MUNICIPAL SOLID WASTE MANAGEMENT

Using fresh Black Soldier Fly Larvae to substiute commercial catfish feed

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Context

Valorising organic waste with the Black Soldier Fly Larvae (BSFL) is becoming increasingly popular, especially in low- and middle-income countries. The popularity links to the opportunity of using the harvested BSFL as an alternative to conventional feed. BSFL could be a very interesting feed source for catfish farmers, however due to the young development and little experience to date, following questions arise:

- Are there any negative effects on catfish growth when substituting parts of conventional feed with BSFL?
- Is there a financial advantage for catfish farmers to use BSFL as feed?

This factsheet presents the set up and results of a simple catfish feeding trial where parts of the conventional feed was replaced with live BSFL. It was decided to test the fresh form of BSFL (alive, directly after harvesting) instead of its processed form (dried and defatted), because of their remarkably lower cost price per kg and thus their higher potential competitiveness with conventional feed. However, live BSFL have a high water content, and thus have a lower protein percentage compared to the conventional feed. Moreover, live BSFL are not storable and need to be purchased by the farmers daily, meaning mainly farmers in close distance to a BSF facility would be targeted buyers. The presented data was collected at the FORWARD BSF pilot site in Sidoarjo (Indonesia).

Set up for catfish feeding trial

Catfish seedlings were fed with different amounts of fresh BSFL and commercial pellets. A control group was fed only with the commercial pellets. The total diet protein content (w/w) decreased by increasing BSF amounts in the feed (see Table 1).

Table 1: Feed composition for four different treatments presented as percentage w/w.

Treatment	dry matter	% BSFL live	% catfish pellets	Diet protein content	Diet fat content
0-BSF	88%	0	100	35%	5%
12.5-5BSF	80%	12.5	87.5	32%	6%
25-BSF	72%	25	75	29%	6%
50-BSF	57%	50	50	23%	8%

A total of 250 fish per group were kept in IBC tanks (1000 L) filled with fresh water and aerated using a system with pipes and an aerator (Repsun LP-100). The fresh water was added to the tanks seven days before adding the catfish seedlings to stabilise the water. The water requirements listed in Table 2, were checked daily berfore feeding for temperature and pH and biweekly for minimum water dissolved oxygen (DO) level and maximum ammonia level. A quarter up to half ot the tank water was replaced with clean fresh water, when parameters did not meet the requirements.

Table 1: Water quality requirements

Water quality parameters	Requirements	Method
Temperature	25-33°C	Thermometer
pH	6.5-8	pH meter
Min. water DO level	3 mg/L	DO meter (Lutron DO-5510)
Max. water amonia level	0.1 mg/L	Ammonia test kit (HI-3824)

The total amount of feed given was based on the fish weight, and increased over the trial period of 37 days. Twice a week, a random sample of ten fish from each treatment tank was transferred to a bucket containing fresh water with a scoop net. The weight and the length of each fish were measured using a digital scale (Fuitsu FSR-C, max. capacity: 1 kg, accuracy: 0.1g) and a stainless steel ruler (see Figure 1). All fish were added back to the respective tanks after the sampling. The amount of feeding per tank was adjusted after each sampling to 5% of total fish weight. The total fish weight was approximated by the mean fish weight (n=10) times 250 (total amount of fish at the beginning). Dead fish have been neglected, as only very few fish died. Feed was given twice per day, early mornings (7:00-8:00) and in the late afternoon (16:00-17:00), according to the trial treatments (see table 1). Feed was given little by little until everything was eaten by the fish. The amount of feed given every day was summed to a total feed intake over the trial time. The total fish weight and total amount of living fish were measured and counted at the beginning and in the end of the trial. The weight of the dead fish was approximated by the mean fish weight of the last sampling day of the respective tank.

Figure 1: Catfish weight and lenghts measuring.

Catfish growth performance parameters

From the measured data, the following parameters can be analysed to compare the fish growth between the different treatments.

