

DEVICE AND METHOD FOR STORAGE TRANSPORTATION AND RELEASE OF FRAGILE INSECTS AND OTHER FRAGILE ITEMS

FIELD AND BACKGROUND OF THE INVENTION

5 The present invention, in some embodiments thereof, relates to a device and method for storage, transportation and release of fragile insects and other fragile items and, more particularly, but not exclusively to the case where the fragile insects are mosquitoes and/or where the release is aerial release.

10 Today there are large regions in the Americas, Africa and Asia that are highly susceptible to vector-borne diseases transferred by mosquitoes, such as Dengue, Malaria, Chikungunya and others. These are infectious diseases carried and spread by a bite from a female mosquito. There may be other diseases which are also spread by other insects.

15 One method of dealing with the mosquito problem involves producing modified laboratory produced mosquitoes and releasing them into the wild. The laboratory produced mosquitoes are provided with characteristics that help fight the spread of the disease. For example they may be sterile male mosquitoes, say as a result of being treated by radiation at some point in their life cycle. Female mosquitoes tend to mate only once, so an environment of sterile males can dramatically reduce the population. Another possibility is to provide genetically modified male mosquitoes. The genetic
20 modification is to ensure that when mating with a wild female, no adult mosquito successfully grows.

 Mosquitoes are fragile insects, and a problem arises when trying to store, transport and release the modified male adults in the very large numbers and over very large areas that are needed to make a significant difference to the wild population.

25 While research continues to explore methods for mass rearing of the lab mosquitoes, there is currently no available product to enable the storage and transport of large quantities of adult mosquitoes and current distribution methods are mostly manual, and limited in the numbers of mosquitoes that can be delivered and the terrain they can be delivered to.

30 The problem is recognized in the literature. The Sterile Insect Technique: can established technology beat malaria? International Atomic Energy Agency, 2006, discloses as follows: "...Unlike the robust medfly, mosquitoes are rather fragile

creatures. Handling, packing and release methods for mosquitoes need to be developed and tested to assess the impact of aerial release on male behaviour and longevity...”.

A second document, Historical applications of induced sterilisation in field populations of mosquitoes, David A Dame, Christopher F Curtis², Mark Q Benedict, Alan S Robinson and Bart GJ Knols, 2009 discloses: “... Production and release of millions per day will demand expedited delivery mechanisms to prevent losses in quality and competitiveness...”. The document explicitly recommends aerial release technology as an important target for active research.

How is it done today? Storage of insects during and prior to release:

The mosquito life cycle is shown in Fig. 1. Eggs are laid and can be stored on paper. Larvae emerge and live underwater, float upside down to the surface of the water and breathe through a breathing tube emerging from the water surface. A pupa is formed, also under water, but needs to breathe so comes to the surface. The adult emerges from the pupa and is terrestrial.

In the laboratory the aquatic stages are accommodated and when the mosquito emerges from the pupa stage, then the mosquitoes are usually stored in small cages.

The most common practice for release of laboratory mosquitoes is to simply open the cage in which they are currently stored and allow the mosquitoes to fly out, see The Sterile-Male Technique for Control of Mosquitoes: A Field Cage Study with *Anopheles Quadrimaculatu*, R. S. PATTERSON, C. S. LOFGREN, AND M. D. BOSTON Entomology Research Division, Agr. Res. Serv., USDA, 1968.

The pupa may be stored in small containers of water, and prior to emergence, may be moved together with some water into a cage. The adult emerges into the open air of the cage and the water is then removed.

A note about fruit flies storage:

Storage of fruit flies may be also in cages or even in paper bags, in which the adults emerge from the pupa directly into the paper bag.

These paper bags may be later used for the release of the fruit flies. The bags are torn open to enable the adult flies to exit the paper bags.

Another option is to store the millions of fruit flies in specialized containers and then to release them from an airplane using elements such as auger system or based on the use of vibrating conveyors to support forwarding the insects to their exit point.

In order to enable a greater number of fruit flies to be stored in the device, the
5 container may be cooled to 4°C. The low temperature keeps the insects motionless during the release period. The flies drop from the bottom of the chill-box into an auger system, which moves them through a chute located on the underside of the airplane fuselage. The release rate (insects per unit area) can be controlled via the revolution speed of the auger system. Insect mortality in this system is negligible and dispersal is
10 satisfactory. However, if this process were to be tried on the much more fragile mosquitoes the mortality rate would be much higher.

Challenges for mass rearing, release and transport of lab mosquitoes

Today the process of mass rearing of mosquitoes is manually managed. If the
15 exact number of released mosquitoes is required, then they need to be manually counted. The pupae are today manually transferred from their storage containers to the release cages in a process which is demanding of time and manpower. The number of pupa stored in a few cubic centimeters can be very large, in the order of hundreds – the limit is the need for them to breathe on the surface, but then upon emergence, a large
20 cage is required to accommodate the large number of adult mosquitoes.

Releasing of the mosquitoes is done today by manually opening the cage. Typically, in the manual system, there are large numbers of dead insects in each cage, due to the fragility of the mosquito. It is this fragility which makes automation of any part of the process challenging.

SUMMARY OF THE INVENTION

A modular and scalable storage, transport and distribution device for fragile content such as insects involves distributing the insects by pushing them out of a storage area. Cartridges are disclosed which are designed for gentle distribution and also for integrated hatching and storage of the insects as well as for part of the rearing process,
30 for rearing from pupa to adult.

According to an aspect of some embodiments of the present invention there is provided a fragile substance storage transportation and release device, comprising:

a frame for inserting cartridges, the cartridges carrying the fragile substance;

5 a propulsion unit for propelling the fragile substance out of successive cartridges, cartridge by cartridge;

an opening mechanism for opening each cartridge;

the opening mechanism being coordinated with the propulsion mechanism to open the cartridge when the propulsion unit is in operation on the cartridge.

10 An embodiment may comprise cooling surfaces extending along the frame for contacting the cartridges to cool the cartridges.

An embodiment may comprise a warming mechanism for warming the fragile substance upon propulsion from a respective cartridge.

In an embodiment, the fragile substance comprises live insects.

15 In an embodiment, the propulsion unit comprises an air blowing unit for blowing air through respective cartridges.

In an embodiment, the air blowing unit is configured to blow air at a velocity selected for a predetermined species of insect.

In an embodiment, the species of insect is a mosquito species and the selected velocity is substantially 3m/s.

20 In an embodiment, the air blowing unit is configured to blow warm air.

In an embodiment, the device comprises one or more manifolds each respectively including an air pipe and a substance outlet, each manifold being configured to travel along the device over the cartridges to fix the pipe and the outlet over the cartridges one by one.

25 In an embodiment, the opening mechanism is connected to the manifold to reach each cartridge with the manifold.

In an embodiment, respective cartridges have an opening covered by a net and the opening mechanism comprises a cutter to cut the net over the opening.

30 In an embodiment, respective cartridges have an opening covered by a closure, the closure being held to the cartridge by breakable elements, and the opening mechanism comprises a cutter to cut the breakable elements over the opening.

In an embodiment, the cartridges comprise drainable liquid-holding compartments to hold pupae prior to hatching.

In an embodiment, the cartridges comprise an input port for connecting to pupa holding compartments, the input port being to allow insects hatching from the pupae to enter a respective cartridge.

In an embodiment, the input port comprises a counter for counting passing insects, thereby to control a number of insects in the respective cartridge.

In an embodiment, the cartridges are weighable to determine an approximate number of insects in a respective cartridge.

In an embodiment, the opening mechanism comprises a movable curtain having an opening, the moving of the curtain placing the opening against one of the cartridges to open the one cartridge.

In an embodiment, the opening mechanism comprises shutters placed opposite openings of respective cartridges, the shutters being openable by a manifold sliding between respective cartridges.

According to a second aspect of the present invention there is provided a cartridge for storage of fragile insects for distribution, the cartridge comprising:

a pupa hatching element;

a storage element; and

an outlet, the outlet being openable to release the insects.

In an embodiment, the pupa hatching element comprises a liquid container for holding pupae in water.

