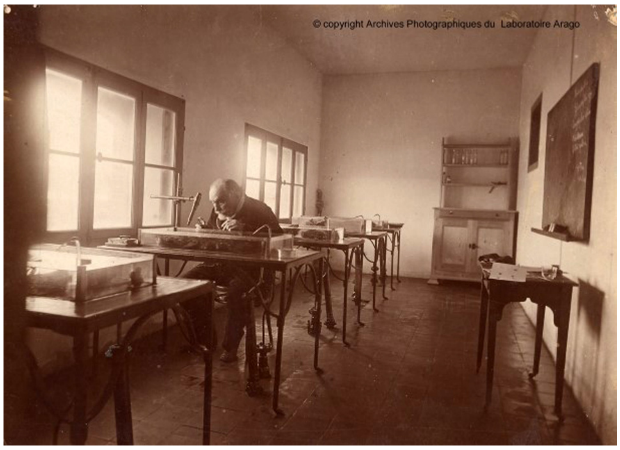

Fig. 1. – Professor Henri de Lacaze-Duthiers observing marine life in his laboratory at the Laboratoire Arago around 1896 (© Archives Laboratoire Arago/Sorbonne Université).

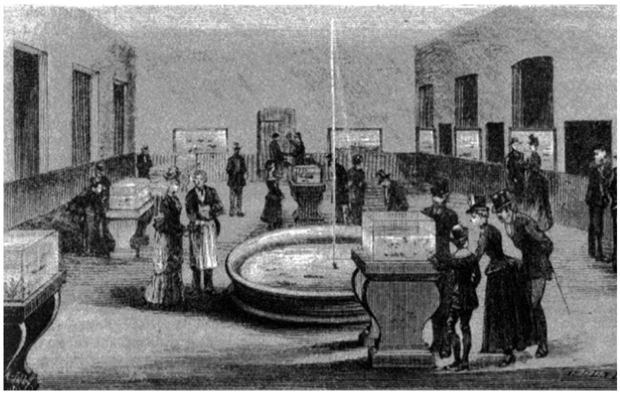
Fig. 2. – Lithography of the public Aquarium of the Laboratoire Arago in 1886. It shows visitors discovering the marine life from the Mediterranean Sea (from Prouho 1886).

AN AQUARIUM TO SHOWCASE MARINE LIFE

The Aquarium of Banyuls quickly became the showroom of the Laboratoire Arago, as Pr. H. de Lacaze-Duthiers testified in 1888: "*The Aquarium, to which foreign visitors have access, is naturally the most ornate room of the establishment. This is the reception room where laymen can come and learn about Zoological science*" (Fig. 3) (Boutan 1900; translation of the authors)[2]. Some years later, in April 1892, during a stay in Banyuls, a student from the Sorbonne described the Aquarium:

[2] French text: "*La salle de l'aquarium, où les visiteurs étrangers ont accès, est naturellement la pièce la mieux ornée de l'établissement. C'est, en quelque sorte, le salon de réception, où les profanes peuvent venir s'initier aux curiosités de la science zoologique.*"

Fig. 3. – The public Aquarium around 1900 (© Archives Laboratoire Arago/Sorbonne Université).

"*It is a large room lit, to the left, on the sea side, by four windows. Garnet curtains strongly filter the light. To the right, and at the back, eight tanks are installed in the wall; and lit of outside. Six other tanks complete the installation. The centre is occupied by circular pond {…}*" (Pervinquière 1892; translation of the authors)[3].

Until the end of the 19th century, an electric arc lamp was activated punctually, allowing to observe and discover the behavior of the marine organisms facing the artificial light. From then and like Jeanne Villepreux-Power, sixty years ago, Pr. Henri de Lacaze-Duthiers used the aquarium like a tool for his studies and experimentation. He presented his first observations during the session of the Academy of Sciences on November 5th, 1888: "*One of the tank, which are 1.60 meter long is richly populated with a beautiful sea actinia* […] *which only appears at night and remains hidden during the day; one might believe that electric light would have the same influence on it as the sun; but nothing happened and the animal did not show anything in front of the lightning*" (Janssen 1888; translation of the authors)[4].

