Original, unedited text as received by EAZA on 19 August 2005

Towards coral reefs in tanks: the CORALZOO project

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In June 2005, an international scientific research project on the breeding and husbandry of stony corals started. This project, entitled CORALZOO, will be executed for the benefit of EAZA associated zoos and public aquaria. The project is funded by the European Union for a period of four years. In the previous issue of this newsletter, a short summary of the project was presented. In this paper, we will further outline the background and the objectives of the CORALZOO project.

Background. In the last decades, an increasing public interest in marine life has led to a concurrent effort among zoo's and public aquaria to improve their capabilities to display coral reef ecosystems in aquaria. Being the most important reef-builders, stony corals in particular have received the attention of aquarists. It is the policy of many zoos and public aquaria to display organisms that originate from sustainable inland breeding facilities rather than collecting organisms from the wild. Therefore breeding techniques need to be developed to allow the acquisition of sufficient coral colonies to create truly representative coral reef exhibits. Significant progress has been made in this respect: it is nowadays possible to grow corals in tanks and to maintain them in reef exhibits. The art of coral culture and husbandry therefore has the potential to become a fully developed methodology that can be optimised, validated and widely applied. In order to take this step, a consortium of 10 zoos and public aquaria (supplemented with an ornamental trade company) will collaborate with four scientific institutes in the CORALZOO project (see Table 1 for an overview of consortium members). As such, CORALZOO is the first comprehensive approach that makes use of molecular biology, mathematical, toxicological and nutritional tools for the development of unique breeding and husbandry protocols for corals in captivity.

Collective Research. CORALZOO meets the EU description of a Collective Research project. Collective Research is an instrument of the European Commission that enables industrial branch associations to outsource research and development on commonly occurring issues within the branch. In CORALZOO, the branch comprises zoos and public aquaria, represented by EAZA, which will outsource research on coral breeding and husbandry to the consortium mentioned above. The results of the project will be for the benefit of the entire branch (i.e. all EAZA members), and training sessions will be organised within the project to introduce the newly developed techniques to staff of zoos and public aquaria. The anticipated main deliverables of the project are a book of protocols for coral breeding and husbandry, and the initiation of a European Breeding program for stony corals. This program will be part of the coral Aquatic Sustainability Program (Coral ASP), to be executed under auspices of the Fish and Aquatic Invertebrates Taxon Advisory Group (FAITAG) of EAZA. The Coral ASP is an initiative of the European Union of Aquarium Curators (EUAC) in collaboration with EAZA.

General objectives. In order to achieve the main deliverables, research will focus on the following topics:
(1) sexual and asexual breeding of corals in captivity, including breeding and feeding techniques and induction of natural coral colony morphogenesis
(2) coral husbandry: development of generic bioassays to evaluate biotic and abiotic husbandry parameters and to monitor coral health, elaboration of methods for identification and treatment of coral diseases and optimisation of transport and acclimation procedures.

The project will mainly concentrate on a limited number of model species, and will in particular focus on the branching corals *Stylophora pistillata* (Fig 1) and *Pocillopora damicornis* (Fig 2). Much of the experimental work will be done using coral nubbin bioassays, these are single polyps attached to a flat support (Shafir et al. 2003). These nubbins generally show a two-dimensional growth pattern during the first months of their development (Fig 3), which allows easy monitoring of growth-related parameters and the execution of quantitative studies with a limited amount of coral material. The studies on *S. pistillata* and the other model species may serve as a blueprint for subsequent development of breeding and husbandry protocols for other species. In the next paragraphs, we will discuss some of the CORALZOO research topics in more detail.

Growing corals: food and light supply. Defining the nutritional requirements of corals is considered a key issue for the successful cultivation of these animals. The majority of the stony coral species are hermatypic, i.e. they live in symbiosis with unicellular algae termed zooxanthellae. The zooxanthellae live within the host corals tissue where they produce organic material by photosynthesis, which is partially consumed by the coral host. As such, corals can be considered as being partially autotrophic. Hence, appropriate lighting should be provided when these corals are to be grown in tanks. Although it has been known for decades that hermatypic corals also feed on organic matter such as plankton and detritus, the importance of this process for the overall metabolism of the corals has not been fully described. It recently became evident that heterotrophic feeding considerably stimulates many biological processes in hermatypic corals, including photosynthesis by zooxanthellae (Houlbreque et al. 2003, 2004). Hence, cost-efficient breeding of corals will be a trade off between light supply and food supply (hereby taking into account that a good water quality must be maintained, see section on water quality below). The CORALZOO project will attempt to establish what food types are most suitable for corals (by analysis of the digestive system of the model species), and how much they should be fed (empirical studies). In addition, the relation between light supply and organic feeding will be further elucidated: what is the combination of light and food that (i) gives the highest yield in coral biomass and (ii) is most cost-efficient to grow corals on a large scale (without compromising on water quality).