In an embodiment, the pupa hatching element comprises a drain opening for draining the water after hatching of the pupae.

An embodiment may comprise a controllable port for insects hatching from the pupae to pass into the storage area.

An embodiment may comprise a counter to count a number of insects entering the port.

An embodiment may comprise a movable plate to move across the storage area to the outlet to expel the insects via the outlet.

An embodiment may comprise an air inlet to connect to a source of air pressure and an air passage to allow the connected source of air pressure to blow air to propel the insects from the storage area towards the outlet.

5 An embodiment may comprise an air inlet to connect to a source of air pressure and an air passage to allow the connected source of air pressure to blow air to propel the insects from the pupa hatching element towards the storage area.

In an embodiment, the air inlet is closed by an openable shutter configured to be opened only when connected to the source of air pressure.

10 In an embodiment, the outlet is closed by an openable shutter configured to be opened when connected to an outlet pipe.

In an embodiment, the outlet is closed by netting.

In an embodiment, the drain is covered by netting.

In an embodiment, the netting covering the drain comprises an outer removable layer and an inner fixed layer.

15 The cartridge may be of adjustable size to store the fragile insects in an animated state and under cooling.

The cartridge may comprise internal surfaces to allow insects to stand thereon.

In an embodiment, the internal surfaces comprise shelves with openings therebetween to allow passage of insects.

20 According to a third aspect of the present invention there is provided a method of distributing fragile content comprising:

storing the fragile content in a storage location;

attaching a source of air pressure to the storage location; and

25 blowing air from the source towards an outlet to carry the fragile content to the outlet for distribution.

In an embodiment, the fragile content comprises fragile insects, the method further comprising applying cooling to cool the insects during storage and applying heating to warm the insects to reanimate for the distribution.

30 In an embodiment, the fragile content comprises fragile insects, the method further comprising hatching pupae into the insects in proximity to the storage location and blowing the insects into the storage location.

An embodiment may comprise placing a counter at an entrance to the storage location to count insects entering and to reroute further insects once a predetermined number of insects is reached.

An embodiment may comprise placing a weighing unit at the storage location to weigh the storage location and to reroute further insects once a predetermined weight is reached.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

Fig. 1 is a simplified diagram illustrating a mosquito life cycle;

Fig. 2 is a simplified block diagram illustrating a cartridge according to an embodiment of the present invention;

Fig. 3A is a simplified block diagram illustrating a transportation and release device according to an embodiment of the present invention;

Fig. 3B is the same as Fig. 3A but emphasizing that some cartridges may be left out or partially loaded so that the number of insects released can be more carefully controlled;

Figs. 4A and 4B are two views, with and without a cover, of a container for hatching pupae directing into a storage unit according to an embodiment of the present invention;

Fig. 5 is a simplified diagram of a telescoping storage unit for fitting on to the hatching container of Figs. 4A and 4B according to an embodiment of the present invention;

Fig. 6 is a simplified diagram showing an alternative arrangement for directly connecting a hatching container to a storage unit according to an embodiment of the present invention;

Fig. 7 is a simplified cross-sectional diagram of a hatching container with water for hatching pupae according to an embodiment of the present invention;

Fig. 8 is a simplified cross-sectional diagram of a hatching container connected to an input port for transporting hatched insects directly into a storage location according to an embodiment of the present invention;

Fig. 9A is a simplified diagram illustrating a telescoping storage location according to an embodiment of the present invention;

Fig. 9B is a simplified illustration from two different angles showing an array of cassettes in a frame of which one of the cassettes is telescoped outwards to an enlarged position according to an embodiment of the present invention;

Fig. 10 is a simplified cross-sectional illustration of a telescoping container similar to that shown in Fig. 9A and illustrating use of an air jet to ensure that insects are not trapped in the gap during telescoping, according to an embodiment of the present invention;

Figs. 11 and 12 are simplified cross-sectional diagrams illustrating an alternative to the embodiment of Fig. 9A in which a container is made of flexible material and is able to maintain two sizes due to device ends moving together and apart according to an embodiment of the present invention;

Fig. 13 is a simplified schematic diagram of a transportation and release device with a manifold according to an embodiment of the present invention;

Fig. 14 is a simplified schematic diagram illustrating the device of Fig. 13 filled with cartridges, and with the option to have both the pushing inlet and the insect outlet on the same side of the storage device;

Fig. 15 is a simplified schematic diagram illustrating the device of Fig. 13 with a cooling mechanism;

Fig. 16A is a simplified flow chart illustrating a procedure for rearing and loading insects into a cartridge at low density according to an embodiment of the present invention;

Fig. 16B is a simplified flow chart illustrating a procedure for high density loading of a cartridge according to an embodiment of the present invention;

Fig. 16C is a simplified flow chart illustrating a procedure for selecting high or low density packing according to an embodiment of the present invention;

Fig. 16D is a simplified flow chart illustrating a procedure for releasing insects from the cartridges, according to an embodiment of the present invention;

Figs. 17A, 17B, 17C, 17D, 17E, 17F, 17G, 17H and 17I are simplified diagrams showing various issues with the passage of insects through the tubes, according to an embodiment of the present invention;

Fig. 18A is a simplified diagram illustrating a cartridge with shelves for increased internal surface area to hold insects and a net or filter on the end, according to an embodiment of the present invention;

Fig. 18B illustrates the cartridge of Fig. 17 with break points to allow the opening mechanism to remove the filter for distribution of the insects;

Fig. 19A is a simplified diagram with inset illustrating a cutter or break point knife cutting the break points of Fig. 18;

Fig. 19B is a simplified diagram showing fully and partially connected cartridges, in accordance with an embodiment of the present invention;

Fig. 20 is a simplified diagram illustrating a sucking mechanism for drawing insects from the hatching area into the storage area, according to an embodiment of the present invention;

Fig. 21 is a simplified flow chart illustrating a procedure for filling cartridges to a predetermined weight or number of insects, according to an embodiment of the present invention;

Fig. 22 is a simplified diagram showing an alternative embodiment of the cartridge in which pupae are injected directly into a cartridge via a fill valve, according to an embodiment of the present invention;

Fig. 23A is a simplified diagram showing a modification of the cartridge to provide increased standing area for mosquitoes to settle on, according to an embodiment of the present invention;

Fig. 23B is a simplified diagram showing how a moving plate can be used as a propulsion mechanism in a cartridge modified to increase standing surface, according to an embodiment of the present invention;

Fig. 24 is a simplified schematic diagram showing a manifold passing over ends of cartridges with trapdoor openings, and a roller system for lifting up netting, according to an embodiment of the present invention;

Fig. 25 is a simplified diagram of a manifold passing over the ends of cartridges with curtain or screen openings, and the manifold lifting the screen, according to an embodiment of the present invention;

Fig. 26 is a simplified diagram showing two views of a curtain on rollers, the curtain moving up and down with a window traveling with the manifold, to open the cartridges when they are opposite the manifold according to an embodiment of the present invention;

Fig. 27 is a modification of the diagram of Fig. 26 with the manifold moved down to show the open window against a cartridge, according to an embodiment of the present invention;

Fig. 28 is a simplified schematic diagram showing a modified cassette in which the air inlet and the insect outlet are on the same side, according to an embodiment of the present invention;

Figs. 29 and 30 are simplified perspective and cross-sectional diagrams respectively of an alternative to the embodiment of Fig. 26 according to an embodiment of the present invention;

Figs. 31, 32 and 33 are perspective, cross sectional and filled perspective views of an embodiment in which the manifold includes a protrusion that opens shutters on the cartridges according to an embodiment of the present invention;

Fig. 34 is a simplified schematic diagram illustrating a further preferred embodiment of the present invention with an alternative arrangement of shutters;

Fig. 35 is a simplified flow chart illustrating tasks involved in expelling insects;

Fig. 36 is a simplified diagram showing an embodiment of a mechanism for continuous or semi-continuous expulsion of insects from a container;

Fig. 37 is a schematic view of an expulsion mechanism that may be used for the embodiment of Fig. 36;

