Insects as feed: house fly or black soldier fly?

A. van Huis^{1*}, D.G.A.B. Oonincx², S. Rojo³ and J.K. Tomberlin⁴

¹Laboratory of Entomology, Wageningen University & Research, P.O. Box 16, 6700 AA Wageningen, the Netherlands; ²Animal Nutrition Group, Wageningen University & Research, De Elst 1, 6708 WD Wageningen, the Netherlands; ³Department of Environmental Sciences and Natural Resources, University of Alicante, P.O. Box 99, 03080 Alicante, Spain; ⁴Department of Entomology, Texas A&M University, College Station, Texas 77843-2475, USA; editor-in-chief@insectsasfoodandfeed.com

© 2020 Wageningen Academic Publishers

OPEN ACCESS

EDITORIAL

Abstract

Industrialised rearing of house flies and black soldier flies in systems for producing protein offers numerous species-specific benefits and challenges. These two dipteran species offer great potential for mass production of protein rich feed ingredients on a global scale. Through this systematic review, various facets of intensive production of these species are evaluated according to criteria, such as development time, abiotic tolerance, ease of rearing, environmental impact, safety risks, range of possible organic side streams, and their role in bioconversion.

1. Introduction

Fly species that are mass produced can be used to feed fish, swine, poultry, and pets, while also recycling organic waste. The two main species are house flies (*Musca domestica*; HF) (Diptera: Muscidae) and black soldier flies (*Hermetia illucens*; BSF) (Diptera: Stratiomyidae). However, there are also other dipteran species available for (artificial) rearing, such as, but not limited to, blow flies (Calliphoridae) and flesh flies (Sarcophagidae) (Biancarosa *et al.*, 2018; Čičková *et al.*, 2015; Krivosheina, 2008; Pastor *et al.*, 2015). Moreover, some Diptera are also used in a wide array of industrial applications such as human or veterinary maggot therapy, fish bait, or as evidence in forensic entomology investigations. The purpose of this paper is to compare HF and BSF in the framework of their high potential to intensively produce feed ingredients at an industrial scale around the world.

There is a natural interaction between HF and BSF because in some cases, their larvae share the same substrates such as poultry manure (Sheppard, 1983; Vásquez-González *et al.*, 1963) or human excrements (Kilpatrick and Schof, 1959). Although BSF are of no veterinary significance, both species are often considered a problem in manure in poultry and laying hen farms (Axtell and Edwards, 1970; Tingle *et al.*, 1975). However, with BSF present the HF problems seem to be less (Bradley and Sheppard, 1984; Furman *et*

al., 1959). This interspecific competition seems to depend on the quantity of manure and the species colonising first (Miranda *et al.*, 2019). Immature HF can successfully complete development in the presence of BSF; however, this most likely requires a low BSF larval density or high resource quality. Both Bradley and Sheppard (1984) and Furman *et al.* (1959), collected data from the field where BSF were well-established in animal waste potentially preventing HF colonisation. Miranda *et al.* (2019) used a low larval BSF density, which could have reduced their ability to outcompete HF larvae.

2. History

During the period from 1946 to 2019, the Web of Science yielded 4,627 hits when using '*Musca domestica*', and only 467 when using '*Hermetia illucens*' (accessed April 2020). However, looking only at the articles published during the last four years (2016-2019) for HF and BSF it was 11% and 75% of the total (1946-2019), respectively, indicating the recent interest in the latter. Of the 154 articles published on HF in 2019, only 11% was on its use as feed, while for BSF, 176 articles were published, almost exclusively on its use as feed (few as food). The remaining 89% of the HF articles dealt with aspects including insecticide resistance, genetic studies, and pathogen transmission. These topics illustrate that although HF is used as a model animal, and can be used as feed, it is primarily considered a pest species.

One of the first who suggested to grow HF and other saprophagous flies on organic waste and then feed the resulting insect biomass to poultry was probably Lindner (1919); but, no further studies were published until fifty years later (Calvert *et al.*, 1969; Miller, 1969). There is one review article of using HF pupae, reared on poultry manure, as animal feed (El Boushy, 1991). The use of BSF as human food had been suggested during pre-Columbian times (Veloz Maggiolo, 2007). The roots and half-buried stems of coontie palm (the cycad *Zamia pumila*) were scratched and left to ferment until they become a ‘boiling’ mass with larvae. The history of using BSF as feed has been dealt with in an editorial of this journal earlier this year (Tomberlin and Van Huis, 2020).

This assessment shows that during the last few years there is a tremendous interest in using BSF as feed, rather than HF. Primarily, the interest in BSF production is due to its ‘non-pest’ status and ability to digest practically anything organic (excepting lignocellulosic materials). HF are more dietarily restricted as they are mainly bacteriophagous (Levinson, 1960) and are a known pathogen vector. The risk of spreading disease resulted in law suits due to HF moving from the manure at confined animal facilities to surrounding suburban areas (Skoda *et al.*, 1993). Currently, it is not allowed to rear insects on manure and use them as feed, even though pathogen transmission is mainly via adults (Khamesipour *et al.*, 2018). There are interesting

possibilities to rear HF in manure (Hall *et al.*, 2018; Hussein *et al.*, 2017). However, pathogen transmission in the production of larval biomass from manure should be considered if legislation is modified in the future.

3. Development time and egg production

Development time of either fly species depends on abiotic factors (e.g. temperature, relative humidity, photophase), and biotic (e.g. diet, density, and strain) factors. HF larvae develop much quicker than BSF larvae (Table 1), but their pupal weight is only a fifth of the BSF prepupal weight.

Whereas BSF oviposit only once or twice, HF commonly oviposit several times. In the latter species, a clutch of 70-150 eggs and 4-6 clutches seems normal (Faraj *et al.*, 2014; Hewitt, 1914; Nayduch and Burrus, 2017). However, extremes of 21 batches yielding 2,387 eggs are reported (Dunn, 1922). The moment of first oviposition in BSF can be as early as 3-5 days after eclosion (Tomberlin *et al.*, 2002), but can also occur 10-17 days post eclosion (Oonincx *et al.*, 2016; Zhang *et al.*, 2010). HF oviposition peaks on the second day of laying and steadily decreases in the ~3 weeks that follow (Wilkes *et al.*, 1948). During their first trimester most eggs (43%) are produced, followed by ~34% in the second, and ~22% in their last trimester (Greenberg, 1955a). The lifetime egg production of HF and BSF varies (Table 2), but the ranges seem to largely overlap. For prolonged

Table 1. The time until (pre)pupation and (pre)pupal weight for house flies (HF) and black soldier flies (BSF).

