

PUPAE SEPARATOR

Field of the Invention

This invention relates to a pupae separator. More particularly, this invention
5 relates to one or more methods for making, assembling, disassembling, installing, configuring maintaining, repairing and using the one or more pupae separators.

Prior Art

Only female mosquitoes require blood meals and bite animals. Stimuli that
10 influence biting or blood feeding of female mosquitos include a combination of carbon dioxide, temperature, moisture, smell, colour and movement of the animals. Male mosquitoes do not bite animals, but feed on nectar of flowers or other suitable sugar source. Acquiring a blood meal as a source of protein is essential for egg production of a female mosquito, although male and female mosquitoes are both nectar feeders for their
15 nutrition. In some species of mosquitos, female mosquitos feed on humans and are therefore vectors for a number of infectious diseases affecting millions of people every year. Past attempts are made to eradicate female mosquito population through genetic modification or using chemicals that harm the environment as well as human beings alike. Therefore, it is desirable to provide more effective and environmentally friendly means to
20 reduce the mosquito population in order to prevent the infectious diseases.

Therefore, those skilled in the art are striving to provide an improved apparatus and method that identifying and sorting of mosquitoes according to gender.

Summary of the Invention

25 The above and other problems are solved and an advance in the art is made by an apparatus in accordance with this disclosure. An advantage of an apparatus in accordance with this disclosure is that the gender of the pupae can be identified and isolated before emerging to adult. Further advantages will be apparent from the description below.

30 The present application aims to provide one or more new and useful pupae separators. The present application further aims to provide one or more new and useful methods of making, assembling, disassembling, installing, configuring, maintaining, repairing and using the one or more pupae separators. Essential features of the

application are provided by one or more independent claims, whilst advantageous features are presented by their dependent claims respectively.

A first aspect of the disclosure describes an apparatus for segregating desired and undesired pupae. The apparatus comprises a separation container for containing the pupae; an image capturing device arranged to capture an image of the pupae in the separation container; a desired container to receive the desired pupae; and a processing unit having a processor, memory and instructions stored on the memory and executable by the processor to: receive the image from the image capturing device, determine a type of pupae from the image, the type of pupae being associated to the desired pupae, and transfer the desired pupae to the desired container.

In accordance with an embodiment of the first aspect of the disclosure, the instruction to determine the type of pupae from the image comprises instructions to: determine a size distribution of the pupae in the image; and selecting a suitable size based on the size distribution, the suitable size being between highest numbers of pupae of two different sizes. Preferably, the suitable size is closer to the highest numbers of pupae with a smaller size among the two different sizes.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises a sieve container including a sieve having plurality of sections, each section having openings with a size that is different from the other sections, and a divider wall movable within the sieve container to direct a flow of the pupae within the sieve container to one of the section.

In accordance with an embodiment of the first aspect of the disclosure, the sieve container further comprises a mechanism to move the divider wall.

In accordance with an embodiment of the first aspect of the disclosure, the instruction to transfer the desired pupae to the desired container comprises instructions to: select one of the sections of the sieve based on the suitable size.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises a plurality of sieve containers, each sieve container having a sieve with openings of a specific size and arranged to receive the pupae from the separation container.

In accordance with an embodiment of the first aspect of the disclosure, the instruction to transfer the desired pupae to the desired container comprises instructions to: select one of the plurality of sieve container based on the suitable size.

In accordance with an embodiment of the first aspect of the disclosure, the plurality of sieve containers are arranged on a rotatable table.

In accordance with an embodiment of the first aspect of the disclosure, the plurality of sieve containers are arranged on a conveyor belt.

5 In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises multiple conduits, each conduit having a valve and in fluid communication with respective sieve container.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises an undesired container; and a picker for transferring an
10 undetermined type of pupae to the undesired container.

In accordance with an embodiment of the first aspect of the disclosure, the picker comprises a plurality of pipette for extracting the undetermined type of pupae.

In accordance with an embodiment of the first aspect of the disclosure, the instructions further comprise instructions to: activate the picker to extract and move the
15 undetermined type of pupae the undesired container.

In accordance with an embodiment of the first aspect of the disclosure, the separation container comprises: a microplate having multiple cavities, each cavity is sized to contain at least one pupa.

In accordance with an embodiment of the first aspect of the disclosure, the
20 apparatus further comprises an undesired container to receive the undesired pupae.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises a rocker table supporting the separation container.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises a larvae-pupae container having an inlet to receive water
25 containing larvae and pupae and an outlet to release the pupae; a conduit to allow fluid communication between the larvae-pupae container and the separation container; and a plurality of lights mounted on a top interior surface of the larvae-pupae container.

In accordance with an embodiment of the first aspect of the disclosure, the instructions further comprise instructions to: separate the pupae and larvae in the larvae-
30 pupae container; and introduce water into the separation container.

In accordance with an embodiment of the first aspect of the disclosure, the instruction to separate the pupae and larvae in the larvae-pupae container comprises instructions to: switch on the plurality of lights mounted on the top interior surface of the larvae-pupae container.

In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises a counter arranged on the conduit for counting the number of pupae being transferred to the separation container.

