

Gryllus Assimilis: an Environmental Alternative in the Minimization of Organic Solid Waste

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The increase in the generation of organic waste and its mismanagement have a negative impact on the natural environment with the propagation of greenhouse gases, bad odors, leachate and other pollutants, so its use would bring a solution to the problems mentioned together with the generation of work, improvement of agricultural activity, the food industry, etc. The objective of the research was to minimize domestic organic waste using the species *Gryllus assimilis*. To do this, organic waste classified into three types (fruit-vegetables, food and the mixture of fruit-vegetables-food waste) was used. Tests were made with 100 g of residues and 15 repetitions for each type. For the reduction of residues, 200 *Gryllus assimilis* were used for each treatment and repetition. The reduction results were: for the first treatment 183 g, in the second treatment 187 g and for the third treatment 182 g, which on average means up to 18.7% reduction. Based on the results, it is established that the higher the number of *Gryllus assimilis*, the percentage of minimization of organic waste increases. In this way, this methodology constitutes a contribution to knowledge, has economic advantages and is easy to replicate in areas where *Gryllus assimilis* exists, with the possibility of scaling to achieve sustainable management of domestic organic waste.

1. Introduction

The annual generation of urban solid waste (USW) in the world is estimated to be 1.3 billion metric tons and it is projected that this amount will increase around 2.2 billion tons by 2025, since; USW generation is influenced by economic conditions, living standards, urbanization and population (Kawai and Tasaki, 2016), which leads to a dramatic increase in the population in urban areas and, as a consequence, a dramatic increase in the amount of USW generated. According to the Ministry of the Environment (MINAM, 2019) In Peru, its more than 32 million inhabitants produce more than 21 thousand tons of solid waste daily, which would mean that the per capita generation of solid waste (PCG-SW) on average is 800 grams of solid waste per day, of which 22.94 % represents inorganic waste and 54.96 % organic waste (OEFA, 2018).

Of the total solid waste generated, only a small percentage is destined for sanitary landfills, which according to MINAM (2019) are a total of 52, distributed in 19 of the 25 regions of the country, and the other percentage is disposed of in informal dumps that According to the report No. 181 of the Ombudsman's Office (2019), in Peru there are 1,585 informal dumps, which degrade approximately 2,000 hectares of soil. Implementing a management based on the life cycle of the products would be an alternative for good waste management (Vázquez et al., 2019). Thus, a large part of the population of Perú has normalized the disposal of their waste in open places such as rivers, streams, among others, commonly called "dumps", whose indiscriminate use has come to cause consequences, many times irreversible, to the environment such as the generation of leachates that are the product of decomposition processes, gravity and climatic conditions, as well as the substantial generation of polluting gases such as methane, 21 times more polluting than carbon dioxide (CO₂) as a gas greenhouse effect (GHG), the consequence is the acceleration of climate change and in turn represents a threat to public health and ecosystems; in addition to water pollution that together with waste leads to global warming) (Kaza et al., 2018).

Secondly, the waste generated by the rural populations of Peru maintains a heterogeneous composition (Codina, 2018); since they are the product of different commercial activities such as livestock, agriculture, among others, since they depend on these for their subsistence, therefore, the destination of said residues is still debated. In some cases, certain lignocellulosic biomass residues are segregated to be used as fertilizer in agriculture (Loyola et al., 2022) and in other cases to obtain energy by transforming them into pellets (Barroso et al., 2022). This problem is common to all regions of the country since the economic activity to which most of its provinces and districts are dedicated, are purely agricultural, (Chamaya, 2019); Added to this is the constant demographic growth and changes in habits, which promote a greater generation of solid waste, which clearly harms the environment by not being adequately treated (Torres, et al., 2021). Morales, (2010) mentions that insects are associated with the solid waste composting process, thus saprophagous macroinvertebrates such as earthworms, termites and numerous dipteran larvae participate in the generation and transformation of the physical and chemical properties of organic matter during the degradation and stabilization processes that take place during composting. In terms of a number of specimens, it indicates that Diptera was the most important group, particularly the Syrphidae *Ornidia obesa*, as a highly positively invasive species, and the Stratiomyidae *Hermetia illucens*, both reported as beneficial in the decomposition of organic matter.

