

## Scheduling work in the rearing unit using a different operational scenario

The rearing unit of the BSF biowaste processing unit presented in the second edition of the step-by-step guide requires an every day operation to ensure the BSF are nurtured at every stage of its life cycle resulting in a high survival rate and thereby high performance of the BSF rearing unit and BSFL conversion unit. However, it might not be possible to operate the BSF biowaste processing plant every day because not a lot of biowaste has to be treated, because the time an operator can invest is limited or simply because one does not wish to setup a large scale site.

This document was produced to offer managers and operators of BSF biowaste conversion systems additional options for handling their site with reduced workload. It goes without saying that the capacity of such a plant is correspondingly lower. This document should always be used in conjunction with the Black Soldier Fly Biowaste Processing – A Step-by-Step Guide book. All operations and activities are described in this book and this document only focusses on presenting the alternative schedules and the effect of these schedules on the operation described in the book.

Although the activities around BSFL the post-processing unit are related to the rearing and conversion units, the schedules for the post-processing do not need to be adapted when following an alternative schedule. Therefore, this manual does not refer to them.

Experience with operating a BSF biowaste processing plant in Indonesia under the FORWARD project resulted in the development of three scenarios for the operation of the plant. These scenarios were developed as a result of a decrease or increase in the amount of biowaste that was delivered to the site over the years it was operated by the FORWARD project. The three scenarios which were developed by the FORWARD team are presented below (overview in table 1):

- **Every day schedule:** This schedule is described in detail in the Publication “Black Soldier Fly Biowaste Processing – A step-by-step guide”. The schedule relies on every day activity at the site and can be used for scales ranging from 14 tons to 35 tons of incoming biowaste average per week. This schedule results in a stable running rearing and conversion unit and therefore we suggest a recuperation rate in the rearing unit of 1-5% (recuperation rate = the percentage of larvae that are diverted from the total production to be used in the nursery).

- **Every other day schedule:** This schedule can be found in Annex A1. The schedule relies on alternating day activity at the site and can be used for scales ranging from 7 tons to 14 tons of incoming biowaste average per week. Using this schedule, small fluctuations in the production can occur. The operators have to ensure a recuperation rate of BSF in the rearing unit of at least 10% to allow for sufficient BSF being produced.

- **Monday-Wednesday-Friday schedule:** This schedule can be found in Annex A2. The schedule relies on activity at the site only on Monday, Wednesday and Friday and can be used for up to 7 tons of incoming biowaste per week. Using this schedule, larger fluctuations in the production can occur. The operators have to ensure a recuperation rate of BSF in the rearing unit of at least 20% to allow for sufficient BSF being produced.

Table 1: Overview of the three operational scenarios developed by FORWARD

Work schedule		Waste capacity	Output of young larvae	Workers required	Area	Daily 5-DOL output fluctuation
-	Every day	35 tons/week	±50 million/week	23	900 m <sup>2</sup>	stable
1	Every other day	14 tons/week	±20 million/week	12	400 m <sup>2</sup>	small fluctuation
2	Mon-Wed-Fri	7 tons/week	±8 million/week	9	250 m <sup>2</sup>	large fluctuation

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Apart from the effect a low-maintenance work schedule has on the fluctuation in the production of young larvae, omitting some days each week from the work schedule also changes the operation of the BSF rearing and BSFL conversion process itself. The main changes are outlined below:



The **evolving process** where larvae transform into pre-pupae is accommodated in the nursery larveros. The system used allows for the pre-pupae to self-harvest by crawling out of the feeding substrate in the nursery larveros and dropping into the outer box from where the pre-pupae can be harvested. Although it would be best to harvest pre-pupae every day, to ensure the pre-pupae which are placed in the pupation crates are all of the same age, leaving the pre-pupae in the outer boxes for a few days when following an alternative schedule does not disturb the operation too much.



The **pupation process** is where the pre-pupae transform into pupae. This process happens inside the pupation crates. Because there is no handling required in moving the BSF to another container as it transforms from a prepupa into a pupa, the activities in the adjusted work schedules are not affected by the reduction in the number of days the operators work.



In the **emerging process** the fly or adult has developed completely and crawls out of its pupa. As with the pupation process, the process of emerging happens inside the pupation crates which have been placed in a dark cage. Following the every day schedule, each dark cage producing flies is harvested daily. Although this is not possible in the two alternative schedules, it is still possible to manage the operation similar to the every day schedule.