- **Body Weight Gain (BWG)** is the total body weight increase (in g) of the fish during the trial, where W_t is the mean final body weight and W_0 is the mean initial body weight.

$$BWG\,[g] = W_t[g] - W_0[g]$$

- **Length Gain (LG)** is the total length increase (in cm) of the fish during the trial, where L_t is the mean final fish length and L_0 is the mean initial fish length.

$$LG\,[cm] = L_t[cm] - L_0[cm]$$

- **Specific Growth Rate (SGR)** is the growth rate given as % increase per day with t as number of feeding days. It is a good growth measure for young fish, as their weight gain is still in exponential phase.

$$SGR = (\ln W_t[g] - \ln W_0[g]) / t\,[d] \times 100$$

- **Feed Conversion Ratio (FCR)** is the ratio between Feed Intake (FI) and fish biomass increase, where P_t is the total final fish biomass per tank, P_i the total intial weight and D the total wight of fish died per tank.

$$FCR = FI\,[g] / ((P_t\,[g] + D\,[g]) - P_i\,[g])$$

- **Protein Efficiency Ratio (PER)** is the ratio between fish bioamss increase and feed intake based on protein content.

$$PER = (P_t\,[g] + D\,[g]) - P_i\,[g] / FI\,[g] \times \text{diet protein content}\,[\%]$$

- **Survivial rate (SR)** is the ratio between total number of living fish at end of the trial (N_t) and living fish at the beginning of the trial (N_0):

$$SR\,(\%) = N_t / N_0 \times 100$$

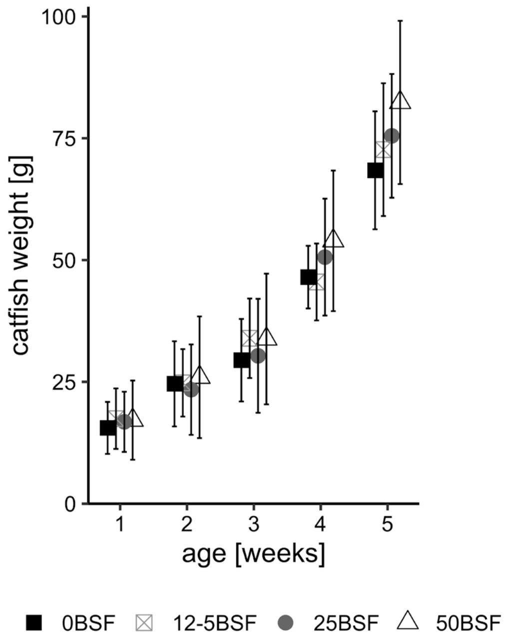

Figure 2: Mean and standard deviation of catfish weight for 0BSF, 12-5BSF, 25BSF and 50BSF over 5 weeks (n=10). * indicates a significant difference to the control group 0BSF (Kruskal Wallis, significance level: a < 0.05).

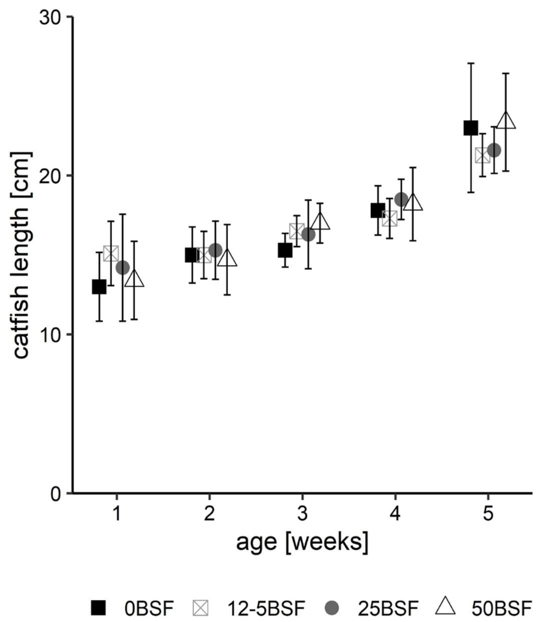

Figure 3: Mean and standard deviation of catfish length for 0BSF, 12-5BSF, 25BSF and 50BSF over 5 weeks (n=10). * indicates a significant difference to the control group 0BSF (Kruskal Wallis, significance level: a < 0.05).

Results and Discussion

Figure 2 and 3 show the mean weight and length increase of the fish over the total trial period of 5 weeks. Growth of all three BSF treatments were higher or similar to the growth of the control. Weight and length data of all the BSF treatments was not significantly different to the control group at any sampling day (Kruskal Wallis, significance level: a < 0.05).

