

SYSTEM AND METHOD FOR REARING INVERTEBRATES**Technical Field**

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The invention relates to a method and system for rearing invertebrates, more specifically insects, in a climate controlled environment. The present invention also relates to a crate for use in the method and system.

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Background to the invention

Insects and their larvae can be used as an animal protein feeds, and for this purpose it may be desirable to farm insects on a large scale. Systems for producing and/or breeding insects on a large scale are known in the art.

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For example, United States Patent 5,158,497 discloses an illuminated dome for the controlled mixing of flying insects. International Patent Publication No. WO 2014/171829 describes a method and system for breeding insects in a climate controlled environment. The system and method comprises a plurality of stacked crates configured to contain insects and/or larvae, and a system for controlling airflow through the crates.

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Problems associated with known systems may include inadequate or inconsistent climate control, insect containment issues, limited capacity for observation, and disruptive insect or larvae 'crawl out' (where larvae and/or insects escape from a designated area).

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Summary of the invention

The present invention seeks to solve one or more of the above problems by providing an improved system, method, and crate for insect rearing.

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Accordingly, in a first aspect of the invention, there is provided a system for rearing invertebrates, the system comprises

a plurality of crates arranged into at least one stack, each crate in the stack defining an airflow path there through from an inlet opening in a first wall to an outlet opening in a second wall opposite the first wall;

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a climate chamber comprising:

an internal volume enclosed by walls, a floor, and a ceiling;

a first row of air outlets extending in a first direction 1ST within the internal volume;

a second row of air outlets extending parallel to the first row of air outlets within the internal volume;

a row of air inlets located between the first and second rows of air outlets, and extending parallel thereto, and spaced apart from the first and second rows of air outlets in a second direction 2ND, perpendicular to the first direction 1ST;

5 at least one first stack of crates arranged in a space between the first row of air outlets and the row of air inlets;

at least one second stack of crates arranged in a space between the second row of air outlets and the row of air inlets;

10 a conduit extending from each of the plurality of air inlets between the first and second stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack;

wherein the crates are arranged with the airflow path oriented perpendicular to the first direction 1ST.

15 The system of the present invention allows for a tightly controlled, automated environment for growing insects, e.g. such as living insect larvae, e.g. black soldier fly (BSF) larvae. In particular, the system provides accurate control of environmental conditions in each crate, thereby ensuring an even, consistent, and predictable growth of insects within each crate and thus consistent and predictable growth of insects in each stack of crates.

In a second aspect of the invention, there is provided a method for rearing invertebrates, the method comprising the steps of:

20 (i) providing a plurality of crates, each crate having a first opening in a first wall and a second opening in a second wall opposite the first opening to define a first air flow path between the first and second openings;

(ii) filling at least a portion of each crate of the plurality of crates with a substrate and a plurality of invertebrates at a first developmental stage;

25 (iii) stacking the plurality of crates;

(iii) providing a climate chamber comprising:

an internal volume;

a climate chamber comprising:

an internal volume enclosed by walls, a floor, and a ceiling;

30 a first row of air outlets extending in a first direction 1ST within the internal volume;

a second row of air outlets extending parallel to the first row of air outlets within the internal volume;

35 a row of air inlets located between the first and second rows of air outlets, and extending parallel thereto, and spaced apart from the first and second rows of air outlets in a second direction 2ND, perpendicular to the first direction;

at least one first stack of crates arranged in a space between the first row of air outlets and the row of air inlets;

40 at least one second stack of crates arranged in a space between the second row of air outlets and the row of air inlets;

a conduit extending from each of the plurality of air inlets between the first and second stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack;

- (iv) positioning at least one stack of crates wherein the crates are arranged with the airflow path oriented perpendicular to the first direction 1ST;
- (v) applying a pressure differential between the air inlet and the air outlet.

The method of the present invention provides the same advantages as the aforementioned system, i.e. allowing for tight control and automation of growing insects, e.g. such as living insect larvae, for example BSF larvae, such as BSF larvae 0 – 5 days of age or BSF larvae 4 – 20 days of age, e.g. 5 – 16 days of age. The method provides accurate control of environmental conditions in each crate, thereby ensuring even, consistent and predictable growth of insects within each crate and thus consistent and predictable growth of insects in each stack of crates.

So given the system and method of the present invention, problems often encountered in the prior art may be dealt with and resolved in that adequate and consistent climate control is provided, containment issues are eliminated or significantly reduced, sufficient or improved capacity for observation is achieved, and insect/larvae 'crawl out' is prevented or mitigated.

In a third aspect of the invention, there is provided an invertebrate rearing crate configured for use in the aforementioned system and/or in the aforementioned method, wherein the crate comprises a base, upstanding side walls and upstanding end walls defining a perimeter around the base, and at least one sensor mounting region in the base of the crate.

The invertebrate rearing crate of the present invention allows for more accurate monitoring of environmental conditions in a crate and as such the crate is ideally suited for use in the system and/or method above for achieving adequate and consistent climate control. Moreover, the crate is ideally suited for use in the system and/or the method above for prevention of insect/larvae 'crawl out' and for prevention of contamination of the system by larvae crawled out of the crate.

Brief description of the Figures

The present invention will now be described with reference to a number of non-limiting, illustrative examples, as shown in the following drawings, in which:

Figure 1A shows a climate chamber in accordance with an embodiment of the invention, the climate chamber containing a plurality of crates;

Figure 1B shows a top view of the climate chamber shown in Figure 1A in accordance with an embodiment of the invention, the climate chamber containing a plurality of air inlets 18 and air outlets 20;

Figure 1C shows a top view of the inner volume of the climate chamber shown in Figure 1A in accordance with an embodiment of the invention, without crates 4 or pallets 8 positioned onto tracks 10;

Figure 2A shows a perspective view of a stack of crates from Figure 1;

Figure 2B shows a perspective view of a track with two walls defining a channel and a robotic device configured to move in the space defined by the walls;

Figure 3A shows a perspective view of an individual crate;

Figure 3B shows a side view of the crate from Figure 3A; and

5 Figure 4 shows a climate chamber according to an embodiment of the invention.

Detailed description of the drawings

10 An exemplary system 1 according to the invention is shown in Figure 1A and Figure 1B, which shows a front view of a climate chamber 2 configured to contain a plurality of crates 4 and which shows a top view of said climate chamber 2. The crates 4 are arranged in stacks 6. In the illustrated embodiment, each stack of crates rests on a pallet 8. Each pallet 8 receives four stacks of crates 4, in a 2 x 2 arrangement. However, it will be appreciated that a pallet 8 can comprise more than four stacks of crates
15 or fewer than four stacks of crates.

Each pallet 8 rests on a track 10 that comprises a pair of upstanding walls 12 separated from each other by a channel 14. The upstanding walls 12 are configured to support the pallets 8 above the channel 14. The track 10 is configured to receive one or multiple pallets 8, e.g. by arranging the pallets 8 in rows.

20 Each track 10 is separated from an adjacent track 10 by a gutter 16. Each gutter 16 is separated from an adjacent channel 14 by an upstanding wall 12 that forms one of a pair of upstanding walls 12. In this manner, a series of parallel tracks 10 can be formed, each separated from each other by the gutter 16, with a channel 14 formed under each row of pallets 8.

It will be appreciated that the system 1 can be configured such that the pallets 8 are omitted,
25 and the stacks of crates 4 rest directly on the tracks 10, e.g. on the upstanding walls 12. However, in such an embodiment the dimension of the crates should be sufficient to span the width of the channel 14, to rest on the upstanding walls 12 that form the track 10. Alternatively, the crates 4 can be secured to each other along adjacent edges 44 and/or 46 (see e.g. Figure 3A) to span the channel 10 and support the stack of crates 6 above.