Abiotic factors. The studies described above closely relate to studies on several other factors that interact with light utilisation and feeding. For example, the uptake of calcium from the surrounding seawater by corals (for building the calcareous skeleton) is augmented by both heterotrophic feeding and light. Hence, monitoring and control of the

calcium levels in a tank is important and relates directly to the feeding and lighting regime. Concurrently, the feeding efficiency is dependent on the hydrodynamic conditions in a tank. Current velocity and flow regime (laminar flow versus turbulent mixing) both affect the ability of corals to take up food particles from the surrounding water, both directly and indirectly. Water movement keeps food particles in suspension, thus improving the availability of food for corals. Too high current velocities may however decrease the ability of a coral polyp to retain a particle from the stream. These direct effects of water movement will be studied using modern image analysis techniques. The indirect effects of water movement on feeding relate to the morphology of the coral colonies, which changes under the influence of changing hydrodynamic conditions. This aspect will be studied using mathematical models, which will be validated with long term growth experiments under different hydrodynamic conditions. The modelling study will provide a tool that enables us to predict the morphology of corals by characterising (and if needed: modifying) the conditions in the tank in which the corals are to be grown. As such, the modelling studies can help to grow and display high quality corals that exhibit a natural growth form.

Water quality. It is well known to most aquarists that excellent water quality is needed to cultivate corals. The term water quality relates to the physical and chemical properties of the seawater, which must be in accordance with the demands of the animals that live in it. Important factors in this respect are concentrations of potentially harmful compounds such as nitrate, ammonium, phosphate and organic wastes, but also trace element concentrations and ratios between different chemical components. The CORALZOO team aims to define the most optimal water quality for a few target species and will improve the analytical methods to monitor some of the water quality parameters. Also, water quality control systems will be reviewed and further improved.

Breeding. In order to find a trade off between mass cultivation and maintaining a genetic diversity, breeding of corals in zoos should both include sexual reproduction (induction of spawning and collection and subsequent handling of coral larvae) and asexual production (cloning) of coral colonies by fragmentation. Whereas fragmentation is a widely applied technique among aquarists, sexual reproduction of corals in tanks is unpredictable and often incomplete. A complete life cycle of the Caribbean coral *Favia fragum* was recently reported by scientists from Rotterdam Zoo (The Netherlands). Building upon this knowledge and observations from the field, the CORALZOO scientists will try to establish controllable methods for induction of spawning in aquaria. In this respect, a close collaboration with the ongoing SECORE project (Sexual Coral Reproduction, an initiative of Rotterdam Zoo) is anticipated.

Coral health: occurrence and control of diseases. Many diseases that affect corals in the wild have been described (see for example review by Richardson and Aronson, 2002), but the occurrence of these diseases in aquaria has hardly been documented. It is one of the aims of CORALZOO to identify the most frequently occurring coral diseases in tanks. This will be done by studying the “grey literature” (websites, informal reports, etc) and by executing a monitoring program in the aquaria of CORALZOO-associated organisations. The next step is to identify the agents that cause these diseases (by using

modern microbiological and molecular techniques) and to develop efficient treatments to cure diseased specimen. One of the expected deliverables in this respect is a diagnostic kit for the rapid identification of pathogens.

Transportation. In order to establish a European breeding program on corals (in which each zoo or aquarium will focus its breeding activities on a limited number of species), it is essential to have effective methods for transportation of cultured corals to other zoos and aquariums, and subsequent acclimation of the transported corals to a new environment. Standardisation of existing methods (see report by Petersen et al. 2004) and further improvement of these methods are the main goals of the CORALZOO project in this respect.

