ECONOMIC FACT SHEET

EDIBLE INSECT FARMS

The CRETAU (Carrefour de recherche, d'expertise et de transfert en agriculture urbaine) is driven by AU/LAB (Laboratoire sur l'agriculture urbaine). AU/LAB is a research, training, innovation and action space that serves the community, making it possible for professionals, citizens, researchers, decision-makers and entrepreneurs to collaborate on the subjects of urban agriculture and food. A not-for-profit organization, the laboratory is a national and international site for action and reflection on urban life and food. Based on a wealth of expertise and more than 10 years of experience, AU/LAB ensures that proposals, initiatives and enterprises concerned with both production and processing as well as distribution and marketing of urban agriculture emerge. The laboratory acts in view of participating in the development of an urban food system, of sustainable urban planning and of a circular economy within cities.

Carrefour de recherche, d'expertise
et de transfert en agriculture urbaine
CRETAU

1401 Legendre Street West, Office 305
Montréal, Quebec
H4N 2R9
cretau.ca

WRITING AND RESEARCH

Adeline Cohen
Coordinator, Economic Research and Accompaniment
CRETAU

DIRECTION

Éric Duchemin
Scientific and Training Director
CRETAU

REVISION

Marie-Josée Vézina, Agronomist
Coordinator, Agronomic Research and Support
CRETAU

Grant Vandenberg
Professor
Université Laval

TRANSLATION

Translation by Guylaine Leclerc, certified translator, was made possible by the Government of Canada.

Funded by the Government of Canada | Canada

To quote this text

Cohen, A. and E. Duchemin (2020). Economic fact sheet – Edible insect farms. AU/LAB (Laboratoire sur l'agriculture urbaine)/CRETAU (Carrefour de recherche, d'expertise et de transfert en agriculture urbaine) 34 p.

ACKNOWLEDGEMENTS

We wish to thank Sandra Barreto from Éco-Protéine, Kubo Dzamba from Third Millennium Farming, Alexis Fortin, Louise Hénault-Ethier, Didier Marquis, Étienne Normandin and Guillaume de la Rochelle Renaud from TriCycle, Peyman Lord from P&A Cricket Farming and David Mellett from Little Food for taking the time to discuss with us to present their projects in the case studies.

We especially wish to thank Louise Hénault-Ethier from TriCycle, for having participated in the design of the data collection grid for economic data from the producers. We also wish to thank the enterprises that have shared their economic data to allow us to create indicators for set-up costs, operation costs, and revenues from urban insect farms and the AETIQ (Association des éleveurs et transformateurs d'insectes du Québec) for having participated in the identification of the Quebec sector of insect farmers.

Study participants having accepted to be identified:

ÉCO-PROTÉINE INC. | TriCycle | vitrine EntoTechnologique

Photo credit p. 34: C-A Mathieu B. Morin

FOREWORD

This fact sheet was created to guide persons who wish to launch a farm project to rear insects or decision-makers and financial institutions who wish to support this type of farm project.

Based on business case analyses as well as on data collected from numerous insect producers, in various contexts, this fact sheet supplies basic information on the potential costs of establishing and operating such a farm operation. They are guidelines as numerous factors can influence a project's final costs or the operation costs, which are exceedingly difficult to predict. The data was collected in 2019 from 6 operations.

This fact sheet is part of a series of economic fact sheets aiming to create an economic framework for the development and implementation of urban farms. This series is in addition to other work done by the CRETAU more specifically on the establishment of urban farming businesses, on the ecosystemic services of urban farms (economic value for the city) as well as the economic impact of commercial urban agriculture.

TABLE OF CONTENTS

EDIBLE INSECT FARMS

The rearing of edible insects has been arousing interest since the FAO's publication in 2013 on the prospects of edible insects for food security and animal feed[1].

Many studies estimate that the global market for edible insects could be worth up to US$410 million[2]. Projections vary between $520 million and $1.2 billion by 2023[3], and up to $8 billion by 2030[4]. According to the studies, the market should experience a steady increase of 20% over the next 5 years[5].

In September 2019, the European insect farming enterprises had raised investments of more than US$670 million and they plan to raise more than US$2.5 billion by 2025[6]. Thus, Ynsect, a French mealworm farming enterprise, has raised US$125 million in 2019 for its development.

Since 2013, the number of insect farms in North America and Europe has seen an important increase. We have documented more than 89 enterprises, including 26 enterprises in Canada and 19 in Quebec[7]. This increase can be seen for farming operations for human consumption as well as those for animal feed (Figure 1). It is also materializing in Europe and North America, although the increase is more important in Europe (Figure 2).

On the 89 enterprises identified in 2020, 33 are in urban environments, 14 in urban perimeters in small towns and 12 in peri-urban areas. The others are in rural areas (zoned for agriculture). Almost 65% of operations are therefore located in urban areas. In Quebec, 63% are in an urban area. Other than a favourable context related to being close to the markets, the presence of insect farms in urban environments can be explained by the will of many entrepreneurs who promote these projects, to enter in a food circular economy while at the same time offering a protein-rich product with a low environmental impact. The farms often establish themselves close to food sources (organic residues from enterprises in the food sector) and processing industries.

