

IMPROVED OVIPOSITION TRAP FOR CAPTURING *Aedes* MOSQUITOES

FIELD

This invention relates to an improved oviposition trap for capturing *Aedes* mosquitoes and to a method of controlling mosquitoes using the trap.

BACKGROUND

The 'ovitrap' or oviposition trap functions by attracting the gravid female mosquito to preferentially oviposit in it, whereupon the resulting progeny can be collected and destroyed. It was first developed in the United States for the surveillance of *Ae. aegypti* (Fay and Perry, 1965; Fay and Eliason, 1966), but has since been modified and improved.

Chan (1973) was the first to document use of the ovitrap for the control of mosquitoes in a 1969 study in which *Ae. aegypti* was successfully eradicated from the Singapore Paya Lebar International Airport after one year. However, field studies showed that only small percentages of marked eggs from released females were retrieved in the large number of ovitraps set out (Liew, 2001). Thus killing the progeny may not have much impact on the population.

Interestingly, the high frequency of single marked eggs found in the ovitraps (Liew, 2001), implied that each female could have visited a large number of oviposition sites in the course of depositing her entire egg batch. Indeed, *Ae. aegypti* is known to distribute its eggs among several oviposition sites in each gonotrophic cycle (Christophers, 1960), and more recent studies using molecular techniques have confirmed this (Reiter, 1996).

In 1977, Chan *et al* developed an advanced autocidal version of the ovitrap, capable of continually destroying the progeny from eggs laid. This autocidal ovitrap allows the deposition of eggs and development of larvae and pupae, but does not permit the emergent adult mosquitoes to escape. The principal components are: an attractive black plastic cylindrical container holding clean water; two rough-surfaced hard-board paddles to absorb water and function as a suitable oviposition substrate; and a float-ring with trapped air inside its sealed hollow space supporting a fine wire mesh. It has been shown to be an effective monitoring tool, and has been used for almost 30 years in the Singapore *Aedes* Control Programme.

There are however limitations to the autocidal ovitrap, particularly if such a trap were to be used as a control tool. Firstly, it does not capture the ovipositing female, which can then go on to take another blood-meal, possibly biting the people in whose home the trap has been placed. Secondly, the trap is not foolproof and requires regular maintenance. The float-ring also tends to get stuck, resulting in accumulation of water above the mesh, thus turning the ovitrap itself into a potential breeding habitat. Furthermore, the trap sometimes floods despite the presence of two small drainage holes.

The present invention relates to an improved mosquito trap for gravid female mosquitoes – the ‘gravitrap’- that is designed to be adulticidal, capable of attracting and subsequently capturing the ovipositing gravid female mosquito herself and her eggs. If every female that enters a trap could be captured, she would be prevented from going to any other oviposition sites. The deployment of

such traps in sufficiently large numbers would contribute to the overall objective of significantly reducing the *Aedes* vector population and bringing it to below the dengue transmission level. This is considered by most experts to be the only realistic target, as complete eradication of the vectors is unlikely to be attainable (Reiter, 1998).

SUMMARY

The present invention relates to an improved trap – the ‘gravitrap’ - for attracting and capturing gravid female mosquitoes and their eggs. The gravitrap does not rely on moving structural parts, resulting in a contraption that is effective and virtually maintenance-free.

The present invention provides a mosquito trap comprising:

- a container capable of holding a liquid for attracting gravid female mosquitoes, the container comprising a body having a base and a sidewall;
- a mesh screen for preventing the passage of adult mosquitoes into and out of the body of the container below the screen;
- a top wall spaced above the container; and
- an inclined surface comprising adhesive for capturing mosquitoes making contact therewith;

wherein the top wall and inclined surface are opposed and provide a confined passage therebetween for mosquitoes attracted by the liquid to promote contact of the mosquitoes with the adhesive.

The container of the apparatus may be of any shape and size that will achieve the advantages of the present invention. The container will typically comprise a base

and a sidewall. In one preferred embodiment, the container has a cylindrical sidewall. In another preferred embodiment, the upper portion of the container sidewall tapers inwardly towards the central axis of the container. In a particularly preferred embodiment, the container sidewall is cylindrical and the inwardly tapering upper portion of the sidewall results in the upper portion of the container sidewall having a circumference that is smaller than that of the base. Preferably, the container sidewall is made of opaque material such as black plastic.

The container may hold any liquid that will be useful for the purpose of attracting gravid female mosquitoes, and any liquid known to be useful in the art will suffice. In a particularly preferred embodiment, the liquid is water. Gravid female mosquitoes are attracted to water.

