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EUROPEAN COMMISSION

Directorate-General for Agriculture
and Rural Development

Expert Group for Technical Advice on Organic Production

EGTOP

FINAL REPORT

on

Insect production for Food and Feed (I)

The EGTOP adopted this technical advice at the plenary meeting
of 2-4 December 2024

About the setting up of an independent expert panel for technical advice

Regulation (EU) 2018/848[1] requires that authorisation of products and substances used in organic production may only be authorised if they comply with the principles, criteria and objectives of organic production described in that Regulation. The Commission has decided that when taking decisions on these authorisations it will take account of scientific advice by a group of independent experts. For that purpose the Commission has set up the Expert Group for Technical Advice on Organic Production by Commission Decision 2021/C343/03 of 4 August 2021.

EGTOP

The Group's tasks are:

(a) to assist the Commission in evaluating technical matters of organic production, including products, substances, methods and techniques that may be used in organic production, taking into account the objectives and principles laid down in Regulation (EU) 2018/848 and additional policy objectives with regard to organic production;

(b) to assist the Commission in improving existing rules and developing new rules related to Regulation (EU) 2018/848;

(c) to stimulate an exchange of experience and good practices in the field of technical issues related to organic production.

EGTOP Permanent Group

MICHELONI Cristina (Chair), OUDSHOORN Frank Willem (Vice-Chair), BLANCO PENEDO Maria Isabel (Vice-Chair), AUTIO Sari, BESTE Andrea, GORACCI Jacopo, KOESLING Matthias, KRETZSCHMAR Ursula, MALUSÁ Eligio, RAIGON JIMENEZ Maria Dolores, SPEISER Bernhard, VAN DER BLOM Jan, WÄCKERS Felix

Contact

European Commission
DG Agriculture and Rural Development
Directorate B: Sustainability
Unit B4 – Organic Farming
Office L130
B-1049 Brussels
Functional mailbox: AGRI-B4@ec.europa.eu

http://ec.europa.eu/agriculture/organic/home_en

[1] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007 (OJ L 150, 14.6.2018, p. 1–92). ELI: http://data.europa.eu/eli/reg/2018/848/2024-12-01

ACKNOWLEDGMENTS

Members of the Group are acknowledged for their valuable contribution to this technical advice. The members are:

Permanent Group members:

MICHELONI Cristina (Chair), OUDSHOORN Frank Willem (Vice-Chair), BLANCO PENEDO Maria Isabel (Vice-Chair), AUTIO Sari, BESTE Andrea, GORACCI Jacopo, KOESLING Matthias, KRETZSCHMAR Ursula, MALUSÁ Eligio, RAIGON JIMENEZ Maria Dolores, SPEISER Bernhard, VAN DER BLOM Jan, WÄCKERS Felix

Sub-Group members:
WÄCKERS Felix (Chair), VAN DER BLOM Jan (Rapporteur), BENNING Luisa, BESTE ANDREA, DERUYTTER David, GUARINO AMATO Monica, LAMBERTZ Christian, MICHELONI Cristina

External experts:
VAN HUIS Arnold

Observers:
DRUKKER Bastiaan

All declarations of interest of Permanent Group members are available at the following webpage:

http://ec.europa.eu/agriculture/organic/home_en

Table of Contents

1. TERMS OF REFERENCE

In view of the need to specify production rules for organic insects for food and feed, the Group is requested:

1. To analyse as background the horizontal rules applying to insects for food and feed in terms of animal health, food safety and feed safety, animal by-products and environment.

2. To analyse as background the work and discussions linked to the draft production rules for insects for food and feed proposed by the Commission and analyse and advice on the comments by the Member States in relation to this document as well as the position of the stakeholders. All comments received from Member States and stakeholders during the GREX discussions will be made available to EGTOP.

3. To advise on specific issues considering the specific needs of insect species that can be placed on the EU market as food or feed:
   - Terminology used, in particular entomological/biological terms
   - Concept of holdings, production units for insects for food and feed, feasibility of mixed holdings with other livestock (insect-insect, poultry, porcine animals and aquaculture)
   - Derogations as regards the origin of animals: conditions to introduce non-organic insects, availability of genetic resources, need to renew genetic resources, need to separate newly introduced insects? Feasibility of a database with available organic insects as for other animals?
   - Conversion rules for insects
   - Nutrition:
     - feasibility of the general livestock rules in terms of landless livestock production and agreements with other organic holdings
     - feasibility of minimum percentage of organic: in-conversion feed originating from the holding/ production unit and advice on such percentage if feasible
     - availability of organic feed for insects, by-products of organic crops, by-products of organic livestock
     - availability of organic side streams and (animal) by-products of low nutritional value including waste of organic origin
     - in case of lack or insufficient availability of organic feed: preferential order for insect feed as proposed by certain Member States and stakeholders
     - Different rules for insects reared for food and feed needed as proposed by certain Member States and stakeholders
       - For feed objective may input of organic side streams of low value be used, that is difficult to be used otherwise
       - For food the input requirements may be higher

   - Housing and husbandry practices:
     - feasibility of the general livestock rules for keeping insects (cages, containers)
     - the characteristics of and technical requirements for buildings and housing materials including technical requirements to prevent the insects from escaping and for avoiding hazards.
     - requirements for temperature, ventilation, humidity, air quality (CO2/NH3 levels) in buildings
     - feasibility to set stocking densities and the minimum surface for indoor areas according to insect species considering natural densities and behaviours of insect populations
   - Health care:
     - Animal health preventive measures, including testing/monitoring of diseases and pests

- Use of veterinary medicines
- Use of feed materials, use of feed additives.

- Animal welfare, considering natural behaviours in insect populations:
  - Significance of access to open air areas / fresh air
  - Risk factors for and preventative measures against cannibalism
  - Mutilations that specifically needs to be banned or covered by a possibility for competent authority to grant derogations.
  - Handling
  - Transport
  - Killing methods, including mincing

- Collection, disposal and use of frass.
  - Difference between frass and manure
  - Is frass to be considered as a product of insect farming?
  - Is frass to be considered as manure?
  - If this frass must be used as manure for the production of feed for the insects

4. Advantages and disadvantages of use of insects as organic feed compared to other sources of protein feed for poultry, porcine animals and aquaculture.