Fly species	Temperature (°C)	Time (d) until (pre)pupation	(Pre)pupal weight (mg)	Reference
BSF	27 and 30	17.7-20.1	128.0-160.0	Tomberlin <i>et al.</i> (2009)
	25 and 30	24.7-32.8	153.0-156.0	Shumo <i>et al.</i> (2020)
	27.6 and 32.2	10.3-15.8	127.0-178.0	Harnden and Tomberlin (2016)
	27.0	22.5-24.1	104.0-111.0	Tomberlin <i>et al.</i> (2002)
HF	23.0 and 32.0	4.0-7.0	17.0-18.0	Barnard and Geden (1993)
	22.0	7.5-9.0	21.0-3.0	Pastor <i>et al.</i> (2014)
	27.0	7.0	9.9-15.8	Hogsette (1992)

Table 2. Fecundity of house flies (HF) and black soldier flies (BSF) females.

BSF		HF	
Number of eggs	Reference	Number of eggs	Reference
206-639	Tomberlin <i>et al.</i> (2002)	90-394	Shipp and Osborn (1967)
603-689	Tomberlin (2001)	198-447	Pastor <i>et al.</i> (2011)
205-820	Stephens (1975)	500±100	Wilkes <i>et al.</i> (1948)
412-1,060	Bertinetti <i>et al.</i> (2019)	265-1,688	Greenberg (1955b)
500-1000	Furman <i>et al.</i> (1959)	0-2,387	Dunn (1922)
185-1,235	Rachmawati <i>et al.</i> (2010)		
546-1,505	Booth and Sheppard (1984)		

production and egg hatchability adult HF require dietary sources of protein and sterols (Shipp and Osborn, 1967; Spiller, 1964). Although for some time it was incorrectly believed that adult BSF have no functional mouthparts and therefore do not feed (Tomberlin and Cammack, 2017). In fact, egg production per female can be tripled when adults are provided with milk, instead of water (Bertinetti *et al.*, 2019).

4. Rearing

Both BSF and HF prefer to pupate in a dry environment. In that stage, they are at a maximum size, with large fat stores to sustain them through metamorphosis. For the BSF, this results in self-harvesting behaviour; they leave their substrate to pupate and turn into an adult. Containers can be devised to automatically collect prepupae (Newton *et al.*, 2005a). HF larvae tend to pupate within the substrate or along its edge, but it is possible to manipulate their behaviour to improve separation from processed substrates (Čičková *et al.*, 2012b).

In tropical regions, BSF are normally kept in cages ranging 3–16 m³ exposed to sunlight. However, in temperate zones, low temperatures and short days in winter are problematic, artificial light sources are required (Heussler *et al.*, 2018; Schneider, 2020). Also, BSF may need some investments in sophisticated oviposition equipment (Kenis *et al.*, 2018).

Kenis *et al.* (2018) compared small scale production of BSF and HF in the tropics using several criteria. HF have a wider temperature range than BSF and tolerate lower temperatures and dryer conditions than BSF. Sun or solar drying of HF larvae is easier than BSF larvae due to their smaller size. Concerning adult rearing and oviposition, HF occur naturally and will oviposit on exposed organic substrates (Koné *et al.*, 2017), while BSF need to be reared locally. In Africa, BSF production for animal feed is considered more problematic than HF production and should be conceived as a small enterprise with full time personnel (Kenis *et al.*, 2014, 2018). Under the mass-rearing conditions of a biodegradation facility, HF survival and the weight of the produced fly biomass can be increased by modifying the larval substrate and via egg dispersal during inoculation (Čičková *et al.*, 2013).

5. Conversion of organic waste stream

The list of organic waste streams that can be tackled by both species is quite large. For both species (municipal) organic waste and manure are listed, but for the BSF more waste streams and by-products such as coffee pulp, catering waste, vegetable, straw, dried distillers gain with solubles (DDGS) have been tested and found suitable (Van Huis and Tomberlin, 2017). During the last few years more substrates have been added for BSF: almond (Palma *et al.*, 2018), sweet potato roots (Aristi *et al.*, 2020), seafood waste (Swinscoe *et al.*, 2019; Villazana and Alyokhin, 2019), olive cake (Starcevic *et al.*, 2019), human faeces (Banks *et al.*, 2014); faecal sludge (Nyakeri *et al.*, 2019), pulp and paper sludge (Norgren *et al.*, 2019), coconut endosperm and soybean curd residue (Lim *et al.*, 2019; Rehman *et al.*, 2017), and mushroom root waste (Cai *et al.*, 2019). However, the suitability of these streams varies greatly. HF can develop on the seed cake left from biodiesel production (Pomalégni *et al.*, 2018) and on a variety of mixed media including those that contain animal by-products (Kökdener and Kiper, 2020). This species is strongly adapted to the consumption (Dowding, 1967) and digestion (Espinoza-Fuentes and Terra, 1987) of microbiota. In fact, they can fully develop on desiccated *Escherichia coli* (Levinson, 1960) and can utilise yeasts (Haupt and Busvine, 1968) and fungi (Pimentel *et al.*, 2018). Hence, inoculating a substrate with bacteria, fungi or yeasts can enhance bioconversion (Brookes and Fraenkel, 1958; Qi *et al.*, 2019; Yang *et al.*, 2015). Conversely, the adaptation to feeding on microbiota might prohibit HF from ingesting and therefore digesting larger particles, especially compared to the larger BSF. This might explain why BSF are able to digest a wider range of organic waste streams efficiently.

al., 2018), sweet potato roots (Aristi *et al.*, 2020), seafood waste (Swinscoe *et al.*, 2019; Villazana and Alyokhin, 2019), olive cake (Starcevic *et al.*, 2019), human faeces (Banks *et al.*, 2014); faecal sludge (Nyakeri *et al.*, 2019), pulp and paper sludge (Norgren *et al.*, 2019), coconut endosperm and soybean curd residue (Lim *et al.*, 2019; Rehman *et al.*, 2017), and mushroom root waste (Cai *et al.*, 2019). However, the suitability of these streams varies greatly. HF can develop on the seed cake left from biodiesel production (Pomalégni *et al.*, 2018) and on a variety of mixed media including those that contain animal by-products (Kökdener and Kiper, 2020). This species is strongly adapted to the consumption (Dowding, 1967) and digestion (Espinoza-Fuentes and Terra, 1987) of microbiota. In fact, they can fully develop on desiccated *Escherichia coli* (Levinson, 1960) and can utilise yeasts (Haupt and Busvine, 1968) and fungi (Pimentel *et al.*, 2018). Hence, inoculating a substrate with bacteria, fungi or yeasts can enhance bioconversion (Brookes and Fraenkel, 1958; Qi *et al.*, 2019; Yang *et al.*, 2015). Conversely, the adaptation to feeding on microbiota might prohibit HF from ingesting and therefore digesting larger particles, especially compared to the larger BSF. This might explain why BSF are able to digest a wider range of organic waste streams efficiently.