In the District of Lamay, one of the 8 that make up the province of Calca in the Cuzco region, where the most outstanding economic activities are agriculture and tourism, especially the last mentioned, which generate a large amount of organic solid waste, The generation of 397.75 t/year of municipal solid waste was reported for the year 2020, of which 22.95 % were food remains (SIGERSOL, 2020). In these circumstances, the search for new methods is required in order to improve the management of said organic waste and thus minimize its impact in the study area; therefore, the objective of the research was to evaluate the minimization of organic waste using the *Gryllus assimilis* commonly called crickets, in the district of Lamay, Calca, Cusco.

2. Methodology

The investigation had the following stages:

2.1 Collection and conditioning of the *Gryllus assimilis*

They were collected inside the cultivation lands near the banks of the Vilcanota river. For the conditioning of the habitat, three rectangular plastic boxes of 0.035 m³ were elaborated and prepared. To cover the boxes, frames were made with a very fine mesh and wood remains that fulfilled the function of ventilating the container and favoring oxygenation, it was maintained at a temperature of around 21 °C and 56 % humidity. The box was made up of a very thin layer of earth, pressed cardboard bases, a container to place organic waste and a water fountain (the materials used were mostly reused). In these compartments, 200 *Gryllus assimilis* were placed in each container. See Figure 1.



Figure 1: Container box *Gryllus assimilis*

2.2 Collection of organic waste

Organic waste was collected from the houses of the town of Lamay in a period of 15 days. The amount collected and selected was 4500 g of organic waste.

2.3 Evaluation of the affinity of *Gryllus assimilis* for organic residues

At this stage, the affinity of *Gryllus assimilis* for certain types of organic residues was preliminarily tested. For this, they were fed with different organic residues in a time of 72 hours. Stage that was of great help for subsequent testing with the specific types of waste to improve the time and quantity of minimization. It was established that *Gryllus assimilis* sought organic residues of fruits and vegetables, food remains and a mixture of the above as preferential food, See Figure 2.



Figure 2: Types of organic waste

2.4 Waste minimization process

With the *Gryllus assimilis* and residues in the test boxes, the minimization of organic residues was monitored for 24 hours. 15 repetitions were made for each type of waste placed in the boxes; for the treatment of each type of waste, 200 crickets were used, a total of 600 crickets during the 3 treatments and repetition, the species that died were replaced by other *Gryllus assimilis*. The initial amount of waste used for each test was 100 g and at the end of each treatment the final weight consumed and the temperature and humidity parameters were controlled with the help of a thermohygrometer.

3. Result and Discussion

3.1 Type of organic waste that is minimized by *Gryllus assimilis*

The organic residues collected were segregated into the types and one sample of each type was fed to the *Gryllus assimilis*. Of these residues, the crickets opted for the softest, freshest and sweetest, including remains of fruits, vegetables and food remains, establishing that these residues were to their liking, see Table 1.

Scientific theory indicates that crickets are omnivorous, they eat everything, including plants, other insects and even textile material, which allows them to live between 4 to 6 months, and they reproduce in quantity when they have a humidity of approximately 80 % 90 %, with temperatures above 20 °C (Cruz and Arévalo, 2021).

Tabla 1: Consumption affinity of *Gryllus assimilis* by type of organic waste

Type of organic waste	Specific waste
Food waste	Rice, French fries, leftover noodles, chicken strips, meat.
Fruit and vegetable waste	Fruits: banana, citrus, pineapple, papaya, grape, mango Vegetables: pumpkin peels, tomato, carrot, potato, peas, lettuce

The growth of crickets associated with the different wastes was not considered in this research, however, Sierra et al. (2020), state that they found no differences in weight or mortality with the food treatments evaluated in crickets, only significant differences related to the variable feed conversion were presented, being the best nutritional treatment the diet that used balanced food enriched with yeast and fresh vegetables such as zucchini

3.2 Amount of minimization of organic waste of fruits and vegetables by the *Gryllus assimilis*

From the initial sample of 100 g of fruit and vegetable residues in each of the 15 repetitions, the 200 *Gryllus assimilis* were fed (consumed) the percentage shown in Table 2, the average percentage being 18 %. This type of waste is also one of the preferred ones for cockroaches, according to what was found in the research carried out by Calderón et al. (2021), where using solid organic waste containing carbohydrates, another group of waste containing proteins, a third group of fruit and vegetable residues and a fourth group with a random mixture of the aforementioned residues, found that fruit and vegetable residues were the most consumed.