30 As shown in Figure 1, the climate chamber 2 comprises a generally closed volume. Access to the chamber 2 is possible through openings, for example, windows, doors, access shafts. However, the chamber 2 is preferably a substantially closed volume when all access points (e.g. doors, windows, hatches) are closed. The chamber 2 can be an internal space in a fixed building, or it can be an internal volume of a portable structure, for example, a shipping container, a reefer, a truck trailer, a freight plane.

35 Each chamber 2 can comprise a plurality of multiple rows of stacked crates 4. The climate chamber 2 is configured with a ventilation or climate control system 84 configured to manage and control the climate conditions within the crates 4. To ensure that the larvae and/or insects stored within the crates develop at the same or similar rates, the climate conditions within the crates 4 (e.g. temperature, humidity) are closely controlled.

The climate control system 1 preferably comprises at least one air inlet 18 configured to introduce climate controlled air to the chamber 2, and at least one air outlet 20 configured to extract air from the chamber 2.

5 The air inlet(s) 18 are preferably provided on a first side of the crates and the air outlet(s) 20 are preferably provided on a second side of the crates 4. By providing (an) air inlet(s) 18 on a first side of a stack of crates 4, and an air outlet 20 on an opposing side of the stack of crates 4, a flow of climate controlled air through or across the crates 4 can be achieved.

10 Moreover, as depicted in Figure 3A and as described in more detail below, in a stack 6 comprising a plurality of crates 4 stacked on top of one another, the openings 48 in the side walls of the crates 4 create a plurality of air flow passage ways 80a extending through the stack 6 and preferably at equally spaced intervals.

In the embodiment shown in Figure 1A and B, a plurality of air inlets 18 and air outlets 20 are provided through a ceiling 22 of the chamber 2. The chamber 2 is sub-divided into a plurality of sub-chambers 2a, 2b, each comprising two tracks 10. The sub-division of the chambers 2a, 2b can be
15 achieved by providing dividers 24, such as walls, separators, or curtains and the like between tracks 10, e.g. between every two tracks 10. Preferably, the dividers 24 are spaced from the tracks 10 by a gutter 16. Accordingly, for example each chamber 2a, 2b comprises a first wall 26, a first gutter 28, a first track 30, a second gutter 32, a second track 34, a third gutter 36, and a second wall 24, e.g. the dividers 24, and a back wall 100 (front wall 100 not shown).

20 As shown in Figure 1A, the crates 4 are arranged such that the air inlets 18 are provided above the second gutter 32, between the first and second tracks 30, 34. In other words, the air inlets 18 open into the space between the first stack 6a of crates 4 and the second stack 6b of crates 4. The air outlets 20 are e.g. provided above the first and third gutters 28, 36 between the stack 6b of crates 4 and the dividers 24 and between the stack 6a of crates 4 and the first wall 26. Accordingly, the air outlets 20
25 open into the space between the track 34 and the second wall 24, and the track 30 and the first wall 26. By arranging the air inlets 18 and air outlets 20 in this manner, climate controlled air can be introduced between the rows of stacked crates 4 and subsequently drawn through each stack of crates 4 towards the air outlets 20, which are positioned on opposing sides of the stacks of crates 4. The air flow through the crates will be described in more detail with reference to Figure 2.

30 As shown in Figure 1A and 2A, climate controlled air can be delivered from the air inlets 18 to the crates 4 via a conduit 38 extending from the air inlets 18 towards the gutter 16. The conduit 38 preferably comprises a series of openings 40, aligned with openings of the crates (described in more detail below). The conduit 38 may comprise a rigid conduit or a flexible conduit such as a hose or an air sock.

35 In Figure 1C, a top view of the inner volume of the climate chamber shown in Figure 1A and 1B, is shown, without pallets and crates placed onto walls 12 or ledges 14a. Conduits 38 located between channels 14 are depicted, as well as flow paths 80a running perpendicular to the direction of the tracks 10. The skilled person will appreciate that the relative orientation of the combination of the tracks 10, bearing stacks of crates, and the conduits 38 comprising the air openings 40 for delivering the flow paths
40 80a running perpendicular to the direction of the tracks 10, when the relative location of the side walls

24 and 26 and the front wall 100 and the back wall 100 is considered, can be freely established, as long as the air flow paths 80a run perpendicular to the direction of the tracks 10 such that air flows 80 can run over and through crates stacked onto walls 12 or ledges 14a, in the direction herein outlined. In the exemplary embodiment of the drawings, side walls run essentially parallel with the channels 14 and gutters 16, whereas the front wall and the back wall are oriented essentially perpendicular to the direction of the channels, which is preferred. Equally preferred is the orientation wherein the front and back walls run essentially parallel with the channels 14 and gutters 16, whereas the side walls are oriented essentially perpendicular to the direction of the channels.

A shown in Figure 2A, to ensure a steady flow 80 of air through the crates 4, from an air inlet side 82 to an air outlet side 83 thereof, a pressure differential is preferably created between air inlet side 82 of the crates and the air outlet side 83, with a lower pressure at the outlet side 83. In an exemplary embodiment, the air inlet side 82 of the crates 4 is located proximal to the conduit 38. The pressure differential can be created by applying a pressure differential between air inlets 18 and the air outlets 20.

The climate chamber 2 shown in Figure 1 preferably further comprises a control system 84, configured to measure the conditions within each chamber 2 or each sub-chamber 2a, 2b and control the pressure differential between the air inlet(s) 18 and the air outlet(s) 20 accordingly. The chamber 2 and/or each sub-chamber 2a, 2b can also comprise sensors 85 configured to detect the temperature and humidity within the crates 4 and/or the chamber 2 or sub-chamber 2a, 2b and control the temperature and/or humidity of the air delivered through the air inlets 18 accordingly.

Further details of the system 1 will now be described with reference to Figure 2, which shows a three dimensional view of a stack 6 of crates 4, e.g. in a 2 x 2 arrangement.

As shown in Figure 2A, each pallet 8 supports four stacks 6 of crates 4, in a 2x2 arrangement. Each crate 4 comprises a base 42 and four upstanding walls: two opposing side walls 44, and two opposing end walls 46.

One pair of opposing end walls 46 (see Fig. 3A) comprises openings 48 or cut-outs 48. The path 80a between the opposing openings 48 or cut-outs 48 defines an air flow path 80a over or through the crate 4.

The crates 4 are arranged with respect in the 2 x 2 arrangement in the same orientation such that two airflow paths 80a spanning two crates 4 are created. For example, a first 4a and a second 4b crate are arranged with their respective openings/cut-outs 48 aligned to define a first flow path 80a, whilst third 4c and fourth 4d crates are arranged with their respective openings 48 aligned to define a second flow path 80a. The first and second crates 4a, 4b are placed adjacent to the third and fourth crates 4c, 4d such that two parallel flow paths 80a are created.

The crates 4 in rows of stacked crates 81 are arranged such that the flow paths 80a extend perpendicular to the tracks 10. As shown in Figure 1A and 2A, this allows the crates 4 to be oriented with aligned openings 48 providing a flow path 80a between an inlet side 82 of the stack 6, 81, i.e. where the air inlets 18 are located, and an outlet side 83 of the stack 6, 81, i.e. where the air outlets 20 are located. Although the arrangement shown in Figure 1 shows air inlet(s) 18 disposed between two tracks 10, and outlets 20 disposed on either side of the arrangement of two tracks 10, the skilled person will

appreciate that the reverse arrangement is possible (with the air outlets 20 disposed above the second gutter 32 shown in Figure 1 and the air inlets 18 disposed above the first gutter 28 and third gutter 36).

