With the increase of the fishmeal and soybean prices over the last decade, insect proteins have become a focus of research into novel alternative livestock feed ingredients. While several insect species have been investigated, the Black Soldier Fly (BSF; Hermetia illucens) remains one of the most credible options.

BSF, generally considered as a non-pest species, is distributed almost worldwide since the Second World War and is not known to carry any pathogenic agents, unlike the common housefly (Musca domestica).

The larvae can grow quickly and have an excellent feed rate. They can consume 25-500 mg of fresh matter/larva/day and feed on a wide range of substrates ranging from manures to food waste. A grow-out cycle takes 15 days to an average larva weight of 0.25g under optimal conditions (30oC) and the substrate/ waste load reduced by up to 70 percent (dry matter basis). The maggots have also been shown to remove pathogenic bacteria, reduce waste odours and to inhibit nuisance housefly oviposition; all valuable secondary sanitation outcomes.

The larvae have a high nutritional value; contingent on the substrate they were bred on, with crude protein levels ranging from 28 to 48 percent, and lipid levels from 12 to 42 percent. With the exception of omega-3 fatty acid, the lipid profile is broadly similar to fish meal and potential exists to augment fatty acid through the use of an appropriate feeds e.g. fish-offal. The essential amino acid profile of the insect meal meets the broad requirements of tilapias simplifying dietary formulation requirements.

Tilapia are widely cultured in the tropical and subtropical regions of the world and constitute the third largest group of farmed finfish after carps and salmonids. To date only four studies have been published on the evaluation of BSF meal on tilapia growth and production outcomes.

Some of the earliest work by Bondari & Sheppard showed disappointing results. In 1981, they demonstrated that the growth rate of Blue tilapia (Oreochromis aureus) in polyculture with catfish, when fed diets containing 50-75% and 100% fresh soldier fly larvae over a 10-week period was comparable with control fish fed with commercial diets. The complex design of the experiment made interpretation of the results problematic however as it was impossible to control for different and possibly competitive feeding behaviours of the two species. A second trial in 1987, found that a monoculture of tilapia fed chopped or whole larvae ad libitum severely depressed fish growth compared to standard diet.

Use of fresh (rather than dry) larvae by the authors also raises issues around potential commercialisation. First, fresh larvae reduce the dry matter and protein intake compared to a "dry" diet. Secondly pre-pupae were used, as it is the easiest larval stage to collect because of their wandering and "self-harvesting" behaviour prior to pupation; at this stage they bare insensitive to light.

However, they have a highly elevated chitin content; an almost-indigestible sugar and the main constituent of insect "skin". Younger white-coloured larvae have negligible chitin content and are correspondingly more digestible, but efficient harvesting from feed-substrates is much more challenging due to light avoiding behaviour. This results in a requirement for mechanical separation of younger larvae from the substrate.

Comparisons between these and other studies are complicated by a range of experimental design factors. Ogunji et al. (2008) used a dry, low-protein maggot meal (28.6% DM basis) and reported that the fish growth was significantly lower than the fishmeal fed fish for the treatments containing 150 and 300g/kg maggot meal. However, the dietary formulation method employed resulted in neither a non-isonitrogenous nor iso-caloric diets, making them hard, if not impossible, to compare.

A more recent study on Nile Tilapia (Devic et al. 2017) used the white larvae dry meal to formulate isonitrogenous and isoenergetic diets with maggot meal inclusions at 0, 30, 50 and 80 g/kg substituting gradually three conventional expensive feedstuffs: fish meal, fish oil and soybean meal. Results showed no significant difference in growth parameters (final weight; weight gain and SGR), feed utilization efficiency (FCR and PER and feed intake) between treatments. Similarly fish whole body composition (dry matter, crude protein, lipid, ash and fibre) was unaffected by the treatments except the fatty acid compositions which mirrored that of the diets.

Thus, the study confirmed the substitution potential of BSF white maggot meal as a potential replacement for other commonly used dietary protein sources with respect to biological (if not economic) performance.

