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Evaluating feed pellet size on carps and tilapia growth, feeding behavior and natural food web in pond polyculture

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Results show that feeding small pellets is the best method for carp-tilapia pond polyculture

Carp and tilapia are the two most cultured species groups in the world aquaculture contributing 48 and 10 percent of the **total finfish production** (https://doi.org/10.4060/cc0461en), respectively, and together, they consume 44 percent of the **total aquaculture feed** (https://doi.org/10.1080/23308249.2019.1649634) sold worldwide. Semi-intensive polyculture in earthen ponds is a common practice in carp farming of Bangladesh, India and Myanmar, raising two to six carp species together.

Often non-carp species, like tilapia, are added to the species mix, but carps remain as the main 'cash crop. In carp-tilapia polyculture, carps are usually harvested after 12–24 months at ~2–3 kg while tilapia are harvested each four to six months at ~300–400 grams, followed by the introduction of a new batch. Thus, per carp culture cycle, there are three to six tilapia cycles.

This study investigated the effect of feed pellet size on carps and tilapia growth, feeding behavior and natural food web in pond polyculture.

Feed pellet size may provide a tool for farmers to feed different fish size groups in polyculture ponds. Small fish may prefer small pellets and large fish large pellets. Pellets need to be small enough to be ingested while being adequately large to be consumed without losing too much energy in the feeding process. Larger pellets are more easily noticed than smaller ones and thus may be consumed more rapidly. In addition, small pellets contain less nutrients per pellet than large pellets and thus fish that feed on small pellets need to spend more energy to consume a full ration as compared with fish eating large pellets. Following the optimal foraging theory, fish are assumed to **optimize energy gain** (https://doi.org/10.1111/j.1095-8649.2003.00214.x) by food intake with respect to the energy loss in food acquisition.

Pellet size influences fish growth in results of studies of many cultured fish species, but it has not been tested yet in a carp-tilapia polyculture system. Since pellet size influences feed waste as well as fish waste production, it may alter the natural food web also because of the role of uneaten feed and fish waste in pond fertilization, and there is a knowledge gap in the performance of large carps and small tilapia in pond polyculture when fed with different pellet size combinations. Moreover, it is also unknown how the natural food web of the pond would be affected by pellet size.

This article – **summarized** (https://doi.org/10.1016/j.aquaculture.2024.741342) from the **original publication** (https://creativecommons.org/licenses/by/4.0/) (Akter, M. et al. 2024. Effect of pellet-size on fish growth, feeding behavior and natural food web in pond polyculture. *Aquaculture* Volume 593, 15 December 2024, 741342) – reports on a study that investigated whether pellet-size can steer the growth of large carps (~ 500 grams) and small tilapias (~30 grams) in polyculture ponds in Bangladesh.

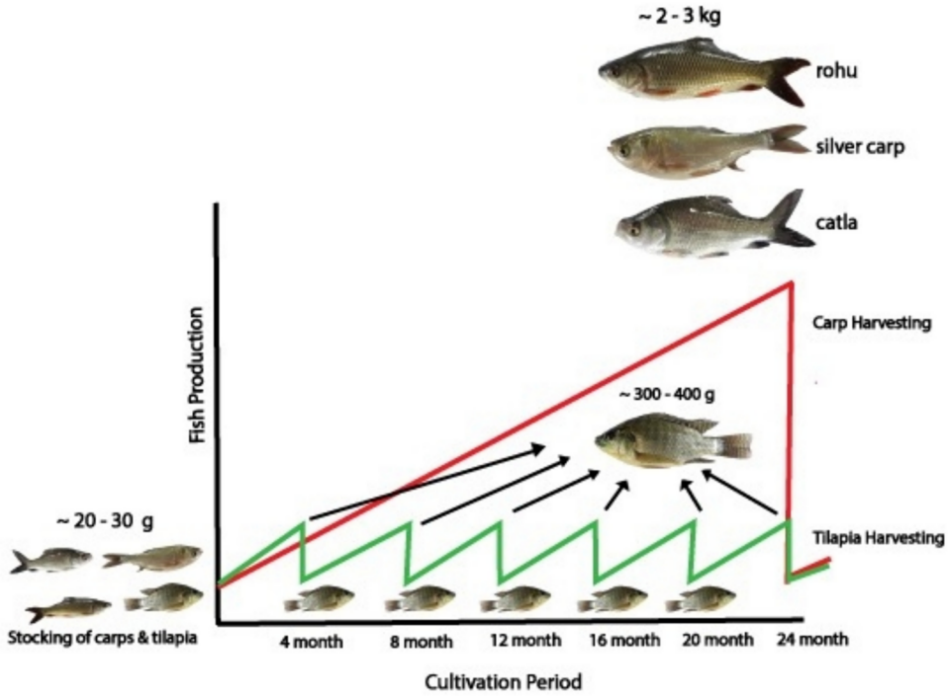

Fig. 1: Conceptual diagram of carp-tilapia polyculture system with one carp production cycle and six tilapia production cycles. The red line indicates carp cycle and the green line indicates tilapia cycles. Each green drop indicates harvesting of existing tilapias and restocking another new batch. Green peaks indicate production of harvestable size of tilapia (~300–400 grams). Red peak indicates production of harvestable carps (~2–3 kg). Fish images were taken during the experiment.