However, the arrangement shown in Figure 1 is preferred in the illustrated example because the pressure differential from pressure to low pressure is inverse to the volume between the crates, e.g. the volume between the crates 4 shown in Figure 1 is smaller than the volume on either side of the crates 4 and thus the pressure differential may be easier to control, and require less energy to maintain.

As shown in Figure 2A, the crates 4 are configured to stack in a series of stacks 81 such that the openings 48 at opposing end walls 46 are aligned. In the embodiment illustrated in Figure 3A, the crates 4 have an elongate cross-section, the opposing side walls 44 having a length L, and opposing end walls 46 having a length W, wherein W is less than L. The openings 48 are formed in the opposing end walls 46 of the crate 4, where the crates are arranged end to end in stacks 81 to form the flow path 80a mentioned earlier.

The opposing side walls 44 of the crate 4 not comprising the openings 48 are preferably configured such that they mate/cooperate with a crate above to provide a combined opposing side wall to the stack of crates 4 without openings. Such a configuration ensures that the flow of air through or over the crates 4 is restricted to the flow path 80a defined between the openings/cut-outs 48.

To further restrict air flow solely through the crates 4, the upstanding walls 12 of the track 10 on which the pallets 8 and/or crates 4 rest preferably comprise solid walls 12. Although an air tight seal between the pallets 8 and the upstanding wall 12 is not required, by providing solid walls, substantially free of openings, the volume of a flow path beneath the crates 4 between the air inlet side and the air outlet side that does not contribute to climate control within the crates 4 can be reduced or even eliminated.

As shown in Figure 2A, the upstanding walls 12 on which the stacks 6 of crates 4 rest result in a channel 14 that extends under the crates 4. The channel 14 under the crates 4 may advantageously allow access to the volume beneath the crates 4 for various reasons. For example, an automated or remote controlled robotic device 86, 86a (Figure 2A, 2B) can travel through the channel 14 beneath the crates 4. The robotic device 86, 86a can be configured to monitor conditions along the length of the channel 14 (e.g. the robotic device is provided with sensors 89). Alternatively or additively, the robotic device 86, 86a can be configured to retrieve stacks 6 of crates 4. It will be appreciated that the channel 14 also allows a manned lifting device to be manoeuvred along the channels 14.

The tracks 14 can further comprise a ledge 14a on an internal surface 12a of the upstanding wall 12, i.e. internal with respect to the channel 14, which provides runners along which the robot device 86 or manned lifting device can run. Such runners can allow a robotic device 86, 86a to run along the channel 14 above the floor F of the chamber 2, or they can confine a robot 86, 86a to a predetermined path.

The solid upstanding walls 12 that form the tracks 10 can provide a further advantage that they prevent escaped larvae or insects from entering the channel 14 under the crate stacks 6. Since the crates 4 are oriented with the airflow path 80a perpendicular to the channels 14, insects and/or larvae escaping from the crates 4 through the openings 48 fall into the gutters 16, and not into the channels 14

between the upstanding walls 12. Since the gutters 16 are separated from the channels 14 by solid walls 12, escaped insects and/or larvae are confined to the gutters 16, from which they can easily be cleaned.

The upstanding walls 12 may, in some embodiments, form a water tight seal between the channel 14 and the gutters 16. This can allow the gutters 16 to be washed without washing liquid running
5 between the gutter 16 and the channels 14 under the upstanding walls 12 of the tracks 14. This can further help to keep the channels 14 beneath the crates 4 free of detritus, larvae, larvae remains, debris, cleaning liquid, etc., and to avoid contact between the robot 86, 86a or the manned lifting device, which runs in the channels 14 beneath the stacks 6 of crates 4, and the detritus, larvae, debris, larvae remains, cleaning liquid, etc. Avoiding the robot (and/or the manned lifting device) from contacting such waste
10 products extends the operation time of the robot, prevents the robot from becoming damaged and prevents hampered performance of the robot. In addition, with a clean robot not contacted with said waste, the risk for contamination of the robotically lifted and transported crates 4 with said waste is avoided.

It will be appreciated that the channels 14 and the gutters 16 can be open at their respective
15 ends, or that they can be formed with closed ends. In many embodiments, open ended channels 14 and/or gutters 16 are preferred since they facilitate access from the floor F of the climate chamber 2, e.g. for sweeping/cleaning or for robot 86, 86a and/or lifting device access.

In at least one exemplary embodiment, the climate chamber 2 may further comprise one or more rails 52 running perpendicular to the channels 14, and configured to allow a robotic device 86, 86a
20 to move between channels 14. For example, the climate chamber 2 can further comprise a rail or pair of rails 52 extending perpendicular to the channels 14 having an open end. The rails 52 can be configured to convey a (second or alternative) robotic device 87 in a perpendicular direction, in front of the open end of the channels 14. The second or alternative robotic device 87 can comprise a frame 88 or carrier 88 configured to travel along the rail(s), and a robot unit 86a configured to travel along the
25 runners in the channel 14 formed by the ledges 14a.

In an advantageous embodiment it is conceivable that the system 1 of the present invention comprises a robotic device 86, 86a, 87 which is configured to move freely and place one or more crates 4 into the stacks 6 of crates 4, or take one or more crates 4 from stacks 6 of crates 4. This robotic device 86, 86a, 87 may be seen as a freely moveably warehouse-like robot that moves a crate/crates around,
30 e.g. horizontally and/or vertically, in the chamber 2 and along any desirable (programmable) route. In an exemplary embodiment, such a robotic device 86, 86a, 87 may move on steerable wheels 90, 90a for maximum degrees of freedom.

As shown in Figure 1 and 2, a plurality of conduits 38 may be configured to deliver climate controlled air from the air inlet 18 directly to the openings 48 in the crates 4, the 2 x 2 arrangements
35 thereof. Each conduits 38 can comprise a sock comprising a flexible wall, e.g. a polymer wall, having a plurality of openings 40. A conduit 38 preferably extends from the air inlet 18 provided in the ceiling of the climate chamber 2 towards the floor/bottom of the gutter 16. The conduits 38 are arranged such that they are preferably provided adjacent each stack of openings 48 of the stack of crates 4. Advantageously, the openings 40 in the conduit 38 are preferably spaced to align with individual

openings 48 of the crates 4. In this manner, climate controlled air can be supplied from the conduits 38 to the openings 48 of the crates 4.

As shown in Figure 1, each stack 6 of crates 4 is preferably configured such that an upper edge of a top crate 4T is positioned adjacent to the ceiling 22 of the climate chamber 2. The upper edge 4U of the top crate is preferably positioned within 50 mm of the ceiling 22 of the climate chamber 2, more preferably within 30 mm of the ceiling 22, and more preferably within 20 mm of the ceiling of the climate chamber 2. This can allow a dead volume within the climate chamber 2 to be reduced, thus further improving the climate control within the chamber 2. Moreover, by minimising the space between the ceiling 22 and the top of each stack of crates, the space through which air can flow past the crates (without passing through the crates) is minimised. This may improve the efficiency of the system since it can help to maintain the pressure and/or temperature difference on either side of the stacks of crates 4.

