

Description

Title: EGG LAYING DEVICE FOR FLIES

Technical field

The invention relates to an egg laying device for flies, intended for entomoculture.

5 **Prior art**

Entomoculture involves rearing insects, generally with the objective of producing food products for humans or animals.

Among insects, a distinction is made with respect to flies, the exploitation of which presents specific problems and requires particular solutions.

10 In particular, the applicant company is exploiting a method involving:

a) rearing flies and causing them to mate, then to lay eggs;

b) retrieving the eggs and ensuring that they hatch in order to obtain young larvae;

c) feeding the young larvae in order to make them grow, preferably by feeding them with food residues;

15 d) processing the adult larvae obtained in order to convert them into harvestable products and in particular into a protein-containing flour which is intended for animal feed and into an agricultural fertiliser.

Carrying out such a method requires an installation 10 (see Figure 1) comprising a unit 12 for producing flies M, a unit 14 for producing eggs O which are laid by the flies, a unit 16 for
20 producing young larvae J which are born from the eggs, a unit 18 for producing adult larvae L from the young larvae J and food residues R, and a unit 19 for processing the adult larvae L in order to produce an oil H, a protein-containing material Pr and a fertiliser F. Some of the larvae produced by the unit 18 are used by the unit 12 for producing flies.

The productivity of such an installation closely depends on the capacity thereof to ensure the
25 optimum development conditions for the flies and the larvae. The equipment used is essential to this end.

Industrial exploitation also requires precise control of the different steps of the process. In particular, the flies are produced by batches of several thousands of individuals and it is desirable for the flies from the same batch to lay eggs substantially simultaneously. The larvae obtained then grow in the same manner, which improves the productivity.

- 5 An object of the invention is to provide an egg laying device which allows the productivity of such an installation to be improved.

Statement of invention

The invention sets out an egg laying device for flies, the device comprising:

- a fly cage preferably comprising a container comprising:
 - 10 - a base wall which defines a base surface which is orientated towards the interior of the cage, which is preferably horizontal, and
 - a lateral wall which surrounds the base surface and which defines a lateral surface which is orientated towards the interior of the cage, which is preferably vertical, and
 - a laying nest which is intended to receive the eggs laid by flies which are enclosed in the cage.
- 15 The term “internal surface” of the container is intended to refer to the surface of the walls thereof which delimit the internal volume thereof.

- According to a first aspect of the invention**, the cage is passed through by at least one egg laying aperture which opens towards the exterior of the cage via an external opening and the laying nest is arranged outside the cage and defines an egg laying zone which extends opposite
- 20 the external opening of the egg laying aperture.

- As will be seen in greater detail in the remainder of the description, such a device allows a fly enclosed in the cage to lay eggs outside the cage, on the egg laying zone, through the egg laying aperture. The eggs can thus be retrieved without it being necessary to enter the cage, which prevents the flies enclosed in the cage from being disturbed, and therefore promotes their
- 25 development. Furthermore, the retrieval of the eggs outside the cage is advantageously very rapid. The productivity of the installation is thereby improved.

Finally, such a device according to the invention advantageously allows any risk of flies escaping from the cage during the retrieval of the eggs to be prevented.

A device according to the first main aspect of the invention may further comprise one or more of the following optional and preferred features:

- the egg laying aperture has, in cross section, that is to say, in a plane of section perpendicular to the axis thereof, preferably in any cross section, a contour without any angle, which is preferably strictly concave when viewed from inside the egg laying aperture;
- the egg laying zone is spaced apart from the external opening of the egg laying aperture by a spacing greater than 3 mm, preferably greater than 5 mm, preferably greater than 8 mm and/or preferably less than 20 mm, preferably less than 15 mm, preferably less than 10 mm;
- the egg laying device comprises an odoriferous source which is arranged outside the cage in order to generate, in the cage and through the egg laying aperture, an odour which attracts the flies;
- the odoriferous source is separated from the external opening of the egg laying aperture by the laying nest which preferably comprises channels which are configured so that the odour emitted by the odoriferous source reaches the egg laying aperture.

According to a second main aspect of the invention, the egg laying zone defines a re-entrant edge, the length of which, following the axis of the edge, is greater than 10 mm, preferably greater than 20 mm, preferably greater than 30 mm, preferably greater than 40 mm, preferably greater than 60 mm, and/or less than 500 mm, preferably less than 300 mm.

The inventors have discovered that such a re-entrant edge length is very effective in order to attract the flies which wish to lay eggs, in particular in comparison with the lengths of small cells. It further facilitates the detachment of the eggs during the retrieval thereof. Without being limited by this theory, the inventors consider that a long edge prevents blockage of the eggs in the microcavity defined by the edge.

A device according to the second main aspect of the invention may further comprise one or more of the following optional and preferred features:

- the re-entrant edge is closed on itself;
- the re-entrant edge extends substantially parallel with the external opening when the device is in accordance with the first main aspect;

- the egg laying zone comprises only such re-entrant edges.

