UNIVERSITÀ DI PISA

DIPARTIMENTO DI SCIENZE VETERINARIE

INSETTI COME NUOVE PRODUZIONI ZOOTECNICHE

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L'ALLEVAMENTO DEGLI INSETTI: OPPORTUNITÀ, PROSPETTIVE, CONTESTO NORMATIVO E NOVEL FOOD - MONTESILVANO (PE) - 24 OTTOBRE 2025

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European Food Safety Authority

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SCIENTIFIC OPINION

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Risk profile related to production and consumption of insects as food and feed

Abstract

The present opinion has the format of a risk profile and presents potential biological and chemical hazards as well as allergenicity and environmental hazards associated with farmed insects used as food and feed taking into account of the entire chain, from farming to the final product. The opinion also addresses the occurrence of these hazards in non-processed insects, grown on different substrate categories, in comparison to the occurrence of these hazards in other non-processed sources of protein of animal origin. When currently allowed feed materials are used as substrate to feed insects, the possible occurrence of microbiological hazards is expected to be comparable to their occurrence in other non-processed sources of protein of animal origin. The possible occurrence of prions in non-processed insects will depend on whether the substrate includes protein of human or ruminant origin. Data on transfer of chemical contaminants from different substrates to the insects are very limited. Substrates like kitchen waste, human and animal manure are also considered and hazards from insects fed on these substrates need to be specifically assessed. It is concluded that for both biological and chemical hazards, the specific production methods, the substrate used, the stage of harvest, the insect species and developmental stage, as well as the methods for further processing will all have an impact on the occurrence and levels of biological and chemical contaminants in food and feed products derived from insects. Hazards related to the environment are expected to be comparable to other animal production systems. The opinion also identifies the uncertainties (lack of knowledge) related to possible hazards when insects are used as food and feed and notes that there are no systematically collected data on animal and human consumption of insects. Studies on the occurrence of microbial pathogens of vertebrates as well as published data on hazardous chemicals in reared insects are scarce. Further data generation on these issues are highly recommended.

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I regolamenti europei pongono le condizioni per la produzione e commercializzazione di tutti i prodotti del settore alimentare e dei mangimi in maniera trasversale, tra cui quindi anche i produttori di insetti.

Pacchetto di testi legislativi che definiscono principi e standard generali nel settore della sicurezza degli alimenti e dei mangimi:

REGOLAMENTO (CE) N. **178/2002** - che stabilisce i principi e i requisiti generali della legislazione alimentare, istituisce l'Autorità europea per la sicurezza alimentare e fissa procedure nel campo della sicurezza alimentare

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0178&from=IT

REGOLAMENTO (CE) N. **852/2004** - sull'igiene dei prodotti alimentari

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R0852&from=EN

REGOLAMENTO (CE) N. **183/2005** - che stabilisce requisiti per l'igiene dei mangimi

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R0183&from=EN

Gli insetti e i loro prodotti derivati - esclusi gli insetti vivi - che sono destinati ad essere utilizzati nei mangimi per animali da produzione sono considerati "sottoprodotti di origine animale"

REGOLAMENTO (CE) n. **1069/2009** - recante norme sanitarie relative ai sottoprodotti di origine animale e ai prodotti derivati non destinati al consumo umano e che abroga il regolamento (CE) n. 1774/2002 (regolamento sui sottoprodotti di origine animale) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R1069&from=en

gli insetti e i loro prodotti derivati sono trattati come materiali di "categoria 3" e sono quindi autorizzati per l'uso nei mangimi per animali da produzione alimentare e alimenti per animali domestici. Occorre tenere presente la "legislazione sulla TSE" (regolamento (CE) n. **999/2001**)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001R0999&from=it

REGOLAMENTO (UE) N. **142/2011** - recante disposizioni di applicazione del regolamento (CE) n. 1069/2009 del Parlamento europeo e del Consiglio recante norme sanitarie relative ai sottoprodotti di origine animale e ai prodotti derivati non destinati al consumo umano, e della direttiva 97/78/CE del Consiglio per quanto riguarda taluni campioni e articoli non sottoposti a controlli veterinari alla frontiera

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0142&from=EN

REGOLAMENTO (UE) **2016/429** - relativo alle malattie animali trasmissibili e che modifica e abroga taluni atti in materia di sanità animale («normativa in materia di sanità animale»)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0429&from=EN

REGOLAMENTO (UE) N. **1143/2014** - recante disposizioni volte a prevenire e gestire l'introduzione e la diffusione delle specie esotiche invasive

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1143&from=EN

DIRETTIVA **98/58**/CE - riguardante la protezione degli animali negli allevamenti

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01998L0058-20030605&from=FR

REGOLAMENTO (UE) **2017/1017** - modifica il regolamento (UE) n. **68/2013** concernente il catalogo delle materie prime per mangimi

https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:32017R1017&from=EN

COMMISSION REGULATION (EU) 2022/1104

of 1 July 2022

amending Regulation (EU) No 68/2013 on the Catalogue of feed materials

(Text with EEA relevance)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1104&from=EN

9.2.1	**Animal fat** (2)	Product composed of fat from land animals, including invertebrates other than species pathogenic to humans and animals in all their life stages. If extracted with solvents, may contain up to 0,1 % hexane	Crude fat Moisture if > 1 %
9.4.1	**Processed animal protein** (2)	Product obtained by heating, drying and grinding whole or parts of land animals, including invertebrates in all their life stages from which the fat may have been partially extracted or physically removed. If extracted with solvents, may contain up to 0,1 % hexane	Crude protein Crude fat Crude ash Moisture if > 8 %
9.16.1	**Terrestrial invertebrates** (1), **live**	Live terrestrial invertebrates, in all their life stages, other than species having adverse effects on plant, animals and human health	
9.16.2	**Terrestrial invertebrates** (1), **dead**	Dead terrestrial invertebrates, other than species having adverse effects on plant, animals and human health, in all their life stages, with or without treatment but not processed as referred to in Regulation (EC) No 1069/2009	Crude protein Crude fat Crude ash

(2) Without prejudice to mandatory requirements concerning labelling, commercial documents and health certificates for animal by-products and derived products as laid down in Regulation (EU) No 142/2011 (Annex VIII, Chapter III) and Regulation 999/2001, Annex IV, and if the Catalogue is used for labelling purposes, the name shall be supplemented as appropriate to provide adequate information, by:

— the animal species processed (e.g. porcine, ruminant, avian, insect) and/or
— the life stage (e.g. larvae) and/or
— the material processed (e.g. bone) and/or
— the process used (e.g. defatted, refined) and/or
— the naming of the animal species not used in respect of the ban on intra-species recycling (e.g. poultry-free).

(1) Without prejudice to mandatory requirements concerning labelling, commercial documents and health certificates for animal by-products and derived products as laid down in Commission Regulation (EU) No 142/2011 (Annex VIII, Chapter III) and if the Catalogue is used for labelling purposes, the name shall be replaced as appropriate to provide adequate information, by:

— the animal species and
— the part of the animal product (e.g. liver, meat (only if skeletal muscle)), and/or
— the life stage (e.g. larvae) and/or
— the naming of the animal species not used in respect of the ban on intra-species recycling (e.g. poultry-free)

or supplemented as appropriate to provide adequate information, by:

— the animal species and/or
— the part of the animal product (e.g. liver, meat (only if skeletal muscle)), and/or
— the life stage (e.g. larvae) and/or
— the naming of the animal species not used in respect of the ban on intra-species recycling.

