AQUACULTURE INFORMATION SERIES NO. 7

INTERPRETING THE FEED CONVERSION RATIO

The feed conversion ratio - the FCR - is perhaps the most misused and least understood concept in all of aquaculture. By definition, it is the kg or pounds of food required to increase the biomass in the pond by one kg or pound. Many fish farmers regard it merely as a goal. For example, two fish farmers are discussing mutual concerns. One says, "This past year I fed Alpha brand feed and got a feed conversion of 1.6 and I am not too happy about that." The other replies, "I fed Beta brand feed and got an over-all conversion of 1.2." So, the first fish farmer switches to Beta feed and - guess what? The resultant FCR is 1.7. Now, this chap is quite concerned that the other fellow did not know what he was talking about or he lied about the 1.2 feed conversion. On the surface of it, one might think I have resorted to fictitious humor to make a point. Not in the least. I hear stories such as this quite frequently - especially during continuing education workshops and fish farming trade shows.

In the foregoing example, there is another concerned participant - the representative for Alpha Feeds. This individual has been touting the feed as being thoroughly evaluated and, energywise, can generate a feed conversion of 1.1-1.2. His credibility could be somewhat in question as well as the reliability of the manufacturer.

The main problem in the example is that the one and perhaps both fish farmers as well as the feed company representative, did not fully realize that the feed conversion ratio is more than just feeding fish and measuring the weight gain. There are at many, perhaps more than 20, factors intrinsic to an aquaculture system which can affect the FCR, ten of which will be discussed.

It should be stated that the majority of high-quality, high energy commercial trout and salmon feeds are formulated to provide an FCR of 1.1 to 1.2 if fed properly.

Considering each of the major causal factors affecting the FCR and suggesting remedial measures should be an all-inclusive process. Each should be considered as an individual and also as part of the whole.

1. **Factor**: Overestimating or underestimating the biomass of fish being fed. If the biomass is greater than that being fed for, the weight gain will less than expected and the FCR will be acceptable. On the other hand, if the biomass is less than that being fed for, the weight gain as well as the FCR will be less than expected.

    Solution: The majority of cases of over or underestimating the biomass and/or growth rate stem from not acquiring reliable inventory data. (Cf. Aquaculture Information Series No. 4)

    The inventory process should begin when the pond is stocked. Determine the number per kg and weigh the fish into the pond. At the completion of the pond stocking determine the number per kg again. Also, anesthetize a group of 40 fish for individual lengths and weights. Calculate the mean, median, midrange and standard deviation values for lengths and weights. Also, calculate the mean condition factor. This

will detect size bias from the original population to the new
population. It will also facilitate constructing the daily feeding
regimen.

If performance data are used to their fullest advantage, the FCR's should improve and the production costs reduced accordingly.

2.   **Factor**: Feeding in conditions of less than optimal dissolved oxygen.

     Solution: The partial pressure of dissolved in the water at the outfall of each pond should be not less than 90 mm Hg. For most facilities in this represents 60-65% of saturation (Table 1).

     Table 1:   Dissolved oxygen content (mg/l) of water when the pO_2 is 90 mm Hg

Water Temperature (^0C)	Dissolved Oxygen (mg/l)
0	8.32
1	8.10
2	7.88
3	7.66
4	7.45
5	7.28
6	7.10
7	6.92
8	6.76
9	6.60
10	6.45
11	6.31
12	6.17
13	6.04
14	5.91
15	5.79
16	5.67
17	5.56
18	5.46
19	5.35
20	5.25

3.   **Factor**: Overestimating or underestimating the temperature-dependent growth rate (mm/day length increase)

     Solution: Prepare an annual average weekly - or at least monthly - water temperature chart. Use this in conjunction with either the historical length increase or the length increase from an appropriate table.

4.   **Factor**: Improper calculation of the daily feeding rate.

     Solution: There are two reliable methods of calculating the daily feeding rate for salmonids. One is the daily length increase method of Haskell and the other is the prepared feeding chart provided by feed manufacturers.

The daily increase method uses the temperature-dependent daily length increase, the delta-l, the feed conversion ratio and a length-weight conversion factor. Its main shortcoming is that it presumes a constant condition factor. Thus, the observed length at the end of the feeding period approximates the expected length. However, the observed weight is usually greater than the expected because of the increase in condition factor.