According to a third main aspect, the base surface and/or the lateral surface and/or the internal surface of the container

- do not have any re-entrant edge or have one or more re-entrant edges, the cumulative length of which L_a is such that the ratio of this cumulative length to the surface-area S of the base surface and/or the lateral surface and/or the internal surface of the container, respectively, L_a/S , is less than 1200 mm/m^2 , preferably less than 1000 mm/m^2 , preferably less than 900 mm/m^2 , preferably less than 850 mm/m^2 , preferably less than 800 mm/m^2 , without counting any re-entrant edges in the junction zone between the base surface and the lateral surface, preferably counting any re-entrant edges in the junction zone between the base surface and the lateral surface; and/or do not have any raised portion or depression, the height or depth of which is greater than 5 mm, greater than 4 mm, 3 mm, 2 mm, 1 mm, 0.5 mm, 0.3 mm, 0.2 mm, or 0.1 mm, respectively; and/or
- have, over more than 90% of the surface-area(s) thereof, preferably over more than 95%, more than 97%, more than 99%, more than 99.5% of the surface-area thereof, preferably substantially 100% of the surface-area(s) thereof, a radius of curvature greater than 0.5 cm, preferably greater than 1 cm, preferably greater than 2 cm, preferably greater than 3 cm, preferably greater than 5 cm, preferably greater than 7 cm, and/or less than 30 cm.

A device according to the third main aspect of the invention may further comprise one or more of the following optional and preferred features:

- the lateral wall comprises, preferably is constituted by, a plurality of substantially planar faces and the junction zone, which is preferably vertical, between two adjacent faces, preferably between any two adjacent faces, does not define any re-entrant edge on the lateral surface and/or has at any point a radius of curvature greater than 0.5 cm, preferably greater than 1 cm, preferably greater than 3 cm, preferably greater than 5 cm, preferably greater than 7 cm, and/or less than 30 cm;
- the internal surface of the container does not have any re-entrant edge in the junction zone between the lateral surface and the base surface;
- the junction zone between the lateral surface and the base surface has at any point a radius of curvature greater than 0.5 cm, preferably greater than 1 cm, preferably greater

than 3 cm, preferably greater than 5 cm, preferably greater than 7 cm, and/or less than 30 cm;

- the base surface and/or the lateral surface has/have a radius of curvature less than 7 cm, 5 cm, 3 cm, 1 cm or 0.5 cm only in junction zones with a laying nest support and/or a connection aperture which can be selectively closed and which is intended for the introduction of flies into the cage;
- no component is positioned or fixed on the base surface, at least when the egg laying device contains flies;
- the base surface and/or the lateral surface is/are smooth to the touch.

10 In a particularly advantageous embodiment, the base surface is continuously planar, that is to say, it extends in a plane in an uninterrupted manner as far as the junction zone with the lateral surface.

No depression, for example, in the form of a slot, a groove, a cavity or a hole, which may or may not be a through-hole, is therefore arranged in the base surface. No protrusion, for example, in the form of a strip of material or a boss, projects from the base surface. In other words, any straight line marked on the base surface joins two points of the external contour of the base surface without being interrupted by a depression or a protrusion.

The inventors have found that an egg laying device according to the third main aspect leads to a substantial limitation of the undesirable clutches of eggs, that is to say, clutches of eggs outside the egg laying zone.

The features of the different main aspects of the invention, whether necessary or optional, may be and are preferably combined.

Independently of the main aspect, a device according to the invention may further comprise one or more of the following optional and preferred features:

- the height of the lateral surface is between 0.4 m and 1.8 m;
- the lateral wall has a profiled shape with a polygonal cross section;
- the cover, which is preferably open-worked, is fixed in a removable manner to the lateral wall, preferably on an upper rim of the lateral wall, preferably by means of a hook-and-loop strip;

- the device comprises a light source, which may be natural or artificial and which emits light towards the lateral surface and/or the base surface, the egg laying aperture being arranged so as not to directly receive the light;
 - the egg laying aperture is arranged in a region of the cage which receives the least of the light;
 - the cage has more than 50 egg laying apertures which are arranged through a removable egg laying plate;
 - the spacing between the external opening of an egg laying aperture and a corresponding egg laying zone is constant, whatever the egg laying aperture being considered, the spacing preferably being greater than 3 mm, preferably greater than 5 mm, preferably greater than 8 mm, and/or preferably less than 20 mm, preferably less than 15 mm, preferably less than 10 mm;
 - the laying nest and the egg laying plate are arranged in a tubular support which extends through the cage, preferably the container, preferably the lateral wall of the container, and they extend, preferably perpendicularly to the axis of the tubular support, so as to substantially close the tubular support;
 - the tubular support projects inside the cage and/or outside the cage over more than 5 cm;
 - the base surface and/or the lateral surface has/have a white or yellow colour which is preferably uniform;
 - the lateral wall of the container is perforated by a connection aperture which can be selectively closed and which is intended for the introduction of flies into the cage;
 - the cage has a volume less than 10 m^3 , preferably less than 5 m^3 , preferably less than 2 m^3 , preferably less than 1 m^3 , and/or preferably greater than 0.2 m^3 , preferably greater than 0.5 m^3 .
- In a preferred embodiment, the base surface and/or lateral surface and/or internal surface of the container do not have any re-entrant edge or have one or more re-entrant edges, the cumulative length of which L_a (sum of the lengths of all re-entrant edges) is such that the ratio of this cumulative length to the surface-area S of the base surface and/or the lateral surface and/or the internal surface of the container, respectively, L_a/S , is less than 1200 mm/m^2 , preferably less than 1000 mm/m^2 , preferably less than 900 mm/m^2 , preferably less than 850 mm/m^2 , preferably less than 800 mm/m^2 , and/or the base surface and/or lateral surface and/or internal surface of the

container do not have any raised portion or depression, the height or depth of which is greater than 5 mm, greater than 4 mm, 3 mm, 2 mm, 1 mm, 0.5 mm, 0.3 mm, 0.2 mm, or 0.1 mm, respectively.