Around 1900, the room of the public Aquarium was equipped with a permanent lighting system while some ponds received the natural light (Fig. 4). The conditions of maintenance, mainly the availability of natural seawater and the lighting system, more and more mastered

Fig. 4. – The public Aquarium in 1910. It has been equipped with permanent lighting system at the beginning of the 20th century (© Archives Laboratoire Arago/Sorbonne Université).

Fig. 5. – The public Aquarium in 1998. After the Second World War, many parts of the Laboratoire Arago had to be rebuilt. Work on the new Aquarium began in 1949. Some improvements have been added over time but the structure of the Aquarium had remained the same from the 50th to 2016, the date of closure of the historic public Aquarium of the Laboratoire Arago (© Jean Lecomte – CNRS)

thanks to modernization of the aquarium, allowed to keep the organisms under conditions close to those encountered in the Mediterranean Sea. Above all, these technical and technological advances made possible to control and modify the parameters of organisms' maintenance, to describe and understand their behaviors and biological activities.

In the early 50's, the public Aquarium underwent a profound renovation, with the creation of a tour circuit of about forty tanks, each presenting a particular marine species (Fig. 5). Over the years, the visit circuit was transformed and the tanks presented the assembled species representative of particular biotopes (*e.g.*, on the continental shelf, from coastal to deep habitats, laguna).

In 2017, the renewal of the public Aquarium gave rise to the birth of a new scientific and pedagogic Aquarium for the Observatoire Océanologique of Banyuls (OOB), named the Biodiversarium (Fig. 6). Continuing the work

[3] French text: "*C'est une grande salle éclairée, à gauche, du côté de la mer, par quatre fenêtres ; d'épais rideaux grenat tamisent fortement la lumière. A droite, au fond, sont huit bacs installés dans le mur, et éclairés du dehors. Six autres cuves complètent l'installation. Le centre est occupé par un bassin circulaire {…}.*"

[4] French text: "*L'un des bacs qui ont 1m60 de longueur est richement peuplé d'une belle actinie, l'Ilélianthe, qui n'apparaît que la nuit et reste cachée le jour ; on pouvait croire que la lumière électrique aurait sur elle la même influence que le soleil ; mais il n'en a rien été et l'animal n'a rien manifesté devant l'éclairement.*"

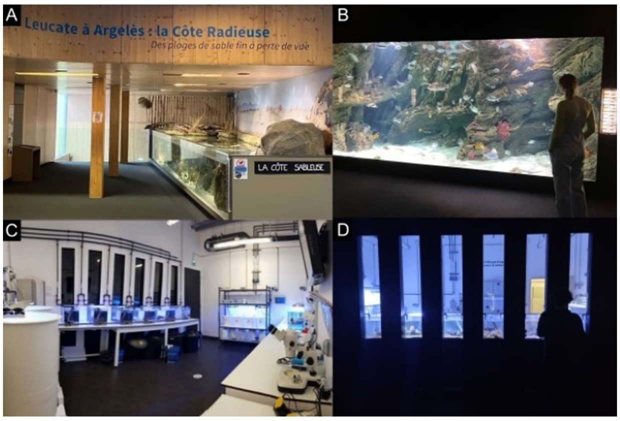

Fig. 6. – The Aquarium of the Biodiversarium opened its doors in a new building in 2017. **A**, **B**: Aquariums reconstituting typical Mediterranean ecosystems are showcases for the local biodiversity. **C**, **D**: Research aquarium rooms can be seen from the public Aquarium by visitors.

done for more than 130 years and perpetuating the philosophy of Pr. H. de Lacaze-Duthiers, the new Aquarium of the Biodiversarium presents the local marine species illustrating the Mediterranean ecosystems, through the research conducted at the marine station. The precise control of the maintenance parameters (*e.g.*, temperature, salinity, light intensity or photoperiod) allows to improve the animal welfare and survival by mimicking coastal ecosystems (Loubet & Romans 2021). The current techniques of animal rearing and the progress made specifically concerning the materials related to aquariology allow today to recreate optimal conditions for the organisms, close to the conditions met at sea. Moreover, this new public Aquarium paves the way for new objectives such as the scientific mediation, new pedagogic approaches and scientific workshops for visitors, children and adults. In addition to the 800 m^2 of the public Aquarium, a large experimental area of 450 m^2 located in the backstage, offers researchers remarkable experimental spaces, in which marine biological models (Mediterranean and tropical species) are reared under controlled environmental conditions dedicated to the study of the life cycle of many marine organisms, which are also used as biological models to test the impact of pollutants or the disruption of environmental parameters related to global change. The research area can harbor up to 400 aquariums following the needs of scientists. With the increase of the surface and the evolution of the demands an Aquariology Department was created, the *Service Mutualisé d'Aquariologie* (SMA). Among this Department, aquariologists provide their expertise to maintain a variety of marine organisms in aquaria with two major objectives. One provides researchers with model marine species necessary to the scientific experimentation. The other is to breed demonstration organisms to show the richness of Mediterranean ecosystems to the general public in the frame of the public Aquarium.