The feeding chart provided by most suppliers contains a built-in feed conversion ratio, which in most cases is greater than what occurs. Thus, the population is very often somewhat overfed, the growth is often what is expected, but the feed conversions are often quite "lousy", to say the least. The Silver Cup Feed Chart does not contain built-in feed conversio ratios. The farmer multiplies the chart value (% body weight to be fed) by the historical feed conversion ratio to get the proper daily feeding rate.

5.   **Factor**: Not weighing the feed accurately

       Solution: Prepare daily feeding amounts for each pond. For hand feeding, weigh the feed into properly labeled containers. For demand feeding, weigh the bag of feed before loading the feeder. For bulk feeding, on at least weekly intervals, calibrate the scale on the feeder.

6.   **Factor**: Poor presentation of the feed

       Solution: For hand feeding, this is a management problem which can be corrected by proper instruction. For demand feeding, adjust the trigger such that the wind cannot activate the feeder. Also, perhaps more feeders per pond are warranted.

7.   **Factor**: Feeding out-of-date feed

       Solution: Do not purchase feed for more than a 3-month period. Beyond that the quality becomes questionable due to the potential for vitamin degradation and fat rancidity. And, do not use last year's starter feeds for this year's fish.

8.   **Factor**: High retention times for ammonia (NH_3) and solids in the ponds.

       Solution: Raceways - especially those arranged for multiple-pass of the water - should have retention times of 20-30 minutes. In circulating ponds, a 95% water replacement time should not exceed 180 minutes. In this case, unlike a raceway, the incoming "new" water mixes with outgoing "old" water, thus providing a dilution effect.

9.   **Factor**: Feeding at less-than-optimal times of day

       Solution: On facilities having significant daily "swings" in water temperature and dissolved oxygen, the optimal times for feeding are in the early morning and at dusk. Heavy noon feedings should be avoided.

10.   **Factor**: Feeding an improper pellet size

       Solution: In populations having a large variation in sizes, the best

pellet size is that which is suited for the smallest fish in the population. In addition, contrary to the recommendations of most feed manufacturers, the largest, optimal pellet size is 1/8" (3 mm). The main reason for this is that there are more pellets available and less dusting than with larger pellets. Thus, more fish get fed and less feed gets wasted.

Summary

The presented 10 fish husbandry factors affecting the feed conversion ratio are the more common. It stands to reason that an improvement in feed efficiency, the reciprocal of feed conversion, would generate an improvement in costs of production. In the following example (Table 2), the cost of production is based upon feed costs being 57% of the production costs and feeding a $0.55/kg formulation.

Table 2: Costs per kg weight gain based upon the
feed conversion ratio.

Feed Conversion Ratio	$/kg weight gain
1.0:1	0.96
1.1:1	1.06
1.2:1	1.15
1.3:1	1.25
1.4:1	1.34
1.5:1	1.44
1.6:1	1.54
1.7:1	1.63
1.8:1	1.73

In this example it should be clear that to optimize the FCR is economically more wise that attempting to economize with labor saving devices.

Finally, the most efficient method to improve over-all production in terms of fish quality and production costs is to utilize the suggested performance indicators (Table 3) to their fullest advantage.

Table 3: Measured and calculated evaluators of growth performance during a
feeding period.
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     1.   Body length (mm) measured at the end of the feeding period
         a. Mean length
         b. Median length
         c. Mid-range length
         d. Standard Deviation
         e. Coefficient of Variation
         f. Mean daily increase (mm) in length since the last inventory
         g. Observed vs expected length increase (%)

     2.   Body weight (g) measured ate the end of the feeding period
         a. Mean body weight
         b. Median body weight
         c. Mid-range body weight
         d. Standard Deviation
         e. Coefficient of Variation
         f. Specific Growth Rate
         g. Observed vs expected weight increase (%)

     3.   Condition Factor
         a. Calculated from inventory data at the end of the feeding period
         b. Change since the last inventory (%)
     4.   Feed Conversion Ratio (FCR)
         a. Calculated from feed fed vs weight gain during the feeding
           period
         b. Observed vs expected FCR

     5.   Headcount
         a. Mortality during the feeding period
         b. Final headcount calculated from beginning headcount minus
           mortality

     6.   Biomass
         a. Calculate total weight gain (kg)
         b. Calculate biomass (kg) at the end of the feeding period.
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