Bioenergetics

PhD. student
Dr. A. Y. Al-Dubakel.

6- What drives growth 1
7- The nature of growth in fish

What drives growth

TOTAL ENERGY NEEDS

=

Gross Energy Content of Feed

X

Digestive Efficiency

=

TOTAL FEED NEEDS

What drives growth

Modeling requirements for protein...

Fish weight (g)	10	100	1000
Growth (g/d)	0.9[illegible]	2.50	6.52
Energy requirement			
Metabolic BW (kg)^0.8	0.03	0.16	1.00
DEmaint (kJ/fish/d)	1.43	9.02	56.91
Energy gain (kJ/fish/d)	4.37	15.84	57.35
DEgrowth (kJ/fish/d)	6.43	23.29	84.33
DEtotal (kJ/fish/d)	7.86	32.31	141.24
Protein requirement			
Protein BW (kg)^0.70	0.040	0.200	1.000
DNmaint (g/fish/d)	0.02	0.12	0.60
Protein gain (g/fish/d)	0.16	0.42	1.09
DNgrowth (g/fish/d)	0.32	0.84	2.18
DNtotal (g/fish/d)	0.35	0.96	2.78

*Efficiency of 50%

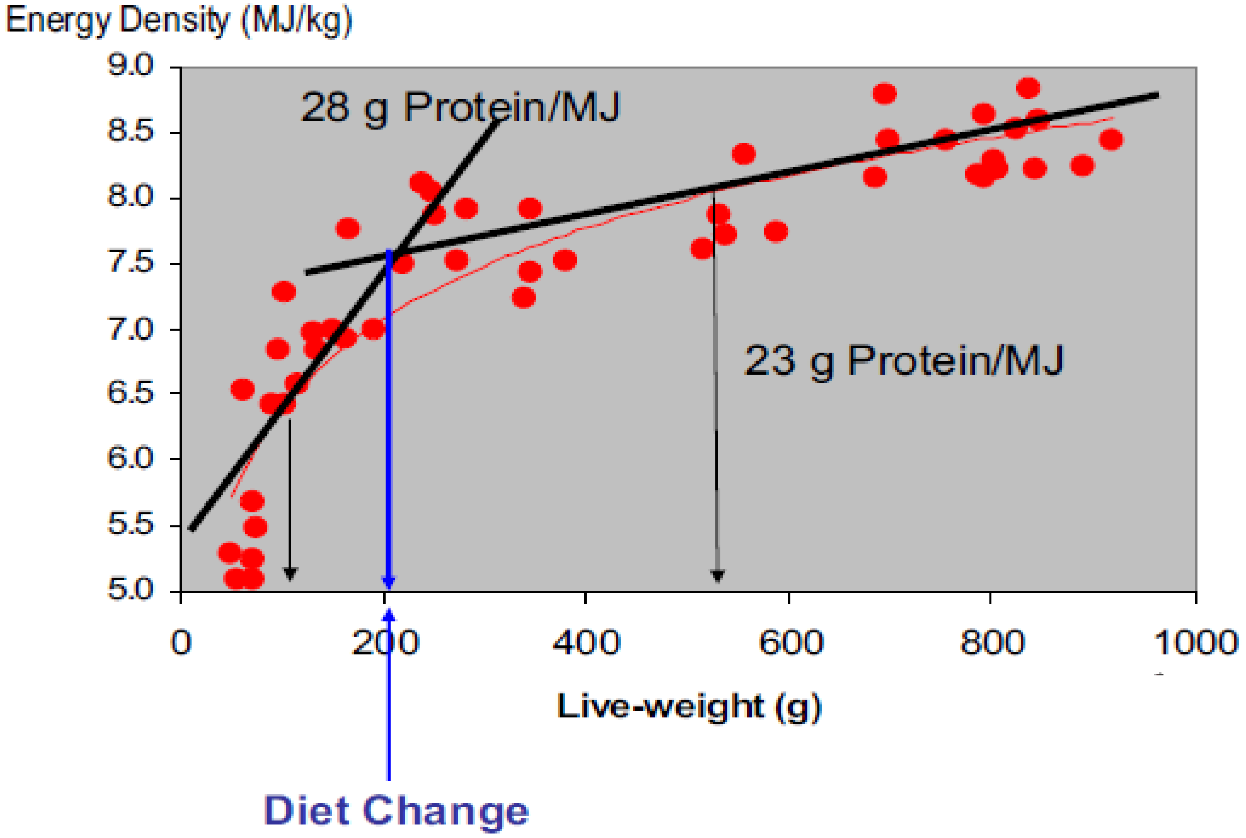
What drives growth

Modeling requirements for nutrients...