2. LIST OF TERMINOLOGY

Cannibalism – Act of feeding on individuals of the same species
Feed – Nutrition destined for feeding livestock
Flicker Frequency (Perception) – Light frequency at which light sources are perceived as flickering (strobe effect) rather than as steady light
Food – Nutrition destined for humans
Frass – a mixture of excrements, the feeding substrate, parts of farmed insects, dead eggs and with a content of dead farmed insects of not more than 5 % in volume and not more than 3 % in weight.
Gregarious – Living in (high density) groups
Larvae – Immature stages of insects, dissimilar to adults, that turn into adults after complete metamorphosis (egg-larva-pupa-adult) (cf nymphs)
Mechanical transmitter – Insects transmitting a disease, without contributing to the multiplication of the disease itself (cf vector)
Mites – Tiny spider-like animals with four pairs of legs
Nosema - Fungal insect disease
Nymphs – Immature stage of insects, similar in appearance to adults, but without wings or sexual organs (cf larvae)
Parasitic wasps – (Often tiny) wasps that reproduce by laying eggs and developing on or in the bodies of other insects or spiders
Phenotype - Set of observable characteristics of an individual, as a resulting outcome from genetic as well as environmental factors
Separated batches – Physically separated groups of individuals (often synchronized stages) in insect rearing
Side streams – Food- and biowaste that is not suitable for human consumption, but can be used, or in the future considered to be assessed in terms of suitability, for insect rearing
Spectral composition (artificial light) – The mix of colours (wavelengths) emitted by a light source
Stamping-out method – Process of repeatedly (over multiple generations) removing all rearing individuals with symptoms of disease, until the rearing population is disease-free
Steinernema – Parasitic nematode (roundworm)
Synchronised cohorts – Groups in insect rearing, consisting of individuals of the same age/life stage.
Vector - organisms, such as mosquitoes, ticks, flies, fleas and lice, that can carry pathogens that can multiply within their bodies before being transmitted to new hosts, usually by biting or stinging. (cf mechanical transmitter)

3. EXECUTIVE SUMMARY

The Group observes that, in general, many aspects remain to be clarified in the horizontal legislation to define rules that are applicable to insect production for food and feed. Although this is a task beyond the mandate of the EGTOP, the Group reflects on some key aspects of the horizontal legislation and provides suggestions for adaptations. In addition, the group proposes recommendations specifically addressing *organic* insect production.

NUTRITION

Recommendations on horizontal legislation

a) The Group considers that the horizontal legislation with respect to nutritional substrates allowed for use in insect farming, sets strict constraints on the substrates that could be used in organic insect rearing. Therefore, the Group proposes to consider adaptations in the horizontal legislation with respect to nutritional substrates allowed for use in insect farming, also taking into account the risk analysis presented by the EFSA Scientific Committee (2015)[2]. These adaptations will be different for insects reared for food or those reared for feed.

Recommendations on organic insect production

a) Regulation (EU) 2018/848, Annex II, Part II, Point 1.4.1 (e) should be adjusted to read: "(e) with the exception of porcine animals, poultry, bees and other insects, livestock shall have permanent access to pasture whenever conditions allow or shall have permanent access to roughage."

Insects produced for food

a) At least 95% of the nutritional input (fresh weight) used in organic insect rearing must be derived from side streams, including those side streams that are suitable as feed for other livestock.
b) The Group proposes that, at present, the percentage of organic input, must be at least 60% (fresh weight) in each batch produced. The aim is to further increase the use of organic and local input, to reach 95% (fresh weight) of the total input within 5 years, once the current proposal has entered into force. The Group recommends that the rules for organic insect production will be re-evaluated at this point.
c) Feed material and additives. Trace elements and vitamins of natural origin can be used when needed. The use of synthetic supplements is not allowed, except for those supplements that are allowed in organic agriculture or animal husbandry (Annex III to Regulation (EU) 2021/1165[3]).

Insects produced for feed

a) At least 95% of the nutritional input (fresh weight) for organic insect rearing must be derived from side streams. The Group suggests giving priority to substrates that are in limited competition with substrates currently used for feed in other livestock production.
b) For plant material used for insects reared for organic feed, at least 25% of the feedstock (fresh weight) should qualify as organic, or in conversion. This is to be re-evaluated 5 years after entering into force of the current regulation.
c) The feedstock should preferentially be sourced regionally.

HOUSING AND HUSBANDRY PRACTICES

[2] Risk profile related to production and consumption of insects as food and feed. https://doi.org/10.2903/j.efsa.2015.4257

[3] Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorising certain products and substances for use in organic production and establishing their lists (OJ L 253, 16.7.2021, p. 13–48). ELI: http://data.europa.eu/eli/reg_impl/2021/1165/2023-11-15

The Group presents recommendations concerning possible clarifications in the horizontal legislation, concerning housing and structural elements used, climate control, ventilation, light conditions, the possibility to express natural behaviour and avoidance of cannibalism.

Recommendations concerning housing and husbandry practices in organic insect production:

a) The Group observes that the standards for the different insect species reared and their life-stages as currently set in the EU horizontal legislation are quite limited in terms of welfare or husbandry practices and create great challenges to formulate specific standards on organic production of insects.
b) Production units for organic production of insects must be completely separated from non-organic production units.

ANIMAL HEALTH RELATED TO INSECT PRODUCTION

Recommendations concerning horizontal rules on animal health in insect production

The Group presents general recommendations for the prevention of disease outbreaks, through hygiene measures and spatial separation of different stages of the rearing process.

Recommendations regarding animal health in organic insect production

(a) For disinfection, only those disinfectants can be used that are allowed in organic animal production facilities (Regulation (EU) 2021/1165, Annex IV, Part A).
(b) For pathogen and pest control, priority is given to environmental / biological control measures as well as the 'stamping out' method. In cases where these methods are insufficient to solve the problem, the use of authorised products and substances under Article 24 of Regulation (EU) 2018/848 could be considered. Only those products allowed in organic animal husbandry can be used. At present, there are no veterinary products registered for insect rearing, other than for honeybees.

ANIMAL WELFARE RELATED TO INSECT REARING

Little specific knowledge is available to define and assess welfare in insects. The Group presents recommendations for horizontal rules related to animal welfare in insect production. This relates to adequate food supply, avoidance of physical harm, transport conditions and killing methods. Setting specific rules for insect welfare in organic production is a challenge considering that in the EU horizontal legislation there are no detailed standards for each relevant species.