Table 3 presents fish performance parameters. The parameters SGR, BWG and LG show higher growth performance for all three treatments compared to the control, however this difference is not significant. Survival rates were higher than 95% for all fish tanks, which is above the national catfish cultivation standard of 80% (SNI, 2014). This indicates uniform growth increase of catfish, good water quality and adequate feeding.

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Table 3: Chicken breeding performance parameters for treatment 0-BSF, 10-BSF, 20-BSF and 30-BSF. Different letters indicate significant differences. (ANOVA, with Tukey post hoc, significance level: a < 0.05).

Growth performance parameter	n	Unit	0-BSF	12.5-BSF	25-BSF	50-BSF
Body Weight Gain (BWG)	10	g	52.8	55.2	58.7	65.2
Length Gain (LG)	10	cm	10.5	7.7	8.5	10.7
Specific Growth Rate (SGR)	10	%/day	4	3.8	4.1	4.2
Survival Rate (SR)	-	%	99	99	95	98
Feed Conversion Rate (FCR)	-	-	1.2	1.3	1.3	1.3
Protein Efficiency Ratio (PER)	-	-	2.3	2.3	2.7	3.3

All BSF treatments showed an FCR of 1.3, whereas the control had a lower ratio of 1.2. The national standard for the FCR is set at 1.0 for catfish, meaning that 1 kg of feed is required for 1 kg of fish biomass (BBPBAT, 2007). Although the FCR differed from the national standard, the variation between all four treatments was minor. The control group feed had a higher nutrient density (see Table 1), which could explain the slightly lower FCR. The PER was higher for the BSF treatments, especially for the treatment using 50% live BSFL as feed. This indicates a better protein efficiency when adding BSF to the feed. By replacing conventional pellets with BSFL, the total protein content of the feed is reduced. The results show that the reduced protein content does not negatively affect growth performance for catfish and no additional feed is required to get the same SGR and output as when feeding 100% conventional catfish pellets.

Feed cost predictions using fresh BSFL

The conventional fish pellets Optimax AL 643 are currently sold at a price of 0.7 USD per kg in Indonesia. The BSF pilot site is currently selling the BSFL at a price of 0.4 USD per kg. At these current prices a catfish farmer could save up to 20% in feeding costs by replacing 50% of the conventional feed by BSFL. At a slightly higher BSF price of 0.6 USD/kg, catfish farmers could still save 4% to 15% of their feed costs by replacing conventional pellets with live BSF (see Table 4).

Table 4: Feed cost saving for different BSF replacement ratios at 0.4 USD/kg and 0.6 USD/kg BSF live.

Treatment	% BSF	Cost saving at 0.4 USD/kg BSF	Cost saving at 0.6 USD/kg BSF
0-BSF	0	0%	0%
12.5-BSF	12.5	5%	4%
25-BSF	25	10%	8%
50-BSF	50	20%	15%

Conclusions & suggested usage of fresh BSFL

Based on the presented results, live BSFL are suitable for feeding catfish and do not have any negative effects on fish performance indicators measured in this trial (body weight gain, length increase, and specific growth rate and feed conversion ratio). Even though the total diet protein content of BSFL treatments was lower, the growth performance was comparable to the control and thus, BSFL treatments resulted in higher protein efficiency ratios.

Based on current sales prices of conventional catfish and live BSFL, substituting conventional feed with BSFL has a financial advantage over a purely pellet based feed. Especially for small scale fish producers, costs for the feed contribute largely to the operational costs, therefore even a small cost reduction of 4% would have a beneficial impact on the farmer's business.

Replacing pellets with fresh BSFL does not lead to a significantly better performance. This means there will be only a financial benefit for the farmer as long as the fresh BSFL have a lower kg price compared to the fish pellets.

For farmers located next to a BSF waste treatment facility, it is recommended to replace up to 50% of the conventional feed with live BSFL, which could result in lower operational costs and more sustainable production.

References

- Balai Besar Pengembangan Budidaya Air Tawar (BBPBAT). 2007. Teknik Budidaya Ikan Lele.
- SNI. 2014. Ikan Lele Dumbo (Clarias sp.). Badan Standarisasi Nasional.