The **mating and oviposition processes** happen in the love cage wherein the flies, harvested from the dark cages are accommodated. The flies mate directly after being harvested from the dark cages and will normally lay eggs about 1-2 days after having mated. Neonates typically hatch from their eggs about 3-4 days after eggs are deposited and thus, it is important to remove the egg laid by the flies before day 3 after they were deposited. This is why, in the every day schedule, the love cage is dismantled after 4 days. Because the every other day schedule uses alternating days for its operation, this process can happen without any changes in the activities. The Mon-Wed-Fri schedule however has an irregular division of work throughout a week and thus cannot ensure the love cages are harvested in time. Therefore, the egg media are instead switched in the love cages and cages remain in place for 7 days instead of 4 days. This way the eggs are removed in time and a love cage is removed on the same weekday seven days after it has been

set up. Because the egg media has to be switched during the time the love cage is standing, an additional operational step (Step 7) was added to the work schedule (annex A2) as well as an additional management schedule (Annex C). The management schedule describes when egg media has to be switched in which love cages. The operation is identical to removing the egg media when dismantling the love cage and adding new egg media when setting up a new love cage. Processing the eggs is also identical to the operation described in the guide book.



The hatching process happens in the tea strainers which hang above the nursery crates where neonates emerge from their egg and fall into the feed substrate which is prepared in the nursery crates. Typically, the hatchlings feed on the substrate for 5 days and are therefore named 5-day-old-larvae (5-DOL). However, using an alternating schedule (every other day) or an irregular schedule (Mon-Wed-Fri), it is not possible to harvest the larvae in time to ensure they are 5-day-old. For the every other day schedule, the larvae will be harvested 6 days after they hatched and for the Mon-Wed-Fri schedule the larvae are harvested after 7 days.



The **grow out process** of the larvae, both for the larvae who remain in the nursery as well as the larvae who will process the biowaste, is affected by the age of the larvae that will be added to the containers. For this, the operation in the work schedules for the BSFL conversion (annex D1 and D2) were adjusted. The main alteration relates to the duration of the process and the use of the incubator units. The incubator units can remain in place when using the every other day schedules for the rearing and conversion operations as larvae will be 6 days old when moved in the incubator units and can therefore stay for 2 days instead of 3 days. The pallets will then stay for 8 days to ensure they are harvested on a day where operators work. For the Mon-Wed-Fri schedule, the treatment unit is operated without incubator units and larvae are directly added to the larvero units. This is done because the larvae are already 7 days old at the stage where they are placed into the Larvero units. The pallet will stay for 14 days instead of 12 days to ensure the larvae can be harvested on the same time for each pallet.

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The different work schedules can be found in the annexes. Each work schedule has a version for the every other day schedule (indicated with a "1") and one for the Mon-Wed-Fri schedule (indicated with a "2"). The original schedules for the every day scenario can be found in the original guide book. The explanation on how to prepare, update and read the schedules can be found in the guide book as well.

**Annex A:** The work schedule for the rearing unit (Annex A1 & A2) contains simplified versions of the steps described in detail in the guide book. A short explanation is provided for each task and the columns to the right are white when the task have to be done on that day and black on days that can be skipped. Each work schedule covers four weeks for the every other day schedule and 9 weeks for the Mon-Wed-Fri schedule and has to be renewed by the facility manager after this period.

**Annex B:** This schedule shows the feeding regime of the nursery containers (Annex C1 & C2). The feeding schedule for the nursery container tells the operator which feed mixture has to be applied to which nursery container.

The left white column indicates the current date. The second column indicates the date code for the nursery larveros that will be set-up on that day. The other cells along the row indicate the ID of the nursery larveros to be fed today. The colour indicates the amount and type of feed they receive. The feed differs in terms of the amount of water added to the chicken feed (CF) and ranges from 70 - 100% water.

The table presented in the annex is meant to serve as a template for an Excel-sheet; an operator can easily update a schedule in Excel according to formulas.

**Annex C:** The egg harvesting schedule (Annex C2) is to keep track of the egg harvesting. The first column indicates the current date. The second column (Set-up) indicates the date when a new love cage is set-up. The code in the same row shows the code of the love cages from which eggies have to be switched on the current day. The love cage representing the code in the last column will be dismantled after its eggies have been harvested. The table presented here is meant to serve as a template for an Excel-sheet; an operator can easily update a schedule in Excel according to formulas.

**Annex D:** The work schedule for the conversion unit (Annex D1 & D2) contains a simplified version of the steps described in detail in the guide book. A short explanation is provided for each task and the columns to the right are white when the task have to be done on that day and black on days that can be skipped. Each work schedule covers four weeks for the every other day schedule and 9 weeks for the Mon-Wed-Fri schedule and has to be renewed by the facility manager after this period.