5 Fig. 38 is a schematic view of a container or cartridge that opens from below to release the insects;

Fig. 39 is a schematic view of a variation of the container of FIG. 38;

Fig. 40 is a simplified diagram of the container of FIG. 38 or 39 with a conveyor belt;

10 Figs. 41 and 42 are simplified diagrams of a further embodiment of the present invention with a continuous release system based on a constant rate which is fixed by the pipe size;

Fig. 43 is a simplified diagram showing multiple containers of the embodiments of Figs 41 and 42 on a frame or rack;

15 Fig. 44 is a simplified diagram of containers according to the present embodiments in a refrigerator or like cooling container;

Fig. 45 is a simplified diagram showing containers according to the present embodiments on a frame and where the containers are coupled with the expulsion path;

20 Fig. 46 is a simplified diagram showing a moving shelf measuring system for obtaining a fixed quantity of insects;

Figs. 47 and 48 are simplified diagrams showing an intermediate storage element for allowing the insects to be warmed prior to expulsion according to an embodiment of the present invention;

25 Fig. 49 is a simplified diagram illustrating a container according to the present embodiments in which insects exit from the top; and

Figs. 50 to 54 are variations of an embodiment of the present invention in which the container or cartridge contains ribs to prevent lateral movement of the insects so that the insects fall vertically onto an underlying conveyor;

30 Fig. 55 illustrates a mechanism for opening flaps on a container according to embodiments of the present invention;

Fig. 56 is a simplified diagram of a double funnel for connecting two containers according to the present embodiments;

Fig. 57 is a simplified diagram showing two containers connected to the funnel of Fig. 56;

Fig. 58 is a simplified diagram showing a container and a system for controlling pressure throughout the cartridge and delivery pipes to the exit of the aircraft; and

Fig. 59 is a simplified diagram having multi-connection funnel with a control to control the pressure into the funnel so the suction can be increased and increase the acceleration of the insects.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to a device and method for storage, transportation and release of fragile insects and other fragile items and, more particularly, but not exclusively to the case where the fragile insects are mosquitoes and/or where the release is aerial release.

A fragile substance storage transportation and release device comprises a frame for inserting cartridges to hold the fragile substance; a propulsion unit for propelling the fragile substance out of successive cartridges, cartridge by cartridge; and an opening mechanism for opening each cartridge one by one in coordination with a propulsion mechanism. The device is useful for distribution of fragile insects such as mosquitoes and there is a mechanism for automatic collection of insects from pupae.

The device can be cooled, say using cooling surfaces or cooling pipes extending along the frame. The pipes contact and cool the cartridges to make the insects more lethargic and thus easier to store. At release however a warming mechanism may then warm the fragile insects. Release may be due to propulsion by an air draught which may be heated to reanimate the insects.

The cartridges may be designed to allow air to blow through them from a source to propel the insects towards the outlet. The air velocity may be selected for the particular species of insect being distributed. For example mosquitoes typically fly at a maximum speed of 1.5 m/s, so a velocity of 3m/s is too strong for them to resist being propelled along and yet is not so fast as to cause them damage.

The device may comprise a manifold including an air pipe and a substance outlet. The manifold may travel along the device over the ends of the cartridges to fix the pipe and the outlet over each cartridge one by one to distribute the insects from the cartridges

one by one. The opening mechanism may be connected to or be part of the manifold to reach each cartridge and open the cartridge just as needed. For example, the cartridges may have openings covered by a net and the opening mechanism may include a roller to roll up the net or a cutter to cut the net over the opening. Or the cartridges may have an opening covered by a closure held to the cartridge by breakable elements. The cutter may cut the breakable elements over the opening.

In order to obtain the insects, cartridges may comprise drainable liquid-holding compartments to hold pupae for hatching directly into the cartridge. This way considerable labor can be saved in obtaining the insects.

The cartridges may use an input port for connecting to the liquid-holding compartments, and a counter can count passing insects, thereby to control the numbers of insects getting into each cartridge. For example it may be desirable to have equal numbers of insects in the different cartridges and it is always advisable to avoid overcrowding and the resulting insect mortality. Instead of counting, weighing of the cartridge can be used.

The cartridges provide a storage location. A storage location is not just somewhere where the insect is ad hoc because it has to be somewhere, but is a location where insects are kept and maintained for a duration after hatching and prior to distribution, and which location is designed so that the duration may be arbitrarily long.

Returning to the opening mechanism, and one embodiment uses a movable screen or curtain having an opening. Moving of the curtain places the opening against the cartridges one at a time to controllably release the insects. Alternatively, the opening mechanism may use shutters. The shutters may be part of the cartridge or part of the frame but in either case open the cartridges one by one to controllably release the insects. The manifold may include a mechanism to open the shutters. For example the manifold may run a projecting member between the shutters to lever the shutters open as the manifold reaches the particular cartridge.

The cartridge itself may include a pupa hatching element, a storage element and an outlet. The pupa hatching element may comprise a drain opening for draining water after hatching of the pupae. The drain may be covered by netting to prevent escape of the insects during draining while still enabling air to move through the net in order to push away the insects towards the opening on the other side. In an embodiment, the

netting covering the drain may include an outer fixed layer and an inner removable layer. The outer fixed layer stays in position to prevent escape and the inner removable layer can be taken out to remove any detritus that may have landed on it. That is to say, the inner is fixed and water can go through and mosquitoes do not. The outer is a removable layer, before removing, it prevents water from spilling so the pupa can live. After hatching, the layer is removed, the water is cleared and the net above it prevent the mosquitoes from escaping. Irrespective of whether there are one or two layers of netting, a removable outer waterproof layer allows for draining.

Instead of an air stream to expel the insects as discussed above, a movable plate may be used to expel insects via the outlet. The moving plate has the advantage that it does not limit the length of the cartridge. The cartridge may be of adjustable size to have enough room to store the fragile insects in an animated state when they are flying around to take up less space when the insects are cooled.

A method of distributing fragile content may involve storing the fragile content in a storage location, attaching a source of air pressure to the storage location; and blowing air from the source towards an outlet to carry the fragile content to the outlet for distribution.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Reference is now made to Fig. 2, which is a simplified schematic block diagram showing elements of a cartridge device 200 used for storage and release of fragile insects according to an embodiment of the present invention. One part of the automation process is to eliminate the stage of manually collecting the pupae. In order to do this a pupa hatching or release element 201 is provided. Connectivity may be provided between the release device 200 and insect storage element 202, using shutter A 204 which is open during hatching to allow hatched insects into the storage element or location 202. Shutter B 206 allows for the insects to be released to the outside world as will be discussed in greater detail below. As an alternative to the cartridge device of Fig.

2, a combined pupa release and adult storage cartridge can be provided, and again, this is discussed in greater detail below.

Reference is now made to Fig. 3A, which is a simplified schematic diagram of a transportation and release device 220 according to an embodiment of the present invention. The cartridges can be of varying sizes depending on the application and the numbers of insects needed. A pushing device 222 may be used to push the fragile insects out of storage cartridges 224, for example using an air stream. The cartridges 224 may be those shown in Fig. 1 or alternatively may be combined pupa release and adult storage cartridges. As shown in Fig. 3, multiple cartridges 224.1 ... 224n may be used in the delivery system and a selectivity option may be provided to control the rate of release and alternate between the cartridges. The selectivity option may be provided by control and synchronization module 226, operating on shutter B 228 as will be discussed in greater detail below. The control and synchronization module may ensure that Shutter B 228 is opened in full sync with the operation of the pushing device 222.

A cooling mechanism 230 may be provided to keep the adult insects at low temperature prior to release. The low temperature reduces their activity and thus allows for more insects to be packaged in the same space and reduces energy expended.

Reference is now made to Fig. 3B, which is the same as Fig. 3A but emphasizing schematically that some of the cartridges can be removed or can be partially loaded so as to provide more precise control over the number of insects released. The storage is divided into sub-units for improved control and in fact different insects or substances can be released from the different cartridges.