Study setup

A polyculture system was studied with large rohu (*Labeo rohita*), catla (*Catla catla*) and silver carp (*Hypophthalmichthys molitrix),* together referred to as carp and small Nile tilapia (*Oreochromis niloticus*). Carps were large enough to consume pellets with a diameter up to 6 mm, while Nile tilapias were small and able to consume pellets up to 2 mm. Feed pellets with a diameter of 2 and 6 mm, and

the same ingredient composition were fed to the polyculture ponds for 56 days. Experimental feed pellets were produced by KNB Agro Industries Ltd. in Kushtia, Bangladesh. The feed ingredient mixture was extruded with different die sizes into small (2 mm) and large (6 mm) pellets. Pellets of both sizes were observed to float >12 hours in the ponds.

Twenty-four 45-square-meter outdoor ponds in a dedicated pond facility at Khulna University were used for this experiment. All ponds were stocked with 18 kg of fish (~400 grams per square meter). Within each pond, the goal was that each fish species (tilapia, carps) contributed 25 percent to the total biomass stocked. Tilapia of 30 grams and carps of 500 grams were stocked. This resulted in a stocking of 150 tilapia and nine fish of each carp species per pond. All male BIG NIN strain juvenile Nile tilapias (originally imported from Thailand) were collected from a local farm in Jessore, and large carps were collected from a supplier who collected fish from different places of Khulna, Bangladesh.

Four pellet-size combinations, each fed to six replicate ponds, were assigned in a one-way ANOVA design. The pellet-size combinations (on weight basis) were S100L0 (100 percent small, 0 percent large pellets), S50L50 (50 percent small, 50 percent large), S25L75 (25 percent small, 75 percent large) and S0L100 (0 percent small, 100 percent large). The goal was to observe how feeding 100 percent of each pellet size (2 vs 6 mm) and the 50-50 mixture affected the different fish species and the food web. In addition, the combination S25L75 was applied as it matches with the size weight distribution of stocked fish biomass: 25 percent by small tilapia and 75 percent by large carps.

Results and discussion

This research investigated whether the strategy of using different pellet-size treatments can direct the production of species in carp-tilapia polyculture ponds where carps are large (~500 grams) and tilapias are small (~30 grams). The experiment lasted only 56 days since longer experimental duration may mask the effect of pellet-size treatments on tilapia, as with time, tilapia would grow fast and their ability to eat large pellet size would increase. Results showed that the strategy did not influence carp production while tilapia benefitted from 100 percent small pellets.

The unresponsiveness of carps could have been related to their lower numbers in ponds than tilapia, and they consumed fewer pellets, as carps are less voracious eaters than tilapia. Additionally, it is possible that carps were disturbed by tilapia while eating. During the experiment, it was regularly observed that tilapia were nibbling on large pellets and it was assumed that by nibbling, they were able to eat on large pellets either by ingesting small pieces of large pellets (as pellets got softer over time in the pond) or reducing the pellet's size. Since at the stocking there were 5.5 times more tilapia than carps, and tilapias were feeding on both small and large pellets, the disturbance by tilapia was high, reducing pellet uptake by carps in all treatments. Previous studies have reported that tilapia is a more aggressive and faster eater than carps in polyculture ponds.

This is evident in this experiment with higher tilapia production than carp (rohu, catla and silver carp) production (Fig. 2). On average, a biomass gain of 9.2 kg tilapia and 1.9 kg carps was achieved in 56 days which is equal to 3.65 and 0.75 grams per square meter per day, respectively. Total production (11.1 kg/45 square meters per 56 days equal to 4.40 grams per square meter per day) and tilapia production (3.65 grams per square meter per day) achieved in this experiment is much higher than reported for other polyculture experiments. Despite the size difference, carp production achieved in our experiment is comparable with the past studies. However, it is possible that the carp production in this experiment was negatively influenced by the high stocking density of tilapia. Overall, the effect of pellet-size treatments is difficult to predict depending on the stocking density of tilapia and carps, the size at stocking and the species combination in the polyculture system.