Table 2: Amount and percentage of organic waste from fruits and vegetables minimized by the *Gryllus assimilis*

Repetition N°	T1: Fruit and vegetable		Reduction (%)
	Initial amount (g)	Final amount (g)	
1	100	83	17
2	100	88	12
3	100	87	13
4	100	82	18
5	100	82	18
6	100	82	18
7	100	81	19
8	100	80	20
9	100	79	21
10	100	79	21
11	100	81	19
12	100	82	18
13	100	78	22
14	100	81	19
15	100	80	20
Average			18

3.3 Amount of minimization of organic food waste by the *Gryllus assimilis*

Fed with 100 g of food residues in each of the 15 repetitions, the 200 *Gryllus assimilis* were fed (consumed) the amount indicated in Table 3. Resulting in an average percentage decrease of 19 %.

Table 3: Quantity and percentage of organic residues of fruits and vegetables minimized by *Gryllus assimilis*

Repetition N°	T2: Food waste		Reduction (%)
	Initial amount (g)	Final amount (g)	
1	100	85	15
2	100	84	16
3	100	83	17
4	100	79	21
5	100	83	17
6	100	83	17
7	100	82	18
8	100	81	19
9	100	78	22
10	100	84	16
11	100	83	17
12	100	80	20
13	100	77	23
14	100	79	21
15	100	79	21
Average			19

3.4 Amount of minimization of organic waste of fruits, vegetables and food by the *Gryllus assimilis*

For initial samples of 100 g of fruit, vegetable and food residues, in each of the 15 repetitions, the 200 *Gryllus assimilis* fed (consumed) the percentage shown in Table 4. There is an average percentage of 18 %.

Table 4: Minimization of organic waste according to type or treatment and number of repetitions

Repetition	T3: Organic waste mix		Reduction (%)
	N°	Initial amount (g)	
1	100	86	14
2	100	84	16
3	100	81	19
4	100	81	19
5	100	80	20
6	100	82	18
7	100	82	18
8	100	82	18
9	100	83	17
10	100	81	19
11	100	79	21
12	100	81	19
13	100	81	19
14	100	80	20
15	100	80	20
Average			18

For the three types of organic waste, in the total amount of 4,500.00 g of organic waste that was used in the experimental stage, 3,668.00 g were minimized (consumed) by the *Gryllus assimilis*, which corresponds to an average of 18.3% of the initial amount; food residues being slightly more preferred for consumption by this type of species. It was established that the conditions of the residues consumed by *Gryllus assimilis* must be in good condition, since they have a preference for those that are not decomposed, of a soft and fresh nature; this is a disadvantage compared to the use of *Periplaneta americana* (cockroach) in minimizing organic waste that has a preference for decomposed waste (Vilca, 2019), being attracted by the putrefied smell (Jesús, 2019), which also makes these species emit unpleasant odors, transmit gastrointestinal diseases, and carriers of viruses and bacteria (Pérez and Rodas, 2015). The temperature and humidity parameters are the most important in the rearing of crickets, the most favorable for their reproduction and growth are at temperatures higher than 20 °C to 35 °C (Erens et al. 2012, cited by Alarcón, 2021). , some researchers say that between 25 °C to 28 °C and a relative humidity between 50-60% are the conditions for the reproduction and occlusion stage of crickets (Booth and Kindell, 2007); something similar also happens with the species of *Periplaneta americana* that at a temperature of 25.7 °C and 69.9 % humidity consumed 6,705 kg per day of waste (Jesús, 2020), in another investigation the *Periplaneta* (1,000 million) consumed 50 tons of waste per day. residues at conditions of 20 to 29 °C and between 80 to 90 % humidity (Espinoza and Zambrano, 2020). Studies also indicate that *Gryllus assimilis* have a high nutritional value that makes them attractive for animal feed since it has been found that they have up to 65.52% protein, 21.80 % lipids, 8.6 % carbohydrates and 408% ashes; and the presence of palmitic, oleic and linoleic acids are the most present in these insects, which make them attractive for human consumption in the near future (Soares, et al., 2019).

4. Conclusion

It was established that *Gryllus assimilis* is an insect that can be used to minimize organic waste from food, vegetables and fruits, reaching up to the level of 18.7 %, after 15 days. This way of managing organic waste constitutes a sustainable alternative with economic advantages by reducing the cost of waste management for its disposal. After the process, the dead crickets can be used as balanced feed for animals due to their high protein content. Although it is true that the elimination rate is apparently not very high, however, when larger volumes of organic waste are subjected to degradation processes, the amount eliminated would be relevant. The method used is natural and leaves no residual effect; it does not involve the use of chemical oxidizing agents for the biodegradation of organic waste, which are a risk to the environment.

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