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Effect of Different Environmental Factors on Fish Appetite

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Introduction

Aquaculture is one of the fastest-growing food production sectors. Fish feed and feeding is an important component of aquaculture as feed accounts for approximately sixty percent of the variable production cost in intensive aquaculture. In fish farming, the aim is to get maximum growth of fish at a minimum cost. Thus, Understanding and controlling fish's feeding behavior is a basic requirement for successful rearing. Feed represents a large part of the money spent on intensive rearing, so the rational management of feeding is essential to ensure profitability (Goddard, 1996). Various studies have treated the importance of physiological and metabolic mechanisms in controlling appetite in fish. The dynamics of gastric evacuation have been studied, particularly their role in re-establishing appetite, and all these studies have pointed to the capital role of temperature. Fish feeding activity is subject to circadian rhythm (Sundararaj et al., 1982). Photoperiod constitutes a key element in this rhythm. In intensive rearing conditions, however, rhythms are disrupted to some extent by the work around the fish farm and by various stress factors, such as high densities.

Hormonal Regulation of Apepite in Fish

Food intake is regulated by hormones produced by both brain and peripheral tissues that affect feeding centres in the brain to either stimulate or inhibit feeding (Volkoff, 2009). Orexin and CART (cocaine and amphetamine regulated transcript) are key factors produced mainly by the brain that stimulate and inhibit the desire to eat in fish, respectively. CCK (cholecystokinin) and PYY (peptide YY), which act as satiety factors, and ghrelin, which stimulates appetite, are produced mainly by the gastrointestinal tract (GIT).In all vertebrates, feeding is regulated by key appetite-stimulating (orexigenic) or appetite-inhibiting (anorexigenic) endocrine factors, which act on feeding centers in the brain to mediate the

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regulation of short-term and long-term dietary intakes. These endocrine factors originate not only from the central nervous system (CNS), but also from peripheral organs such as the gastrointestinal (GI) tract, pancreas, liver and adipose tissue. Peripheral hormones convey information to central feeding centres either via the vagus nerve or by crossing the blood-brain barrier and acting directly through central receptors (Brightman and Broadwell, 1976).

The Central peptides which control the apetite are:

- **Orexigenic**:It includes neuropeptide Y (NPY), orexins & galanin
- **Anorexigenic**: The inhibiting factors are cocaine- and amphetamine-regulated transcript (CART) and corticotropin-releasing hormone (CRH)
- **Peripheral signals:** The satiety factors cholecystokinin (CCK), gastrin releasing peptide (GRP)/bombesin-like peptides & amylin & only one known circulating appetite stimulant, ghrelin, which is produced by the stomach.

Effect of Environmental Factors on Fish Apetite

Different environmental factors affecting appetite of fish are mainly the water quality parameters, photoperiod and seasonal changes affecting the maturation and spawning in fishes.

1. **Temperature**

Being ectothermic, fish are very sensitive to changes in water temperature. Increase in water temperatures increase oxygen consumption and metabolic rates and thus energy requirements (Sandblom *et al.*, 2014). Although changes are species-specific, in fish, food intake usually increases with moderate temperature. A few studies have reported that these changes in feeding are correlated with changes in some appetite-regulating endocrine factors e.g., changes in plasma concentrations of ghrelin and leptin in Atlantic salmon Salmo salar; CART expression in Atlantic cod Gadus morhua (Kehoe and Volkoff, 2008).

The prevailing water temperature is one of the most important variables affecting vital functions in fish. Growth rate, feed intake, feed conversion efficiency (FCE), and stomach evacuation rate are significantly influenced by temperature. There is a positive relationship between feed consumption and water temperature. There is a dramatic increase in feed intake with increasing temperature (Koskela et al., 1997). Although, increasing water temperature above the optimal temperature of a species results in the reduction in feeding behaviour and high variation of temperature within a shortperiod, however, reduce appetite. It is therefore recommended to halt feeding at temperatures beyond optimum levels as warm water fish perform better at temperatures between 25 – 32 °C.

2. **Dissolved Oxygen**

Dissolved oxygen (DO) is the single most important and critical water quality parameter for fish in pond culture systems. Reduced oxygen concentration is considered as a foremost factor affecting feed intake in cultured fish species. It is common to see fish at the water surface gasping for oxygen in water of poor quality as a last resort for gaseous exchange. Usually, lethargy and fish going off feed may be an indicator of poor oxygen content in the culture system. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth, vulnerability to diseases and parasitic infestation as well as mortality. Fastest growth rate in occurs with high DO and the slowest growth in the low DO. Dissolved Oxygen level greater than 5 ppm is essential to support good fish production. Dissolved Oxygen level greater than 5 ppm is essential to support good fish production. At dissolved oxygen levels between 3.0 – 5.0 ppm feeding should be slashed when DO level is between 3.0-5.0ppm and stopped when below 3.0 ppm.

3. **Ammonia**

Ammonia Of the two form of ammonia (unionized ammonia and ionized ammonia) that is present in water, the unionized ammonia is most toxic to fish and other aquatic organisms. Ammonia concentrations in water have a marked and predictable effect on the feed intake. Elevated ammonia level in water leads to a diminution in feed intake in cultured fishes, under otherwise identical environmental condition. The level of ammonia in a culture system is dependent on temperature, feeding type, feeding rate and the size of the fish. Ammonia concentration in the water starts to increase few hours after feeding. but peaks at 4 – 6 hours. High temperature as well as increased pH levels favours the unionized form of ammonia in a fish production system. If more feed is given without considering the apetite of fish then the waste feed will again contribute in raising the pH of water.

