Digestion, assimilation and nutrient excretion

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***Abstract*—Fish feed supplies nutrients to an aquaponic system, but its nutrient content cannot be equated with either fish growth or dissolved nutrients in water. This paper explains how digestion, assimilation and nutrient excretion distinguish the principal routes by which feed-derived nutrients are retained or released. Aquaponic reviews describe a division among nutrients retained in fish biomass, soluble excretions, faeces and uneaten feed. They identify digestibility as relevant to this division and feed protein metabolism as a pathway to ammonia excretion. Nutrients released in soluble form also differ from those held in solids, which require further breakdown before becoming available in solution. A carp trial reports differences in feed conversion, growth and water ammonium and nitrate associated with stocking density, but does not measure the physiological partition responsible for those outcomes. Together, the evidence supports a causal explanation of nutrient destinations, not a universal numerical allocation of feed among them. Interpreting nutrient formation therefore requires separate consideration of feed consumption, fish retention, soluble excretion and solid material. Quantification for a particular system would require measurements that connect those destinations rather than inferring them from water concentration or fish growth alone.**

I. Introduction

The first question in explaining nutrient formation from fish feed is where its nutrients go. Aquaponic nutrient-cycling evidence distinguishes nutrients retained in fish biomass from soluble excretions, faeces and uneaten feed [1]. Those destinations cannot be collapsed into a single quantity called waste: retained nutrients contribute to the fish, soluble releases enter the surrounding water in one form, and nutrients in solids may require further breakdown before becoming available in solution [1]. The distinction matters because supplying a nutrient in feed does not establish how much the fish used or how much became available outside it. A sound account begins with the alternative routes, then explains the processes that allocate nutrients among them.

Digestion and assimilation connect consumed feed with nutrient use by the fish. A review of fish diets in aquaponics describes feed nutrients being digested and assimilated or released in waste, and identifies feed protein metabolism as a pathway to ammonia excretion [2]. Excretion is consequently related to dietary processing, but cannot be treated as another name for all feed not retained in biomass: uneaten feed has not passed through the fish, and faecal solids differ from soluble excretions [1]. The central argument of this paper is that these distinctions explain the scientific meaning of digestion, assimilation and nutrient excretion more reliably than an assumption that fish feed becomes dissolved nutrient in a single step.

System-level observations illustrate why the distinction is necessary without resolving every route. In an aquaponic carp trial, feed conversion and fish growth differed across stocking conditions, as did measured water ammonium and nitrate [3]. The trial provides applied evidence about production and water conditions, but did not directly measure digestion, assimilation or the partition of nutrient excretion. It would therefore be unsound to assign the observed water differences to a particular physiological pathway. This paper defines the relevant nutrient destinations, explains their relationships, examines what the trial adds to the reviews, and identifies the measurements needed for a quantitative account.

II. Background and Scope

The available reviews address connected but distinct parts of nutrient fate. The fish-diet account describes nutrients being digested and assimilated, retained by fish or released, and connects protein metabolism with ammonia excretion [2]. The aquaponic nutrient-cycling account describes the resulting destinations more broadly, including fish biomass, soluble excretions, faeces and feed that remains uneaten [1]. Combining these accounts makes it possible to distinguish an event within the fish from a nutrient stream subsequently found outside it. It also prevents uneaten feed from being classified as a product of fish digestion. Neither review implies that every diet or set of conditions produces the same division among those destinations.

The carp trial asks a different kind of question: how fish performance and water conditions vary in a particular aquaponic comparison. It reports feed conversion, growth, ammonium and nitrate under differing stocking densities [3]. Such observations are relevant to nutrient formation because they place fish production alongside nutrient concentrations. They are not, however, direct measurements of the intervening partition between retained nutrients and the different released forms. The scope here is accordingly a causal explanation of what digestion, assimilation and excretion mean and how they relate to those outcomes. It is not an estimate of pathway shares derived from a trial that did not measure them [1], [2], [3].

III. Core Concepts and Mechanisms

Digestion applies to feed that the fish eats, not to all feed supplied to an aquaponic system. Its importance lies partly in digestibility: the nutrient-cycling review identifies digestibility as relevant to whether feed-derived nutrients are retained or pass into waste [1]. Material left uneaten enters a separate

stream without first undergoing fish digestion. This difference is essential when reasoning from feeding to nutrient formation. A feed input records what was supplied, whereas the amount processed by fish depends at least on what was consumed and digested. Treating those quantities as identical would obscure an alternative source of solid material and overstate what feed supply alone reveals about fish physiology.

Assimilation concerns the fish's use of nutrients obtained from digested feed, and must be distinguished from digestion itself. The fish-diet review describes both assimilation and the subsequent division between nutrient retention and release [2]. Retention in fish biomass is also identified as a destination in the nutrient-cycling review [1]. These accounts explain why feed consumption cannot be taken as a measure of retained nutrients: not everything supplied is eaten, and not everything associated with feeding becomes fish biomass. Conversely, growth is a production outcome rather than a complete accounting of nutrients that were digested, used or released. The distinctions clarify what each observation can establish without imposing an unsupported numerical partition.