5 In a preferred embodiment, one or more through-openings are made through the walls of the container to provide fluid communication between the inside and the outside of the container.

In a preferred embodiment, for the calculation of L_a , any re-entrant edges in the junction zone(s) between the said through-opening(s) and the internal surface of the container are not counted.

In a preferred embodiment, for the calculation of L_a , any re-entrant edges in the junction zone(s) between the said through-opening(s) and the lateral surface of the container are not counted.

10 In a preferred embodiment, for calculation of L_a , any re-entrant edges in the junction zone between the base surface and the lateral surface of the container are not counted.

In a preferred embodiment, for calculation of L_a , any re-entrant edges in the junction zone(s) between the said opening(s) and the internal surface of the container are not counted, nor are any re-entrant edges in the junction zone(s) between the base surface and the lateral surface of the
15 container.

The through-opening(s) may be substantially polygonal in shape, for example rectangular or square. Alternatively, the opening(s) may not be polygonal in shape, for example may be circular or elliptical. The container can have as many through-openings as there are faces of the lateral wall. Alternatively, the container may have fewer through-openings than faces of the lateral wall.

20 For example, the container may have two through-openings on opposite sides of the lateral wall. For example, if the lateral wall has four planar faces defining a rectangular cross-sectional profile, the container may have one through-opening on each of the two larger faces.

Alternatively, the container may have a through-opening on each of the two smaller faces.

Alternatively, the container can be provided with a through-opening on each of the four faces.

25 The through-opening(s) height may be greater than 40% of the height of the face of the lateral surface carrying it, preferably greater than 50%, greater than 60%, greater than 75%, greater than 90% of the height of the face of the lateral surface carrying it. The through-opening(s) height may be less than 95% of the height of the face of the lateral surface that carries it. Through-opening(s) may be made in the upper half of the face of the lateral surface that carries it (them).

The through-opening(s) may extend over more than 40% of the area of the face of the lateral surface that carries them, preferably over more than 50%, over more than 60%, over more than 75%, over more than 90% of the area of the face of the lateral surface that carries it (them). The through-opening(s) may extend over less than 95% of the area of the face of the lateral surface that carries it (them).

The through-opening(s) may extend over more than 20% of the area of the face of the lateral surface that carries it (them), preferably over more than 30%, over more than 40%, over more than 50%, over more than 60% of this area, preferably substantially extend on 75% of the area of the face of the lateral surface that carries it (them). The through-opening(s) may extend over less than 95% of the area the face of the lateral surface that carries it (them).

The through-opening(s) may be covered with a wire mesh. This mesh can be fixed in a removable manner to the lateral wall, preferably by means of a hook-and-loop strip. These mesh-covered through-openings allow air to circulate inside the fly cage while preventing the individuals from escaping. Such a through-opening also makes it possible to observe the inside of the fly cage without having to open it.

The invention further relates to an installation comprising an egg laying device according to the invention, the cage preferably containing more than 1000 and/or less than 100,000 flies, preferably of the BSF type.

The invention also relates to an installation comprising a unit for producing flies, and in particular flies, a unit for producing eggs which are laid by the flies, a unit for producing young larvae from the eggs, a unit for producing adult larvae from the young larvae, and a unit for processing the adult larvae in order to produce harvestable products, for example, a protein-containing product, in particular a protein-containing flour, and/or preferably a fertiliser and/or an oil. These products can be used, for example, for animal feed, agriculture or technical applications.

According to the invention, the unit for producing eggs comprises an egg laying device according to the invention.

Preferably, the flies are flies of the BSF type (Black Soldier Fly) or *Hermetia illucens*.

Preferably, some of the larvae produced by the unit for producing larvae are used by the unit for producing flies.

The young larvae are more preferably fed by means of food residues.

Definitions

- 5 The “service position” is the position in which the egg laying device is used to cause flies enclosed in the cage to lay eggs in the laying nest.

The adjectives “lower” and “upper”, “internal” and “external”, “horizontal” and “vertical” make reference to orientations or positions in the service position.

- 10 The terms “horizontal” and “vertical” are intended to be understood to be an orientation forming with a completely horizontal and vertical plane, respectively, an angle less than 20° , preferably less than 15° , preferably less than 10° , preferably less than 5° , or less than 2° , or less than 1° .

- The “edges” of a surface are constituted by the points of this surface to which a line having a greater gradient has a gradient variation, also referred to as a “change of slope”, greater than 45° . By extension, it is also said that the angle of the edge is greater than 45° or that the surface has a change of slope greater than 45° . An edge is a re-entrant edge when it defines an indentation. For example, Figure 2 illustrates a surface S_1 on which the line having the greatest slope G has a change of slope of θ at any point M_A of the line A . If the angle θ is greater than 45° for all the points of the line A , the line A is an edge. In practice, it is possible to measure the change of slope between two points M_1 and M_2 of the line having the greatest slope which are separated by a spacing of 3 mm, the spacing of 3 mm being measured by following the line.
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The “smallest radius of curvature” at a point of a surface is the smallest radius of curvature considering all the directions. For example, at a point of a cylinder having a circular cross section, the smallest radius of curvature at a point of the cylindrical surface is the radius of the cylinder.