[1] Van Huis, A. et al. (2013). Edible insects: Future prospects for food and feed security. Food and Agriculture Organization of the United Nations. FAO Forestry Paper, No. 171.

[2] Grand View Research. (2019). Edible insects market size, share & trends analysis report by product (Beetles, Cricket), by application (Powder, protein bars), by region, and segment forecasts, 2019 – 2025.
Statista. (2018). Forecast market value of edible insects worldwide from 2018 to 2023.

[3] Research Nester. (2019). Edible insect food market: global demand analysis & opportunity outlook 2023.
Statista. (2018). Forecast market value of edible insects worldwide from 2018 to 2023.

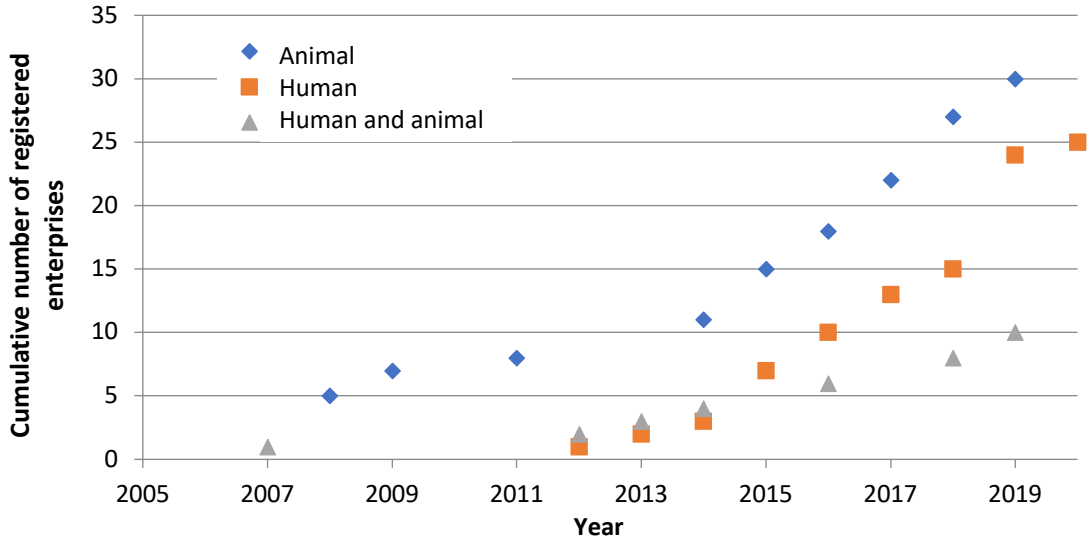
[4] Meticulous Research. (2019). Edible insects market by product type (whole insect, insect powder, insect meal), insect type (Crickets, Black Soldier Fly, Mealworms), application (animal feed, protein bar and shakes, bakery, confectionery, beverages) - Global forecast to 2030

[5] Meticulous Research (2018): https:// www.meticulousresearch.com/edibleinsects-market-2023

[6] International Platform of Insects for Food and Feed. (2019). The European insect sector today: challenges, opportunities and regulation landscape.

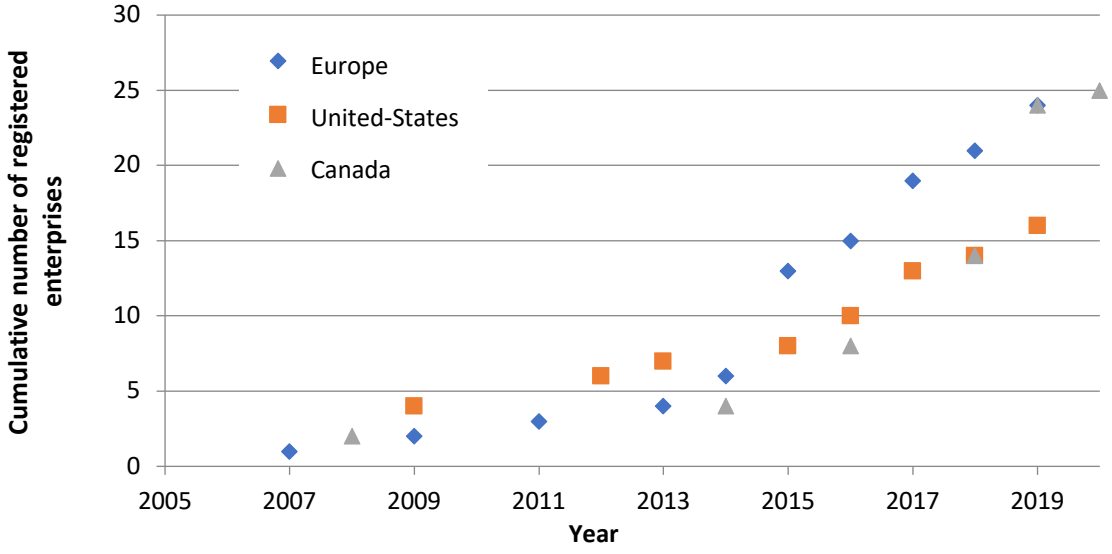
[7] A special effort was made to identify Quebec enterprises in this sector. It is therefore likely that we underestimate the number of projects in the rest of Canada. The AETIQ was one of the sources.