Fig. 2: Mean biomass gain (panel, A) and mean growth rate (panel, B) for each of the four fish species kept in a carps-tilapia polyculture pond as affected by pellet-size treatment. Ponds were fed similar amounts of feed, but subjected to one of four ratios of small (S, 2 mm) and large (L, 6 mm) pellets. Biomass gain was affected by fish species, pellet-size treatment and their interaction. Individual growth rate was affected by fish species and not affected by pellet-size treatment and their interaction. S100L0 = 100 percent small pellet and 0 percent large pellet, S50L50 = 50 percent small pellet and 50 percent large pellet, S25L75 = 25 percent small pellet and 75 percent large

pellet, S0L100 = 0 percent small pellet and 100 percent large pellet.
Error bars represent SD.

Among the carps, the biomass gain of silver carp was negligible small (Fig. 2A). This may be because silver carp did not consume much supplementary feed and, they may have suffered from strong competition for natural food with tilapia, rohu and catla. Silver carp is known to have moderate dietary overlap in natural food types with rohu and catla. No study has been found on the dietary (natural food items) overlap between silver carp and tilapia, however, the index of preponderance for these species in this study shows that they have overlap in their natural food diet. Additionally, it was reported that in polyculture of catla and silver carp, one of these two species becomes dominant and the other achieves poor growth.

For tilapia, feeding only small pellets was beneficial in this polyculture ponds (Fig. 2A). Strong preference or competition for small pellets is clear from the much shorter feed intake time in the S25L75 treatment. Tilapia spent more time and energy on the acquisition of large pellets by nibbling on those. In addition to higher energy expenditure in feed acquisition, feed loss during nibbling and biting may also contribute to the lower growth of tilapia in the treatments with large pellets.

An economic evaluation was done on each treatment using the biomass gain of each species per pond and the median of average prices in Bangladesh in the year 2023. It showed that feeding 100 percent small pellets in carp-tilapia polyculture is the best strategy to maximize production.

The pellet-size treatments altered the diversity of phytoplankton in the ponds (Fig. 3), while the abundance of phytoplankton remains unaffected. The diversity and abundance of zooplankton and benthos of the ponds remained the same across treatments. Since the amount of feed was the same across pellet-size treatments, the food web and water quality were not affected much. However, feeding large pellets had a positive effect on phytoplankton diversity, most likely because the long intake time of large pellets facilitates nutrients leaching, stimulating algae production. The percentage of nutrients leaching from the pellet varies depending on the formulation of the feed and the pellet size.

Fig. 3: Phytoplankton diversity over different sampling days of experiment depending on the pellet-size treatment. Phytoplankton diversity was affected by pellet-size treatments, sampling day and

their interactions. S100L0 = 100 percent small pellet and 0 percent large pellet, S50L50 = 50 percent small pellet and 50 percent large pellet, S25L75 = 25 percent small pellet and 75 percent large pellet, S0L100 = 0 percent small pellet and 100 percent large pellet. Error bars represent SD. Adapted from the original.

The relative abundance of natural food group in the diet of the carps and tilapia in this trial is comparable to other studies except that the abundance of macrophytes in the diet of rohu and catla in our experiment is higher and of the insects is lower. Pellet-size treatments influenced the contribution of natural food to the fish biomass gain.

When the pellets were eaten quickly in treatments with no (S100L0) or lower amounts of large pellets (S50L50), tilapia grazed more on natural food, evidenced by the higher volume of food in the stomach of tilapia in those treatments, which may have contributed to the higher biomass gain and higher protein deposition. In contrast, tilapia remained busy for longer periods nibbling on large pellets, which decreased competition for natural food for carps and rohu took the opportunity to eat more natural food in these treatments, leading to the trend of higher fat deposition and lower ash content in rohu.

No effects of pellet-size on total amount of natural food in fish gut were found for catla and silver carps. However, pellet-size treatments influenced the relative abundance of natural food group in the gut of catla and silver carps. More phytoplankton and less detritus were consumed by these two carp species when there are more large pellets in the diets. This is possibly because of the increased concentration of phytoplankton in the water when more large pellets are fed. For rohu and tilapia, we did not see such an effect which may be because both phytoplankton and zooplankton abundance in the water increased with the progression of the experiment, and thus for rohu and tilapia, the abundance of the plankton was not limiting.

Perspectives

Pellet-size offers a feed management tool to enhance total fish production by steering biomass gain of tilapia and not of carps in our studied carp-tilapia polyculture combination with large carps and small tilapia. Silver carp suffered in our experimental setting most likely due to the interspecies competition for both pelleted feed and natural food. Rohu and catla, also, could not take full advantage of large pellets because of the nibbling behavior of tilapia on those pellets, hampering their feed intake.

On the other hand, nibbling on large pellets hampered the growth of tilapia costing them much time and energy. No differences in the natural food web of the pond were observed between pellet size treatments, except for phytoplankton diversity. Overall, feeding small pellets proved to be the best feeding method in carp-tilapia pond polyculture.

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