- 25 A surface has an area A_s and is constituted by a set of points. Each of these points has a smaller radius of curvature, which is identical to or different from that of the other points. The set of points of this surface, the smallest radius of curvature of which is greater than x cm (or less than x cm), covers an area A_x . The ratio A_x/A_s represents the percentage of the area of the surface which is covered by these points.

The surface “has a radius of curvature greater than x cm (or less than x cm) over more than y% of its area” when the ratio A_x/A_s is greater than y%, that is to say, when the set of points of this surface for which the smallest radius of curvature is greater than x cm (or less than x cm, respectively) covers more than y% of the area of this surface.

- 5 In practice, as illustrated in Figure 2, in order to measure a radius of curvature at a point P in a direction, there is marked, on the surface, a line which passes through the point P and which follows this direction. Subsequently, there are placed on this line two points P1 and P2 which are each spaced apart by 1.5 mm from the point P and which are arranged at each side of the point P. Then, there is marked a circular arc C which passes through the three points P1, P and P2. The
10 radius of curvature R is the radius of this circular arc.

The term “equivalent diameter” of an opening or a surface is intended to be understood to mean the diameter of a disc which has the same area as this opening or as this surface, respectively.

A “junction zone” is an intermediate surface which connects two other surfaces and which, between these two other surfaces, is strictly concave, when viewed from the interior of the cage.

- 15 A junction zone may particularly connect two planar surfaces which are orientated differently.

The term “blue” is intended to be understood to be a colour, the wavelength of which is between 472 nm and 490 nm.

The term “green” is intended to be understood to be a colour, the wavelength of which is between 490 nm and 573 nm.

- 20 The term “yellow” is intended to be understood to be a colour, the wavelength of which is between 573 nm and 584 nm, preferably between 575 nm and 579 nm.

Unless otherwise indicated, the term “to fix” means “to fix in a rigid manner”. A “fixing” may be temporary, that is to say, it may allow release, or it may be definitive.

- The terms “comprise”, “define”, “have” or “include” must be interpreted in a broad, non-limiting
25 manner.

Brief description of the Figures

Other features and advantages of the invention will be further appreciated from a reading of the following detailed non-limiting description and the examination of the appended drawings, in which:

- [Fig 1] Figure 1 schematically illustrates an entomoculture installation using flies;
- 5 – [Fig 2] Figure 2 schematically illustrates the definition of a re-entrant edge and a radius of curvature;
- [Fig 3] Figure 3 is a schematic perspective view of an example of an egg laying device according to the invention, the cover being detached;
- [Fig 3bis] Figure 3bis is a view similar to figure 3 of an embodiment;
- 10 – [Fig 4] Figure 4 is a schematic longitudinal section of a simplified example of a detail of the device of Figure 3, the number of egg laying apertures preferably being much higher;
- [Fig 5] Figure 5 is a schematic front view of the examples of laying nests.

In the different Figures, identical or similar reference numerals are used to denote components or component portions which are identical or similar.

15 **Detailed description**

Figure 3 and 3bis illustrate an example of an egg laying device 13 according to the invention. This device is intended for the exploitation of BSF flies, but the invention is not limited to this fly.

This device comprises a fly cage 20 and a laying nest 50.

20 *Fly cage*

The fly cage 20 is intended to enclose a batch of flies M, which is preferably constituted by more than 500 flies, preferably more than 1000 flies, and/or less than 50,000 flies, preferably less than 20,000 flies.

The cage is preferably constituted by a container 22 and a cover 24 for closing the container 22.

- 25 The container 22, which is preferably monobloc, is preferably made from a polymer material, for example, polyethylene. It comprises a base wall 26 and a lateral wall 28 which together define the internal surface of the container. Preferably, the internal surface of the container does not

have any undercut surface, that is to say, a surface which would prevent or inhibit the container from being removed from the mould along the axis X.

The base wall 26 internally defines a base surface 30, which is preferably substantially planar and which, in the service position, preferably extends horizontally.

- 5 The lateral wall 28 defines, at the side of the interior of the cage, a lateral surface 33 which extends, preferably substantially perpendicularly to the base surface 30 as far as an upper rim 34.

The base and lateral walls also define a junction zone 36 between the lateral surface 33 and the base surface 30. The junction zone 36 preferably ensures a progressive transition between the lateral surface 33 and the base surface 30.

- 10 The internal surface of the container is thus constituted by the base surface 30, the lateral surface 28 and the junction zone 36 between these base and lateral surfaces.

The cage 20, preferably the container 22, more preferably the lateral wall 28, is preferably passed through by a connection aperture 29 which can selectively be closed and which is intended for

- 15 greater than 50 cm², preferably greater than 100 cm², and/or preferably less than 1500 cm², preferably less than 1000 cm².