In accordance with the present embodiments, a modified rearing process for rearing the modified mosquitoes may be provided along with the cartridges and the transportation release devices. The size of the cartridge or the number of insects contained therein allows for releasing of insects in pre-defined batch sizes.

Reference is now made to Fig. 4A, which is a simplified diagram illustrating a detachable container for allowing hatching of pupae. The container 240 allows for pupae to be kept beneath a water surface until they hatch to release an adult insect into the body of the container. The container can then be plugged into a separate cartridge for storage of the hatched mosquitoes. The back of the container contains netting 241,

which allows the water used to hold the pupae to be drained away afterwards without allowing for the insects to escape.

Reference is now made to Fig. 4B, which shows the detachable container with waterproof cover 242 covering the netting 241. The pupa box 240 may be supplied with a net 241 covering one face. Over the net there may be a cork or other easily removable waterproof element 242, for example a removable sticker, so that the box can be partly filled with water to provide the water surface needed by the pupae. Removal of the cork allows for the water to drain away and the net prevents the adults from escaping.

Referring now to Fig. 5, once the pupae have begun to hatch and box 240 begins to fill with adult insects, the box may be connected to storage element 244. A surface of the box includes a net 241 and a waterproof cover 242. Mosquito adults emerge from the pupa box and are stored in the storage box. The box stands on the surface having the net 241 and waterproof cover 242 and the waterproof cover is removed to expose the net and drain the box. The net 241 ensures that mosquitoes do not exit from the bottom as the cork or other waterproof covering is removed to allow the water out.

In some embodiments, there is more than one layer of netting. If necessary, the inner net may be removed while the second outer net remains attached. Elements such as dead mosquitoes and other detritus can thus simply be removed, again without giving an opportunity for the live insects to escape.

The opposite side of the storage box 244 may comprise an opening, and the opening may be sealed with a net. Sugar may be placed above the net (top), or the net itself may be soaked with sugar, as a way of feeding the insects. The box may have a telescoping section 245 to provide room for the insects while animated and prior to cooling, as will be discussed in greater detail below.

The trays of pupa and their matching cartridges may be arranged as a matrix of multiple storage elements, thereby increasing the quantity of the mosquitoes in a modular fashion.

Reference is now made to Fig. 6, which is a simplified diagram showing a variation of Figs. 4A, 4B and 5, where pupa tray 232 is placed at the bottom of cartridge 234. The pupa hatch and the insects rise into the space in the cartridge, for example on a current of air indicated by arrows 236. In this arrangement, shelves 233 provide additional standing room for the insects, and each shelf 233 has an opening underneath

to allow the insects to enter. The insects enter the cartridge directly from below and there is no need to reorient the cartridge after filling, unlike the embodiment of Figs. 4A – 5 where the hatching element has to rotated to drain. In this case there are openings on either side of the cartridge as before and also an opening underneath to allow water
5 to drain once the pupae have all hatched. The opening underneath may comprise a waterproof covering which is removed and a net which is not removed, to prevent escape by the insects, as with the previous embodiment.

Entry of the insects into the cartridge is thus vertical, on a vertical draught of air. The cartridge can be inserted horizontally into the storage and transport device and
10 remains in the horizontal orientation.

Reference is now made to Fig. 7, which is a simplified schematic diagram illustrating an embodiment showing multiple containers of pupae being arranged together.

In Fig. 7 pupa box 250 is a matrix which comprises three compartments or cups
15 252, 254 and 256. Each compartment is partly filled with water 258 and the water contains pupae which hatch.

Fig. 8 shows the arrangement of Fig. 7 being connected to a single storage cartridge. Parts that are the same as in Fig. 7 are given the same reference numerals and are not described again except as needed for an understanding of the present
20 embodiment. An open region 260 above the compartments leads to storage device 262 which is meant for storing the adult mosquitoes. An air flow, typically constant, may blow across the open region 260 towards storage area 262 and may thus take away every emerging adult from the pupa hatching element to the corresponding storage element or cartridge. Sensors such as IR sensors 264 may be placed at the passage ways
25 to 266 to identify movement of insects in the tubes towards the storage 262. The flow of air may provide a gradually decreasing temperature so that when the mosquitos arrive at storage area 262 they are knocked down. Knocked out insects require considerably less storage space and space is at a premium inside an aircraft. Mosquitoes can be grouped together and they barely move at temperatures below around degree Celsius. Thus tank
30 258 may be at room temperature so that the pupa may evolve and grow as needed, and then there may be a transition along the way until reaching 4 degrees Celsius at storage tank 262.

Once full, tank 262 may be disconnected and passed on to the next station – either loaded into a release system or poured into a smaller size storage for release or for awakening in small dosages for providing food.

The use of the IR sensors may provide information regarding how many insects are stored in each storage box or cartridge. In an embodiment the count may set an indicator when a preset number of insects is reached to allow for manual change of the cartridges. In this way, homogenous filling of multiple cartridges may be provided.

In an alternative embodiment the count may operate an automatic switch to open and close different cartridges, again enabling homogeneous filing.

Reference is now made to Fig. 9A, which illustrates an adjustable cartridge. In an embodiment, the cartridges can be adjustable, say by having telescoping side walls. Numeral 270 indicates a telescoping cartridge at maximum size. Numeral 272 illustrates a cutaway view of the open position. Numeral 274 shows a cutaway view of the cartridge in a minimal size position and numeral 276 illustrates the adjustable cartridge in the minimal size position.

The cartridges can thus be reduced in size after filling, in particular as the temperature is reduced so that insect activity is reduced prior to the release, as will be discussed in greater detail below.

Fig. 9B illustrates storage and transport device 277 in which one of the cartridges 278 has been telescoped outwards to provide room for the insects escaping from the pupae. Once the insects have escaped, the device is cooled so that the insects stop flying around and then the cartridge 278 can be slid shut into the minimal size position. The embodiment of Fig. 9B is particularly suitable for the pupa hatching arrangement of Fig. 6 above. The device 277 is shown with the telescoped cartridge side on in a) and end on in b).

Reference is now made to Fig. 10, which illustrates a telescoping cartridge 280. During the telescoping or size changing operation, air may be streamed along gaps 282 between the telescoping wall segments to ensure no mosquito is caught in the gaps during the process.

Reference is now made to Figs. 11 and 12 which show the large and small states of a variable size storage body or tank according to an alternative embodiment. In the present embodiment, the changing the size of a storage device may also be achieved

with a flexible or balloon-like material. Rigid walls 284 and 286 are disposed between flexible material 288 and the distance between the walls is adjusted to change the internal volume.

Reference is now made to Fig. 13, which illustrates a transportation and release device 290, which comprises a frame 292 designed to hold a stack of cartridges. An adjustable manifold 294 is raised and lowered over the frame to be applied to one cartridge at a time. The manifold 294 includes an outlet 296 (Fig. 14) at one end through which the insects leave the cartridge, and an intake 298 at the other end to connect an air pressure source to blow the insects in the exit direction.

Fig. 14 illustrates the frame 292 filled with cartridges. The cartridges are held in the frame both for storage and transportation, including transportation for release, and release is from the cartridges, cartridge by cartridge.

Reference is now made to Fig. 15, which illustrates a cooling system applied to the frame. A refrigeration source, not shown, is connected to cooling pipes 299 which extend vertically along the frame to contact each of the cartridges held in the frame. Each cartridge is in contact with a cooling pipe or cooling fin and thus is refrigerated, and the frame forms a refrigerating frame.

Reference is now made to Fig. 16A which is a simplified flow chart illustrating a procedure for rearing mosquitoes, usually male mosquitoes, and placing them in a cartridge according to the present embodiments. Mosquitoes are initially hatched and reared in water to the pupa stage 500. The pupae are then transferred to hatching chambers which may be parts of cartridges or may be connected to cartridges, 502. The hatching chambers are connected as necessary 504 and the outlet side of the cartridge is sealed 506. The adults emerge 508 and make their way to the storage area of the cartridge 510, helped as necessary by air currents.