COMMISSION REGULATION (EU) 2017/893

of 24 May 2017

amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council and Annexes X, XIV and XV to Commission Regulation (EU) No 142/2011 as regards the provisions on processed animal protein

(Text with EEA relevance)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0893&from=EN

(12) The amendment to Regulation (EC) No 999/2001 with a view to authorise processed animal protein derived from insects for feeding aquaculture animals is likely to open the opportunity for bigger production of processed animal protein derived from insects in the Union. Whereas the current small scale rearing of insects for petfood can adequately be addressed by existing national control schemes, Union provisions addressing animal health, public health, plant health or environmental risks are appropriate to ensure that insect rearing within the Union on a larger scale is safe. With respect to the insect species reared in the Union, these should not be pathogenic or have other adverse effects on plant, animal or human health; they should not be recognised as vectors of human, animal or plant pathogens and they should not be protected or defined as invasive alien species. Taking into account these national risk assessments, as well as the EFSA opinion of 8 October 2015, the following insect species can be identified as those insect species currently reared in the Union which fulfil the abovementioned safety conditions for insect production for feed use: Black Soldier Fly *(Hermetia illucens)*, Common Housefly *(Musca domestica)*, Yellow Mealworm *(Tenebrio molitor)*, Lesser Mealworm *(Alphitobius diaperinus)*, House cricket *(Acheta domesticus)*, Banded cricket *(Gryllodes sigillatus)* and Field Cricket *(Gryllus assimilis)*.

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

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1143&from=EN

COMMISSION REGULATION (EU) 2021/1372

of 17 August 2021

amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals

(Text with EEA relevance)

(16) Commission Regulation (EU) 2017/893 (9) authorised the use of processed animal protein derived from insects and compound feed containing such processed animal protein for feeding aquaculture animals. Poultry are insectivorous animals, porcine animals are omnivorous, and there are no concerns with this feed material. As a consequence, processed animal protein derived from insects should be authorised to feed poultry and porcine animals, under the same conditions as required for feeding aquaculture animals.

'(f) poultry of the following feed materials and compound feed:

(i) processed animal protein derived from porcine animals and compound feed containing such processed animal protein, which are produced, placed on the market and used in accordance with the general conditions laid down in Chapter III and the specific conditions laid down in Chapter IV, Section G;

(ii) processed animal protein derived from farmed insects, and compound feed containing such processed animal protein, which are produced, placed on the market and used in accordance with the general conditions laid down in Chapter III and the specific conditions laid down in Chapter IV, Section F;

(g) porcine animals of the following feed materials and compound feed:

(i) processed animal protein derived from poultry and compound feed containing such processed animal protein, which are produced, placed on the market and used in accordance with the general conditions laid down in Chapter III and the specific conditions laid down in Chapter IV, Section H;

(ii) processed animal protein derived from farmed insects, and compound feed containing such processed animal protein, which are produced, placed on the market and used in accordance with the general conditions laid down in Chapter III and the specific conditions laid down in Chapter IV, Section F.';

COMMISSION REGULATION (EU) 2021/1372

of 17 August 2021

amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals

(Text with EEA relevance)

Table 1

Farmed animals from which the processed animal protein is derived	Farmed animals to which the processed animal protein may be fed
Farmed insects	Aquaculture animals, fur animals, porcine animals, poultry
Porcine animals	Aquaculture animals, fur animals, poultry
Poultry	Aquaculture animals, fur animals, porcine animals
Farmed insects and porcine animals	Aquaculture animals, fur animals, poultry
Farmed insects and poultry	Aquaculture animals, fur animals, porcine animals
Porcine animals and poultry	Aquaculture animals, fur animals
Farmed insects, porcine animals and poultry	Aquaculture animals, fur animals'

COMMISSION REGULATION (EU) 2021/1925

of 5 November 2021

amending certain Annexes to Regulation (EU) No 142/2011 as regards the requirements for placing on the market of certain insect products and the adaptation of a containment method

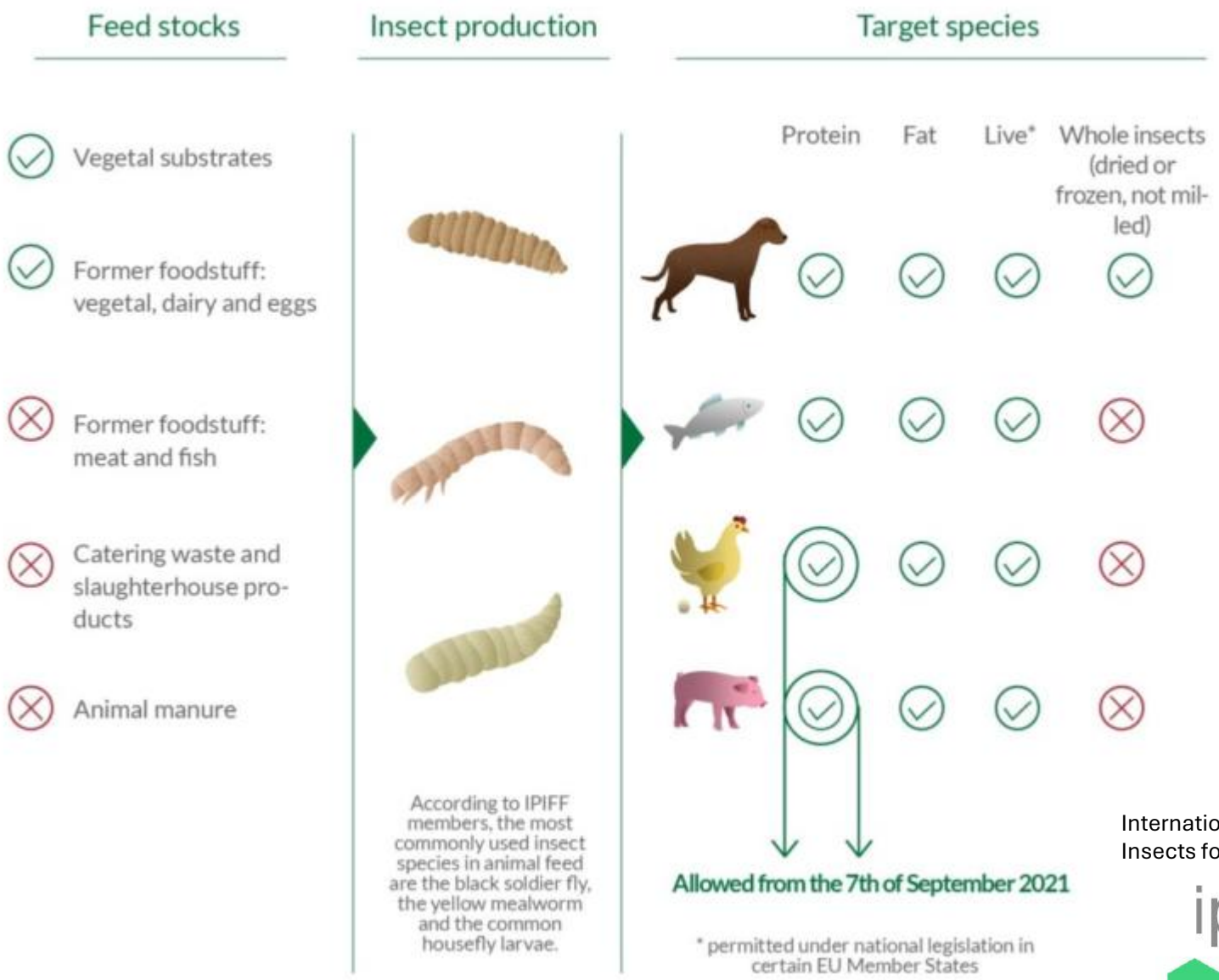
(Text with EEA relevance)

