Bioenergetics

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4- Energy Balance in Fish 2

Another Index: Gross Conversion Efficiency (K)

- Referred to as "**K**", often used as an indicator of the bioenergetic physiology of fish under various conditions
- does not refer to an energy "budget"
- measures growth rate (SGR) relative to feed intake (RFI) over similar time periods
- both factors are related to body size:
- SGR = $(\ln Wt_f - \ln Wt_i)/(T_f - T_i) \times 100$
- RFI = $(\text{feed intake})/((0.5)(Wt_f - Wt_i)(T_f - T_i))$

$$K = (SGR/RFI) \times 100$$

Energy and Growth

- Dietary excesses or deficiencies of useful energy can reduce growth rate.
- This is because energy must be used for maintenance and voluntary activity before it is used for growth.
- Dietary protein will be used for energy when the diet is deficient in energy relative to protein.
- When the diet contains excessive energy, feed intake is typically reduced.
- This also reduces intake of protein and other nutrients needed for growth.

Dietary Sources of Energy:
proteins

- Considerable interaction between major nutrient groups as energy sources.
- protein can be used as an energy source.
- not typically used because of cost and use for protein synthesis (growth).
- optimal ratio of protein : energy is around 22 mg PRO/kJ (45 kJ/g PRO; old info).
- species variation: 17 for tilapia, 29 for catfish, (Watanabe, et al., 2001);
- digestibility variation
- temperature variation

Energy and Growth

- Consumption of diets with low protein to energy ratios can lead to fat deposition (fatty acid synthetase)
- this is undesirable in food fish because it reduces the dress-out yield and shortens shelf life
- undesirable in shrimp due to build-up in hepato-pancreas (midgut), ultimately affecting cooking
- low protein:energy diets can be useful for maturation animals, hatchery animals raised for release

Energy Requirments of Fish

- Determining the energy requirement of fish has been a difficult task, slow in coming
- most research has been devoted to identifying protein requirements, major minerals and vitamins
- in the past, feeds were formulated letting energy values “float”
- excess or deficiency of nutritional energy does not often lead to poor health

Energy Requirements of Fish

- Further, if feeds are formulated with practical feedstuffs (ingredients), their energy levels are not likely to be off
- it is really a matter of cost: protein is the most expensive component of the diet, COH sources are cheap, why use protein as an energy source?
- In terrestrials, feed is consumed to meet energy requirements
- thus, as energy level of the feed goes up, protein level is also designed to go up

Energy Requirements of Fish

- This is because terrestrial animals are typically fed on an ***ad libitum*** basis
- fish, on the other hand, aren't fed this way
- they are fed on a feed allowance basis (we estimate feed fed)
- various studies have shown that the digestible energy (DE) requirement for channel catfish and carp was around 8.3-9.7 kcal DE/100 g fish/day
- in terms of age, dietary level of DE and protein typically drop with age

Protein, DE Requirements of Channel Catfish, by Age

ble 2.1. PROTEIN AND DIGESTIBLE ENERGY (DE) REQUIREMENTS BY VARIOUS ES OF CHANNEL CATFISH FOR MAXIMUM PROTEIN SYNTHESIS

h size (g)	Protein (g/100 g fish/day)	DE (kcal/100 g fish/day)	DE/Protein ratio (kcal/g)
3	1.64	16.8	10.2
10	1.11	11.4	10.3
56	0.79	9.0	11.4
198	0.52	6.1	11.7
266	0.43	5.0	11.6

urce: Mangalik (1986).

From Lovell, 1989

Energy Requirements of Fish

- DE and protein requirements typically follow each other, so the DE:P ratio (kcal/g) is fairly similar with age (if anything, a small increase)
- this is partially due to the fact that fish grow faster when young (higher tissue turnover rate, demand for protein)
- however, the influence of energy is stronger than that of protein relative to growth (Cuzon and Guillaume, 1997)
- energy levels in crustacean diets usually range similar to those of fish

Energy Requirements of Crustacea

- The objective in formulating diets for most aquatic species is the same: finding a cheap energy source that is digestible and will spare protein
- for shrimp, glucose is not acceptable in that it causes high blood sugar levels, poor growth, poor survival
- complex dietary COH's prove better
- COH typically spares protein for growth
- increase in dietary energy tends to increase performance when a diet low in protein is fed