BY-PRODUCTS OF INSECT REARING, I.E. FRASS

Frass is defined in Annex I, point 61 to Regulation (EU) No 142/2011: it means a mixture of excrements derived from farmed insects, the feeding substrate, parts of farmed insects, dead eggs and with a content of dead farmed insects of not more than 5 % in volume and not more than 3 % in weight.

Manure is defined in Article 3, point 20 of Regulation (EC) No 1069/2009: it means any excrement and/or urine of farmed animals other than farmed fish, with or without litter.

The group considers that, since frass is a source of organic nitrogen, its use should be limited with respect to a maximum of 170 Kg of nitrogen per hectare per year. Further, the conditions for the placing on the market of frass must respect the requirements set out in Annex XI, Chapter II, Section 2(f) to Regulation (EU) No 142/2011.

LANDLESS LIVESTOCK PRODUCTION

The Group recommends that, as with bees, landless production of insects in general should be allowed.

CONVERSION FROM CONVENTIONAL TO ORGANIC INSECT PRODUCTION

Recommendations for the rules on conversion from conventional to organic insect production: Part II of Annex II to Regulation (EU) 2018/848 is amended as follows:

(a) the following point 1.2.2 (i) should be inserted:

(i) one single life cycle, from egg to egg, for insects intended for food or feed production, [the parental animals may stay in the culture]

(b) the following point 1.9.7 should be inserted:

1.9.7. For insects intended for food or feed production

1.9.7.1 Origin of animals

a. Considering the present limited availability of organic starting material, by way of derogation from point 1.3.1, non-organic insects may be introduced for genetic regeneration of populations, or extension of the production. The weight of non-organic reared insects (eggs and small larvae / nymphs) introduced shall not exceed 5% of the total fresh biomass of the finally harvested insects per batch.

b. The conversion period between the introduction of non-organic starting material to organic production should at least be 2/3 of the total life cycle of the species, which means the time span between the hatching of the eggs and the final harvesting (killing).

4. INTRODUCTION: Insects used as food and feed

Value of insects as sources of food or feed

Various species of insects, such as crickets, mealworms, and locusts, are edible and highly nutritious as food and feed (van Huis et al., 2013). As animal feed, insects provide an alternative to other protein-rich feed sources. An important advantage of the use of insects for food or feed may result from the possibility to rear them on side streams of the food industry that are not suitable for other purposes. Several species reared for feed, exclusively live on organic material in decomposition. As such, they can form an important element in creating circularity in agricultural systems. Furthermore, insects have a high feed conversion efficiency when compared to conventional livestock, although this varies depending on the reared species (Oonincx et al., 2015; Lundy and Parrella, 2015). For example, crickets are twice as efficient in converting feed to meat than chicken, at least four times more efficient than pigs, and 12 times more efficient than cattle (van Huis et al., 2013). Altogether, insect production for food and feed may help reduce waste and recycle nutrients into high-quality protein. The residues of insect rearing, i.e. faeces mixed with insect- and food remains (commonly referred to as 'frass'), can be used as a highly valuable organic fertiliser (Hénault-Ethier et al., 2023; Abd Manan et al., 2024; Amorim et al., 2024; Idris et al., 2024, Zande et al., 2023*)*, as defined in Annex I, point 61 to Regulation (EU) No 142/2011.

The variability in biology among insect species/groups requires differentiated production rules

In the Terms of Reference, the Group was requested to address several aspects of the horizontal regulations, and to analyse the applicability of some of these rules for insect production. According to Regulation (EU) 2018/848, Article 3(27), 'Insect production' is generically included in 'livestock production' and should thus comply to the general rules on livestock production (See ANNEX 1 for currently applicable legislation). Given the specific life characteristics of insects, and the broad range of species that are reared (for an overview of the species currently authorised as food and as feed, see ANNEX 2), the generic rules cannot always be applied to the rearing of insects and also need to be differentiated per individual species. This makes it necessary to define specific rules for the rearing of the different species of insects for food and feed, just like specific rules have been set for honeybee keeping. Although this is a task beyond the mandate of the EGTOP, the Group reflects on some key aspects of the horizontal legislation and provides some suggestions for adaptations.

5. NUTRITION

Nutrition, reflections on horizontal legislation

In the current EU legislation, the feeding substrates used in insect farming must comply with the EU animal by-product rules, feed safety regulations, in particular Regulation (EC) No 1069/2009 on animal by-products, Regulation (EC) No 183/2005[4] on feed hygiene, Directive 2002/32/EC[5] on undesirable substances in animal feed and Regulation (EC) No 767/2009[6] on the placing on the market and use of feed. As regards animal by-products to be fed to farmed animals, certain prohibitions apply (e.g., Article 11(1)(b) of Regulation (EC) No 1069/2009), while animal by-products destined for feeding to farmed animals are laid down in Article 31 thereof. The catalogue of feed materials is defined in Regulation (EU) No 68/2013[7].

The rearing of insects for food or feed offers many possibilities to contribute to a circular economy, as long as it is based on the use of local agricultural or alimentary byproducts or side streams. However, many of these side streams are currently not allowed as nutrition for livestock.

EFSA's study (2015) reviewed the risk profile related to production and consumption of insects as food and feed, and including the expected occurrence of hazards in non-processed insects, grown on different substrate groups, in comparison to the occurrence in other protein sources of animal origin (see page 36 of EFSA study). EFSA analysis is not legally binding.

EFSA's study (2015), categorises the potentially available nutritional substrates for insect rearing as follows:

- A: Animal feed materials according to the EU catalogue of feed materials (Regulation (EU) No 68/2013, Annex Part C) and authorized as feed for food-producing animals.
- B: Food produced for human consumption, but which is no longer intended for human consumption, for reasons such as an expired use-by date or due to problems of manufacturing or packaging defects. Meat and fish may be included in this category;
- C: By-products from slaughterhouses (hides, hair, feathers, bones etc.) that do not enter the food chain, originating from animals fit for human consumption;
- D: Food waste from food for human consumption of both animal and non-animal origin from restaurants, catering establishments and households;
- E: Animal manure and intestinal content;
- F: Other types of organic waste of vegetable nature such as gardening and forest material;
- G: Human manure, and sewage sludge.

Currently, only category A is allowed for the general production of livestock.