In order to limit the impact of sampling at sea for the presentation of marine species in the tanks, the whole life cycle of some of them can be realized in captivity, which requires a strong investment of aquariologists. In the process, larviculture can constitute a bottleneck, especially the feeding of young stages (larvae, juveniles), which require high quality live preys. Recently, the technical teams of the Aquariology Department developed the breeding of pelagic copepods based on the work of Takayama *et al.* (2020). This small-sized zooplanktonic species offers very interesting perspectives for the rearing of a majority of fish species in the world. Controlling the biological cycle of aquatic species represents a major interest not only in the frame of aquaculture or recreative aquariology, but also in conservation programs.

An emblematic species presented in the public Aquarium is the deep-sea yellow tree coral, *Dendrophyllia cornigera*, some specimens of which have been sampled during the campaign MEDSEACAN (2008-2010) exploring the Mediterranean submarine canyons (Fourt & Goujard 2012). Acclimating and maintaining these deep-sea species in aquarium is challenging due to the nature of the environment from which they have been taken. This has been successfully achieved by the experts of the Aquariology Department in Banyuls, so that this species is now presented in an aquarium dedicated to the illustration of deep Mediterranean ecosystems in the public Aquarium. It should also be noted that some individuals, including some Mediterranean tube sea anemone, *Cerianthus membranaceus*, are presented to the public for about 40 years thanks to the constant intention of the aquariologists.

FROM OBSERVATION TO EXPERIMENTATION: EFFECT OF LIGHT MANIPULATION ON THE BIOLOGY OF MARINE ORGANISMS

When Pr. H. de Lacaze-Duthiers introduced the use of an arc lamp in the public Aquarium in 1888, he was thus capable to manipulate the light regime in the tanks and observed subsequent behaviors of the reared specimens, such as the astonishment and curiosity of fishes and the disappearance of annelids in their tubes (Janssen 1888). He also noticed that an actinia (*Actinia equina*), which hides during the day and emerges at night in natural environment, did not hide when exposed to artificial light. This observation by Pr. H. de Lacaze-Duthiers is reminiscent of some experiments conducted much earlier, on a plant named the sensitive, *Mimosa pudica,* by Jean-Jacques Dortous de Mairan (1978-1771), a mathematician and astronomer, who discovered in 1729 the endogenous nature of rhythm in this plant (Klarsfeld 2013). These pioneering observations opened up the field of chronobiology, *i.e.* the study of the effect of time on the synchronization of biological activities, biological rhythms and internal biological clocks in living organisms. Chronobiology is a current research at the OOB, focused on rhythms and cycles in the marine environment. The Mediterranean mussel, *Mytilus galloprovincialis*, is a biological model currently used for understanding if rhythmic environmental variations and/or biological clocks are driving the process of periodic formation of increments in their shell during biomineralization (Louis *et al*. 2022). To answer this question, the first aim is to identify the putative biological clock of the Mediterranean mussel. To achieve that, experimentations are conducted in aquariums. The opening/closing valve activity of the bivalves has been reported as driven by biological clocks in some other bivalves (Mat *et al*. 2012, Tran *et al*. 2016). In the case of the Mediterranean mussel, circadian (~24 hours) and circatidal (~12.4 hours) rhythms of valves apertures has been previously described in the field (Comeau *et al*. 2018). However, the endogenous nature of the rhythms, meaning the presence of a biological clock orchestrating biological activities, and the characterization of clock environmental drivers are still open questions (Louis *et al*. 2022). Therefore, the valve behavior of mussels was tracked in tanks, in which environmental conditions are manipulated to keep them all (*e.g.*, the temperature, the pH, the food quantity), but the light condition, steady. Their valve aperture rhythm observed in a photoperiodic condition with an alternance of 12 hours of light and 12 hours of darkness (LD 12:12), still occurred under constant light condition, *i.e.*, continuous darkness (DD) or continuous light (LL) if driven by biological clocks. Similarly, the modified photoperiodic condition induced by the arc lamp toward the actinia did not change its behavior, as Pr. H. de Lacaze-Duthiers reported in 1888, suggesting the presence of a biological clock in that species. However, a more recent studies (di Milia & Geppetti 1964, Bell *et al*. 2006) showed that it is not the case as circadian and circatidal rhythms that are observed in the field do not occur under constant controlled environment in aquarium. On the contrary, sea anemones expansion-contraction rhythm directly followed the photoperiodic cycles to which they are submitted in the aquariums (di Milia & Geppetti 1964, Bell *et al*. 2006).

