Intensive Production of Ornamental Fish in Recirculating Aquaculture Systems

Managing Director – National Aquaculture Training Institute Pty Ltd.
Melbourne, Australia.
Email: shanew@natiaquaculture.com
www.natiaquaculture.com.au
Intensive Production of Ornamental fish

• There are around 100’s of millions of ornamental fish sold around the world each year, with more than 80% of these farm produced.

• Successful production of ornamental fish (like all aquaculture ventures) is dependent on a range of factors, the most important being:
  – Climate – are temperatures suitable?
  – Quality and quantity of water available – pH, GH, minerals?
  – Land availability, topography, geology and soil type
  – Infrastructure including access to markets (airports, roads), utilities (electricity, gas etc) – can I access what I need?
  – Availability of skilled and unskilled labour

• So where and how are ornamental fish farmed?
Industry Culture Practices

• Production techniques vary considerably with species, and region – predominantly Asia

• Most production of ornamentals is undertaken in small fertilised ponds (generally less than 50 m²), with larger ponds sometimes being used.
Intensive Production

• Western countries with unsuitable climate, glass aquaria or recirculating systems are used to maintain appropriate environmental conditions.

• This generally means heating and light through artificial means……..EXPENSIVE

• Therefore need for intensive production
  – intensity increases so do yields and a greater financial return per unit volume.
Industry Culture practices

• We are now seeing an emerging trend towards RAS for both ponds and large outdoor tanks throughout Asia
• Due to higher yields and better quality control.
What are RAS?

- Recirculating Aquaculture Systems (RAS) are culture systems that reuse water more than once after some form of treatment.
- Provide the necessary environment for the growth or holding of the culture species.
- The most fundamental problem faced in a recirculating system is the maintenance of suitable water quality and the removal of waste products generated by the culture species in an economical manner.
- Economics very important – many RAS operations have failed due to high capital and operating costs!
The wastes that RAS need to process are: faecal material, ammonia, urea, CO$_2$ and other metabolic wastes).
What are RAS?

• Fish wastes have a negative impact on the water quality, with an increase in:
  – turbidity and suspended solids, increased bacterial load
  – CO₂ levels, ammonia, nitrite, nitrate, and a range of other compounds.

• RAS use a range of physical, chemical and biological processes must be undertaken in order to maintain a suitable environment for the culture species.

• While it is technically possible to design a system where all waste products are removed, such a system would be uneconomical.

• Design and operation of a recirculating system is therefore a trade-off between the level of capital and operating investment, and the level of environmental control needed.
Basic components of RAS

• The most basic requirements of a recirculating system are a holding tank for growing and/or holding fish, some form of filtration to maintain water quality, and a pump to recirculate water.

• An example of a simple recirculating system is a glass aquarium or larger tank with an internal filter

• Commercial RAS can be much more complicated
A highly intensive Food-fish RAS
• The problem with large commercial RAS for ornamentals:
  – Very expensive to construct and operate
  – Stocking density for ornamental fish generally lower than that of food fish, therefore yields are comparatively low affecting economics of production
A more practical RAS for Ornamentals

Water in, flow controlled by taps

Main Grow-out Vats

Gravel bed filter for biological filtration

Pump

Reservoir for collecting filtered water

Effluent water return

Excess water return to filter

Direction of water flow
• RAS for ornamental fish, do not have to be as high tech as for
  food fish
  – Cheap, readily available materials can be used to reduce
    construction costs
  – In tropical climates, operating costs are reduced because
    heating is not needed
  – Major advantage is they allow greater control over the growing
    environment which means faster growth rates and improved
    survival
Holding/culture tanks

- These provide space for the fish to be held in a range of shapes, sizes and construction methods are used.
- However, round tanks are generally used as they are self-cleaning; due to the circular water flow, uneaten food and faeces is pushed to the centre of the tanks where it passes out through a central drainpipe.
Solids filter

• Used to remove solids from tank effluent water – important to maintain low levels of bacteria and water clarity

• Types of solids filters used are:
  – 1. Settlement or sedimentation systems (large scale, pond systems),
  – 2. Mechanical filtration (filter wool, filter mats, screens),
Solids Filters

• Larger pond or recirculating systems may use more than one method of filtration to remove solids from a system
  – eg. screen filters may be used to pre-filter water before passing through a sand filter
• Whatever filter system used – must be washed regularly to remove the debris.
Biological filter

• A biological filter (biofilter) relies on bacteria to convert ammonia into nitrate via a two step process called nitrification.