[4] Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene (OJ L 35, 8.2.2005, p. 1–22). ELI: http://data.europa.eu/eli/reg/2005/183/2022-01-28

[5] Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed - Council statement (OJ L 140, 30.5.2002, p. 10–22). ELI: http://data.europa.eu/eli/dir/2002/32/2019-11-28

[6] Regulation (EC) No 767/2009 of the European Parliament and of the Council of 13 July 2009 on the placing on the market and use of feed, amending European Parliament and Council Regulation (EC) No 1831/2003 and repealing Council Directive 79/373/EEC, Commission Directive 80/511/EEC, Council Directives 82/471/EEC, 83/228/EEC, 93/74/EEC, 93/113/EC and 96/25/EC and Commission Decision 2004/217/EC (OJ L 229, 1.9.2009, p. 1–28). ELI: http://data.europa.eu/eli/reg/2009/767/2018-12-26

[7] Commission Regulation (EU) No 68/2013 of 16 January 2013 on the Catalogue of feed materials (OJ L 29, 30.1.2013, p. 1–64). ELI: http://data.europa.eu/eli/reg/2013/68/2022-07-24

EFSA (2015) analyses the hazards associated with the use of non-processed insects after being produced with the different categories of nutritional substrates, compared to the occurrence of these hazards in other protein sources of animal origin. For microbiological hazards, this risk is expected to be equal or lower when insects are fed on substrate groups A, B, C, D, F. The risk related to substrate groups E and G (manure, sewage, sludge from animals/humans) should be specifically evaluated, considering the kind of treatment applied, to minimize the microbial contamination (such as sterilization treatments, e.g. with high temperatures). The possible presence of spore-forming bacteria, which can survive heat treatment, as well as other contaminants, must be carefully considered.

On the basis of that risk analysis, the group considers that nutritional substrates that belong to categories B, C, D and F, in addition to substrates belonging to category A, might be considered for future authorisation as nutritional substrates to produce insects for food and feed. Category C (by-products from slaughterhouses) may even contain essential amino acids (e.g. lysine and methionine) that are only available in low concentrations in plant-derived diets. For insects produced for feed, substrates belonging to category E (Animal manure and intestinal content) might also be considered. This category might not be desirable to produce insects produced for food, because of consumer acceptance. The risk of microbiological contaminations is mitigated since the raw insect materials used to produce protein, fat/oil and chitin in animal feed, may be required to undergo heat treatment, as is described in the legislation on animal by-products (Regulation (EC) No 1069/2009[8]). In any case, at the EU level, manure is a Category 2 material in accordance with Article 9, point (a) of Regulation (EC) No 1069/2009 and its use is specifically regulated due to inherent risks in accordance with Article 13 of that Regulation.

Nutrition, recommendations on horizontal legislation.

The Group proposes to consider adaptations in the horizontal legislation with respect to nutritional substrates allowed for use in insect farming, also taking into account the risk analysis presented by the EFSA Scientific Committee (2015). These adaptations will be different for insects reared for food or those reared for feed.

Nutrition, reflections on organic production

a) The basic principle of organic insect rearing is to utilise input material derived from (organic) side streams. However, the Group realises that the availability of these inputs of organic origin is currently not sufficient to satisfy the needs, so a transition period is proposed during which the use of conventional material will be allowed for part of the nutrition.
b) Regulation (EU) 2018/848, Annex II, Part II, Point 1.4.1. (e) states: “with the exception of porcine animals, poultry and bees, livestock shall have permanent access to pasture whenever conditions allow or shall have permanent access to roughage”. Considering the confined production conditions and the diet of many reared insect species, this article should be extended to include ‘other insects’ in the exceptions.

[8] Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation) (OJ L 300, 14.11.2009, p. 1–33). ELI: http://data.europa.eu/eli/reg/2009/1069/2019-12-14

In choosing feedstock, it is important to differentiate between insects destined for food and those to be used as feed.

Insects produced for food

For insects produced for food, the Group is of the opinion that there should be a priority for the use of side streams, i.e. nutrition that is not suitable for human consumption. Side streams that can be used as feed for other live stock should be available for insects produced for food, since these insects have a higher conversion rate (efficiency of converting feed into meat). The Group is of the opinion that, at present, there is not enough local organic feed available for certain species, given that there are not enough side streams of organic origin or they are not collected separately (requirement in Point 1.4.1(a) of Part II of Annex II of Regulation (EU) 2018/848). This also means that the condition laid down in point 1.4.1(b) of Part II of Annex II of Regulation (EU) 2018/848 , i.e. 'livestock shall be fed with organic or in-conversion feed' , can often not be met. If the local availability of organic input can be demonstrated to be insufficient, the Group proposes that, at present, the percentage of organic side streams, must be a minimum of 60% (fresh weight) in all production cycles. The remaining 40% should be derived from conventional side streams.

Examples: In the case of locusts reared on a diet of fresh green plant materials, reaching 60% organic material should be feasible based on organic crop residues and other sources of organic plant material, like plant material from landscape management. On the other hand, mealworms depend on waste from the food chain (e.g. cereals and cereal parts). In this case, it may be more challenging to reach the 60% threshold, since it is more difficult to ascertain the organic production standards of the original crops.

The aim is to further increase the use of organic and local input, to reach 95% of the total input within 5 years, from the time the current proposal has entered into force. The Group recommends that the rules for organic insect production be re-evaluated at this point.

Insects produced for feed

According to Regulation (EU). 2018/848 *(Art. 6 (m))*, livestock should be fed on feed materials produced in accordance with the rules of organic production. In principle, the feeding rules for organic monogastrics requires that at least 95% of the nutrition should be organic. This should also be the long-term goal for organic production of insects produced for feed. However, considering that there is a very limited availability of separated side streams of organic origin, the Group proposes that, for the time being, a minimum of 25% of the feed-stock should be organic, with the intention to re-evaluate and possibly increase this percentage 10 years after publication of the current guidelines. For sustainability purposes, it is desirable that the nutritional input for insects reared for feed are sourced regionally.

Nutrition, recommendations on organic production

All insects

a) Regulation (EU) 2018/848, Annex II, Part II, Point 1.4.1. (e) should be adjusted to read: "(e) with the exception of porcine animals, poultry, bees **and other insects**, livestock shall have permanent access to pasture whenever conditions allow or shall have permanent access to roughage."

