INSECT SINGULATION AND CLASSIFICATION

BACKGROUND

[0001] As part of a Sterile Insect Technique (SIT) program, insects may be classified as male or female and selectively sterilized before being released into the wild. Such programs may be implemented to minimize or eliminate insect-borne diseases and/or to manage insect populations in certain areas. Depending on the program, classification and sterilization may be performed at one or more stages of insect development. For example, adult male and female insects may be classified based on sex prior to one sex being sterilized.

BRIEF SUMMARY

[0002] Various examples are described including systems, methods, and devices relating to singulating and sorting adult insects.

[0003] One general aspect includes an insect sortation system, including: an insect pathway defining an interior volume and having an inlet and an outlet, wherein an approach zone of the insect pathway is defined adjacent the inlet, a classification zone of the insect pathway is defined adjacent the outlet, and a singulation zone of the insect pathway is defined between the approach zone and the classification zone. The insect sortation system also includes a puff back system defined adjacent the inlet. The insect sortation system also includes a puff forward system defined adjacent the outlet. The insect sortation system also includes an imaging system disposed adjacent the insect pathway and configured to image insects on the insect pathway, wherein the puff back system is disposed between the inlet and the imaging system, and is configured to blow the insects away from the imaging system and toward the inlet, and wherein the puff forward system is disposed between the outlet and the imaging system, and is configured to blow the insects away from the imaging system and toward the outlet.

[0004] Another general aspect includes an insect sortation method, including: receiving image data from an imaging system disposed adjacent to an insect pathway, the image data representative of one or more insects on the insect pathway, the insect pathway comprising an inlet and an outlet. The insect sortation method also includes determining positions of one or more insects with respect to a plurality of zones of the insect pathway based on the image data. The insect sortation method also includes causing movement, by a puff back system disposed between the inlet and the imaging system, of at least one insect of the one or more insects based on a first position of the at least one insect with respect to the plurality of zones, wherein causing the movement of the at least one insect comprises instructing the puff back system to puff a burst of

air that moves the at least one insect away from the imaging system and toward the inlet, and causing movement, by a puff forward system disposed between the outlet and the imaging system, of the at least one insect toward the outlet based on a second position of the at least one insect with respect to the plurality of zones, wherein the second position is different than the first position. The insect sortation system may be computer-implemented. Other examples of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the method.

[0005] Another general aspect includes a non-transitory computer-readable storage device including computer-executable instructions that, when executed by a computer system, cause the computer system to perform operations including: receive image data from an imaging

system disposed adjacent to an insect pathway, the image data representative of one or more insects on the insect pathway, the insect pathway comprising an inlet and an outlet. The operations also include determine positions of one or more insects with respect to a plurality of zones of the insect pathway based on the image data. The operations also include causing movement, by a puff back system disposed between the inlet and the imaging system, of at least one insect of the one or more insects based on a first position of the at least one insect with respect to the plurality of zones, wherein causing the movement of the at least one insect comprises instructing the puff back system to puff a burst of air that moves the at least one insect away from the imaging system and toward the inlet, and causing movement, by a puff forward system disposed between the outlet and the imaging system, of the at least one insect toward the outlet based on a second position of the at least one insect with respect to the plurality of zones, wherein the second position is different than the first position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The accompanying drawings, which are incorporated into and constitute a part of this specification, illustrate one or more certain examples and, together with the description of the example, serve to explain the principles and implementations of the certain examples.

[0007] FIG. 1 illustrates a top view of an insect sortation system, according to at least one example.

[0008] FIG. 2 illustrates a section view of the insect sortation system of FIG. 1, according to at least one example.

[0009] FIG. 3 illustrates an example device including a management module for managing aspects of the insect sortation system of FIG. 1, according to at least one example.

[0010] FIG. 4 illustrates example images of pairs of insects, according to at least one example.

[0011] FIG. 5 illustrates an example flow chart depicting process for classifying insects, according to at least one example.

[0012] FIG. 6 illustrates an example system for implementing techniques relating to classifying insects, according to at least one example.

DETAILED DESCRIPTION

[0013] Examples are described herein in the context of an insect sortation system and corresponding methods for singulating and classifying adult stage insects, and in particular adult stage mosquitoes of particular species. Those of ordinary skill in the art will realize that the following description is illustrative only and is not intended to be in any way limiting. For example, the systems and processes described herein can be used to singulate and classify mosquitoes and insects in other stages and/or other species. Reference will now be made in detail to implementations

of examples as illustrated in the accompanying drawings. The same reference indicators will be used throughout the drawings and the following description to refer to the same or like items.