6. Bioconversion

The organic (substrate) reduction and bioconversion rate of organic resources into biomass depend on substrate types, strains, larval density, feeding rate, and feeding frequency. Weight reduction of swine manure was estimated for HF to be 18–65% (Čičková *et al.*, 2012a) and for BSF 50–56% (Newton *et al.*, 2005a,b). The composition of swine manure, including moisture content, is extremely variable due to difference in the production system (intensive vs extensive, liquid manure vs semisolid, etc.), bedding, pig age, and diet. One kg of manure could be converted to a pupal mass of 22–27 g by HF and 155 g of BSF according to the authors. A review of BSF bioconversion of a large number of waste streams estimated the substrate reduction (% dry matter) to be between 13 and 68%, but mostly between 40 and 60% (K.C. Surendra *et al.*, unpublished data).

7. Environmental impact

There are only a few published studies on environmental impact of fly production. The available data for greenhouse gas emissions, energy use, and land use are extremely variable (Table 3). This impairs a valid comparison regarding the environmental impact of producing these two species. A large part of this variation is due to differences in methodology, scale, and function of the studied systems, as well as the used substrate. The chosen substrate has a large influence on the environmental impact of animal production systems, as does the alternative potential use of such substrates (Oonincx, 2017). For instance, if these

Table 3. Environmental impact recalculated to 1 kg of dried, defatted, insect powder by Smetana *et al.* (2016) using data for black soldier fly (BSF) (Komakech *et al.*, 2015; Salomone *et al.*, 2016; Smetana *et al.*, 2015) and for house fly (HF) production (Roffeis *et al.*, 2015; Van Zanten *et al.*, 2015).¹

Species	GWP (kg CO ₂ eq)	Energy (MJ)	Land use (m ²)
BSF	1.2-15.1	1.5-99.6	0.03-5.32
HF	0.8	9.3-288.5	0.03-7.03

¹ GWP = global warming potential; MJ = megajoule.

substrates would alternatively be used for energy production via anaerobic digestion, energy use is likely to be relatively high (Van Zanten *et al.*, 2015, 2018). Conversely, if such substrates would alternatively be composted, greenhouse gas emissions are likely to be greatly reduced. For instance, Digestion of swine manure mixed with corn cob by BSF larvae reduced CH₄, N₂O and NH₃ emissions compared to conventional composting by 73 to almost 100%, when using an optimal moisture content (Chen *et al.*, 2019).

8. Feed for production animals

Both HF and BSF can be used as a protein source for fish, poultry, or swine. The suitability of BSF has been widely tested in fish and shrimp (Van Huis and Tomberlin, 2017), whereas this is less the case for HF. The larvae and pupae of HF have a higher crude protein and a lower lipid content than BSF (Makkar *et al.*, 2014). Another compositional difference is the abundance of lauric acid in BSF and its virtual absence in HF (Finke and Oonincx, 2017). This might be a benefit for the use of BSF compared to HF, as there are indications that this fatty acid can provide health benefits to the consuming animal (Gasco *et al.*, 2018) and is a suitable lipid source in poultry diets (Bartosz *et al.*, 2020; Schiavone *et al.*, 2017). However, when these fly species are commercially used in feed, a defatting step is likely included to improve their suitability as an ingredient (Gasco *et al.*, in press). The digestibility of BSF prepupae is lower than for HF pupae or BSF larvae, when used as feed for broilers, swine, dogs, or cats, probably due to the heavily mineralised exoskeleton. Furthermore, the amino acid score of HF is higher than for BSF due to the higher methionine and lysine contents, which are often the first limiting amino acids. Dried HF larvae are small and can be added directly to animal feed, while BSF dried larvae may need to be grinded first, which can be an advantage in developing countries (Kenis *et al.*, 2018). In any case, the amino acid profile of both these species is similar to that of fish meal, which is the conventional standard in aquaculture (Barroso *et al.*, 2014).

9. Transmission of pathogens

The adults of BSF tend to rest on vegetation and do not approach humans or animals. To date, no known data indicate they are a pathogen vector. Their larvae can thrive in environments rich in microbes, some of which are pathogenic. In some instances, BSF larvae will decrease the pathogenic load in waste, such as populations of *E. coli* and *Salmonella*, (Erickson *et al.*, 2004; Lalander *et al.*, 2015; Liu *et al.*, 2008). However, the larvae themselves can still contain viable *Salmonella* at the end of the rearing period (Erickson *et al.*, 2004). Extracts of larvae of both species show anti-microbial effects (Li *et al.*, 2017; Park *et al.*, 2014).

Adult HF are a nuisance to man and other animals, and are mechanical vectors (Junqueira *et al.*, 2017) of about 100 pathogens of infectious diseases (bacteria, protozoa, helminths and viruses) (Dahlem, 2003; Greenberg, 1965; Iqbal *et al.*, 2014; Keiding, 1986). In fact, many pathogens can survive pupation (Greenberg, 1959a,b,c,d). For example, HF can transmit a variety of bacteria, including *E. coli* and antibiotic resistant bacteria (Graczyk *et al.*, 2001; Macovei and Zurek, 2006; Rahuma *et al.*, 2005) (Alam and Zurek, 2004); pathogens responsible for trachoma and epidemic conjunctivitis; and infect wounds with pathogens causing skin diseases, such as cutanic diphtheria, framboesia and leprosy (Graczyk *et al.*, 2001; Keiding, 1986; Rozendaal, 2011). However, this risk is very low when HF are reared and securely retained in their rearing facility. Similar to BSF, HF larvae can also reduce the pathogenic load of *E. coli*, *Salmonella enteritidis* and *Campylobacter jejuni* in poultry manure (Nordentoft *et al.*, 2017).

10. Conclusions

The advantages of producing HF compared to BSF is that the development is quicker, tolerate a larger range of abiotic conditions, and generally require less expertise for mating and adult biology. Their disadvantage is that they are smaller and seem more likely to transmit diseases as adults, while BSF adults are less likely to do so. HF have been used as model organisms for decades, whereas studies on BSF are fewer and more recent, with important aspects of their

biology still unknown. The advantage of BSF is that they can be reared on a wider range of organic side streams than HF. Legislation may favour BSF versus HF as adults are less likely to transmit pathogens, which may be an issue when more rearing substrates, such as manure, will be allowed. However, both species could fulfil an important role as farmed insects in intensive production systems in the near future.