Figure 1. Growth per market type of the number of insect farms in North America and Europe between 2005 and 2020.



Note: we were only able to get start year data for 65 of the 89 enterprises.

Figure 2. Growth per geographic area of the number of insect farms in North America and in Europe between 2005 and 2020.



Note: we were only able to get start year data for 65 of the 89 enterprises.

The sector's development has been accompanied by numerous changes, namely the closure or takeover of many of the pioneering enterprises. In Canada, most operating enterprises were created

between 2017 and 2019. Eight enterprises created between 2008 and 2016 are still in operation, 6 were established in 2018 and nine enterprises were created in 2019. However, for some kinds of recently established enterprises, their research and development (R&D) activities started almost 15 years ago.

At the beginning of 2020, on the 89 enterprises identified in Europe and North America, 42 produce for animal feed, 36 for human consumption and 11 for both human and animal consumption. In Quebec, half of the farms target human consumption and 5 exclusively target animal feed, the others target both markets.

The 3 most common kinds of insects reared by these operations are the cricket, mealworm, and black soldier fly. Because of the production costs, crickets and mealworms are mostly intended for human consumption while the black soldier fly is exclusively intended for animal feed.

THREE MAIN KINDS OF INSECTS REARED

Historically, insect producers were mainly focused on reptile and domestic fish feed as well as fishing. This is less the case with the new enterprises. The development of new farms is concentrated on 3 types of insects.

Cricket

On the 89 identified enterprises in North America and in Europe, 42 rear crickets. In Canada, 13 enterprises rear this insect. More than half of the start-up enterprises rear crickets for human consumption, however, producers benefit from the possibility of selling this insect on the pet feed market. Crickets are reared more often in urban areas compared to other insects.

The disadvantages of the rearing of this insect include more sensitivity to the rearing environmental parameters that can create production losses and additional labour costs in part due to a lack of automation in current farms, a larger production space and the need for a higher temperature.

Cricket (*Acheta domesticus*). Photo credit: Sandra Barreto (left) and Adeline Cohen (right)

Mealworm

Among the identified enterprises, 35 rear mealworms (*Tenebrio molitor*). One third of the enterprises target their production for human consumption, one third focus on the animal market and the last third on the 2 markets. Almost 40% of operations are in urban areas. In Canada, we have identified 12 enterprises that rear this insect.

The mealworm's main advantage is the ease with which it is produced. It is tolerant to environmental conditions, can adapt to various types of food, and needs little space for its production and reproduction. The possibility of targeting the production to the 2 markets—human consumption and pet feed—generally appears as an advantage.

Giant mealworms (*Zophobas morio*), raised in a similar fashion, also raise producers' interest.

Mealworm larvae (*Tenebrio molitor*). Photo credit: Sandra Barreto.

Black soldier fly

Among the identified farms, 27 rear the black soldier fly. The entrepreneurs wager on this insect to feed pets, for aquaculture, poultry farming, and ultimately for livestock feed. However, to feed animals other than pets, the enterprises need to be certified by the Canadian Food Inspection Agency.

This insect is not raised for human consumption. In comparison with other insects, these farms are most often found in rural or peri-urban areas. In Canada, we have identified 3 enterprises that rear the black soldier fly. However, only 2 companies have currently been certified by the Canadian Food Inspection Agency for livestock feed.

The main advantages of the black soldier fly include a rapid life cycle and an ability to consume numerous kinds of residual wet organic matter (between 60 and 75% humidity) and its great efficiency for food conversion.

The quick life cycle of the black soldier fly is also a disadvantage as it limits the possibility of delaying operations. The obligation of using aviaries for their reproduction, which complicates raising operations, is also a limitation to the rearing of this insect.

Black soldier fly larvae (*Hermetia illucens*).

SOCIAL ACCEPTANCE FOR INSECT CONSUMPTION

Accepting insects in the regular diet is one of the issues for the sector's development. Insects are not part of Québécois or Canadian culinary habits and many people remain reluctant to eating them. However, with producers' awareness raising and the development of environmental consciousness, a larger number of consumers are interested in or are ready to test the products.

In a survey of a population[1] aware of the existence of entomophagy in Quebec and Canada, researchers have shown that this customer base is more inclined to consume processed insects (in flour, for example) rather than a product where the insect can be recognized[2]. This same study also demonstrates that these target consumers would prefer, when the insect is identifiable, to consume mealworms rather than crickets. As far as insect flour goes, whether it is one or the either does not matter.

They are also sensitive to the production's environmental value (recycling of organic matter through the farm). The fact that a producer has an environmental action is an incentive for them. This highlights the importance for producers to emphasize and demonstrate their production's environmental impact.

[1] 90% of the surveyed population had already heard about entomophagy and 50% of them were ready to consume insects, [2] Marquis, D., Hénault-Ethier, L., LeBel, J. & Vandenberg, G.W. (2018). "Acceptance of entomophagy amongst Canadians". Joint annual congress of The Entomological Society of Canada and of the American Entomological Society of America, Vancouver Convention Centre, November 11, 2018.