5 In accordance with an embodiment of the first aspect of the disclosure, the apparatus further comprises an emerging container in fluid communication with the desired container for keeping the desired pupae; and a counter between the emerging container and the desired container.

10 A second aspect of the disclosure describes a method of segregating desired and undesired pupae. The method comprises introducing water with pupae into a separation container; activating a rocker table supporting the separation container dispersing the pupae; releasing water out of the separation container until the dispersed pupae are trapped in separate cavities of the separation container; capturing an image of the pupae; processing the image to determine a type of pupa; selecting a sieve with openings being bigger than the dimension of the determined type of pupa and smaller than the dimension
15 of an undetermined type of pupa; transferring the pupae from the separation container to the a sieve container having the selected sieve; separating the desired pupae from the undesired pupae; and transferring the desired pupae to a desired container.

20 In accordance with an embodiment of the second aspect of the disclosure, the step of processing the image to determine a type of pupa comprises: determining a size distribution of the pupae in the image; and selecting a suitable size based on the size distribution, the suitable size being between highest numbers of pupae of two different sizes.

25 In accordance with an embodiment of the second aspect of the disclosure, the step of separating the desired pupae from the undesired pupae comprises varying a water level in the selected sieve container at certain interval.

30 In accordance with an embodiment of the second aspect of the disclosure, the step of varying the water level in the selected sieve container at certain interval comprises: adding water from a top of the selected sieve container and subsequently from a bottom of the selected sieve container to modulate the water level within the selected sieve container up and down.

Brief Description of the Drawings

The above and other features and advantages in accordance with this invention are described in the following detailed description and are shown in the following drawings:

5 Figure 1 illustrating an apparatus for identifying and separating desired pupae from undesired pupae in accordance with an embodiment of this disclosure;

 Figure 2 illustrating another embodiment of the apparatus in accordance with an embodiment of this disclosure;

10 Figure 3 illustrating a larvae pupae separation unit in accordance with an embodiment of this disclosure;

 Figure 4 illustrating a counting unit in accordance with an embodiment of this disclosure;

 Figure 5 illustrating a pupae separation unit in accordance with an embodiment of this disclosure;

15 Figure 6 illustrating another embodiment of the pupae separation unit in accordance with an embodiment of this disclosure;

 Figures 7.1, 7.2 and 7.3 illustrating water levels in the separation container in accordance with an embodiment of this disclosure;

20 Figure 8 illustrating a top view of the microplate in the separation container in accordance with an embodiment of this disclosure;

 Figure 9 illustrating a picker with pipettes in accordance with an embodiment of this disclosure;

 Figure 10 illustrating a block diagram of circuitry provided to perform the processes in accordance with an embodiment of this disclosure;

25 Figure 11 illustrating an example of a processing system in the processing unit in accordance with an embodiment of this disclosure;

 Figure 12 illustrating a flow diagram of a process performed by the processor in processing unit for segregating desired and undesired pupae in accordance with an embodiment of this disclosure;

30 Figure 13 illustrating a flow diagram of a process performed by the processor in processing unit for selecting a sieve container in accordance with an embodiment of this disclosure;

Figure 14 illustrating a flow diagram of a process performed by the processor in processing unit for activating the picker in accordance with an embodiment of this disclosure;

Figure 15 illustrating the file distribution of the desired and undesired pupae in accordance with an embodiment of this disclosure; and

Figure 16 illustrating a sieve container having a sieve with different size of openings in accordance with an embodiment of this disclosure.

Detailed Description

This invention relates to a pupae separator. More particularly, this invention relates to one or more methods for making, assembling, disassembling, installing, configuring maintaining, repairing and using the one or more pupae separators.

It is envisioned that an apparatus in accordance with embodiments of this disclosure aims to accurately and efficiently separate desired pupae from undesired pupae. In particular, the apparatus in accordance with embodiments of this disclosure allows identification of desired pupae based on certain pupae signatures so that only the desired pupae are allowed to emerge as adult mosquitoes and subsequently released to the public. Details of the apparatus and the method of separating will be described as follows.

Figure 1 illustrates an apparatus 100 for identifying and separating desired pupae from undesired pupae. Figure 2 illustrates another embodiment of the apparatus 100. The apparatus 100 comprises a first part 110, a second part 120, a first container 130, a second container 135, a first counter 140, a second counter 150 and a processing unit 160.

The first part 110 acts as a larvae pupae separation unit. Water containing larvae and pupae are introduced to the first part 110 via inlet 111. The specific configuration of the first part 110 ensures that the larvae will settle at the bottom of the first part 110 while the pupae will float proximate the surface of the water level within the first part. Further details of the first part 110 will be described below with reference to figure 3.

The second part 120 serves to separate the male pupae from the female pupae. Water containing pupae is introduced into a container. An imaging capturing device 124 scans through the container and a distribution profile of the sizes of the pupae is obtained. Specifically, the processing unit 160 receives the images from the image capturing device 124 and executes an algorithm to identify a specific type of pupae. For purposes of this

disclosure, the specific type of pupae is male pupae. The male pupae are the desired pupae while the female pupae are the undesired pupae. The desired pupae are then moved to the first container 130 while the undesired pupae are moved to the second container 135.