References

- Alam, M.J. and Zurek, L., 2004. Association of *Escherichia coli* O157:H7 with houseflies on a cattle farm. *Applied and Environmental Microbiology* 70: 7578-7580. <https://doi.org/10.1128/aem.70.12.7578-7580.2004>
- Aristi, H., Mudji, E.H., Soepranionondo, K., Haridjani, N. and Aprilia, Z., 2020. Levels of protein and fat produced by black soldier fly (*Hermetia illucens*) larvae in the bioconversion of organic waste. *E3S Web of Conferences* 151: 01041. <https://doi.org/10.1051/e3sconf/202015101041>
- Axtell, R.C. and Edwards, T.D., 1970. A *Hermetia illucens* control in poultry manure by larviciding. *Journal of Economic Entomology* 63: 1786-1787. <https://doi.org/10.1093/jee/63.6.1786>
- Banks, I.J., Gibson, W.T. and Cameron, M.M., 2014. Growth rates of black soldier fly larvae fed on fresh human faeces and their implication for improving sanitation. *Tropical Medicine & International Health* 19: 14-22. <https://doi.org/10.1111/tmi.12228>
- Barnard, D.R. and Geden, C.J., 1993. Influence of larval density and temperature in poultry manure on development of the house fly (Diptera: Muscidae). *Environmental Entomology* 22: 971-977. <https://doi.org/10.1093/ee/22.5.971>
- Barroso, F.G., De Haro, C., Sánchez-Muros, M.-J., Venegas, E., Martínez-Sánchez, A. and Pérez-Bañón, C., 2014. The potential of various insect species for use as food for fish. *Aquaculture* 422-423: 193-201. <https://doi.org/10.1016/j.aquaculture.2013.12.024>
- Bartos, K., Jędrzej, S., Mateusz, R., Wojciech, C., Sylwester, Ś. and Damian, J., 2020. From waste to sustainable feed material: the effect of *Hermetia illucens* oil on the growth performance, nutrient digestibility, and gastrointestinal tract morphometry of broiler chickens. *Annals of Animal Science* 20: 157-177. <https://doi.org/10.2478/aoas-2019-0066>
- Bertinetti, C., Samayoa, A.C. and Hwang, S.-Y., 2019. Effects of feeding adults of *Hermetia illucens* (Diptera: Stratiomyidae) on longevity, oviposition, and egg hatchability: insights into optimizing egg production. *Journal of Insect Science* 19: 19. <https://doi.org/10.1093/jisesa/iez001>
- Biancarosa, I., Liland, N.S., Day, N., Belghit, I., Amlund, H., Lock, E.J. and Gilburn, A.S., 2018. The chemical composition of two seaweed flies (*Coelopa frigida* and *Coelopa pilipes*) reared in the laboratory. *Journal of Insects as Food and Feed* 4: 135-142. <https://doi.org/10.3920/JIFF2018.0008>
- Booth, D.C. and Sheppard, C., 1984. Oviposition of the Black Soldier Fly, *Hermetia illucens* (Diptera: Stratiomyidae): eggs, masses, timing, and site characteristics. *Environmental Entomology* 13: 421-423. <https://doi.org/10.1093/ee/13.2.421>
- Bradley, S.W. and Sheppard, D.C., 1984. House fly oviposition inhibition by larvae of *Hermetia illucens*, the black soldier fly. *Journal of Chemical Ecology* 10: 853-859. <https://doi.org/10.1007/BF00987968>
- Brookes, V.J. and Fraenkel, G., 1958. The nutrition of the larva of the housefly, *Musca domestica* L. *Physiological Zoology* 31: 208-223.
- Cai, M., Zhang, K., Zhong, W., Liu, N., Wu, X., Li, W., Zheng, L., Yu, Z. and Zhang, J., 2019. Bioconversion-composting of golden needle mushroom (*Flammulina velutipes*) root waste by black soldier fly (*Hermetia illucens*, Diptera: Stratiomyidae) larvae, to obtain added-value biomass and fertilizer. *Waste and Biomass Valorization* 10: 265-273. <https://doi.org/10.1007/s12649-017-0063-2>
- Calvert, C.C., Martin, R.D. and Morgan, N.O., 1969. House fly pupae as food for poultry. *Journal of Economic Entomology* 62: 938-939. <https://doi.org/10.1093/jee/62.4.938>
- Chen, J., Hou, D., Pang, W., Nowar, E.E., Tomberlin, J.K., Hu, R., Chen, H., Xie, J., Zhang, J., Yu, Z. and Li, Q., 2019. Effect of moisture content on greenhouse gas and NH₃ emissions from pig manure converted by black soldier fly. *Science of the Total Environment* 697: 133840. <https://doi.org/10.1016/j.scitotenv.2019.133840>
- Čičková, H., Pastor, B., Kozánek, M., Martínez-Sánchez, A., Rojo, S. and Takáč, P., 2012a. Biodegradation of pig manure by the housefly, *Musca domestica*: a viable ecological strategy for pig manure management. *PLoS ONE* 7: e32798. <https://doi.org/10.1371/journal.pone.0032798>
- Čičková, H., Kozánek, M., Morávek, I. and Takáč, P., 2012b. A behavioral method for separation of house fly (Diptera: Muscidae) larvae from processed pig manure. *Journal of Economic Entomology* 105: 62-66. <https://doi.org/10.1603/ec11202>
- Čičková, H., Kozánek, M. and Takáč, P., 2013. Improvement of survival of the house fly (*Musca domestica* L.) larvae under mass-rearing conditions. *Bulletin of Entomological Research* 103: 119-125. <https://doi.org/10.1017/S000748531200065X>
- Čičková, H., Newton, G.L., Lacy, R.C. and Kozánek, M., 2015. The use of fly larvae for organic waste treatment. *Waste Management* 35: 68-80. <http://doi.org/10.1016/j.wasman.2014.09.026>
- Dahlem, G.A., 2003. House fly. In: Resh, V.H. and Cardé, R.T. (eds.) *Encyclopedia of insects*. Academic Press, Cambridge, MA, USA, pp. 532-534.
- Dowding, V.M., 1967. The function and ecological significance of the pharyngeal ridges occurring in the larvae of some cyclorrhaphous Diptera. *Parasitology* 57: 371-388. <https://doi.org/10.1017/S0031182000072164>
- Dunn, L.H., 1922. Observations on the oviposition of the house-fly, *Musca domestica*, L., in Panama. *Bulletin of Entomological Research* 13: 301-305. <https://doi.org/10.1017/S0007485300045399>
- El Boushy, A.R., 1991. House-fly pupae as poultry manure converters for animal feed: a review. *Bioresource Technology* 38: 45-49.
- Erickson, M.C., Islam, M., Sheppard, C., Liao, J. and Doyle, M.P., 2004. Reduction of *Escherichia coli* O157:H7 and *Salmonella enterica* serovar Enteritidis in chicken manure by larvae of the black soldier fly. *Journal of Food Protection* 67: 685-690. <https://doi.org/10.4315/0362-028x-67.4.685>