(7) On 8 October 2015, the European Food Safety Authority (EFSA) published a scientific opinion on a risk profile related to the production and consumption of insects as food and feed ([3]). Among several insect species, the EFSA assessed silkworms as a possible source for the production of processed animal protein. Sericulture has a long-standing tradition in certain regions of the Union. Since the domestic silkworm consumes only mulberry leaves (*Morus alba* and *Morus nigra*), there is no risk of contamination with feed of animal origin, which is not authorised for the feeding of insects. It should therefore be authorised for processing into processed animal protein intended for the manufacturing of feed for farmed animals, after the silk has been harvested. It is appropriate to add silkworms (*Bombyx mori*) to the list of authorised insect species for the production of processed animal protein intended for the manufacturing of feed for farmed animals. Annex X to Regulation (EU) No 142/2011 should therefore be amended accordingly.

https://ipiff.org/wp-content/uploads/2019/12/IPIFF-Guide-on-Good-Hygiene-Practices.pdf

Authorised	Prohibited
Feed materials of vegetal origin	**'Feed Marketing' Regulation - Regulation (EC) No 767/2009 Annex III:** - Faeces and separated digestive tract content - hide treated with tanning substances - seeds and other plant-propagating materials (treated with plant protection products) - wood or other materials derived from wood, which have been treated with wood preservatives - waste derived from urban, domestic and industrial waste treatment - packaging from agri-food products and parts thereof - protein products obtained from yeasts of the Candida variety cultivated on n-alkanes.
Feed materials of animal origin **TSE Regulation (EU) No 999/2001, Article 7 and Annex IV, Chapter 1 and 2:** - Hydrolysed proteins, collagen and gelatine or blood products derived from non-ruminants (or parts of non-ruminants) (including compound feed containing such products) - Hydrolysed proteins from ruminant hide and skins - Dicalcium phosphate and tricalcium phosphate of animal origin (including compound feed containing such phosphates) - Fishmeal	**EU Animal By-Products (ABP) Regulation (EC) No 1069/2009:** -catering waste (Art. 11 (1) (b))
Former Foodstuffs **TSE legislation - Regulation (EC) No 999/2001 Annex IV, Chapter II:** - Without meat and/or fish - only products containing the following ingredients of animal origin: eggs and egg products; milk, milk based-products and milk-derived products; honey; rendered fat; collagen; gelatine **these ingredients must have been **previously processed** (either prior their intended use as food product or after being requalified as animal-by-product).*	**TSE legislation - Regulation (EC) No 999/2001 (Annex IV, Chapter 1 and 2)** - Processed Animal Proteins (PAPs) referred to in Annex IV are prohibited: PAPs from ruminants; PAPs from poultry animals; PAPs from swine animals and PAPs from famed insects and PAPs from other non-ruminants except fishmeal. - Blood products from ruminant animals - hydrolysed proteins of animal origin and derived from ruminants

Residue limits for contaminants and requirements applying to feed additives	The **'Feed Marketing' Regulation** (i.e. Regulation (EC) No 767/2009) provides that animals (including therefore insects) bred in the EU may be only be fed with **safe feed**.
	Regulation (EC) No 396/2005 - maximum residue levels of **pesticides in feed**
	Undesirable Substances Directive (i.e. Directive 2002/32/EC)
Feed additives	Only the feed additives which are authorised for all animal species may be used as feed ingredient for insects. - **Regulation (EC) No 1831/2003**. No specific additives for insects have been defined.



International Platform of Insects for Food and Feed

ipiff

Ministero della Salute
DIREZIONE GENERALE DELLA SANITÀ ANIMALE E
DEI FARMACI VETERINARI
UFFICIO 7 UFFICIO 2 UFFICIO 3 E UFFICIO 8

DGSAF :I.5.h.g

OGGETTO: Allevamento di insetti ed uso di insetti vivi per l'alimentazione di animali da allevamento (pesci, pollame e suini)

2. DEFINIZIONI

Oltre alle definizioni applicabili riportate nella normativa vigente, ai fini della presente nota si forniscono di seguito le seguenti definizioni:

a) **Insetto vivo:** insetto vivo a qualsiasi stadio di accrescimento (uovo, larva, crisalide/pupa, adulto);

b) **Insetto trattato**: insetto morto a qualsiasi stadio di accrescimento sottoposto a un trattamento, quale ad esempio disidratazione, essiccazione, fermentazione, frantumazione, congelamento, surgelazione ecc., diverso dai metodo di trasformazione di cui al reg. (UE) 142/2011, allegato IV capo III;

c) **PAT di insetto**: proteine animali trasformate come definite nel reg. (UE) 142/2011, derivate da insetti a qualsiasi stadio di accrescimento;

d) **Stabilimento**: i locali e le strutture di qualsiasi tipo o, nel caso dell'allevamento all'aria aperta, qualsiasi ambiente o luogo in cui sono detenuti insetti, su base temporanea o permanente.

https://www.fnovi.it/sites/default/files/MinSal_0011399-05_05_2017-DGSAF-MDS-P.pdf

4. SCOPO

Con la presente nota, nel rispetto della normativa vigente, s'intende **ammettere l'uso di insetti vivi nell'alimentazione di animali da allevamento**, restringendo tale possibilità alle specie per cui è già ammesso l'utilizzo delle PAT, ovvero **pollame, suini e pesci di acquacoltura**, che sono anche le specie di animali per cui vi è maggiore interesse nella ricerca di fonti proteiche alternative.

Per quanto riguarda le specie di insetti utilizzabili vivi per l'alimentazione dei suddetti animali da allevamento, **si ritiene coerente e cautelativo dal punto di vista sanitario, ammettere esclusivamente l'uso delle specie di insetti già autorizzate per la produzione di PAT destinate ad animali di allevamento** ovvero:

- mosca soldato nera (Hermetia illucens)
- mosca comune (Musca domestica),
- tenebrione mugnaio (Tenebrio molitor)
- alfitobio (Alphitobius diaperinus),
- grillo domestico (Acheta domesticus),
- grillo tropicale (Gryllodes sigillatus)
- grillo silente (Gryllus assimilis),
- baco da seta (Bombyx mori).

Nello specifico, la presente nota fornisce indicazioni riferibili agli insetti vivi delle specie eterometabole (Acheta domesticus, Gryllodes sigillatus, Gryllus assimilis), e alle fasi larvali vive delle specie olometabole (Hermetia illucens, Musca domestica, Tenebrio molitor, Alphitobius diaperinus e Bombyx mori).

COMMISSION REGULATION (EU) 2021/1925

of 5 November 2021

amending certain Annexes to Regulation (EU) No 142/2011 as regards the requirements for placing on the market of certain insect products and the adaptation of a containment method

(Text with EEA relevance)

For the purpose of Regulation (EU) No 142/2011, '*frass*' should be defined as the mixture of insect excrements with parts of dead insects and feeding substrate. Insect larvae, which are commonly used for the production of processed animal protein or for human consumption, live in the frass. A definition of 'frass' should be inserted in Annex I to Regulation (EU) No 142/2011 in order to align the requirements for the treatment and placing on the market of frass with the requirements for processed manure. Annex I to Regulation (EU) No 142/2011 should therefore be amended accordingly.