5 In one embodiment as shown in figure 1, after a distribution profile of the sizes of the pupae is obtained, the water with pupae in the a separation container 121 are moved to a sieve container 170 with a suitable sieve 172 having a suitable size is selected from a series of available sieve containers in the apparatus 100 and moved into the sieve container 170. The openings of the sieve allow the smaller male pupae (i.e. desired pupae) to pass through while the larger female pupae (i.e. undesired pupae) remain
10 above the sieve 172. The desired pupae 190a are then transferred to the first container 130 while the undesired pupae 190b are transferred to the second container 135.

In another embodiment, the water with pupae in the separation container are moved to a sieve container which consist of a sieve with openings of different sizes.
15 Divider walls are provided to divide the sieve according to the size of the openings. A mechanism is provided that moves a divider wall or multiple divider walls within the sieve container to restrict the pupae from reaching the sieve openings with size larger than the desired pupae. The smaller male pupae pass through the openings.

In another embodiment as shown in figure 2, the second part 120 extracts the undesired pupae 190b by a picker 125 and released to the second container 135. The
20 remaining desired pupae 190a are then transferred to the first container 130 via outlet 126. Further details of the second part 120 will be described below with reference to figures 5 and 6.

The outlets of the first part 110 and the second part 120 are passed through the
25 first counter 140 and second counter 150 respectively. Further details of the first counter 140 and second counter 150 will be described below with reference to figure 4.

The first container 130 and second container 135 are containers for containing the desired and undesired pupae 190. The processing unit 160 controls the process flow of the apparatus 100. Further details of the processing unit 160 will be described below with
30 reference to figure 10.

Figure 3 illustrates the first part 110. Accordingly, the first part 110 comprises a larvae-pupae container 115 and a plurality of lights 116 mounted on a top interior surface of the larvae-pupae container 115. An inlet 111 is located at a side wall of the larvae-pupae container 115. Specifically, the inlet 111 is located proximately one third of the

length of the side wall of the larvae-pupae container 115 measured from the bottom of the larvae-pupae container 115. This ensures that when the water containing larvae and pupae enters the larvae-pupae container 115 via the inlet 111, the larvae 195 at the bottom of the larvae-pupae container 115 are not disturbed and are prevented from being moved to the top of the larvae-pupae container 115. In other words, when liquid containing larvae and pupae enters the inlet 111, the pupae 190 at the brim will flow out of the larvae-pupae container 115 via the outlet 112 while the larvae 195 remains at the bottom of the larvae-pupae container 115.

The inlet 111 has a valve that regulates the water flow rate into the larvae-pupae container 115. The valve may be operated manually or controlled by the processing unit 160. The outlet 112 is located at a side wall opposite the inlet 111. Although figure 3 shows the outlet 112 being positioned at the side wall opposite from the inlet 111, one skilled in the art will recognise that the inlet 111 can be located at any parts of the side wall without departing from the disclosure. Importantly, the outlet 112 is located proximate the top of the larvae-pupae container 115. Specifically, the outlet 112 is provided proximate the top of the larvae-pupae container 115 in order for the liquid containing pupae 190 to flow out of the larvae-pupae container 115. The distance between the top of the larvae-pupae container 115 to the outlet 112 is dependent on the size of the light 116 and the allowance between the light and the top surface of the water.

The lights 116 are electrically powered and controlled by the processing unit 160. The lights are light emitting diodes. The lights 116 are provided at the inner top surface of the larvae-pupae container 115. Larvae 195 react to changes in light intensity. Hence, activating the lights at the top will cause the larvae 195 to move downwardly and away from the top water surface.

The outlet 112 is fluidly connected to the inlet of the second part 120 via a conduit 145. The conduit is made up of clear transparent material, for example, glass. The cross sectional shape of the conduit is circular.

Some of the larvae may mature and moult to become pupae. The pupae will float on the surface of the water inside the larvae-pupae container 115.

Figure 4 illustrates the first counter 140 and the second counter 150. The first counter 140 is positioned between the first and second parts 110 and 120. The second counter 150 is position after the first container 130. The first and second counters count the number of pupae that pass through the conduit 145. Each of the first and second counters comprises an image capturing device 141 and a light 142. The image capturing

device 141 and light 142 are arranged such that the conduit 145 is between the image capturing device 141 and the light 142. The image capturing device 141 is an image sensor, for example a CMOS sensor providing fast speed with low power consumption. The image capturing device 141 captures the light from the light source and converts into electrical signals. In use, the light 142 will be switched on while the image capturing device 141 will continuously capture images of the conduit 145. The images will be transmitted to the processing unit 160 to determine the number of pupae that pass through the conduit based on the number of black blobs determined. For example, if a pupa passes through the conduit, the image captured by the image capturing device 141 will include a shadow of the pupa since the pupa will block the light from entering the image capturing device 141. One skilled in the art will recognise that the image capturing device 141 with light 142 configuration is only one method of counting the number of pupae and that other types of counters can be implemented without departing from the disclosure.

