Mass Production of
Black Soldier Fly Prepupae for Aquaculture Diets

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After decades of work in Tifton, Georgia, University of Georgia researchers think soldier flies will be a viable alternative to fish meal in aquaculture diets. Early work with the black soldier fly (*Hermetia illucens*) used manure as the growth media, but recent efforts show that food byproducts can be a better soldier fly diet. Catfish grow well on soldier flies and other fish, including tilapia and rainbow trout have been fed the prepupae. The most exciting opportunity shows that changing the composition of the soldier fly diet will change the final composition of the soldier fly prepupae in a value-added way.

Scientists in Asia, Europe, Israel, Australia, and North and South America have long proposed using insect biomass as a high quality feedstuff for food animals including poultry, swine and fish. Insects, especially fly larvae, can convert low value organic materials into protein and fat. House flies have been the most intensively studied in this role because their biology is well understood and because of their high reproductive rate. But the house fly is a pest and potential disease vector.

Recent advances in black soldier fly culture make this insect the best candidate for industrial scale production. Forty years ago massive populations of black soldier fly larvae lived under caged laying hens or swine housed in open sided structures. A solid layer of larvae hundreds of feet long consumed manure as rapidly as it was deposited. Manure (residue) removal was not needed for years (versus months) since the migratory prepupae carried manure nutrients away as they left the manure beds. These huge populations no longer exist because ovipositing females will not enter modern enclosed animal housing. We intend to harness the productivity of this robust natural system.

Black soldier flies are an ideal candidate for mass production. Adults are not pests and larvae tolerate and thrive at densities up to almost 3lb per sq. ft. (14kg/m^2).

Prepupae are self-collected as they leave the larval mass to pupate, then processed before developing into flies. With larvae maturing to crawl-off in four weeks or less, high rates of production are possible in an intensive system. This will require scaleing up and refinement of already proven systems. These systems were developed during 30 years of university research trials and more recent commercial production of Phoenix Worm larvae. This is the specially reared black soldier fly larvae produced as a live food for captive reptiles, fish and birds. A proprietary system is being developed to support very intensive automated production in a controlled environment. Waste food or fresh swine manure will be fed at up to 2lb per sq. ft. per day. Feed conversion rates of up to 25% (dry matter basis) are expected. Conservative projections indicate that a 400,000 square foot production plant would produce 3,750 tons of dry whole prepupae meal per year. However, we expect the prepupae to be processed into protein, fat (especially lauric acid), chitin and other products for best utilization.

Channel catfish fingerlings grew well on all diets containing soldier fly prepupae or skinless prepupae. Survival during feeding trials was excellent and the presence of soldier fly up to 30% of the diet did not seem change diet palatability. Weight gain per fish remained similar among treatments up to the 30% addition level and no higher inclusion levels have been tested (Table 1). The absence of negative are remarkable due to the high chitin content and high fat content of the soldier fly pre-pupae meal.

Although digestible energy in catfish diets was formulated to be approximately the same in all treatments, crude fat content increased as the amount of soldier fly pre-pupae meal increased. Also, calcium and phosphorus content increased with increasing amounts of the soldier fly pre-pupae meal. However, from practical considerations of the addition of the new ingredient, addition of more than 7.5% soldier fly pre-pupae meal seems unnecessary. The possibility of eliminating fish meal from catfish diets without a decline in performance is encouraging.

Soldier fly pre-pupae meal should cost less to obtain than menhaden fish meal. Fuel to capture, ship and process menhaden fish meal would cost more than the cost of food byproducts used to produce soldier fly prepupae. Since soldier fly prepupae are more than 40% dry matter, drying costs are expected to be less than for fish meal since fish are 20 to 25% dry matter. A system for commercializing soldier fly meal is illustrated in Figure 1.

Table 1. Channel catfish performance[a] when fed diets containing soldier fly pre-pupae meal. Means within rows were not different from the reference containing menhaden fish meal, P<.05.