Nutrient excretion concerns release associated with the fish's processing and use of nutrients. In particular, feed protein metabolism is identified as a route to ammonia excretion [2]. The aquaponic nutrient-cycling account distinguishes soluble excretion from nutrients remaining in faeces and other solids, whose availability depends on further breakdown [1]. These are not merely alternative names for the same waste. They indicate different initial forms of nutrient release and different steps before nutrients held in solids can become available in solution. The evidence supports the existence and significance of these pathways, but not a fixed rate of ammonia excretion or solid nutrient release for every fish and diet.

IV. Evidence Synthesis

Viewed together, the reviews establish a sequence with several possible destinations rather than a direct conversion from feed to dissolved nutrient. Dietary processing helps determine what the fish can assimilate and retain, while nutrient-cycling evidence distinguishes retained biomass from soluble excretions, faeces and uneaten feed [1], [2]. Each requested concept occupies a different position in this sequence. Digestion concerns processing of consumed feed, assimilation concerns its use, and excretion concerns one form of release after that use. Uneaten feed does not belong to the same physiological pathway. This synthesis is important because an external nutrient input can have more than one origin even when all of it ultimately derives from supplied feed.

A second distinction concerns nutrient form at the point of release. The fish-diet review links protein metabolism to ammonia excretion [2]; the nutrient-cycling review distinguishes soluble outputs from nutrients in solid material that require further breakdown [1]. The connection between these findings explains why the total amount of waste cannot simply be read as an immediately available dissolved nutrient supply. One route already yields a soluble excretion, while another leaves nutrients in material subject to an additional transformation. The reviews also caution against assuming invariant rates across contexts [1]. Their strongest shared contribution is therefore the arrangement of pathways and forms, rather than a universal conversion factor.

The carp trial provides a useful test of how far that explanatory sequence can be taken from observed outcomes. Its fish growth and feed conversion results, together with measured ammonium and nitrate differences across stocking conditions, demonstrate that fish and water outcomes can vary together [3]. Yet the trial does not measure how much feed nutrient was digested, assimilated, retained or excreted. The reviews explain why those unobserved distinctions matter [1], [2], but cannot transform the trial's water concentrations into measurements of them. The combined evidence warrants a qualitative account of possible routes; it does not identify which route accounts for a particular difference observed in that trial.

V. Practical Implications and Limitations

A feed quantity should be interpreted as an input to several potential nutrient routes, not as an estimate of soluble excretion. Some supplied feed may remain uneaten; nutrients in consumed feed may be retained in fish or released in soluble and solid forms [1], [2]. This distinction places a clear limit on what can be inferred from feeding alone. Even if the amount supplied is known, the available causal account does not establish how it was divided in a specific system. A quantitative explanation would require observations that distinguish feed consumption, fish retention and forms of release, rather than allocating all unaccounted feed to one presumed waste pathway.

Fish performance measures need the same restraint. The carp trial reports differences in growth and feed conversion under its tested stocking conditions [3]. Those results describe production outcomes, but neither outcome directly measures assimilation or nutrient excretion. The reviews establish that nutrients can be retained or released through distinguishable streams [1], [2]; the trial does not determine the size of each stream. A change in growth therefore should not be converted into a claimed change in excretion without additional evidence. The practical implication is interpretive: growth and feed conversion can frame questions about nutrient fate, but they cannot answer those questions independently.

Water ammonium and nitrate likewise need to be kept separate from claims about an individual fish's physiological output. The trial measured these concentrations, but did not directly resolve the mechanisms or partition of nutrient excretion [3]. The reviews identify a pathway from feed protein metabolism to ammonia excretion and distinguish soluble release from nutrients in solids that require further breakdown [1], [2]. Consequently, an observed water concentration cannot by itself quantify the amount excreted through either route. The remaining limitation is not uncertainty about whether distinct routes exist; it is the absence of linked measurements needed to assign their relative contributions under the particular conditions being examined.

VI. Conclusion

Digestion, assimilation and nutrient excretion answer different questions about feed nutrient fate. Digestion concerns the processing of consumed feed, assimilation concerns the fish's use of nutrients, and excretion concerns nutrients released after dietary processing [2]. Feed nutrients may instead be retained in fish biomass, leave in faecal solids or remain in uneaten feed, while soluble excretions differ from solids that require further breakdown [1]. The principal causal lesson is therefore a distinction among routes and forms, not an assumption that the nutrient content of feed becomes immediately available in water.

The carp trial adds applied observations of fish performance and water ammonium and nitrate, but does not quantify the physiological routes connecting them [3]. A stronger system-specific explanation would measure consumption, retained nutrients and released forms together, allowing the pathways described in the aquaponic reviews to be assessed without inferring them solely from growth or water concentrations [1], [2]. Until those links are measured, the evidence supports a clear qualitative account of digestion, assimilation and excretion, while the proportions following each route must remain unassigned.

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References

[1] M. Eck, O. Körner, and M. H. Jijakli, "Nutrient cycling in aquaponics systems," *Aquaponics Food Production Systems (Springer, edited by S. Goddek et al.)*, 2019.

[2] L. Robaina, J. Pirhonen, E. Mente, J. Sánchez, and N. Goosen, "Fish diets in aquaponics," *Aquaponics Food Production Systems (Springer, edited by S. Goddek et al.)*, 2019.

[3] C. Maucieri, C. Nicoletto, G. Zanin, M. Birolo, A. Trocino, P. Sambo, M. Borin, and G. Xiccato, "Effect of stocking density of fish on water quality and growth performance of european carp and leafy vegetables in a low-tech aquaponic system," *PLOS ONE*, 2019.