Rapportage projectinformatie PPS-en Landbouw, water, voedsel

Datum versie: 7 december 2020

1. Projectinformatie

1.1 Organisatie/financiering *(keuze maken)*	TKI A&F
1.2 Projectnummer	TKI-AF-17104 / ALWGK.2016.017
1.3 Project titel	Towards utilizing livestock manure for mass rearing of houseflies for feed
1.4 Projectleider *(naam en emailadres)*	Prof. Leo W. Beukeboom l.w.beukeboom@rug.nl
1.5 Startdatum (*dd-mm-jjjj)*	01-03-2018
1.6 Einddatum (*dd-mm-jjjj)*	01-03-2022
1.7 MMIP primair *(nummer en naam van het MMIP, zie overzicht bijlage 1)*	A3 Hergebruik zij- en reststromen
1.8 MMIP secundair *(deze alleen invullen als er een 2e MMIP is waar het project aan bijdraagt)*	

2. Projectomschrijving

2.1 Samenvatting *Geef een korte samenvatting van wat het project inhoudt en beoogt. Het gaat om een publiek beschikbare samenvatting (doel, bijdrage aan de missie, op te leveren resultaten in termen van kennis voor doelgroep x en de partners in het project).*

Given the ever growing human population, the livestock sector is in urgent need for more sustainable feed sources and a reduction of the environmental impact. There is a rapidly growing interest in the use of insects in livestock farming, both as an alternative source of protein in animal feed and to reduce farm waste through biodegradation of manure. This project aims to develop an efficient and sustainable production method to locally rear the common housefly on farm manure and supply the larvae as feed for production animals. Specifically, we will determine the suitability of manure as feeding substrate for the housefly by investigating (1) the nutritional value of the manure and its effect on housefly larvae nutritional composition, (2) the optimal mass rearing conditions for the houseflies in terms of manure type, rearing temperature, and population sex ratio. The strength of the our research is that we take an integrated, multidisciplinary approach with a strong public-private partnership between three leading academic groups and the industrial partner *Amusca* who has long-term expertise with production of houseflies and close contacts with agricultural customers. Our ultimate goal is to develop a fully-closed production system that can be applied locally, mitigating the need for transport of their end-product. This should lead to a significant reduction in the use of raw materials and production of waste, which will in turn reduce the environmental impact of the livestock industry and improve human food safety as part of a circular economy.

2.2 Doel van het project *Wat gaat het project bijdragen aan de doelen van de KIA, de missies en de MMIP's?*

Our project aims at improving the commercial production of houseflies in the agri-business sector and falls directly under the mission of the topsector Agri&Food to improve human food safety. A specific aim is to re-use waste products for animal production with a clear relevance to the top sectors Tuinbouw & Uitgangsmaterialen and Energy and Water which aim at more food safety and conservation of biodiversity as part of a circular economy. Our results further have links with the Logistiek and Creative Industry topsectors, because we will develop efficient insect production facilities tailored towards commercial stakeholders (e.g. poultry farmers) that can be applied locally, reducing the need for transport of materials. Our research is practice-based and will develop novel technology fitting the goal of responsible innovation under the "Smart Industry" roadmap. Knowledge build-up on the nutritional requirements and metabolism of houseflies also has cross-overs to the topsector Chemie as insect food digestion and metabolism is combined with efficient biomass conversion under the "Chemistry of Life" roadmap.

2.3 Motivatie *Licht toe waarom dit project passend en nodig is binnen het MMIP*

This project aims to contribute to a more sustainable food production, including improved livestock well-being, by developing efficient mass rearing procedures for houseflies as feed. As such it complies to the "Circular economy and resource efficiency" route of the National Science Agenda. It also has direct relevance to the routes "Sustainable production of heathy and safe food", "Quality of the environment" and "Logistics and transport in an innovative and sustainable society". As our results will lead to reduction of waste streams and re-use of resources, we also contribute to the Agenda's energy transition and sustainable development goals.