- Espinoza-Fuentes, F.P. and Terra, W.R., 1987. Physiological adaptations for digesting bacteria. Water fluxes and distribution of digestive enzymes in *Musca domestica* larval midgut. *Insect Biochemistry* 17: 809-817. [https://doi.org/10.1016/0020-1790\(87\)90015-1](https://doi.org/10.1016/0020-1790(87)90015-1)
- Faraj, A.M., Mawlood, N.A. and Khidhir, A.L.A.-Q.S., 2014. Morphological study of house fly stages *Musca domestica* L. (Diptera: Muscidae). *Zanco Journal of Pure and Applied Sciences* 26: 1-10.
- Finke, M.D. and Oonincx, D.G.A.B., 2017. Insects and nutrients. In: Van Huis, A. and Tomberlin, J.K. (eds.) *Insects as food and feed: from production to consumption*. Wageningen Academic Publishers, Wageningen, the Netherlands, pp. 291-316. <https://doi.org/10.3920/978-90-8686-849-0>
- Furman, D.P., Young, R.D. and Catts, P.E., 1959. *Hermetia illucens* (Linnaeus) as a factor in the natural control of *Musca domestica* Linnaeus. *Journal of Economic Entomology* 52: 917-921. <https://doi.org/10.1093/jee/52.5.917>
- Gasco, L., Biancarosa, I. and Liland, N.S., in press. From waste to feed: a review of recent knowledge on insects as producers of protein and fat for animal feeds. *Current Opinion in Green and Sustainable Chemistry*. <https://doi.org/10.1016/j.cogsc.2020.03.003>
- Gasco, L., Finke, M. and Van Huis, A., 2018. Can diets containing insects promote animal health? *Journal of Insects as Food and Feed* 4: 1-4. <https://doi.org/10.3920/JIFF2018.x001>
- Graczyk, T.K., Knight, R., Gilman, R.H. and Cranfield, M.R., 2001. The role of non-biting flies in the epidemiology of human infectious diseases. *Microbes and Infection* 3: 231-235. [https://doi.org/10.1016/S1286-4579\(01\)01371-5](https://doi.org/10.1016/S1286-4579(01)01371-5)
- Greenberg, B., 1955a. Fecundity and cold survival of the house fly. *Journal of Economic Entomology* 48: 654-657.
- Greenberg, B., 1955b. Fecundity and cold survival of the house fly. *Journal of Economic Entomology* 48: 654-657. <https://doi.org/10.1093/jee/48.6.654>
- Greenberg, B., 1959a. Persistence of bacteria in the developmental stages of the housefly. I. Survival of enteric pathogens in the normal and aseptically reared host. *The American Journal of Tropical Medicine and Hygiene* 8: 405-411.
- Greenberg, B., 1959b. Persistence of bacteria in the developmental stages of the housefly. II. Quantitative study of the host-contaminant relationship in flies breeding under natural conditions. *The American Journal of Tropical Medicine and Hygiene* 8: 412-416.
- Greenberg, B., 1959c. Persistence of bacteria in the developmental stages of the housefly. III. Quantitative distribution in prepupae and pupae. *The American Journal of Tropical Medicine and Hygiene* 8: 613-617.
- Greenberg, B., 1959d. Persistence of bacteria in the developmental stages of the housefly. IV. Infectivity of the newly emerged adult. *The American Journal of Tropical Medicine and Hygiene* 8: 618-622. <https://doi-org.ezproxy.library.wur.nl/10.4269/ajtmh.1959.8.618>
- Greenberg, B., 1965. Flies and disease. *Scientific American* 213: 92-99.
- Hall, H.N., Masey O'Neill, H.V., Scholey, D., Burton, E., Dickinson, M. and Fitches, E.C., 2018. Amino acid digestibility of larval meal (*Musca domestica*) for broiler chickens. *Poultry Science*: 97: 1290-1297. <https://doi.org/10.3382/ps/pex433>
- Harnden, L.M. and Tomberlin, J.K., 2016. Effects of temperature and diet on black soldier fly, *Hermetia illucens* (L.) (Diptera: Stratiomyidae), development. *Forensic Science International* 266: 109-116. <https://doi.org/10.1016/j.forsciint.2016.05.007>
- Haupt, A. and Busvine, J.R., 1968. The effect of overcrowding on the size of houseflies (*Musca domestica* L.). *Transactions of the Royal Entomological Society of London* 120: 297-311.
- Heussler, C.D., Walter, A., Oberkofler, H., Insam, H., Arthofer, W., Schlick-Steiner, B.C. and Steiner, F.M., 2018. Influence of three artificial light sources on oviposition and half-life of the black soldier fly, *Hermetia illucens* (Diptera: Stratiomyidae): improving small-scale indoor rearing. *PLoS ONE* 13: e0197896. <https://doi.org/10.1371/journal.pone.0197896>
- Hewitt, C.G., 1914. *The house-fly: Musca domestica* Linn: its structure, habits, development, relation to disease and control. University Press, Cambridge, UK.
- Hogsette, J.A., 1992. New diets for production of house flies and stable flies (Diptera: Muscidae) in the laboratory. *Journal of Economic Entomology* 85: 2291-2294.
- Hussein, M., Pillai, V.V., Goddard, J.M., Park, H.G., Kothapalli, K.S., Ross, D.A., Ketterings, Q.M., Brenna, J.T., Milstein, M.B., Marquis, H., Johnson, P.A., Nyrop, J.P. and Selvaraj, V., 2017. Sustainable production of housefly (*Musca domestica*) larvae as a protein-rich feed ingredient by utilizing cattle manure. *PLoS ONE* 12: e0171708. <https://doi.org/10.1371/journal.pone.0171708>
- Iqbal, W., Malik, M.F., Sarwar, M.K., Azam, I., Iram, N. and Rashda, A., 2014. Role of housefly (*Musca domestica*, Diptera: Muscidae) as a disease vector: a review. *Journal of Entomology and Zoology Studies* 2: 159-163.
- Junqueira, A.C.M., Ratan, A., Acerbi, E., Drautz-Moses, D.I., Premkrishnan, B.N.V., Costea, P.I., Linz, B., Purbojati, R.W., Paulo, D.F., Gaultier, N.E., Subramanian, P., Hasan, N.A., Colwell, R.R., Bork, P., Azeredo-Espin, A.M.L., Bryant, D.A. and Schuster, S.C., 2017. The microbiomes of blowflies and houseflies as bacterial transmission reservoirs. *Scientific Reports* 7: 16324. <https://doi.org/10.1038/s41598-017-16353-x>
- Keiding, J., 1986. *The house fly – biology and control*. Vector Biology and Control Division, World Health Organization, Geneva, Switzerland.
- Kenis, M., Bouwassi, B., Bofo, H., Devic, E., Han, R., Koko, G., Koné, N.G., Maciel-Vergara, G., Nacambo, S., Pomalegni, S.C.B., Roffeis, M., Wakefield, M., Zhu, F. and Fitches, E., 2018. Small-scale fly larvae production for animal feed. In: Halloran, A., Flore, R., Vantomme, P. and Roos, N. (eds.) *Edible insects in sustainable food systems*. Springer International Publishing, Cham, Switzerland, pp. 239-261. https://doi.org/10.1007/978-3-319-74011-9_15
- Kenis, M., Koné, N., Chrysostome, C.A.A.M., Devic, E., Koko, G.K.D., Clotey, V.A., Nacambo, S. and Mensah, G.A., 2014. Insects used for animal feed in West Africa. *Entomologia* 2: 107-114. <https://doi.org/10.4081/entomologia.2014.218>
- Khamesipour, F., Lankarani, K.B., Honarvar, B. and Kwenti, T.E., 2018. A systematic review of human pathogens carried by the housefly (*Musca domestica* L.). *BMC Public Health* 18: 1049. <https://doi.org/10.1186/s12889-018-5934-3>