WHAT IS CLAIMED IS:

1. An insect sortation system, comprising:

an insect pathway defining an interior volume having an inlet and an outlet, wherein an approach zone of the insect pathway is defined adjacent the inlet, a classification zone of the insect pathway is defined adjacent the outlet, and a singulation zone of the insect pathway is defined between the approach zone and the classification zone;

a puff back system defined adjacent the inlet;

a puff forward system defined adjacent the outlet; and

an imaging system disposed adjacent the insect pathway and configured to image insects on the insect pathway, wherein the puff back system is disposed between the inlet and the imaging system, and is configured to blow the insects away from the imaging system and toward the inlet, and wherein the puff forward system is disposed between the outlet and the imaging system, and is configured to blow the insects away from the imaging system and toward the outlet.

2. The insect sortation system of claim 1, further comprising:

a computing device comprising a memory and a processor configured to:

receive image data from the imaging system; and

determine positions of at least some of the insects on the insect pathway based on the image data.

3. The insect sortation system of claim 2, wherein the computing device is further configured to classify one or more insects when the one or more insects are in the classification zone.

4. The insect sortation system of claim 2, wherein each of the puff back system and the puff forward system comprises:

one or more puff outlets;

an air source that provides an air flow to the one or more puff outlets; and

a control valve disposed between the air source and the one or more puff outlets, and that controls the air flow to the one or more puff outlets.

5. The insect sortation system of claim 4, wherein the computing device is further configured to control the control valve in each of the puff back system and the puff forward

system based on the positions of the insects to separate a single insect from the insects when the insects are in the singulation zone.

6. The insect sortation system of claim 1, wherein the insect pathway defines a rectangular cross section, with a height and a width selected to correspond to a representative insect of the insects.

7. The insect sortation system of claim 1, further comprising a shutter disposed within the singulation zone, the shutter comprising a track and a door that is moveable between an open state and a closed state.

8. The insect sortation system of claim 7, wherein, when the door is in the open state, the insects can freely move along the insect pathway.

9. The insect sortation system of claim 7, wherein, when the door is in the closed state, the insects are prohibited from moving along the insect pathway.

10. The insect sortation system of claim 7, wherein, when the door is in the closed state, the interior volume is divided into a first volume and a second volume.

11. The insect sortation system of claim 1, wherein the insect pathway comprises:

a floor on which the insects move;

a ceiling disposed above the floor; and

a pair of walls extending between the floor and the ceiling.

12. The insect sortation system of claim 11, wherein the floor is formed from a translucent material.

13. The insect sortation system of claim 12, further comprising one or more lighting elements disposed below the floor and positioned to provide light through the translucent material.

14. The insect sortation system of claim 11, wherein the ceiling is formed from a transparent material.

15. The insect sortation system of claim 1, wherein:

the imaging system is a position tracking imaging system configured to capture images of the insects for position tracking of the insects along the insect pathway; and

the insect sortation system further comprises an insect classification imaging system configured to capture images of the insects for classification of the insects within the classification zone.

16. An insect sortation method, comprising:

receiving image data from an imaging system disposed adjacent to an insect pathway, the image data representative of one or more insects on the insect pathway, the insect pathway comprising an inlet and an outlet;

determining positions of one or more insects with respect to a plurality of zones of the insect pathway based on the image data;

causing movement, by a puff back system disposed between the inlet and the imaging system, of at least one insect of the one or more insects based on a first position of the at least one insect with respect to the plurality of zones, wherein causing the movement of the at least one insect comprises instructing the puff back system to puff a burst of air that moves the at least one insect away from the imaging system and toward the inlet; and

causing movement, by a puff forward system disposed between the outlet and the imaging system, of the at least one insect toward the outlet based on a second position of the at least one insect with respect to the plurality of zones, wherein the second position is different than the first position.

17. The insect sortation method of claim 16, wherein the imaging system comprises one or more cameras.

18. The insect sortation method of claim 16, wherein the plurality of zones comprise an approach zone disposed adjacent to the inlet of the insect pathway, a classification zone disposed adjacent to the outlet of the insect pathway, and a singulation zone disposed between the approach zone and the classification zone.

19. The insect sortation method of claim 18, wherein causing the movement, by the puff back system, of the at least one insect further comprises instructing the puff back system to puff the burst of air based at least in part on determining that the at least one insect has remained within the approach zone beyond a maximum amount of time.

20. The insect sortation method of claim 18, wherein causing the movement, by the puff back system, of the at least one insect further comprises instructing the puff back system to puff the burst of air based at least in part on determining that a quantity of insects within the approach zone exceeds a maximum quantity of insects for the approach zone.