The same authors (in 2014) went on to estimate that BSF substitution of 30 percent of the fish meal used in cage-farm producing 6000 MT/pa of tilapia would respectively require1.4 MT, 60.8 MT and 175.5 MT of dry maggot meal to produce the requisite amounts of broodstock, juvenile and food fish respectively.

However, while the technology is still in development, scaling up the production remains a major challenge. The main constraints addressed at the moment, beside obvious automatisation technology yet to develop, are the use of a suitable, consistent (quality and availability) low-cost substrate and the harvesting of the white larvae from the substrate.

At the moment, the BSFML is not yet commercialised, but considering its potential value, its use should be targeted toward high value stages, such as fry-feed or high value species. Recent trials on poultry demonstrated its efficiency: in a study published this year by Wallace et al. the body weight gain significantly increased in guinea fowl fed with incremental Black Soldier Fly substitution diets, compared to the control group fed with a fishmeal based-diet. Their health was significantly improved by this substitution, opening the door to a potential immunomodulatory-feed, yet to be demonstrated in fish, or other livestock species.

While this technology is still in its infancy, there is a real potential market in low income countries, where organic waste remediation and lack of reliable and cheap proteins sources are often issues to overcome. In that optic, if a proper separation process of the waste is taking place, and if the technology takes the move forward, the BSF larvae could be effective agents to convert these into a sustainable and local source of high value protein, creating at the same time employment, and reducing the environmental hazard posed by organic waste disposal.

However, in Europe –or even the Western world- the situation is different. Beside a change of legislation recently (EU Regulation2017/893–1st of July 2017) insect meal can only be produced on vegetable substrates and unprocessed former food, restraining the potential substrates to wastes already valorised by the livestock feed sector. In addition, at the moment, insect protein can only be used for pet food and aquaculture, but not poultry nor piggeries. The extension of the authorisation is currently in discussion, and might extend next year to other livestock feed, and allow a wider range of substrates, potentially making it cost-effective.

The production of insect meal, even if there are no additional effects such as probiotic or other functional effects, could only be sustainable and logical if the bugs are produced on low value substrates which currently incur cost for disposal. Their role is therefore best viewed as a component of a circular economy through upcycling waste. In the meantime, further research is required to unlock the potential of Black Soldier Fly meal, as a local and cheap feed ingredient for aquaculture.

Further reading

Devic E., Leschen W., Murray F.J., Little D.C., 2017. Growth performance, feed utilization and body composition of advanced nursing Nile tilapia (Oreochromis niloticus) fed diets containing Black Soldier Fly (Hermetia illucens) larvae meal. Aquaculture nutrition. DOI 10.1111/anu.12573

Barroso F.G., De Haro C., Sanchez-Muros M.J., Venegas E., Martinez-Sanchez A., Perez-Banon C., 2014. The potential of various insect species for use as food for fish. Aquaculture. 422-423:193-201p.

Bondari, K. and Sheppard, D.C., 1987. Soldier fly Hermetia illucens L., as feed for channel catfish, Ictalurus punctatus (Rafinesque), and blue tilapia, Oreochromis aureus (Steindachner). Aquaculture and Fisheries Management. 18: 209-220.

Maquart P.O., Murray F.J., Newton R.W., Leschen W.A., Little D.C. Potential for commercial scale insect-based transformation of organic waste for aquafeed and crop production in Ghana. PhD conference. University of Stirling, Scotland. 22 February 2015. Poster

Want to know more about insects as feed?

Makkar H.P.S., Tran G., Heuzé V., Ankers P., 2014. State of the art on use of insects as animal feed. Animal Feed Science and Technology. 197:1-33.

Wang Y-S. & Shelomi M., 2017. Review of Black Soldier Fly (Hermetia illucens) as animal feed and human food. Foods. 6(10): doi:10.3390/foods6100091

Kenis M., Koné N., Chrysostome C.A.A.M., Devic E., Koko G.K.D., Clottey V.A., Nacambo S., Mensah G.A., 2014. Insects used for animal feed in West Africa. Entomologia. 218(2): 107-114.