Insects produced for food

d) At least 95% of the nutritional input (fresh weight) for organic insect rearing must be derived from side streams, including side streams that are potentially suitable as feed for other livestock.
e) The Group proposes that, at present, the percentage of organic input, must be a minimum of 60% (fresh weight) in each batch produced. The aim is to further increase the use of organic and local input to reach 95% (fresh weight) of the total input within 5 years, starting from the time the current proposal has entered into force. The Group recommends that the rules for organic insect production will be re-evaluated at this point.
f) Feed material and additives. Trace elements and vitamins of natural origin can be used when needed. The use of synthetic supplements is not allowed, except for those formulations that are allowed in organic agriculture or animal husbandry (Annex 3 to Regulation (EU) 2021/1165).

Insects produced for feed

d) At least 95% of the nutritional input (fresh weight) for organic insect rearing must be derived from side streams. The Group suggests giving priority to substrates that are in limited competition with substrates currently used for feed in other livestock production.
e) For plant material used for insects reared for organic feed, at least 25% of the feedstock (fresh weight) should qualify as organic, or in conversion. This is to be re-evaluated 5 years after the current regulation entered into force of.
f) The feedstock should preferentially be sourced regionally (either coming from the agricultural holding where the insects are being produced, or from other holdings or food processors as close as possible to the unit).

For the remaining, non-organic, feedstock, non-organically produced materials can be used as listed in Regulation (EU) No 68/2013, ANNEX, part C.

6. HOUSING AND HUSBANDRY PRACTICES

Reflections on horizontal legislation

With respect to animal well-being in vertebrate livestock management, the principles are laid down in Council Directive 98/58/EC[9]. This directive was based on the concept of 'The Five Freedoms', first described in 1965 in a UK governmental report, led by Dr. R. Bramble. These are:

1. **Freedom from Hunger and Thirst**: by ready access to fresh water and a diet to maintain full health and vigor.
2. **Freedom from Discomfort**: by providing an appropriate environment including shelter and a comfortable resting area.
3. **Freedom from Pain, Injury or Disease**: by prevention or through rapid diagnosis and treatment.
4. **Freedom to Express Normal Behaviour**: by providing sufficient space, proper facilities and company of the animal's own kind.
5. **Freedom from Fear and Distress**: by ensuring conditions and treatment which avoids mental suffering.

In the last years, the international community has transitioned from the 'Five Freedoms' model to the 'Five Domains' as the standard for animal welfare assessment. The 'Five Domains' model takes into account positive experiences and covers a more comprehensive range of mental states that animals may experience (Mellor et al, 2020)

[9] Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. (OJ L 221, 8.8.1998, p. 23–27) ELI: http://data.europa.eu/eli/dir/1998/58/2019-12-14

However, Directive 98/58/EC[10] excludes invertebrates from its scope of application and therefore does not apply to insects. For most of the species that are reared, there is very little information available concerning the optimal or tolerated conditions. These conditions can differ drastically between different insect species, and even between the different life stages one of a given species (see Annex 2 of the present report). This makes it often impossible to set generic rules and/or values, e.g. with respect to specific levels of light, temperature, humidity, CO_2, ammonia, etc. Furthermore, some concepts, like animal welfare, discomfort, fear and distress, are not clearly defined or measurable for insects.

Recommendations concerning the horizontal rules on housing and husbandry practices

a) Insects should be kept under controlled appropriate climate conditions, to avoid excessively low or high temperature/humidity. Overheating can be especially critical in species like black soldier fly, where the larvae create a substantial amount of metabolic heat.
b) Proper ventilation should be provided, to assure appropriate climatic conditions and air quality (CO_2, ammonia levels, etc.). In cases where the substrate heats up, appropriate ventilation of the substrate should also be foreseen. Horizontal legislation exists with respect to climate conditions and air quality for people who work in closed environments. Specific thresholds are also defined for poultry and pig farms. In addition, specific rules have also been defined for other livestock farms at national level. However, for insects these have not been defined, and will be very different between insect species and life stages. The CO_2 and/or ammonia concentrations, as well as climate conditions, may be drastically different from conditions tolerated and allowed in legislation for other livestock and for humans, with insects often having substantially higher tolerance levels.
c) The type of flight cages (well-ventilated), boxes or containers for housing insects need to be such that the insects are effectively contained. The management of the rearing, the facilities and the accommodation shall be designed such that the escape of the insects at any stage of development into the environment is precluded.
d) Structural elements (housing containers, boxes, cages) used for housing shall not cause injuries to insects; there should be no contact possible between the insects and heat sources (such as light bulbs).
e) Structural elements, as well as other elements that are introduced into the cages (e.g. oviposition structures or resting places), shall not be made of materials that may be harmful to, or may be ingested by, the reared insects.
f) Materials used should present no risk of contamination of the insects being reared. Structural elements used for housing should be biodegradable and/or re-usable and, in the latter instance, suitable for proper disinfection and cleaning.
g) Appropriate husbandry practices shall ensure that the species can express natural behaviours as much as possible. In the case of insect production, this needs clarification. For example, many species of insects that are reared for food and feed are highly gregarious. Cannibalism can be part of the natural behaviour expressed in several of these species. This natural tendency towards cannibalism should nonetheless be reduced by giving the insects sufficient and nutritionally

[10] Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. (OJ L 221, 8.8.1998, p. 23–27) ELI: http://data.europa.eu/eli/dir/1998/58/2019-12-14

balanced food. For the same reason, cannibalistic species should be reared in synchronized cohorts, at appropriate stocking densities. Another example may be flight, which may be an element of the natural behaviour of certain species in search for essential resources. The ability to fly is limited when these species are reared in confined conditions, but as long as sufficient resources are provided, this is not necessarily problematic. The Group proposes to further define the appropriate husbandry practices elsewhere, for each of the farmed species and their life stages.

h) Light conditions shall be provided according to the needs of the species and the specific life stages that are reared. Some species, e.g. larvae of black soldier flies, avoid light and naturally develop under conditions of complete darkness. In other cases, the photoperiod and light intensity shall be appropriate to the conditions required for development and reproduction. As insects (together with birds) have higher flicker frequency perception than other animal taxa, low frequency (<300 Hz) light tubes should be avoided. In the case of artificial light sources, spectral composition and light/dark regime may also impact insect behaviour, such as mating, oviposition, adult longevity, and the resulting number of young larvae. For example, see Liu et al. (2020).

Recommendations on housing and husbandry practices in organic insect production

c) The Group observes that since Directive 98/58/EC does not apply to invertebrates, there is no horizontal legislation currently applicable to insects in relation to welfare.

d) Production units for organic production of insects must be completely separated from non-organic production units.

