SIEVING APPARATUSES FOR PUPAE SEPARATION

BACKGROUND

[0001] Generally, a sieve can be formed of a wire or plastic mesh held in a frame. The sieve can be used for straining solids from liquid or for separating coarser objects from finer objects.

[0002] Among those objects that can be separated are insects. Other devices have been designed to separate insects such as a device that includes parallel glass plates. The reasons for separating insects are various. For example, as part of a Sterile Insect Technique (SIT) program, male insects may be separated from female insects. Depending on the program, separation may be performed at one or more stages of insect development. For example, insects having an aqueous pupal stage may be separated while in the pupal stage.

[0003] Use of conventional mesh screens to separate pupae may create challenges given the physiological structures of the pupae. Additionally, use of devices including parallel glass plates may create challenges given their difficulty to operate and required user interaction. These challenges may result in prohibitively low throughput and similarly low yield.

SUMMARY

[0004] Various examples are described relating to sieving devices, systems including the sieving devices, methods for using the sieving devices, and methods for forming the sieving devices.

[0005] In an aspect, an apparatus is described. The apparatus includes a frame, a sieving device, a basin, and an actuation system. The sieving device includes a sieve surface including a first side and a second side and defining a set of openings to define a set of pathways extending between the first side and the second side. Individual openings of the set of openings are defined by a length dimension measured along a longitudinal axis of the respective opening, and a width dimension measured along a transverse axis of the respective opening. The width dimension corresponds to a cephalothorax width of a mosquito. The length dimension is greater than the width dimension. The sieving device also includes a sieve rim including a first wall defining a volume. The sieve surface is attached to a lower portion of an interior surface of the sieve rim and one side of the sieve surface is exposed

within the volume. The basin is attached to the frame and includes a wall and a bottom. The wall is attached to the bottom so as to define an opening opposite the bottom. The basin is sized to receive the sieving device and to retain a liquid. The actuation system is attached to the frame and the sieving device. The actuation system is configured to move the sieving device along a substantially vertical lifting axis between a first position within the basin and a second position within the basin. The second position is different than the first position. Moving the sieving device along the substantially vertical lifting axis between the first and second position is configured to separate a population of mosquitoes within the liquid based on cephalothorax size.

[0006] In another aspect, an apparatus is described. The apparatus an apparatus includes a frame, a sieving device, a basin, and an actuation system. The sieving device includes a sieve surface including a first side and a second side. A set of elongate openings is formed in the sieve surface, wherein individual elongate openings of the set of elongate openings are defined by: a length dimension measured along a longitudinal axis of a respective elongate opening; and a width dimension measured along a transverse axis of the respective elongate opening, the width dimension corresponding to a representative cephalothorax width of a representative insect of a population of insects. The sieving device also includes a sieve rim attached to the sieve surface. The sieve rim forms a wall portion of the sieving device, with the sieve surface forming a bottom portion of the sieving device. The basin is attached to the frame. The basin is sized to receive the sieving device and to retain a liquid. The actuation system is attached to the frame and the sieving device. The actuation system is configured to move the sieving device along a lifting axis between a first position within the basin and a second position within the basin. The first position is different than the second position. Moving the sieving device along the lifting axis between the first position and the second position separates a population of insects present in the liquid based on cephalothorax width.

[0007] In an example, a computer-implemented method is described. The method includes instructing addition of a population of insect pupae to a sieving device. The sieving device is at least partially submerged in a water held within a first basin. The method also includes causing a lifting actuator that is attached to the sieving device to cycle between a first elevation and a second elevation so as to cyclically submerge a sieve surface of the sieving device in the water held within the first basin. The population of insect pupae is separated into a first group of insect pupae and a second group of insect pupae based at least in part on the cycling. The method also includes causing a valve to open to drain the water from the first basin. The first group of insect pupae is disposed in the water. The method also includes causing a lateral actuator that is attached to the sieving device to move the sieving device from a first position adjacent to the first basin to a second position adjacent to a second basin. The second group of insect pupae is disposed in the sieving device. The method

also includes, when the sieving device is at the second position, causing a rotational actuator to rotate the sieving device about a rotational axis between a first orientation and a second orientation. The method also includes, when the sieving device is in the second orientation, instructing removal of the second group of insect pupae from the sieving device.