The apparatus of the present invention comprises a top wall spaced above the container. In a preferred embodiment, the top wall is so disposed as to provide a spacing above the container that enables the entry of mosquitoes at the periphery of the trap. In another aspect of the present invention, the top wall comprises an opening that extends into the trap for facilitating the addition of liquid to the container body. The opening is preferably centrally located and the top wall is preferably frustoconical so that it downwardly tapers and narrows towards the central opening. In a preferred embodiment, the top wall is held up by supporting members projecting upward from the upper portion of the container sidewall. Preferably the top wall is made of plastic. It is particularly preferred that the top wall be transparent and UV-permeable to ensure transparency to the mosquito eye and easy visibility of captured mosquitoes. The top wall is preferably located over the inclined surface. It serves both to assist in delivering liquid onto the mesh

screen, and to protect the apparatus from environmental factors such as rain, and reduce the risk of debris falling onto and thus clogging up the mesh and adhesive surface. In one embodiment, the top wall is a cover. In another embodiment, the top wall comprises a combined funnel/lid.

The apparatus of the invention comprises an inclined surface. The inclined surface preferably adjoins the container sidewall and extends downward and inward towards the center of the container. In one embodiment, the inclined surface is integrally formed with the container sidewall. Preferably, the inclined surface adjoins the upper portion of the container sidewall. It is further preferred that the inclined surface be annular. Most preferably the inclined surface is an inverted frustoconical surface extending down towards the central axis of the container.

In another aspect of the present invention, the inclined surface of the apparatus comprises an adhesive surface. The adhesive surface may be provided by an adhesive composition applied to at least a portion of the inclined surface. The adhesive may be any non-setting, water-insoluble adhesive composition that will achieve the advantages of the present invention. Preferably, the adhesive is a rodent glue. Particularly preferred is the rodent glue named 'Rodent Glueboard'TM (Ikari Services Pte Ltd., Singapore). Other adhesives suitable for the application will be apparent to the person skilled in the art. The adhesive is preferably applied to the whole of the inclined surface above the mesh. In a preferred embodiment of the present invention, the top wall and the inclined surface are opposed and co-operate so as to provide a confined passage that promotes the contact of mosquitoes with the adhesive surface as they attempt to exit the trap.

The apparatus of the invention includes a mesh screen for preventing the passage of adult mosquitoes into and out of the body of the container below the screen. In one preferred embodiment, the mesh screen is attached adjacent to the bottom edge of the inclined surface. Further, the mesh screen is preferably located substantially centrally in the apparatus. In a preferred embodiment in which the inclined surface is an inverted frustoconical surface, the mesh screen may extend across the opening formed at the lower end of the frustoconical surface to inhibit the passage of adult mosquitoes at the smaller diameter end. The mesh is disposed so as to interrupt access of adult mosquitoes to the water. The holes or openings of the mesh screen must be small enough to prevent access of adult mosquitoes to the liquid, but may permit the passage of eggs from the gravid female mosquito through the mesh into the liquid. When the container body comprises a cylindrical sidewall, preferably the mesh screen is in the shape of a disc. It is particularly preferred that the mesh screen co-operates with the container body and/or the inclined surface to seal the container body below the screen against the ingress or exit of adult mosquitoes. In this way, the mosquito trap operates by using the liquid to attract gravid mosquitoes without providing an environment in which they may breed. In the event of any eggs being deposited in the liquid, the trap further operates to prevent the escape of adult progeny from the trap.

In another aspect of the present invention, the apparatus comprises at least one drainage channel extending outwardly from above the mesh screen to the container sidewall. The drainage channel allows liquid above the mesh to drain from the container. Preferably, the container comprises three drainage channels

spaced circumferentially around the container body. The drainage channel may be substantially parallel with the base of the container, but preferably forms a downward incline extending from the mesh screen to the container sidewall. In use, the drainage channels inhibit larval breeding above the level of the mesh screen by effectively draining any water present above the mesh.

In another aspect, the present invention provides a method of using an apparatus as herein described to trap gravid female mosquitoes and their eggs. The method employs a liquid within the container for attracting gravid female mosquitoes. Preferably, the liquid is water. The attracted gravid female mosquitoes thus land on the container sidewall and then in search of the water, walk onto the inner inclined surface. The inclined surface, being coated with an adhesive, forms a 'sticky' surface that immobilizes and captures any mosquito that comes into contact with the adhesive surface. The mesh screen further acts to prevent any adult mosquitoes from entering the body of the container and accessing the water below the mesh screen. Inaccessibility to the water by the gravid female mosquito would mean that no eggs would be laid there and thus no progeny would develop. Instead, the female herself would be captured on the adhesive surface and any eggs deposited on the adhesive surface by the female mosquito would remain unhatched. In the event that the gravid female mosquito succeeds in depositing her eggs in the water, for example, if the water level reaches the mesh screen, the screen will further act to prevent any potential emergent adult progeny resulting from the eggs from escaping from the body of the container below the mesh screen. The top wall assists in preventing the escape of mosquitoes from the trap by only permitting a narrow gap between the top wall and the inclined surface. The narrow gap forces mosquitoes to contact the adhesive surface when exiting

the container, thus reducing the chances of mosquitoes alighting on the mesh from flying off and avoiding capture.