The crate 4 of the present invention will now be described in more detail with reference to Figure 3A-3B. Figure 3A shows a perspective view of a single crate 4 according to an exemplary embodiment of the invention. As shown in Figure 3A, the crate 4 comprises a base 42 providing a closed bottom to the crate 4. Upstanding walls 44, 46 extend from edges of the base 42 to provide the opposing side walls 44 and end walls 46 of the crate 4. The top of the crate 4 is open, although the skilled person will appreciate that the top of the crate 4 can also be provided with a lid 4L for closing/covering the top. In an exemplary embodiment, the crate 4 has a generally rectangular cross-section.

The openings 48 are formed in the opposing end walls 46, wherein the openings 48 may be formed as through holes, i.e. surrounded on all sides by the material of the end wall 46. Alternatively, and as shown in Figure 3A, the openings 48 may be formed as recesses or cut-outs in an upper edge of the end walls 46 extending towards the base 42 of the crate 4.

The openings 48 preferably extend across at least 50% of the width of the end wall 46, more preferably at least 80% of the width of the end wall 46. Further, the openings 48 preferably comprise between 25 mm and 100 mm of the height of the crate 4, more preferably between 50 mm and 100 mm.

The base 42 of the crate is preferably smooth or substantially smooth, without ridges or recesses. By smooth it is meant that the base does not comprise planar surfaces that meet at a vertex having an angle of less than 130 degrees, more preferably 150 degrees, and more preferably 160 or 170 degrees. Preferably angled vertices are eliminated in the base 42 (except where the base 42 joins the walls 44, 46); and, in an embodiment in which the base 42 does not extend in a single plane, any transition between surfaces extending in different planes is curved, e.g. rounded corners. Such an arrangement may facilitate cleaning and hygiene of the crates.

The base 42 may further comprise one or more mounting points 50 for sensors 52 configured to measure various conditions, such as temperature, humidity, oxygen concentration, dry matter content etc. within the crates 4. In the example shown in Figure 2 and 3A, eight sensor mounting points 50 for each crate 4 are shown, however the skilled person will appreciate that fewer than eight sensor mounting points 50 can be provided.

Embodiments with more than eight sensor mounts 50 are also possible. The mounting points 50 for sensors 52 can comprise openings in the lower surface of the base 42 into which sensors 52 can

be placed. In an advantageous embodiment, the sensors 52 may be configured to measure the conditions in the crate 4e below and/or in the crate 4b in which they are mounted.

5 In at least one embodiment, the sensor mounts 50 comprise a cavity extending into the interior volume of the crate 4 from the base 42. By providing a cavity that extends into the interior volume of the crate 4 in which a sensor 52 can be mounted, the sensor 52 can more accurately measure the conditions within the biomass contained in the crate. Multiple sensors 52 can be arranged within the base 42 of the crate 4, preferably equally spaced and arranged across the base 42 such that conditions throughout the biomass distributed in the crate 4 can be measured.

10 The openings in base 42 can be in direct communication with the interior volume of the crates 4, or a cover layer can be disposed between the sensors and the interior volume of the crates 4. The sensor(s) 52 can be in wired or wireless communication with control system 84 and/or with sensors 85 described above with reference to Figure 1. Conditions detected by the sensors 52 can be used to adjust the flow rate of the air through the crates 4, the temperatures, and/or humidity of the air supplied through the air inlets 18, etc. Crates 4 according to the invention can be configured with integrated sensors or
15 removable sensors 52.

Alternatively, the control system 84 can be configured to operate according to set values, independent of the input of the sensors 52 and/or sensors 85. Instead, the sensors 52 can be used to monitor conditions within the climate chamber 2 without providing a direct feedback loop to the control unit.

20 As further depicted in Figure 3A and 3B, each crate 4 may comprise a generally planar or flat upper edge 54. Each of the opposing side walls 44 may further comprise at least one (and preferably two) upstanding projections 56 extending from the upper edge 54 of the side walls 44.

A lower edge 58 of the side walls 44 preferably comprise a recess 60 configured to receive an upstanding projection 56 formed on an upper edge 54 of the crate 4e below when the crates 4 are
25 stacked in alignment. This arrangement ensures alignment of the crates 4, and thus alignment of the crate openings 48 with each other, and with the openings 40 in the conduits 38.

Referring to Figure 3B, a crate 4 may further comprise a receiving portion 62 for an identification tag, for example a radio frequency identification (RFID) tag. The RFID tag can be removably mounted in the receiving portion 62. The receiving portion 62 can take any form capable of receiving and retaining
30 an identification tag. The tag can be slid, push fit, or magnetically retained in the receiving portion 62.

The projections 56 are preferably arranged on the opposing side walls 44 of the crate 4 such that the crate 4 has at least two-fold rotational symmetry about a vertical axis (with reference to projections 56). In other words, at least two projections 56 can be located on the crate 4 such that crates stack together as long as the side walls 44 are aligned with each other.

35 Similarly, the receiving portions 62 are preferably arranged on the side walls 44 of the crate 4 such that the crate has at least two fold-rotational symmetry about a vertical axis (with respect to receiving portions 62). In other words, at least two receiving portions 62 are provided, one on each side wall 44, i.e. lower edge 58, the receiving portions 60 being positioned such that they are in the relative position on the crate 4 as long as the side walls 44 are aligned. In the example shown in Figure 3B, a
40 receiving portions 62 is provided on the right hand side of the side wall 44, from the perspective of an

observer facing the side wall 44 as depicted. On the opposing side wall 44, the receiving portion 62 is also provided on the right hand side of the side wall 44, from the perspective of an observer facing the opposing side wall 44. This can ensure that an identification tag is always visible in a stack of crates 4, and in a consistent location in a stack of crates 4.

5 The crate 4 can comprise a dual layer construction, having a structural exterior layer, which provides rigidity and structural stability, and an interior skin or layer, configured to provide a smooth interior surface. The smooth interior surface may also reduce the risk of larvae and/or insects escaping from the crate 4 or becoming lodged in crevices and recesses within the crate 4.

10 The dimensions of the crate 4 can be chosen according to the requirements of the climate chamber 2, the configuration of the tracks 10, and the developmental stage of the larvae and/or insects to be reared. For example, crates 4 configured for the rearing of neonate black soldier fly larvae, typically 0-5 days of age or 0-4 days of age can have: 400 mm length, 300 mm width, and 100 mm height. The skilled person will appreciate that other dimensions are also possible. For example, crates configured for the rearing of black soldier fly larvae, typically 3-25 days of age or 5-16 days of age can have: 800
15 mm length, 550 mm width, and 180 mm height.

Referring now to Figure 4, and exemplary embodiment of a climate chamber 2 without crates 4 is shown.

As shown in Figure 4, the chamber 2 comprises a plurality of elongate sub-chambers, 2a, 2b each comprising parallel sets of tracks 10. The plurality of elongate sub-chambers 2a, 2b are provided
20 adjacent to each other. Each track 10 extends from a closed end 64, to an open end 66. A rail 52 may be arranged adjacent the open ends 66. The rails 52 may be configured to carry an electronic device between tracks 10, such as a robotic device 87, optionally comprising a robotic unit 86a for movement along the tracks 10 underneath the stacks 6 of crates.

The air inlets 18 and air outlets 20 are provided in the ceiling 22 of each sub-chamber 2a, 2b, i.e. ceilings 22a, 22b. As shown in Figure 4, the air inlets 18 are supplied with climate controlled air via
25 a duct 68 along which the plurality of air inlets 18 are arranged. The duct 68 is supplied by a master inlet 70 in fluid communication with the duct 68.