Criterion	30% SF	22.5% SF	15% SF	7.5% SF	0% SF Reference
Gain/Fish, g (SD)	15.9 (4.7)	13.7 (3.6)	17.3 (2.5)	18.0 (1.9)	15.9 (3.6)
Feed/Gain (g/g)	2.31	2.55	1.96	1.87	2.2
Feed Intake (g/fish)	33.79	33.36	33.36	33.36	33.36
Survival (%)	95.0	97.5	97.5	97.5	97.5
Protein Efficiency Ratio	1.46	1.28	1.62	1.68	1.48
Value[b] as % of Reference	113	95	114	112	100

[a]Data represent means of four tanks of fish per treatment held 20 fish per tank.
[b]Based on total diet cost times ratio of PER diet to PER reference with menhaden fish meal.

Figure 1.

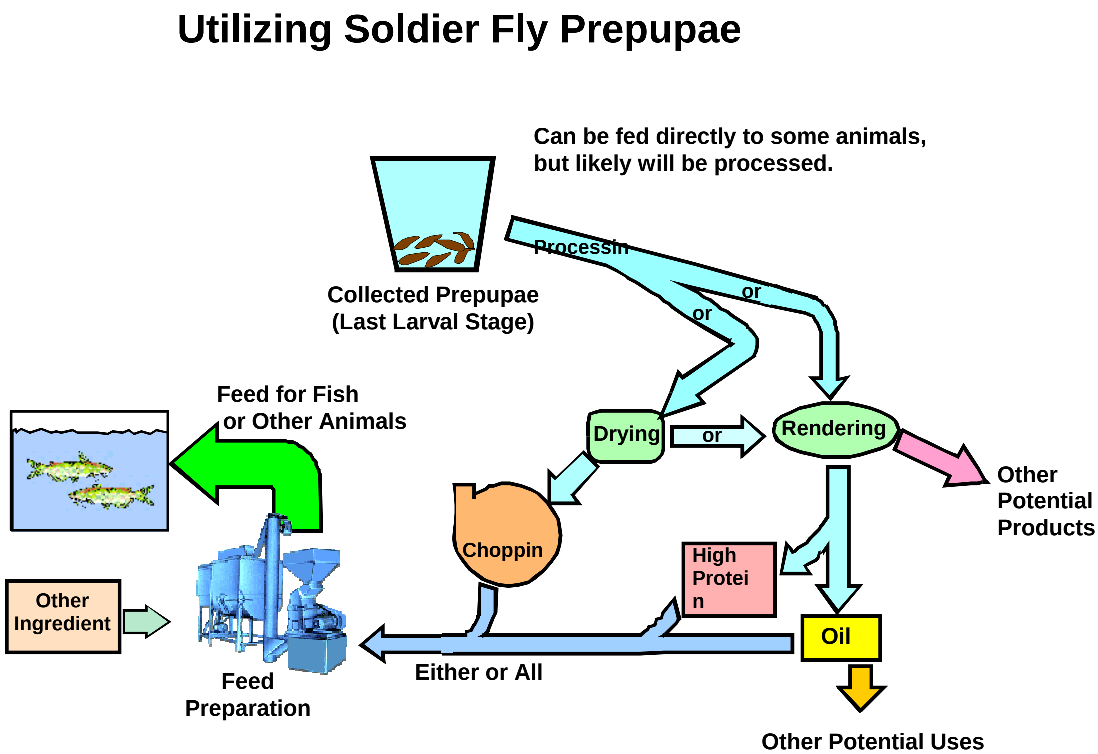

Figure 2. Black Soldier Fly (*Hermetia illucens*)

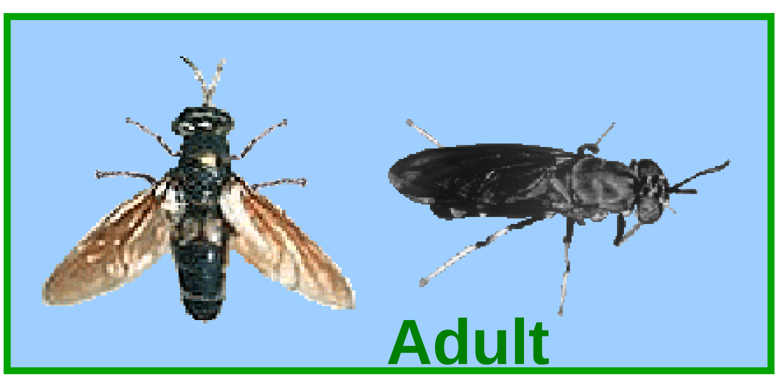

Figure 3. Soldier fly prepupae growing in a pilot-scale facility.

Figure 4. Catfish feeding.