Figure 5 illustrates the second part 120 that separates the pupae in accordance with a determined type of pupae. For purposes of this disclosure, the second part 120 may also be referred as a pupae separator. The second part 120 comprises a separation container 121 having a microplate 122, a sieve container 170, an image capturing device 124, the first container 130, the second container 135 and the rocker table 127. Functionally, the second part 120 provides detection, identification, and separation of a determined type of pupae. For example, the determined type of pupae may be according to the gender of a pupa. Figure 6 illustrates another embodiment of the second part 120 where the sieve container 170 is replaced with a picker 123.

The separation container 121 has an opening at the top and one end of the conduit 145 is suspended above the microplate 122. Specifically, the conduit 145 is detachably attached for the first counter 140 such that one end of the conduit 145 is suspended above the microplate 122.

The bottom of the separation container 121 includes an outlet 124 for releasing water out of the separation container 121 and an inlet 125 for injecting water into the separation container 121. Each of the outlet 124 and inlet 125 has a valve that regulates the water flow out or into the separation container 121. The valve may be operated manually or controlled by the processing unit 160. Although figures 1-2 and 5-6 show that the outlet 124 and inlet 125 are provided separately, one skilled in the art will recognise the outlet and inlet may be combined as one without departing from the disclosure.

Another outlet 126 is located at a side wall of the separation container 121. The outlet 126 is located proximate the top of the separation container 121 in order for the liquid containing pupae 190 to flow out of the separation container 121 and into the sieve container 170. In the embodiment shown in figure 6, the liquid containing identified first
5 type pupae 190a flows out of the separation container 121 and into the first container 130.

The microplate 122 has a plurality of cavities. Each cavity is circular at the surface and extended downwards from the surface of the microplate like a cylinder. One cavity accommodates one pupa. Each cavity has a cavity water outlet and inlet that are fluidly connected to the outlet 124 and inlet 125 respectively. This means that if there are 81
10 cavities in the microplate, there will be 81 pairs of water conduits attaching to the outlet 124 and inlet 125. Figure 8 illustrates top view of the microplate 122 which is configured in 9 by 9 arrays having a total of 81 cavities. One skilled in the art will recognise that the use of the microplate 122 is to allow the pupae to be evenly spread out in the microplate 122 and hence, other number of cavities may be provided without departing from the
15 disclosure.

The separation container 121 is placed on a rocker table 127 to provide a revolving motion (clockwise or anti-clockwise) on a horizontal plane. The revolving motion ensures that pupae dispersed and get trapped in the separate cavities on the microplate 122. The image capturing device 124, the lights 128 are connected to the processing unit
20 160. The lights 128 are provided to illuminate the microplate 122 so that the image capturing device 124 can capture the image of the pupae. The image capturing device 124 and lights are positioned above the microplate 122. The lights 128 are between the image capturing device 124 and the microplate 122. The image capturing device 124 is positioned above the microplate with a wide area of coverage covering the entire
25 microplate 122. The image capturing device 124 is connected to the processing unit.

The sieve container 170 contains a sieve 172. When in use, the openings of the sieve 172 are sized to allow the desired pupae (i.e. smaller male pupae) to pass through while the undesired pupae (i.e. larger female pupae) remain above the sieve 172. A number of sieve containers 170 may be provided where each sieve container 170
30 includes a sieve 172 with openings of a certain size. The appropriate sieve container 170 can be moved into place through a mechanical mechanism such as a rotatable table or a conveyor belt. This way, a sieve container 170 is selected from a set of sieve containers 170 within the apparatus 100 that optimally separates the female from the male pupae. For example, the processing unit 160 may cause the mechanical mechanism to move the

selected sieve container 170 to a location to receive the pupae 190 from the separation container 121. The Pupae from separation container 121 are allowed to flow to the selected sieve container 170. The openings of the sieve 172 allow the smaller male pupae to pass through while the larger female pupae remain above the sieve 172.

5 Specifically, the selected sieve container 170 has a sieve with openings being bigger than the dimension of the desired pupae but smaller than the dimension of the undesired pupae.

Alternatively, the sieve containers 170 can be fixedly arranged. Multiple conduits 131 are provided, each having a valve. In this configuration, the appropriate valve
10 connecting the transfer of the pupae from separation container 121 to the appropriate sieve container 170 is activated to open instead.

In another embodiment, only one sieve container 170 is provided. Figure 16 illustrates a view from the top of the sieve container 170. The sieve container 170 includes a sieve 172 having openings of different sizes. As shown in figure 16, the sieve
15 172 has different sections 172a-172d, each section has openings of different sizes and arranged in a manner where the biggest size openings are at one side of the sieve container and the smallest size openings are at the other size of the sieve container. A divider wall 175 is movable within the sieve container 170 to direct the flow of the pupae within the sieve container 170 to the section where with openings of the sieve 172 are
20 larger than desired pupae size but smaller than the undesired pupae size. Although figure 16 only shows one divider wall, one skilled in the art will recognise that more than one divider wall may be implemented without departing from the disclosure. A mechanism is provided to move the divider wall to direct the flow of the pupae within the sieve container to the section where with openings of the sieve are larger than desired pupae size but
25 smaller than the undesired pupae size. The mechanism may be a conveyor belt system.

