Project update

Project title (Acronym):	Bringing Insect Farming to the Next Level – Promoting sustainable insect farming and preserving in Cambodia and Thailand to increase shelf life and obtain innovative foodstuffs based on local resources in order to counteract malnutrition, particularly of mothers and children
Geographical focus:	Cambodia, Germany, Thailand
Call reference:	Innovative approaches to processing local food in Sub-Saharan Africa and Southeast Asia, which contribute to improved nutrition and reduce qualitative and quantitative losses
Cooperating partners:	TiHo: Institute for Food Quality and Food Safety, Hannover University of Veterinary Medicine (Institut für Lebensmittelqualität und -sicherheit, Stiftung Tierärztliche Hochschule Hannover) RUA: Faculty of Veterinary Medicine, Royal University of Agriculture (សាកលវិទ្យាល័យភូមិន្ទកសិកម) LDC: Centre for Livestock and Agricultural Development (មជ្ឈមណ្ឌលអភិវឌ្ឍន៍ការចិញ្ចឹមសត្វ និងកសិកម្ម) KMITL: Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang (สถาบันเทคโนโลยีพระจอมเกล้าเจ้าคุณทหารลาดกระบัง) MUT: Faculty of Veterinary Medicine, Mahanakorn University of Technology (มหาวิทยาลัยเทคโนโลยีมหานคร)
Duration:	36 months
Budget:	643.522,02 €

Aim of the project:

Thailand and Cambodia are both affected by malnutrition of children and mothers, be it by the by the sheer number of persons suffering from it (Thailand), be it by the high percentage of the general population (Cambodia). While consuming insects (entomophagy) has a long tradition in these countries and is relatively widespread, this tradition involves gathering from the wild and subsequent preparation and consumption of the fresh or frozen insects. On one hand, if food insects, because of their nutritional benefits, are to play a major role in providing food for mankind, farming rather than collecting from the wild will be necessary. These techniques, already practiced in some parts of Thailand and Cambodia, have the potential to be used as minilivestock by families, as many insect species may be raised sustainably on agricultural side streams with less ecological impact as more typical livestock. On the other hand, rearing insects is prone to create surpluses in insect production, making preservation techniques necessary to ensure food safety by extending shelf life. These novel products may be produced for the family or sold at local markets creating an extra income.

IFNext attends these needs. The overall goal is to produce insects sustainably for the own consumption resp. to generate products that can be sold on the market and that actually meet the expectations of farmers and consumers alike.

For that, starter kits for insects (sometimes including building adaptions) will be developed and distributed to the participating 40 Southeast Asian families. Regarding insect species, the consortium agreed on one species which will be reared by all, i.e. Mediterranean field cricket (*Gryllus bimaculatus*) to compare results. Besides, each consortium member will also attend another species of national interest: Thailand will work with the silkworm (*Bombyx mori*), Cambodia with the Jamaican field cricket (*Gryllus assimils*), and Germany with the meal-

worm (*Tenebrio molitor*) – rearing in the latter country will take place at the institute's insectarium. Along with the kits, participating families will be briefed in terms of insect production and accompanied by the local consortium partners.

During the project, these kits will be put to the test, evaluated and modified in case of need in order to suit local conditions, following the farmers' feedbacks.

In order to develop accepted insect product types, national surveys will be performed in which participants can choose among different types, (e.g. fermented, smoked, home-canned or as deep-fried crackers) and can also make own suggestions. The preferred techniques will be developed and evaluated by the consortium in terms of food safety and sustainable practicability under tropical conditions.

For the raw, cooked, and preserved insects, sensorial, compositional, and microbiological parameters will be selected, determined, and evaluated, so that local public health agencies will be able to assess the quality of these products in the future. This assessment will be done on species level, as it is known that these quality parameters are affected by species and rearing system, among others.

To assess the acceptance (and thus practicability) of the project, farmers and consumers will be interviewed in relation to their experiences and expectations with rearing, processing, and consuming these insects resp. their products. Again, this evaluation is done on national level and seeks to pinpoint the (a) safest and (b) most accepted product.