Nowadays, the behavioral activity of marine organisms can be recorded via cameras and/or computers linked to captors which is an opportunity to observe specimens on longer periods and also in larger quantity connected to a computer (Fig. 7). In the case of mussel, a hall captor and a magnet are glued on the valves of the shell and connected to a computer. When the valves of the mussel are open, the captor is further from the magnet leading to a decrease of the difference of potential registered by the computer.

NEW PERSPECTIVES IN THE SCIENCE OF AQUARIOLOGY

The "science of aquariology" (McCormick-Ray 1993) is now flourishing in various disciplines of marine biology. Thus, the aquarium is not only a valuable tool for describing the biology of aquatic organisms under controlled rearing condition, it is also a system for characterizing how this biology can be disrupted by degraded or adverse environmental conditions. Ecotoxicology, *i.e.*, the study of the effect of polluting substances on the biology and behavior of organisms, is still emerging in the marine environment and is based on the rearing of model marine organisms under controlled toxicological conditions in aquariums, corresponding to marine bioassays. In the context of global change, where various parameters of the marine environment are changing (increase in temperature, decrease in the pH of seawater) and where polluting substances are being discharged into the marine environment (*e.g.,* pesticides, plastic, medical waste), it is crucial to be able to establish the impact of these stressors on marine ecosystems in order to be able to subsequently protect them and establish rules for their use. At the OOB, marine ecotoxicology is a current research topic, in the frame of which researchers characterized the effect of plastic pollution in coastal marine species, such as bacteria, mussel, amphioxus and fishes, as well as in deep-sea corals since plastic particles have been found even in deep-sea canyons (Chapron *et al*. 2018, Dussud *et al*. 2018, Cheng *et al*. 2023). Other disturbances are tracked in those model species considering toxic molecules linked with local activities impacting marine environment such as the effect of pesticides used in viticulture or UV filters included in sunscreen creams (El Azzi *et al*. 2013, Genevière *et al*. 2020, Downs *et al*. 2021). Thus, such an aquarium allowing a strict control of the environmental conditions of breeding constitutes a tool to establish projections of the ocean ecosystems of the future.

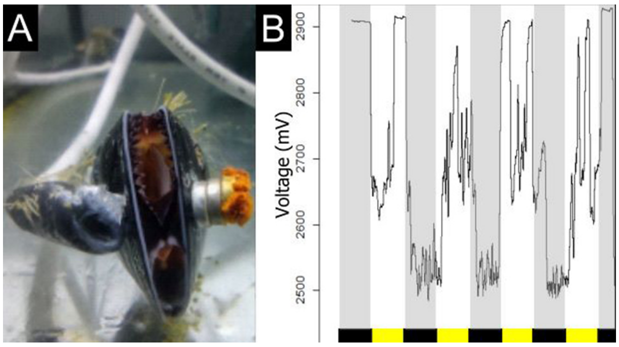

Fig. 7. – Valvometry measurements. **A**: Device on a mussel. A hall captor (left) and a magnet (right) were glued on the valves of the mussel. The captor is linked to a computer by a wire. **B**: The difference of potential varies according to the valves movements and is recorded by a computer. The graph shows that valves were open (lower voltage) at night (black) and closed (higher voltage) during the day (yellow).

