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Insects: An alternative for sustainable production in Mexico

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ABSTRACT

Objective: To analyze the sociocultural, economic and environmental aspects of insects in Mexico.

Design/Methodology/Approach: A bibliographic review was conducted from October 2021 to January 2022, searching for literature available in databases from Google Academic, Sciencedirect, SpringerLink, Google Patent, EBSCO, Semantic Scholar and the content available through the remote access of the CONRICyT. The bibliographic systematization of the articles consulted was developed using the Excel 2016 software and the Mendeley Desktop version 1.19.4 software.

Results: Entomology presents high ecological, economic and social value, directed towards the horizons of food security, care for the environment, and as an alternative for productive diversification. The economic importance that edible insects represent for Mexico stood out, visualizing commercial alternatives for small-scale producers.

Study Limitations/Implications: The results only present data referring to Mexico.

Findings/Conclusions: The importance of sustainability that insects in Mexico present was made evident. Practices to raise awareness are suggested, which mitigate neophobia and strengthen the adoption and consumption of this resource in the different social strata of the Mexican society.

Keywords: Mystical, playful, medicinal, environmental, edible.

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INTRODUCTION

Facing the constant increase of the human population, food insecurity is becoming a challenge of global nature (Van Huis and Oonincx, 2017); therefore, there is an inquiry about the search for food as an alternative for sustainable consumption and production (Batat and Peter, 2020). Within this context, the phylum Arthropoda (particularly the class Insecta), the largest group of the animal kingdom, is considered an ideal candidate as

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option for food rich in proteins, fats and minerals, and friendly with the environment, which can contribute to mitigate problems of hunger and malnutrition (Puzari, 2021).

The consumption and use of insects is an ancestral activity represented approximately by 3,071 ethnic groups, who search for, harvest, prepare, store and trade this resource in a sustainable way, allowing the conservation of 90% of the natural germplasm (Ramos-Elorduy, 2009). Although the origin of entomophagy (consumption of insects) is unknown, it is believed that the first experiences emerged from the guest-host relationship in which humans hosted parasitic organisms (fleas and lice), which they acquired in the transition from nomad to sedentary living, projecting entomophagy to approximately 10,000 years ago (López de la Cruz *et al.*, 2015).

Insects are part of the human diet in different places of the planet, particularly in countries of Asia, Africa and Latin America. This resource is rich in nutrients and considered a delicacy for its consumers, particularly in Japan, Australia and Europe (Raheem *et al.*, 2019). In fact, entomophagy is practiced in every country, particularly in human groups of low income, by consuming eggs, larvae, pupae and adult organisms (Feng *et al.*, 2018).

In addition to the nutritional benefits, insects also present a series of economic and ecological advantages, since they carry out functions such as pest control, pollination and nutrient recycling. Their production is low-cost and reduces environmental problems such as agricultural pressure, aquaculture and animal breeding, by requiring less reproductive time, less amount of soil, water and food (Barton *et al.*, 2020).

In Mexico, the consumption of insects constitutes part of the culture and identity of different ethnic groups; they are natural resources that society has known how to exploit, characterizing gastronomy from various communities, particularly in rural, peasant and indigenous zones (López de la Cruz *et al.*, 2015).

Comparatively to other means of subsistence from animal protein (pork meat and beef), which cause great environmental problems, insects are a means of protein purveyance based on a sustainable model; therefore, the Food and Agriculture Organization of the United Nations (FAO) recommends the consumption and production of these organisms (Iseppi *et al.*, 2021). In parallel, the intake of arthropods that could become pests reduces the use of chemical contaminants that harm the environment. Therefore, eliminating pests by consuming them can be a practical and promising path (Van Huis and Oonincx, 2017).

Regarding food conversion, to produce 1 kg of beef, 10 kg of feed are required; for 1 kg of pork, 5 kg of feed; and for 1 kg of chicken, 2.5 kg of feed; this is all of low environmental sustainability (Fleta-Zaragozano, 2018). In turn, only 1.7 kg of feed is necessary to produce 1 kg of insects (Saara-Maria *et al.*, 2019). Under the same context, the water footprint represented by the production of insects per ton (4,341 m^3) is relatively low, compared to beef (154,115 m^3) and pork meat (5,988 m^3) (Van Huis and Oonincx, 2017).