7. ANIMAL HEALTH RELATED TO INSECT PRODUCTION

Considerations on horizontal regulations concerning animal health in insect rearing

Current legislation on animal health does not lay down specific conditions with respect to insect production. For example, in Regulation (EU) 2016/429[11], no diseases are currently listed for insects, with the exceptions of honeybees (Annex II), hence insects are largely without any specific requirements contrary to other species. They are only mentioned as possible vectors of diseases and as elements that have to be controlled. Nevertheless, many of the principles from this regulation can be applied to insect rearing for food and feed. The Group has the following recommendations.

Recommendations on horizontal rules concerning animal health in insect production

a) Housing containers, boxes and cages or other structures within the cages that are in direct contact with the insects shall be emptied, cleaned and disinfected after each production cycle; In those cases where cages are used continuously, e.g. for mating purposes, or in cases of mixed

[11] Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law') (OJ L 84, 31.3.2016, p. 1–208). ELI: http://data.europa.eu/eli/reg/2016/429/2021-04-21

generation rearing, the cages shall be cleaned and disinfected regularly, at least after every production cycle or, when these cycles are mixed, at least every month.

b) For disease and pest prevention, insects should be reared in fully separated batches. New batches should be started from healthy 'mother cultures', kept in separate room(s).

Recommendations regarding animal health in organic insect production

a) For disinfection, only those disinfectants can be used that are allowed in organic animal production facilities (Regulation (EU) 2021/1165, Annex IV, Part A) may be used.

b) For pathogen and pest control, priority is given to environmental / biological control measures as well as the 'stamping out' method. In cases where these methods are insufficient to solve the problem, only products allowed in organic animal husbandry can be used. At present, there are no veterinary products registered for insect rearing, other than for honeybees.

8. ANIMAL WELFARE RELATED TO INSECT PRODUCTION

Setting specific rules for insect welfare in organic production is a challenge as different species have different biological requirements and given that the EU horizontal legislation does not provide detailed standards for the relevant species.
Little specific knowledge is available to define welfare in insects. The Group has the following suggestions which might be applied to insect rearing.

Recommendations on horizontal rules concerning animal welfare in insect production

a. Welfare should be guaranteed by adequate supply of feed and water with respect to the species- and stage-specific needs. Depending on the species and developmental stage, a period of one day, or several days, without feeding is allowed before killing, or during transportation. This period should not cause excessive stress due to food deprivation as insects tend to have sufficient energy reserves to survive one or several days without food in nature.

b. Species which tend to engage in cannibalism should be reared in synchronized cohorts.

c. Physical harm to the insects should be avoided as much as possible, including during the handling and harvesting processes.

d. Transport conditions and other handling procedures of live insects shall respect the suitable climatic conditions, physiological needs and properties of insects. If the duration of transport and handling causes food deprivation stress, adequate amounts of food and/or water should be provided.

e. With respect to the killing methods, limited knowledge is available concerning the stress or pain experienced by insects under different conditions. When selecting the killing method, differences in size and species-specific properties shall be considered. The killing method should be as stress-free and/or expeditious as possible. The animals are killed either by 1) cooling and freezing, which is supposed to be low-stress, or 2) in the quickest way, by blanching, or by mechanical means (crushing, shredding). Killing by sun drying or oven-drying, including killing in micro-wave ovens, should not be allowed.

Recommendations regarding animal welfare in organic insect production

The Group does not propose any specific rules for insect welfare in organic production beyond the general rules described above.

9. BY-PRODUCTS OF INSECT REARING, I.E. FRASS

'Frass' is defined in Annex I, point 61 to Regulation (EU) 142/2011, as 'a mixture of excrements derived from farmed insects, consisting of excrements, the feeding substrate, parts (skins) of farmed insects, dead eggs and with a content of dead farmed insects of not more than 5% in volume and not more than 3% in weight.' Frass, also from non-organic insect production, is authorised as fertiliser in organic agriculture (included in Regulation (EU) 2021/1165). Frass may also be used for biogas production. Before being placed on the market, frass needs to be processed through a heat treatment, at 70ºC for 1 hour, according to the requirements set out in Annex V to Regulation (EU) 142/2011.

Manure is defined in Article 3, point 20 of Regulation (EC) No 1069/2009: it means any excrement and/or urine of farmed animals other than farmed fish, with or without litter.

The group considers that, since frass is a source of organic nitrogen, its use should be limited with respect to a maximum of 170 Kg of nitrogen per hectare per year.

10. LANDLESS LIVESTOCK PRODUCTION

Regulation (EU) 2018/848, Recital (40), states that "…livestock production naturally involves the management of agricultural land, where manure is used to nourish crop production, landless livestock production should be prohibited, except in the case of beekeeping". Furthermore, in Annex II Part II (Livestock production rules), point 1.1, it is stated that "except in the case of beekeeping, landless livestock production, where the farmer intending to produce organic livestock does not manage agricultural land and has not established a written cooperation agreement with a farmer as regards the use of organic production units or in-conversion production units for that livestock, shall be prohibited".

Differently from feed for other livestock, feed for insects is often not directly derived from agricultural production, but rather from by-products of food processing and/or from food waste. Usually, e.g. in the case of wheat for organic flour production, the land-animal-manure link has already been respected in the cultivation of crops from which the by-products were derived.

Recommendations regarding rules on landless insect production

As with bees, landless production of insects in general should be allowed.

11. CONVERSION FROM CONVENTIONAL TO ORGANIC INSECT PRODUCTION

Regulation (EU) 2018/848, Annex II, Part II, Point 1.3.1., states: "Without prejudice to the rules on conversion, organic livestock shall be born or hatched and raised on organic production units".

Consequently, a conversion period of one generation, from egg to egg, is enough. Given that the starting material for organic production is not always available from other organic productions, it is to allow the use of non-organically reared insects for this purpose.

Recommendations for the rules on conversion from conventional to organic insect production

Part II of Annex II to Regulation (EU) 2018/848 is amended as follows:

(c) the following point 1.2.2 (i) should be inserted:

'(i) one single life cycle, from egg to egg, for insects intended for food or feed production, [the parental animals may stay in the culture]'

(d) the following point 1.9.7 should be inserted:

1.9.7. For insects intended for food or feed production

1.9.7.1 Origin of animals

(a) Considering the present limited availability of organic starting material, by way of derogation from point 1.3.1, non-organic insects may be introduced for genetic regeneration of populations, or extension of the production. The weight of non-organic reared insects (eggs and small larvae / nymphs) introduced shall not exceed 5% of the total fresh biomass of the finally harvested insects per batch.