(1) in Annex I, the following point 61 is added:

'61. "**frass**" 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.';

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1925&from=EN

►B

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

(Text with EEA relevance)

(OJ L 54, 26.2.2011, p. 1)

Section 2

Guano from bats, frass, processed manure and derived products from processed manure

The placing on the market of guano from bats, processed manure, and derived products from processed manure shall be subject to the conditions set out in the following points (a) to (e). In addition, in the case of guano from bats the consent of the Member State of destination shall be required as referred to in Article 48(1) of Regulation (EC) No 1069/2009:

(a) They must come from a plant for derived products for uses outside the feed chain or from a biogas or a composting plant or from a plant for the manufacturing of organic fertilisers or soil improvers.

(b) They shall have been subjected to a heat treatment process of at least 70 °C for at least 60 minutes and they shall have been subjected to reduction in spore-forming bacteria and toxin formation, where they are identified as a relevant hazard.

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02011R0142-20220417&from=EN

Hermetia illucens

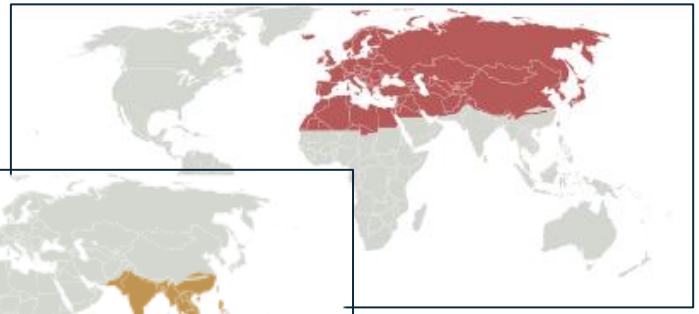
Mosca soldato nera

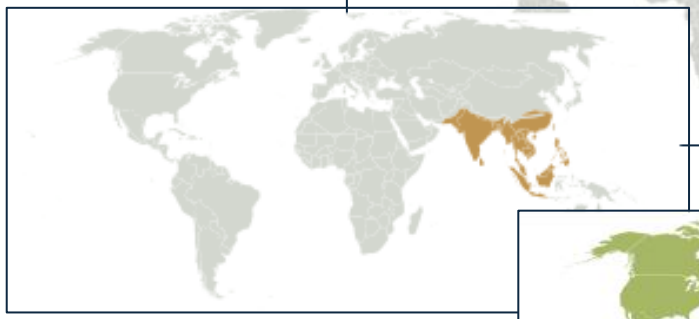
Prof. Simone Mancini

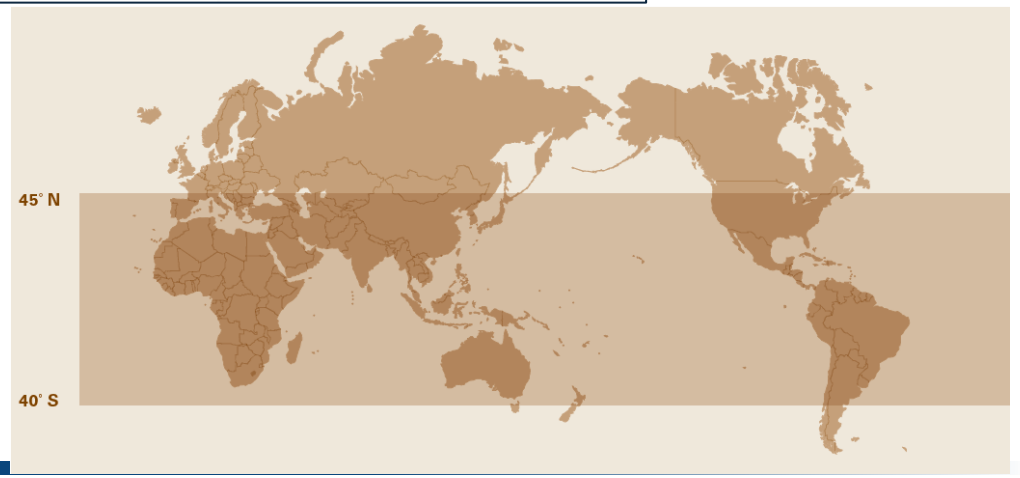
Dipartimento Scienze Veterinarie

Scientific classification	
Domain:	Eukaryota
Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Diptera
Family:	Stratiomyidae
Subfamily:	Hermetiinae
Genus:	*Hermetia*
Species:	***H. illucens*** (Linnaeus, 1758)

Black Soldier Fly - BSF







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Focus article

The death scenario of an Italian Renaissance princess can shed light on a zoological dilemma: did the black soldier fly reach Europe with Columbus?

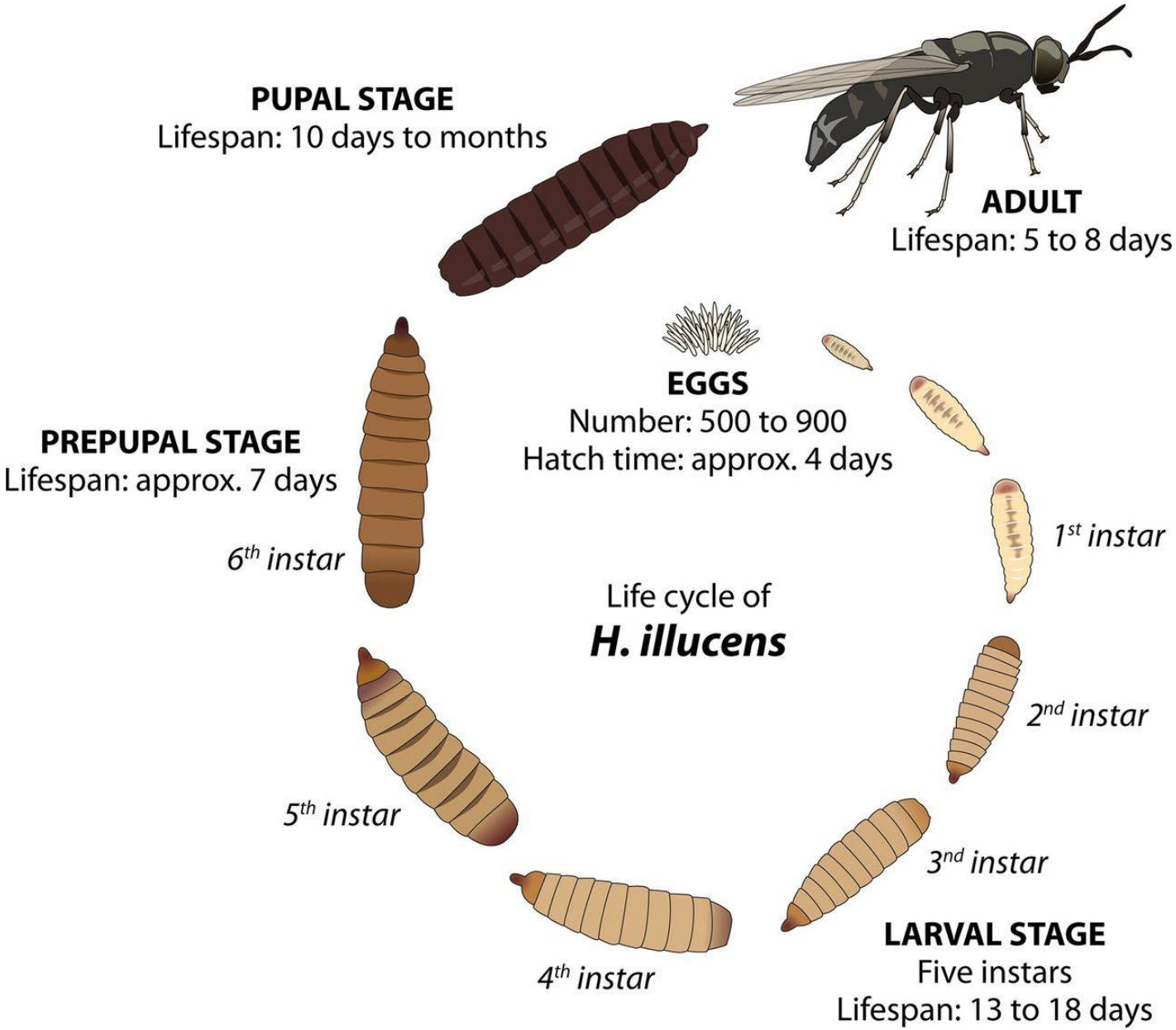
Giovanni Benelli [a, *], Angelo Canale [a], Alfio Raspi [a], Gino Fornaciari [b]

