COMPARISON OF FIELD AND LAB APPLICATION OF *HERMETIA ILLUCENS* LARVAE

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ABSTRACT

From a perspective of a waste manager, advantageous features of *Hermetia illucens* (HI) (Linnaeus, 1758) is no preferences of animal or vegetable origin of consumed material. Neither is there a necessity to separate waste of vegetable origin for composting technology nor the waste of animal origin for processing of biogas as traditional ways are required. This report includes comparison of lab and field application in condition Czech Republic. In our experiments larvae Hermetia illucens consumed various decaying material. The best results were in lab application, where waste material was reduced by 64%. After consuming biodegradable communal waste the largest adults were 2.5 to 3.8 mm. HI in field application reached developmental stages of "pupae" and "adults", and their size was 1.8 to 2.8 mm. The average waste reduction in field application was 47% of the original weight. Lab application is preferable, because there are stable conditions, especially temperature and moisture, and there are any weather events. These waste materials (biodegradable communal waste: kitchen and garden) are suitable for consuming by larvae Hermetia illucens. It was also observed that in the setting of appropriate temperature the larvae are able to complete their life cycle when they are close to suitable places to lay eggs. The larvae that hatch from eggs may be used for another experiments and thereby reach a cyclical supply of larvae to consume other waste materials.

Key words: Hermetia illucens, waste management, strategy of municipal, biodegradable waste

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INTRODUCTION

From a perspective of a waste manager, advantageous features of *Hermetia illucens* (HI) (Linnaeus, 1758) is no preferences of animal or vegetable origin of consumed material. Neither is there a necessity to separate waste of vegetable origin for composting technology nor the waste of animal origin for processing of biogas as traditional ways are required. It is known that *Hermetia illucens* larvae are used for reducing weight of food waste (Zheng *et al*. 2012, Jeon *et al.* 2011) and for reducing weight of manure (Li *et al.* 2011, Yu *et al*. 2011). For very favourable results, the usage of HI for the treatment of organic waste is discussed not only in states, where the incidence of HI is natural (Diener *et al.* 2009) but also in states where the controlled breeding is needed (Holmes *et al.* 2012), as is in the case of Czech Republic. Thus, if we assume that the use of HI will be possible in Czech Republic, then we need to find out in which condition biodegradable waste could be effectively weight-reduced by larvae of *Hermetia illucens*, and this was the aim of this research.

MATERIALS AND METHODS

For experiments we used insect that is commonly recognized as a forensic indicator for determination post mortem interval: *Hermetia illucens* (Linnaeus, 1758). Biological classification is Insecta: Diptera: Stratiomyidae. Often this insect is called Black soldier fly. Larvae were bought from commercial breeding MD Terraristik Ammerweg (Germany) where they are offered as a feed for pets (reptile, amphibian, insect). This insect is not widespread but is common in warmer regions of the Czech Republic. Incidence of *Hermetia illucens* in Europe is shown from Second World War as majority non-original species of Diptera from North America (Roques 2010) thus Black soldier fly is not original species in the Czech Republic. Larvae were delivered in packages of 120 pieces in breeding substrate (millet), the size of the larvae at delivery was 0.5 mm in average (from 0.2 to 0.7 mm).

Experimental containers and spaces: BioPod Plus (Prota Culture™ LLC, USA) is especially designed according to typical behaviour of *Hermetia illucens* in order to consume waste. Larvae (grubs) consume waste in the body of BioPod Plus, consequently climb after migration ramp to the harvest bucket, when grubs want to become pupae. Pupae can be either a feeding or can emerge adults who in appropriate temperature conditions mates and they sit on the lid BioPod Plus where adults lay their eggs. New small larvae hatched from eggs crawl holes in the lid for the waste which closes a development cycle of HI. For measuring of temperature and humidity we used sensors type Minikin TH and TT (EMS Brno, Czech Republic). These sensors work permanently and they save values every ten minutes as we set. Average temperature was 27.2°C and average humidity 45.2% in lab application. In field application average temperature was 22.2°C and average humidity 62.3%.

Principle of methodology was to compare lab and field application HI larvae from perspective of possible involvement of HI for treatment. Ten kilograms of biodegradable waste (biodegradable communal waste: kitchen and garden) were added to each experimental pod and 360 pieces larvae (three commercially supplied boxes) of size 0.2 to 0.7 mms were added. The experiment was terminated on the day when the first adults began to hatch. First adults started to hatch after 35 days from beginning of experiment. In this moment experiments were stopped. Always at the end of the experiment consideration of waste residues was performed. Residues were taken from BioPod on the device for weighing. Grubs, pupae and adults were measured after finishing the experiment, from each pod or harvest bucket 30 specimen were taken and measured.

RESULTS AND DISCUSSION

During the 35 days of testing, larvae have reached different stages of development: pupae or adults. In lab application the larvae reached the stage of "adults" and their sizes were between 2.5 to 3.8 mm. The average reduction in lab application was 64%, unconsumed remnants were 36%. HI in field application reached developmental stages of "pupae" and "adults", and their size was 1.8 to 2.8 mm. The average waste reduction in field application was 47% of the original weight, unconsumed remnants were 53%.

Different reduction may be influenced by many factors. The most important factor was the temperature. Temperature and humidity are important conditions for living, growth and activities of insects generally. For insects *Hermetia illucens* ideal temperature range is between 27 and 37°C which guarantees 74-97% survival (Tomberlin *et al*. 2009). Larvae *Hermetia illucens* consume also waste in low temperature conditions but not very quickly because their behaviour is generally slower. The lowest temperature for satisfactory consuming waste was determined on value 21°C. Optimum value of moisture varies according to the different stages of the development cycle HI. Particularly after the larvae leave the stage larvae posfeeding their food source, they are exposed to ambient humidity which value significantly affects the pupation and emergence of adults (Holmes *et al.* 2012). A significant factor is amount and composition of bacteria in the digestive tract of the larvae HI (Jeon *et al*. 2011). It could be impact on growth and development of larvae HI after inoculating poultry manure with bacteria from HI larvae (Yu *et al.* 2011). The actual weight reduction may not be the only indicator of positivity using larvae HI processing biological waste. It was demonstrated an increase in ammonia (NH4+) concentration five-to sixfold relative to unprocessed leachate by larvae (Popa and Grenn 2012).

Pupae and consequently adults are suitable for making other generation of *Hermetia illucens*. There is a possibility to use pupae and adults as a feed for fish (Sealey *et al*. 2011), reptiles and other pets. Other potential area where insects *Hermetia illucens* could be used is a prevention of waste production. This option is interesting from the perspective of municipal waste management that is inherent problematic for further use of the material (composting, processing into biogas) as required by Directive 2008/98/EC of European parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, which provides landfill as a last level of hierarchy of waste management.

CONCLUSIONS

In our experiments larvae *Hermetia illucens* consumed various decaying material. The best results were in lab application, where waste material was reduced by 64%. After consuming biodegradable communal waste the largest adults were 2.5 to 3.8 mm. HI in field application reached developmental stages of "pupae" and "adults", and their size was 1.8 to 2.8 mm. The average waste reduction in field application was 47% of the original weight. Lab application is preferable, because there are stable conditions, especially temperature and moisture, and there are any weather events.

These waste materials (biodegradable communal waste: kitchen and garden) are suitable for consuming by larvae *Hermetia illucens*. It was also observed that in the setting of appropriate temperature the larvae are able to complete their life cycle when they are close to suitable places to lay eggs. The larvae that hatch from eggs may be used for another experiments and thereby reach a cyclical supply of larvae to consume other waste materials.

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