The duct 68 has a length P and extends along the length of the tracks 10. One duct 68 is provided per pair of tracks 10. The master inlet 70 may be provided approximately half way along the
30 length of the duct 68. The duct 68 has a height that is greatest at the junction with the master inlet 70, and decreases as the duct 68 extends away from the master inlet 70 towards its opposing ends 68a, 68b. Such a tapering height of the duct 68 reduces the volume of the duct 68 as the duct 68 extends away from the master inlet 70. This reduction in volume can reduce the pressure drop along the length of the duct 68, thereby improving the consistency with which airflow is distributed across the plurality of
35 air inlets 18 arranged along the length of the duct 68.

It will be appreciated that a similar system can be employed with multiple ducts 68 provided along the length of the track 10. Each duct 68 may be provided with its own master inlet 70, and can comprise a maximum height at the junction with the master inlet 70, with the height reducing as the duct 68 extends away from the inlet 70 towards closed ends. It will be appreciated that a similar volume

reduction can be achieved by varying other dimensions of the duct 68 as it extends away from the master inlet 70. Such configurations also fall within the scope of the present invention.

The plurality of air outlets 20 is also shown in Figure 4, wherein the air outlets 20 are arranged in the ceiling 22a, 22b of each sub-chamber 2a, 2b at either side of the pairs of tracks 10 (see also Figure 1). The air outlets 20 are in communication with a void 72, which is in turn in communication with a master outlet 74.

It will be appreciated that flow of air 80 through the crates 4 may be controlled in different manners. For example, the only controlled parameter may be the flow of air 80 through the crates 4. This can be controlled by generating a pressure difference between the air inlets 18 and the air outlets 20. Such a pressure differential can be applied by applying a positive pressure (e.g. above atmospheric pressure) to the air inlet(s) 18 and/or a negative pressure (e.g. below atmospheric pressure) to the air outlet(s) 20.

Alternatively, one of the inlets 18 or the outlets 20 may be in fluid communication with a region of atmospheric pressure, whilst the other of the inlets 18 or the outlets 20 are controlled (either above or below atmospheric pressure) to provide the required pressure differential.

The climate can be further controlled by controlling the temperature and/or humidity of the air entering the climate chamber 2, e.g. sub chambers 2a, 2b, through the air inlets 18. The air flow 80 through the crates 4 and/or the temperature and/or humidity can be maintained at constant levels, or they can be varied cyclically, independently, or individually. The precise parameters desired for each climate chamber 2 or sub-chamber 2a, 2b depend on the insect species, developmental stage of the insects, and current production rate requirements, and can be chosen by the skilled person accordingly. Typically, the insect species reared in the crates 4 stacked in the chamber 2, 2a, 2b is the BSF, and typically, the developmental stage of said BSF is the neonate larvae stage for example between 0 and 5 days post hatching or between 0 and 4 days post hatching, or is the larvae stage for example between 4 and 20 days post hatching.

The airflow 80 (and/or the temperature and/or humidity of delivered air) can be further controlled based on environmental conditions measured by the sensors 52 and/or sensors 85. The control unit or control system 84 can be configured to adjust the supplied air in real time, or at predetermined intervals based on conditions detected by the sensors 52. The controller can be configured to maintain the conditions within all sub-chambers 2a, 2b within a predetermined range, according to a set level. Alternatively, the control unit or the control system 84 can be configured to control the air supply to the sub-chambers 2a, 2b without sensor information. Instead, the sensors 52 can be used to issue an alert if the conditions deviate from a predefined set level.

Conditions within the sub-chambers 2a, 2b can be controlled individually. This arrangement can improve the consistency with which the larvae and/or insects are reared through each developmental stage. In many cases, it is preferably for large numbers of insects and/or larvae to develop at the same rate. According, the conditions in each sub-chamber 2a, 2b can be measured independently, and the airflow and climate control adjusted accordingly to harmonise, as far as possible, the rate of development of larvae and/or insects in each sub-chamber 2a, 2b.

A chamber 2 may house multiple sub-chambers 2a, 2b, each optimised for a different developmental stage or different species and/or different pace of development. In such embodiments, the crates 4 used in each such chamber 2a, 2b may comprise a different colour, indexed to indicate the developmental stage and/or species of larvae and/or insects. The colour coding of crates 4 can allow
5 automatic detection of species and/or development stage, e.g. by a robotic device 86, 86a, 87 comprising an optical sensor 89, which can provide feedback to the climate control system and/or stock management information.

Thus, in summary, a first aspect of the invention relates to a system for rearing invertebrates, the system comprising:

10 a plurality of crates arranged into at least one stack, each crate in the stack defining an airflow path there through from an inlet opening in a first wall to an outlet opening in a second wall opposite the first wall; a climate chamber comprising: an internal volume enclosed by walls, a floor, and a ceiling; a first row of air outlets extending in a first direction within the internal volume; a second row of air outlets extending parallel to the first row of air outlets within the internal volume; a row of air inlets located
15 between the first and second rows of air outlets, and extending parallel thereto, and spaced apart from the first and second rows of air outlets in a second direction, perpendicular to the first direction; at least one first stack of crates arranged in a space between the first row of air outlets and the row of air inlets; at least one second stack of crates arranged in a space between the second row of air outlets and the row of air inlets; a conduit extending from each of the plurality of air inlets between the first and second
20 stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack; wherein the crates are arranged with the airflow path oriented perpendicular to the first direction.

An embodiment is the system according to the invention, wherein the climate chamber further comprises at least one track extending in the first direction with the climate chamber, said track
25 comprising a first wall and a second wall, and a channel defined there between.

An embodiment is the system according to the invention, wherein the track is positioned between the first row of air outlets and the row of air inlets, and wherein the system, preferably, comprises a second track positioned between the row of air inlets and the second row of air outlets.

An embodiment is the system according to the invention, wherein the at least one track
30 comprises a pair of walls separated from each other by a channel, said channel extending in the second direction, which is perpendicular to the first direction; and optionally, wherein the at least one stack of crates is arranged on the tracks such that the airflow path extends in the first direction.

An embodiment is the system according to the invention, wherein each track is configured to support a row of crate stacks above the channel.

35 An embodiment is the system according to the invention, wherein each track is configured to support a pallet comprising four stacks of crates arranged in a 2x2 arrangement.

An embodiment is the system according to the invention, wherein the pair of walls comprise solid, opposing walls, arranged parallel to each other.

An embodiment is the system according to the invention, wherein each of the walls is a solid
40 wall and separates the channel from an adjacent gutter.

An embodiment is the system according to the invention, wherein the climate chamber further comprises a plurality of air inlets and a plurality of air outlets.

An embodiment is the system according to the invention, wherein the at least one air inlet and/or the at least one air outlet are provided in a ceiling of the climate chamber.

5 An embodiment is the system according to the invention, wherein the climate chamber is divided into a plurality of sub-chambers.

10 An embodiment is the system according to the invention, wherein each sub-chamber has a first side wall and a second side wall, and a first track and a second track, wherein the first track is separated from the first wall by a first gutter, wherein the first track is separated from the second track by a second gutter, and wherein the second track is separated from the second wall by a third gutter.

An embodiment is the system according to the invention, wherein the plurality of air inlets are arranged above the second gutter, and wherein the plurality of air outlets are arranged above the first and third gutters.

15 An embodiment is the system according to the invention, further comprising a control system configured to maintain a pressure gradient between the inlet openings and the outlet openings, wherein a pressure at the inlet openings is higher than a pressure at the outlet openings, such that air flows from the inlet openings, through the climate chamber, and out of the outlet openings.