(b) The conversion period between the introduction of non-organic starting material to organic production should at least be 2/3 of the total life cycle of the species, which means the time span between the hatching of the eggs and the final harvesting (killing).

12. DOCUMENTATION

Abd Manan, F., Yeoh, Y.-K., Chai, T.-T., Wong, F.-C., 2024. Unlocking the potential of black soldier fly frass as a sustainable organic fertilizer: A review of recent studies. *Journal of Environmental Management* 367:121997 https://doi.org/10.1016/j.jenvman.2024.121997 https://www.sciencedirect.com/science/article/pii/S0301479724019832

Amorim, C.S., Ashworth, A. J., Arsi, K., Rojas, M. G., Morales-Ramos, J. A., Donoghue, A., Robinson, K., 2024. Insect frass composition and potential use as an organic fertilizer in circular economies. *Journal of Economic Entomology* https://doi.org/10.1093/jee/toad234

EFSA Scientific Committee, 2015. Risk profile related to production and consumption of insects as food and feed. https://doi:10.2903/j.efsa.2015.4257

Hénault-Ethier, L., Reid, B., Hotte, N., Paris, N. Quinche, M., Lachance, C., Fortin, A., Normandin, E., Laderriere, V., Vandenberg, G., 2023. Agricultural Science & Technology 2023. Growth Trials on Vegetables, Herbs, and Flowers Using Mealworm Frass, Chicken Manure, and Municipal Compost DOI: https://doi.org/10.1021/acsagscitech.2c00217

Hénault-Ethier, L. Quinche, M., Reid, B., Hotte, N., Fortin, A., Normandin, E., 2024. Opportunities and challenges in upcycling agri-food byproducts to generate insect manure (frass): A literature review. *Waste Management* 176: 169-191 DOI: https://doi.org/10.1016/j.wasman.2023.12.033

Huis, A. van, Itterbeeck, J. van, Klunder, H., Mertens, E., Halloran, A., Muir, G., Vantomme, P., 2013. Edible insects: future prospects for food and feed security. *FAO Forestry Paper* **171**. Food and Agriculture Organization of the United Nations, Rome. 201 pp.

M. Idris, M.,Rismayani, D., Aulia, A., Nopiyanti, T., Rahayu, R., 2024. Biology of Black Soldier Fly (Hermetia illucens) and Utilization of its Waste (Maggot Frass) for Plant Growth: A Literature Review. *Jurnal Biologi Tropis* Vol. 24 Issue 3 Pages 273-291. DOI: 10.29303/jbt.v24i3.7226. https://jurnalfkip.unram.ac.id/index.php/JBT/article/view/7226

Liu, Z., Najar-Rodriguez, A.J., Minor, M.A., Hedderley, D.I., Morel, P.C.D., 2020. Mating success of the black soldier fly, Hermetia illucens (Diptera: Stratiomyidae), under four artificial light sources. *Journal of Photochemistry and Photobiology B: Biology*. 205: 111815 https://www.sciencedirect.com/science/article/pii/S1011134419307808

Lundy, M.E. & Parrella, M.P., 2015. Crickets Are Not a Free Lunch: Protein Capture from Scalable Organic Side-Streams via High-Density Populations of *Acheta domesticus*. PLOS One https://doi.org/10.1371/journal.pone.0118785

Mellor DJ, Beausoleil NJ, Littlewood KE, McLean AN, McGreevy PD, Jones B, Wilkins C. 2020 The Five Domains Model: Including Human-Animal Interactions in Assessments of Animal Welfare. Animals (Basel). 2020 Oct 14;10(10):1870. doi: 10.3390/ani10101870. PMID: 33066335; PMCID: PMC7602120.

Oonincx, D.G.A.B., van Broekhoven, S., van Huis, A., van Loon, J.J.A. (2015). Feed Conversion, Survival and Development, and Composition of Four Insect Species on Diets Composed of Food By-Products. PLoS One. doi: 10.1371/journal.pone.0144601

Zande, M. van de, Wantulla, M, van Loon, J. J. A., Dicke, M. 2023. Soil amendment with insect frass and exuviae affects rhizosphere bacterial community, shoot growth and carbon/nitrogen ratio of a brassicaceous plants. *Plant and Soil:* https://doi.org/10.1007/s11104-023-06351-6

ANNEX 1. Current legislation on livestock production

Breeding

- Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes
- Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law')
- Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species
- Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007
- Commission Implementing Regulation (EU) 2020/464 of 26 March 2020 laying down certain rules for the application of Regulation (EU) 2018/848 of the European Parliament and of the Council as regards the documents needed for the retroactive recognition of periods for the purpose of conversion, the production of organic products and information to be provided by Member States (Text with EEA relevance)
- Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorising certain products and substances for use in organic production and establishing their lists

Feeds

- Regulation (EC) No 767/2009 of the European Parliament and of the Council of 13 July 2009 on the placing on the market and use of feed, amending European Parliament and Council Regulation (EC) No 1831/2003 and repealing Council Directive 79/373/EEC, Commission Directive 80/511/EEC, Council Directives 82/471/EEC, 83/228/EEC, 93/74/EEC, 93/113/EC and 96/25/EC and Commission Decision 2004/217/EC
- Commission Regulation (EU) 2022/1104 of 1 July 2022 amending Regulation (EU) No 68/2013 on the Catalogue of feed materials
- Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition
- Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene
- Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation)
- Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive
- Regulation (EC) No 999/2001 of the European Parliament and of the Council of 22 May 2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies

- Commission Regulation (EU) No 744/2012 of 16 August 2012 amending Annexes I and II to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for arsenic, fluorine, lead, mercury, endosulfan, dioxins, Ambrosia spp., diclazuril and lasalocid A sodium and action thresholds for dioxins
- Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed - Council statement
- Commission Notice Guideline for the feed use no longer intended for human consumption C/2018/2035
- 2011/25/EU: Commission Recommendation of 14 January 2011 establishing guidelines for the distinction between feed materials, feed additives, biocidal products and veterinary medicinal products