Preferably, the base surface 30 which is delimited by an external contour 31 is continuous, that is to say that it remains planar and uninterrupted as far as its external contour, where it joins the junction zone 36 with the lateral surface 33. In particular, it does not comprise any through-

- 20 opening, for example, a bung-hole which is intended for the discharge of liquid contained in the container 22. The term "planar base surface" is intended to be understood to mean that the base surface 30 does not have any raised portions or depressions, the height of which measured perpendicularly to the general plane of the base surface is greater than 20 mm, preferably greater than 15 mm, preferably greater than 10 mm, preferably greater than 5 mm, preferably greater than 4 mm, 3 mm, 2 mm, 1 mm, 0.5 mm, 0.3 mm, 0.2 mm, or 0.1 mm. Preferably, the base
- 25 surface 30 is smooth to the touch.

More preferably, the base surface 30 has a white, green, blue or yellow colour, preferably yellow, or is transparent. The colour spectrum is preferably between 472 nm and 600 nm.

The colour is preferably uniform. Surprisingly, the inventors have discovered that these colours were favourable for the reproduction of the flies.

In a preferred embodiment, the base wall 26 defines sleeves 32 which are suitable for introducing forks of a pallet truck. A plurality of egg laying devices according to the invention may thus be
5 stacked in order to constitute a vertical farm according to the invention.

The height h_{33} of the internal surface of the container is preferably constant. It is preferably greater than 0.4 m, preferably greater than 0.5 m and/or preferably less than 2 m, preferably less than 1.8 m or less than 1.5 m or 0.8 m. A height between 0.4 m and 1.8 m is particularly advantageous. This is because the inventors have discovered that such a height does not impede
10 the flight of the flies and therefore promotes their well-being. When a pair of flies falls onto the base surface 30 in order to mate, however, the impact suffered by these flies remains insignificant and does not lead to them becoming separated.

The lateral wall 28 is preferably constituted by a polymer material, preferably polyethylene, preferably constituted from the same material as the base wall.

15 Preferably, the lateral surface 33 has a white, green, blue or yellow colour, preferably yellow, or is transparent. The colour is preferably uniform, preferably identical to the colour of the base surface. The colour spectrum is preferably between 472 nm and 600 nm.

Preferably, the junction zone 36 between the lateral surface 33 and the base surface 30 has a white, green, blue or yellow colour, preferably yellow, or is transparent. The colour is preferably
20 uniform, preferably identical to the colour of the base surface. The colour spectrum is preferably between 472 nm and 600 nm.

The shape of the lateral wall 28 is not limiting. Preferably, however, the lateral wall 28 is constituted by a plurality of substantially planar faces, preferably more than 3 faces and/or less than 10 faces, preferably less than six faces, preferably four faces. The angle which is formed
25 between two adjacent faces is preferably constant, whatever pair of two faces is being considered. In one embodiment, the faces of the lateral wall 28 all have the same length.

In the preferred embodiment, the lateral wall 28 has a plurality of planar faces which define a profile-member having a cross -section (that is to say, in a plane perpendicular to the axis X)

which is polygonal, preferably rectangular, preferably square. The spatial requirement of the cage is thereby advantageously reduced.

In a particularly advantageous embodiment, the junction zone 35 between two adjacent faces which is delimited by broken lines in Figure 3, and which is preferably substantially vertical, does not define a re-entrant edge. In other words, the change in direction of the lateral surface 28 is progressive between these two faces. The junction zone 35 preferably ensures a progressive transition between the two adjacent faces.

More preferably, the junction zone 36 between the lateral surface 33 and the base surface 30 does not have any re-entrant edge.

10 The absence of edges advantageously limits the clutches of eggs in the junction zones between the faces or between the lateral wall and the base wall.

In general, the internal surface of the container 22 defines only a minimum of re-entrant edges. On average, on the base surface 30 and/or on the lateral surface 33, or on the whole of the internal surface of the container, the cumulative length of the re-entrant edges is preferably such that, if La denotes the cumulative length of the re-entrant edges on the surface being considered, and S denotes the area S of this surface, $La/S < 1200 \text{ mm/m}^2$, preferably $La/S < 1000 \text{ mm/m}^2$, preferably $La/S < 900 \text{ mm/m}^2$, preferably $La/S < 850 \text{ mm/m}^2$, preferably $La/S < 800 \text{ mm/m}^2$, without counting any re-entrant edges in the junction zone between the base surface and the lateral surface, preferably counting any re-entrant edges in the junction zone between the base surface and the lateral surface.

20 Preferably, the orientation of the internal surface changes progressively everywhere (when it changes). Preferably, the lateral surface 28 and the base surface 30 have, over more than 70% of the area(s) thereof, preferably over more than 80%, more than 90%, more than 95%, more than 99% of the area thereof, more than 99.5%, more than 99.9%, preferably substantially 100% of the area(s) thereof, a radius of curvature greater than 0.5 cm, preferably greater than 1 cm, preferably greater than 3 cm, preferably greater than 5 cm, preferably greater than 7 cm, and/or less than 30 cm.

The cover 24 is intended to close the container 22. It is preferably removable. More preferably, it is fixed to the upper rim 34 of the lateral wall 28. It can particularly be fixed to the container by

means of a hook-and-loop strip of the Velcro® type, the first and second portions 40₂₂ and 40₂₄ of which are bonded to the upper rim 34 and the periphery of the cover 24, respectively. The attachment and detachment of the cover 24 are thus very rapid. Furthermore, a continuous hook-and-loop strip effectively prevents the flies from moving towards the exterior of the cage.