OTHER ACTIVITIES RELATED TO INSECT FARMING

Involvement in a circular economy

An advantage of an urban or peri-urban insect farm is the possibility of adding organic residues in the insects' feed, making it possible to reclaim this waste that would otherwise be handled by the municipalities. Depending on the production, it is possible to reclaim different organic residues. The black soldier fly is the insect that is most likely to accept a variety of organic residues while crickets are the most demanding in terms of their feed. Mealworm and black soldier fly farmers use fresh organic residues (from a fruit and vegetable distributor or from a restaurant's kitchen, for example). Cricket farmers also do so, but less often. This method tends to become a prized source of reclaimed food for the cricket and mealworm producers to reduce their production costs.

The management of organic residues to feed insects requires high labour time for regular pick ups, as well as investments to refrigerate the fresh residues or to dehydrate them. However, it allows to reduce the cost of feed purchases for the insects. The use of residues requires that partnerships be developed with surrounding enterprises that have a regular and homogeneous production of available residues. However, only organic residues from specialized food processing enterprises (e.g. mushroom producers, flour mills, bakeries, microbreweries) or organic residues of the "pre-consumption" type from food stores and restaurants are likely to supply reliable sources to feed insects for human consumption. The enterprises must be able to demonstrate the traceability of the organic inputs as well as their chemical and biological safety, and the advantageous nutritional value for the farm.[8, 9]

Frass reclamation

Insect farming also makes it possible to reclaim a farming by-product—frass—composed of organic residues, feces and insect exoskeletons. Frass attracts researchers' interest as studies show that it has an interesting nitrogen, phosphorous and potassium content. Furthermore, for the mealworm, the properties that favour the development of microorganisms that promote plant growth can be found in the frass.[10] This fertilizer arouses interest for some gardeners and numerous enterprises which are trying to develop this market. In Canada, market authorizations are done on a case-per-case basis. Enterra Feed commercializes frass for gardening and agriculture.[11] in Europe, the IPIFF has emitted recommendations to harmonize European regulations for the commercialization of frass as an animal-based fertilizer for agriculture.

[8] Cabrera, P., Hénault-Ethier, L., Lefebvre, B., Tchuam-Tchouwo, A. (2015). La faisabilité des élevages d'insectes pour la consommation humaine ou animale en milieu urbain.

[9] Hénault-Ethier, L. et al. (2017). Les insectes au service de l'humain pour la gestion des résidus organiques. Vecteur Environnement. pp.46-53.

[10] International Platform of Insects for Food and Feed. (2019). Contribution paper on the application of insect frass as a fertilising product in agriculture.

[11] According to the enterprise's website : https://enterrafrass.com (April 2020).

REGULATIONS

Regulations regarding the production and sale of edible insects varies depending on the insects' destination — consumption by humans, farm animals or pets — and are operated at the federal and provincial levels[12]. At the municipal level, zoning regulations can also interfere in the establishment or the operation of an insect farm.

Crickets and mealworms for human consumption are considered as food according to Canada's Food and Drugs Act. If it cannot be demonstrated that the insect has a history of being consumed without danger or if the insect is derived from biotechnology, it is considered a new food and notification must be made before it is released to market. As far as labelling of allergens, insect products are not specified in the last amendment of the 2011 Canadian regulation. However, insect producers often include on their packaging a warning for consumers allergic to shellfish.

According to Quebec's Regulation respecting food, rearing farms need a permit for sale to retailers or restaurants, but wholesale sales can be made without a permit. For human consumption, farms must respect the regulation that defines production and processing standards for food processing, and especially the hygiene and traceability regulations.

Insects for farm animals are considered as new food according to Canada's Feeds Act. The registration of insect products is currently done on a case-by-case basis to characterize the risks, the processes and the efficiency specific to various farms. The Canadian Food Inspection Agency is currently working on the generalization and harmonization of regulations that will make it possible in the future to simplify sales. This restriction does not apply to farms intended for pet feed. For Quebec, the Food Products Act and the Animal Health Protection Act do not regulate feed manufacturing for pets and farm animals made from insects. However, the Animal Health Protection Act prohibits to feed to animals intended for human consumption, feed unfit for animal consumption. Thus, although the enterprises that manufacture this type of feed do not need to get a permit from the government of Quebec, the manufacturers of meat-based feed for pets and the enterprises that wish to manufacture medicated feed must get one.

[12] Source: Lähteenmäki-Uutela, A. et al. (2017). Insects as food and feed: Laws of the European Union, United States, Canada, Mexico, Australia, and China. *European Food and Feed Law Review, 12 (1), 22-36.*

KEY PARAMETERS TO LAUNCH AN INSECT FARM IN AN URBAN ENVIRONMENT

Development of a minimal stock appropriate for operation and supply

One of the first challenges of insect farming is the creation of a minimal stock for the farm's operation. The size of the stock must match the space and production equipment, but also the insects' food supply and the farm's processing and conservation capacity of the product (frass, dried, frozen or processed into flour insects).

Proximity of reliable and adapted sources of organic matter

Establishment in urban and peri-urban areas is generally accompanied by the identification of sources of organic matter available to feed the insects. Some enterprises, such as Enterra Feed, have chosen their operation place based on the proximity of available feed sources. Others have developed partnerships with processing enterprises or neighbouring urban or peri-urban vegetable farms.