An embodiment is the system according to the invention, further comprising at least one sensor configured to measure at least one environmental condition within at least one of the plurality of crates.

20 An embodiment is the system according to the invention, wherein the at least one environmental condition includes one or more of: temperature; humidity; oxygen concentration; carbon dioxide concentration; pressure; and air flow.

An embodiment is the system according to the invention, wherein the at least one sensor is arranged in a base of the crates.

25 An embodiment is the system according to the invention, wherein the plurality of air inlets are arranged along a duct, wherein the duct is configured to be supplied with climate controlled air via a master inlet.

An embodiment is the system according to the invention, wherein the duct has a variable height H, and wherein the height of the duct decreases as the distance from the master inlet increases.

30 An embodiment is the system according to the invention, wherein the system further comprises a conduit in fluid communication with the duct, and wherein the conduit comprises a flexible conduit comprising a plurality of holes along opposing sides.

An embodiment is the system according to the invention, wherein the climate chamber is provided in a static structure.

35 An embodiment is the system according to the invention, wherein the climate chamber is provided in a portable container, e.g. a shipping container, a reefer, a truck trailer.

40 An embodiment is the system according to the invention, wherein the control system is configured to adjust at least one of the following parameters based on environmental conditions detected by at least one sensor: temperature; humidity; oxygen concentration; carbon dioxide concentration; pressure at the inlet and/or outlet; and air flow.

An embodiment is the system according to the invention, wherein the climate chamber further comprises at least one rail extending in the second direction adjacent open ends of the at least one track.

5 An embodiment is the system according to the invention, wherein the at least one track comprises a ledge on an internal surface of the upstanding wall with respect to the channel, which provides runners along which a robot device or manned lifting device can run.

10 An embodiment is the system according to the invention, wherein the at least one rail is configured to convey a robotic device in a perpendicular direction, in front of the open end of the channels, wherein optionally the robotic device comprises a frame or carrier configured to travel along the rail(s), and comprises a robot unit configured to travel along the at least one track or along the runners in the channel formed by the ledges.

15 An embodiment is the system according to the invention, wherein the climate chamber further comprises at least one robotic device configured to move along the at least one track. An embodiment is the system according to the invention, further comprising at least one robotic device configured to freely move and place one or more crates into the first and/or the second stack of crates, or take one or more crates from the first and/or the second stack of crates.

20 The present invention also provides a method of rearing invertebrates, the method including the steps of: providing a plurality of crates 4; filling at least a portion of each crate 4 with a substrate and a plurality of invertebrates in a first developmental stage, and arranging said crates in a climate chamber 2 as described above to form a plurality of parallel air flow paths 80a through the crates 4.

The method further comprises passing a flow of air 80, preferably having controlled temperature and humidity, through said air flow paths 80a formed by said crates 4, by providing a plurality of air inlets 18 on a first side of said stack 6 of crates 4, and an air outlet 20 on an opposing side of said stack 6 of crates 4.

25 Optionally, the method further comprises measuring, with at least one sensor 52 disposed within the stack of crates 4, an environmental condition within the stack 6. Advantageously, the airflow 80 through the stack 6 can be modified based on the conditions detected by the sensor(s) 52. Additionally or alternatively, the environmental condition in the volume surrounding the stack 6 in climate room 2, 2a, 2b is measured with at least one sensor 85 disposed in the climate room, outside crates 4, according to the method of the invention. Additionally or alternatively, the environmental condition in the volume surrounding the stack 6 in climate room 2, 2a, 2b is measured with at least one sensor 89 disposed on the robot 86, 86a, 87, according to the method of the invention.

35 The method further comprises the step providing a channel 14 extending in a first direction 1ST below a plurality of crate stacks 6, and arranging said stacks 6 with said airflow path 80a perpendicular to the first direction 1ST. Further optional and advantageous steps of a method according to the invention will be apparent from the above description of the exemplary system.

40 Like the system 1 as described above, the method of the present invention may further comprise the step of operating a robotic device 86, 87 to freely move and place one or more crates 4 into stacks 6 of crates 4 or take one or more crates 4 from the stacks of crates 4. Such a robotic device 86, 87 is operated like a freely movable warehouse robot which is able to move and manipulate one or more

crates 4 along any desirable (programmable) route within the climate chamber 2. In an embodiment, the robotic device 86, 86a, 87 may have steerable wheels 90, 90a for achieving maximum degrees of freedom. The robotic device 87 can comprise a frame 88 or carrier 88 configured to travel along the rail(s), and a robot unit 86a configured to travel along the runners in the channel 14 formed by the ledges 14a.

The climate chamber 2 of the invention and the system 1 of the invention comprising the climate chamber 2 are particularly suitable for application in the method of the invention.

The crate 4 of the invention is particularly suitable for application in the method of the invention.

The crate 4 of the invention is particularly suitable for use in the climate chamber of the invention and for use in the climate chamber of the invention.

Thus, in summary, a second aspect of the invention relates to a method for rearing invertebrates, the method comprising the steps of: (i) providing a plurality of crates, each crate having a first opening in a first wall and a second opening in a second wall opposite the first opening to define a first air flow path between the first and second openings; (ii) filling at least a portion of each crate of the plurality of crates with a substrate and a plurality of invertebrates at a first developmental stage; (iii) stacking the plurality of crates; (iii) providing a climate chamber comprising: an internal volume; a climate chamber comprising: an internal volume enclosed by walls, a floor, and a ceiling; a first row of air outlets extending in a first direction within the internal volume; a second row of air outlets extending parallel to the first row of air outlets within the internal volume; a row of air inlets located between the first and second rows of air outlets, and extending parallel thereto, and spaced apart from the first and second rows of air outlets in a second direction, perpendicular to the first direction; at least one first stack of crates arranged in a space between the first row of air outlets and the row of air inlets; at least one second stack of crates arranged in a space between the second row of air outlets and the row of air inlets; a conduit extending from each of the plurality of air inlets between the first and second stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack; (iv) positioning at least one stack of crates wherein the crates are arranged with the airflow path oriented perpendicular to the first direction and in the second direction; (v) applying a pressure differential between the air inlet and the air outlet.

An embodiment is the method of the invention, wherein the climate chamber further comprises at least one track extending in the first direction with the climate chamber, said track comprising a first wall and a second wall, and a channel defined there between.

An embodiment is the method of the invention, wherein the at least one track is positioned between the first row of air outlets and the row of air inlets, and wherein the system preferably comprises a second track positioned between the row of air inlets and the second row of air outlets.

An embodiment is the method of the invention, wherein the at least one track comprises a pair of walls separated from each other by a channel, said channel extending in a second direction, which is perpendicular to the first direction; and optionally, wherein the at least one stack of crates is arranged on the tracks such that the airflow path extends in the first direction.

An embodiment is the method of the invention, wherein the pair of walls comprise solid, opposing walls, arranged parallel to each other.

An embodiment is the method of the invention, wherein each of the walls is a solid wall and separates the channel from an adjacent gutter.

5 An embodiment is the method of the invention, wherein the method further comprises providing a plurality of air inlets and a plurality of air outlets, and positioning at least one stack between an air inlet and an air outlet aligned with each other in the first direction.

An embodiment is the method of the invention, wherein the method further comprises: sensing, using at least one sensor, an environmental condition within one or more of the plurality of crates, where in the sensed environmental condition can comprise one or more of: temperature; humidity; oxygen concentration; carbon dioxide concentration; pressure; and air flow.