- Kilpatrick, J.W. and Schof, H.F., 1959. Interrelationship of water and *Hermetia illucens* breeding to *Musca domestica* production in human excrement. The American Journal of Tropical Medicine and Hygiene 8: 597-602.
- Kökdener, M. and Kiper, F., 2020. The impact of diet protein and carbohydrate on select life-history traits of the housefly *Musca domestica* Linnaeus, 1758 (Diptera: Muscidae). Munis Entomology & Zoology 15: 171-179. <https://doi.org/10.3390/insects8020056>
- Komakech, A.J., Sundberg, C., Jönsson, H. and Vinnerås, B., 2015. Life cycle assessment of biodegradable waste treatment systems for sub-Saharan African cities. Resources, Conservation and Recycling 99: 100-110. <https://doi.org/10.1016/j.resconrec.2015.03.006>
- Koné, N., Sylla, M., Nacambo, S. and Kenis, M., 2017. Production of house fly larvae for animal feed through natural oviposition. Journal of Insects as Food and Feed 3: 177-186. <https://doi.org/10.3920/jiff2016.0044>
- Krivosheina, M., 2008. On insect feeding on cyanobacteria. Paleontological Journal 42: 596-599. <https://doi.org/10.1134/S003103010806004X>
- Lalander, C.H., Fidjeland, J., Diener, S., Eriksson, S. and Vinnerås, B., 2015. High waste-to-biomass conversion and efficient *Salmonella* spp. reduction using black soldier fly for waste recycling. Agronomy for Sustainable Development 35: 261-271. <https://doi.org/10.1007/s13593-014-0235-4>
- Levinson, Z.H., 1960. Food of housefly larvae. Nature 188: 427-428. <https://doi.org/10.1038/188427a0>
- Li, H., Inoue, A., Taniguchi, S., Yukutake, T., Suyama, K., Nose, T. and Maeda, I., 2017. Multifunctional biological activities of water extract of housefly larvae (*Musca domestica*). PharmaNutrition 5: 119-126. <https://doi.org/10.1016/j.phanu.2017.09.001>
- Lim, J.-W., Mohd-Noor, S.-N., Wong, C.-Y., Lam, M.-K., Goh, P.-S., Beniers, J.J.A., Oh, W.-D., Jumbri, K. and Ghani, N.A., 2019. Palatability of black soldier fly larvae in valorizing mixed waste coconut endosperm and soybean curd residue into larval lipid and protein sources. Journal of Environmental Management 231: 129-136. <https://doi.org/10.1016/j.jenvman.2018.10.022>
- Lindner, P., 1919. Zur Fettgewinnung aus Kleintieren [Extraction of fat from small animals]. Zeitschrift für technische Biologie 7: 213-220.
- Liu, Q., Tomberlin, J.K., Brady, J.A., Sanford, M.R. and Yu, Z., 2008. Black soldier fly (Diptera: Stratiomyidae) larvae reduce *Escherichia coli* in dairy manure. Environmental Entomology 37: 1525-1530. <https://doi.org/10.1603/0046-225x-37.6.1525>
- Macovei, L. and Zurek, L., 2006. Ecology of antibiotic resistance genes: characterization of *enterococci* from houseflies collected in food Settings. Applied and Environmental Microbiology 72: 4028-4035. <https://doi.org/10.1128/AEM.00034-06>
- Makkar, H.P.S., Tran, G., Heuzé, V. and Ankers, P., 2014. State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology 197: 1-33. <https://doi.org/10.1016/j.anifeedsci.2014.07.008>
- Miller, B.F., 1969. Biological digestion of manure by Diptera. Feedstuffs 41: 32-33.
- Miranda, D.C., Cammack, A.J. and Tomberlin, K.J., 2019. Interspecific competition between the house fly, *Musca domestica* L. (Diptera: Muscidae) and black soldier fly, *Hermetia illucens* (L.) (Diptera: Stratiomyidae) when reared on poultry manure. Insects 10: 440. <https://doi.org/10.3390/insects10120440>
- Nayduch, D. and Burrus, R.G., 2017. Flourishing in filth: house fly – microbe interactions across life history. Annals of the Entomological Society of America 110: 6-18. <https://doi.org/10.1093/aesa/saw083>
- Newton, G.L., Sheppard, D.C., Watson, D.W., Burtle, G.J., Dove, C.R., Tomberlin, J.K. and Thelen, E.E., 2005a. The black soldier fly, *Hermetia illucens*, as a manure management/resource recovery tool. In: Proceedings of the 2005 Symposium on the State of the Science of Animal Manure and Waste Management, January 5-7, 2005, San Antonio, TX, USA, pp. 2-17.
- Newton, L., Sheppard, C., Watson, D.W. and Burtle, G., 2005b. Using the black soldier fly, *Hermetia illucens*, as a value-added tool for the management of swine manure. Report for Mike Williams, Director of the Animal and Poultry Waste Management Center, North Carolina State University, Raleigh, Nc. Available at: <https://p2infohouse.org/ref/37/36122.pdf>.
- Nordentoft, S., Fischer, C., Bjerrum, L., Heckmann, L.H. and Hald, B., 2017. Reduction of *Escherichia coli*, *Salmonella enteritidis* and *Campylobacter jejuni* in poultry manure by rearing of *Musca domestica* fly larvae. Journal of Insects as Food and Feed 3: 145-153. <https://doi.org/10.3920/jiff2016.0058>
- Norgren, R., Björkqvist, O. and Jonsson, A., 2019. Bio-sludge from the pulp and paper industry as feed for black soldier fly larvae: a study of critical factors for growth and survival. Waste and Biomass Valorization. <https://doi.org/10.1007/s12649-019-00864-x>
- Nyakeri, E.M., Ayieko, M.A., Amimo, F.A., Salum, H. and Ogola, H.J.O., 2019. An optimal feeding strategy for black soldier fly larvae biomass production and faecal sludge reduction. Journal of Insects as Food and Feed 5: 201-213. <https://doi.org/10.3920/JIFF2018.0017>
- Oonincx, D.G.A.B., 2017. Environmental impact of insect production. In: Van Huis, A. and Tomberlin, J.K. (eds.) Insects as food and feed: from production to consumption, pp. 78-93. Wageningen Academic Publishers, Wageningen, the Netherlands, 448 pp. <https://doi.org/10.3920/978-90-8686-849-0>
- Oonincx, D.G.A.B., Volk, N., Diehl, J.J.E., Van Loon, J.J.A. and Belušič, G., 2016. Photoreceptor spectral sensitivity of the compound eyes of black soldier fly (*Hermetia illucens*) informing the design of LED-based illumination to enhance indoor reproduction. Journal of Insect Physiology 95: 133-139. <https://doi.org/10.1016/j.jinsphys.2016.10.006>
- Palma, L., Ceballos, S.J., Johnson, P.C., Niemeier, D., Pitesky, M. and VanderGheynst, J.S., 2018. Cultivation of black soldier fly larvae on almond byproducts: impacts of aeration and moisture on larvae growth and composition. Journal of the Science of Food and Agriculture 98: 5893-5900. <https://doi.org/10.1002/jsfa.9252>
- Park, S.-I., Chang, B.S. and Yoe, S.M., 2014. Detection of antimicrobial substances from larvae of the black soldier fly, *Hermetia illucens* (Diptera: Stratiomyidae). Entomological Research 44: 58-64. <https://doi.org/10.1111/1748-5967.12050>

