

# Crop production in a loach (*Misgurnus anguillicandatus*) – lettuce (*Lactuca saliva*) raft aquaponics system

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## Highlights:

- Aquaponics, as it rallies agriculture with fish farming , make good use of water and reduce the use of arable land . It could contribute to the adaptation to climate change and to zero hunger SDGs
- Loaches are high value commodities in Japan and other North East Asian countries while lettuce is a leafy green highly adaptable for aquaponics
- The final outputs were marketable size loaches of  $4.75 \pm 2.25$  g corresponding to  $8.34 \pm 2.7$  cm and an average fresh shoot of lettuce of  $154.75 \pm 37.56$  g.
- Despite producing satisfying amount of total ammonia and phosphorus, the raft system was highly lacking potassium

## Introduction:

Background:

The current world population of 7.6 billion is expected to reach 9.8 billion in 2050 according to United Nations report (2017). Therefore, relying on only exploitation of renewable natural resources cannot remain as sustainable anymore compared to 50-100 years ago. In the view of food security, agriculture, livestock and fish farming are being implemented for food production. However, global warming has threatened the access to water and arable land which are both fundamental to agriculture and aquaculture. Hence, there is a significant interest in finding alternatives to conventional livelihood systems.

Objectives:

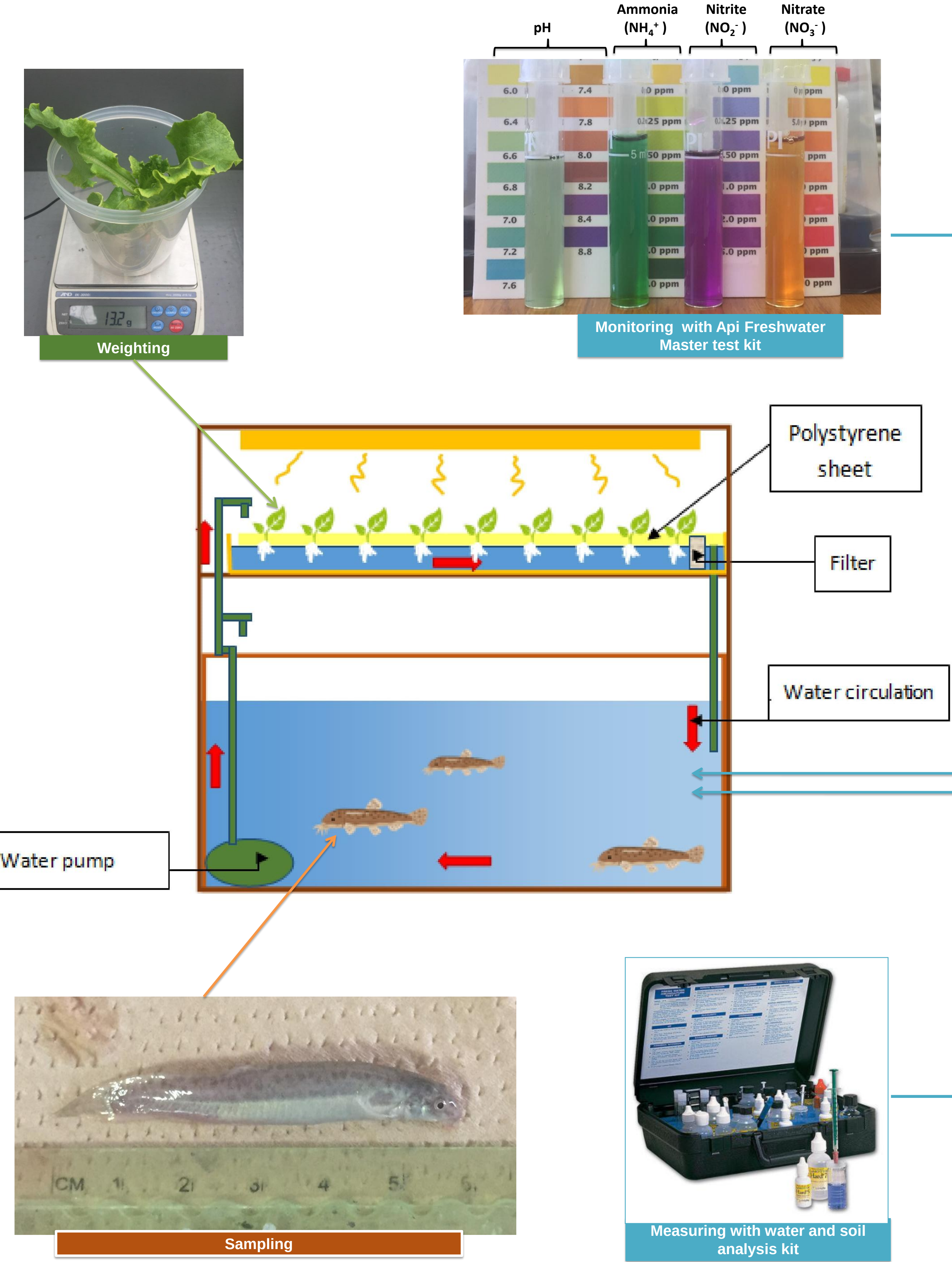
In Africa, leafy green and fish are considered as a luxury commodity in landlocked remote area. Developing efficient and integrated agriculture techniques producing both of the above mentioned outputs will then largely enhance the living standards. In this matter, aquaponics offers a solution by combining a recirculating system that incorporates three main components: fish, plants and bacteria. The fish provides nitrogenous waste to aerobic bacteria; after nitrification, all nutrients become available to the plants. In other words, the fish feed the plants and the plants filter the recycled water. The main objective of this research is then to produce marketable size of a variety of vegetables in a short term culture.