Research is, however, still necessary to characterize the health hazards and the processes that increase the safety of residual organic matter sources adapted to the farm, as well as to understand the conversion rate of each kind of organic matter available on the market.

Raising awareness of customers and partners

Most entrepreneurs spend part of their work time raising customers' awareness about products made from insects, whether it be during fairs, specialty events or in farmers' markets. Although the market is still a niche, the presence of entomophagy in the media and the availability of products in grocery stores contribute to customers' initiation. The environmental argument and the advent of new food trends (e.g., flexitarian, paleo diet) are incentives for the market's development.

Awareness is also necessary for the various business partners to recognize insect farming as livestock production. A special approach must be taken with landowners to facilitate the acquisition of an urban lease.

Decrease in prices and market development

The sale prices for products made of insects must be reduced in the coming years to be able to compete with other protein sources, both for human and animal consumption.

To feed farm animals, the current sales price for proteins from insects remains higher than equivalent protein sources. However, the instability of world prices of farming feed is an advantage for insect producers. Since it is carried out in a controlled environment, insect production can offer a more stable price.

For human consumption, the sale price of products made of insects remains high and is still unable to answer basic food needs. These products are currently considered as a niche market. Furthermore, insect meal buyers for processing ask for a low price that the small farms (so most current enterprises) have a hard time supporting financially.

Generally, the market must continue to develop, through research, optimization of space and operations—including through automation—and by raising customers' awareness.

CASE STUDIES

This section presents various cases, which, each in their own way gives information on the viability model of an urban insect farm and that illustrates the key parameters of a project that will work.

THIRD MILLENNIUM FARMING


P&A Cricket Farming farm, the first enterprise in Third Millennium Farming's network. Photo credit: Adeline Cohen

Third Millennium Farming is a private enterprise established in 2016 by an architect who has been researching the potential of urban insect farming since 2007. The company's objective is to make cricket farming part of the urban agriculture landscape by promoting its multiple applications: human food, animal feed, and plant fertilization.

In 2019, the enterprise entered a partnership with a second enterprise, P&A Cricket Farming, to develop a network of urban cricket farms.

Production

The 2 farms are in neighbouring units in a commercial area of the Greater Toronto Area. The pilot farm is used as the testing ground for innovation in food production. The second 150 m^2 farm is dedicated to production and uses the latest knowledge in cricket farming.

Insects are raised vertically in 30 cm tall containers with lids. P&A Cricket Farming will include 400 compartments at full capacity, producing 11 million crickets per year. Both farms produce crickets that are sold alive or frozen with no further processing.

Distribution

The frozen production is distributed to a processor for human food, while for the live production, the enterprise targets 10 to 12 regular clients for the tropical pet market (e.g. for lizards, fish and spiders).

Economic model

Three staff are employed by Third Millennium Farming in addition to the owner. Labour time is divided between production, commercialization, and R&D. Relatively little time is dedicated to procuring feed for the insects, as the crickets are fed a mix of poultry grains purchased from the animal feed industry.

While the main objective is to produce a high-quality cricket product for human consumption, the company today sells a large portion of its live production to the pet market to remain viable. The high sale price of the live insect market is supporting R&D costs while the price of edible insects remains lower. The space also includes a workshop for the development of custom-made farming equipment that is sold to other farms.

Third Millennium Farming is also involved in research projects to support the development of a frass market. This farming by-product has a great potential because of its fertilizing and growth stimulating properties.

It was a deliberate choice not to rely on grants for the enterprise's development to demonstrate the viability of its economic model without external sources of revenue. The owner has greatly relied on personal investments to cover the set-up and innovation costs. Third Millennium Farming received a $45,000 loan from Futurepreneurs, and research grants from SR&ED and NSERC in collaboration with Perdue University and Humber College.

Moving forward, Third Millennium Farming intends to function on a mixed revenue model from research and consulting and will specialize in cricket egg production for the network of farms that the enterprise plans on developing.

TRICYCLE


Farming and processing of mealworms by TriCycle - Photo credit: Mathieu B Morin (left) and Nicholas Damato (right)

TriCycle is a private enterprise established in 2019 after 3 years of R&D in a pilot farm. This enterprise with an educational and commercial purpose is dedicated to the development of best practises and wishes to participate in a circular economy and contribute to the makeover of Montréal as a food ecosystem. Its model farm is a technology showcase for the MAPAQ that is trying to demonstrate the technological feasibility and economic viability of the enhancement of local food residues in a real enterprise context and ensure knowledge transfer toward sector stakeholders. The mealworms raised in its premises are mainly intended for human consumption to help them discover the benefits of entomophagy.

Production

The enterprise rears mealworm larvae in a controlled atmosphere in a 128 m^2 space located in the Centrale Agricole, a Montréal-based cooperative that unites urban farm producers, processors, and distributors. It was possible, in the first year, to develop the stock in 1,200 rearing containers able to produce at full capacity 3.8 tons of fresh insects per year and 19.2 tons of frass.

Distribution

Commercialization started with the sale of dehydrated, whole, or powdered insects to food processing enterprises, institutions, and restaurants or directly to customers through retailers or on-line sales. Occasionally, the insects are sold fresh, parboiled then frozen, or in a live format. Part of the insects are intended for animal feed or to supply other insect farmers. The mealworm frass is commercialized as a

special fertilizer and is mainly intended for individuals through retailers and on-line sales or to public institutions and the farming sector through wholesale.

