ALLIANCE™
(https://www.globalseafood.org)

Responsible Seafood ADVOCATE

Aquafeeds

Feed management for RAS, part 1

1 February 2001

By Phillip G. Lee, Ph.D. and Addison L. Lawrence, Ph.D.

Nutrition and filtration aspects

The filtration system in shrimp recirculating raceways at Harbor Branch Oceanographic Institution (Fort Pierce, Florida, USA) uses a nitrifying biofilter to convert toxic ammonia to non-toxic nitrate. Photo by Darryl E. Jory.

Pond culture is a system in which many environmental subsidies are realized, including sunlight, wind, water and soil, while no such subsidies are available in a recirculating aquaculture system (RAS). In an RAS, all inputs and outputs are more easil quantified, but they also have quantified costs. Even an efficient RAS will appear to have higher operating costs than a traditional pond, but there will also be fewer negative environmental costs.

Feed is the major source of potential pollutants (e.g., NH3/NH4) in recirculating aquaculture systems. Hence, the physical and nutritional qualities of the feed, as well as the methods to present it, have as much to do with culture water and effluent quality as do the animals’ digestive and metabolic abilities.

System inputs and outputs

The quality (palatability, physical characteristics, and nutrient composition) and quantity (feeding rate and frequency) of the feed input affect the wasted feed and excretion, as well as the growth of the cultured animals.

Filtration systems

Feeds for recirculating systems must be formulated to meet all nutritional requirements of the target species.

These same factors also affect the design of components and size of filtration systems, due to their effects on suspended particulates and nitrogen wastes. Feeding frequency and rate, as well as animal biomass and feed protein content, also have an effect on the total ammonia nitrogen (TAN) added to the system. TAN value then determines the size and cost of the filtration components, bead filter, and fluidized sand filter.

For example, using a feed with improved amino acid balance would add to feed costs, but could result in lower protein levels, better assimilation with enhanced growth, and reduced TAN loads to the system. As a result of these factors, a less-expensive filtration system would be required. Hence, the inputs and outputs are inextricably tied together, and one must approach the optimization of an RAS from both the input and output ends.

Cost-effective feed program

The Hazard Analysis and Critical Point (HAACP) concept can be applied directly to the development of aquaculture feeds of any type, but especially high-performance feeds for intensive RAS. The most critical step is to identify the rate-limiting factors that affect the development of a costeffective feed.

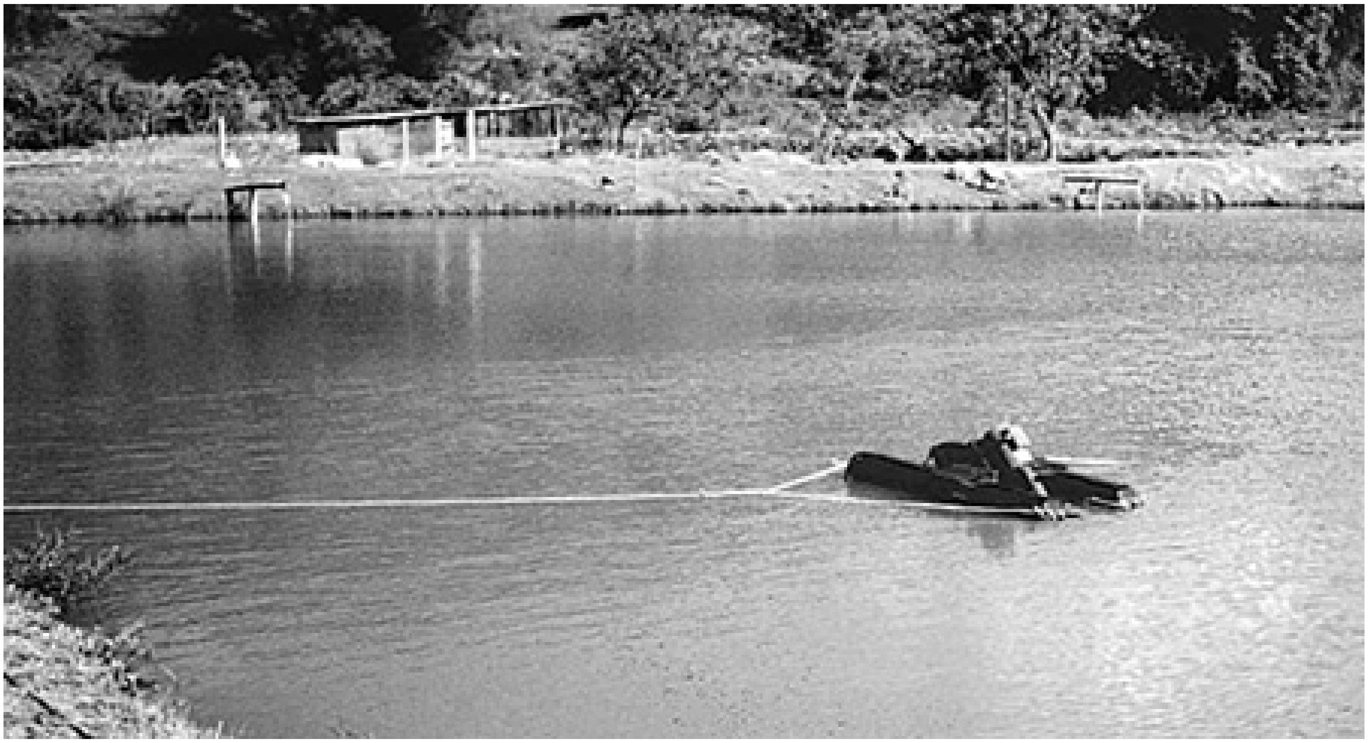
In general, the following five areas are of greatest concern for RAS feeds:

- Understanding the reduction or loss of natural productivity in an RAS versus a pond.
- Application of low-pollution or “environmentally friendly” feeds to RAS.
- Feed management as a tool to improve feed utilization and reduce nutrient loading in RAS.
- Use of feeding attractants, incitants, and stimulants to improve feed utilization in RAS.
- Development of feed additives for improving disease resistance and immune response in RAS.