Another very important role of marine aquariology is to be involved in conservation programs, designed to the protection of particularly endangered species and to the proposal of conservation measures. In this context, an emblematic species reared in the OOB is the red coral, *Corallium rubrum*, which has been extensively studied by Pr H. de Lacaze-Duthiers (Lacaze-Duthiers 1864, see in this special issue Vielzeuf *et al*. 2022). For several years now, this species is under the focus of the International Union for Conservation of Nature (IUCN), and qualified as "endangered" by the IUCN Red List of Threatened Species in Mediterranean region, regarding the decrease in population size by dramatic mortality rates (Garrabou *et al*. 2015). The two main sources of mortality are harvesting, and more recently the occurrence of mass mortality events associated to current warming trend. Red coral colonies are reared in the Aquariology Department of the OOB for numerous years now, allowing studies about reproduction and growth in order to better understand its biology and ecology (Martínez-Quintana *et al*. 2015, Giordano & Bramanti 2021, Giordano *et al*. 2023). Aquarium can also constitute a tool of protection, as illustrated in the case of the Mediterranean endemic fan mussel, *Pinna nobilis*, a species referred as "endangered" by IUCN (Kersting *et al*. 2019) and whose stocks in the Western Mediterranean Sea drastically collapsed mainly due to the emergence of an epizooty, which agent *Haplosporidium pinnae* was identify as an invasive protozoan species likely introduced by shipping (Catanese *et al*. 2018). A consortium of specialists from the "Centre de recherches insulaires et observatoire de l'environnement" (CRIOBE, University of Perpignan), the Marine Natural Reserve of Cerbère-Banyuls, and the Aquariology Department of the OOB implemented a program of conservation of the fan mussel in aquarium (Frioul & Laudet 2019) with the aims of protecting individuals from the parasitic infection and establishing *in vitro* reproduction for several wild specimens. Similarly, obtaining information on the biology (*e.g*. reproduction, feeding patterns, behavior) of invasive species, is crucial for the implementation of measures to protect and conserve ecosystems. Currently, intensive research on these biological traits is being achieved in the invasive American blue crab, *Callinectes sapidus*, which population severely increased in 2020 impacting local species such as eels.

Finally, the science of aquariology within a marine station such as the OOB also supports the emergence of new biological animal models dedicated to research in marine biology. For that purpose, it is crucial to be able to establish the whole life cycle of the chosen species in captivity, which is far from trivial. Recent advances in aquariology techniques and materials allow to provide the animals environmental rearing conditions close to natural ones. Thus the list of marine biological models established in aquaria for scientific research is growing, as reported in Boutet & Schierwater (2022), including invertebrates such as jellyfishes, ascidians (sea squirts), deep-sea cor-