## Materials and methods:

Materials

For the test, oriental weatherfish or pond loach *Misgurnus anguillicaudatus* (Cypriniformes; Cobitidae) locally known as ドジョウ dojō was cultured. As a freshwater teleost which inhabits streams, ditches, and rice paddy fields, this species is widely distributed in Japan, Korea, and the eastern coasts of the Asian continent from the Amur River to North Vietnam (Saitoh 1989). It has been used as traditional Chinese medicine in folk remedies for treatment of hepatitis, osteomyelitis and ageing and researchers have found some active substance of high medical value. In Japan, loach has been cited as a main aquaculture species with a high commercial value for a long time, moreover it is one of the Kanazawa delicacies. This bottom-dwelling scavenger has an omnivorous diet and can thrive from 0°C to 30°C and in low oxygen conditions by utilization of atmospheric oxygen for respiration in oxygen-depleted water (Kim et al. 2020).

Many types of vegetables can be grown in aquaponic systems. However, the goal is to culture a vegetable that will generate the highest level of income per unit area per unit time in a short period of time. Regarding these criterions, lettuce *Lactuca saliva* was a fit choice since it can provide a market size shoot in one month depending of the culture condition. As it is a vegetative plant and not fruit bearing, growth and maturation solely depend on nitrogen element. Furthermore, as this plant requires lot of water, hydroponic or aquaponics will highly reduce the possible water stress in a conventional on soil planting system.