[a] Division of Entomology, Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto 80, 56124 Pisa, Italy
[b] Division of Paleopathology, Department of Translational Research on New Technologies in Medicine and Surgery, University of Pisa, Via Roma 57, 56126 Pisa, Italy

Italian Renaissance princess Isabella d'Aragona (1470–1524)

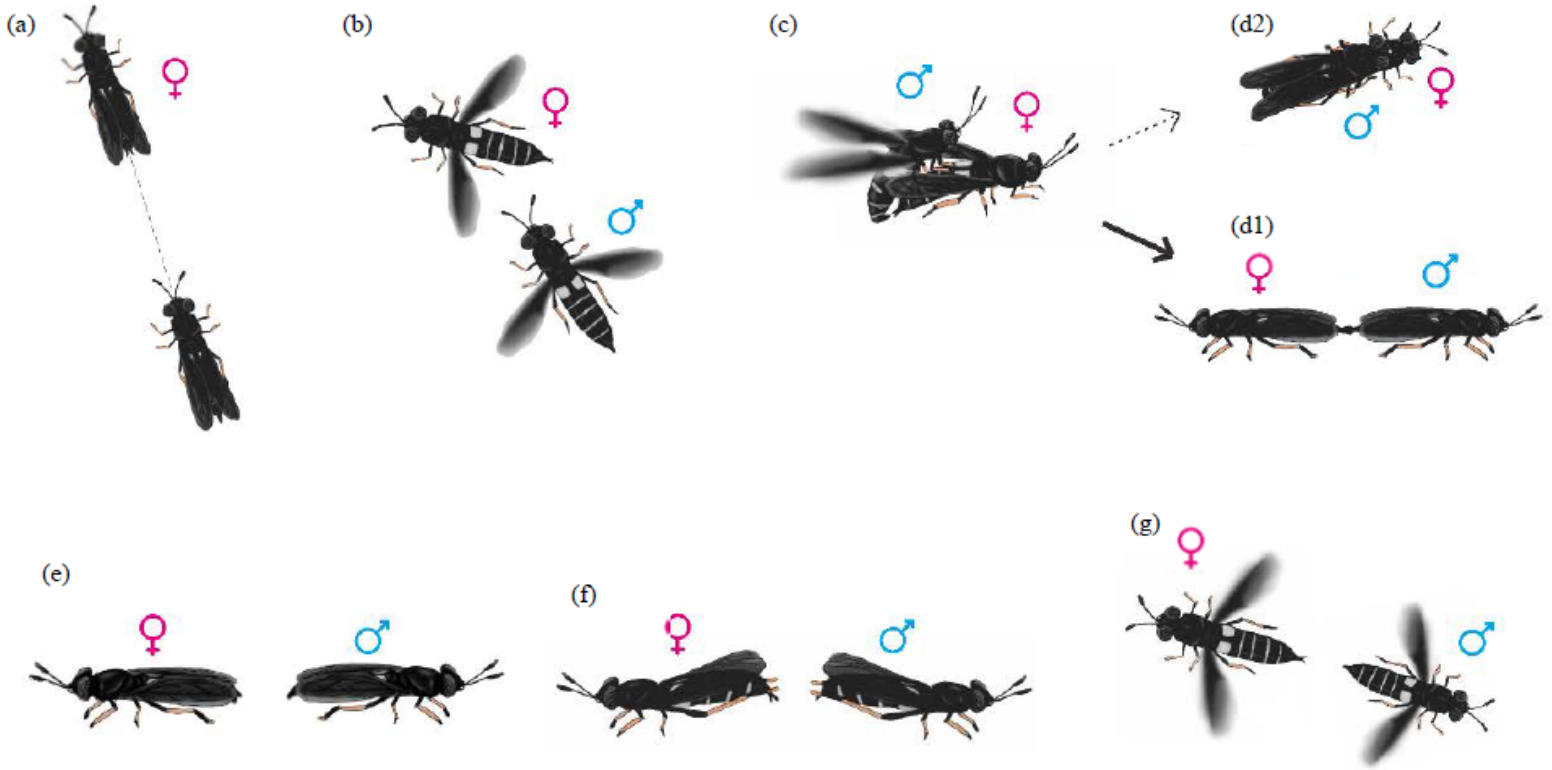
"In close proximity of the Isabella's skull, two body parts belonging to a Diptera larva were found."

"Isabella d'Aragona ***died*** *in February 12,* ***1524****, just 30 years after the America's discover by Columbus. In that period, many Spanish commercial "galleons" visited the port of Naples, allowing us to suppose that* ***H. illucens could be accidentally transferred to Europe in those years****."*


PUPAL STAGE
Lifespan: 10 days to months
ADULT
Lifespan: 5 to 8 days
EGGS
Number: 500 to 900
Hatch time: approx. 4 days
1st instar
2nd instar
3nd instar
LARVAL STAGE
Five instars
Lifespan: 13 to 18 days
4th instar
5th instar
6th instar
PREPUPAL STAGE
Lifespan: approx. 7 days
Life cycle of
H. illucens


GolonLite

doi: 10.3923/je.2020.117.127



BSF mating sequences (personal drawing), (a) Orientation, approaching and following (♂ to ♀), (b) Chasing (in-flight approach) and attempt mounting, (c) ♂ Attempt copulation: wing fanning, abdomen curling male mount the female, tap the female abdomen with the tarsi, ♀ Wings extention, decrease locomotion, (d) D1: Reverse coupling, D2: copulation, genital contact and spermtransfer, antennal waving (♀ and ♂), (e) End copulate/end genital contact, (f) Grooming with the tarsi of its third pairs of legs and (g) ♂ and ♀ move away, walking then flying


female


male


female
male


#2 산란장은 성으로 산란상태만...