It has been shown that greenhouse gas emissions from the production of insects is low, compared to emissions from beef production; for example, the emission of methane gas in insect breeding ranges between 0.00 and 0.16 g kg^{-1} of mass per day, compared to the emission of cattle which in average produces 0.239 g kg^{-1} of corporal mass per day (Anankware *et al.*, 2015).

Because of the aforementioned, this review had the objective of analyzing the sociocultural, economic and environmental aspects of insects in Mexico.

MATERIALS AND METHODS

A bibliographic search based on scientific literature was applied for the development of this study. The review was centered on the search for cultural (medicinal, mystical, playful, aesthetic and decorative), nutritional, environmental (pollination, biodegradation, biological pest control) importance, forms of consumption, price of sale and perspectives of consumption in Mexico. The articles available in databases in Google Academic, Sciencedirect, SpringerLink, Google Patent, EBSCO, and Semantic Scholar were identified, as well as the content available through the remote access of the CONRICyT. To filter the information, keywords were used such as: entomophagy, entomophagy and sustainable development, importance of insects in Mexico, food security and edible insects, entomologic environmental services, among others (all terms in Spanish). To order, classify and generate the references of the articles consulted, the Excel 2016 software and the Mendeley Desktop version 1.19.4 software were used. This review began in the first week of October 2021 and concluded in January 2022.

RESULTS AND DISCUSSION

Cultural value of insects in Mexico

Since immemorial times, insects have been part of the cultural identity of different ethnic groups, constituting part of their diet, medicine, art, with religious and mystical value; at the same time, they have strengthened the biocultural diversity of various social groups that have given them a value and respect for natural resources (Ramos Elorduy *et al.*, 2006; Ramos Elorduy and Viejo Montesinos, 2007; Costa Neto, 2015) (Tables 1, 2, 3 and 4).

Nutritional value of the insects

The dietary habit and preference for the consumption of insects in each region is linked to the historical background and geographical origin, in addition to their abundance, easy harvest and nutritional value (Ramos-Elorduy *et al.*, 1997), coevolving depending on lifestyle, tradition and educational level. This phenomenon explains how a certain food resource is considered for a certain group a primitive food, while the same resource in a different social stratum is valued as gourmet food and of high economic value. In addition to the cultural value that the entomological group denotes for Mexico, recently nutritional characteristics have been described that could contribute to mitigate the problems of hunger and malnutrition, particularly in rural zones where currently 11,238,031 households experience these problems (Ramírez-Sánchez *et al.*, 2021). However, the rural areas are those that show the highest consumption of insects, compensating the nutritional requirements that the conventional diet contributes; this thanks to the nutritional levels offered by this resource, such as described by Carmona-López *et al.* (2021) and different researchers who have enlisted a diversity of orders, families, genera and species of edible insects.

Table 1. Medicinal value of some entomological groups in Mexico.

Entomological group	Part used	Disease that heals
Melipona fasciata Latreille	Honey	Flu, cough, conjunctivitis
Apis mellifera	Honey and stinger	Flu, cough, rheumatism
Polybia occidentalis	Honey	Flu, cough
Polybia sp.	Honey	Flu, cough
Taeniopoda eques	Insect legs	Mouth ulcer
Cicadidae	Whole consumption	Dyslalia
Armadillidiidae	Whole consumption	Fever
Gryllus sp.	Insect legs	Developmental dysphasia and fever
Agriotes sp.	Whole consumption	Blisters on the hands
Neuroptera	Whole consumption	Stye
Apidae	Insect bite	Rheumatism and bad air
Scarabaeidae	Whole consumption	Wart removal
Oniscidea	Sofrito (spread)	Ear pain and deafness
Lepidoptera	Toasted in the comal	Speaking difficulties
Hymenoptera	Insect bite	Sloth of the hand
Zopherus jourdani	Necklace	Insomnia and crying of children
Ulomoides dermestoides	Living consumption	Cancer and diabetes

Table 2. Magical, mystical, and religious use of some entomological groups in Mexico.