- Pastor, B., Cickova, H., Kozanek, M., Martinez-Sanchez, A., Takac, P. and Rojo, S., 2011. Effect of the size of the pupae, adult diet, oviposition substrate and adult population density on egg production in *Musca domestica* (Diptera: Muscidae). *European Journal of Entomology* 108: 587-596. <https://doi.org/10.14411/eje.2011.076>
- Pastor, B., Martínez-Sánchez, A.S., Ståhls, G.A. and Rojo, S., 2014. Introducing improvements in the mass rearing of the housefly: biological, morphometric and genetic characterization of laboratory strains. *Bulletin of Entomological Research* 104: 486-493. <https://doi.org/10.1017/S000748531400025X>
- Pastor, B., Velasquez, Y., Gobbi, P. and S. Rojo, S., 2015. Conversion of organic wastes into fly larval biomass: bottlenecks and challenges. *Journal of Insects as Food and Feed* 1: 179-193. <https://doi.org/10.3920/JIFF2014.0024>
- Pimentel, A.C., Barroso, I.G., Ferreira, J.M.J., Dias, R.O., Ferreira, C. and Terra, W.R., 2018. Molecular machinery of starch digestion and glucose absorption along the midgut of *Musca domestica*. *Journal of Insect Physiology* 109: 11-20. <https://doi.org/10.1016/j.jinsphys.2018.05.009>
- Pomalégni, S.C.B., Gbemavo, D.S.J.C., Gnanglè, P.C., Djossou, S., Kenis, M., Babatoundé, S., Kakai, L.R.G. and Mensah, G.A., 2018. Seed cake of *Jatropha curcas* (L), potential substrate to produce maggots as feed for reared monogastric animals. *The Journal of Animal & Plant Science* 28: 1591-1596.
- Qi, X., Li, Z., Akami, M., Mansour, A. and Niu, C., 2019. Fermented crop straws by *Trichoderma viride* and *Saccharomyces cerevisiae* enhanced the bioconversion rate of *Musca domestica* (Diptera: Muscidae). *Environmental Science and Pollution Research* 26: 29388-29396. <https://doi.org/10.1007/s11356-019-06101-1>
- Rachmawati, R., Buchori, D., Hidayat, P., Hem, S. and Fahmi, D.M.R., 2010. Perkembangan dan kandungan nutrisi larva *Hermetia illucens* (Linnaeus) (Diptera: Stratiomyidae) pada bungkil kelapa sawit. *Indonesian Journal of Entomology* 7: 28-41.
- Rahuma, N., Ghenghesh, K.S., Ben Aissa, R. and Elamaari, A., 2005. Carriage by the housefly (*Musca domestica*) of multiple-antibiotic-resistant bacteria that are potentially pathogenic to humans, in hospital and other urban environments in Misurata, Libya. *Annals of Tropical Medicine & Parasitology* 99: 795-802. <https://doi.org/10.1179/136485905X65134>
- Rehman, K.u., Rehman, A., Cai, M., Zheng, L., Xiao, X., Somroo, A.A., Wang, H., Li, W., Yu, Z. and Zhang, J., 2017. Conversion of mixtures of dairy manure and soybean curd residue by black soldier fly larvae (*Hermetia illucens* L.). *Journal of Cleaner Production* 154: 366-373. <http://doi.org/10.1016/j.jclepro.2017.04.019>
- Roffeis, M., Muys, B., Almeida, J., Mathijs, E., Achten, W.M.J., Pastor, B., Velásquez, Y., Martinez-Sanchez, A.I. and Rojo, S., 2015. Pig manure treatment with housefly (*Musca domestica*) rearing – an environmental life cycle assessment. *Journal of Insects as Food and Feed* 1: 195-214. <https://doi.org/10.3920/JIFF2014.0021>
- Rozendaal, J.A., 2011. Houseflies. Vector control: methods for use by individuals and communities. WHO, Geneva, Switzerland, pp. 302-323.
- Salomone, R., Saija, G., Mondello, G., Giannetto, A., Fasulo, S. and Savastano, D., 2017. Environmental impact of food waste bioconversion by insects: application of life cycle assessment to process using *Hermetia illucens*. *Journal of Cleaner Production* 140: 890-905. <https://doi.org/10.1016/j.jclepro.2016.06.154>
- Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., Bergagna, S., Dezzutto, D., Gai, F., Dabbou, S., Gasco, L. and Dalle Zotte, A., 2017. Partial or total replacement of soybean oil by black soldier fly larvae (*Hermetia illucens* L.) fat in broiler diets: effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. *Italian Journal of Animal Science* 16: 93-100. <https://doi.org/10.1080/1828051X.2016.1249968>
- Schneider, J.C., 2020. Effects of light intensity on mating of the black soldier fly (*Hermetia illucens*, Diptera: Stratiomyidae). *Journal of Insects as Food and Feed* 6: 111-119. <https://doi.org/10.3920/JIFF2019.0003>
- Sheppard, D.C., 1983. House fly and lesser fly control utilizing the black soldier fly in manure management systems for caged laying hens. *Environmental Entomology* 12: 1439-1442.
- Shipp, E. and Osborn, A.W., 1967. The effect of protein sources and of the frequency of egg collection on egg production by the housefly (*Musca domestica* L.). *Bulletin of the World Health Organization* 37: 331-335.
- Shumo, M., Khamis, M.F., Tanga, M.C., Fiaboe, K.M.K., Subramanian, S., Ekesi, S., Van Huis, A. and Borgemeister, C., 2020. Influence of temperature on selected life-history traits of black soldier fly (*Hermetia illucens*) reared on two common urban organic waste streams in Kenya. *Animals* 9: 79. <https://doi.org/10.3390/ani9030079>
- Skoda, S.R., Thomas, G.D. and Campbell, J.B., 1993. Abundance of immature stages of the house fly (Diptera: Muscidae) from five areas in beef cattle feedlot pens. *Journal of Economic Entomology* 86: 455-461. <http://doi.org/10.1093/jee/86.2.455>
- Smetana, S., Mathys, A., Knoch, A. and Heinz, V., 2015. Meat alternatives: life cycle assessment of most known meat substitutes. *The International Journal of Life Cycle Assessment* 20: 1254-1267. <https://doi.org/10.1007/s11367-015-0931-6>
- Smetana, S., Palanisamy, M., Mathys, A. and Heinz, V., 2016. Sustainability of insect use for feed and food: life cycle assessment perspective. *Journal of Cleaner Production* 137: 741-751. <https://doi.org/10.1016/j.jclepro.2016.07.148>
- Spiller, D., 1964. Nutrition and diet of muscoid flies. *Bulletin of the World Health Organisation* 31: 551-554.
- Starcevic, K., Lozica, L., Gavrilovic, A., Heruc, Z. and Masek, T., 2019. Fatty acid plasticity of black soldier fly (*Hermetia illucens*) larvae reared on alternative feeding media: crude olive cake and processed animal protein. *Journal of Animal and Feed Sciences* 28: 374-382. <https://doi.org/10.22358/jafs/114434/2019>
- Stephens, C.S., 1975. *Hermetia illucens* (Diptera: Stratiomyidae) as a banana pest in Panama. *Hermetia illucens* (Diptera: Stratiomyidae) como plaga del banano en Panamá. *Tropical Agriculture* 52: 173-178.
- Swinscoe, I., Oliver, D.M., Gilburn, A.S., Lunestad, B., Lock, E.J., Ørnsrud, R. and Quilliam, R.S., 2019. Seaweed-fed black soldier fly (*Hermetia illucens*) larvae as feed for salmon aquaculture: assessing the risks of pathogen transfer. *Journal of Insects as Food and Feed* 5: 15-27. <https://doi.org/10.3920/JIFF2017.0067>