Reference is now made to Fig. 16B which is a simplified flow chart illustrating a cartridge loading procedure. The cartridge is initially set to large (telescoped) size 512 and loading begins as insects start to arrive 514. Once loaded the cartridge is set to small size 516 as cooling is switched on 518.

Reference is now made to Fig. 16C which is a simplified flow chart illustrating the loading process in more detail. Rearing as in Fig. 16A produces pupae – 520. The user can choose between high or low density cartridge packing 522, depending on the

requirements. For high density, the telescoping procedure of Fig. 16B is used - 524. For low density the cartridge is used as is 526. The cartridge is loaded into the storage device 528 and then insects are released 530 using the procedure outlined in Fig. 16D.

Reference is now made to Fig. 16D, which is a simplified flow chart illustrating a release process for releasing the insects from the cartridges. Once all the cartridges are stored inside the storage device, and the cooling system is operational as needed, the frame with the cartridges may be taken to the release location. At the release location the pipe arrangement is lined up with the first cartridge whose content is to be released 300. The seal on the cartridge is broken or the cartridge is otherwise opened into the exit pipe. Air is streamed through the air intake to provide an air stream to blow the insects into the exit pipe, 304. Heat may be applied along the exit route to warm up and reactivate the insects after cooling 306 and finally the insects are blown out into the outside world 308.

Thus, instead of using vibrating plates or an auger system, the present embodiments blow the insects out using an air stream, which is far more gentle than the augur system and thus more suitable for fragile insects such as mosquitoes.

Returning again to Figs. 13, 14 and 15, and manifold 296 moves between each cartridge and may blow air at a typically constant speed of 3 meters per second. The speed may be changed according to the type of insect. The flight speed of mosquitoes is around 1.5 meters per second, thus 3 meters per second is too fast for them to resist but not so fast as to cause them injury.

On the other hand, the faster the individual cartridges are emptied and the higher the velocity of the air stream or the number of manifolds working in parallel, the greater is the release rate of the insects. The release device may move during release and the release rate divided by the distance covered may give a release density.

Now returning again to Fig. 16D, the airstream may be heated (~25 degree for mosquitoes) in order to awaken the cooled- down mosquitoes 304. Alternatively a heating element may heat parts of the exit pipes through which the exiting mosquitoes travel, to wake the mosquitoes traveling in the pipe before release.

The cartridges may remain sealed to contain the insects prior to release and may then be opened one by one as they are connected to the manifold. One side of the cartridge may have been unsealed prior to mounting into the device, say by removing a

cork or a sealant tape as shown in earlier figures – to leave netting, and allows the air supply to be connected as needed.

Reference is now made to Figs. 17A to 17H which are simplified schematic diagrams illustrating the passage of insects through the pipes. Figs. 17A to 17C illustrate various ways in which insects can get stuck in the pipes. As the air moves, the insects are pushed against each other – Fig. 17A. This in itself is problematic for the insects but they may also be pushed against each other to form into lumps Fig. 17B and even completely block the pipes, Fig. 17C.

The air stream may be continuous, or pulses of air or a combination Figs. 17D and 17E. The speed may vary during the continuous air stream or between the continuous air stream and the pulses which may be of higher speed. The reason may be to prevent insects from clinging to the side walls. Prevention is by means of pulses or continuous momentary high speed, for example a speed of 5-7 meter per second for a mosquito, other speeds as suitable for other insects, and then returning to a continuous low speed. As mosquitoes may try to cling once again to the side ways, additional pulses may be provided. As shown in Figs. 17F and 17G, as the pulses get under way they push apart the lumps and thus prevent blockages from being formed.

The period the air steam is active is calibrated in advance, depending on the type of insect/material, density and length of the device and pipes to the final release point. In one embodiment, after enough time has been allowed for all material or insects to be expelled, a final strong air pulse, say 10-15 meter per second for mosquitoes, is then applied for a final flushing out, to ensure that nothing remains within the storage element. A high speed flush may also be used for cleaning purposes, and pulses at an even higher rate may be used to clean the entire storage system and distribution pipes.

To insure the flow of the mosquitoes through the system when using air to push the mosquitoes out of storage and then along the distribution pipes, then as above air pulses can be used to prevent lumping. However, it is also possible to use a linear pipe system that provides air jets in critical positions. Nozzles can be provided at the critical positions at angles that ensure that the mosquitoes are moved forward.

Fig. 17H is a simplified diagram illustrating the provision of holes 309 in flow pipe 311, to provide air pressure to smooth the flow of the insects.

Reference is now made to Fig. 17I, which is a simplified diagram showing air

pipes extending along cartridge 310 and along the insect outlet pipe 312. The pipe terminals may meet to provide air pressure to blow air along the air outlet pipe 312. Referring now to Fig. 18A and the release end - Shutter B in the earlier figures, has a net filter 320 on the exit opening of the cartridge which is removed in sync with the operation of the manifold in order to enable the exit of the mosquitoes in accordance with the timing of the manifold.

In the embodiment of Fig. 18A, the way the net 320 is mounted on the end of the cartridge is correlated with the structure of the manifold, so that the net is automatically mechanically removed by the arrival of the manifold. The netting may be rolled up in one embodiment or cut in another embodiment.

Fig. 18B shows a variation in which break points 322 are provided on the netting, which are broken as the manifold fits over the cartridge.

Fig. 19A shows corresponding structure on the manifold to cut the netting at the break points. A break point knife 324 on the manifold 326 engages the break points 322 as the manifold fits over the cartridge and ruptures the break points. As a result the netting falls away. The insert shows how the break point knife gets behind the netting and cuts the break point.

Once the manifold has removed the net, the air stream pushes away the mosquitoes from the current cartridge out of the storage device and to the outside world through a set of pipes, either for direct release or towards other release devices, such as the aircraft distribution device disclosed in applicant's copending US Provisional patent application US 62/053,242 filed September 22, 2014, Method and Apparatus for Artificial Distribution of Insects, the contents of which are hereby incorporated by reference as if written herein in their entirety.

The two elements and actions – streaming the mosquitoes using an air stream and opening the exit may be controlled to occur simultaneously by a controller 226 (see Fig. 3), which may be calibrated and adjusted depending on the mission.

Reference is now made to Fig. 19B, which is a simplified diagram illustrating two different cassettes, one 332 partially connected to the outlet 326 and one 330 not connected at all to the outlet 326. The cartridges are loaded into storage, but the cartridges may only be partially loaded – depending on the quantity required to be released.

The ability to partly load different cartridges and the ability to control each cartridge separately allows one to decide on the quantity to be released at particular locations, something which is currently not possible with the auger and vibrating systems. An embodiment may even be able to release different materials at different
5 locations over a single flight.

The transportation and release device may be mounted on a vehicle, airplane or even a UAV as best suits the availability of resources and the intended release locations.

Reference is now made to Fig. 20, which illustrates a variation in which, instead of letting the mosquitoes emerge from the pupa and remain inside the storage element,
10 adult mosquitoes can be sucked into the cartridge using the same or a similar manifold system as that used to extract them for distribution. In Fig. 20 a net 340 is removed from the face of empty cartridge 342. Cartridge 342 is within cartridge storage device 344, and manifold 346 sucks insects in on a current of air.

Reference is now made to Fig. 21, which is a simplified flow chart illustrating a
15 procedure for filling cartridges based on weight, in order to fill the cartridges to optimal density as well as filling different cartridges equally.

In stage 350, the cartridge weight or counter indicator is set, or reset. The weight or counter indicator, which may be built into the cartridge, is used to determine how many mosquitoes have entered. A sufficient resolution may be in quantities of 100
20 or 1,000 mosquitoes. Initially, in stage 352, the cage hatch is opened to allow transfer of mosquitoes. In stage 354, the air flow is initiated. In stage 356, the cell is moved backwards and sealed 358, and the air flow is stopped 360, so that the cell can be weighed in stage 362. If the weight is right then the flow moves to the next cell. If the weight is too high then the seal is temporarily opened 364 to release some of the
25 mosquitoes. If the cell is too light then flow returns to stage 354 to continue filling.