10 An embodiment is the method of the invention, further comprising controlling at least one of the following parameters based on the sensed environmental conditions within the crates: temperature; humidity; oxygen concentration; carbon dioxide concentration; pressure at the inlet and/or outlet; and air flow.

15 An embodiment is the method of the invention, wherein the method further comprises arranging a plurality of stacks of crates in rows along the tracks, wherein each stack abuts an adjacent stack in the second direction.

An embodiment is the method of the invention, wherein the stacks are arranged in a 2 x 2 arrangement.

20 An embodiment is the method of the invention, further comprising, operating a robotic device to move along at least one track, wherein the robotic device is configured to: move at least one stack of crates along the tracks; detect environmental conditions within the channel; read information from at least one crate stacked above the channel.

25 An embodiment is the method of the invention, further comprising, operating a robotic device to freely move and: place one or more crates into the first and/or the second stack of crates, or take one or more crates from the first and/or the second stack of crates.

30 An embodiment is the method of the invention, wherein the method further comprises conveying a robotic device in the second direction, in front of the open end of the channels, wherein the climate chamber comprises at least one rail extending in the second direction adjacent open ends of the at least one track wherein the at least one rail is configured to convey the robotic device, optionally the robotic device comprises a frame or carrier configured to travel along the rail(s), and comprises a robot unit configured to travel along the at least one track or along the runners in the channel formed by the ledges.

An embodiment is the method of the invention, further comprising running a robot device or manned lifting device along runners provided by the at least one track comprising a ledge on an internal surface of the upstanding wall with respect to the channel.

35 In summary, a further aspect of the invention relates to an invertebrate rearing crate configured for use in the system of the invention or in the method of the invention, wherein the crate comprises a base, upstanding side walls and upstanding end walls defining a perimeter around the base, and at least one sensor mounting region arranged in the base of the crate.

40 An embodiment is the invertebrate rearing crate according to the invention, wherein the base further comprises a plurality of sensors arranged in the base of the crate.

An embodiment is the invertebrate rearing crate according to the invention, wherein the crate further comprises at least one projection in an upper edge surface thereof, and at least a corresponding recess in a lower edge region, the recess being configured to receive a projection of a further crate stacked thereupon.

5 An embodiment is the invertebrate rearing crate according to the invention, wherein the crate further comprises a first receiving portion configured to receive a removable identification tag, e.g. an RFID tag.

10 An embodiment is the invertebrate rearing crate according to the invention, wherein the crate further comprises a second receiving portion positioned on an opposing side of the crate in a corresponding position, such that the position of the second receiving portion maps the position of the first receiving portion when the crate is rotated 180 degrees about a vertical axis.

An embodiment is the invertebrate rearing crate according to the invention, wherein the second receiving portion comprises an identification tag, e.g. an RFID tag.

15 It will be understood that the disclosed embodiments described above are exemplary configurations of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting. Rather, the examples described herein are intended to illustrate exemplary ways in which the invention may be put into effect.

The skilled person will understand that modifications can be made without departing from the scope of invention, which is defined by the appended claims.

20 Moreover, terms and phrases used herein are not intended to be limiting, but rather, to provide an understandable description of the invention.

The terms 'a' and 'an', as used in the present disclosure, are intended to mean one, or more than one. The term 'plurality', as used herein, is defined as two, or more than two.

25 The terms comprising, including and/or having, as used herein, are intended to mean 'including but not limited to', and a system, device or method comprising certain features and/or steps may include additional features and/or steps. Any reference signs in the claims should not be construed as limiting the scope of the claims or the invention.

The embodiments of the invention described herein can operate in combination and cooperation, unless specified otherwise.

CLAIMS

1. A system for rearing invertebrates, the system comprising:
a plurality of crates arranged into at least one stack, each crate in the stack defining an airflow
5 path there through from an inlet opening in a first wall to an outlet opening in a second wall opposite the first wall;
a climate chamber comprising:
an internal volume enclosed by walls, a floor, and a ceiling;
a first row of air outlets extending in a first direction within the internal volume;
10 a second row of air outlets extending parallel to the first row of air outlets within the internal volume;
a row of air inlets located between the first and second rows of air outlets, and extending parallel thereto, and spaced apart from the first and second rows of air outlets in a second direction, perpendicular to the first direction;
15 at least one first stack of crates arranged in a space between the first row of air outlets and the row of air inlets;
at least one second stack of crates arranged in a space between the second row of air outlets and the row of air inlets;
a conduit extending from each of the plurality of air inlets between the first and second
20 stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack;
wherein the crates are arranged with the airflow path oriented perpendicular to the first direction.
2. The system according to claim 1, wherein the climate chamber further comprises at least one
25 track extending in the first direction with the climate chamber, said track comprising a first wall and a second wall, and a channel defined there between.
3. The system according to claim 2, wherein the track is positioned between the first row of air
outlets and the row of air inlets, and wherein the system, preferably, comprises a second track positioned
30 between the row of air inlets and the second row of air outlets.
4. The system according to claim 2 or claim 3, wherein the at least one track comprises a pair of
walls separated from each other by a channel, said channel extending in the second direction, which is
perpendicular to the first direction; and
35 optionally, wherein the at least one stack of crates is arranged on the tracks such that
the airflow path extends in the first direction.
5. The system according to claim 2, 3 or 4, wherein each track is configured to support a row of
crate stacks above the channel.

6. The system according to any of claims 2-5, wherein each track is configured to support a pallet comprising four stacks of crates arranged in a 2x2 arrangement.
7. The system according to claim 4, or any of claims 5 and 6 when dependent on claim 4, wherein the pair of walls comprise solid, opposing walls, arranged parallel to each other.
8. The system according to claim 4 or 7, wherein each of the walls is a solid wall and separates the channel from an adjacent gutter.
9. The system according to any preceding claim, wherein the climate chamber further comprises a plurality of air inlets and a plurality of air outlets.
10. The system according to any preceding claim, wherein the at least one air inlet and/or the at least one air outlet are provided in a ceiling of the climate chamber.
11. The system according to any preceding claim, wherein the climate chamber is divided into a plurality of sub-chambers.
12. The system according to claim 11, wherein each sub-chamber has a first side wall and a second side wall, and a first track and a second track,
wherein the first track is separated from the first wall by a first gutter,
wherein the first track is separated from the second track by a second gutter, and
wherein the second track is separated from the second wall by a third gutter.
13. The system according to claim 12, when depending from claim 9, wherein the plurality of air inlets are arranged above the second gutter, and wherein the plurality of air outlets are arranged above the first and third gutters.
14. The system according to any preceding claim, further comprising a control system configured to maintain a pressure gradient between the inlet openings and the outlet openings, wherein a pressure at the inlet openings is higher than a pressure at the outlet openings, such that air flows from the inlet openings, through the climate chamber, and out of the outlet openings.
15. The system according to any preceding claim, further comprising at least one sensor configured to measure at least one environmental condition within at least one of the plurality of crates.
16. The system according to claim 15, wherein the at least one environmental condition includes one or more of:
temperature;
humidity;

oxygen concentration;
carbon dioxide concentration;
pressure; and
air flow.

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17. The system according to claim 15, wherein the at least one sensor is arranged in a base of the crates.

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18. The system according to claim 9 or any preceding claim depending from claim 9, wherein the plurality of air inlets are arranged along a duct, wherein the duct is configured to be supplied with climate controlled air via a master inlet.