Germany was asked to coordinate the project. Within the consortium, the coordinator is *primus inter pares*, and decisions will be made democratically. Results will be published in many ways, both in scientific, peer-reviewed journals in English and in popular magazines and digital media, in these cases also in Thai, Khmer, and German.

Results:

Animal husbandry

- Farming systems for crickets, silk moths and mealworms for small farms have been established. They enable women farmers to breed insects cheaply and sell the harvest themselves, partly to feed their families, partly as goods at local markets.
- Silk moths are traditionally kept on frames. The participating cooperative receives silkworm eggs from the government, which are turned into larvae in a community hatchery, which after 10 days are distributed to the farmers who look after the animals until they pupate. Performance parameters have been created for production, which are used to evaluate each run. One round takes about 4 weeks.
- In Asia, crickets are kept in tanks of approx. 2 x 1.5 x 1.5 m standing on metal frames. Equipment includes egg carton trays that increase walking space, sources of food and water, and containers for laying eggs (for breeding colonies). Humidity is ensured by plant material (banana leaves, rice straw sprayed with water). Some farmers have their drinking

water in a plastic pipe system with holes on the top; Cloth cuts act as a "wick" and one pass lasts approximately 10 weeks.

- In Germany, a system based on the Asian model was developed (IFNext-TiHo-Krabbelkist), which is based on 52-l plastic boxes. The interior consists of egg carton, bowls for the food and a plastic bottle that has been cut open, with a household towel serving as a “wick” for water in the cut. This gives the crickets constant access to drinking water without the risk of drowning. One round lasts about 10 weeks.
- Mealworms are kept in commercially available trays. The equipment consists of wheat bran, green fodder and some egg cardboard. One round lasts about 8 weeks.
- The feeding of the silk moth consists of mulberry leaves and cannot be changed since the species is monophagous. Crickets and mealworms are omnivorous, but are supplied with concentrated feed for poultry and green fodder in the project. The concentrated feed is the actual cost factor, since the green fodder is either collected and fed directly on site, as in Asia (including plants that are invasive) or, as in Germany, from vegetable and fruit cuts from the canteen or supermarket. Both food sources are free. Combinations of cassava green and cassava root flours have also been experimented with in Cambodia, and one combination appears promising.
- The growth curves of crickets and mealworms in Germany were characterized. Three distinct patterns were identified for crickets that affect the performance of the run.
- As a by-product of insect farming, "frass" refers to the sum of faeces, leftover food and moulting, and any animals that may have died. For every approx. 250 g of harvested crickets there is an average of approx. 530 g of frass.
- As expected, there was a high influence of the insect species during breeding.
- In Cambodia, neighbours of the participating farmers have now adopted the IFNext breeding system. Project farmers themselves have entered into a contract with the concentrate supplier whereby they get a discount on their feed buyers and the supplier acts as an intermediary for their crickets.
- Continuation of insect breeding in all three countries and better yields for many of the farmers due to the experience now available
- Creation of data sheets to evaluate the runs
- Yield of the cricket harvest also depends on the population density

Animal health

- The farms were repeatedly attacked by flies and phoretic mites, which enter the farms with the green fodder. They can be successfully combated with traps and special hygiene management.
- In Thailand, conspicuous deaths were examined using molecular biology for the occurrence of the cricket iridovirus; the technique corresponded to the specifications from the literature, but the samples were negative.

Sustainability in feeding

- Experiments with bulky milk pudding, asparagus peel flour and giant mealworm flour as side streams for feeding Mediterranean and steppe crickets showed a very diversified picture with regard to the content of amino acids and related substances.
- Mediterranean crickets matured faster than steppe crickets

- In the case of Mediterranean crickets, the choice of feed mostly played no role, in Jamaican field crickets it had an effect on the amount of amino acids. The individual developmental phases of the crickets also often contained significantly different amounts of more or fewer amino acids.
- Many amino acids were found in economically interesting concentrations of >1 g/100 g fresh sample, including some essential amino acids such as valine, leucine, lysine and arginine.
- Frass was also a valuable source of amino acids, especially when derived from animals fed giant mealworm meal.
- Based on the initial content in the feed, the substances were concentrated by 50 to 1200% in animals and fodder.
- The best survival rate was achieved with barrier milk pudding, which, however, also contained antibiotics.
- The feeding (but not the type of cricket) influenced the weight development of the animals, with asparagus peel flour achieving the best values.
- However, the harvested biomass, in a sense the synthesis of survival rate and individual weight development, there was no effect in Mediterranean crickets, which produced comparatively less biomass than steppe crickets, while feeding had an effect on the biomass of Jamaican field crickets.