21. The insect sortation method of claim 18, wherein the at least one insect is a first at least one insect, the burst of air is a first burst of air, the method further comprising causing movement, by the puff forward system, of a second at least one insect by at least:

determining that the second at least one insect has remained within the classification zone beyond a maximum amount of time; and

instructing the puff forward system to puff a second burst of air that moves the second at least one insect toward the outlet, wherein the second at least one insect is different than the first at least one insect.

22. The insect sortation method of claim 18, wherein the burst of air is a first burst of air, the method further comprising causing movement, by the puff forward system, of a plurality of insects by at least:

determining that a quantity of the plurality of insects within the classification zone exceeds a maximum quantity of insects for the classification zone; and

instructing the puff forward system to puff a second burst of air that moves the plurality of insects toward the outlet.

23. The insect sortation method of claim 18, wherein causing the movement, by the puff back system, of the at least one insect comprises isolating the at least one insect from the one or more insects.

24. The insect sortation method of claim 18, wherein:

the imaging system comprises one or more cameras; and

the method further comprises:

receiving additional image data from the imaging system when the at least one insect is located within the classification zone;

identifying one or more characteristics of the at least one insect based on the additional image data; and

classifying the at least one insect based on the one or more characteristics.

25. The insect sortation method of claim 24, wherein the one or more characteristics comprise a head, a body area, a body length, a tail, or an antenna.

26. The insect sortation method of claim 24, wherein classifying the at least one insect comprises classifying the at least one insect based on sex, health, species, genus, or size.

27. The insect sortation method of claim 24, further comprising causing movement, by the puff back system, of the at least one insect based on classifying the at least one insect.

28. A non-transitory computer-readable storage device comprising computer- executable instructions that, when executed by a computer system, cause the computer system to perform operations comprising:

receive image data from an imaging system disposed adjacent to an insect pathway, the image data representative of one or more insects on the insect pathway, the insect pathway comprising an inlet and an outlet;

determine positions of one or more insects with respect to a plurality of zones of the insect pathway based on the image data;

causing movement, by a puff back system disposed between the inlet and the imaging system, of at least one insect of the one or more insects based on a first position of the at least one insect with respect to the plurality of zones, wherein causing the movement of the at least one insect comprises instructing the puff back system to puff a burst of air that moves the at least one insect away from the imaging system and toward the inlet; and

causing movement, by a puff forward system disposed between the outlet and the imaging system, of the at least one insect toward the outlet based on a second position of the at least one insect with respect to the plurality of zones, wherein the second position is different than the first position.

29. The non-transitory computer-readable storage device of claim 28, wherein the plurality of zones comprise an approach zone dispose adjacent the inlet of the insect pathway, a classification zone disposed adjacent the outlet of the insect pathway, and a singulation zone disposed between the approach zone and the classification zone.

30. The non-transitory computer-readable storage device of claim 29, wherein causing the movement, by the puff back system, of the at least one insect further comprises instructing

the puff back system to puff the burst of air based at least in part on determining that the at least one insect has remained within the approach zone beyond a maximum amount of time.

31. The non-transitory computer-readable storage device of claim 29, wherein causing the movement, by the puff back system, of the at least one insect further comprises instructing the puff back system to puff the burst of air based at least in part on determining that a quantity of insects within the approach zone including the first insect exceeds a maximum quantity of insects for the approach zone.

32. The non-transitory computer-readable storage device of claim 29, wherein the burst of air is a first burst of air, the computer-readable storage device comprising additional computer-executable instructions that, when executed by the computer system, cause the computer system to perform additional operations comprising causing movement, by the puff forward system, of the at least one insect by at least:

determining that the at least one insect has remained within the classification zone beyond a maximum amount of time; and

instructing the puff forward system to puff a second burst of air that moves the at least one insect toward the outlet.

33. The non-transitory computer-readable storage device of claim 29, wherein the burst of air is a first burst of air, the computer-readable storage device comprising additional computer-executable instructions that, when executed by the computer system, cause the computer system to perform additional operations comprising causing movement, by the puff forward system, of a plurality of insects by at least:

determining that a quantity of the plurality of insects within the classification zone exceeds a maximum quantity of insects for the classification zone; and

instructing the puff forward system to puff a burst of air that moves the plurality of insects toward the outlet.

34. The non-transitory computer-readable storage device of claim 29, wherein causing the movement, by the puff back system, of the at least one insect comprises isolating the at least one insect from the one or more insects.