All aspects described above will be experimentally studied. In addition to experimental research, the CORALZOO consortium aims to document the large pool of currently existing (but often fragmented and anecdotal) knowledge in such a way that it becomes available for a broad audience. It is expected that CORALZOO will significantly improve the scale and success of zoos and public aquaria in their efforts to exhibit coral reefs in tanks. We hope that images such as the one illustrated in Fig. 4 can soon be seen enjoyed by zoo visitors at many locations, including those far away from the sea.

References:

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Petersen, D., Laterveer, M., van Bergen, D. and Kuenden, M. (2004) Transportation techniques for massive scleractinian corals. *Zoo Technology* **23**, 165-176.

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Figure Captions

Fig. 1. An adult colony of *Stylophora pistillata* (picture by courtesy of Shai Shafir).
Fig. 2. An adult colony of *Pocillopora damicornis* (picture by courtesy of Claudia Gili).

Fig. 3. Example of a nubbin of *S. pistillata* that has grown laterally over the surface of its support (picture by courtesy of Shai Shafir).
Fig. 4. A natural coral reef (photo by Ronald Osinga).

Table 1: Participants and associates to the CORALZOO project.

Industrial Grouping:	EAZA
Research Institutes:	Wageningen University, The Netherlands (coordinator) Israel Oceanography and Limnology Research Institute Technical University of Dresden, Germany Italian consortium for Marine Sciences
Zoos and aquaria:	Burgers'Zoo, The Netherlands Rotterdam Zoo, The Netherlands Running Deep, UK London Zoo, UK Acquario di Genova, Italy Aquatopia, Belgium Oceanario de Lisboa, Portugal Nausicaa, France Oceanopolis, France Schoenbrunner Tiergarten, Austria Tierpark Hagenbeck, Germany
Ornamental trade:	Red Sea Corals Ltd., Israel

Fig. 1.