2.4 Resultaat *Zo SMART mogelijke beschrijving van de beoogde resultaten van het project. Het gaat om zowel de inhoudelijke resultaten (in relatie tot vraag 2.2) als resultaten zoals bijeenkomsten en rapporten. Geef zoveel mogelijk ook de planning per jaar.*

	2018				2019				2020				2021				2022			
WUR PhD: Suitability and risk of manure																				
Literature review																				
Risks of feeding manure to housefly larvae																				
Nutritional value of manure for larvae rearing																				
Optimise manure for larval growth																				
Publications (PhD thesis, scientific journals)																				
VUA PhD: Lipid composition																				
Literature review																				
Temporal lipid dynamics																				
Effect of rearing temperature and substrate																				
Screen natural lines of houseflies																				
Selective breeding experiments																				
Publications (PhD thesis, scientific journals)																				
RUG Postdoc: Population sex ratios																				
Literature review																				
Culturing houseflies for all subprojects																				

Models of sex determination dynamics																			
Effect of sex ratio on production																			
Temperature effect on sex ratio + production																			
Sex ratio and production under mass rearing																			
Publications (scientific journals)																			

WUR: Wageningen University & Research; VUA: Vrije Universiteit Amsterdam; RUG: University of Groningen

Jaarrapportage (svp ook laatste jaar invullen)

3. Status project

3.1 Status project *(keuze maken)*	project loopt op schema/project loopt achter
3.2 Toelichting incl. voorziene wijzigingen t.o.v. het oorspronkelijke werkplan	Work restrictions in 2020 Due to the COVID-19 pandemic, work restrictions in 2020 had consequences on delivering results and required changes in the timetable and plans of the project. Several months delay have been incurred in the planning for the large experiment at VUA (experimental evolution) and the writing of the results and final thesis of the PhD student Francesco Boatta (PhD candidate at VUA). The pandemic has also incurred unexpected challenges and delays for the commercial partner *Amusca* in provision of their insect mass rearing unit for research purposes. Therefore, experiments on mass rearing of houseflies are redefined and will be performed in 2021.

4. Behaalde resultaten

4.1 Korte beschrijving van de inhoudelijke resultaten en hun bijdrage aan het MMIP (zoals beschreven in 2.2)
At WUR, an experiment aimed to improve our understanding of the interactions between the larvae and microbiota present in the manure. Laboratory analyses on samples were finalised and the resulting scientific manuscript is in the final stage of writing. This first experiment formed the basis for a second study in which the optimum amount of starch for manure conversion into larval biomass was evaluated. This study was conducted in Q4 of 2020 and results from this study are pending. Additional study was conducted to quantify the effects of storage time and temperature on the suitability of pig manure as feed for housefly larvae. Based on the outcomes of these first studies and project goals, we will design and conduct one or two studies at laboratory scale in the coming year. An experiment on artificial selection for increased protandry started in September 2020 at RUG. The experimental design includes crosses between first emerging (fast developing) males and last emerging (slow developing) females over six successive generations in order to make improvements in the time interval between male and female emergence and increase sex separation. We registered insignificant improvement in the time interval between male and female emergence by comparing selected lines with unselected control housefly strains. In addition, our observations revealed noticeable wing/body size differences between the first and