Economic model

The enterprise is managed by 5 shareholders. A bit less than half of the labour time is dedicated to research while the remaining time is shared between farming activities, the development of business partnerships and the promotion of entomophagy. The enterprise also offers R&D and accompaniment services to numerous Quebec farmers and processors. It also regularly hosts interns and employees in insertion.

TriCycle benefits from an affordable rent as well as access to the Centrale Agricole's shared infrastructure, such as a washing room, offices, a commercial kitchen, and a freezing room. The enterprise has developed privileged relationships with local enterprises and coordinates the recuperation of residual organic matter such as the pulp from fruits and vegetables, mushroom mycelium, residues from cocoa, coffee, and brewery spent grains. This can reduce the costs of inputs while reclaiming its partners' waste. The residual organic matters are collected and distributed fresh to the insects and a part is dehydrated and ground at the Centrale Agricole.

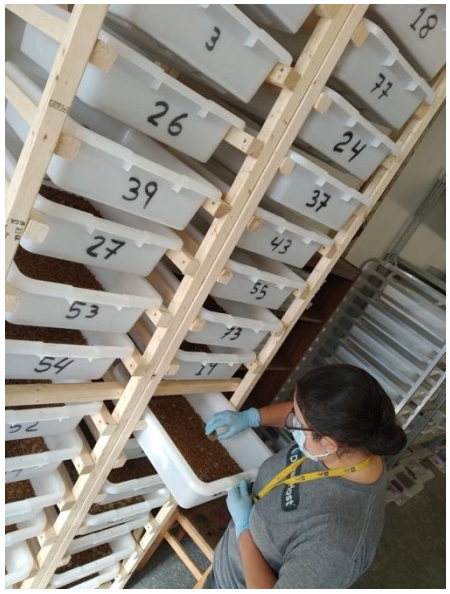
TriCycle obtained $305,000 in financial support in the form of grants and awards mainly for research and technological transfer. The enterprise also benefits from a rich network of experts and mentors. Numerous research activities concerning both the development of farming processes and market development are carried out simultaneously with Laval and Concordia universities, École de Technologie Supérieure, Cégep de Saint-Jean-sur-Richelieu and CCTT Agrinova thanks to academic funding from FRQNT, NSERC and Mitacs.

The enterprise is also funded by the Quebec-Canada Agricultural Partnership to coordinate the Vitrine Entotechnologique with the CRETAU and Université Laval. This grant funds the part of the operations that is critical for the dissemination of scientific knowledge and for technological transfers with the Quebec insect farmers.

In the future, TriCycle wishes to scale its farming activities to 560 m^2, to support diversified professional insertion, to become a supplier of quality larvae and of adapted equipment for Quebec farmers and to contribute to the development of new products intended for animal feed.

ÉCO-PROTÉINE





Éco-Protéine's cricket farm Mealworm farm Photo credits: Sandra Barreto

Éco-Protéine is an enterprise established in 2019, however, it emanates from an idea that was thought more than 20 years ago. The research started in 2007 in the basement of a private house. The enterprise's objective is to develop high-quality insects and processed products for human consumption.

Production

The farm includes 3 types of insects: crickets, mealworms, and more recently, giant mealworms. Pre-installation research has allowed to develop ideal conditions for the coexistence of the 3 insects in an 89 m^2 space in the Centrale Agricole. The farm has 150 cricket compartments and 130 for mealworms. R&D is carried out in 25 compartments with giant mealworms.

The insects eat a combination of dry and wet food and the enterprise is operating at full capacity since April 2020.

Distribution

Because of the enterprise's youth, the production is not yet distributed. The current sale price of wholesale insects is unfavourable, and the enterprise is targeting the processed products market. Research is currently underway for the development of hamburger and protein bars.

The development of processed products is carried out in the Centrale Agricole's shared space as well as at the Centre de valorisation de l'aliment de l'Estrie. Among other things, the enterprise shares a dehydrator for the development of protein extracts, a commercial kitchen for the development of protein bars and equipment for the industrial production of hamburgers.

Economic model

Éco-Protéine is a family business lead by one full-time person and the volunteer support of a family member.

The Centrale Agricole offers affordable rent and the possibility of benefiting from shared equipment which limits initial investment and operation costs, while complying with farming and processing regulations. Equipment access represents a small part of the rent.

The enterprise is negotiating with numerous potential customers for the sale of its processed products. Éco-Protéine is also working to reduce its feed costs by developing local partnerships to recuperate clean organic residues.

The enterprise's material investments are to this day less than $10,000. However, labour investments are important and currently covered by the family's personal revenues. A total of $20,000 and enterprise management support were obtained from Emploi Québec's Support for Self-Employment program.

LITTLE FOOD

Little Food's cricket farm. Photo credit: Little Food

Cricket rearing compartment at Little Food

Little Food is a pioneer of entomoculture in Europe. In 2014, the enterprise focused on cricket farming, devoting a large part of its activities to raising customers' awareness in Belgium. Starting in 2015 and in the following years, the variety of whole cricket and cricket meal products has expanded, and the enterprise started selling on the Belgian and European markets. However, at the beginning of 2020, Little Food joined the list of market builders that filed for bankruptcy.

