Environmental life cycle assessment of insect mass-rearing facilities: current challenges and future prospects

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Objectives: Insects are seen as a promising alternative source of protein for animal feed. Despite a growing literature in the field, very few studies have been conducted to assess environmental impacts associated with mass-rearing systems. The aim of this study was to provide references on a yellow mealworm *(Tenebrio molitor)* large-scale facility and to identify the principal hotspots.

Methods: A life cycle assessment from cradle to farm gate was performed using inventory data from a pilot building. Chemical composition of larvae and manure were obtained by laboratory analyses. Ammonia, methane, and nitrous oxide emissions were recorded by in situ measurements. LCIA was conducted using CML-IA baseline method and TCED v1.8 implemented in Simapro Software v8.1.0.60. We used the ECO-ALIM database for French feed ingredients and the ecoinvent V3.1 database for background data.

Results: Environmental impacts associated with one kg fresh live weight of mealworm larvae harvested after 13 weeks were significantly lower than those found in literature which can be explained by differences in electricity consumption and electricity country mix, and a lower feed conversion ratio. Feed contribution ranges from 32 to 90% depending on the impact category. The results for gas measurement show very low NH_3, CH_4 and N_2O emissions. The feed conversion ratio (kg of ingested feed per kg larvae harvested, calculated on fresh matter basis) was 1.78.

Discussion and conclusion: The feed production has the higher contribution to total impact over all categories. The feed conversion ratio is thus the main driver as in many animal production systems. This study raises several questions concerning the development and the assessment of future large-scale production systems: How to overpass the attributional LCA as the insect production may compete with traditional sources of ingredients for livestock feed? Is it possible to eco-design an insect biorefinery on the basis of pilot scale farms as the environmental impacts rely on the availability of large amounts of wastes and co-products? Is there a contradiction between a goal of efficiency for the production of protein for livestock feed and the idea of insect biorefinery implying the use of waste and co-products? All these points will be commented in the presentation on the basis of actual results.