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19. The system according to claim 18, wherein the duct has a variable height H, and wherein the height of the duct decreases as the distance from the master inlet increases.

20. The system according to claim 18 or claim 19, wherein the system further comprises a conduit in fluid communication with the duct, and wherein the conduit comprises a flexible conduit comprising a plurality of holes along opposing sides.

20

21. The system according to any preceding claim, wherein the climate chamber is provided in a static structure.

22. The system according to any preceding claim, wherein the climate chamber is provided in a portable container, e.g. a shipping container, a reefer, a truck trailer.

25

23. The system according to claim 14 or any preceding claim depending from claim 14, wherein the control system is configured to adjust at least one of the following parameters based on environmental conditions detected by at least one sensor:

30

temperature;
humidity;
oxygen concentration;
carbon dioxide concentration;
pressure at the inlet and/or outlet; and
air flow.

35

24. The system according to any preceding claim, when depending from claim 2, wherein the climate chamber further comprises at least one rail extending in the second direction adjacent open ends of the at least one track.

25. The system according to claim 24, wherein the at least one track comprises a ledge on an internal surface of the upstanding wall with respect to the channel, which provides runners along which a robot device or manned lifting device can run.
- 5 26. The system according to claim 24 or 25, wherein the at least one rail is configured to convey a robotic device in a perpendicular direction, in front of the open end of the channels, wherein optionally the robotic device comprises a frame or carrier configured to travel along the rail(s), and comprises a robot unit configured to travel along the at least one track or along the runners in the channel formed by the ledges.
- 10 27. The system according to any preceding claim, when depending from claim 2, wherein the climate chamber further comprises at least one robotic device configured to move along the at least one track.
- 15 28. The system according to any of claims 1-27, further comprising at least one robotic device configured to freely move and
place one or more crates into the first and/or the second stack of crates, or
take one or more crates from the first and/or the second stack of crates.
- 20 29. A method for rearing invertebrates, the method comprising the steps of:
(i) providing a plurality of crates, each crate having a first opening in a first wall and a second opening in a second wall opposite the first opening to define a first air flow path between the first and second openings;
(ii) filling at least a portion of each crate of the plurality of crates with a substrate and a plurality
25 of invertebrates at a first developmental stage;
(iii) stacking the plurality of crates;
(iii) providing a climate chamber comprising:
an internal volume;
a climate chamber comprising:
30 an internal volume enclosed by walls, a floor, and a ceiling;
a first row of air outlets extending in a first direction within the internal volume;
a second row of air outlets extending parallel to the first row of air outlets within
the internal volume;
a row of air inlets located between the first and second rows of air outlets, and
35 extending parallel thereto, and spaced apart from the first and second rows of air outlets
in a second direction, perpendicular to the first direction;
at least one first stack of crates arranged in a space between the first row of air
outlets and the row of air inlets;
at least one second stack of crates arranged in a space between the second
40 row of air outlets and the row of air inlets;

a conduit extending from each of the plurality of air inlets between the first and second stack of crates, said conduit comprising a plurality of conduit openings configured to align with inlet openings of the plurality of crates in each stack;

- 5 (iv) positioning at least one stack of crates wherein the crates are arranged with the airflow path oriented perpendicular to the first direction and in the second direction;
- (v) applying a pressure differential between the air inlet and the air outlet.

30. The method according to claim 29, wherein the climate chamber further comprises at least one track extending in the first direction with the climate chamber, said track comprising a first wall and a second wall, and a channel defined there between.

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31. The method according to claim 30, wherein the at least one track is positioned between the first row of air outlets and the row of air inlets, and wherein the system preferably comprises a second track positioned between the row of air inlets and the second row of air outlets.

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32. The method according to claim 30 or claim 31, wherein the at least one track comprises a pair of walls separated from each other by a channel, said channel extending in a second direction, which is perpendicular to the first direction; and

optionally, wherein the at least one stack of crates is arranged on the tracks such that the airflow path extends in the first direction.

20

33. The method according to claim 32, wherein the pair of walls comprise solid, opposing walls, arranged parallel to each other.

25 34. The method according to claim 32 or 33, wherein each of the walls is a solid wall and separates the channel from an adjacent gutter.

35. The method according to any one of the claims 32-34, wherein the method further comprises providing a plurality of air inlets and a plurality of air outlets, and positioning at least one stack between an air inlet and an air outlet aligned with each other in the first direction.

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36. The method according to any of claims 29-35, wherein the method further comprises: sensing, using at least one sensor, an environmental condition within one or more of the plurality of crates, where in the sensed environmental condition can comprise one or more of:

- 35 temperature;
- humidity;
- oxygen concentration;
- carbon dioxide concentration;
- pressure; and
- 40 air flow.

37. The method according to claim 36, further comprising controlling at least one of the following parameters based on the sensed environmental conditions within the crates:
- 5 temperature;
 humidity;
 oxygen concentration;
 carbon dioxide concentration;
 pressure at the inlet and/or outlet; and
 air flow.
- 10 38. The method according to any of claims 29-37, when depending from claim 30, wherein the method further comprises arranging a plurality of stacks of crates in rows along the tracks, wherein each stack abuts an adjacent stack in the second direction.
- 15 39. The method according to any of claims 29-38, wherein the stacks are arranged in a 2 x 2 arrangement.
40. The method according to any of claims 29-39, further comprising, operating a robotic device to move along at least one track, wherein the robotic device is configured to:
- 20 move at least one stack of crates along the tracks;
 detect environmental conditions within the channel;
 read information from at least one crate stacked above the channel.
41. The method according to any of claims 29-39, further comprising, operating a robotic device to
- 25 freely move and:
 place one or more crates into the first and/or the second stack of crates, or
 take one or more crates from the first and/or the second stack of crates.
42. The method according to any preceding claim, when depending from claim 30, wherein the
- 30 method further comprises conveying a robotic device in the second direction, in front of the open end of the channels, wherein the climate chamber comprises at least one rail extending in the second direction adjacent open ends of the at least one track wherein the at least one rail is configured to convey the robotic device, optionally the robotic device comprises a frame or carrier configured to travel along the rail(s), and comprises a robot unit configured to travel along the at least one track or along the runners
- 35 in the channel formed by the ledges.
43. The method according to claim 42, further comprising running a robot device or manned lifting device along runners provided by the at least one track comprising a ledge on an internal surface of the upstanding wall with respect to the channel.

44. An invertebrate rearing crate configured for use in the system of claims 1-28 or in the method of claims 29-43, wherein the crate comprises a base, upstanding side walls and upstanding end walls defining a perimeter around the base, and at least one sensor mounting region arranged in the base of the crate.

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45. The invertebrate rearing crate according to claim 44, wherein the base further comprises a plurality of sensors arranged in the base of the crate.

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46. The invertebrate rearing crate according to claim 44 or 45, wherein the crate further comprises at least one projection in an upper edge surface thereof, and at least a corresponding recess in a lower edge region, the recess being configured to receive a projection of a further crate stacked thereupon.

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47. The invertebrate rearing crate according to any of claims 44-46, wherein the crate further comprises a first receiving portion configured to receive a removable identification tag, e.g. an RFID tag.

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48. The invertebrate rearing crate according to claim 47, wherein the crate further comprises a second receiving portion positioned on an opposing side of the crate in a corresponding position, such that the position of the second receiving portion maps the position of the first receiving portion when the crate is rotated 180 degrees about a vertical axis.

49. The invertebrate rearing crate according to claim 48, wherein the second receiving portion comprises an identification tag, e.g. an RFID tag.

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