DETAILED DESCRIPTION

Specific embodiments of the invention will now be described with reference to the drawings:

Figure 1 shows the side view of a mosquito trap in accordance with the invention.

Figure 2 shows the top view of the mosquito trap of Figure 1.

Figure 3 shows a cross-sectional view of the mosquito trap of Figure 2 bisected by the line denoted A – A'.

Figure 4 shows a cross-sectional view of the mosquito trap of Figure 2 bisected by the line denoted B – B'.

With reference to the drawings, the Figures show a mosquito trap of the present invention comprising an apparatus with a container (1), said container having a body comprising a base (2) and a sidewall (3). The container body may be made of any suitable material, for example: metal, plastic or glass. Preferably, the container body is made of plastic. An upper portion of the container sidewall (4) tapers inward towards the central axis of the container (1). A downwardly sloping annular inclined surface (5) adjoins the upper portion of the container sidewall (4) and extends inwards into the container (1). The inclined surface (5) is provided with a coating of a suitable adhesive composition on at least a portion of its

surface. A mesh screen (6) is attached adjacent to the base of the inclined surface (5), and is located substantially centrally relative to the diameter of the container (1). The mesh screen (6) extends across an opening (6a) formed at the base of the annular inclined surface (5), and acts to prevent the passage of adult mosquitoes into and out of the container body. The mesh screen (6) may be made of any suitable material, for example metal or plastic. Preferably, the mesh screen (6) is made of plastic. The container (1) is provided with at least one drainage channel (7) that serves to ensure that no water will collect above the level of the mesh screen (6). Preferably, three radial drainage channels (7) are provided that are formed at the inclined surface (5) and interrupt the sidewall (3) to provide drainage ports (7a) circumferentially spaced around the container (1). A top wall (11) is located above the container (1) and is held up by supporting members (9) projecting upward from the upper portion of the container sidewall (4). The supporting members (9) of the apparatus are preferably of equal height. The top wall (11) is located substantially centrally above the container (1). The top wall (11) is preferably transparent and UV-permeable and may be made of any suitable material known in the art, for example glass or plastic. In a preferred embodiment, the top wall (11) is made of plastic. The top wall (11) comprises a peripheral edge (8) spaced above the sidewall (3) of the container (1) and has a downwardly sloping annular wall portion (10) defining an inlet opening (12) for facilitating the addition of water to the container (1) through the mesh screen. The top wall (11) is generally funnel shaped with the inlet opening (12) located above the mesh screen (6). The gap between the peripheral portion (8) of the top wall (11) and the inclined surface (5) is narrow so as to force mosquitoes to contact the adhesive on the inclined surface (5).

EXAMPLES

Adhesive Sourcing

A non-setting, water-insoluble adhesive would provide the adulticidal component of the trap, by capturing the ovipositing female. Several commercially available rodent glues were tested for this purpose. Rodent Glueboard™ (Ikari Services Pte. Ltd., Singapore) was found to be the most suitable.

Gravitrapp Apparatus

The gravitrapp has a main container body comprising a black (opaque) plastic cylinder. The container has approximate dimensions as follows: diameter 9.0 cm; height 6.0 cm; wall thickness 1.0 mm. On the top surface of the container, a flat plastic mesh screen with a hexagonal grid of small holes (diameter 1.5 mm) is located centrally. The inner circumferential portion around the mesh forms a sloping inclined surface, onto which the adhesive is applied evenly. Three narrow drainage channels are provided that radiate outwards from the mesh to the outer sidewall of the container.

A transparent plastic top wall with dimensions of height 2.7cm, inlet diameter 9.0 cm and thickness 1.0 mm is positioned directly above the container, and is held in place by three supporting members. The top wall is translucent and UV-permeable to ensure transparency to the mosquito eye and further, to ensure that any captured mosquitoes can be easily seen. The top wall is located substantially centrally above the container in order to allow for easy pouring of water into the trap and further, to facilitate the introduction of additional water in the replacement of evaporated water.

Adhesive Efficacy Evaluation

Rodent Glueboard™ was found to effectively capture the gravid female mosquito, with virtually 100% capture in all studies. Furthermore, there was lasting efficacy of the glue over time, when kept under laboratory conditions: 100% capture at 2 months; 60% capture at 6 months.