Reduction or loss of natural productivity

Whatever the species, feed used in an RAS must satisfy all the minimum nutrient requirements for the cultured animals, because there will be little or no natural productivity in the tanks. A lack of vitamin C in feed used for laboratory rearing of shrimp resulted in over 50 percent mortality within three weeks. In contrast, up to 6 metric tons (MT) per hectare per crop with over 80 percent survival and 2 grams per week growth have been produced for shrimp reared in earthen ponds on a feed with no supplemental vitamin C. Moreover, it has been shown that the contribution to nutritional requirements varies for different classes of nutrients. Differences in the nutritional value of natural productivity have been demonstrated to be speciesrelated as well.

Some recent research seems to contradict the need for complete feeds, and suggests that protocols will be developed to create natural productivity in an RAS. While most of the research has been done in small recirculating ponds, there is some indication that large raceway systems could be created in



Open ponds typically have high rates of natural productivity, which is not the case for most RAS. Photo by Darryl E. Jory.

which natural productivity – bacterial as well as algal – can provide significant nutrients to the cultured animals.

In general, these systems have not been operated for long periods in continuous production modes, and the longterm effects on settling particulates and elevated nitrate and phosphorous concentrations have not been evaluated. However, it is clear that bacterial and algal populations can be manipulated in ways that would benefit the operation of an RAS.

Environmentally friendly feeds

The most enigmatic aspect of aquatic nutrition is the fine point at which nutrients become pollutants in terms of inputs as well as outputs. In fact, it is hard for a nutritionist to ever consider carbon, nitrogen and phosphorous as pollutants unless they interfere with normal metabolism. However, engineers and environmental scientists consider these elements to be exactly that when they are suspended or dissolved in effluent.

System designers must create containment or filtration systems to remove or convert these pollutants to lessidentifiable forms, regardless of their impact on the system itself. There are three major classes of nutrients/pollutants from feeds: nitrogenous compounds, dissolved and particulate organic matter, and phosphate.

Nitrogenous excretory products

The production of nitrogenous pollutants reflects the complexity of factors that impact pollution. For aquatic animals, ammonia is the major excretory product. It generally comprises 70 to 80 percent of all nitrogenous catabolites excreted, and is quantified as TAN. The three major groups of factors that affect the amount of ammonia excretion are non-dietary, dietary, and feed management strategies.

Non-dietary factors

Non-dietary factors can be subdivided into two groups: biological or biotic, and abiotic factors. Biotic factors are animal age, size, species (e.g., herbivorous or carnivorous), and others. Abiotic factors are pH, temperature, salinity, ambient ammonia concentrations and others.

Dietary factors

Examples of dietary factors that affect ammonia excretion include factors that affect digestive enzyme activity (e.g., activators and inhibitors), nutrient availability or apparent digestibility, protein-sparing action through optimized feed energy level, and protein quality of essential dietary amino acid profile.

Using a feed low in one of the essential amino acids will result in the under-utilization of the remaining amino acids until the animal satisfies the deficiency. As a result, the excess amino acids will be metabolized for energy, adding TAN to the system with little benefit to growth. And one must realize this additional TAN has capital and operating costs of filtration.

Protein content

Recent laboratory research has shown the protein content of pelleted feeds can be decreased significantly, by optimizing the preceding dietary factors and feed management strategies. This reduction has major environmental ramifications, or in the case of RAS, significant effects on filtration system design. One can estimate the contribution of nitrogen from feeds containing 15 percent protein and 30 percent protein, since FCR, production values, and amount of feed added to pond systems are known.

Results have shown that a 15 percent protein feed contributed 60 percent less dissolved nitrogen than a 30 percent protein feed. Hence, development of environmentally friendly feeds can make a significant impact on the accumulation rate of pollutants in RAS, and consequently on the size, efficiency and operation of filtration systems. In the future, RAS feeds may be formulated in terms of environmental impact rather than least cost, although low-pollution or environmentally friendly feeds may be more expensive than least-cost formulated feeds.

(Editor's Note: This article was originally published in the February 2001 print edition of the Global Aquaculture Advocate*.)*

Authors

PHILLIP G. LEE, PH.D.

Director, National Resource Center for Cephalopods,
University of Texas Medical Branch
Galveston, Texas, USA

pglee@utmb.edu (mailto:pglee@utmb.edu)

ADDISON L. LAWRENCE, PH.D.

Reagent Professor and Project Leader
Texas A&M Shrimp Mariculture Project
Port Aransas, Texas, USA

smpall@yahoo.com (mailto:smpall@yahoo.com)