Entomological group	Way of use	Action that causes
Automeris sp.	Mystical	Nahuales
Apidae	Mystical	Used in mystical prayers
Musca domestica	Larval stage	Make enemies sick
Oligochaeta	Adult phase	Make enemies sick
Araneae	Whole consumption	Black and white magic
Geometridae	Mystical	Short height in children
Arachnis aulaea	Mystical	Double hair disease (rash)
Araneae	Mystical	Herpes labialis
Pachylia syces	Nahual	Sterilization and cleft lip
Formicidae	Symbolic	Sign of omen
Hesperiidae	Symbolic	Family visit
Cicadidae	Song	Weather events
Apidae	Honey	Bath with petals (sweetness)
Odonata	Whole consumption	Attract love partner
Odonata	Whole consumption	Lucky attraction
Theraphosidae	Insect legs	Damage an enemy
Phasmida	Whole consumption	Love sign
Euschistus sulcacitus	Shredded	Illnesses of the heart and sorceries
Gryllus assimilis	In powder	Poisoning

Table 3. Value of ludic use of some entomological groups in Mexico.

Entomological group	Use	Part used	Way of use
Hymenoptera	Children's game	Indirect use	Children's song
Coleoptera	Children's game	Direct use	Capture and confinement
Eucheira socialis	Textile use	Capullo	Dresses for dolls
Lepidoptera	Festivity	Indirect use	Outfit
Schausiana trojesa	Children's game	Direct use	Collection and jokes
Formicidae	Children's fun	Direct use	Collection and classification
Musca domestica	Children's fun	Direct use	Observation and mutilation
Phasmida	Fun	Direct use	Indicates the location of the sun
Leptophobia aripa	Fun	Direct use	Capture and observation
Oniscidea	Children's toy	Direct use	Projectile
Oligochaeta			They collect and mutilate

Table 4. Value of aesthetic and decorative use of some insects in Mexico.

Entomological group	Use	Way of use
Coleoptera	Collection and light	Gifts in the form of a flashlight
Sceliphron sp.	Honeycomb preservation	Scenic beauty of housing
Eucheira socialis	Use of silk	Purse making
Alaus lusciosus	Artisanal use	Living necklaces and headdresses
Pyrophorus noctilucus	Ornamental use	Live brooches attached to a pin

Ecological importance of insects

The ecological importance of insects is in function of environmental services that they offer. These emerge from numerous interactions between animals, plants and the biophysical surroundings where they are found (Rojas Rodríguez *et al.*, 2019). Some of these benefits are the following:

Pollination: Insects carry out an important role in the reproduction of various flower species, developing very specific adaptive vectors that allow the plant-pollinator coexistence (Ku-Ruiz and Sosenski, 2021). Presently, around 100,000 species of pollinators are recognized, of which 98% correspond to the Insecta class (Stefanescu *et al.*, 2018). A value higher than 90% of 250,000 species of angiosperms require pollinating organisms for their production, including 75% of the one hundred species of agricultural cultivation that make up most of the cereals, foods recognized globally.

Biodegradation: The degradation of organic wastes is regulated by the role that it plays in the entomological community (Figueredo-Matheus and Albarracín-Balaguera, 2021). In such a process, organisms such as ants, flies, termites, beetles, among others, degrade the plant matter forming small fractions that allow the final decomposition by soil microorganisms (Smetana *et al.*, 2019). Likewise, close to 4,000 species of dung beetles contribute to the disintegration of manure from different vertebrates, avoiding the loss

of approximately 80% of atmospheric nitrogen which contributes to global warming and controlling the emission of bad odors (Chowdhury *et al.*, 2017). On the other hand, because of the COVID-19 sanitary crisis, a massive amount of waste has been generated (products based on polyethylene and polystyrene) that are economically unviable for their recycling, the same as various plastic wastes that affect the environment; a strategy of sustainable innovation that attempts to reduce this impact includes actions where insects (particularly moths and beetles) contribute to the degradation of such material based on the microbiological action of their digestive tract, mitigating the ecological impact on the planet (Rodríguez-Carreón *et al.*, 2021).

Biological pest control: Pest control in agricultural production is fundamental to obtain quality yields and to offer a better price for the sale of products; however, in most of the cases, this activity is carried out through chemical products that deteriorate the environment and alter the microbiological activity of the soil. Recently, a trend for the biological control of insects has been generated as an alternative for sustainable production, enlisting various parasite and predator organisms that keep the impact of harmful insects stable. Among some of these orders of predator insects of pests, there are the following: Neuroptera (crisopas, ants), Odonata (dragon flies), Coleoptera (beetles), Hemiptera (bedbugs), Diptera (flies), and Himenoptera (ants, bees and wasps), exceeding by far the number of beneficial insects in comparison to the number of harmful species (Chowdhury *et al.*, 2017).