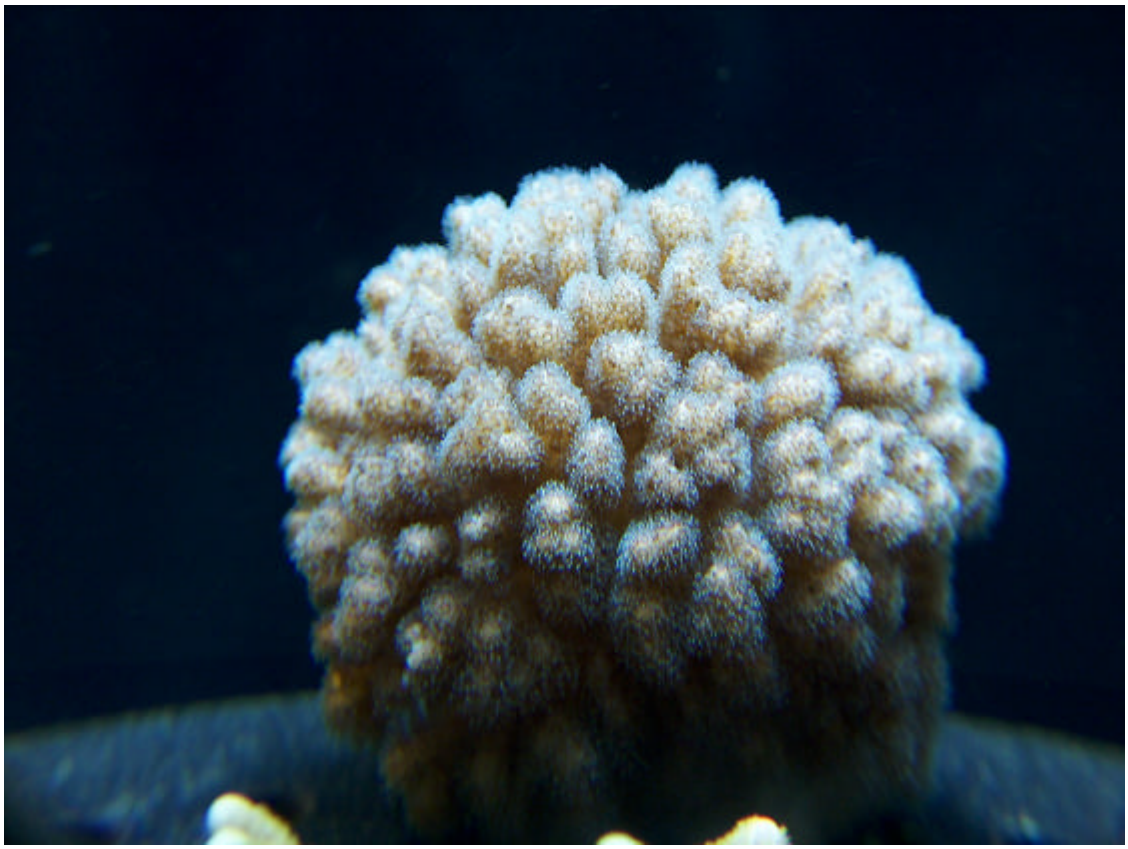

Fig. 2

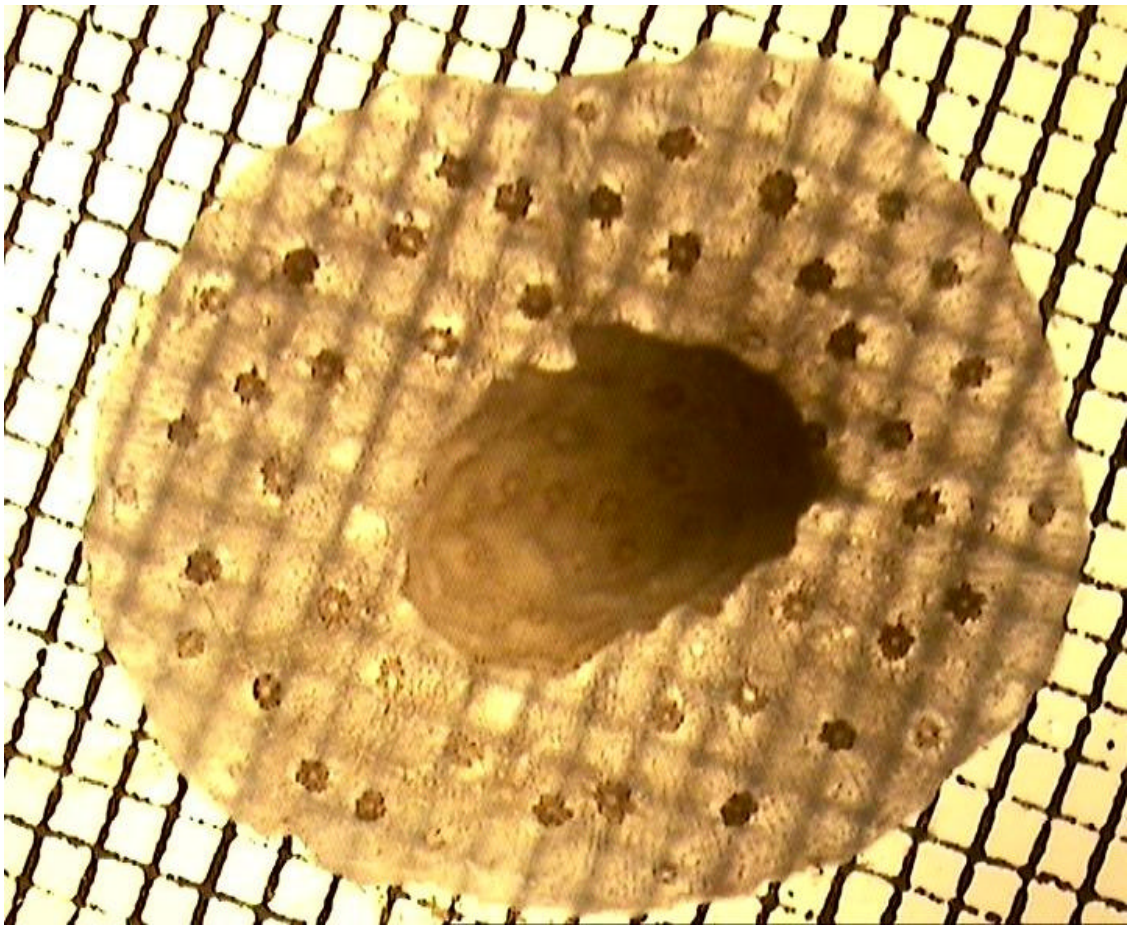

Fig. 3

Fig. 4