One skilled in the art will recognise that the sieve 172 with different sections 172a-172d as shown in figure 16 may in fact be separate sieves coupled together to form one single sieve.

In the embodiment shown in figure 6, the picker 123 is proximate the separation container 121 such that the arm of the picker is able to extend to the area of the microplate 122 and the second container 135. The first container 130 is positioned on the right side of the separation container 121 while the second container 135 is positioned on the left side of the separation container 121.
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The picker 123 may be an anthropomorphic robot holding one or more pipette to provide an automated means to extract a determined type of pupa from the microplate 122 to the second container 135. The movement of the anthropomorphic robot is controlled by the processing unit 160. The anthropomorphic robot moves in a horizontal plane and a vertical plane. The horizontal plane pertains to the movement between the cavities. The vertical movement pertains to the down and up movement, in and out of the cavities respectively. While figures 1 and 4 show only one pipette is coupled to the picker 123, one skilled in the art will recognise that the picker 123 can be easily modified to hold a plurality of pipette 129 as shown in figure 9. The pipette provides an extraction of the water and an identified type of pupa out from the cavity of the microplate 122. The pipettes 129 are connected to the processing unit 160 so that the desired pipette 129 can be activated to extract the water and an identified type of pupa out from the cavity of the microplate 122. While figure 9 illustrates 9 pipettes 129, the exact number of pipette 129 is left as a design choice for the person skilled in the art.

The process of distributing the pupae to the relevant first and second containers can be described in the following manner.

1. Water is introduced into the separation container 121 up to the water level 510 as shown in figure 7.1.
2. Water with pupae is then introduced into the separation container 121 from the conduit 145.
3. After the water with pupae is introduced into the separation container 121, the rocker table 127 is caused to move to disperse the pupae.
4. Water is released out of the separation container 121 until the water level 520 as shown in figure 7.2. When the water level is lower than the cavity edge, the dispersed pupae will be trapped in separate cavities.
5. Image capturing device is activated to capture an image.
6. The image is transmitted to the processing unit to determine the type of pupae in each cavity.
7. An appropriate sieve opening size is selected based on the determined type of pupae. Specifically, a sieve container 170 having a sieve with openings being bigger than the dimension of the determined type of pupa but smaller than the dimension of an undetermined type of pupa.
8. Water is introduced into the separation container 121 up to the water level 530 as shown in figure 7.3. At this water level 530, water with pupae will flow out of

the separation container 121 from outlet 126 and into the selected sieve container 170 via conduit 131.

9. Desired pupae are separated from the undesired pupae. Specifically, the openings of the sieve 172 allow the smaller male pupae to pass through while the larger female pupae remain above the sieve 172.

10. The desired smaller pupae 190a are allowed to flow through the sieve slits and into first container 130.

11. Water is introduced to the sieve container 170 to flush the top undesired pupae into second container 135

In step 6, the processing unit may include processes to determine whether the pupae are evenly spread out among the cavities. For example, if 55% of the cavities are empty (i.e. only 45% of the cavities are filled with pupae), steps 1, 3, 4 and 5 may be repeated to further disperse the pupae.

In the embodiment shown in figures 2 and 6, steps 7-11 are replaced with the following process.

7. The picker is activated to extract and move a first determined type of pupae to the second container 135.

8. Water is introduced into the separation container 121 up to the water level 530 as shown in figure 7.3. At this water level 530, water with a second determined type of pupae will flow out of the separation container 121 from outlet 126 and into the first container 130 via conduit 131.

While the cross sectional view of the separation container 121 shows that the cavities having a flat top surface, one skilled in the art will recognise that the walls of the cavities are thin to the extent that pupa will not be trapped on the top surface of the cavities after the water is released out of the separation container 121 until the water level 520 in step 4. Nevertheless, assuming a microplate with thicker walls are provided instead, the top surface of the cavities may have round edges to guide the pupa into respective cavities. This will also ensure that the pupa will not be trapped on the top surface of the cavities after the water is released out of the separation container 121 until the water level 520 in step 4.

Figure 10 illustrates the block diagram of circuitry 1000 provided to perform the processes in accordance with the disclosure. The circuitry 1000 comprises the processing unit 160, water controller 1020, image capturing device 1030, sieve selector 1040, first counter 1050, second counter 1060 and the rocker table 127. The circuitry 1000 is driven

by a power source 1090. In the embodiment shown in figures 2 and 6, the sieve selector 1040 is replaced with a picker 1040a.

Processing unit 160 is a system that executes instructions to perform the application described below in accordance with this disclosure. Processing unit 160 is communicatively connected to water controller 1020, image capturing device 1030, sieve selector 1040, picker 1040a, first counter 1050, second counter 1060 and the rocker table 127. Further details of processing unit 160 will be described below with reference to figure 11.

Figure 11 illustrates an example of a processing system 1100 in the processing unit 160. Processing system 1100 represents the processing systems in the processing unit 160 that execute instructions to perform the processes described below in accordance with embodiments of this disclosure. One skilled in the art will recognize that the instructions may be stored and/or performed as hardware, firmware, or software without departing from this invention. Further, one skilled in the art will recognize that the exact configuration of each processing system may be different and the exact configuration of the processing system executing processes in accordance with this invention may vary.