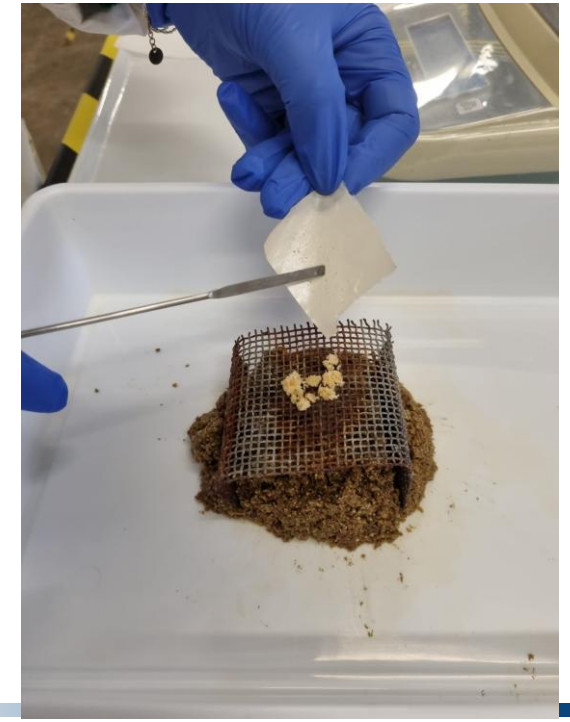

(b)

IN SUPREMÆ DIGNITATIS 1343

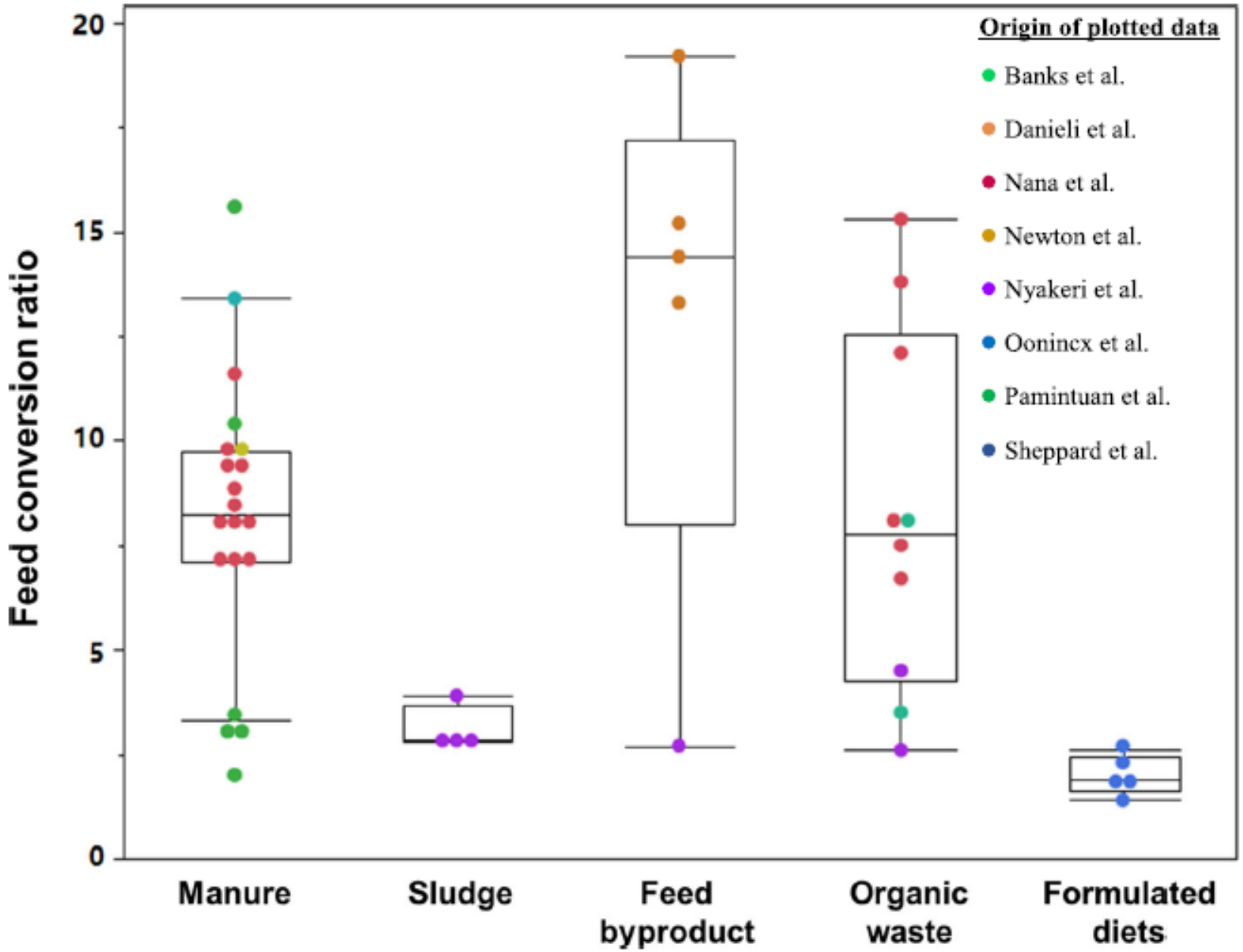
to Scienze Veterinarie


ELECTRONIC BALANCE
72.14
SONIC


39.3



- Optimal moisture content of the feed: **70%**
- **Protein** level ≈ **16% on DM**
- Light: **not necessary**
- Optimal temperature: **27-33 °C**
  - Low temperatures cause a slowdown in metabolism and growth
  - **Diapause**: generally defined as an arrest of the direct development that proceeds with an alternative program of physiological events
    - This natural phenomenon is used for the **transport of live larvae** at the temperature of 12-16 °C

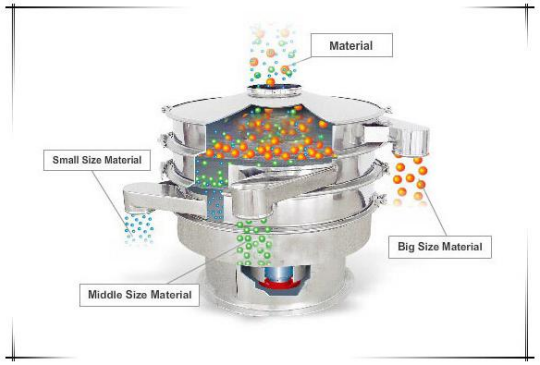


doi: 10.1186/s40104-022-00682-7


Sagel Oink Ventures
At Jewel Farm


gettyimages
Credit: picture alliance
1238193856


筛分黑水牝虫子


Material
Small Size Material
Big Size Material
Middle Size Material

Research Article

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Nutritional composition of black soldier fly (*Hermetia illucens*) prepupae reared on different organic waste substrates

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doi:10.1002/jsfa.8081

RESULTS: Protein content of prepupae varied between 399 and 431 g kg^{-1} dry matter (DM) among treatments. Differences in amino acid profile of prepupae were small. On the other hand, the ether extract (EE) and ash contents differed substantially. Prepupae reared on digestate were low in EE and high in ash (218 and 197 g kg^{-1} DM, respectively) compared to those reared on vegetable waste (371 and 96 g kg^{-1} DM, respectively), chicken feed (336 and 100 g kg^{-1} DM, respectively) and restaurant waste (386 and 27 g kg^{-1} DM, respectively). Prepupal fatty acid profiles were characterised by high levels of C12:0 in all treatments.