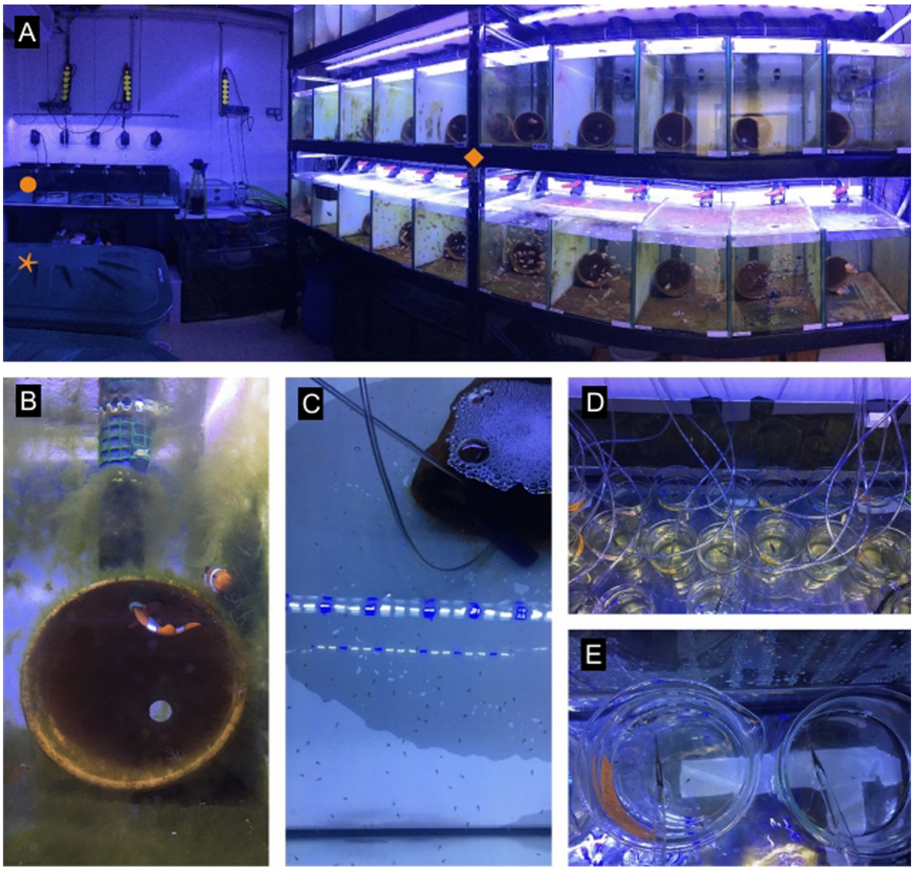

Fig. 8. – Rearing structure of anemonefish in Banyuls-sur-Mer. **A**: Aquarium room containing the breeding pairs, juveniles and larvae. **B**: *Amphiprion ocellaris* breeding pair and a terracotta pot used for eggs deposition. **C**: Larvae in an aquarium. **D**, **E**: Experimental set up in small volume (© Roux *et al*. 2020).

Fig. 9. – Aquarium as a mediation tool. Local pupils discovering Mediterranean marine organisms.

Fig. 10. – In the entrance of the Aquarium of the Biodiversarium, Pr. Henri de Lacaze-Duthiers welcomes the visitors together with the Vénus, as on day one.

als and amphioxus (lancelets), or vertebrates such as coral reef fishes like anemonefish (Fig. 8) (Roux *et al*. 2020).

THE AQUARIUM: AN EXTRAORDINARY MEDIUM FOR SCIENTIFIC MEDIATION

Since its creation in 1888, to its complete overhaul in 2017, the public Aquarium of the Laboratoire Arago has been driven by the same philosophy, that of Pr. H. de Lacaze-Duthiers, *i.e*., making the magnificent marine diversity of the Mediterranean Sea visible and comprehensible to as many people as possible. It is therefore a question of informing, of exhibiting, with the aim of teaching knowledge in order to then respect and protect. The current public Aquarium is an outstanding medium for scientific communication and since its opening in 2017, has attracted a large local audience, from the youngest primary school children, pupils from the departmental high schools, to students from Sorbonne University involved in training courses with local research teams (Fig. 9) (Frioul & Laudet 2019). This mediation space relates the history of the place, from the Laboratoire Arago to the OOB and, as such, it receives many visitors, whether they are interested in cultural tourism or simply curious (Fig. 10). Numerous activities are organized by the team in charge of the scientific mediation in dedicated areas of the public Aquarium, such as a room mimicking a research laboratory or a classroom that welcomes pupil for practical works. The spirit of Lacaze-Duthiers still hovers in this place guiding this science of aquariology in the service of research, management, education, and conservation of Mediterranean marine biodiversity.

Acknowledgments. – This paper has been done based on a conference made for bicentenary of the birth of Professor Henri de Lacaze-Duthiers (July 2021 – Banyuls-sur-Mer). Authors would like to thank V Arnaud & S Bodin from the library of the Laboratoire Arago – OOB, for the organization of the conferences and their help in historical researches. We are grateful to P Romans, curator of the Biodiversarium and head of the Aquariology Department of the OOB, for his critical reading of the manuscript and useful comments. Finally, we would like to thank F Lartaud & V Arnaud for their invitation to contribute to this special issue and the two anonymous reviewers for insightful comments on the manuscript.

REFERENCES

Bell J, Shaw C, Turner J 2006. Factors controlling the tentacle and polyp expansion behaviour of selected temperate Anthozoa. *J Mar Biol Ass UK* 86(5): 977-992.

Boletzky SV, Centelles J 1978. *Argonauta argo* (Mollusca, Cephalopoda) dans la région de Banyuls-sur-Mer. *Vie Milieu*. 28: 659-660.

Boutan L 1900. La Photographie sous-marine et les Progrès de la Photographie. Paris, Schleicher: 163 p.