Processing system 1100 includes a processor 1110, a memory 1120, wireless transceiver 1130, and I/O ports 1140.

The memory 1120, wireless transceiver 1130, 680, and any number of other peripheral devices connected via I/O ports 1140 connect to processor 1110 to exchange data with processor 1110 for use in applications being executed by processor 1110.

The memory 1120 is a device that transmits and receives data to and from processor 1110 for storing data.

The wireless transmitter 1130 allows processing system 1100 to be connectable with other devices to update applications stored on memory 1120 or install new applications onto the memory 1120.

Other peripheral devices that may be connected to processor 1110 via the I/O ports include a USB storage device, an SD card or other storage device for transmitting information to or receiving information from the processing system 1100. In addition to updating applications stored on memory 1120 or installing new applications onto the memory via using the wireless transceiver 1130, a user may alternatively install new applications or update applications on the memory 1120 through a user interface such as a USB via the I/O port.

The processor 1110 is a processor, microprocessor, or any combination of processors and microprocessors that execute instructions to perform the processes in accordance with the present invention. The processor 1110 has the capability to execute various applications that are stored in the memory 1120.

5 Figure 12 illustrates a flow diagram of process 1200 performed by the processor in processing unit 160 in accordance with an embodiment of this disclosure. Process 1200 begins with step 1205 to separate the pupae and larvae in the larvae pupae separation unit and introduce water into the separation container 121 up to the water level 510 as shown in figure 7.1.

10 Specifically, the processing unit 160 switches on the lights 116 and triggers a signal to turn on the valve at the inlet 125 to introduce water into the separation container 121 via the inlet 125 up to the water level 510. With the lights 116 being switched on, the larvae 195 are caused to move downwardly and away from the top water surface while the pupae will float proximate the surface of the water level within the larvae pupae separation unit. The volume of water to be introduced into the separation container 121 may be fixed according to the size of the separation container 121. Alternatively, water level sensors that detects water may be implemented may be positioned at the water level 510 to trigger a signal to the processing unit 160 turn off the valve at the inlet 125 preventing more water from flowing into the separation container 121. The lights 116 will be switched on for a first predetermined period of time. The first predetermined period of time has to be at least long enough to fill separation container 121 up to the water level 510.

25 Essentially, the first predetermined period of time has to be sufficient for the larvae 195 to move to the bottom or as far away from the top water surface and long enough to fill separation container 121 up to the water level 510.

The lights 116 may continue to be switch on after the first predetermined period of time to ensure that the larvae 195 be positioned away from the top water surface while the pupae are being transported to the separation container in step 1210.

30 In step 1210, process 1200 introduces water with pupae into the separation container 121 from the conduit 145. Specifically, processing unit 160 triggers a signal to turn on the valve at the inlet 111 to introduce water into the larvae pupae separation unit. In turn, water with pupae will flow out of the larvae pupae separation unit via conduit 145 and into the separation container 121. Concurrently, the first counter 1050 will be activated to count the number of pupae passing through the conduit 145. Specifically, the

light 142 will be switched on while the image capturing device 141 will continuously capture images of the conduit 145. The processing unit 160 will receive the images and determine the number of pupae that pass through the conduit based on the number of black blobs determined. The processing unit 160 triggers a signal to turn off the valve at the inlet 111 preventing water from flowing into the separation container 121 after a certain volume of water is introduced into the separation container 121. This is to ensure that water with pupae does not escape out of the separation container 121 via outlet 126. If more water is required to be introduced to the separation container 121, the processing unit 160 triggers a signal to turn on the valve at the outlet 124 to release water until water level 510. In an alternatively embodiment, processing unit 160 triggers a signal to turn off the valve at the inlet 111 preventing water from flowing into the separation container 121 after a certain number of pupae is determined to have passed through the first counter 1050. In this alternative embodiment, the processing unit 160 triggers a signal to turn on the valve at the outlet 124 to release water at a flow rate that is similar to the flow rate of water flowing into the larvae pupae separation unit.

In step 1215, process 1200 activates the rocker table 127 to disperse the pupae 190. Step 1215 begins after a predetermined volume of water or certain number of pupae 190 is introduced into the separation container 121.

In step 1220, process 1200 releases water out of the separation container 121 via outlet 124 until the water level 520 as shown in figure 7.2.

In step 1225, process 1200 activates the image capturing device 124 to capture an image. Particularly, lights 128 will be switched on while the image capturing device 124 will capture image or images of the pupae in the cavities. The image or images will be transmitted to the processing unit 160.

