KYMENLAAKSON UNIVERSITY OF APPLIED SCIENCES
Degree Programme in Design

Jurgens Johannes Schoeman

A CONCEPT FOR CAPTURING FRUIT FLIES IN DOMESTIC HOMES

Bachelors Thesis 2012

ABSTRACT

KYMENLAAKSON AMMATTIKORKEAKOULU
University of Applied Sciences
Degree in Design
SCHOEMAN, JURGENS JOHANNES Concept for capturing fruit flies in domestic homes
Bachelor's Thesis 53 pages
Supervisor Marjo Suviranta, Senior Lecturer
November 2012
Keywords fruit fly, infestation, fruits, vegetables, eradicate, domestic dwelling, environmentally safe

The purpose of this research was to identify an effective concept for capturing fruit flies in Finnish households. Potentially, the product of this work could be utilized in households across the world.

Every summer, Finnish homes are infected with fruit flies, also called vinegar flies. The scientific name for this fly is Drosophila Melanogaster. Drosophila is an ideal subject for genetic studies and is often referred to as the "workhorse" of genetic research. It has a short life cycle, is easy to keep, convenient to store and highly fruitful.

The Drosophila family shares its common name: fruit fly, with another family group called Trypetidae. While both groups feed on fruit, Trypetidae feed solely on ripening fruit. Drosophila on the other hand, feed on soft ripe fruit and other household waste. Despite this difference, methods for capturing both families were studied. Finally, a suitable commercial solution was identified and adapted for domestic use.

Primarily, information was gathered from scientific articles and academic journals published on the Internet. Furthermore, an interview was held with Henna Myllykoski, an expert on Drosophila Melanogaster. The Internet was further used to collect images and information on commercial and domestic methods for trapping fruit flies.

ACKNOWLEDGEMENTS

A great deal of thanks to my wife and family for their support. Appreciation to Marjo Suviranta, the supervisor for this work and study mentor throughout this degree. Thanks to Henna Myllykoski for sharing her expertise and time. Above all to my Creator.

TABLE OF CONTENTS

LIST OF TERMS AND ABREVIATIONS

Drosophila M.: Drosophila Melanogaster, the common fruit fly, also called the vinegar fly.

Consumer: For the purposes of this paper, the term consumers implies those people who, often unknowingly, purchase produce infected with fruit flies, fruit fly eggs or fruit fly larva from producers and other retailers.

User: Someone using traps or other methods in order to catch or eliminate fruit flies from their dwelling.

Spontaneous generation: The theory that life emerges from non-living matter.

Funnel-entrance: A cone shaped entrance with a wide opening that narrows toward the end.

INTRODUCTION

Every year, during the warm summer months, Drosophila Melanogaster invades Finnish homes. Once the flies have established themselves in a dwelling, they become a nuisance that often last deep into the winter months. Primarily homemade traps are deployed to deal with these flies. The reason for this might be the limited amount of commercial traps available on the Finnish market. This does not include products that can be bought on the Internet from other countries. Relatively few viable options exist on the Internet for Finnish users. In relation to the price of the product, the shipping fees might be very high, potentially doubling the price of the product.

The Encyclopaedia Britannica defines fruit flies as:
any two-winged insect of either the family Trypetidae or the family Drosophilidae (order Diptera) whose larvae feed on fruit or other vegetative matter.

Because these two family groups are so closely related, as are the means for luring and attracting them, for the purposes of this paper, it is beneficial to study the methods used to eliminate both groups. Thereby a suitable solution might be found that could be deployed against either family group.

The main difference between the two family groups is that Trypetidae live on developing fruit, since they are able to pierce the skin of fruit in order to feed and deposit its eggs, while Drosophilidae prefer to feed and reproduce on soft or broken produce. While both family groups may occur in domestic settings, Drosophilidae thrives in this type of environment where it has adopted to feeding and breeding on degradable household wastes.

BASIC WORKING REFERENCE PLAN

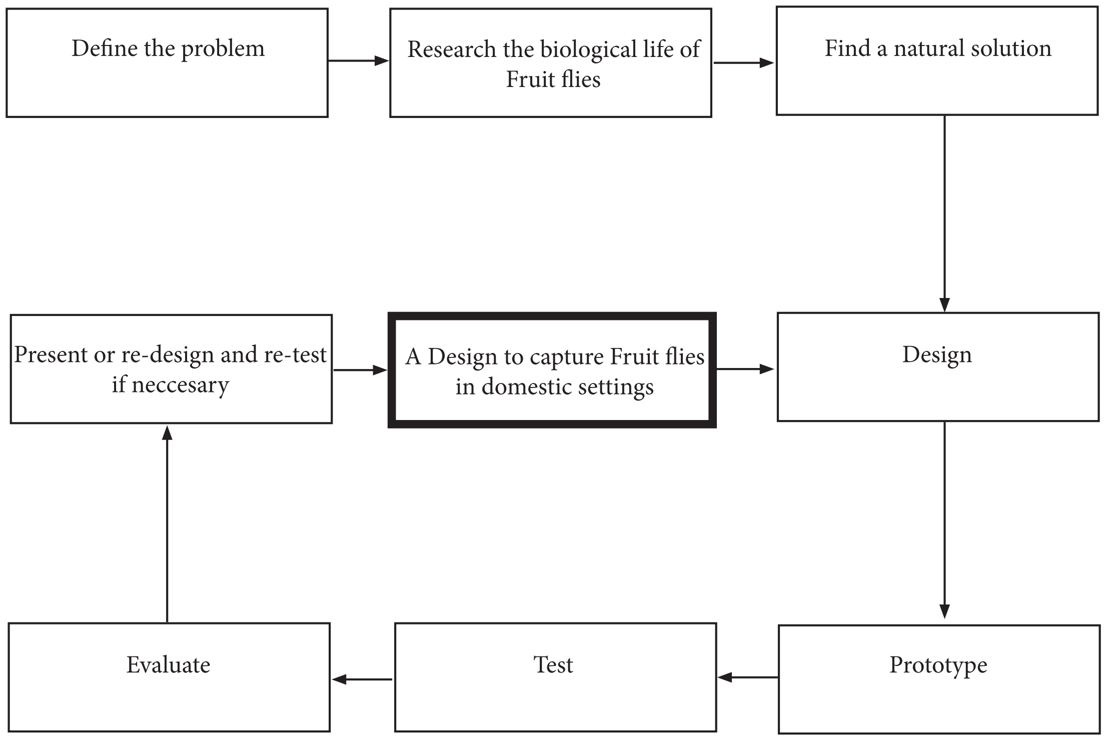

Figure 1. Illustration of Basic Work Strategy (Schoeman 2012)

By defining the problem and conducting a thorough research of the biological life cycle of the fruit fly, the aim of this paper is to discover a logical solution to deal with fruit fly infestations in domestic dwellings. Since the design process is an on-going process, this stage of the work is continually to be revisited, to include new insights as more information is gathered.

Under the guidance of the supervisor responsible for this paper, two steps were included into the research process. The first step was to evaluate existing products available for capturing fruit flies. The second was an interview with an expert on Drosophila Melanogaster. This interview was held with Henna Myllykoski, M.Sc. from the University of Tampere, on the 27th February 2012, at the Institute of Biomedical Technology, Tampere. Currently, Myllykoski and her team examine phagocytosis and innate immunity. By studying how certain genes effect on the immune system response of Drosophila to various bacterial infections, these responses can be analysed, through the signalling cascades that regulate Drosophila Melanogaster's immunity.