[0008] In yet another example, a computer-implemented method is described. The method includes causing an actuation system to cycle between a first elevation and a second elevation to cyclically submerge a sieve surface of a sieving device in a liquid held within a basin. A population of insects present in the liquid is separated into a first group of insects and a second group of insects as a result of the cycling. The method also includes causing a valve to open to drain the liquid from the basin. The first group of insects is disposed in the liquid. The method also includes causing the actuation system to move the sieving device from a first position over the basin to a second position other than over the basin. The second group of insects is disposed in the sieving device.

[0009] In yet another aspect, a system is described. The system includes a separation station, a rinse station, and an actuation system. The separation station includes a sieving device, a first basin, and a fill nozzle. The sieving device includes a sieve surface including a first side and a second side. A set of elongate openings is formed in the sieve surface. The sieving device also includes a sieve rim attached to the sieve surface and forming a wall portion of the sieving device. The sieve surface forms a bottom portion of the sieving device. The first basin is sized to receive the sieving device and to retain a volume of liquid. The fill nozzle is disposed adjacent to the first basin and controllable to add first liquid to the first basin. The rinse station includes a second basin sized to receive the sieving device. The rinse station includes a spray nozzle disposed adjacent to the second basin and controllable to spray second liquid toward the second basin. The actuation system is attached to the sieving device. The actuation system is configured to move the sieving device between a first position within the first basin and a second position within the first basin. The actuation system is also configured to move the sieving device between a third position adjacent to the first basin and a fourth position adjacent to the second basin.

[0010] The illustrative examples are mentioned not to limit or define the scope of this disclosure, but rather to provide examples to aid understanding thereof. Illustrative examples are discussed in the Detailed Description, which provides further description. Advantages offered by various examples may be further understood by examining this specification.

WHAT IS CLAIMED IS:

1. An apparatus, comprising:

a frame;

a sieving device comprising:

a sieve surface comprising a first side and a second side and defining a set of openings to define a set of pathways extending between the first side and the second side, individual openings of the set of openings defined by:

a length dimension measured along a longitudinal axis of the respective opening; and

a width dimension measured along a transverse axis of the respective opening, the width dimension corresponding to a cephalothorax width of a mosquito, and the length dimension greater than the width dimension; and

a sieve rim comprising a first wall defining a volume, the sieve surface attached to a lower portion of an interior surface of the sieve rim and one side of the sieve surface exposed within the volume;

a basin attached to the frame and comprising a wall and a bottom, the wall attached to the bottom so as to define an opening opposite the bottom, the basin sized to receive the sieving device and to retain a liquid; and

an actuation system attached to the frame and the sieving device, the actuation system configured to move the sieving device along a substantially vertical lifting axis between a first position within the basin and a second position within the basin, the second position different than the first position,

wherein moving the sieving device along the substantially vertical lifting axis between the first and second positions is configured to separate a population of mosquitoes within the liquid based on cephalothorax size.

2. The apparatus of claim 1, wherein, when the sieve surface is submerged in the liquid:

a first mosquito having a first cephalothorax width that is less than the width dimension is free to move through any one of the set of pathways between the first side and the second side; and

a second mosquito having a second cephalothorax width that is greater than the width dimension is prevented from moving between any one of the set of pathways between the first side and the second side.

3. The apparatus of claim 1, wherein moving the sieving device along the substantially vertical lifting axis between the first position and the second position is configured to cyclically submerge the sieve surface in the liquid, wherein an upper portion of the sieve rim is not submerged in the liquid while the sieve surface is cyclically submerged.

4. The apparatus of claim 1, wherein the actuation system comprises a lifting actuator that comprises:

a vertical rail extending in a vertical direction that corresponds to the substantially vertical lifting axis;

a first carrier slidably attached to the vertical rail and attached to the sieving device; and

a first actuator device configured to move the first carrier along the vertical rail to cause the sieving device to move along the substantially vertical lifting axis.

5. The apparatus of claim 4, wherein the actuation system comprises a lateral actuator that comprises:

a horizontal rail extending in a horizontal direction relative to the vertical rail;

a second carrier comprising a first carrier side and a second carrier side, the first carrier side slidably attached to the horizontal rail and the second carrier side attached to the vertical rail; and

a second actuator device configured to move the second carrier along the horizontal rail to cause the sieving device to move along a lateral axis between:

a first lateral position at which the sieving device is disposed above the basin; and

a second lateral position at which the sieving device is not disposed above the basin.