Official Controls

- Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation).
- Commission Regulation (EC) No 152/2009 of 27 January 2009 laying down the methods of sampling and analysis for the official control of feed establishes the sampling method and the methods of analysis of feed for control purposes.
- Commission Regulation (EU) 2017/771 of 3 May 2017 amending Regulation (EC) No 152/2009 as regards the methods for the determination of the levels of dioxins and polychlorinated biphenyls updates the analytical requirements for the analysis of dioxins and polychlorinated biphenyls.
- Guidance Document on the Estimation of LOD and LOQEN••• for Measurements in the Field of Contaminants in Feed and Food and a Guidance Document on Measurement Uncertainty for Laboratories performing PCDD/F and PCB Analysis using Isotope Dilution Mass Spectrometry which have been elaborated by the European Reference Laboratories in the field of contaminants in feed and food.
- Commission Regulation (EU) No 691/2013 amending Regulation (EC) No 152/2009 as regards methods of sampling and analysis
- A guidance document for the implementation of Commission Regulation (EU) No 691/2013 by the Standing Committee on the Food Chain and Animal Health – section Animal Nutrition.

https://food.ec.europa.eu/safety/animal-feed/undesirable-substances_en

ANNEX 2. Overview of insects for food and feed

Part A - Insect species from which processed animal protein derived from farmed insects, intended for the production of feed for farmed animals other than fur animals may be obtained, as laid down in Annex X, Chapter II, Section 1, point A.2 to Regulation (EU) No 142/2011

(i) Black Soldier Fly (*Hermetia illucens*) and Common Housefly (*Musca domestica*);
(ii) Yellow Mealworm (*Tenebrio molitor*) and Lesser Mealworm (*Alphitobius diaperinus*);
(iii) House cricket (*Acheta domesticus*), Banded cricket (*Gryllodes sigillatus*) and Field Cricket (*Gryllus assimilis*);
(iv) Silkworm (*Bombyx mori*)

Part B - Insect species authorised in the EU as novel food, pursuant to Annex to Commission Implementing Regulation (EU) 2017/2470[12] and its subsequent amendments.

- *Tenebrio molitor* larva (dried yellow mealworm)
- *Locusta migratoria* (frozen, dried and powder forms of migratory locust)
- *Tenebrio molitor* larva (frozen, dried and powder formulations from whole yellow mealworm)
- *Acheta domesticus* (frozen, dried and powder forms of whole house cricket)
- *Acheta domesticus* (partially defatted powder formulations from house cricket)
- *Alphitobius diaperinus* (frozen and freezedried formulations of lesser mealworm)
- UV-treated powder of whole *Tenebrio molitor* larva (yellow mealworm)

Part C – Examples of insect species known to be farmed on commercial basis both within and outside Europe (source: EFSA, 2015 – not legally binding)

Common name	**Flies (Diptera)**	**Crickets (Othoptera, Gryllidae)**	**Locusts (Orthoptera, Acrididae)**	**Mealworms (Coleoptera, Tenebronidae)**
Latin name (species)	*E,G. Hermetia illucens* (black soldier flies, BSF); *Musca domestica* (houseflies)	*E,g. Acheta domesticus*	*E.g. Locusta migratoria*	*E.g. Tenebrio molitor*
Natural habitat	BSF are distributed in the tropics and is	Crickets can be found in a range of	Locusts can be found in a range of open	beneath rocks, rotten logs or in animal

[12] Commission Implementing Regulation (EU) 2017/2470 of 20 December 2017 establishing the Union list of novel foods in accordance with Regulation (EU) 2015/2283 of the European Parliament and of the Council on novel foods (OJ L 351, 30.12.2017, p. 72–201, ELI: http://data.europa.eu/eli/reg_impl/2017/2470/oj)

	found in humid and nutrient-rich ecosystems with an abundance of decomposing animal and plant remains. Houseflies have a world-wide distribution and live in decaying plant material or animal carcasses. Houseflies have a global distribution	habitats including forests, grasslands and wetlands	habitats, including grasslands and arable cropping systems	burrows. They will eat decaying leaves, dried grasses, or grains. Mealworms have adapted to human-created facilities with stored grains, such as warehouses, mills, or farms.
Reared for	Feed	Food/Feed	Food/Feed	Food/Feed
Specific characteristics	BSF larvae produce heat in substrate Typically fly pupae are used for feed	With crickets, both nymphs and adults are used for food and feed	The gregarious and the solitary phase are two distinctly different phenotypes. In production, migratory locusts occur mainly in the gregarious phase	Mealworms are the larval form of the darkling beetle, Tenebrio molitor
Larval/nymphal food used in production	Can grow on a wide range of organic matter, such as cereals, fruits and vegetables in decay	Typically a combination of vegetables and chick starter feed (corn and soy)	Fresh grass with wheat bran supplements.	Various cereals (bran), vegetables, fruit.
Adult food	Adult BSF are non-feeding. Adult houseflies feed on liquid and semi-liquid substances	Same as nymphs	Same as nymphs	Same as larvae
Adult flight	In oviposition cages	Not all species can fly. Those capable of flying, typically prefer to crawl.	Adults only fly short distances, except in the migratory phase	They generally only fly in search of food. When fed ad libitum in captivity they rarely fly.
Cannibalism	BSF: No Houseflies: Yes	Yes, can be reduced by feeding nutritionally balanced diets supplements	Locusts are vegetarian but at high densities engage in cannibalism. This cannibalism plays a crucial role in natural swarm formation. Cannibalism can be reduced through the provision of ad libitum food	Larvae are gregarious and mostly vegetarian, but do occasionally engage in cannibalism. This can be reduced by synchronizing larval batches. Adult darkling beetles are highly cannibalistic towards the eggs.
Frass separation during production	No, larvae naturally feed in substrate consisting of food and frass	No	No	No. Only when larvae reach full size, are they separated from frass and food residues by sifting
Mortality factors	Overheating, Poor ventilation of substrate, Parasitic wasps, mites, insect viruses (Yang 2017). Pesticides	Crickets can suffer infestation with Nosema spp., Gregarine spp. and Steinernema spp. Several cricket viruses have been identified.	Nosema spp. and Gregarine spp. are the most prevalent locust parasites. Insect pathogenic fungi, such as Metharhizium acridum, can also infect locusts	Crickets can suffer infestation with Nosema spp., Gregarine spp. and Steinernema spp.Mealworm parasites include Gregarine spp.,

				Hymenolepis diminuta and mites of the family Acaridae (Galecki and Sokol, 2019). Overheating can occur at very high densities.
Duration of cycle	40 days	40 days		3-4 months
Rearing density	1-2 larvae/cm³			1-2 larvae/cm³