Boutet A, Schierwater B 2022. Handbook of Marine Model Organisms in Experimental Biology: Established and Emerging. Boca Raton. CRC Press Ed: 471 p.

Brettingham Sowerby G 1857. Popular History of the Aquarium of Marine and Fresh-Water Animals and Plants. Reeve: 327 p.

Carrau T 2022. Objectivity according to Lacaze-Duthiers. *Vie Milieu* 72(3-4): 53-61.

Catanese G, Grau A, Valencia JM, Garcia-March JR, Vázquez-Luis M *et al*. 2018. *Haplosporidium pinnae* sp. nov., a haplosporidan parasite associated with mass mortalities of the fan mussel, *Pinna nobilis*, in the Western Mediterranean Sea. *J Invertebr Pathol* 157: 9-24.

Chapron L, Peru E, Engler A, Ghiglione JF, Meistertzheim AL *et al*. 2018. Macro- and microplastics affect cold-water corals growth, feeding and behaviour. *Sci Rep* 8: 15299.

Cheng J, Meistertzheim AL, Leistenschneider D, Philip L, Jacquin J *et al*. 2023. Impacts of microplastics and the associated plastisphere on physiological, biochemical, genetic expression and gut microbiota of the filter-feeder amphioxus. *Environ Int* 172: 107750.

Chéruel M 1856. Mémoires complets et authentiques du Duc de Saint-Simon sur le Siècle de Louis XIV et La Régence. Collationés sur le Manuscrit original de Louis de Rouvroy, Duc de Saint-Simon. Tome 6. Paris, Hachette Ed: 475 p.

Comeau LA, Babarro JMF, Longa A, Padin XA 2018. Valve-gaping behavior of raft-cultivated mussels in the Ría de Arousa, Spain. *Aquac Rep* 9: 68-73

di Milia A, Geppetti L 1964. On the expansion-contraction rhythm of the sea anemone, *Actinia equina* L. *Experientia* 20(10): 571-72.

Downs CA, Dinardo JC, Stien D, Rodrigues AMS, Lebaron P 2021. Benzophenone accumulates over time from the degradation of octocrylene in commercial sunscreen products. *Chem Res Toxicol* 34(4): 1046-1054.

Dussud C, Hudec C, George M, Fabre P, Higgs P *et al*. 2018. Colonization of non-biodegradable and biodegradable plastics by marine microorganisms. *Front Microbiol* 9: 1571

El Azzi D, Viers J, Guiresse M, Probst A, Aubert D *et al*. 2013. Origin and fate of copper in a small Mediterranean vineyard catchment: New insights from combined chemical extraction and δ65Cu isotopic composition. *Sci Total Environ* 463-464: 91-101.

Fourt M, Goujard A 2012. Rapport final de la campagne "MEDSEACAN" (Têtes des canyons méditerranéens continentaux) novembre 2008-avril 2010 : Partenariat Agence des aires marines protégées – GIS Posidonie, GIS Posidonie publ: 218 p.

Frioul V, Laudet V 2019. Guide du Biodiversarium et de La Méditerranée. Privat Ed: 233 p.

Gage MJ 1883. Woman as an Inventor. *North Am Rev* 136 (318): 478-489.

Garrabou J, Bavestrello G, Cattaneo-Vietti R, Cerrano C, Garcia S *et al*. 2015. *Corallium rubrum* (Mediterranean assessment) (errata version published in 2017). The IUCN Red List of Threatened Species 2015 e.T50013405A110609252. Downloaded on 4 May 2023.

Genevière AM, Derelle E, Escande ML, Grimsley N, Klopp C *et al*. 2020. Responses to iron oxide and zinc oxide nanoparticles in echinoderm embryos and microalgae: uptake, growth, morphology, and transcriptomic analysis. *Nanotoxicology* 14(10): 1342-1361.

Giordano B, Bramanti L 2021. First report of chimerism in Mediterranean red coral (*Corallium rubrum*). *Medit Mar Sci* 22(1): 157.

Giordano B, Bramanti L, Perrin J, Kahramanoğulları O, Vielzeuf D 2023. Early stages of development in Mediterranean red coral (*Corallium rubrum*): the key role of sclerites. *Front Mar Sci* 10: 1052854

Gosse PH 1854. The Aquarium: An Unveiling of the Wonders of the Deep Sea. London, John Van Voorst: 278 p.