Through this research, deductions could be made, which might be applied in the study of mammalian inflammatory infections. [Section 2.7]

1 DEFINING THE EFFECTS OF FRUIT FLIES AND METHODS UTILIZED AGAINST INFESTATIONS

1.1 Defining the Effects of Fruit Flies on a Commercial Level

On a commercial scale, the impact of fruit flies is far reaching. Unless a crop originates from a fruit fly free area, fumigation and cold treatment is often necessitated, in order to market produce. Significant efforts are undertaken annually, to deal with this, the most important group of quarantined pest. (Hallman, Loaharanu 2002: 1.) This impact is exemplified through the case of an entire ship, which was sent back from Spain to South Africa in 2003; because of the discovery of a single live fruit fly upon the vessel. (ARC 2010.) For fruit producers, and those dependants on the fruit industry, the economic effects and quarantine status of fruit flies can be devastating. Especially so for developing countries, where a large percentage of exports, are fruit. One such example is the Republic of South Africa, and in particular the wine industry. Dr. Brian Barnes, of ARC Infruitec-Nietvoorbij, states in his article "Fruit flies on wine grapes - infestation success, cultivar effects and impact on area-wide control", that: *Apart from economic crop losses and associated control costs, the international quarantine status of fruit flies can cause far greater economic losses due to restrictions in the free international trade in fruit* (Barnes 2000).

1.2 Methods for Dealing with the Adverse Effects of Fruit Flies on a Commercial Level

A wide range of methods is deployed, in an attempt to deal with the adverse effects of fruit flies, on orchards and other fresh agricultural produce. On a commercial scale, a combination of methods is used, that often include chemicals and pesticides such as methyl bromide. Alternative methods are based on either biological, or biochemical solutions. The former involves the introduction of new predacious alien species or parasites that feed on the fruit fly, while the second, refers to the use of chemicals such as pheromones and food attractants.

We find numerous examples where the introduction of new species has had predominantly negative consequences. Despite extensive environmental impact studies and feasibility tests, it remains unknown how the introduction of alien species will affect established species. It then becomes a process of discovering the effects, which the newly introduced species, has on its environment and on existing species. Since this is often an irreversible process, the long-term effects could mean the extinction of other indigenous species. One such example is Africanized bees, which are wreaking havoc across the Southern United States of America. Despite the long lasting risks involved, this method retains its appeal because of the numerous biological and environmental benefits that many believe it could hold.

Diachasmimorpha Longicaudata is a solitary Braconid wasp, first introduced to the State of Hawaii in 1948 (Bess, van den Bosch, Haramoto 1961: 367-378.). The female wasp deposits her eggs into the larva of the Caribbean fruit fly. When the wasp larva emerges from the egg, it immediately starts to feed on the fly pupa, thereby killing the pupa before it develops into an adult fly.

Figure 2. Adult Female Diachasmimorpha Longicaudata (Ashmead), an Braconid Endoparasitic Wasp Which Parasitizes the Caribbean Fruit Fly, Ovipositing into a Fly Larva (Lotz 2004)

During the 1930s, E.F. Knipling (Curtis, Klassen 2005:4) developed the sterile insect technique. This technique involves the use of gamma radiation, so as to induce dominant lethal mutations in insects. Male flies are reared in very large numbers and sterilized through radiation. These infertile males are released into orchards to mate with females, which will then lay unfertilized eggs, thereby greatly reducing the population size. Both economically and environmentally, this is a highly competitive method to manage fruit fly populations. The sterile insect technique is not sufficient by itself, as a method of control, but is most effective when used in conjunction with other pest management technologies, such as bait application and sanitation.

The rapid spread of various fruit fly species across the globe, has proven to be a major obstacle. The unprecedented increase in international trade and travel, has simultaneously lead to the cross continental extension of the fruit flies domain.

1.3 Defining the Effects of Fruit Flies in Domestic Settings

While preventing the spread of fruit flies across international borders has proven too difficult, it is no more difficult, than preventing transmissions to domestic settings. Despite the numerous attempts made by governments, scientists and producers (those who grow produce that is commercially jeopardised as a result of fruit flies) to control the spread and effects of fruit flies, it is unlikely that this problem will be brought under control in the near future.

In domestic settings Drosophila Melanogaster, or the common fruit fly, often deposits its eggs into produce consumed by humans. The fly spends several days of its life, first as an egg and then a pupa, feeding, growing and defecating inside household foods such as fruits and other perishables. Although fruit flies are primarily a source of nuisance in domestic dwellings, according to Demerec (1950: 536), it is also possible that these flies can act as disease carriers. Demerec further explains this by stating that:

Textbooks of human parasitology list Drosophila species as agents of intestinal myiasis and as vectors of disease-producing bacteria (Demerec 1950: 536).

In 1859, many scientists still held strongly to the theory of spontaneous generation. It was believed that through this process, fruit flies came from rotting meat. Louise Pasteur disproved the theory that these flies and other organisms seem to appear out of nowhere. To this day, people misunderstand where fruit flies “appear from”.

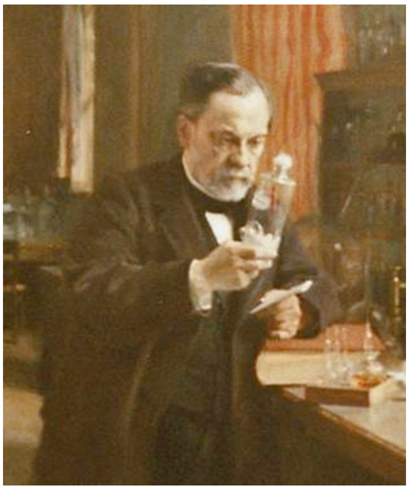

Figure 3. Louis Pasteur. Painting by Edelfelt, A. 1885 (Havala 2009)

Contrary to the popular believe, that fruit flies are carried into a house on fruit and vegetables bought from a store, fruit flies are far more likely to enter a house from the surrounding environment than from a grocery store. The common fruit fly, which we most often encounter in domestic settings, exclusively feed on ripe fermenting fruit. Most of the fruit in Finnish stores are still ripening. While it remains possible that fruit flies, their larvae or eggs can be brought into a household along with fresh fruit from the store, the amount of flies that enter a dwelling from the surrounding natural environment, far surpass those who enter through produce purchased from a store. Consider for example, the amount of flies that can breed under a single apple tree. Then consider how many other fruits and berries are grown in a typical Finnish residential neighbourhood.

1.4 Methods for Dealing with the Adverse Effects of Fruit Flies in Domestic Settings

Most commonly, consumers create their own devices to deal with fruit fly infestations in their homes. These contraptions vary greatly. From placing two dirty plates on top of one another in a facing position, to the adaption of vacuum machines, in order to suck flies out of the air.

2 RESEARCH THE BIOLOGICAL LIFE OF DROSOPHILA MELANOGASTER

2.1 Data Collection

Primary data was collected by means of an interview with Henna Myllykoski, from the University of Tampere. Secondary data was gathered from scholarly articles and academic journals published on the Internet. Specific information concerning companies and products for trapping fruit flies was also accessed over the Internet.

2.2 Classification

Drosophilidae is a large group of flies from the order of Diptera, under the suborder of Brachycera, commonly referred to as fruit flies. Under the family group of Drosophilidae, we find the subfamily Drisophilinae and the genus of Drosophila, which includes more than 1 500 different species (Markow, O'Grady : 2006).