Analytics

- Standard sets for checking the microbial and chemical-compositional properties have been established.
- From a microbiological point of view, the classic pathogens such as *E. coli, Staphylococcus aureus*, salmonellae, and listeriae were not detected. Nevertheless, as expected, high bacterial counts occurred in raw insects, which, however, can be effectively reduced by cooking. It remains to be seen whether this sterility will also persist in dried flours.
- From a chemical point of view, there were, as expected, high protein contents (between 50 and 70%, all chemical information on dry matter basis) and interesting amino acid profiles. Nitriles (in the cassava feed trial), heavy metals and mycotoxins were not detected.
- The individual results varied not only according to the species, but also with the feeding.
- Frass is characterized by high bacterial counts, but also high protein (up to 23%) and ash values (up to 20%) and thus a valuable by-product, e.g. as a fertilizer.

Food Safety: Microbiology

- Analysis of the microbiome and mycobiome of Mediterranean crickets and yellow mealworms showed striking differences, both in terms of the species detected and the percentage of each species in the total
- Typical food-related germs such as *E. coli*, salmonella, listeria or *S. aureus* were not detected
- Some microorganisms that have occurred have not yet been detected in the two IFNext species, and some microorganisms are known both as potential pathogens (mostly opportunists in immunocompromised patients) and as food-related or probiotics, e.g. lactic acid bacteria.

Food Safety: Sensory Analysis

- An individual profile was created for each species, showing how fresh and spoiled insects look, smell, taste and what mouthfeel they evoke.

Culinary

- As part of a questionnaire, consumption habits and preferences were asked in all three participating countries. Various innovative insect-based products were given a choice and insect meal was the favorite across the board.
- First trials work with insect homogenates (including flour) as a basis for spicy crackers or pasta.
- Thailand: Ramen Soups (not finished yet)
- Cambodia: cassava cricket noodles, fried snacks in sweet and salty
- Germany: Insect crisps made from insects and tapioca starch, sweet or savoury, plus other products based on raw and strained insects (falafel and dumplings, baked goods)
- Creation of professional cooking videos showing the manufacture of German products

Consumption habits

- The analysis of the questionnaire with regard to consumption habits resulted in a complex, country-specific picture. Insect consumption is still not very widespread in Germany, although the benefits are well known. Insects are often eaten in Cambodia, but people are not certain about the benefits. Insects are less commonly eaten in Thailand and the benefits are largely unknown.
- There are also differences in gender, age and lifestyle in rural and urban areas.
- In Thailand, the home and residence province were also queried. Here, too, a complex picture emerged, which shows that insect consumption is practiced and assessed differently from region to region.

External impact

- The project is designed for a strong external impact. In addition to the publication of specialist articles in scientific journals and popular science magazines, the project has a presence in social media (homepage, Facebook, Twitter) as well as in traditional media such as print, radio and television.
- Results are presented at congresses.
- The project has been presented and discussed in presentations and lectures at home and abroad. A series of lectures at the Universidad de Guadalajara (Mexico, since 2020) and a learning module on the veterinary care of beneficial insect populations at the Congress of Practicing Veterinarians (November 2020) are particularly noteworthy.
- The consortium members are part of an international network on animal health and welfare in beneficial insects initiated by the coordinator of IFNext.
- Many contributions for experts and lay people at home and abroad, which led to increasing acceptance and knowledge growth

Key statements and policy advice:

- Farming beneficial insects in small farms is a valuable addition to any agricultural practice. The success depends on how well locally (and cheaply) available elements for rearing

and breeding (species, building material, feed) can be used. Constant contact with the farmers is also necessary in order to be able to react quickly to problems.