5 The cover 24 is preferably open-worked so as to allow the external light, the ambient air and a liquid, preferably water, to pass. In the preferred embodiment, the cover comprises a grill 42, the mesh of which is sized to prevent the passage of a fly. Preferably, each mesh has an equivalent diameter less than 2 mm, preferably less than 1.5 mm. A flexible grill of the type used to constitute anti-mosquito nets is highly suitable.

10 In the embodiment shown in Figure 3bis, container 22 of fly cage 20 may have at least one through-opening 220 on the lateral wall 28. This through-opening 220 is rectangular.

The through-opening 220 shall extend over more than 90% of the face of the lateral surface carrying it.

15 The through-opening 220 extends over more than 90% of the area of the face of the lateral surface carrying it.

The through-opening has a mesh 221 identical to the mesh 221 on cover 24.

Laying nest and egg laying aperture

The laying nest 50 is intended to receive and fix eggs laid by the flies which are enclosed in the cage.

20 Preferably, the laying nest 50 is fixed to the cage, preferably in a removable manner. It defines an egg laying zone 52 which preferably defines at least one re-entrant edge 53, for example, in the form of an angle or a corner, as illustrated in Figure 4. Preferably, the angle of the re-entrant edge 53 is greater than 60°, 80° and/or less than 120°, 100°, preferably of approximately 90°.

25 Preferably, at least one re-entrant edge 53 of the egg laying zone 52 has a length greater than 5 mm, preferably greater than 10 mm, preferably greater than 20 mm, more preferably greater than 40 mm, 60 mm or 100 mm. In a preferred embodiment, the re-entrant edge 53 is closed on itself, that is to say that it forms a closed loop. The inventors have discovered that such an edge is particularly effective for bringing about the laying of eggs.

Figure 5 illustrates different examples of laying nests 50 which have different re-entrant edges 53. In each example, a re-entrant edge has been drawn with bold lines. The length of this edge is the length of the bold line.

The laying nest 50 is preferably constituted by a polymer material.

- 5 As illustrated in Figure 4, the laying nest 50 is preferably at the outer side of the cage and is arranged near an egg laying aperture 54 which is arranged through the cage 20, preferably through the container 22 and more preferably through the lateral wall 28.

- The egg laying aperture 54 preferably has a tubular shape. In cross section, that is to say, in a plane of section perpendicular to the axis Y of the egg laying aperture, the egg laying aperture 54
10 has a contour without any angle, which is preferably strictly concave, preferably circular or oval. The risk of eggs being laid in an undesirable manner in the egg laying aperture 54 itself is thus advantageously limited.

- In a cross section, preferably in any cross section, the equivalent diameter of the egg laying aperture 54 is preferably greater than 1 mm, preferably greater than 2 mm, preferably greater
15 than 2.5 mm and/or preferably less than 5 mm, preferably less than 4 mm.

The length L_{54} of the egg laying aperture 54, measured along the axis Y, is preferably greater than 0.1 mm, preferably greater than 0.3 mm, preferably greater than 0.5 mm, preferably greater than 1 mm, and/or preferably less than 3 mm, preferably less than 2.5 mm, preferably less than 2 mm.

- 20 The inventors have discovered that such dimensions of the egg laying aperture 54 limit the risk of eggs being laid in an undesirable manner in the egg laying aperture while preventing the passage of the flies.

- The egg laying aperture 54 opens, towards the exterior of the cage, via an external opening 56. The egg laying zone 52 which is associated with the egg laying aperture 54 is the zone of the
25 laying nest on which the flies can lay eggs when they are laying eggs through the egg laying aperture 54. It is preferably ribbed.

The laying nest 50 is arranged in relation to the external opening 56 in such a manner that the egg laying zone 52 is facing the external opening 56 and is preferably spaced apart from the external opening 56. Advantageously, eggs can thus be deposited on the egg laying zone 52

without coming into contact with the edge of the external opening 56, and more generally without coming into contact with the egg laying aperture 54.

Preferably, the egg laying zone 52 is spaced apart from the external opening 56 by a spacing d greater than 3 mm, preferably greater than 5 mm, preferably greater than 8 mm, and/or

5 preferably less than 20 mm, preferably less than 15 mm, preferably less than 10 mm.

Preferably, the egg laying zone 52 is spaced apart from the internal opening of the egg laying aperture 54, which is opposite the external opening and via which the egg laying aperture opens in the cage, by a spacing ($d+L_{54}$) greater than 4.5 mm, preferably greater than 6.5 mm, preferably greater than 9.5 mm and/or preferably less than 21.5 mm, preferably less than 16.5 mm,

10 preferably less than 11.5 mm.

More preferably, the laying nest 50 is not in contact with the portion of the lateral wall which defines the egg laying aperture. Preferably, it is spaced apart therefrom by a spacing δ greater than 0.1 mm and/or less than 5 mm.

Preferably, the egg laying aperture 54 is provided in a region of the cage which, in the service position, receives less light than the remainder of the internal surface of the container 22, and in particular receives less light than the remainder of the lateral surface. To this end, particularly when the interior of the cage 20 receives light through the cover 24, the cage comprises an obstacle 58 which prevents the light from directly illuminating the egg laying aperture 54. This obstacle 58 may be constituted by, for example, a cap or a sleeve which opens at one side inside the cage and, at the opposite side, towards the egg laying aperture 54. The shape of the sleeve is not limited and may, for example, be tubular. The sleeve may or may not be rectilinear and may particularly have a baffle. The inventors have found that a protection of the egg laying aperture 54 in order to prevent it from being directly illuminated effectively promotes the egg laying through the egg laying aperture.