last emerging flies, and no changes in hatchability, fecundity and egg-to-adult survival of selected lines.
Detailed analyses on housefly sperm quantity and functionality in three strains originated from Italy, Spain and The Netherlands were performed at RUG. Impact of age, body size, rearing temperature and geographic origin was tested as possible factors that influence overall fertilizing potential of housefly males. Males reared at 32 °C appear to possess functional sperm already 24 hours after emergence, while males reared at 25 °C are characterised by low numbers of mature sperm cells in first post-eclosion days (days 1-3). Non-functional sperm cells were registered at both the rearing temperatures and in all tested strains, and noticeable decrease of fertilizing potential over the lifespan was revealed. In combination with previously obtained results on mating activity and body size, data on sperm viability are needed in order to determine the optimal proportion of males in housefly production colonies reared at either 25 °C or 32 °C.
The major effort in the past year at VUA was in starting up the experimental evolution. This large experiment has the purpose of understanding how the lipid metabolism of the house fly is altered by exposure to high energy diets. For multiple generations (we aim for 20 generations) the developing larvae are exposed to two dietary treatments that predispose them to produce high fat reserves: a sugar-rich diet and a lipid-rich diet, and a control diet. The experiment is very labour-intensive due to its large population size, quintuple replicated treatments, and multiple back up populations. The restrictions due to the Corona pandemic have forced the interruption of the experiment in March (first lockdown), and it was possible to resume only at the end of August. Despite the difficult circumstances due to the Corona pandemic, as of February 2021 the experiment is now in generation 6, where we will do our first measurements of lipid content and other life history traits. To get the most data out of this unique experiment, the VUA group have invited collaboration with other researchers to expand the aims of the experimental evolution. This resulted in a joined project that will investigate the effect of the dietary treatment on the microbiome of the larvae and on the immune system of the houseflies. Additional researchers involved are 1 Post-Doc and 2 PhD students from RUG and VUA. In addition, several students are involved in the project, including a MBO student working on optimizing the rearing conditions in the experiment, and a MSc student who will work on a study to quantify the heritability of the lipid accumulation trait in houseflies. In addition, a paper is in preparation about the experiments run in the previous year, looking at geographic variation among fly strains in their lipid metabolism.
A study utilising the mass rearing unit of our industrial partner, *Amusca*, is foreseen. List of parameters and experimental set-ups will be developed in the following period by three academic parties and first tests in the *Amusca* mass rearing unit will be performed in 2021.Parallel to this study, a lab scale study is planned at WUR. This parallel study will provide insight in how well results from at laboratory scale can be extrapolated and are correlated with larger scale production systems.
A collaborative review of the entire consortium about houseflies and their applicability as production animal is in preparation. PhD-student Francesco Boatta is in the lead on this paper. Draft of the manuscript is in its final stage and will be submitted to a relevant scientific journal in 2021.
Finally, one MSc student at RUG and one MSc student at WUR completed their thesis, and two groups of 5-6 students following the BSc course Insects as Food and Feed at WUR worked on cases related to our project.

4.2 Deliverables (bijeenkomsten en andere output, die niet benoemd wordt in 4.3 en 4.4)

Results generated under the project were presented at the Insect to Feed the World 2020 virtual conference (November 23-26, 2020). Francesco Boatta, PhD candidate at VUA was awarded for the best presentation of the conference and draw additional attention to our project.

Boatta, F., Jansen, W., Beukeboom, L.W., Ellers, J. (2020) Genetic variation in qualitative/quantitative lipid content of three strains of housefly larvae at different temperatures. Journal of Insects as Food and Feed: 6 (Supplement 1) - S32

Francuski, L., Jansen, W., Beukeboom, L.W. (2020) Effect of temperature on life-history parameters and production performances of the common housefly, *Musca domestica.* Journal of Insects as Food and Feed: 6 (Supplement 1) - S32
4.3 Communicatie (lijsten)
4.3.1 Wetenschappelijke artikelen en hun doi (*Digital Object Identifiers)*
Francuski, L., Jansen, W., Beukeboom, L.W. (2020) Effect of temperature on egg production in the common housefly. Entomologia Experimentalis et Applicata 168: 513-522. DOI: 10.1111/eea.12912 Francuski, L. Beukeboom, L.W. (2020) Insects in production – an introduction. Entomologia Experimentalis et Applicata 168: 422-431. DOI: 10.1111/eea.12935
4.3.2 Rapporten/artikelen in vakbladen
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4.3.3 Overige communicatie-uitingen (inleidingen/posters/radio-tv/social media/workshops/beurzen)
We presented and discussed our findings at the NWO Closed Cycles day on 2 March 2020 in Utrecht
4.4 Overige resultaten: technieken, apparaten, methodes
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4.5 Projectwebsite: geef het adres van de projectwebsite (indien beschikbaar)
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