Fish weight (g)	10	50	100	500	1000	2000
Protein (g/MJ)	38	31	28	23	21	19
Lysine (g/MJ)	1.53	1.26	1.15	0.93	0.85	0.77

What drives growth

Diet Assignment by Fish Size



What drives growth

- By using bio-energetic approaches, the required protein and energy demands for any particular species can be estimated, for any point of its production cycle.
- Based on dietary energy demands the requirements for protein and even specific amino acids can be estimated.
- The greatest strength in modeling approaches to nutritional research is in refining multiple hypotheses to further test in practical experimentation.

The nature of growth in fish

The generalized growth pattern in fish is different from that found in higher vertebrates.
In mammals and birds, subject to individual variability, there is a characteristic rate of growth and ontogeny for each species and a characteristic adult size, which normally coincides with sexual maturation .In contrast, organismic growth in fish is demonstrably plastic in nature. Growth in fish is essentially indeterminate, to the extent that it is difficult to establish the ultimate maximum body size of individuals of a particular species. Fish appear to continue growing for as long as they live. Various ecological and evolutionary theories to account for the difference in growth pattern and intraspecific growth variation between fish and higher vertebrates are discussed by Weatherley & Gill (1987)

The nature of growth in fish

The final adult body size so characteristic of sexual maturity in higher vertebrates is not usually observed in fish. In fish, maturity appears to depend on the attainment of a critical body size; the age at which this critical size is reached will depend on somatic growth rate. In Arctic charr *(Salvelinus alpinus)* for example, wild populations of fish typically mature at an age of 4-7 years, but under farming conditions, charr normally mature at an age of 1-3 years . It was concluded that fish generally mature at the earliest age at which they are developmentally able to do so. A positive correlation between growth rate and age of maturity has been shown for almost every salmonid species ,and this may depend on the trophic opportunities at critical times of the year when they are sensitive to the triggering of the maturation process.

The nature of growth in fish

In salmonids, initiation of maturation is known to be regulated via photostimulation of their gonadotrophic hormone systems. This occurs in nature during spring when daylength is increasing, but the reproductive cycle can be manipulated by artificially controlling the photoperiod. Despite the indeterminate nature of growth in fish, it is clear that fish, as in most if not all animals, have genetically-determined maximal growth rates and body size to which they tend. Fishes range in size from one of the smallest so-far described, the goby *(Trimmatom nanus)* of the Chagos Archipelago, where mature females reach only 8-10 mm in length, to the giant whale shark *(Rhincodon typus),* which attains a length estimated to reach about 18 m .

The nature of growth in fish

Fish are amongst the most efficient of animals in converting food into body tissue. The daily energy requirement for maintenance in thermally acclimated fish at near their optimum temperature (for growth) ranges from 40 to 100 kJ/kg body weight$^{0.75-0.85}$.This energy requirement is about 10-20% that of homeotherms of the same body weight. The dietary protein intake required per unit body-weight gain in fish does not differ greatly from that of other terrestrial vertebrates. However, the energy required per unit protein gain is between 2 and 20 fold lower in fish than in chickens, pigs and cattle.

There are several factors which contribute to the low energy requirement of fish. First, the metabolic costs of locomotion are generally considerably lower than those in land animals, and fish do not need the large antigravitational muscles of land animals.

The nature of growth in fish

Second, unlike mammals and birds, fish are poikilotherms and do not expend metabolic energy in thermoregulation. Finally, the excretion of nitrogenous waste products resulting from protein catabolism is an energy-costly process in terrestrial animals. NH_3, derived principally from the deamination and transamination of amino acids, is toxic in its unionized form and must be rapidly excreted or converted to a less toxic form. Mammals and birds convert NH_3 to urea or uric acid at considerable energy cost. Teleost fish are ammoniotelic, but they excrete approximately 60-90% of their waste N as NH_3/NH_4^+ by passive diffusion down a concentration gradient through the gills into the water, with little or no energy cost. Consequently, fish derive more metabolizable energy from catabolism of proteins than do terrestrial animals.

The nature of growth in fish

In teleosts, excretion of NH_3 is dependent largely on the dietary N intake, but temperature and the weight of the fish are also contributing factors. For rainbow trout *(Oncorhynchus mykiss),* The average NH3 excretion rate over 20-24 h following the ingestion of a single meal of known total N content by:

$$E = 13.274k^{7\cdot677(R) + 0\cdot016(T)} . W^{0\cdot616}$$

where, E is NH_3 excretion rate $(\mu g/h)$, k is 10, R is N intake (g/d), T is temperature (o), and W is live fish weight (g).

The nature of growth in fish

In salmonids, NH_3 excretion typically peaks between 4 and 8 h following a meal at temperatures of about 10-15^o.

The timing of this peak is directly related to temperature, reflecting temperature-dependent digestion processes such as gut evacuation rates .Endogenous N excretion derived from the turnover of tissue proteins ranges from 30 to 300 mg N/kg per d, depending on species, fish size, temperature, and previous nutritional history.