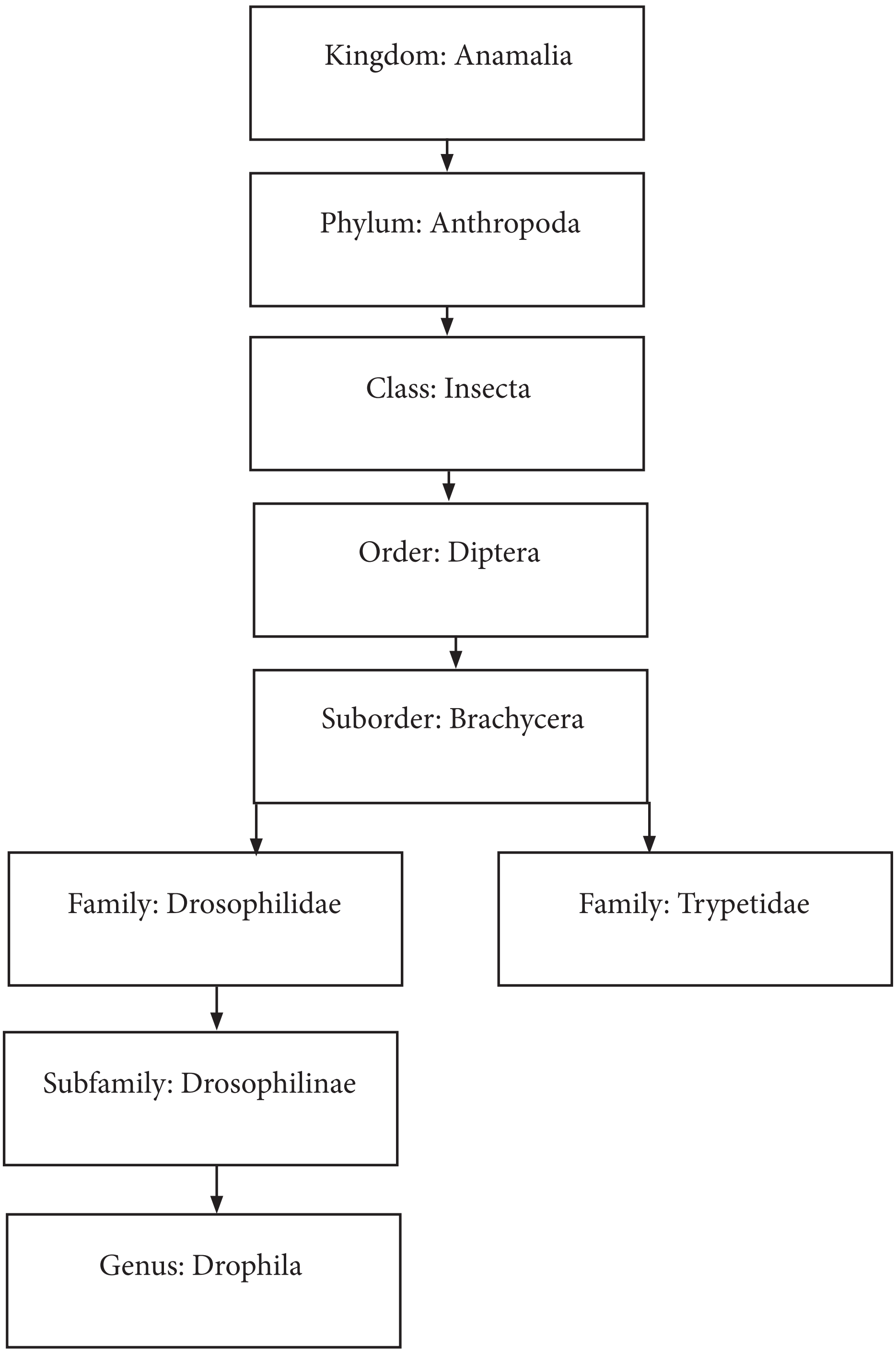

Figure 4. An Illustration of the Classification of Drophila and Trypetidae (Schoeman 2012)

2.3 Drosophila Lifecycle

Drosophila Melanogaster has a very short lifespan of around eight to ten days at a temperature of 29°C. During time, the fly goes through a complete metamorphosis.

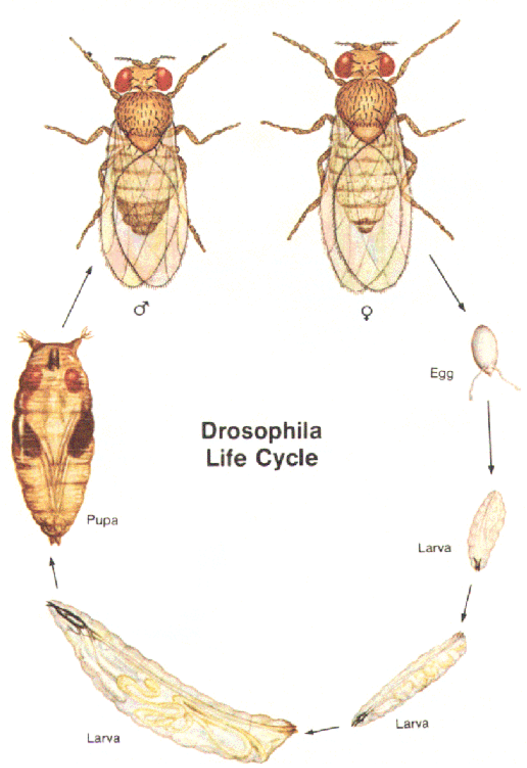

Figure 5. Drosophila Lifecycle (Flagg 1979)

A single female may lay up to five hundred eggs, usually near the surface of degrading biomaterials. The egg will hatch within thirty hours from the time that it is laid.

Figure 6. Female Drosophila Melanogaster Flies Start Laying Eggs Shortly After Mating (Research Institute of Molecular Pathology 2007)

The larva lacks eyes and legs. There are two mouth hooks located at the front of the head. These are black, while the rest of the body is mostly white. Abdominal breathing pores are located on both sides of the terminal posterior. During the next five to six days, the larvae primarily feed on the yeast produced by the fermenting produce and grow to seven or eight millimetres in length, tapering towards the front of the body. After this period, the larva will move to a drier area.

An exoskeleton will form from the exterior skin, transforming the larva into a pupa. This brown seed-like sheath will enfold the developing fly for a very short time. Only two days later the fully formed fly emerges, ready to mate.

Adults vary from three to four millimetres in length, wings included. With bright red eyes, the fly is very easy to identify under a magnifying glass.

2.4 Habits and Natural Tendencies

The sexual behaviour of Drosophila M. is another factor that might play into the design of an effective trap, or more specifically, the placement of the traps. Although males are notably smaller than females, they are more aggressive. Territorial males will defend their breeding grounds by fighting off other males. After a territory has been established, the courtship process is initiated through the male chasing the female. Once the female stops running, the male performs a song, by rubbing his wings together. Finally, they mate.

Much like humans, Drosophila M. has a built in biological clock. They are light dependant and most active in dim light, such as found during dawn and dusk. It would therefore be beneficial to advise users, to set out traps, for a minimum period of twenty-four hours. This is to ensure that all the flies in a specific area have undergone two active periods during the time in which the trap was set out.

Motion in Drosophila, or more specifically flight, is an aspect that has recently become a major point of interest. Thanks to new technological advances, scientists are able to study the flight of fruit flies, through the use of flight simulators. The fly is attached to a metal pin, with liquid glue, which is cured by light. The pin is suspended in a magnetic field, which forms the centre of the flight arena. The fly is free to turn. All movements, including wing and antenna positions, are continually monitored and recorded. This information is used to configure the images displayed around the arena, thereby creating an interactive environment wherein the flight motion can be studied.

Figure 7. A Fruit Fly Suspended in a Magnetic Field Alters its Flight Path Depending on Cues it Receives from Light Polarization (Weir 2012)

Figure 8. A Fruit Fly (Drosophila melanogaster) in a Virtual Reality Display System (Straw 2011)

Through the use of these flight arenas, it was discovered that drosophila, is attracted to long vertical objects. In contrast, small spots are avoided, as they might be perceived as hazardous. (Dickson, Maimon, Straw 2008: 464-470). Through this process of attraction and repulsion, the insect regulates its flight. Drosophila M. orientate itself, by focusing on prominent vertical features.