Reference is now made to Fig. 22, which is a simplified diagram showing an alternative embodiment of the cartridge in which pupae are injected directly into cartridge 370 via a fill valve 372. The pupae fall to water in the bottom of the cartridge and hatch directly into the air space 374 of the tank. The fill valve 372 may be sealed
30 after use, and is used instead of the attachable pupa box described above.

A further embodiment is shown in Figs. 23A and 23B. The idea is to increase the surface area on which mosquitoes are able to stand. Fig. 23A illustrates a

rectangular design in which a cartridge 380 comprises inner plates 382. Fig. 23B shows a cell 390 containing circular pipes 392. The mosquitoes are able to stand on the pipe walls. A rectangular construction may include inner pipe like elements so that the mosquitoes stand on them instead of inside them.

5 In a further development, instead of pushing the mosquitoes away by blowing air inside the rectangular or circular element they are in, they can be pushed away by physically reducing their available space. This is less preferred because it may harm the mosquitoes. Moving plate 394 moves over the pipe elements and pushes the mosquitoes out. An advantage of the embodiment of Fig. 23B is that there is no limitation on the
10 length of cartridge 390, unlike the blowing or sucking mechanisms which have to be powered according to the length needed.

 Reference is now made to Fig. 24, which is a simplified diagram showing a multiple cartridge storage element 400 having a manifold 402 on a slideable mounting to ascend between the cartridges. A gate 404 is manually or automatically pushed up
15 along the cartridges. The gate 404 includes rollers 406 which may roll the net up as it moves long, thus opening the cartridge without tearing the net, and allowing the net to be reused. The net serves as a means to control which cartridge to use to push the mosquitoes out. Thus opening the cartridge using the manifold may be achieved in various ways apart from tearing the net element at the end as was described above.

20 Reference is now made to Fig. 25 which illustrates a simplified embodiment in which a curtain or screen type gate 420 is mechanically pushed up over cartridge 422 by manifold 424. In a) the gate 422 is fully closed. In b) and c) the manifold steadily pushes the gate 422 upwards. Finally in d) the gate 422 is fully open.

 Reference is now made to Fig. 26, which is a simplified diagram illustrating a
25 further option for opening individual cartridges in turn to release the mosquitoes. In Fig. 26 the net on each individual cartridge is replaced with a sliding element on the overall storage device. A two-way moving curtain 428 on the frame of the storage device is rolled up and down driven between upper roller 430 and lower roller 431 with an opening that travels with the manifold 432 to open the cartridges one by one.

30 In the embodiment of Fig. 26, the moving curtain is driven by drive elements centered on the roller 430 on top of the storage device, and the curtain has a window which is raised and lowered to correlate with the location of the opening of the desired

cartridge. Thus at given positions, different cartridges may be opened, and at any position of the curtain only one cartridge is opened. Separate curtains and rollers and provided for the air intake and the mosquito exit sides of the manifold.

Referring now to Fig. 27, and the curtain 428 and its corresponding rollers 430 and 431 are shown to be semi-transparent, revealing middle row cartridge 434 as the cartridge uncovered by the curtain 428 in the current position. Normally the open row would be covered by the manifold 432, but the manifold is here shown elsewhere for illustrative purposes. It will be seen that as the curtain is rolled up or down, different cartridges are exposed.

Referring now to Fig. 28, and a variation 440 of the manifold is shown in which the air inlet 442 and the mosquito exit pipes 444 are shown to be on the same side. Such a construction may be advantageous if space is scarce. In such a case curtain 428 and associated rollers 430 and 431 need be provided only on one of the sides, the opening in the curtain being able to cater for both the air inlet and the mosquito exit pipes at the same time.

In the above embodiments, the two elements of the manifold and the gate are synchronized so that they both open the same cartridge.

Reference is now made to Figs. 29 and 30, which are simplified schematic diagrams that illustrate a further embodiment of a storage and transportation device according to the present embodiments. Fig. 29 is a perspective view and Fig. 30 is a cross-sectional view of device 448. In the device of Figs. 29 and 30 the manifold 450 on the one hand and curtains 452 and 454 are arranged to be perpendicular. The manifold 450 travels across the ends of the cartridges as before, across the top of the device 448 along rails 456 and 458. The moving curtains 452 and 454 with their respective drive rollers 460 and 462 are seen on both sides.

Reference is now made to Figs. 31, 32, and 33 which are simplified schematic diagrams that illustrate a further embodiment of a storage and transportation device according to the present embodiments. Fig. 31 is a perspective view with a single row of cartridges, and Fig. 32 is a cross-sectional view of device 470. Fig. 33 is the same perspective view as Fig. 31 but showing the case of the device being filled with cartridges.

In device 470, shutters or doors 472 are mounted at the end positions of the cartridges. The shutters are opened as the manifold 474 passes over the row of cartridges.

In an optional mechanism for opening the shutters, the shutters 472 are mounted on hinges 476 and each shutter has a small protrusion 478 on the far side of the hinge away from the shutter. An extension 480 from the manifold travels up the line between opposing hinges and as it arrives at each row, the extension 480 pushes the protrusions of the shutters to force the shutters open.

Fig. 33 shows how the extensions 480 travel along the line between the shutters. All the shutters are shown open for illustrative purposes but it will be appreciated that in use only the shutters whose protrusions 478 are being pressed by extensions 480 are actually opened.

Reference is now made to Fig. 34, which is a simplified perspective view of device 490, which is a variation of the device 470 in which the cartridge ends are located on the side, and the shutters 492 are on one side of each cartridge. As manifold 494 passes each row of cartridges, the shutters 492 are opened.

In an embodiment, the cartridge can be pre-pressurized. In such a case all closures must be air-sealed. A pressurized cartridge may do without a separate air pressure source and may be useful for handheld insect distribution devices or for use in other cases where weight is critical. The pressurized cartridge then scatters the insects automatically simply by removing a cover from the outlet, and continues to scatter until the air pressure equalizes.

The present embodiments can be used for any delicate or fragile material that needs to be delivered or sprayed over a large area, for example materials that comprise nano-particles, sprays of various kinds, lures for various purposes, typically biological purposes, that need to be distributed over a large area, and other delicate insects such as moths, flies, and the like. Various parameters of the device, such as air blowing speeds, temperatures, including both the temperature at distribution and the storage temperature, storage density, distribution densities, etc, may be altered according to the needs of the species or material being distributed and the distribution requirements. The general geometry of the device, tightness of corners, numbers and distribution of shelves, arrangement for hatching of pupae, shapes of cartridges etc. may need to be different.

In embodiments, there may be separate shelves or tubes or other sub-containers within each cartridge. In such cases there may be connecting tubes between the sub-containers or between the shelves to keep air or insect densities constant within the cartridge.

5 The storage and transport devices are scalable. The system can be designed so that cartridges are standard size, but different size storage and transport devices store more cartridges as needed. Alternatively, the cartridges themselves may vary in size, say being made longer or shorter, and thus fitting in to different storage and transport devices. The overall size is selected for the particular distribution means. Thus at one
10 extreme, distribution via a relatively large aircraft may use a single large storage and transport device connected to outlet pipes on the aircraft, and at the other extreme, smaller devices may be used say for hand distribution or distribution from the back of a motorcycle.

As discussed above, the present embodiments relate to storing mosquitoes or
15 other insects, in particular fragile insects and then effectively releasing the insects using an ejection means such as air, to the outside world.

Ejection of the mosquitoes can be from an ejection cartridge. A switching element may be provided for quick switching between cassettes or storage elements – providing the option for continuous release in the case that release is from a different
20 cartridge each time.

There are a number of ways of obtaining the material, such as the mosquitoes, from the storage element, as discussed herein.

In the case of a single storage unit, ejection may be from the bottom, from the top or from the sides of the cartridge. Multiple storage units may work the same way.

25 In the following embodiments a number of methods are shown for obtaining predetermined measured quantities of the material, insects etc during release from the storage units.

One method is to store a measured quantity of the material in advance per each cartridge/storage unit.

30 Another method involves measuring out quantities in real time from a larger storage. Thus an automatic system may retrieve a measured quantity of insects each time for their release.