- Tingle, F.C., Mitchell, E.R. and Copeland, W.W., 1975. The soldier fly, *Hermetia illucens*, in poultry houses in north central Florida. Journal of the Georgia Entomological Society 10: 179-183.
- Tomberlin, J.K., 2001. Biological, behavioral, and toxicological studies on the black soldier fly (Diptera: Stratiomyidae). PhD thesis, University of Georgia, Athens, GA, USA.
- Tomberlin, J.K., Adler, P.H. and Myers, H.M., 2009. Development of the black soldier fly (Diptera: Stratiomyidae) in relation to temperature. Environmental Entomology 38: 930-934. <https://doi.org/10.1603/022.038.0347>
- Tomberlin, J.K. and Cammack, J.A., 2017. Black soldier fly: biology and mass production. In: Van Huis, A. and Tomberlin, J.K. (eds.) Insects as food and feed: from production to consumption. Wageningen Academic Publishers, Wageningen, the Netherlands, pp. 231-246. <https://doi.org/10.3920/978-90-8686-849-0>
- Tomberlin, J.K., Sheppard, D.C. and Joyce, J.A., 2002. Selected life-history traits of black soldier flies (Diptera: Stratiomyidae) reared on three artificial diets. Annals of the Entomological Society of America 95: 379-386.
- Tomberlin, J.K. and Van Huis, A., 2020. Black soldier fly from pest to 'crown jewel' of the insects as feed industry: an historical perspective. Journal of Insects as Food and Feed 6: 1-4. <https://doi.org/10.3920/JIFF2020.0003>
- Van Huis, A. and Tomberlin, J., 2017. The potential of insects as food and feed. In: Van Huis, A. and Tomberlin, J.K. (eds.) Insects as food and feed: from production to consumption. Wageningen Academic Publishers, Wageningen, the Netherlands, pp. 25-58. <https://doi.org/10.3920/978-90-8686-849-0>
- Van Zanten, H.H.E., Bikker, P., Meerburg B.G. and De Boer, I.J.M., 2018. Attributional versus consequential life cycle assessment and feed optimization: alternative protein sources in pig diets. The International Journal of Life Cycle Assessment 23: 1-11. <https://doi.org/10.1007/s11367-017-1299-6>
- Van Zanten, H.H.E., Mollenhorst, H., Oonincx, D.G.A.B., Bikker, P., Meerburg, B.G. and De Boer, I.J.M., 2015. From environmental nuisance to environmental opportunity: housefly larvae convert waste to livestock feed. Journal of Cleaner Production 102: 362-369. <https://doi.org/10.1016/j.jclepro.2015.04.106>
- Vásquez-González, J., Young, W.R. and Ramirez-Genet, M., 1963. Reducción de la población de mosca doméstica en gallinazo por la mosca soldado del tropico. Agricultura Técnica en México 2: 53-57.
- Veloz Maggiolo, M., 2007. La dieta aborigen precolombina (apuntes para una gastronomía silvestre). In: Dipp, H.T. and Maggiolo, M.V. (eds.) Gastronomía dominicana. Historia Del Sabor Criollo, Codetel, Santo Domingo, Dominican Republic, pp. 13-83.
- Villazana, J. and Alyokhin, A., 2019. Development of black soldier fly larvae (Diptera: Stratiomyidae) on seafood wastes. Journal of Insects as Food and Feed 5: 313-319. <https://doi.org/10.3920/JIFF2019.0008>
- Wilkes, A., Bucher, G.E., Cameron, J.W.M. and West Jr, A.S., 1948. Studies on the housefly (*Musca domestica* L.): I. The biology and large scale production of laboratory populations. Canadian Journal of Research 26d: 8-25. <https://doi.org/10.1139/cjr48d-003>
- Yang, S., Xie, J., Hu, N., Liu, Y., Zhang, J., Ye, X. and Liu, Z., 2015. Bioconversion of gibberellin fermentation residue into feed supplement and organic fertilizer employing housefly (*Musca domestica* L.) assisted by *Corynebacterium variabile*. PLoS ONE 10(5): e0110809. <https://doi.org/10.1371/journal.pone.0110809>
- Zhang, J., Huang, L., He, J., Tomberlin, J.K., Li, J., Lei, C., Sun, M., Liu, Z. and Yu, Z., 2010. An artificial light source influences mating and oviposition of black soldier flies, *Hermetia illucens*. Journal of Insect Science 10: 202. <https://doi.org/10.1673/031.010.20201>