2.5 The Drosophila Sensory Systems

2.5.1 Visual Perception

Fruit flies possess colour vision. Each of their compound eyes consists of ≈700 ommatidia cells. Each ommatidium, contains eight photoreceptors (R1–R8) (Hardie

1985:1-79). It is claimed that Drosophila is attracted to the colour yellow. This might be so, because 70% of the ommatidia found on the centre of the retina, are long wavelength sensitive, evoking the colour yellow. However, a study undertaken by Wave (1964: 295), proved that red is the most effective trap colour in catching Drosophila M. Furthermore, red also happens to be the natural colour of the Drosophila eye.

Figure 9. Drosophila Melanogaster (Mr.Checker)

Despite all the research conducted on Drosophila Melanogaster, allot remains to be discovered about this fly. For example the reason why the eye is covered with bristles.

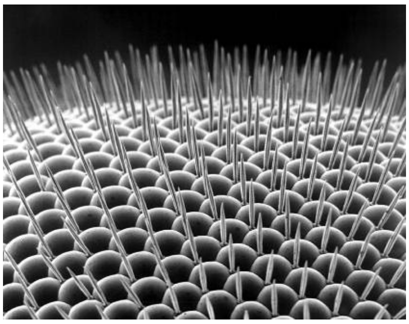

Figure 10. Drosophilidae Compound Eye Edit1 (Original author Dartmouth College retouched by Papa Lima Whiskey 2012)

2.5.2 Olfactory and Gustatory Systems

Various studies have been undertaken to establish the most attractive bait for luring various types of fruit flies. A large number of the studies conducted on Drosophila M. has concluded, that the scent of ripe bananas, is the most effective attractant (McKenrick).

2.5.3 Auditory System

As part of the mating ritual of Drosophila Melanogaster, males perform a song. By rubbing their wings together, they are able to produce sound. The efficiency of auditory traps has been tested in studies on female flies. Since male flies are not attracted to these traps, it would not suffice when dealing with a fruit fly infestation in domestic dwelling.

3 EXISTING PRODUCT ANALYSIS AND EVALUATION

3.1 Product Analysis and Evaluation – Commercial Traps

3.1.1 The M3 Fruit Fly Bait Station

Figure 11. The M3 Fruit Fly Bait Station (Botes 2011)

This bait station is a re-design by M3 Design, of an existing product for Green Trading cc. Intended for use in commercial citrus orchards; the bait station is hung from tree branches. The body of the trap holds a foam pad of which the bottom is exposed. This pad contains a protein based broad-spectrum insecticide. It also contains the luring pheromone. This pheromone is very specific, in that it only lures the males of two specific fruit fly species. The insecticide pad stays effective for up to four months before it completely degenerates after six months. For effective results, the application rate is four hundred units per hectare.

It is only possible to access the poison from the underside of the trap. The body of the trap covers the insecticide, thereby protecting the environment and those who handle the traps.

3.1.2 The Fly Catcher or Mcphail Trap

Figure 12. The Fly Catcher or McPhail Trap (Russel Integrated Pest Management 2012)

This trap was specifically designed to catch Bactrocera Tryoni, more commonly known as the Queensland fruit fly. This species is the most harmful to fruit and vegetable crops in its native Australian environment. The upper part of the trap consists of translucent polypropylene. Either a solid or liquid lure can be placed in the trap. Since the trap is reusable for several seasons, only the lure needs to be changed. For monitoring purposes, the rate of application is one or two per hectare. The Fly Catcher is a product of Russel IPM, Integrated Pest Management.

In practice, the translucent top permits visual inspections of the catch. All the flies caught, are contained inside the trap. Consequently it is possible to dispose of all poisoned flies, in an appropriate manner. This closed-trap design is therefore environmentally more suitable than other open-trap designs, which allow flies to carry poisonous insecticides back into the environment.

3.1.3 The Eco Trap

Figure 13. The Eco Trap (Vioryl 2012)

Primarily used against the Olive fruit fly. The Eco Trap is baited with a sex pheromone called spirochete, and the entire trap is covered with a parathyroid insecticide . Another attractant, ammonium bicarbonate, is contained inside the bag. When the fly lands on the bag, it immediately receives a lethal dose of insecticide. It is claimed that these bags stay effective for extended periods. One device is placed in every olive tree, unless the trees are still very small. According to Vioryl, the company that produces the Eco Trap:
ECO-TRAP is, at present, the only product for olive fruit fly control that complies with organic farming guidelines according to European Union regulations 2091/1991, 1488/1997 and 473/2002 (Vioryl 2012).

Despite its green colour, the ecological quality of this product remains questionable, since any insect, animal or human that may come into contact with the trap will be exposed to the poison.

3.1.4 The Pherocon Trap

Figure 14. Pherocon® AM, AM/NB Trap (Trece Incorporated 2012)

Pherocon is a registered trademark of Trece Incorporated. This trap is primarily deployed to detect and monitor insect population migrations. It is baited with insect specific pheromones. As an insect lands on the trap, it immediately becomes stuck. Unable to get away the insect eventually dies. The trap is divided into equally sized squares, thereby making it easier to count the flies for monitoring purposes. The yellow colour further attracts specific species of fruit flies.

This sticky subject is both popular and widely used. According to the manufacturer the trap is easy to handle. Nonetheless, like other sticky traps and sticky rolls, it would not fit well in a domestic setting.

3.2 Product Analysis and Evaluation – Commercially Produced Domestic Traps

3.2.1 The Fatal Funnel

Figure 15. The Fatal Funnel (Fatal Funnel Traps.com 2012)

As illustrated above, the Fatal Funnel is a design based on the basic funnelling entrance where flies are attracted into the funnel-entrance, but unable to find the small exit since it is facing back into the trap. The user is required to find some kind of container, such as a two-litre soda bottle, and make several cuts into the side of the container. The Fatal Funnel then needs to be inserted into these cuts. Thereafter the bottle is filled with a liquid lure, such as a mixture of apple juice and sugar.

The Fatal Funnel is an environmentally safe and re-usable product. No pesticides are required and the content of the trap can easily be discarded. However, the container or plastic bottle that housed the funnel would probably be disposed off, since it is hard to clean. Therefore a new container would be required every time it is used. After some period, depending on the temperature, the lure will start to ferment and give off a foul smell. This odour and the unsightly view of dead flies, makes this trap a very unattractive feature in any kitchen.

3.2.2 The Terro Fruit Fly Trap

Figure 16. Terro Fruit Fly Trap (Urban Garden Solutions 2012)

The Terro Fruit Fly Trap is yet another product that is based on the funnel-entrance design. Included in the package, is a bottle of lure that needs to be poured into the trap. The lure consists of acetic water and sodium lauryl sulphate. The trap itself resembles an apple. The funnel is located in the upper part of the trap. A translucent patch is located on the lower part of the trap. This allows light to illuminate the inside of the trap. It further facilitates visual inspections of the lure level and contents of the trap.

It is indeed clear, that the user was considered, during the design of this product. Despite the attempt to make this trap more aesthetically pleasing, its appearance remains flawed, as it recalls memories of fake plastic fruit and flower decorations. Washing it could be difficult.

3.2.3 The Fruit Fly Trap

Figure 17. The Fruit Fly Trap (Spring Star Incorporated 2012)

This device can either be suspended in the air or placed on a flat surface. Flies are able to crawl in underneath the trap, because of the foot-pieces located around the bottom edge of the trap, which holds the trap of the ground. The bottom consists of a funnel-entrance through which the flies can enter. The trap also contains a liquid lure. A semi-translucent stained glass bottle forms the body of the product. This allows for visual inspections of the trap content, while to some degree, concealing dead flies.