### Experimental design

Due to the fragility of the loach, handling were minimized and counting were done roughly by extrapolating the optimum capacity of a scope net. An average number of 300 individuals of oriental weather fish ranging from 3 to 11.3 cm in body length and 0.2 to 6 g in body weight were transferred to white glass tanks of 600 L capacity. Tap water were stocked and set 2 days prior the filling in order to remove the chlorine. The fish tank, filled with 430L water, was stocked with 300 larvae under the following environmental conditions: dissolved oxygen 8.1 mg L<sup>-1</sup>, water temperature 27°C and pH 7.2. A submersible water pump of a maximum capacity of 20 L.min<sup>-1</sup> was set in the fish tank to convey the water to an auxiliary filtering device and the growing bed on a higher shelf. This latter is made of styrofoam box (54 cm x 162 cm x 6 cm) covered with a plastic waterproof sheet. The box removable lid was perforated with 2.5 cm hole, 15 cm of each other. Bags of gravel and ceramic rings were put transversally onto the grow bed 10 cm to the outlet in order to maintain a maximum of fish waste and then provide more nutrients to the plants before returning the clean water with a flow of 120 ml.min<sup>-1</sup> into the fish tank. Lettuce seedlings were transferred onto the lid once their root systems was well developed enough. For enhancing photosynthesis, light was supplied by two overhead fluorescent tubes to produce a light intensity between 50 -60 Hz and the photoperiod set at 05:00 to 19:30 to mimic summer daylight.

### Fish breeding

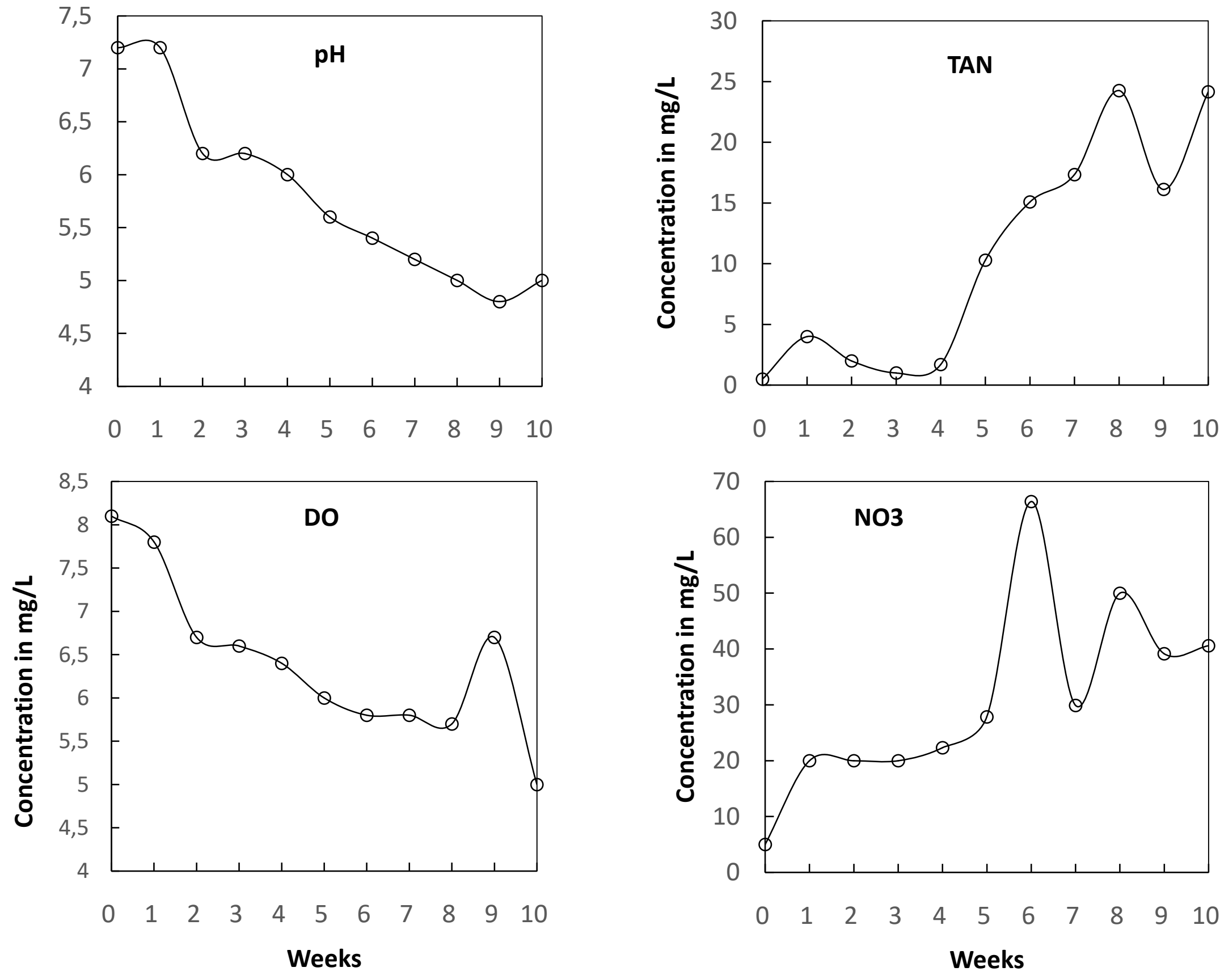
In this research, feeding was done with sinking pellet containing 50.0% protein four times a day (01:00, 7:00, 13:00 and 19:00). As their morphology suggested, these post-metamorphosed loach had a nocturnal intense feeding. The tank was then covered with black sheet in order to improve the feeding incidence and the feeding efficiency. The feeding amount was increased every week as the specific growth rate was expected to be 7% (Wang et al., 2010) and the feeding rate at 6% of the biomass (Wang et al., 2009). Water lost through evaporation and transpiration were replenished twice a month.