25 Odoriferous source

In a preferred embodiment, the egg laying device further comprises an odoriferous source 62 which generates an odour which attracts the flies, preferably a putrefaction odour.

The form of the odoriferous source 62 is not limiting. Preferably, the odoriferous source 62 is dry. It may in particular be in the form of a solid block or a powder. In an embodiment, the

odoriferous source 62 is humid, for example, constituted by a wick soaked in an odoriferous liquid.

The odoriferous source 62 is arranged so as to attract the flies present in the cage towards the egg laying aperture 54. Preferably, the odoriferous source 62 is arranged at the side of the external
5 opening 56 of the egg laying aperture 54 in such a manner that, for the flies, the odour comes from the egg laying aperture 54.

In a particularly preferred embodiment, the odoriferous source 62 is arranged at the side of the laying nest 50 opposite the egg laying zone 52. More preferably, the laying nest 50 is perforated with one or preferably several channels 64 which allow(s) the passage of the odours emitted by
10 the odoriferous source 62 towards the egg laying aperture 54. Preferably, any channel 64 is formed to prevent the passage of the eggs of the flies. The equivalent diameter of the cross section of the channel 64 is preferably less than 3 mm, preferably less than 2 mm and/or preferably greater than 0.5 mm.

At least one channel 64 is preferably arranged near the egg laying aperture 54, preferably at less
15 than 30 mm, preferably at less than 20 mm, preferably at less than 10 mm from the egg laying aperture 54. Preferably, at least one channel 64 is arranged at less than 20 mm, preferably at less than 10 mm from any egg laying aperture 54.

The cage 20 preferably has a plurality of egg laying apertures, preferably more than 10, preferably more than 50, preferably more than 100 egg laying apertures 54. The risk of
20 obstructing an egg laying aperture 54 is thus limited. Preferably, the cage has less than 10,000, preferably less than 5000, preferably less than 1000 egg laying apertures.

The spacing between two adjacent egg laying apertures 54 is preferably greater than 1 mm, preferably greater than 2 mm, and/or preferably less than 10 mm. The inventors have discovered that such a distribution of the egg laying apertures offers a good compromise between
25 dimensions and efficiency.

Preferably, the egg laying aperture(s) is/are arranged in an egg laying plate 66 which is preferably removable, that is to say, detachable. The egg laying plate 66, which is preferably planar, may particularly be in the form of a grill perforated by egg laying apertures which are substantially circular.

More preferably, the egg laying plate 66 extends parallel with the laying nest 50, preferably without being in contact with it. Preferably, the smallest spacing δ between the egg laying plate 66 and the laying nest, when measured along the axis Y of the egg laying apertures 54, is greater than 0.1 mm and/or less than 5 mm.

- 5 The egg laying plate 66 is preferably sufficiently rigid not to become deformed. Advantageously, the spacing between the external openings of the egg laying apertures 54 and the corresponding egg laying zones 52 is thus constant over time, and preferably identical whatever the egg laying aperture being considered. The distribution of the eggs between the different egg laying zones is advantageously more uniform. Preferably, this spacing d is greater than 3 mm, preferably greater than 5 mm, preferably greater than 8 mm and/or preferably less than 20 mm, preferably less than 15 mm, preferably less than 10 mm, whatever the egg laying aperture being considered.

- The thickness of the egg laying plate 66 defines the length L_{54} of the egg laying apertures. It is preferably constant, preferably greater than 0.1 mm, preferably greater than 0.3 mm, preferably greater than 0.5 mm, preferably greater than 1 mm, and/or preferably less than 3 mm, preferably less than 2.5 mm, preferably less than 2 mm.

Preferably, the spacing $(d+L_{54})$ is greater than 4.5 mm, preferably greater than 6.5 mm, preferably greater than 9.5 mm, and/or preferably less than 21.5 mm, preferably less than 16.5 mm, preferably less than 11.5 mm.

- The egg laying plate 66 is preferably made from a plastics material or a metal, preferably from a stainless steel.

- An egg laying zone of the laying nest is associated with each egg laying aperture. In a preferred embodiment, all the egg laying zones 52 are defined by the same monobloc laying nest. The laying nest 50 may in particular extend parallel with the egg laying plate 66. When observed perpendicularly to the egg laying plate, it may have an external contour which is substantially identical to the contour of the egg laying plate 66 so as to extend in alignment with the egg laying plate 66 in the service position, as illustrated in Figure 5.

The laying nest 50 may extend vertically, as illustrated in Figure 4. However, the vertical orientation is not limiting. In particular, in one embodiment which is not illustrated, the laying nest 50 may extend horizontally.

The laying nest 50 is preferably fixed to the cage. Advantageously, the egg laying device is more easily manipulable, in particular in order to constitute a vertical farm. The laying nest 50 may be fixed to the cage 20 by any means.

In a preferred embodiment, the laying nest 50 and the egg laying plate 66 are arranged in a tubular support 68, for example, a tube, for example, of PVC, which has an internal diameter greater than 100 mm and which extends through the container 22, preferably the lateral wall 28. They preferably extend substantially perpendicularly to the axis Z of the tubular support 68 and more preferably have an external contour which substantially complements the internal surface of the tubular support 68 so as to substantially close the tubular support 68.