In step 1230, process 1200 determines the type of pupae in each cavity. An algorithm is provided that determines a type of pupa. Specifically, the type is based on the gender of the pupae. More specifically, a size of the determined type of pupa is determined so that a suitable sieve container 170 can be selected. Hence, at least two types of pupae are determined where a first type refers to male while a second type refers to female. The gender of the pupae may be differentiated based on the size of the pupa. This is because female pupa is typically bigger than male pupa. Therefore, process 1200 measures and obtains a size distribution of the pupae in the cavities. One method of obtaining the size distribution of the pupae is to first measure the size of each pupa in the image captured by the image capturing device. As shown in figure 15, two peaks will form

where the first peak shows the size distribution of the desired pupae 190a while the second peak shows the size distribution of the undesired pupae 190b. After the size distribution of the first type of pupa is determined (i.e. desired pupae 190a), a suitable sieve opening size can be selected. Specifically, the size of the sieve openings is equal or
5 approximate to the median 1501 of the two peaks. In other words, the suitable size of the sieve openings is between highest numbers of pupae of two different sizes. Alternatively, to ensure that only the male pupae are allowed to pass through the sieve openings, the size of the sieve openings is based on a size 1502 that is closer to the first peak and further away from the second peak. In other words, the suitable size of the sieve
10 openings is between highest numbers of pupae of two different sizes and closer to the highest numbers of pupae with a smaller size among the two different sizes.

In the alternative embodiment as shown in figures 2 and 6, the differentiation is done by comparing either a plurality of stored images or dimensions of a preferred pupa with the captured images of the live pupae from the captured image. The dimensions
15 from the captured image are compared with the stored dimensions at the processing unit. Vital dimensions are a length of a respiratory trumpet, a length of a tracheal gills, a length from the respiratory trumpets to the ninth abdominal segment. Other differentiating method includes colour and shape of the pupae.

Optionally in step 1230, process 1200 may first determine if the pupae are evenly
20 spread out among the cavities before applying the algorithm to determine the gender of the pupae. For example, if 55% of the cavities are empty (i.e. only 45% of the cavities are filled with pupae), process 1200 introduces water to water level 1 and repeats from step 1215 to further disperse the pupae.

In step 1240, process 1200 transfers the relevant pupae to the first and second
25 containers 130 and 135. Specifically, the first determined type of pupae is transferred to the first container 130 while the remaining pupae are transferred to the second container 135.

Process 1200 ends after step 1240.

After the desired pupae 190a are transferred to the first container 130, the desired
30 pupae 190a may be transferred to another container to allow the desired pupae 190a to emerge to adult. This is achieved by introducing water into the first container 130, by opening valve 176a and 176b and closing the bottom outlet of the sieve container 170, to allow the desired pupae 190a to flow out of the first container 130 via the outlet 133 to the container for emerging of the pupae. The second counter 150 is positioned between the

first container 130 and the container for emerging of the pupae. This allows the apparatus 100 to record the number of desired pupae 190a exiting from the apparatus 100.

Figure 13 illustrates a flow diagram of process 1300 performed by the processor in processing unit 160 in accordance with an embodiment of this disclosure. Process 1300 is executed for the embodiment shown in figures 1 and 5 and in relation to step 1240 of process 1200. Process 1300 begins with step 1305 by selecting a suitable size of sieve openings. In step 1230 of process 1200, the images are processed to obtain a distribution of the sizes in the pupae. With the information of the size of the pupae, a suitable sieve container 170 is selected from a number of sieve containers optimally separates the undesired pupae 190b from the desired pupae 190a. Specifically, the size distribution of the pupae with reveal 2 peaks where the first peak shows the size distribution of the male pupae while the second peak shows the size distribution of the female pupae. Once the size distribution of the first peak is determined, a suitable sieve container 170 can be selected. Specifically, the size of the sieve openings is equal or approximate to the median of the two peaks. Alternatively, to ensure that only the male pupae are allowed to pass through the sieve openings, the size of the sieve openings is based on a size as close to the first peak and further away from the second peak. Also in this step, process 1300 activates the sieve selector 1040 to select the suitable sieve container 170 to receive pupae 190 from the separation container 121. Specifically, the selected sieve container 170 is moved by a mechanical mechanism such that the selected sieve container 170 is located below the outlet of the conduit 131. In the alternate embodiment, process 1300 activates the sieve selector 1040 to open the appropriate valve to direct the pupae 190 to the selected sieve container 170.

In another embodiment where only one sieve container is used, the sieve selector 1040 is activated to move the divider wall 175 such that the pupae are directed to the section with selected sieve opening size, i.e. sieve openings that are larger than desired pupae size but smaller than the undesired pupae size.

In step 1310, water is introduced into the separation container 121 to allow pupae 190 to flow to the selected sieve container 170. The openings of the sieve 172 allow the smaller pupae (i.e. desired pupae) to pass through while the larger pupae (i.e. undesired pupae) remain above the sieve 172.

In step 1315, process 1300 varies the water level in the selected sieve container 170 at certain interval. Specifically, water is added from the top or through the bottom of the selected sieve container to modulate the water level within the selected sieve

container up and down to assist the smaller sized pupae to pass through the sieve openings. Water is introduced from the bottom of the selected sieve by the opening the valve 176a and closing valve 176b. Water level can be lowered till it is below the sieve openings. The turbulence of the water in doing so also helps to prevent pupae from being stuck at the sieve openings.

In step 1320, process 1320 transfers the desired pupae 190a to the first container 130. Particularly, the desired smaller pupae flow through the sieve slits and into first container 130 by opening valve 176b.

In step 1325, process 1300 introduces water to flush the top undesired pupae into the second container 135. Particularly, water is introduced into the sieve container 170 by opening valve 176a and closing valve 176b. The undesired pupae can also be sucked out from the sieve container from the top or flushed away with water through to the second container 135.