### Data collection

Being given the sensitiveness of the loach, the initial length, weight and the amount of the available fish was roughly estimated at the beginning of the research. Trials of sampling was conducted twice during the breeding. A dozen of fish was measured and weighted randomly. Anaesthesia was used beforehand in order to minimize stress. During the 10 weeks experiment, a fixed mercury thermometer water was permanently kept in the tank to monitor the temperature. The dissolved Oxygen and water temperature were monitored in the morning every 2 days, while pH, Ammonia, Nitrite and nitrate concentration were assessed twice a week with test kit (Api Freshwater Master test kit). For accuracy, the Total Ammonia Nitrogen (TAN), NO<sub>3</sub>-N, PO<sub>4</sub>-P, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Fe<sup>3+</sup> were weekly measured through spectrophotometry with a portable soil and water analysis kit. The total body mass of the vegetables were randomly weighed once a week.

## Results and discussions

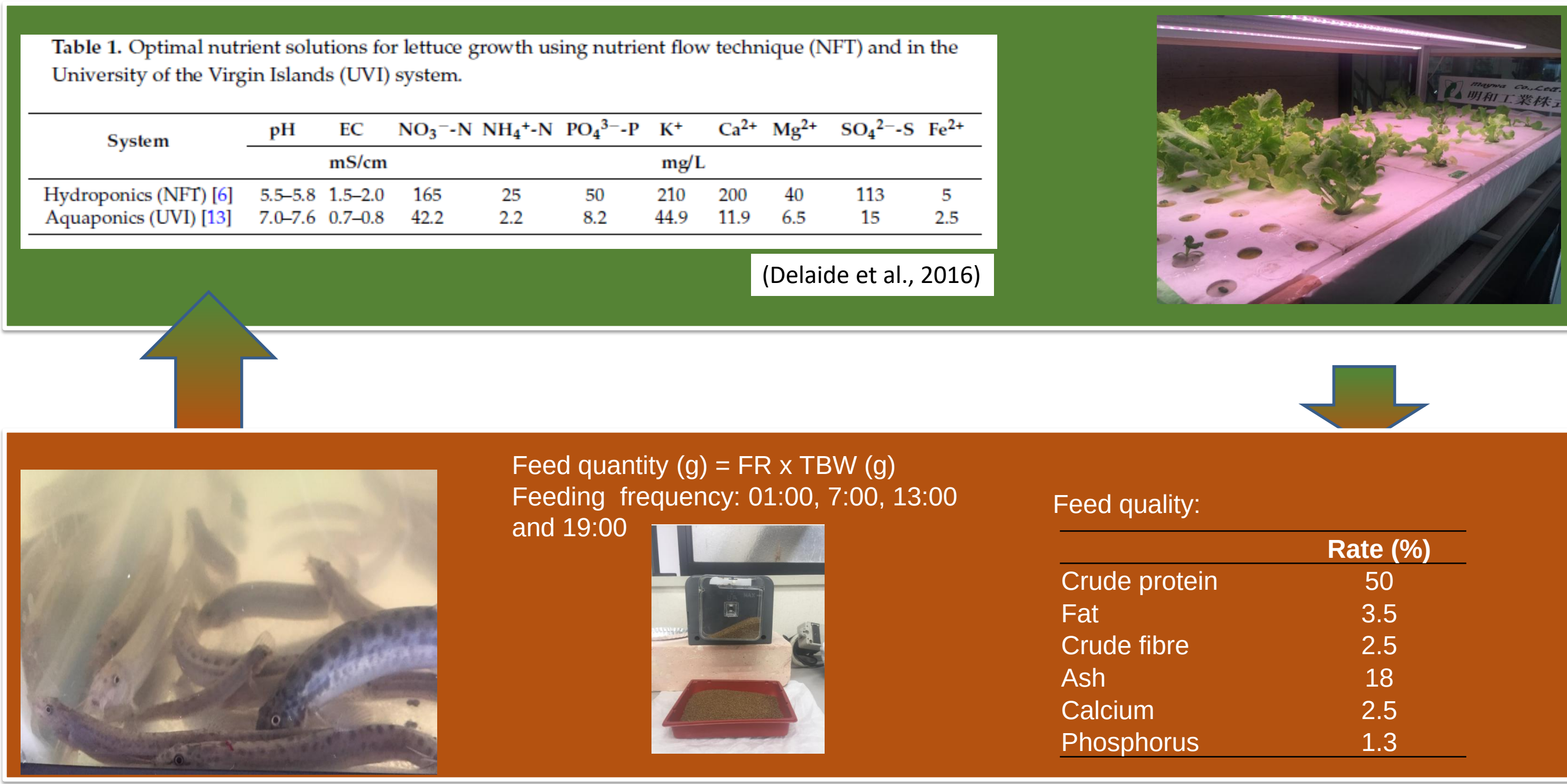
As the loaches grew, the pH was observed to decrease from 7.2 to 5 along with the dissolved oxygen which was recorded to move from 8.1 to 5 mg/L after the 10 weeks experiment. The natural excretion of total ammonia reached 24.16 mg/L which resulted in an increased concentration of nitrite NO<sub>3</sub>-N to 40.59 through the nitrification process.