6. The apparatus of claim 4, wherein the actuation system comprises a rotational actuator that comprises:

a shaft attached to the sieving device and the first carrier, the shaft defining a rotational axis; and

a third actuator device attached to the shaft and configured to rotate the sieving device about the rotational axis between:

a first orientation in which the sieving device opens upward; and

a second orientation in which the sieving device opens downward.

7. The apparatus of claim 1, wherein:

the basin defines a drain opening in a bottom surface of the basin; and

the apparatus further comprises a first valve in fluid communication with the drain opening.

8. The apparatus of claim 7, further comprising:

a second valve in fluid communication with the first valve via a drain pipe; and

a manifold disposed between the first valve and the second valve and in fluid communication with the first valve and the second valve via the drain pipe, at least a portion of the drain pipe disposed within the manifold and comprising a plurality of openings sized smaller than the width dimension.

9. The apparatus of claim 8, wherein:

opening of the first valve and closing of the second valve allows the liquid to drain from the basin into the manifold via the plurality of openings and to trap mosquitoes in the drain pipe; and

opening of the second valve after the liquid has drained into the manifold allows dispensing of a portion of the population of mosquitoes.

10. The apparatus of claim 1, further comprising:

a rinse basin attached to the frame and disposed adjacent to the basin; and

a rinse head attached to the frame and disposed above the rinse basin, the rinse head configured to rinse the sieving device when the sieving device is disposed between the rinse head and the rinse basin.

11. The apparatus of claim 1, further comprising a computing device in electrical communication with the apparatus, the computing device configured to communicate with a remote computing device to manage operation of the apparatus.

12. An apparatus, comprising:

a frame;

a sieving device comprising:

a sieve surface comprising a first side and a second side, wherein a set of elongate openings is formed in the sieve surface, wherein individual elongate openings of the set of elongate openings are defined by:

a length dimension measured along a longitudinal axis of a respective elongate opening; and

a width dimension measured along a transverse axis of the respective elongate opening, the width dimension corresponding to a representative cephalothorax width of a representative insect of a population of insects; and

a sieve rim attached to the sieve surface and forming a wall portion of the sieving device, with the sieve surface forming a bottom portion of the sieving device;

a basin attached to the frame, the basin sized to receive the sieving device and to retain a liquid; and

an actuation system attached to the frame and the sieving device, the actuation system configured to move the sieving device along a lifting axis between a first position within the basin and a second position within the basin, the first position different than the second position,

wherein moving the sieving device along the lifting axis between the first position and the second position separates the population of insects present in the liquid based on cephalothorax width.

13. The apparatus of claim 12, wherein, when the sieve surface is submerged in the liquid:

a first insect is free to move through any one of the set of elongate openings, the first insect having a first cephalothorax width that is less than the width dimension of the set of elongate openings; and

a second insect is prevented from moving through any one of the set of elongate openings, the second insect having a second cephalothorax width that is greater than the width dimension of the set of elongate openings.

14. The apparatus of claim 12, wherein the actuation system provides vertical translation of the sieving device, horizontal translation of the sieving device, and rotation of the sieving device.

15. The apparatus of claim 144, wherein the vertical translation is provided by a lifting actuator, the horizontal translation is provided by a lateral actuator, and the rotation is provided by a rotational actuator.

16. The apparatus of claim 12, further comprising a sensing device configured to sense a level of liquid in the basin.

17. A system, comprising:

a separation station comprising:

a sieving device comprising:

a sieve surface comprising a first side and a second side, wherein a set of elongate openings is formed in the sieve surface; and

a sieve rim attached to the sieve surface and forming a wall portion of the sieving device, with the sieve surface forming a bottom portion of the sieving device;

a first basin sized to receive the sieving device and to retain a volume of liquid; and

a fill nozzle disposed adjacent to the first basin and controllable to add first liquid to the first basin;

a rinse station comprising:

a second basin sized to receive the sieving device; and

a spray nozzle disposed adjacent to the second basin and controllable to spray second liquid toward the second basin; and

an actuation system attached to the sieving device, the actuation system configured to:

move the sieving device between a first position within the first basin and a second position within the first basin; and

move the sieving device between a third position adjacent to the first basin and a fourth position adjacent to the second basin.