Process 1300 ends after step 1325.

Figure 14 illustrates a flow diagram of process 1400 performed by the processor in processing unit 160 in accordance with an embodiment of this disclosure. Specifically, process 1300 is executed for the embodiment shown in figures 2 and 6 and in relation to step 1240 of process 1200. Process 1400 begins with step 1405 by activating the picker 123 to extract and move a second determined type of pupae to the second container 130.

In step 1410, process 1400 introduces water into the separation container 121 up to the water level 530 as shown in figure 7.3. At this water level 530, water with a first determined type of pupae will flow out of the separation container 121 from outlet 126 and into the first container 130 via conduit 131.

Process 1400 ends after step 1410.

The above is a description of exemplary embodiments of a pupae separator in accordance with this disclosure. It is foreseeable that those skilled in the art can and will design alternative systems based on this disclosure that infringe upon this invention as set forth in the following claims.

Claims:

1. An apparatus for segregating desired and undesired pupae, the apparatus comprising:

a separation container for containing the pupae;

an image capturing device arranged to capture an image of the pupae;

a desired container to receive the desired pupae;

a plurality of sieve containers, each sieve container having a sieve with openings of a specific size and arranged to receive the pupae from the separation container; and

a processing unit having a processor, memory and instructions stored on the memory and executable by the processor to:

receive the image from the image capturing device, determine a type of pupae from the image, the type of pupae being associated to the desired pupae, and

select one of the plurality of sieve containers based on the determined type of pupae; and

transfer the desired pupae to the desired container via the selected sieve container.

2. The apparatus of claim 1 wherein the image capturing device is being arranged above the separation container to capture the image of the pupae.

3. The apparatus of claim 1 wherein the instruction to determine the type of pupae from the image comprises instructions to:

determine a size distribution of the pupae in the image; and

selecting a suitable size based on the size distribution, the suitable size being between highest numbers of pupae of two different sizes.

4. The apparatus of claim 3 wherein the suitable size is closer to the highest numbers of pupae with a smaller size among the two different sizes.

5. The apparatus of any one of claims 3-4 wherein the instruction to select one of the plurality of sieve container comprises instructions to:

select one of the plurality of sieve container based on the suitable size.

6. The apparatus of claim 5 wherein the plurality of sieve containers are arranged on a rotatable table.

7. The apparatus of claim 5 wherein the plurality of sieve containers are arranged on a conveyor belt.

8. The apparatus of claim 5 further comprising multiple conduits, each conduit having a valve and in fluid communication with respective sieve container.

9. The apparatus of any one of claims 1-8 wherein the separation container comprises:

a microplate having multiple cavities, each cavity is sized to contain at least one pupa.

10. The apparatus of any one of claims 1-9 further comprising:
an undesired container to receive the undesired pupae.

11. The apparatus of any one of claims 1-10 further comprising:
a rocker table supporting the separation container.

12. The apparatus of any one of claims 1-11 further comprising:
a larvae-pupae container having an inlet to receive water containing larvae and pupae and an outlet to release the pupae;
a conduit to allow fluid communication between the larvae-pupae container and the separation container; and
a plurality of lights mounted on a top interior surface of the larvae-pupae container.

13. The apparatus of claim 12 wherein the instructions further comprise instructions to:
separate the pupae and larvae in the larvae-pupae container; and
introduce water into the separation container.

14. The apparatus of claim 13 wherein the instruction to separate the pupae and larvae in the larvae-pupae container comprises instructions to:

switch on the plurality of lights mounted on the top interior surface of the larvae-pupae container.

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15. The apparatus of claim 14 further comprising:

a counter arranged on the conduit for counting the number of pupae being transferred to the separation container.

10 16. The apparatus of any one of claims 1-15 further comprising:

an emerging container in fluid communication with the desired container for keeping the desired pupae; and a counter between the emerging container and the desired container.

15 17. A method of segregating desired and undesired pupae comprising:

introducing water with pupae into a separation container,

activating a rocker table supporting the separation container dispersing the pupae,

releasing water out of the separation container until the dispersed pupae are trapped in separate cavities of the separation container;

20 capturing an image of the pupae;

processing the image to determine a type of pupa;

selecting a sieve with openings being bigger than the dimension of the determined type of pupa and smaller than the dimension of an undetermined type of pupa;

transferring the pupae from the separation container to a sieve container having

25 the selected sieve;

separating the desired pupae from the undesired pupae; and

transferring the desired pupae to a desired container.

30 18. The method according to claim 17 wherein the step of processing the image to determine a type of pupa comprises:

determining a size distribution of the pupae in the image; and

selecting a suitable size based on the size distribution, the suitable size being between highest numbers of pupae of two different sizes.

19. The method according to claim 17 or 18 wherein the step of separating the desired pupae from the undesired pupae comprises:

varying a water level in the selected sieve container at certain interval.

5 20. The method according to claim 19 wherein the step of varying the water level in the selected sieve container at certain interval comprises:

adding water from a top of the selected sieve container and subsequently from a bottom of the selected sieve container to modulate the water level within the selected sieve container up and down.