Commercialization of insects in Mexico

From the 549 species of edible insects recorded in Mexico (Ramos-Elorduy *et al.*, 2008), only 95 (18.84% of the total species) are traded in different life stages (eggs, larvae, pupae and adults). This commerce is carried out in higher proportion during the rainy season, taking into account the phenology and seasonality of the organisms (polyvoltine and univoltine). However, several species are preserved (dry, in brine or frozen) and are sold according to the demand in different seasons of the year (Ramos-Elorduy *et al.*, 2006). For the sale of such a resource, insects acquire various presentations: dry, frozen, roasted, fried, boiled, wrapped, alive, by liter, by weight, by measure, by taco, in gorditas, quesadillas, ice-creams, turnovers, pizzas, soups, mole, tamales, sandwiches, among others (Pino-Moreno *et al.*, 2017). For their part, prices vary according to the directed market, showing exorbitant prices in international trade in cities like Tokyo, Paris, New York, Los Angeles, among others (Fleta-Zaragozano, 2018). However, the prices in Mexico vary in function of the form of sale (by insect, kilogram or dish), seller (harvester or intermediary), and the product's presentation, acquiring prices from $ 0.50 per insect to $ 3,040 per kg (Table 5).

Perspectives of consumption of insects in Mexico

Despite the benefits offered by the consumption of insects, there are still psychological (neophobia-fear-disgust), cultural and religious factors, which limit the acceptance of these products as an entomophagy practice (Toti *et al.*, 2020); this is particularly in young people and inhabitants of rural zones where young people avoid their consumption (Orkusz *et al.*, 2020). On the other hand, the external market integrated by tourism and visitors

Table 5. Average price for the sale of some edible insects in Mexico.

Entomological group	Average Price (MXN)		
	Collector	Intermediary	Saucer
Acentrocneme hesperiaris	$ 190 kg	$ 3 149 kg	$ 210
Liometopum apiculatum Mayr	$ 550 kg	$ 3 040 kg	$ 611
Myrmecocystus mexicanus	$ 1 an insect		
Hypopta agavis	$ 75 kg	$ 475 kg	$ 240
Helix aspersa	$ 14 kg		
Sphenarium sp.	$ 150 kg; $ 5 an insect	$ 1 204 kg	
Thasus gigas	$ 400 kg; $ 0,50 an insect	$15 a bag	
Atta mexicana S	$ 270 kg	$ 800 kg	$ 35 a glass of sauce
Atta cephalotes L.			
Arsenura armida armida Cramer	$ 46 kg		
Phasus triangularis H.E.	$ 3 an insect		
Aeschna sp. o *Anax* sp.	$ 150 kg		$ 25 (50 g)
Euleucophaeus tolucensis	$ 350 kg		$ 10 (30 g)

Source: Pino-Moreno *et al.* (2017); Pino-Moreno *et al.* (2020).

from different countries have given a high price to the consumption of this resource, attributing them nutritional, medicinal and aphrodisiac properties, and as an alternative for sustainable diversification with environmental advantages, exhibiting added value and increasing economic profit for sellers (Van Huis and Oonincx, 2017). In addition to this, the value of an emotional aspect has been derived, based on recreational actions such as adventure, wildness and the audacity to consume these products, generating new challenges and opportunities in the sale for local commerce (Tuccillo *et al.*, 2020).

CONCLUSIONS

Sociocultural, economic and environmental aspects of insects in Mexico were analyzed. This resource represents good horizons on the path to food security, caring for the environment, and as an alternative for productive diversification. The economic importance that insect trade represents in Mexico stands out, showing opportunities for small-scale producers of marginalized zones and tourist areas in Mexico. This study suggests awareness-raising practices to mitigate neophobia as a limitation in the adoption and consumption of this product by certain social strata in Mexico.

REFERENCES

Anankware, P. J., Fening, K. O., Osekre, E. A., & Obeng-Ofori, D. (2015). Insects as food and feed: A review. *International Journal of Agricultural Research and Review, 3*(1), 143-151.