Table 4. Fatty acid composition of the tested substrates (Subst.) and black soldier fly prepupae (Prep.) (g kg^{-1} fatty acid methyl esters)

	Chicken feed		Digestate		Vegetable waste		Restaurant waste	
Fatty acid	Subst.	Prep.	Subst.	Prep.	Subst.	Prep.	Subst.	Prep.
C10:0	1.4	14.3	8.5	11.7	2.3	16.3	13.3	20.3
C12:0	14.5	573.5	97.5	436.5	21.3	608.9	154.9	575.6
C14:0	3.3	73.4	43.1	68.7	12.8	94.8	59.0	71.4
C16:0	160.0	96.5	236.3	101.2	305.2	87.0	231.2	102.9
C18:0	25.1	13.6	38.5	17.5	31.8	11.1	67.5	9.8
SFA	214.6	774.4	483.2	648.2	406.8	828.0	540.5	782.9
Iso- and ante-iso	0.5	1.0	80.3	64.6	4.6	7.1	6.0	2.9
C16:1	2.0	19.7	8.8	75.8	15.3	29.3	17.2	33.4
c9C18:1	239.6	75.4	119.3	79.3	66.0	56.6	251.3	79.7
c11C18:1	8.4	2.3	35.7	23.2	28.3	3.3	99.0	1.2
MUFA	255.3	100.1	189.8	190.8	119.6	95.4	289.4	119.9
C18:2*n*-6	499.9	115.5	163.5	79.0	312.2	45.2	138.3	78.3
n-6 PUFA	501.0	115.9	175.6	80.4	319.3	46.2	142.4	80.0
C18:3*n*-3	24.3	7.0	17.3	8.3	116.4	13.7	16.3	11.0
C18:4*n*-3	0.5	0.7	0.8	6.5	4.4	8.7	2.1	0.5
C20:5*n*-3	0.2	0.6	1.3	1.1	1.3	0.1	0.7	2.3
C22:6*n*-3	3.2	0.1	35.0	0.2	15.0	0.1	1.4	0.1
n-3 PUFA	28.5	8.6	71.1	16.0	149.7	23.3	21.8	14.3

BSF larvae meal

BSF larvae fat/oil

Full-fat

Partially-defatted

“Totally” defatted

native

after centrifugation

liquid (t = 40 °C)

solid (t = 20 °C)

BSF frass

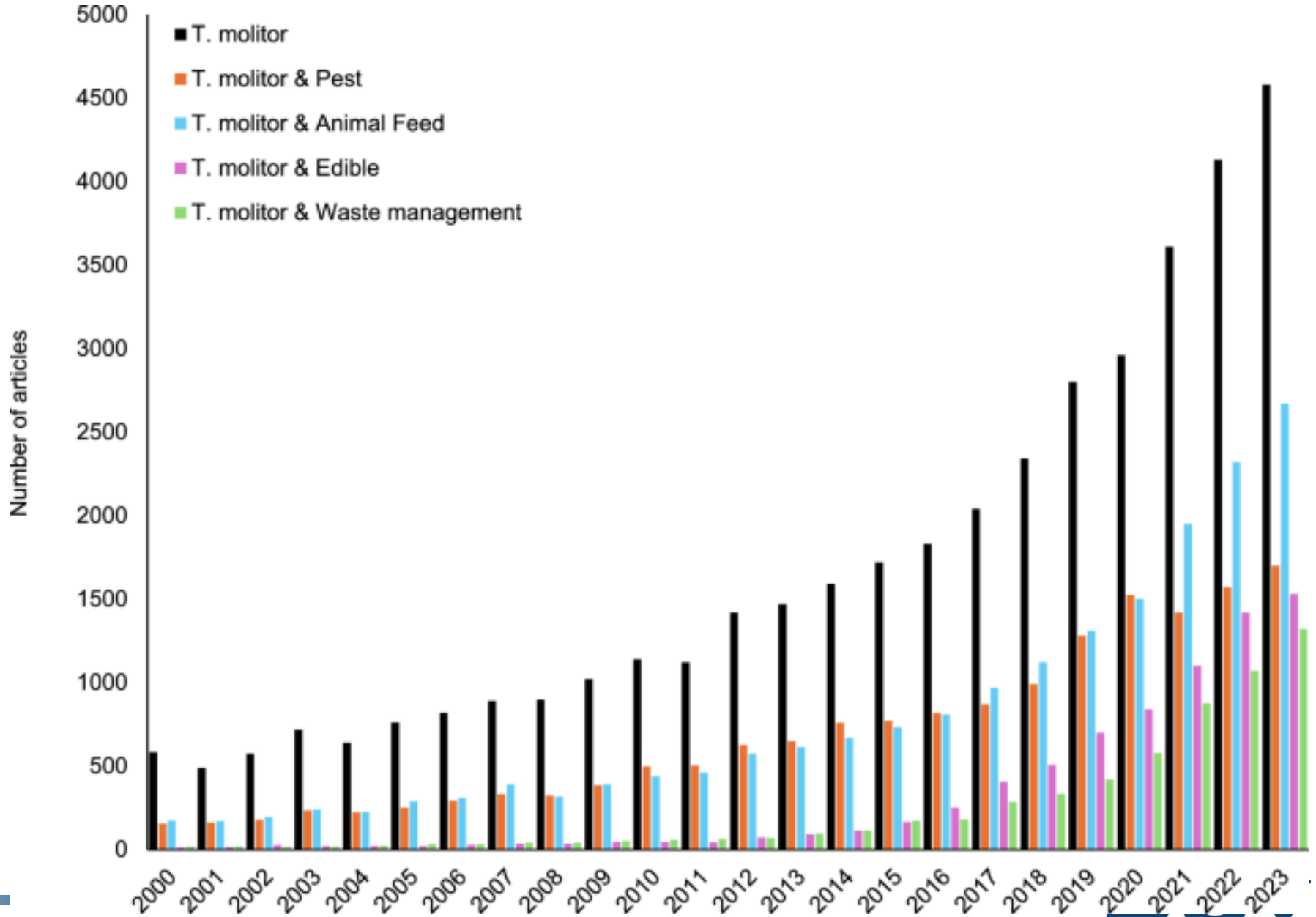
	Parameter	unit	$Mean_{literature}$ (CV)
Physical parameters	DM	%	78.03 (0.25)
	OM	% DM	84.93 (0.03)
	pH		6.80 (0.18)
	EC	mS cm^{-1}	3.24 (0.42)
Macronutrients	N_t	% DM	3.35 (0.32)
	NH_4^+–N	% DM	0.64 (0.57)
	NH_4^+–N	% of N_t	16.21 (0.48)
	C:N ratio		15.73 (0.36)
	P	% DM	1.50 (0.27)
	K	% DM	2.99 (0.41)
	Mg	% DM	0.42 (0.97)
	Na	% DM	1.07 (0.79)
	Ca	% DM	0.64 (---)
	S	% DM	0.65 (0.34)
Micronutrients	Cu	mg kg^{-1}	16.33 (0.28)
	B	mg kg^{-1}	16.00 (0.80)
	Zn	mg kg^{-1}	85.33 (0.54)
	Mn	mg kg^{-1}	81.00 (1.19)
	Fe	mg kg^{-1}	855.67 (0.43)