The measuring stage may be used to separate between storage and ejection of the material.

An option is to move the material through indexed cells, providing the insects with time to warm up and awaken from cold storage while being measured.

- 5 The number of cells, that is the index number, may be set as appropriate to allow the insects sufficient time to awaken.

Reference is now made to Fig. 35, which is a simplified flow chart showing the options for awakening and providing a predetermined dosage, that is amount of material or insects. In some cases the stored insects are already in the correct dosage, thus in box 10 500 the answer is yes and the process moves to stage 504, where it is determined whether awakening is required. Alternatively, measurement has to be carried out to produce the correct quantity, box 502, and box 504 is reached following measurement of a quantity. In box 506 the insects are awakened, typically by being warmed after cold storage. Finally in box 508 the awakened and measured insects are ejected.

- 15 Fig. 35 relates to the design process of the system, and in some cases, awakening and measuring, if both required, would take place at the same time.

Reference is now made to Fig. 36, which is a simplified diagram showing views from the side and from above of multiple cartridges 510 one underneath the other in a container 512, each having a predetermined quantity of insects and designed for release 20 from the side. Each cartridge is connected to an air pressure source 514, and shutters 516 at the entrance to each cartridge open in sequence to expel the insects from the cartridge away from the air pressure source, thus expelling a predetermined quantity of insects for each shutter opening event.

Reference is now made to Fig. 37, which is a schematic diagram showing one 25 way in which two of the cartridges of Fig. 36 may work. Two cartridges, 517 and 518 are connected to air blowers 520 and 522 respectively. Each cartridge has shutters at each end, 524, 526, 527, and 528. At the end opposite to the air blowers, hereinafter the receiving ends, 530 and 532 the cartridges are connected to ejection device 534 to eject the insects. The receiving end may comprise a funnel or hopper.

- 30 Control 536 may operate the shutters at the air blower end or at the receiving end as preferred in order to provide a continuous stream of insects at a steady rate or to provide intermittent measured doses.

The embodiment of Fig. 37 may allow expelling each time of a pre measured dosage, as per each cartridge. An advantage is that there is no need to sort, count or separate insects in real time, there are no moving parts moving the insects for sorting, and hence there is less chance of doing damage to the fragile insects.

5 Controller 536 controls timing and duration for each element in the system. The controller determines when each of the blowers 520 and 522 are blowing air, how strong (air velocity) and for how much time, when input shutters 524, 527, 529 are open and closed, and when receiving elements 530 and 532 are connected to shutter 526 and 528 for receiving insects.

10 Reference is made to Fig 38, which shows top and perspective views respectively of a storage unit for release from below. Storage unit 540 funnels downwards to shutter 542 which is arranged alongside air pipes 544, 546, that are arranged on either side of the shutter in the funnelled part of the storage unit. The pipes open into nozzles 548 and air is driven from the nozzles to push the insects downwards
15 to the opening when the shutter is opened. The shutter can be default open or default closed, and controlled to be other position as needed.

 Reference is briefly made to Fig. 39, which is a simplified diagram of another container 550 that opens below, in which shutter 552 can be controllably closed when a predetermined amount of insect material has been released, using lever 554, which is
20 typically mechanically operated.

 Reference is now made to Fig. 40, which is a simplified diagram showing the bottom release containers of either of Figs 38 and 39, in which a conveyer is used to catch the falling insects and transport them to the expulsion mechanism. The insects in container 560 fall from the shutter 562 onto conveyer 564, as conveyer 564 passes
25 underneath.

 Reference is now made to Figs. 41 and 42, which show different angles of an embodiment of a container and extraction mechanism designed to give a continuous dose of insect material. The vibrator continuously expels mosquitoes into the funnel. The release is approximately at constant rate due to the mechanism.

30 Container 570 is vibrated by vibration mechanism 572 to expel insects into a funnel 574 fixed at the front of container 570. The funnel allows the insects to fall at a steady rate into release tube 576. A sensor detects when the release tube is full and then

closes the funnel 574. Blower 578 then expels the insects and the process is repeated until the container 570 is empty, thus providing a measured amount each time. Arrow 580 shows the direction of moving material.

Reference is now made to Fig. 43, which is a simplified diagram showing four
5 of the containers of Fig. 41 mounted together in a frame. As shown, four containers 590 are held together in frame 592.

Reference is now made to Fig. 44 which shows the four containers of Fig. 41 mounted, not in a frame, but in a temperature-maintaining cabinet 594. The temperature
10 maintaining cabinet may be a refrigerator, or simply a cooler or may be attached by a pipe or the like to a cold source.

Reference is now made to Fig. 45, which is a simplified diagram showing an embodiment in which multiple containers are mounted together and each container is directly connected to an ejection pipe. Frame 596 holds multiple containers 600. Insects from container 600 fall into release pipe 602 which receives air from air source
15 604 at a speed of around 2 – 15m/s. The insects are then blown towards the release point.

Reference is now made to Fig. 46, which is a simplified diagram illustrating an alternative embodiment of a way of providing a controlled dosage of insect material. Two funnels 610 and 612 are attached to two containers (not shown here but see
20 previous figures) and lead to a moving shelf 614 held in housing 616. Air source 618 is attached to the housing 616 and exit pipe 620 leads to the point at which insects are expelled from the plane.

Insects fall from the containers into the respective funnel 610, 612 and into pipes 622, 624 inside the moving shelf 614.

25 A laser or like sensor measures the height of the insects inside the cartridge, and when a predetermined height is reached or after a predetermined time duration, the moving shelf 614 moves horizontally to align the pipe 622, 624 with the exit pipe 620. The air source then blows along the aligned pipes to expel the insects.

The shelf moves across to service the second pipe while the first pipe refills.

30 Reference is now made to Figs. 47 and 48 which are perspective and plan views respectively of an embodiment for providing a measured amount of insect material and also to allow for awakening of the insects.

Containers 630 are vibrated by vibrators 632 and connected to funnels or
hoppers 634. Insects enter from the hoppers 634 to the moving shelf arrangement 636
described in respect of the previous two figures. The exit pipe 638 is connected to air
pressure source 639 (Fig. 48) and leads to a carousel 640 of horizontal pipes 642 which
5 serve as temporary storage cartridges and warm the insects before release. Air pressure
source 644 connects to the pipe that is at any given time aligned with output pipe 646
(Fig 48). The carousel thus has a fixed input position, aligned with pipe 638 and a fixed
output position, aligned with pipe 646. The insects remain in the pipes as they rotate
and can be warmed to revive them.

10 With the embodiment of Fig 47, instead of directly releasing the insects from the
moving shelf arrangement 636, it is possible to store them inside the horizontal pipes or
temporary storage cartridges 642.

The temporary storage pipes can be warmed if needed, and thus enable chilled
insects to awaken. The air pressure source 644 pushes the insects from their cartridges
15 to the release point.

It is noted that the temporary storage tubes 642 are horizontal. The awakening
insects, being spread along the horizontal tube, are able to move sideways during
awakening, which they would be unable to do if they are stored in vertical
configuration.

20 Reference is now made to Fig. 49, which is a simplified diagram showing
perspective and plan views of a further embodiment of the present invention for
providing a measured amount of insect material.

In Fig. 49 storage containers 650 are designed for the insects to be removed
from the top. The containers are vibrated and the insects move up spiral pathway 652 to
25 exit pipe 654. The insects are fed into hoppers 656 and moving shelf arrangement 658
provides a measured amount of insect material each time to exit pipe 660.

Reference is now made to Figs 50 to 54, which show another embodiment for
obtaining a measured amount of insect material. In the embodiment shown in Fig. 50,
frame 660 holds multiple horizontally extending cartridges 700. The mosquitoes are
30 stored in the cartridges 700 and the cartridges have ribs or dividers 702. The cooled
mosquitoes are poured into the cartridge in comatose state in preparation for
distribution. Full of comatose mosquitoes, sliders 704 that are underneath can be

removed, and the mosquitoes fall out into conveyors 710 which underlie each container. The conveyors empty into hoppers 662 which in turn empty into sliding shelf arrangement 664, to produce a measured dose as discussed above. A single cartridge can be separated into more than one part by introducing separate sliders 704, which all
5 operate separately. The use of separate compartments and separate sliders can give greater control to the number of insects being expelled at any given movement and also to the height as per which the mosquitoes are piled up one on top of the other is smaller. A typical height may be about 4 cm per each floor.