Barton, A., Richardson, C. D., & McSweeney, M. B. (2020). Consumer attitudes toward entomophagy before and after evaluating cricket (Acheta domesticus) -based protein powders. *Journal of Food Science, 85*(3), 781-788. https://doi.org/10.1111/1750-3841.15043

Batat, W., & Peter, P. (2020). The healthy and sustainable bugs appetite: factors affecting entomophagy acceptance and adoption in Western food cultures. *Journal of Consumer Marketing, 37*(3), 291-303. https://doi.org/10.1108/JCM-10-2018-2906

Carmona-López, J. L., Escamilla-Rosales, M. F., & Ariza-Ortega, J. A. (2021). Evaluación de macronutrimentos y microelementos en avispa (orden Hymenoptera). *Educación y Salud, 10*(19), 232-238. https://doi.org/10.29057/icsa.v10i19.6943

Chowdhury, G. R., Datta, U., Zaman, S., & Mitra, A. (2017). Ecosystem services of insects. *Biomedical Journal of Scientific & Technical Research, 17*(1), 1-3. https://doi.org/10.26717/BJSTR.2017.01.000228

Costa-Neto, E. M (2015). Anthropo-entomophagy in Latin America: an overview of the importance of edible insects to local communities. *Journal of Insects as Food and Feed, 1*(1), 17-23. https://doi.org/10.3920/JIFF2014.0015

Feng, Y., Chen, X. M., Zhao, M., He, Z., Sun, L., Wang, C. Y., & Ding, W. F. (2018). Endible insects in China: Utilization and prospects. *Insect Science, 25*(2), 184-198. https://doi.org/10.1111/1744-7917.12449

Figueredo-Matheus, J. A., & Albarracín-Balaguera, M. A. (2021). Alternativas de alimentación de monogástricos a base de larvas de Soldado Negro (*Hermetia illucens*): Revisión de literatura. *Revista Colombiana de Zootecnia, 7*(12), 35-48.

Fleta-Zaragozano, J. (2018). Entomofagia: ¿Una alternativa a nuestra dieta tradicional? *Sanidad Militar, 74*(1), 41-46. http://dx.doi.org/10.4321/s1887-85712018000100008

Iseppi, L., Rizzo, M., Gori, E., Nassivera, F., Bassi, I., & Scuderi, A. (2021). Rasch model for assessing propensity to entomophagy. *Sustainability, 13*(1), 4346. https://doi.org/10.3390/su13084346

Ku-Ruiz, C., & Sosenski, P. (2021). El calor de las flores: plantas termogénicas y sus polinizadores. *Cuadernos de Biodiversidad, 61*(1), 22-27. https://doi.org/10.14198/ cdbio.2021.61.03

López-de la Cruz, E., Gómez-y Gómez, B., Sánchez-Cortés, M. S., Junghans, C., & Martínez-Jímenez, L. V. (2015). Insectos útiles entre los tsotsiles del municipio de San Andrés Larráinzar, Chiapas, México. *Etnobiología, 13*(2), 72-84.

Orkusz, A., Wolańska, W., Harasym, J., Piwowar, A., & Kapelko, M. (2020). Consumers' attitudes facing entomophagy: Polish case perspectives. *International Journal of Environmental Research and Public Health, 17*(7), 2427. https://doi.org/10.3390/ijerph17072427

Pino-Moreno, J. M., Guerrero-Mayorga, I., Flores-Ramírez, M. E, & Galán-Ángeles, Y. (2017). Presencia de los insectos comestibles en la muestra gastronómica de Santiago de Anaya Hidalgo, México. *Entomología Mexicana, 4*(1), 663-668.

Pino-Moreno, J. M., Rodríguez-Ortega, A., & García-Flores, A. (2020). Los insectos comestibles de Tepantepec, Hidalgo, México: Situación actual problema y perspectivas. *Entomología Mexicana, 7*(1), 457-463.