The tubular support 68 preferably protrudes inside the cage 20, preferably over a length d_{58} which is greater than 5 cm, preferably greater than 10 cm and/or less than 30 cm, preferably less than 20 cm. Thus, it may constitute an obstacle 58 to the light which irradiates the interior of the container, without increasing the spatial requirement of the device.

The device preferably comprises a stopper 69 for closing the tubular support at the side opposite the cage.

Liquid source

The egg laying device 13 preferably comprises a liquid source 70, preferably a water source, which is arranged so as to be able to introduce the liquid Li inside the cage, preferably as a result of gravitational force, preferably through the cover.

The form of the liquid source is not limiting.

Light source

An egg laying device according to the invention also preferably comprises a light source 80, which is preferably external with respect to the cage and which is suitable for exposing the interior of the cage to a light Lu and which is preferably suitable for not directly illuminating the egg laying aperture(s) 54.

The form of the light source is not limiting.

Operation

The operation of the egg laying device 13 according to the invention follows directly from the above description. It is described in the preferred, non-limiting embodiment of the device.

Initially, the cage 20 which does not contain any flies, but also preferably no other object either, is closed by attaching the flexible cover 24 over the entire length of the upper rim 34 of the lateral wall 28. The laying nest 50 is fixed in the tubular support 68 on the exterior of the egg laying plate 66, which is itself fixed in the tubular support 68. The odoriferous source 62 is arranged in the tubular support, at the side of the laying nest opposite the egg laying zones 52. The tubular support 68 is then closed with the stopper 69 at the side opposite the cage so as to prevent the diffusion of odours from this side.

The connection aperture 29 is then connected to a source of flies, which is not illustrated, for example, by means of a flexible pipe.

After the connection aperture 29 has been opened, flies M are thus introduced, via the connection aperture 29, into the cage 20. The connection aperture 29 is then closed so as to enclose the flies in the cage. The pipe can be disconnected.

The dimensions of the cage 20 allow the flies to fly and to mate. In particular, when a female fly and a male fly prepare to mate, they fall together onto the base surface 30. The limited height of the lateral wall prevents this fall from being excessively violent.

At least until the eggs are laid, a nutritional liquid, preferably water, produced by the liquid source 70, is introduced into the cage 20. The quantity of liquid introduced is controlled in order to prevent any accumulation of liquid in the bottom of the container 22.

The light source 80 illuminates the interior of the cage through the grill 42 of the cover 24. The tubular support 68 protects the egg laying apertures from any direct illumination by the light source 80.

When they are ready to lay eggs, the female flies search for micro-cavities which are defined by re-entrant edges in order to deposit their eggs there. However, the internal surface of the container 22 is smooth and its orientation changes progressively, including in the junction zones 35 between the faces of the lateral wall and in the junction zones 36 between the lateral wall and the base wall. It does not comprise such re-entrant edges or comprises very small quantities thereof.

Furthermore, the odoriferous source 62 emits an odour which passes through the laying nest 50 via the channels 64, then passes through the lateral wall, in this instance the egg laying plate 66, in order to be introduced into the cage 20 via the egg laying apertures 54. This odour attracts the female flies.

- 5 Furthermore, the female flies search for the micro-cavities which are least exposed to light and are therefore attracted by the shaded zone produced by the tubular support 68 when the light source 80 is above the cage 20. The female flies on the point of laying eggs are therefore attracted towards the egg laying apertures both by the attractive odour and by the shade.

- 10 When a fly M reaches a location near an egg laying aperture 54, it can observe, through the egg laying aperture 54, the presence of an egg laying zone 52 which has a micro-cavity, in the shade, and from which the attractive odour appears to come. Therefore, it is powerfully encouraged to deposit its eggs at that location.

- To this end, as illustrated in Figure 4, it introduces its ovipositor in the egg laying aperture 54. The egg laying aperture 54 is sufficiently narrow to prevent the fly from leaving the cage.
15 However, it allows it to reach the egg laying zone 52 in order to deposit its eggs O at that location.

Subsequently, the fly returns to the cage 20.

- At any time, an operator can access the laying nest 50 without having to enter the cage 20, and without any risk that a fly can leave the cage. The operator therefore retrieves the eggs without
20 disturbing the life of the flies inside the cage, for example, by removing the laying nest of the tubular support and then by shaking it. He/she can then place the eggs in incubation in order to ensure the hatching of the larvae, then their rearing. Finally, he/she can process the adult larvae in order to obtain the desired products.

- As now clearly appears, the invention provides an egg laying device which is highly suitable for
25 a method of entomoculture using flies.

The eggs can be retrieved at any time in a simple manner without disturbing the flies in the cage. The form of the cage, and in particular the limitation of the length of the re-entrant edges, limits the undesirable clutches of eggs and therefore makes it easier to maintain the egg laying device.

Tests have shown that the flies from the same batch mate and lay eggs substantially simultaneously, which improves the productivity.

Naturally, the invention is not limited to the embodiments which are described and illustrated and which are provided only for illustrative purposes. In particular, the BSF fly is the fly which
5 is preferentially involved in the invention, but the invention is not limited to this fly.

The form and number of laying nests, the form of the support used to fixedly join the laying nest to the cage, the number and form of the egg laying apertures are not limiting.