Huyge D 1994. On labyrinth fish-fenses in Saharan rock art. *Sahara: Prehist Hist Sahara* 6: 77-80.

Janssen M 1888. La lumière électrique à Banyuls. *La Nature* 783: 383-84.

Jessus C 2022. Being Henri de Lacaze-Duthiers. *Vie Milieu* 72 (3-4): 35-52.

Kersting D, Benabdi M, Čižmek H, Grau A, Jimenez C *et al*. 2019. *Pinna nobilis*. The IUCN Red List of Threatened Species. e.T160075998A160081499. Downloaded on 15 May 2023.

Klarsfeld A 2013. Aux aurores de la chronobiologie. Bibnum, Sciences de la vie. http://journals.openedition.org/bibnum/511

Lacaze-Duthiers H 1864. Histoire naturelle du Corail. Organisation, Reproduction, Pêche en Algérie, Industrie et Commerce. Paris, Éd Ba: 450 p.

Lorenzi C 2009. L'engouement pour l'aquarium en France. *Soc Représ* 2: 253-271.

Loubet J, Romans P 2021. L'aquarium, près de cent quarante ans d'Histoire. *In* Jacques G, Desdevises Y Eds, Du Laboratoire Arago à l'Observatoire Océanologique de Banyuls. Paris. Sorbonne Univ Ed: 253 p.

Louis V, Besseau L, Lartaud F 2022. Step in time: biomineralisation of bivalve's shell. *Front Mar Sci* 9: 906085

Martínez-Quintana A, Bramanti L, Viladrich N, Rossi S, Guizien K 2015. Quantification of larval traits driving connectivity: the case of *Corallium rubrum* (L. 1758). *Mar Biol* 162(2): 309-318.

Mat AM, Massabuau JC, Ciret P, Tran D 2012. Evidence for a plastic dual circadian rhythm in the oyster *Crassostrea gigas*. *Chronobiol Int* 29(7): 857-867.

Matthews M 2016. A Brief History of Victorian Goldfish Globes and Goldfish-Hawkers. https://www.mimimatthews.com/2016/06/09/victorian-goldfish-globes-and-goldfish-hawkers/

McCormick-Ray MG 1993. Aquarium science: the substance behind an image. *Zoo Biol* 12(5): 413-424.

Pervinquière L 1892. Une visite au Laboratoire Arago. *Cosmos* 384: 294-297.

Prouho H 1886. Le Laboratoire Arago, Station biologique de Banyuls-sur-Mer. *La Nature* 659: 97-99.

Roux N, Salis P, Lee SH, Besseau L, Laudet V 2020. Anemonefish, a model for Eco-Evo-Devo. *Evodevo* 11(1): 1-11.

Schmölcke U, Nikulina EA 2008. Fischhaltung im antiken Rom und ihr Ansehenswandel im Licht der politischen Situation. *Schr Naturwiss ver Schlesh-holst* 70: 36-55.

Takayama Y, Hirahara M, Liu X, Ban S, Toda T 2020. Are egg production and respiration of the marine pelagic copepod *Acartia steueri* influenced by crowding? *Aquac Res* 51(9): 3741-3750.

Tran D, Sow M, Camus L, Ciret P, Berge J, Massabuau JC 2016. In the darkness of the polar night, scallops keep on a steady rhythm. *Sci Rep* 6: 32435.

Vielzeuf D, Allemand D, Shick JM, Arnaud V, Bodin S, Bramanti L 2022. The biology and biomineralogy of the red coral: the Lacaze-Duthiers Legacy. *Vie Milieu*. 72(3-4): 63-127.

Villepreux-Power J 1856. Observations physiques sur le Poulpe de l'Argonauta Argo : commencées en 1832 et terminées en 1843, dédiées à M. Le Professeur Owen F.R.S. Paris, Imprimerie Charles de Mourges frères: 32 p.

Warington R 1850. IX. – Notice of observations on the adjustment of the relations between the animal and vegetable kingdoms. *Q J Chem Soc Lond* 3(1): 52-54.

Yue P, Liang Z 1995. A sketch on the fishery history and its development in ancient China. *Chinese J Zool* 30: 54-58.

Received on February 23, 2023
Accepted on June 6, 2023
Associate editor: F Lartaud