Recycling Manure and Food Waste by Use of Concentrated Insect Feeding Operations (CIFOs)

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Dairy farms, hog farms, and "concentrated animal feeding operations" (CAFOs) create massive quantities of manure that must be handled, stored, and disposed of. Ironically, we believe that the best way of utilizing this resource is to create a new type of CAFO: Concentrated Insect Feeding Operations, or "CIFOs". CIFOs are essentially large-scale bio-converters that feed organic wastes such as manure and food waste to massive numbers of insect larvae. These larvae convert this feed material into high-value protein, edible oils, chitin, and a reduced volume of residual material ("frass"). The total reduction in residual N-P-K resulting from this process can be as much as 80%, 75%, and 79% respectively.[1]

Our proposed CIFOs utilize the larva of the Black Soldier Fly (*Hermetia illucens*) (BSFL), a well-characterized non-pest insect that is native to the southern United States. But while the idea of using black soldier flies for manure and food waste recycling has been around for decades, the technologies, operating models, and business models that we have been developing can make it truly practical on an industrial scale in temperate climates. Whereas large BSFL operations have traditionally required massive surface areas maintained at temperatures of 70°-80°F and elaborate breeding operations, our approach makes it possible to grow massive numbers of BSFL in a small fraction of the space while eliminating the need for local entomology expertise and on-site breeding facilities entirely. The CIFO approach is completely scalable; handling more waste material is largely a matter of adding additional larval feeding bins. From a business perspective it can be implemented either as an add-on to current pig, dairy, cattle, or poultry operations, or as a separate independent business run by local entrepreneurs. Either way, the net result is that large quantities of organic waste material are converted to highly salable agricultural and industrial feedstocks such as insect protein, edible oils (which may be converted to biofuels), chitin, and organic fertilizer.

CIFOs offer considerable environmental benefits as well. Microbial degradation of food waste and manure generates enormous quantities of greenhouse gasses as they metabolize complex proteins and carbohydrates into carbon dioxide, methane, nitrous oxide, and water. Excess NPK often leaches into ground water. In contrast, BSFL recycle a large percentage of the organic nitrogen, phosphorous and carbon into edible proteins, oils, and chitin, thereby preventing their conversion into greenhouse gasses and groundwater contaminants. Because BSFL produce a high-quality animal protein similar to fish protein they can be used as a partial or complete replacement for fishmeal in many applications, thus reducing pressure on ocean stocks of wild fish. With respect to potential pathogens, BSFL have been shown to reduce counts of E. coli and Salmonella in animal waste by 6-8 $\log_{10}$.[2,3,4] Finally, BSFL rapidly attenuate odors originating from organic wastes, drive away competing insects such as house and stable flies (reducing populations of house flies in pig and poultry manure by 94%-100%), and reduce the solid mass of waste material by nearly 60%.[5,6]

The best part is that CIFOs have the potential to be good business for everyone. The products and services that can be created by the mass production of black soldier flies grown on food waste and manure fit into six separate multibillion dollar markets: waste management, aquaculture feed, animal feed, chitin and derivatives, edible oils and organic fertilizers.[i] Together, these markets total over $290 billion. Numerous studies have demonstrated that BSFL-based feeds produce excellent results in fish, pigs, and poultry.[7] Potential investors and commercial partners include food and protein companies, feed manufacturers, clean energy concerns, users of industrial commodities such as edible oil and chitin, and fertilizer operations. With economies of scale in manufacturing the equipment needed, we believe that CIFOs should be able to achieve a return on investment of between 11%-19% per year (EBITDA), with a capital cost recoupment time of 5 years.

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[i] Chitin is a nitrogen-containing polysaccharide chemically related to cellulose that constitutes the primary component of insect shells. Chitin-derived products are a $63 billion per year business. (http://aquapreneur.com/issue-12/by-year-2015-global-market-for-chitin-derivatives-expected-to-reach-63-billion-global-chitosan-market-could-exceed-21-billion/) Insects produce a low molecular weight chitin that could be easily converted to high-value chitosan and glucosamine.