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fish, which is fairly risky or to take them from the wholesaler as soon as possible to reduce the chance of new arrivals being diseased.

Wild caught fish have the additional problem of getting used to alien conditions. For native fish, stress can easily be reduced by careful handling and by using oxygen and a mild tranquillizer eg MS-222.

At Bolton MS-222 is used to quieten wild caught native fish. This, coupled with careful handling, has reduced deaths in transport to virtually nil. A stock solution is made up so that 100ml of solution holds 450mg of tranquillizer; 10ml of stock solution added to 1 gallon of water will give approximately 45mg/gallon. According to D J Solomon and A D Hawkins[1] a concentration of 10-30 mg/l is sufficient to tranquillize fish.

As there are 4.5 litres per gallon then 10ml of stock solution added to 1 gallon gives the lowest concentration. Note this is only used in transport; prolonged exposure to MS-222 can lead to respiratory problems.

During the next few years it is hoped that Bolton can join the Lake Victoria cichlid scheme to preserve fish stock native to the Lake. It is also hoped that the two pairs of freshwater stringray, at present housed in the aquarium, will attain sexual maturity and start breeding.

References

1 Hawkins, A D (ed), 1981. AQUARIUM SYSTEMS. Academic Press

3 The Management of Temperate and Tropical Marine Displays

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Introduction

Liverpool Museum has a long tradition of living displays. For example, the 5th Annual Report for 1857 states that:

"During the year several aquaria, both salt and freshwater, have been established in the Museum and have proved objects of very great interest to visitors; indeed, there is good reason to suppose that it is mainly owing to the new additions to the Museum that the number of visitors has been so much in advance of previous years."

The 'advance' referred to was an increase of no less than 16,145 visitors over the previous year's total of 106,914.

We are particularly fortunate that this tradition continues to receive the backing of the museum's management team who are prepared to underwrite the considerable effort and resources necessary for the upkeep of the displays. The result is that some 130 years on, live displays remain at the forefront in the popularity stakes, and continue to play an important role in the Museum's educational programme.

Display techniques

Management of large-scale marine displays requires, above all else, an ability to keep a host of disparate elements in relative equilibrium at all times. Whilst attempting such a biological balancing act, usually within the confines of a multitude of aquaria, one must also be constantly mindful of the needs not just of the inmates, but of the observers as well. After all there is little point in providing optimum conditions for your favourite species of burrowing goby if all the visitor has to look at is an occasional cloud of mud and a hundred-word label! The most successful living displays should have immediate aesthetic appeal and educational impact. This can only be achieved through excellent presentation supported by dedicated staff with access to comprehensive maintenance facilities.

The present aquarium and vivarium replaced the original one which was destroyed in the last war, and was first opened to the public in March 1966. Unfortunately, from the outset it suffered from the effects of poor design in several important areas. The 26 rectangular display aquaria were of mild steel construction and their internal resin coating soon chipped off, causing corrosion problems. The light level achievable over displays was inadequate and the safety of the installation questionable.

Large but inefficient sand filters, located below floor level, required the laborious removal of floor boards in order to inspect or service. Only twelve small aquaria were provided for quarantine purposes. They were located in a 10ft x 10ft room which also doubled as an office, enquiry point and store. An ambient temperature in excess of 30°C (86°F), caused by uninsulated sub-floor steam pipes, frequently resulted in 'cold water' displays operating at temperatures higher than those found in the tropics.

Fortunately, most of these problems are now things of the past. We have full quarantine and breeding facilities of over sixty tanks contained in two rooms. On the west display gallery the ambient temperature is maintained at 20°C (68°) by four individual air-conditioners and the water temperature of the thirteen local marine and freshwater displays is further reduced to 10°C (50°F) by a titanium cooling plant of advanced design.

The east gallery is fitted out with thirteen marine and freshwater display tanks which contain a wide range of tropical species. High-tech backup includes automatic photoperiod control, emergency power supplies to essential equipment, dual circuit air turbines, UV water irradiation equipment and

a fully-equipped cold room. We are about to embark on the final phase of replacing the corroded display tanks with lightweight, free-standing fibreglass tanks and integral biological filters, all built to our specification.

Having got the basic infrastructure right, we have been able in recent years to concentrate on improving the scope and content of several existing displays and have created many entirely new ones, developed around specific themes. Topics of local interest such as the Wreck of the Mary (Charles II's yacht, discovered in 1971 off Anglesey) and New Brighton Pier are particularly popular themes, together with natural habitat reconstructions such as Anglesey Rocky Coastline and Hilbre Island Sandy Shore. We were greatly assisted in their production by model-making colleagues from the Technical Services Department, who helped us not only to translate our ideas into reality but also to develop our own techniques in using a wide range of 'new generation' plastics and rubbers.

Creating some displays occasionally involved us in field work. For example, the rock-effect backs in several tanks, which only occupy 2-3 inches of space yet create an impressively 'massive' backdrop, were formed from 45ft long by 5ft wide latex rubber moulds made in the geographic areas depicted in the displays. On one occasion two days' work was almost lost due to gale-force winds tearing half of the mould from the rock face overnight - fortunately we were out at first light and retrieved the pieces!

Other items, such as ships' timbers and bronze cannon, unsuitable in themselves because of their toxicity in closed seawater systems, were reproduced in fibreglass, along with several cannon balls and 'pieces of eight'. The overall appearance is so effective that the majority of visitors remain unaware of the deception and of the effort we have put into achieving it! The less obvious benefits of man-made structures include being very easy to sterilise should disease occur, being light in weight, easy to move, and totally non-toxic. Furthermore several tons of rock and other display materials can be replaced by such structures in each tank, and the resultant increase in space is of great benefit to the occupants, which have responded with improved colours, reduced aggression and more successful spawnings.