- Traditional treatment and processing must be re-evaluated for its efficiency under today's conditions in order to be able to continue to produce safe food. This is all the more true for novel products such as insect flours.

- In Asia, too, there are different proportions of the population who do not traditionally eat insects. With the use of homogenisates, access to insects is made easier for those who disdain them because of their appearance.

- The system developed within the framework of IFNext is universally applicable if it is adapted to the respective local conditions. In this respect, follow-up work in other regions with a similar climate is just as conceivable as the adaptation of the breeding of other arthropods, which are also commercially successful, in the same climate as Thailand or Cambodia.

- Insect breeding is successful in all three countries.

- Interesting new products based on dried or fresh homogenates were designed, which are accepted in terms of taste.

- Numerous events in Germany have led to an improvement in acceptance and increased knowledge among visitors.

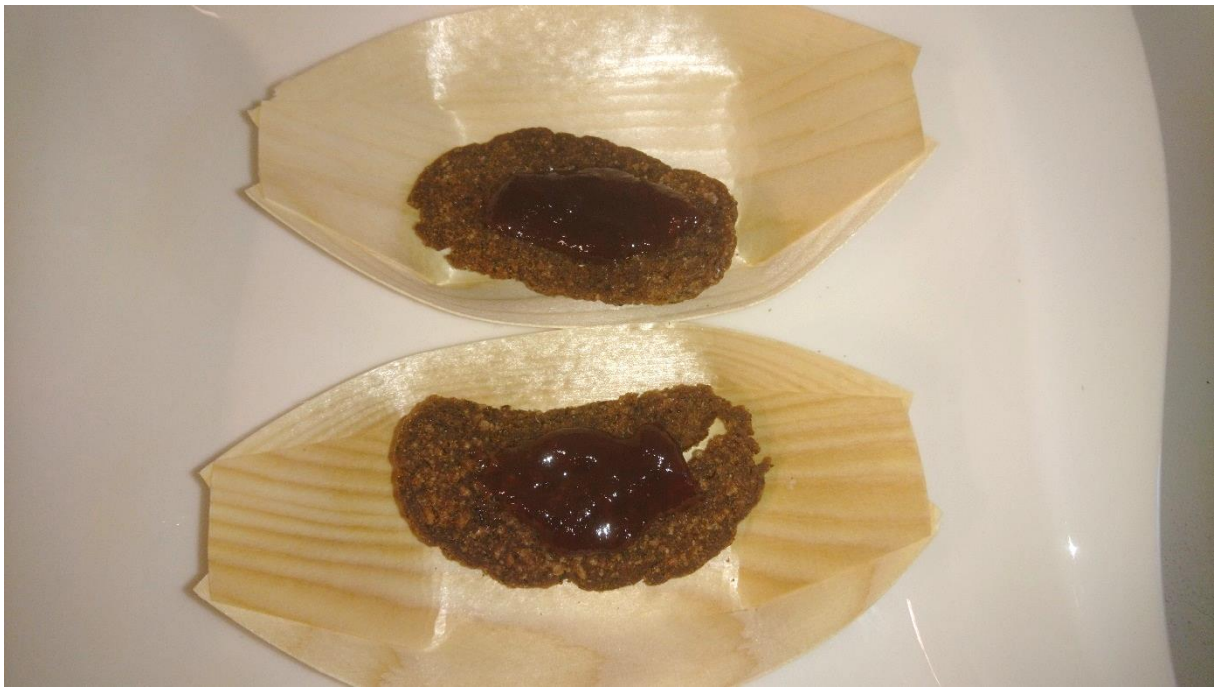

Fig. 1: Mediterranean cricket crisps with amarena cherry mustard sauce; picture: Grabowski

Fig. 2: Insect dishes: pe kyaw (upper left), German marriage soup (upper right); speculaas (lower left), East Frisian New Year waffles (lower right); pictures: Grabowski

Fig. 3: Broadcasting cricket chirps via microphone during a presentation; picture: Grabowski