4. **pH**

Increase in CO2 accompanied by low pH reduce food intake and feeding behaviour in several fish. Exposure to elevated CO2 can also impair swimming performance as they can impair visual and olfactory functions in teleost fish and might result in decreases in feeding and escape behaviors. In addition, low pH waters can shift fish taste preferences, perhaps by modifying palatability of different food. Species-specific differences in response have been shown among fish as some fish are more resilient to changes in CO2 and pH. High CO2 levels also affects digestive processes. Fish held at lower pHs had higher brain expression of CART1 and CART2 and higher intestinal expressions of CCK and PYY compared to fish held at pH 7.5, which suggests that low pHs might affect feeding behavior in part via increases in central and peripheral anorexigenic peptides (N. Nadermann, et al.,2019).

5. **Pollutants & stress**

Taste receptors of the fish are always exposed to the water and make them susceptible to the pollutant present in the water. Pollutants can also affect the taste receptacle by either destroying the taste bud and/or reduction in the sensitivity of the taste stimuli. stress can be considered as a biological response that drives physiological systems outside their normal range. Fishes typically respond to short-term or acute stress by mechanisms designed to maintain physiological function; compensating for the stress for a while, and then when the stress is resolved the fish can return to its previous physiological state. Also, stress due either to excessive handling, diseases and social interactions do affect fish's appetite. Interest for food reduces when fish are subjected to stress.

6. **Photoperiod or Day length**

It has been found in some studies that day length is the most important environmental factor acting on appetite of Atlantic salmon and reductions in day length are correlated with reductions in feeding. Similarly, appetite of turbot seems to be markedly influenced by day length; feeding was best on days when the photoperiod was longer than 15 h. It has been reported that growth in juvenile turbot is the faster in fish exposed to continuous light, but this growth accelerating effect was maintained only over a limited period. Whether temperature or day length has the major influence on appetite depends on both the time of year and the age of the fish.

7. **Spawning Season**

Links between energy homeostasis and reproduction have been demonstrated in several vertebrates (Mircea *et al.*, 2007) where animals usually reduce their food intake during the breeding season. Quantitative gender-specific differences have also been reported for several appetite regulators, including for tachykinins (Peyon*et al*., 2000), galanin (Rao *et al.*, 1996), and ghrelin. These data suggest that interactions might occur between appetite related and reproductive hormones. An interaction has recently been proposed in goldfish, between orexin and gonadotropin-releasing hormone (form 2, GnRH2), a reproductive hormone that has been shown to stimulate spawning behaviour in goldfish (Volkoff and Peter, 1999). In female goldfish, central injections of orexin at doses that stimulate feeding inhibit spawning behaviour, and this inhibition is mediated by a decrease in the brain mRNA expression of cGnRH.

8. Turbidity

A decrease in feeding rates in high turbidity has been reported for some carnivorous visual predatory fish species. However, in the planktivorous fish turbidity does not affect food consumption. It is likely that goldfish use senses other than vision to find food. Indeed, as opposed to carnivorous predator fish, which use almost solely vision to capture their preys, omnivorous fish such as catfish and carp *Cyprinus carpio* and goldfish, in addition to vision, use the taste and olfactory systems to excite and discriminate chemical stimuli. In addition, carp and goldfish have taste-controlled reflex snapping/biting mechanisms and use oral food sorting to separate edible from inedible object. In high turbidity, fishes have more difficulty finding food and spend more time and energy looking for food.

9. Turbulence

Fish submitted to turbulence (waves) display higher food intake than control fish (N. Nadermann, et al. 2019). In southern catfish *Silurusmeridionalis* (Li et al., 2016) and qingbo*Spinibarbus sinensis*, long-term mild exercise increases food intake and in juvenile Chinese sturgeon, *Acipenser sinensis*, food consumption increases as water current speed increases (Gu et al., 2017). Similarly, in larval seahorses *Hippocampus erectus*, fish submitted to low continuous currents have similar but slightly higher food intake than control fish (Qin et al., 2014). This increase in feeding is likely needed to counterbalance the energy expenditure needed to sustain swimming efforts. However, in Pacific bluefin tuna *Thunnus orientalis*, feeding rates decrease at higher turbulence levels (Kato *et al., 2008*), and in larval Atlantic cod, prey hunting success and thus feeding rates decreases as turbulence increases. These differences are likely due to the differences in habitats that exist among species, as some fish use high speed swimming in fast flowing water (e.g., tuna, salmon, cod), whereas others (e.g., cyprinids such as goldfish, carp as well as catfish) live in relatively still waters and cannot handle high currents. Turbulence decreases the mRNA expression levels of

CART1 and CART2 in the hypothalamus and both CCK and PYY in the intestine but did not affect brain orexin or irisin and intestine ghrelin. The decrease in the expression of central and peripheral appetite-inhibiting factors might indicate that the increase in feeding is mediated by partial inhibition of anorexigenic systems. The increasing frequency and intensity of storms and cyclones due to climate changes might lead to higher winds and larger oceanic tides, and disturbances of currents in oceans, rivers and freshwater bodies (e.g., lakes and ponds) (Johansen *et al.*, 2015). These water movements might affect foraging and feeding activity in fish. Turbulent waters have been shown to increase energy intake in fish, as animals need more muscle work to keep their balance and to sustain swimming efforts.

Conclusion

Different sizes and species of fish and the diverse environmental and management conditions used in aquaculture require different feeding strategies. Feed allowance and frequency of feeding are important for growth rate and feed efficiency. It must be kept in mind that these effects appear to be largely species-specific and depend on culture conditions. The environmental factors should be taken into account before feeding the fishes. The farmers or farm manager should know when to feed the fish and when to stop feeding. Proper management of feeding not only saves the feed from wastage, it also saves the water from being deteriorated due to feed waste and increases the profitability of the business.

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