• The biofilter provides a substrate (gravel, bioballs, sponge etc.) for bacteria to colonise and contact with the water to be processed
  – larger surface area = larger bacterial population = greater the nitrification capacity = better water quality & more fish

• A biofilter is an organism in its own right and needs to be maintained, operators need to consider nutrition, water quality, general environment.
Nitrification

- Nitrification is performed by two groups of aerobic bacteria in a two stage process:
  - *Nitrosomonas spp.* (NH$_4$ to NO$_2$) and
  - *Nitrobacter spp.* & *Nitrospira spp.* (NO$_2$ to NO$_3^-$)

- The nitrification As the process is aerobic, oxygen and continual water movement is essential
Types of Biofilters

- There are many different types and variations of biofilters, can be classified into the following types:
  - Submerged, Trickle, Fluidised bed
Sump/reservoir

- This increases the volume of water in the system – generally point where water is exchanged
- can be used to facilitate water quality control and acts as a collection point for the pump to recirculate water.
Pump & aeration

- Some form of pump is needed to recirculate the water through the culture system and aeration is needed to maintain suitable DO levels.
- In a simple system an airlift pump might provide enough water circulation
- Larger more intensive systems require an electrical pump
- Pump should be a low energy pump – although generally more expensive than a standard pump the operating costs are generally much lower
Additional equipment

- This may include disinfection systems such as Ultra-violet sterilisers and ozonators for disinfection of water to control microorganisms,
Large scale ornamental RAS
Low cost RAS
Management of systems

- Regular water quality checks – especially for new systems
  - pH, general hardness and mineral content
  - nitrogenous wastes – ammonia, nitrite.
  - dissolved oxygen – important to maintain water movement
- Daily/regular siphoning of tanks
- Prophylactic treatment of parasites
- Sequential rearing - minimises biomass and shock-load of systems
- Polyculture - generally stock catfish sp. with other fish in nursery and growout systems
Stocking Densities

- Capital costs vary with the densities of fish and the type of equipment/systems employed in the production of fish.
- Some species require superior water quality conditions to others, and consequently, more expensive filtration equipment is required.
- Stocking density varies with life stage and species of fish. For example, Salmonid smolt are stocked at 1-3kg/m³, grown out at 10-40kg/m³ plus.
- Stocking rates for ornamental are normally much lower 0.1 to 1kg/m³ but intensive systems can get to 3 kg/m³.
- The following table indicates the commonly used culture systems for the various species groups and stocking densities.
<table>
<thead>
<tr>
<th>Species</th>
<th>Commonly used culture systems</th>
<th>Stocking densities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bubble nest breeders</td>
<td>Indoor tanks, ponds for growout</td>
<td>1 to 8 fish per Litre</td>
</tr>
<tr>
<td>Barbs</td>
<td>Indoor tanks, ponds for growout</td>
<td>1 to 10 fish per Litre</td>
</tr>
<tr>
<td>Catfish</td>
<td>Indoor tanks, ponds for growout</td>
<td>0.1 to 2 fish per litre</td>
</tr>
<tr>
<td>Cichlids</td>
<td>Indoor tanks and recirculating systems</td>
<td>0.1 to 2 fish per litre</td>
</tr>
<tr>
<td>Livebearers</td>
<td>Recirculating systems, outdoor tanks and ponds</td>
<td>1 to 20 fish per litre</td>
</tr>
<tr>
<td>Tetras</td>
<td>Indoor tanks, ponds for growout</td>
<td>1 to 20 fish per litre</td>
</tr>
</tbody>
</table>
Feeding

• A good quality artificial pellet is best for use in RAS to help maintain good water quality
  – Protein level is generally 40% or higher
  – Pellets need some form of pigment
  – Should have good vitamin levels (Vitamin B and C important)
  – Supplemental feeding of livefeeds can help improve growth and colour/quality of fish

• Natural pigment blends such as capsicum extract (produces red colours) or marigold extract (produces yellow/orange colours) can also be used. These are mixed at 0.1 - 0.5% into feeds.