Our efforts to enhance the aquatic environment have had another important result. The displays now fully comply with one of the requirements of the Zoo Licensing Act (1981), which states (Standard no.9):

"In the case of aquatic animals, materials such as weed, shingle, etc [are required] to aid and encourage normal behaviour patterns among them."

Display lighting has been greatly improved by the use of metal halide lamps, and near-perfect colour rendition is now easily achievable. They are also powerful enough to stimulate the growth of the smaller green algae such as Enteromorpha and Caulerpa. They also improve the health of anemones, which rely on their symbiotic allies, the zooxanthellae, for an important and irreplaceable part of their nutrition.

Many of the larger species of seaweed play a crucial role in the natural environment, yet in display work they are virtually impossible to cultivate successfully alongside fish and invertebrates. We are therefore perfecting a technique for producing replicas and so far have been most successful with Laminaria saccharina, L. digitata and several Fucus species. However, we still have to improve the colours and find a way of creating 'buoyancy without bubbles' which would enable us to tackle some of the 'green' and 'red' algae as well.

Perhaps the most ambitious and exciting experiment yet undertaken will, on completion, result in far more realistic displays of tropical reef communities than previously possible. The idea for such a scheme first came to me in 1979 whilst studying coral reefs in the South Pacific. I was lucky enough to spend ten days on Green Island, situated on the Australian Great Barrier Reed 17^{o} south of the equator near Cairns. For the first time I was able to observe at close quarters hundreds of fish and invertebrate species previously known to me only through studies made in aquaria.

The experiment brought to mind an observation made by the famous naturalist Philip Henry Goss in 1865 in his book A YEAR AT THE SHORE.:

"He who has never seen marine animals except in the confinement of an aquarium, cannot but be conscious of many chasms in his knowledge, which are filled up by him who is in the habit of collecting his own specimens in their proper haunts".

Nothing could have been more true. On joining the reef inhabitats in their own environment, it became increasingly obvious to me just how impoverished were even the best man-made marine displays, and how garish and out-of-place the few reef creatures they contained.

Here, the numerous and brilliantly-coloured inhabitats harmonised perfectly with the equally gaudy and exotic backdrop of the living reef and the multitude of sessile forms which covered it. Here, then, was the way forward in marine display work. A method had to be found of reproducing the principal and most colourful reef inhabitats, such as corals, sponges, clams and algae and assembling them into 'mixed media' displays of living fish and invertebrates.

So far we have identified several major families of reef-building corals, gorgonians and sea whips and obtained suitable specimens from old collections. Their in-life colours have been established and accurately reproduced by the use of specialised pigmented plastics. Life-like models of the giant clam, Tridacna, have been made and several

prototypes produced. Work will soon start on some of the more robust calcareous algae such as Halimeda and various sponges. Such work is fascinating but time-consuming, not least because all materials used have to be tested in aquaria behind the scenes to ensure their suitability. It was at this stage that some novel problems arose. For example, we soon discovered that many species of fish attempted to eat the more life-like algae and corals and steps had to be taken to toughen them up, thus preventing all but the most persistent and best-equipped of them, such as Triggers and Parrotfish (which will be kept in other displays) from coming to an untimely end through blocked digestive tracts.

The numbers of species (370) and specimens (1460) currently on display have been deliberately depressed in order to minimise the considerable upheaval which inevitably results whilst producing new displays. However, once these are completed we will be able almost to double the number of species and include many unusual or demanding species never previously displayed at Liverpool. By so doing we hope to secure our position at the forefront of public aquarium display management, at least for the forseeable future, if not for the next 130 years!

Acknowledgements

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Vivarium Design for Public Display

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Cotswold Wildlife Park

Displaying reptiles and amphibians for the public is not as easy as creating decorative vivariums, or basic vivariums for the home. When a display is set up for public viewing, there are three main considerations:

1 the animals - it has to offer security, be hygenic, and have the correct furnishings for the species;
2 the keepers - the cage must be easy to service, must not be time consuming, and arranged so that the minimum disturbance is caused to the animal;
3 the public - the cage must be presentable, and be as aesthetically pleasing to the viewer as possible.

When creating a vivarium from scratch, it helps to have some idea of the intended stock, then the cage can be designed accordingly. There will have to be an area for water. This can be in the form of a shallow dish, or a 'sink' type pool, that can be emptied by removing a plug. The 'sink' type pool is easily emptied and filled in a short space of time; it also makes cleaning out reptiles easier as they have a habit of defecating in the water. The pool should have a good drainage system, which can be easily serviced if necessary.

The first step in decorating an empty cage is to paint the walls. Emulsion paint provides an ideal wall covering, and there is a good choice of colours. Soft colours or pastel colours work best as they do not distract the viewer from the animal being exhibited.

The rockwork of the cage has to be planned carefully as this is normally a permanent fixture. Some rockwork can be cemented in position, so as not to cause any injury to the livestock. Local stone can be used to keep the budget down, and can be disguised by mixing garden pond sealer with cement colouring, which also helps protect the rockwork from strong reptile urates.

When making the rockwork, remember to slope it slightly so water will run into the pool when it is washed down. Small crevices and difficult angles cause problems as they are hard to clean.

Having created a base to work on, four other points have to be dealt with: substrate, furnishings, heating and lighting.

1 Substrate is probably one of the most difficult points to get right; there are various options:

1a sand is very fine and difficult to keep clean, when the animal is feeding it can consume small quantities which build up and cause impaction in the stomach;