Puzari, M. (2021). Prospects of entomophagy. *International Journal of Tropical Insect Science, 41*(1), 1989-1992. https://doi.org/10.1007/s42690-020-00317-2

Raheem, D., Raposo, A., Bolanle, O. O., Nieuwland, M., Saraiva, A., & Carrascosa, C. (2019). Entomophagy: Nutritional, ecological, safety and legislation aspects. *Food Research International, 126*(1), 108672. https://doi.org/10.1016/j.foodres.2019.108672

Ramírez-Sánchez, E. U., Contreras-Molotla, F., Contreras-Suárez, E., & Roldan-Amaro, J. A. (2021). Panorama de la alimentación en los hogares de México. Una aproximación al estudio del hambre. *Interdisciplina, 9*(25), 93-113. http://dx.doi.org/10.22201/ceiich.24485705e.2021.25.79968

Ramos-Elorduy, J., Pino-Moreno, J. M., & Conconi, M. (2006). Ausencia de una reglamentación y normalización de la explotación y comercialización de insectos comestibles en México. *Folia Entomológica Mexicana, 45*(3), 291-318.

Ramos-Elorduy, J. (2009). Anthropo-entomophagy: Cultures, evolution and sustainability. *Entomological Research, 39*(1), 271-288. https://doi.org/10.1111/j.1748-5967.2009.00238.x

Ramos-Elorduy, J., & Viejo-Montesinos, J. L. (2007). Los insectos como alimento humano: Breve ensayo sobre la entomofagia, con especial referencia a México. *Boletín de la Real Sociedad Española de Historia, 102*(1-4), 61-84.

Ramos-Elorduy, J., Landero-Torres, I., Murguía-González, J., & Pino Moreno, J. M. (2008). Biodiversidad antropoentomofágica de la región de Zongolica, Veracruz, México. *Revista de Biología Tropical, 56*(1), 303-316.

Ramos-Elorduy, J., Pino-Moreno, J. M., Escamilla-Prado, E., Alvarado-Pérez, M., Lagunéz-Otero, J., Ladrón-de Guevara, O. (1997). Nutritional Value of Edible Insects from the State of Oaxaca, Mexico. *Journal of Food Composition and Analysis, 10*(1), 142-157. https://doi.org/10.1006/jfca.1997.0530

Rodríguez-Carreón, A., Ortiz-Rivera, Y., Hernández-Peña, C. C., & Figueroa, C. (2021). Biodegradación de espumas plásticas por larvas de insectos: ¿una estrategia sustentable? *Revista Especializada en Ciencias Químico-Biológicas, 24*(1), 1-10. https://doi.org/10.22201/fesz.23958723e.2021.311

Rojas-Rodríguez, J., Rossetti, M. R., & Videla, M. (2019). Importancia de las flores en bordes de vegetación espontánea para la comunidad de insectos en huertas agroecológicas de Córdoba, Argentina. *Revista de la Facultad de Ciencias Agrarias UNCUYO, 51*(1), 249-259.

Saara-Maria, K., Ida-Nilstad, P., & Casper, B. (2019). Consumer acceptance of edible insects and design interventions as adoption strategy. *The International Journal of Food Design, 4*(1), 39-62. http://hdl.handle.net/11250/2620135

Smetana, S., Schmitt, E., & Mathys, A. (2019). Sustainable use of *Hermetia illucens* insect biomass for feed and food: Attributional and consequential life cycle assessment. *Resources, Conservation and Recycling, 144*(1), 285-96. https://doi.org/10.1016/j.resconrec.2019.01.042

Stefanescu, C., Asís, J. D., Baños-Picón, L., Cerdà, X., Marcos-García, M. A., Micó, E., Ricarte, A., & Tormos, J. (2018). Diversidad de insectos polinizadores en la península ibérica. *Ecosistemas, 27*(2), 9-22. https://doi.org/10.7818/ECOS.1391

Toti, E., Massaro, L., Kais, A., Aiello, P., Palmery, M., & Peluso, I. (2020). Entomophagy: A narrative review on nutritional value, safety, cultural acceptance and a focus on the role of food neophobia in Italy. *European Journal of Investigation in Health, Psychology and Education, 10*(2), 628-643. https://doi.org/10.3390/ejihpe10020046

Tuccillo, F., Marino, M. G., & Torri, L. (2020). Italian consumers' attitudes towards entomophagy: Influence of human factors and properties of insects and insect-based food. *Food Research International, 137*, 109619. https://doi.org/10.1016/j.foodres.2020.109619

van Huis, A., & Oonincx, D. G. A. B. (2017). The environmental sustainability of insects as food and feed. A review. *Agronomy for Sustainable Development, 37*, 43. https://doi.org/10.1186/s40066-015-0041-5