The trap is hard to wash, but re-usable, provided you do not loose the cork. It might be appropriately in certain settings or household contexts. Regular washing is required to prevent the lure from emitting a fowl odour.

3.3 Product Analysis and Evaluation – Homemade Domestic Traps

3.3.1 Funnel-entrance

Figure 18. Fruit Fly Trap (Downtowngal 2012)

Homemade traps are mostly based on the funnel-entrance design. Predominantly lures such as vinegar, yeast or ripe fruits are used to bait the trap.

These traps can be highly effective if the correct bait is used and the trap is properly constructed. They are however very unsightly, an item most people would not want to display when friends come around for dinner.

Despite being trapped, the flies might actually thrive inside the trap, unless they are terminated. Having been provided with everything they need for successful multiplication, they will immediately get underway. As mated females enter the trap, they will immediately start to deposit their eggs inside the trap. These eggs will continue to develop, unless they are adequately dealt with. Washing the trap might be difficult; therefore discarding the trap might require further consideration on behalf of the user.

3.3.2 Surface Tension

Figure 19. A Jar Filled with a Liquid Lure and a Small Amount of Soap (Rurification 2012)

The second method, commonly used for homemade traps, is based on the surface tension of liquids. By adding a small quantity of soap to a liquid lure, such as apple juice, the water tension can be reduced by up to 90%. This is because soap and other detergents, tend to aggregate at the surface of water, where it interferes with the hydrogen bonding process between various water molecules. Soap molecules consist of one charged hydrophilic polar end, which is water attracting, and another uncharged hydrophobic non-polar end, which is water repelling. Since not all the soap molecules can fit on top of the water, some molecules are forced to be in the water, thereby drastically reducing the water surface tension. Whereas before the addition of soap, the flies were able to sit on top of the liquid surface, they now fall into the liquid and consequently drown.

This method for trapping fruit flies works very well. However, the sight of drowned fruit flies remains unattractive. The liquid could also release a repulsive smell after a certain period. Care is to be taken when handling the jar so as not spill the content. Cleaning the container is simple, after discarding the liquid and the flies into a toilet; the jar can be washed and re-used. Some people might however be repulsed by having to discard of the dead flies into a toilet or drain.

4 INTERVIEW

4.1 Conclusions

From the interview held with Henna Myllykoski from the University of Tampere, the following information was extracted.

First it was determined that Drosophila Melanogaster is indeed the species of fruit fly, commonly found during the warm summer months, in Finnish households.

It was established that it is best to target adult flies, since they are the easiest to detect. Flies should ideally be killed as they enter the trap, to prevent them from breeding inside the trap. This would further facilitate the easy and proper disposal of the flies. Examples of the laboratory traps containing ethanol were examined.

Figure 20. An Example of a Trap Utilized at the Institute of Biomedical Technology (Schoeman 2012)

The fly cultures are kept on a mashed potato based feed. The flies are typically contained in clear plastic cylinders. To prevent the flies from escaping, as well as to facilitate the exchange of air, a piece of cotton is shoved into the top of the cylinder.

Figure 21. Drosophila Melanogaster kept in Clear Plastic Cylinders (Schoeman 2012)

The short lifespan and rapid reproductive abilities of Drosophila M. has made it an excellent subject for genetic research. These qualities have also had a negative result on laboratory cultures. Laboratory flies, often characterized by their white eyes instead of the original red, often suffer from partial blindness due to degeneration. Another characteristic associated with laboratory cultures, is their inability to fly or the fact that they are flight impaired, because of having curled wings. According to Myllykoski, this is the result of certain strains of flies, being kept in laboratories for decades.

Understanding the significant difference between degenerated laboratory fly cultures and the wild types has proven the pre-eminence of obtaining wild type flies. To achieve accurate results, suitable wild type flies are required to test new concepts. Since laboratory insects spend their entire lives confined in small crowded spaces, their fitness and ability to fly freely, remains questionable.

4.2 Experiment

While conducting the interview, an experiment was done, to establish whether Drosophila M. would be able to find its way out of a dark funnel-entrance trap. The entire trap, was constructed in such a way, that the only light coming into the trap, would enter through the opening of the funnel. Five male and five female flies were placed inside the trap. Since there was no food inside the trap, the flies had no incentive to stay inside. The trap was sealed and left for a week. When the trap was inspected, three dead flies were found inside the trap. One of the flies had gotten stuck to the tape that was used to seal the trap. It stands to reason, that this fly might also have found its way out of the trap, as did most of the other flies. The purpose and conclusion of this experiment is further discussed in section 5.3.

4.3 Observations

Diptera Psychodidae, or the common drain fly, was also caught and identified. Although these flies may also occur in Finnish households, they are more likely to be found in bathrooms where they breed in drains and sinks.

Despite the thousands of laboratory flies handled by scientist each day, surprisingly little is known about the habits, behaviour and natural preferences of wild Drosophila.

5 THE DESIGN PROCESS

This process often varies greatly from one person to another and even from one project to another. Typically, the process would start by doing research. (Slack 2006: 30.) Before doing the research, it is essential to understand the requirements that the design has to meet. While doing the research, it is essential to apply relevant information, into the design of the product.

In order to find the most effective concept for eliminating Drosophila Melanogaster, the design should be based on the fly itself. Therefore, a significant portion of this work is dedicated toward achieving a better understanding of the wild type Drosophila Melanogaster. This understanding might also form a basis for the development of future products deployed against fruit flies.

Furthermore, careful consideration should be taken regarding the user to ensure that the product is suitable, safe and as attractive as possible. A major challenge exists in balancing the efficiency of the trap, and its aesthetic appeal. A sufficient number of trapping methods already exist, yet most of them lack any aesthetic appeal. Unless the concept is also attractive, it would fail for the purpose of this work. However, aesthetics is not an aspect in which to be carried away.

5.1 Product requirements

The following requirements will be discussed:

- Safety and Environment
- Colour and Aesthetic Appeal
- Shape and Size

- Material
- Economics and Convenience
- Maintenance
- Efficiency
- Simplicity

Safety is a crucial feature, since the product will be used in family residences. In no way should the product be able to cause injury or harm to anyone.

Finnish designs have attracted worldwide attention through the work of people such as Alvar Aaalto. However, Finnish design as a whole, is predominantly found in Finnish homes. Therefore, new products aimed at the Finnish market, should consider the existing environment inside Finnish homes. A neutral colour would fit into a variety of environments. However, research indicates that red is the most effective colour for attracting Drosophila. (Wave 1964: 295).

As a result of studying Drosophila Melanogaster, the shape of the trap can be deduced from the fact that Drosophila M. is attracted to long ventricle shapes. (Dickson, Maimon, Straw 2008: 464-470). This attraction would further affect the placement of the product. Traps placed on a prominent vertical feature such as a window should, according to theory, attract more flies. The size of the object should be kept to minimum, thereby saving production costs and creating less waste.

Initially it was considered to use durable materials such as porcelain, glass and steel, which are also washable and re-usable. During the working process, it was understood that it would be better to create an environmentally friendly, single-use disposable product.

The laws of economics require that a fitting product be offered to the market. During times of economic uncertainty, low consumer confidence often results in people making smaller purchases. Individuals identify themselves through their possessions, consequently the need to acquire and accumulate remain consistent. People still have the need to buy, but are more conscious of the how much they spend per item. Instead of making a large purchase, it is preferred to indulge in multiple small acquisitions. It might be easier to market a low priced, single use item, than a costly, one-off purchase item that is meant to be re-used. Several opportunities exist within such an economic

situation. Firstly, the consumer's perceived "needs" are met, ensuring that the product will be sold. No maintenance is required and no cleaning is involved. Neither do consumers have to store the product during the long winter months. New inexpensive traps can simply be bought as needed.
Businesses profit by being able to sell the same product to the same users. By making small changes to the product, such as graphic illustrations, new markets sectors and even overseas markets could be reached.