Production

The enterprise reared crickets in a 240 m^2 space with 10 m high ceilings in an urban green building. The space was set up on 3 floors for a surface of 600 m^2. The 52 cricket cages spread on 2 floors have produced in recent years around 7.2 tons of fresh crickets per year.

Distribution

The enterprise distributed all its production as well as that of a partner in the Netherlands, which had a larger production scale. At its summit in 2017, the enterprise distributed 12 tons of insects. The whole or processed into meal insects were sold by retailers in 120 outlets in Belgium as well as wholesale on the export market to 5 or 6 European countries.

Economic model

The enterprise started with 2 employees, and in 2019, it had 9 full- or part-time employees, 3 of whom were devoted to production, 3 to processing and 3 to sales and management. The enterprise notably

supported the professional insertion of marginalized people through a grant-funded program from the region of Brussels.

At the start, customer awareness activities represented 80% of the annual revenues, but in 2019, 90% of revenues came from wholesale and retail sales.

Over the years, the enterprise experimented with the recuperation of various organic residues that have turned out to be unsatisfactory, except for sunflower oil processing residue from a source located at less than 40 km from the farm. An investment in R&D would have been necessary to include the enterprise more completely in a circular process. In the same manner, the *dermestidae,* a parasite frequently encountered in cricket farms turned out to be difficult to halt.

Little Food raised close to €700,000 in funding over a 3-year period, including personal investments, loans and around €100,000 in grants for professional insertion.

After a peak in 2017, Little Food's business revenues started to decline as a result of the market taking too long to be established. The slow process of standardization and regulation in Europe played against the enterprise that could not export to all European countries. The enterprise lost an important customer, in a fragile customer base, and was unable to raise the necessary funds for its evolution against better-funded competitors. The partners preferred to file for bankruptcy.

ECONOMIC ANALYSIS

BASIS OF THE ECONOMIC RESEARCH

This economic study of urban insect farms is based on 7 cases for which we have obtained, for the most part, set-up, and operation costs as well as the revenues generated by production activities. These enterprises all mainly target the human consumption market. One enterprise also sells living insects on the animal feed market.

The collected data allowed us to create projections to obtain the costs, revenues and human resources needs per m^2 equivalent (the sum of the area of all the rearing containers).

Table 1: Characteristics of the cases used in this fact sheet.

	Number of years in operation	**Equivalent production surface (m^2)**
Cricket		
Case 1	1	238
Case 2	1	36
Case 3	5	156
Case 4	3	80
	4	101*
Mealworm		
Case 5	1	28
Case 6	1	151
Case 7	1	12
	2	87**

Note: * The farm changed its production containers to save space, ** the farm moved to scale.

IMPLEMENTATION OF A FARM PROJECT TO REAR INSECTS

On top of the time that is necessary to find an appropriate urban space, investments are needed for space layout changes to ensure that rearing is done in a controlled environment, as well as for equipment purchases.

In the pilot phase, some enterprises can have relatively low costs. This study documents cases with low investment levels varying between $10,000 and $25,000 and more advanced cases that include more important investments, reaching between $200,000 and $1 million.

Table 1 Set up costs for an insect farm.

	Number of years in operation	Total cost	Total floor-level m^2 cost
Cricket			
Case 1	1	$240,000	$1,611
Case 2	1	$10,400	$276
Case 3	1	$448,100	$1,867
	3	$1,045,500	$4,356
Case 4	4	$25,000	$112
Mealworm			
Case 5	1	$6,100	$119
Case 6	1	$200,000	$1,558
Case 7	1	--	--
	2	$25,000	$347

Note: * the farm moved to expand.

Beyond the studied cases, enterprises that target the animal feed market have raised the highest known funds, that is between US$7 and US$15 million for mealworm farms and between US$30 and US$200 million for black soldier fly farms.

REVENUES FROM INSECT FARMING

The mature operations studied that have shared information with us on their production-related revenues, had or were on the point of generating annual revenues between $200,000 and $415,000. For equivalent productions, revenues of close to $2,000 per m^2 of production are observed. One case that shared its data (Case 7) was still growing its stock in its second year, which explains that revenues are still low.

Apart from the quantity and quality of the stock and of the installations, the elements that influence revenues include the marketing strategy, the development of a customer base, as well as the knowledge and market experience accumulated through R&D.

Table 2 Insect farm revenues.

	Number of years in operation	Yearly production revenues	Revenues per m^2 equivalent
Cricket			
Case 1	1*	$416,000	$1,748
Case 2	1	--	--
Case 3	2	$61,240	$1,020
	4	$298,700	$1,915
Case 4	3	$73,425	$918
	4	$198,150	$2,477
Mealworm			
Case 5	1	--	--
Case 6	2*	$300,000	$1,984
Case 7	1	--	--
	2	$10,000	$115

Note: * Projected revenues

ANNUAL INSECT PRODUCTION

Production starts with the development of stock from a base population of insects, which explains the lower production in the first year. The development of a mature farm can take between 9 months and 3 years, period during which a move is sometimes necessary.