doi:10.1007/s42729-021-00703-w

Tenebrio molitor

Tarma della farina

From **pest** to promising feed and food **resource**



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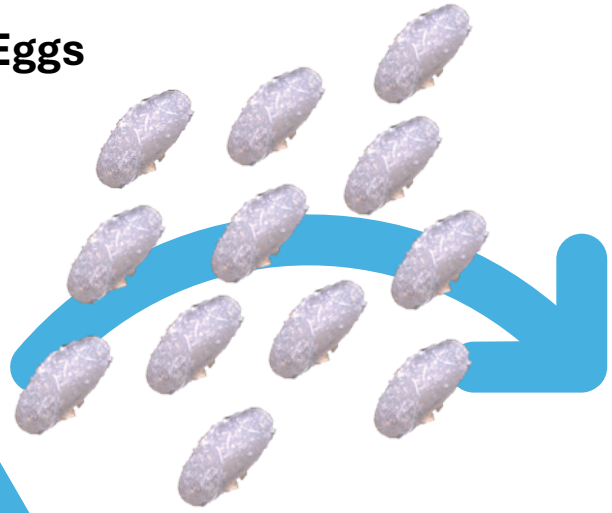
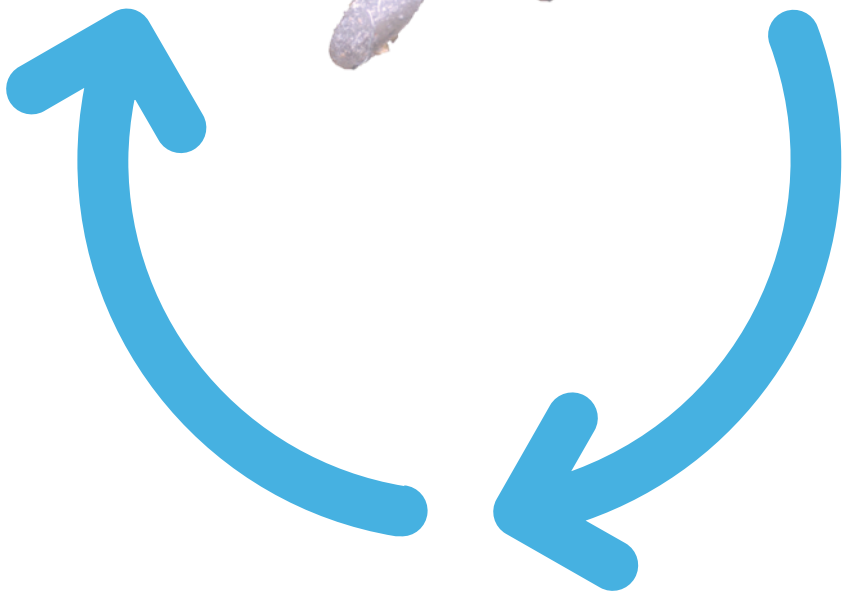
https://link.springer.com/article/10.1007/s10340-024-01851-5

Eggs

Adults





Larvae

Pupae


CW4
CW5

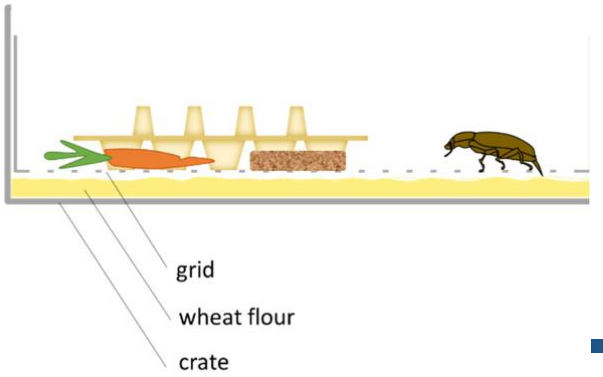

VERGELIJKING
TUSSEN INSECTEN EN
LANDBOUWDIEREN

- Temperature 25 - 30 °C (optimal **25**°C)
- Humidity 50 – 75% RH (optimal **60**%)
- Ventilation (CO_2, NH_3, CH_4 and N_2O)
- Light cycling

- Crucial for **growth**, **development** and **reproduction**
- Digestible carbohydrates are a primary **energy** source for mealworm
- Protein-to-carbohydrate ratio lies between **1:1** and **1:3**
- Mealworm are able to synthetise fat even if they are fed low-fat diets
- Particle size below **2mm** for optimal growth
- **Water sources**: vegetables or fruits, hydrated gels or sprays

7 days

Remove adults



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Frass

Fertilizer and phytofortifier

Enhance plant tolerance to **abiotic stresses** and **resistance to biotic stresses** by directly supplying nutrients to the soil and plants, along with chitin and microorganisms

Chard

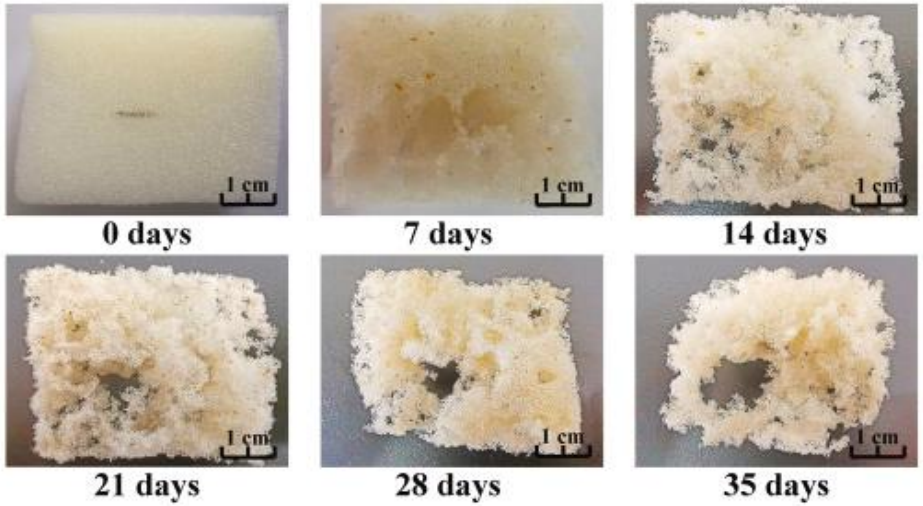
Zucchini

Ryegrass

Barley

Other applications

Polyether (PE)



Polistyrene (PE)

Polyvinyl chloride (PVC)

Sub-micron microplastics and small microplastics are **found** in the **frass** of mealworms fed with PE, PS, and PVC

Bombyx mori

Baco da seta

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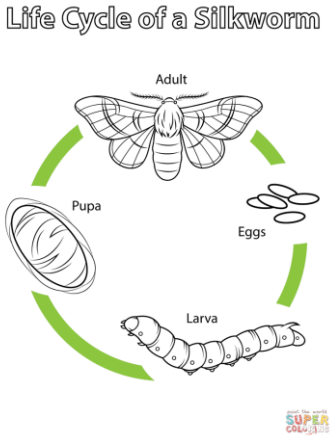
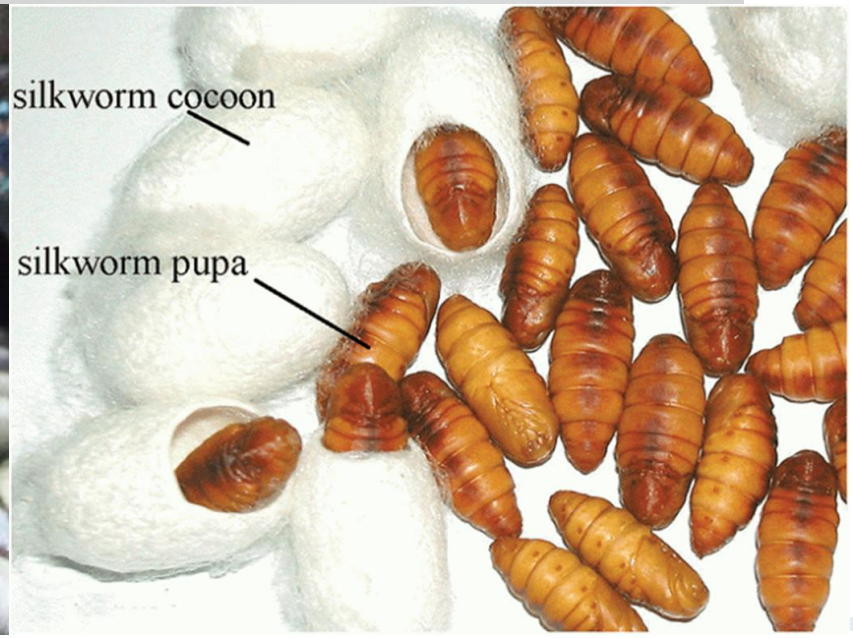

Life Cycle of a Silkworm
Adult
Pupa
Eggs
Larva


silkworm cocoon
silkworm pupa

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