Product maintenance might have been an expected feature to previous generations. However today, product requirements are of such a nature, that the user can simply replace a product, instead of cleaning or maintaining it. The values held by Finnish society have drastically changed during the past decade. Despite social trends, such as environmental awareness, societies across the world have become more and more convenience driven. Convenience is now of the utmost importance. The product should require the minimum amount of effort from the user. This would minimize the possibility of the product to be used in another manner than the way originally intended.

Efficiency is another requirement that is crucial to the successful adaptation of any product into a culture or society. Finnish society continues to place a high value on product efficiency. If the trap did not work as expected, the chances are, that users would not replace the used traps, but seek a different solution that might work better.

Finally, simplicity is a requirement. It is also a key aspect of many Finnish designs. Several versions of electric powered products exist. These products emit light or produce sounds to lure flies into the trap. None of these are essential for attracting Drosophila Melanogaster, and would therefore be excluded from the trap.

5.2 Product Context

The context for this product is set in Finnish households. Careful consideration should be taken regarding the aesthetic appearance of the trap.

5.3 Ideation, Conceptualization and Evaluation

The funnel-entrance is a proven method, which has been used to capture a vast array of animals. Initial ideas incorporated the funnel-entrance trap, into the fruit bowl or the fruit bowl cover.

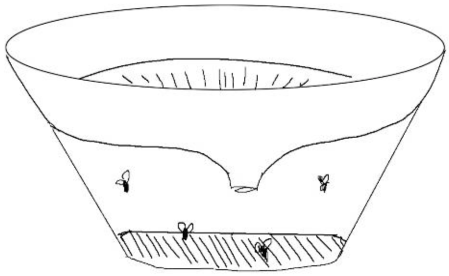

Figure 22. Fruit Bowl Trap with a Funnelling Base (Schoeman 2012)

The most effective method to deal with a fruit fly infestation would be to eliminate or enclose all fruits and other attractants. Adding a funnel-entrance trap into a fruit bowl cover would capture flies, that by some means, gained access to the fruit. Funnel-entrances around the outside of the bowl might attract and capture flies before they reach the actual fruit.

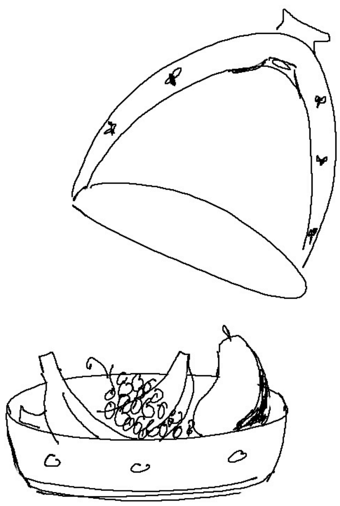

Figure 23. Double-Walled Cover and Bowl with Funnel-Entrances (Schoeman 2012)

By studying various traps, it was noted that traps placed over a lure, captured high percentages of flies. Placing the trap over a bowl of fruit would further eliminate the need for bait, since the fruit itself would attract the flies. Since Drosophila M. tend to crawl and fly upwards, flies leaving the bowl would consequently enter the trap and be caught. However, the flies would not be prevented from feeding and breeding on the fruit before being captured.

The following concept was to capture flies that might have landed on top of the cover, and flies that had already flown into the fruit bowl, which is beneath the trap. The trap basically covers a fruit bowl. It is constructed by placing a funnel-entrance on the top, and on the bottom of the trap. The second funnel-entrance was placed underneath the cover, to capture flies as they try to crawl or fly out of the bowl.

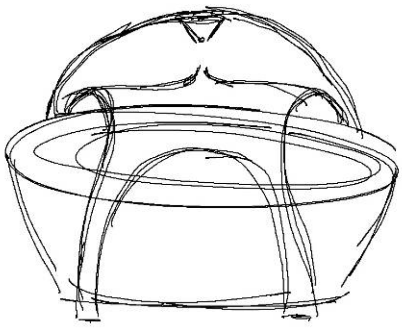

Figure 24. A Glass Cover that Incorporates Two Funnel-entrances (Schoeman 2012)

Creating a product for trapping fruit flies does not necessarily have to be complicated. It would be beneficial to add value to a product by making it visually attractive, and/or interesting.

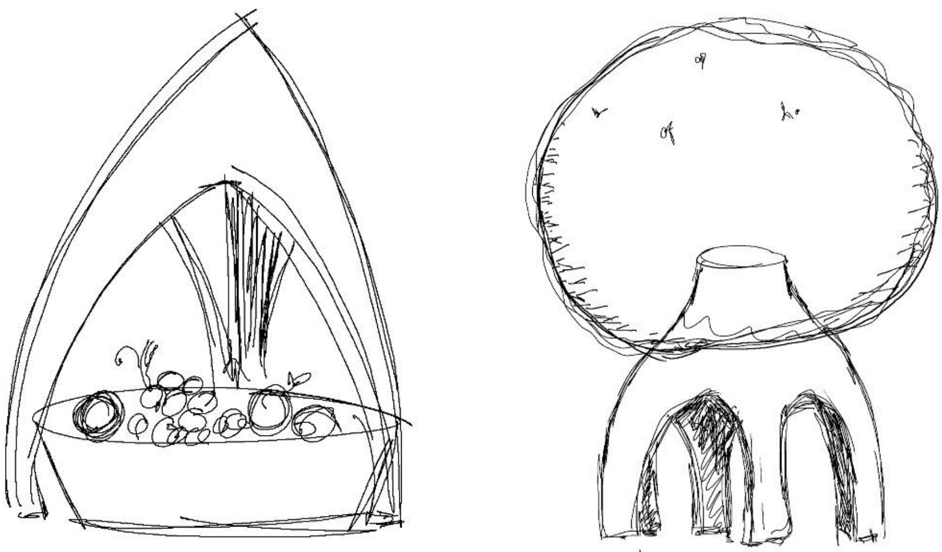

Figure 25. Potentially More Intriguing Shapes (Schoeman 2012)

The above concepts only allowed the user limited access to the fruit. The next concept would allow access to the fruit from all side. An attractant is required, since the trap is not placed over the fruit. The trap is a part of the fruit bowl, with its entrance located in the centre of the bowl and surrounded with fruit.

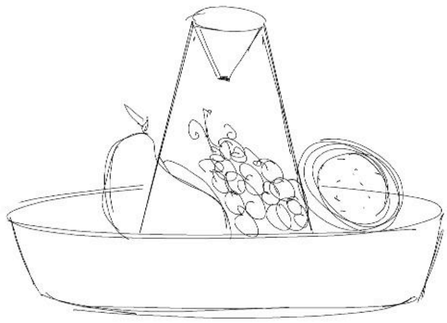

Figure 26. A Fruit Bowl that Incorporates a Trap (Schoeman 2012)

As mentioned above, the sight of dead flies floating in a fermenting liquid is not an acceptable feature of a suitable solution. Constructing a funnel-entrance trap from a solid opaque material would eliminate this problem. However, the following two questions emerged. Firstly, whether fruit flies would enter a completely dark trap. Secondly, it needed to be established whether the flies would be able to find their way out of such a trap. In order to evaluate this idea, a prototype was constructed. With the help of Henna Myllykoski, flies were placed into the trap. An inspection of the trap revealed that 70% of the flies managed to find their way out of the trap. (Section 4.2) Although it was not tested whether flies would enter a completely dark trap, it was determined that flies are able to find their way out of such a trap, by following the light source.