In the studied cases, annual production greatly varies depending on the enterprise's age and the entrepreneur's knowledge. Most of the studied enterprises increased their production by m^2 equivalent during the first years of production, except for one farm (Case 7) that was faced with a power outage that caused considerable losses. A mature farm's production ranges between 10 kg and 20 kg of insects per m^2.

Table 3 Current or projected production of insects (dry matter).

	Number of years in operation	Annual production (kg of dry matter)	Production in kg per m^2 equivalent
Cricket			
Case 1	1*	5,000	21.0
Case 2	1	18	0.5
	2*	86	2.4
Case 3	2	--	--
	4	1,800	11.5
Case 4	3	850	10.6
	4	1,488	14.7
Mealworm			
Case 5	1	36	1.3
	2*	583	20.8
Case 6	2*	1,800	11.9
Case 7	1	100	8.6
	2	300	3.4

Note: * projected production

The farms produce more frass than insects. The ratio between the 2 products varies between 1.5 and 3.5 for crickets and between 2 and 3 for mealworms.

Here again, for frass, a large production disparity can be observed. As well as the elements influencing insect production, the type of feed is another factor influencing the quantity of frass produced.

Table 4 Current or projected production of frass (dry matter).

	Number of years in operation	**Annual production (kg of dry matter)**	**Production in kg per m^2 equivalent**
Cricket			
Case 1	1*	6,781	28.5
Case 2	2*	192	5.3
Case 3	4		
Case 4	3	1,700	37.2
	4	2,975	37.2
Mealworm			
Case 5	2*	1,555	55.3
Case 6	2*	19,200	127.0
Case 7	1	210**	18.1
	2	650**	7.5

Note: * projected production, ** the value listed here is underestimated as it does not include the frass that was given by the enterprise to various partners.

WORK TIME NEEDED TO OPERATE AN INSECT FARM

Depending on the cases studied, time allotted for production varies from 32% to 83% of the operation's total labour time. On the other hand, processing time always represents less than 35% of total labour time. Commercialization represents between 10% and 63% of total labour time, while research time varies between 0 and 42% of the labour time.

Taking the data into consideration, we observe that the annual labour time per equivalent production surface varies between 14 h/m^2 and 50 h/m^2. If Case 1 is excluded, as their labour time is projected, it can be observed that crickets require between 30 and 60 hours of work per m^2 equivalent while mealworms require between 20 and 40 hours of work per m^2 equivalent. The reproduction and production of crickets is more time consuming than that of mealworms.

Table 5 Annual work time devoted to insect production and marketing

	Number of years in operation	Annual hours of work					Labour hours per m^2 equivalent
		Reproduction and production	Processing	Commercialization	R&D	Total	
Crickets							
Case 1	1*	2,079	825	429	-	3,300	13.9
Case 2	1	1,075	358	179	179	1,792	49.8
Case 3	4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Case 4	3	1,118	572	468	442	2,600	32.5
	4	1,650	500	1,100	1,750	5,000	62.5
Mealworm							
Case 5	1	538	179	090	90	896	31.9
Case 6	1	1,300	650	1,820	2,730	6,500	43.0
Case 7	1	216	5	39	-	260	22.4
	2	787	123	1,550	-	2,460	28.2

Note: * projected work time

ENERGY CONSUMPTION TO OPERATE AN INSECT FARM

Insect farming is sensitive to the production space's environmental parameters, especially temperature that must be relatively high for some of the production phases. Processing (including drying) also requires an important quantity of energy.

Thus, energy consumption in the studied cases shows a range located between 8 kWh and 334 kWh per m^2 equivalent which translates to between CA$0.8 to CA$33.4 per m^2 equivalent of production.[13]

Table 6: Energy consumption to operate an insect farm

	Number of years in operation	kWh/year	kWh per m^2 equivalent
Cricket			
Case 1	1*	2,000	8
Case 2	1	4,165	116
Case 3	4		
Case 4	3	26,693	334
	4	21,701	271
Mealworm			
Case 5	1	3,251	116
Case 6	1	12,144	80
Case 7	1	Not available	Not available
	2	Not available	Not available

Note: * Projected energy consumption

[13] This cost estimate is based on an energy cost at $0.10/KWh

ESTIMATE OF THE ECONOMIC VIABILITY OF AN INSECT FARM

Currently, insect farms are young and in constant development. The producers operate with vastly different knowledge levels and thus, operation and product processing techniques are also very diversified. Although they often start after many years of R&D, the enterprises are still young and scientific data on the farms' behaviour, common pathogen agents and production factors still need to be documented.

It is not surprising to find great variability in the collected economic data, as it reflects the diversity of each farm's choices—at the technical level, marketing, etc. The data presented in this study is useful to increase understanding of the sector and of the evolution of enterprise strategies. However, it is currently risky to estimate the viability of the studied operations.

The important issues related to the production of insects remain the sales price on the market and their acceptability for human consumption. However, optimization and automation of the farms will make production costs decline, thus increasing the potential for market penetration for these proteins. R&D therefore remains core for this sector, both for production and marketing.

Carrefour de recherche, d'expertise
et de transfert en agriculture urbaine

CRETAU

laboratoire
agriculture urbaine