The ribs inside the cartridge ensure that upon opening the slider, the mosquitoes
10 fall down directly from the closest hole onto the conveyor 710 beneath, and are not dragged lengthways first.

The slider 704, which may be a door on the bottom or a sliding element opens the opening on the bottom and the mosquitoes fall down. As an alternative to sliding, the door may be turned on an axis.

As shown in Fig. 50, air pressure sources 706 may blow the mosquitoes to their
15 next station, for example the outlet. The conveyor pushes the insects to the sliding shelf to ensure (a) the dosage is correct and/or (b) there is no interference due to air turbulence.

As shown in Fig. 51, cartridge 700 may lie over a conveyer 710. The insects fall
20 from the cartridge 700 onto conveyor 710, which moves in the direction of arrow 712. The insects then fall onto receiving funnel 714 and are pushed, typically by air pressure, to the outside. In the embodiment of Fig. 51, the speed of the conveyor actually determines the dosage / quantity of insects. In an example a height of 40mm of knocked out mosquitoes inside the cartridge, are extracted by a conveyor with a speed of 8mm
25 per second. The cartridge thus releases some 2,000 mosquitoes per second.

Greater heights are possible but then more mosquitoes are released per second and control is less exact.

The funnel 714 can be combined with the moving shelf of earlier embodiments to provide a more accurately measured dose.

Fig. 52 shows two cartridges 700 connected via two conveyors 710 to a single
30 output hopper 720. The connection of two cartridges in this way combines a controlled height of insects with a faster output rate.

Reference is now made to Fig. 53, which is a simplified diagram showing details of the cartridge 700 with sliders 704, conveyors 710 and output hoppers 720. Detail of the ribs 702 is shown.

As shown in Fig. 54, instead of falling down and being released while knocked
5 down, mosquitoes can be transferred to awakening cells 722, in which the temperature is raised, allowing the mosquitoes to awaken from their comatose state prior to being ejected to the outside via exit pipe 724 using air pressure source 726.

Reference is now made to Fig. 55, which shows a flap opening mechanism for opening multiple flaps in a storage container having multiple compartments, to allow
10 the insects to exit. Container 750 has flaps 752 underneath each compartment that are opened with levers 754.

Fig. 56 shows a funnel construction for a single funnel 760 with openings to be connected to two containers. Exit pipe 761 conveys the insects for expulsion. Exit pipe 761 may be constructed to provide a vacuum in the rear part of the pipe upon
15 having air pressure brought to the middle part, and thus provide suction from the rear part towards the front part. The result is to push the insects away, instead of blowing from behind with a risk of turbulence inside the funnel.

Fig. 57 shows the funnel 760 with two containers 762 and 764 connected via containers 710.

Fig. 58 is a simplified diagram showing a container and a system for controlling
20 pressure throughout the cartridge and delivery pipes to the exit of the aircraft. More particularly interior of aircraft 800 has a different pressure and airspeed from exterior of aircraft 802 and the present embodiments are to manage the insects' transition between the two. Pressure control 804 applies pressure to cartridge 806 and interface 808 –
25 where the interface is any of the cartridge emptying and delivery systems discussed above. Delivery pipe 810 leads to the exterior, and the controlled pressure is provided to the delivery pipe.

Likewise, Fig 59 shows the option in which the cartridge 806 is held at pressure. As the mosquitoes pass interface 808 on the way to the exit, pressure control 808
30 controls the pressure and may increase the pressure, hence increasing the air speed inside the pipes and thus accelerating the mosquitoes to the exit point. The pressure increase creates a situation in which the mosquitoes are delivered outside of the moving

vehicle/aircraft at a speed closer to the air speed of the outside and reducing the wind shear impact.

The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

5 The term "consisting of" means "including and limited to".

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination
10 in a single embodiment, and the above description is to be construed as if this combination were explicitly written. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention, and the above description is to be construed as if
15 these separate embodiments were explicitly written. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations
20 will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same
25 extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. A fragile insect storage, transportation and release device for release of insects, the insects being fragile insects, comprising:

a frame for inserting cartridges,

a plurality of cartridges carrying the fragile insects, each of said plurality being inserted into said frame;

a propulsion unit configured to propel said fragile insects out of successive cartridges, cartridge by cartridge for release;

an opening mechanism for opening each cartridge;

the opening mechanism being coordinated with the propulsion mechanism to open a respective one of said cartridges when said propulsion unit is in operation on said respective cartridge.

2. The device of claim 1, further comprising cooling surfaces extending along the frame for contacting the cartridges to cool the cartridges, and/or further comprising a warming mechanism for warming the fragile insects upon propulsion from a respective cartridge.

3. The device of claim 1, wherein said propulsion unit comprises an air blowing unit for blowing air through respective cartridges, and/or wherein said propulsion unit comprises a vibrator for vibrating the cartridge, and/or wherein said propulsion unit comprises a pressure source, and pressure produced by said pressure source is controlled to provide a defined velocity for insects exiting said aircraft.

4. The device of claim 3, wherein said air blowing unit is configured to blow air at a velocity selected for a predetermined species of insect, said species of insect being a mosquito species and the selected velocity being substantially 3m/s.

5. The device of claim 1, wherein said device comprises an intermediate storage area to warm said insects, the intermediate storage area comprising a series of

horizontally placed storage containers rotating between a fixed input location and a fixed output location.

6. The device of any one of the preceding claims, wherein said device comprises one or more manifolds each respectively including an air pipe and an insect outlet, each manifold being configured to travel along said device over said cartridges to fix said pipe and said outlet over said cartridges one by one.

7. The device of claim 6, wherein the opening mechanism is connected to said manifold to reach each cartridge with said manifold, and/or wherein said opening mechanism comprises shutters placed opposite openings of respective cartridges, said shutters being openable by a manifold sliding between respective cartridges

8. The device of claim 7, wherein respective cartridges have an opening covered by a net and said opening mechanism comprises a cutter to cut said net over said opening, and/or wherein respective cartridges have an opening covered by a closure, said closure being held to said cartridge by breakable elements, and said opening mechanism comprises a cutter to cut said breakable elements over said opening.

9. The device of any one of the preceding claims, wherein said cartridges comprise drainable liquid-holding compartments to hold pupae prior to hatching, and/or wherein said cartridges comprise an input port for connecting to pupa holding compartments, the input port being to allow insects hatching from said pupae to enter a respective cartridge.

10. The device of claim 5, further comprising a receptacle for receiving a predetermined amount of said fragile insects from said containers and wherein said device is configured to carry out an expulsion action upon being filled with said predetermined amount.

11. The device of any one of the preceding claims, further comprising a conveyor moving at a preset rate to collect said fragile insects for expulsion.

12. The device of any one of the preceding claims, comprising a pupa hatching element; and wherein said cartridge comprises a storage element; and an outlet, the outlet being openable to release said insects.

13. The device of claim 12, comprising a controllable port for insects hatching from said pupae to pass into said storage element, and/or a movable plate to move across said storage area to said outlet to expel said insects via said outlet, and/or an air inlet to connect to a source of air pressure of said propulsion unit and an air passage to allow said connected source of air pressure to blow air to propel said insects from said pupa hatching element towards said storage area, and/or wherein said outlet is closed by an openable shutter configured to be opened when connected to an outlet pipe.

14. A method of distributing fragile insects comprising:
storing said fragile insects in an insect storage location in a plurality of cartridges held together in a frame;
attaching a source of air pressure to said insect storage location; and
using said air pressure to carry said fragile insects from successive cartridges at said insect storage location

15. The method of claim 14, further comprising hatching pupae into said insects in proximity to said storage location and blowing said insects into said storage location.