Gravitrapping Efficacy Evaluation

A study was carried out to evaluate the gravitrapping for oviposition attractiveness and capture efficacy.

In selecting the mesh shape to be incorporated into the trap design, it had been necessary to ascertain whether or not accessibility to water was a necessary attractant for the gravid female mosquito. Thus a gravitrapping with a round dipped mesh screen was compared to one with a flat mesh screen.

The following three set-ups were tested:

- (1) 'Exposed water': Prototype with round dipped mesh screen; water above the mesh and accessible.
- (2) 'Hidden water': Prototype with flat mesh screen; water below the mesh and inaccessible.
- (3) 'No water / Control': Prototype with flat mesh screen; no water.

The three traps were placed in a straight row, inside a large cage with netting on all sides. A group of ten gravid female mosquitoes, blood-fed three days earlier, were released into the cage and allowed to freely fly around and oviposit. At 30-minute intervals, the trap positions were rotated to account for positioning bias.

After 90 minutes (or earlier if all females were stuck), the replicate was terminated and any remaining unstuck females were removed from the cage and discarded. The number of females stuck on each trap was recorded.

In total, seven replicates with ten fresh gravid female mosquitoes each were conducted, and cumulative capture numbers recorded. The mean number of females stuck per replicate (group of ten) on 'No water/Control' was significantly lower ($x = 0.429$) than for the other two set-ups. There was however, no difference between the numbers stuck on 'Exposed water' and 'Hidden water' (for both: $x = 3.571$).

In the present study, the gravid female mosquitoes were found to be consistently attracted to and captured by the set-ups of 'Exposed water' and 'Hidden water', but not by 'No water/Control'. Accordingly, the presence of water is an important attractant for the gravid female.

The numbers captured on 'Exposed water' and 'Hidden water' were found to be the same, with a mean of almost 4 (from the group of ten) captured by each set-up. Thus both set-ups were equally effective, and accessibility to water does not appear to be necessary to attract the ovipositing female. This is a critical discovery, as all previous ovitrap designs have been based on the female having access to water.

It is understood that various other modifications and/ or alterations may be made without departing from the spirit of the present invention as outlined herein.

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CLAIMS:

1. A mosquito trap comprising:
 - a container capable of holding a liquid for attracting gravid female mosquitoes, the container comprising a body having a base and a sidewall;
 - a mesh screen for preventing the passage of adult mosquitoes into and out of the body of the container below the screen;
 - a top wall spaced above the container; and
 - an inclined surface comprising adhesive for capturing mosquitoes making contact therewith;wherein the top wall and inclined surface are opposed and provide a confined passage therebetween for mosquitoes attracted by the liquid to promote contact of the mosquitoes with the adhesive.
2. An apparatus according to claim 1 wherein the mesh screen comprises holes of a size that is capable of inhibiting the access of adult mosquitoes but permits the passage of mosquito eggs.
3. An apparatus according to claim 1 wherein the spacing of the top wall above the container provides an entry for mosquitoes at the periphery of the trap.
4. An apparatus according to claim 1 wherein the inclined surface is integrally formed with the container sidewall.
5. An apparatus according to claim 1 wherein the inclined surface is annular and extends inwardly and downwardly from the container sidewall.

6. An apparatus according to claim 1 wherein the inclined surface is an inverted frustoconical surface.
7. An apparatus according to claim 6 wherein the mesh extends across the lower end of the inverted frustoconical surface.
8. An apparatus according to claim 1 wherein the mesh screen co-operates with the body of the container and/or the inclined surface, whereby the body of the container below the screen is sealed against the ingress or exit of adult mosquitoes.
9. An apparatus according to claim 3 wherein the upper portion of the container sidewall tapers inwardly towards the central axis of the container to provide a narrowly tapering entrance for mosquitoes.
10. An apparatus according to claim 1 wherein the adhesive is applied over the whole of the inclined surface.
11. An apparatus according to claim 1 wherein the adhesive is rodent glue.
12. An apparatus according to claim 1 wherein the container further comprises at least one drainage channel extending outwards from above the mesh screen to the outer sidewall of the container.
13. An apparatus according to claim 11 wherein the container comprises at least three drainage channels spaced about the container.

14. An apparatus according to claim 1 wherein the top wall is transparent.
15. An apparatus according to claim 7 wherein the top wall is frustoconical, downwardly tapering to a central opening above the mesh screen.
16. An apparatus according to claim 5 wherein the top wall is located over the annular inclined surface to protect the adhesive surface thereof from environmental conditions and falling debris.
17. An apparatus according to claim 1 wherein the container body contains water to a level below the screen whereby the screen prevents access of adult mosquitoes to the water.
18. A method of trapping gravid female mosquitoes and their eggs comprising the use of the apparatus of claim 1.