• Good colouration is the key to production of high quality fish.
Pelleted Feeds

- **Formulated diets** can be provided in a range of sizes, types and shapes:
  - Pellets, powders (crumbles) or **emulsions** (usually fed to live food species to boost their nutritional value for the culture species) to match the mouth size of the predator species;
  - Discs, hexagons, biscuits, ‘spaghetti’ rings;
  - Floating, slow sinking, sinking;
  - Soft pellets (mimic natural feeds) or hard pellets.
<table>
<thead>
<tr>
<th>Species</th>
<th>Estimated time to produce market sized fish</th>
<th>Expected Survival (Egg to market size)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabantids</td>
<td>12 – 16 weeks</td>
<td>70</td>
<td>High mortality common around day 10-14 when inflating labyrinth organ</td>
</tr>
<tr>
<td>Barbs</td>
<td>14 – 16 weeks</td>
<td>80</td>
<td>Size grading important to prevent aggressive behaviour</td>
</tr>
<tr>
<td>Catfish</td>
<td>16 – 20 weeks</td>
<td>75</td>
<td>Often grown with other species to clean tanks</td>
</tr>
<tr>
<td>Cichlids</td>
<td>16 – 20 weeks</td>
<td>85</td>
<td>Can become aggressive as they age</td>
</tr>
<tr>
<td>Livebearers</td>
<td>14 – 20 weeks</td>
<td>90</td>
<td>Removing females at early age can assist in growing better quality male fish</td>
</tr>
<tr>
<td>Tetras</td>
<td>12 – 20 weeks</td>
<td>70</td>
<td>Fast growing at high density</td>
</tr>
</tbody>
</table>
Stress and disease

• Disease control is essential in RAS
• Stress and disease are inter-related, control of these factors is important for health of fish.
• Stress causes physiological changes that compromise immunity and leaves the fish more susceptible to disease.
• Maintaining optimal conditions and good hygiene is essential.
Disease Detection

• in-house ability to diagnose at least routine disease issues - essential in controlling spread of disease
• Parasites are easily diagnosed with a microscope, recommended to have this
• Diagnosis of bacterial and viral would generally involve sending samples to a laboratory
• Government surveillance
  o Important to be involved
  o Valid health certificate – what is the implication to the export country if fish are found to carry disease in certified disease free fish?
Facility Hygiene

• Good hygiene practices are essential in preventing disease
  – Avoid using equipment from other farms, unless properly cleaned
  – using separate equipment in different parts of the facility also reduces risk
• Staff or visitors can easily spread disease
  o Footbaths and washing hands can reduce this risk
• Always work from clean to dirty
• For farm – cleanest and strictest hygiene should be for hatchery – eggs / larvae most susceptible to disease
  o Should have separate equipment / workforce
Facility Hygiene

- Ensure all equipment is cleaned and disinfected properly after use e.g.
  - Wash thoroughly, remove all mud/dirt/debris first
  - There are many choices of disinfection but the effectiveness can vary
  - Drying and exposure to sunlight
  - Salt, Chlorine based products, Disinfectants, Boiling
Summary

• RAS is relatively new technology for ornamental fish production

• Increased capital and operating costs are off set by better control over production and higher yields

• System design and operation does not need to be complicated

• Hygiene and disease control are important to reduce mortality – once in RAS disease is difficult to eradicate
The end – Thankyou!

• Any questions?

• I can be contacted on email:

  shanew@natiaquaculture.com