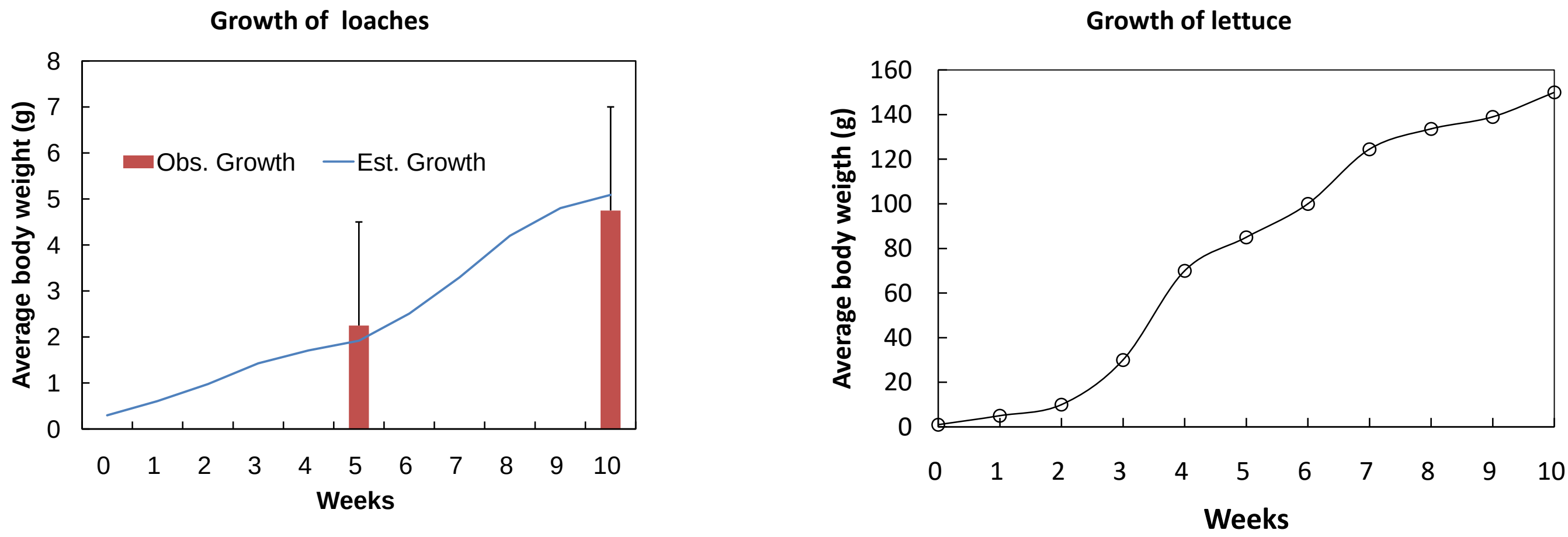
These measurements demonstrated that the present aquaponic system provided a higher concentration of total ammonia nitrogen compared to aquaponic solution defined by Delaide et al. (2016) (Tukey test, p<0.01) and were not significantly different from complemented aquaponic in terms of Phosphorus PO<sub>4</sub>-.

|                        | pH         | TAN (mg/L)   | NO <sub>3</sub> -N(mg/L) | PO <sub>4</sub> -P(mg/L) | K+(mg/L) | Ca2+(mg/L)    | Mg2+(mg/L)  | Fe3+(mg/L) |
|------------------------|------------|--------------|--------------------------|--------------------------|----------|---------------|-------------|------------|
| Complemented Aquaponic | 5.87       | 25.79        | 215.54                   | 52.66                    | 219.31   | 175.09        | 43.02       | 4.4        |
| Hydroponic solution    | 5.77       | 23.95        | 193.29                   | 50.93                    | 242.27   | 205.68        | 43.11       | 3.87       |
| Aquaponic solution     | 7.5        | 1.82         | 50.31                    | 7.83                     | 59.51    | 14.72         | 7.36        | 3.47       |
| Loach aquaponic Meiwa  | 5.8 ± 0.84 | 10.58 ± 9.25 | 31.02 ± 17.02            | 55 ± 20.81               | 0        | 38.24 ± 22.41 | 3.73 ± 0.24 | 1 ± 0.06   |

The average concentrations of NO<sub>3</sub>-N, PO<sub>4</sub>-P, Ca<sup>2+</sup> and Mg<sup>2+</sup> in the present research were also optimal to the growth of lettuce in aquaponics and were not different from condition offered by the aquaponics used by the University of the Virgin Islands (UVI) system.



Looking at the outputs, the loaches had a satisfying growth compared to the estimation (Est. Growth). Indeed, the pond loach reached an average size of  $4.75 \pm 2.25$  g corresponding to  $8.34 \pm 2.7$  cm, which is above the market size. The lettuce acquired an average shoot fresh weight of  $154.75 \pm 37.56$  g.



## Conclusion:

The raft aquaponic system with loach provided the requirement concentration of nutrients for the optimal growth of the lettuce. Even though the water condition became acidic and less oxygenated, the loach experienced a satisfying growth. Nevertheless, the aquaponics solution had a remarkably low concentration of potassium which could negatively affect the growth of lettuce in the long run.

## Reference:

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