Figure 27. Flies Were Able to Escape From a "Dark-Trap" (Schoeman 2012)

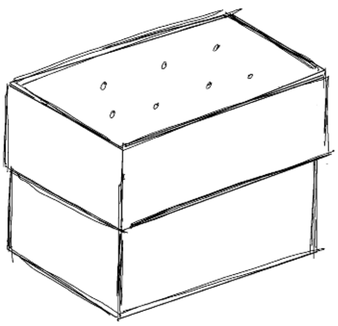

Figure 28. A Fully Enclosed Trap (Schoeman 2012)

Understanding that Drosophila Melanogaster exhibits positive photo tactic behaviour, and is therefore attracted to light, plays a vital role in the design of this trap. It is essential to allow light to enter the trap in such a way, that the flies would not be able to find their way out of the trap. At the same time, the flies inside the trap should not be visible, except for when the trap is inspected.

Figure 29. Spheres Comprised of a Tinted Glass Cap and Funnel-Entrance Base (Schoeman 2012)

Further concepts considered how many entrances could be used and in which position the entrance would be the most effective.

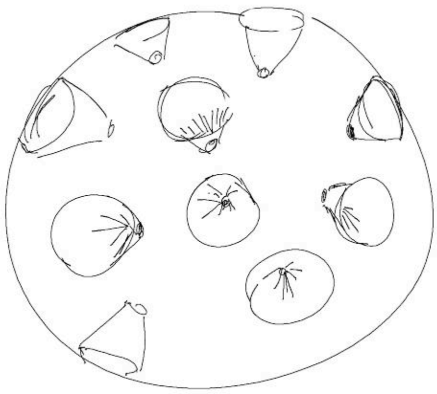

Figure 30. A Sphere Possessing Multiple Funnel-Entrances (Schoeman 2012)

When the basic funnel-entrance trap was simplified, it was recognized that the product could simply be a funnel. By placing the funnel-entrance over a transparent glass, a trap is formed. However, the concept resembles many home traps and partially is.

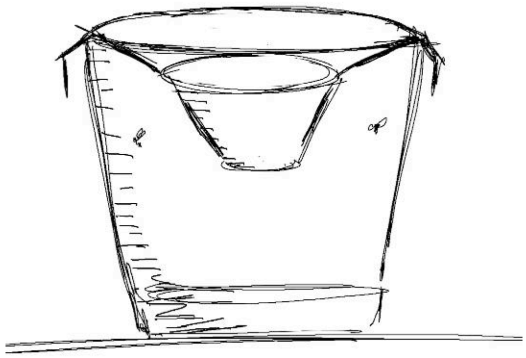

Figure 31. A Funnel Entrance Placed on Top of a Clear Glass (Schoeman 2012)

After going through the ideation stage, it was concluded that the basic funnel-entrance design, containing a liquid lure with reduced water tension, was preferred. Furthermore it was noticed, that more flies were caught in traps where the funnel ended close to the bait. It was considered to use materials such as porcelain, glass and steel in order to create a product that could be washed and re-used. By constructing the body of the trap from porcelain, dead flies would be hidden from sight. The light colour of porcelain would further neutralize the product. The glass ring under the rim would allow light to come into the trap. Additionally it would prevent flies from exiting the trap by attracting them away from the entrance. The brushed steel lid and funnel would add a modern touch.

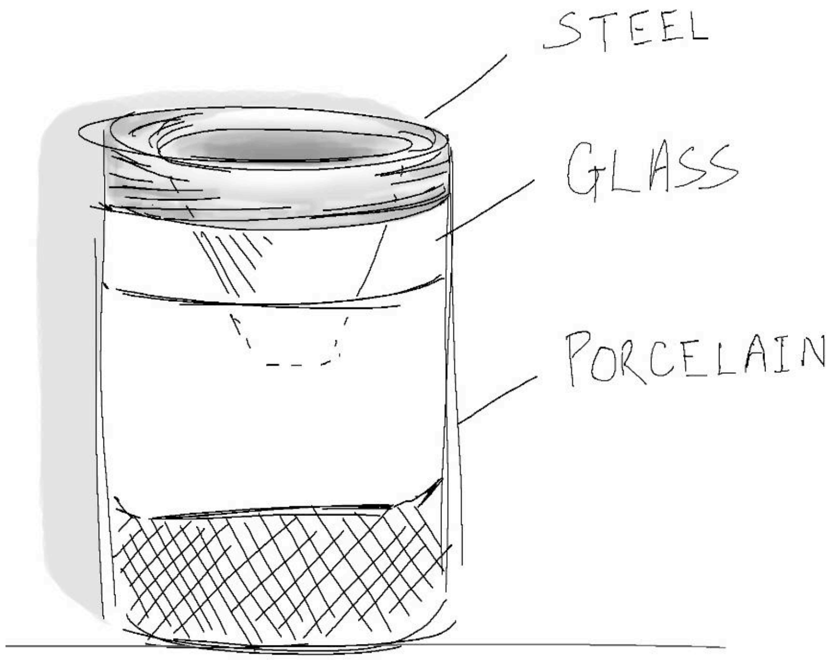

Figure 32. Basic Funnel-Entrance Design (Schoeman 2012)

At this stage of the process, the materials were reconsidered. It was understood that the need of users, for an ecological product, could also be met by using materials that are not washable or re-usable, but recyclable or recycled. It is often noted that the form of an object should comes from its function. The same might apply to the material used for a product. Many new possibilities came from changing the material.

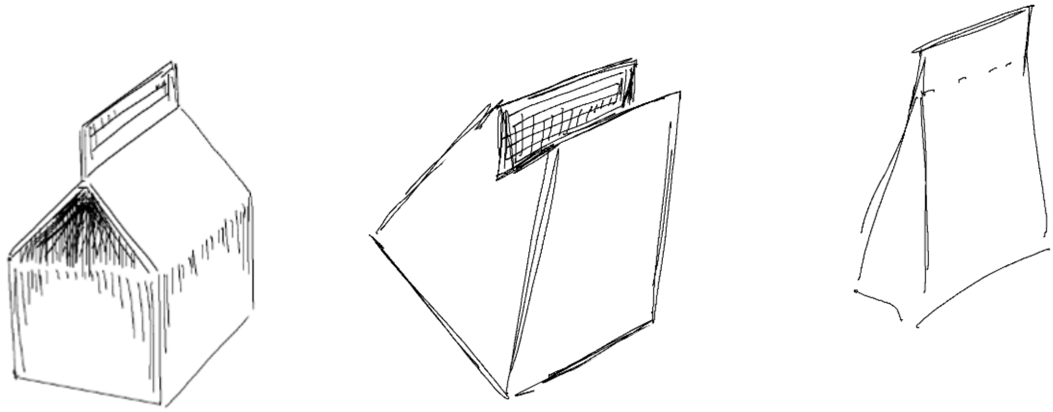

Figure 33. Examples of Carton Traps (Schoeman 2012)

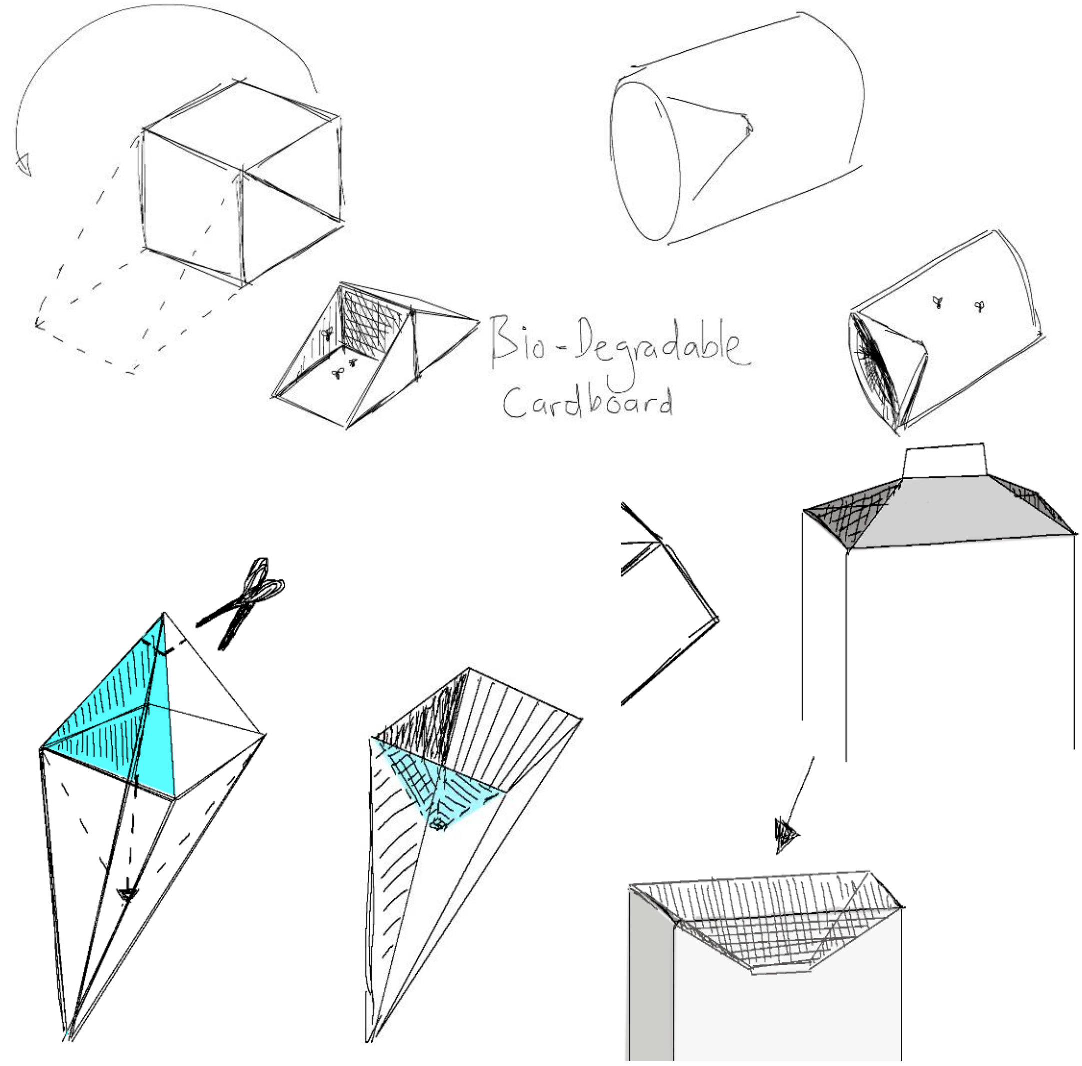

Figure 34. More Cardboard Concepts (Schoeman 2012)

Again the trap was broken down and simplified. The liquid lure, often used in funnel-entrance traps, was replaced by a sticky glue lure. The glue would prevent the flies from escaping and breeding.

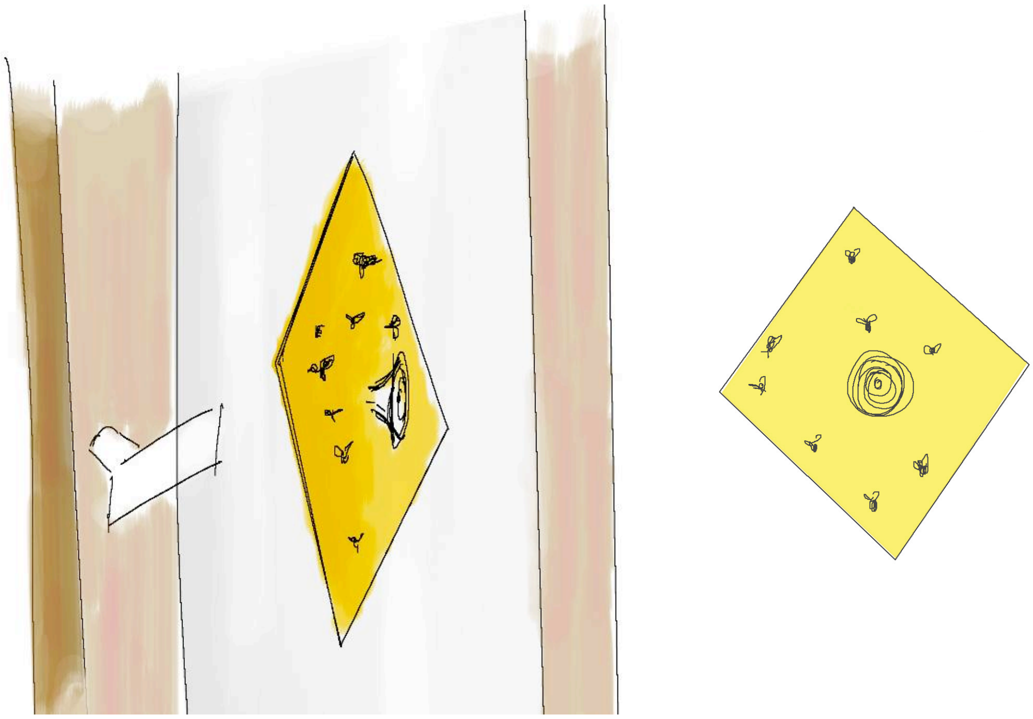

Figure 35. A Sticky Card Attached to a Window with a Suction Cup (Schoeman 2012)

A number of shapes were considered. Understanding the meaning of shapes forms an essential part of design. (Vihma 1992: 27.)

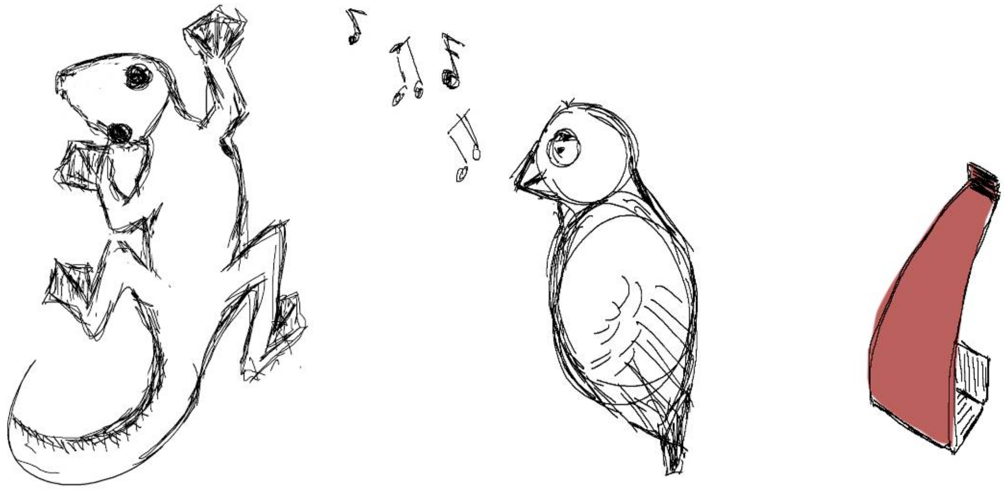

Figure 36. Forms for Sticky Paper Traps (Schoeman 2012)

A major drawback of using gluey sheets of paper, is the fact that they tend to stick to everything. Enclosing the gluey sheet would eliminate this problem.

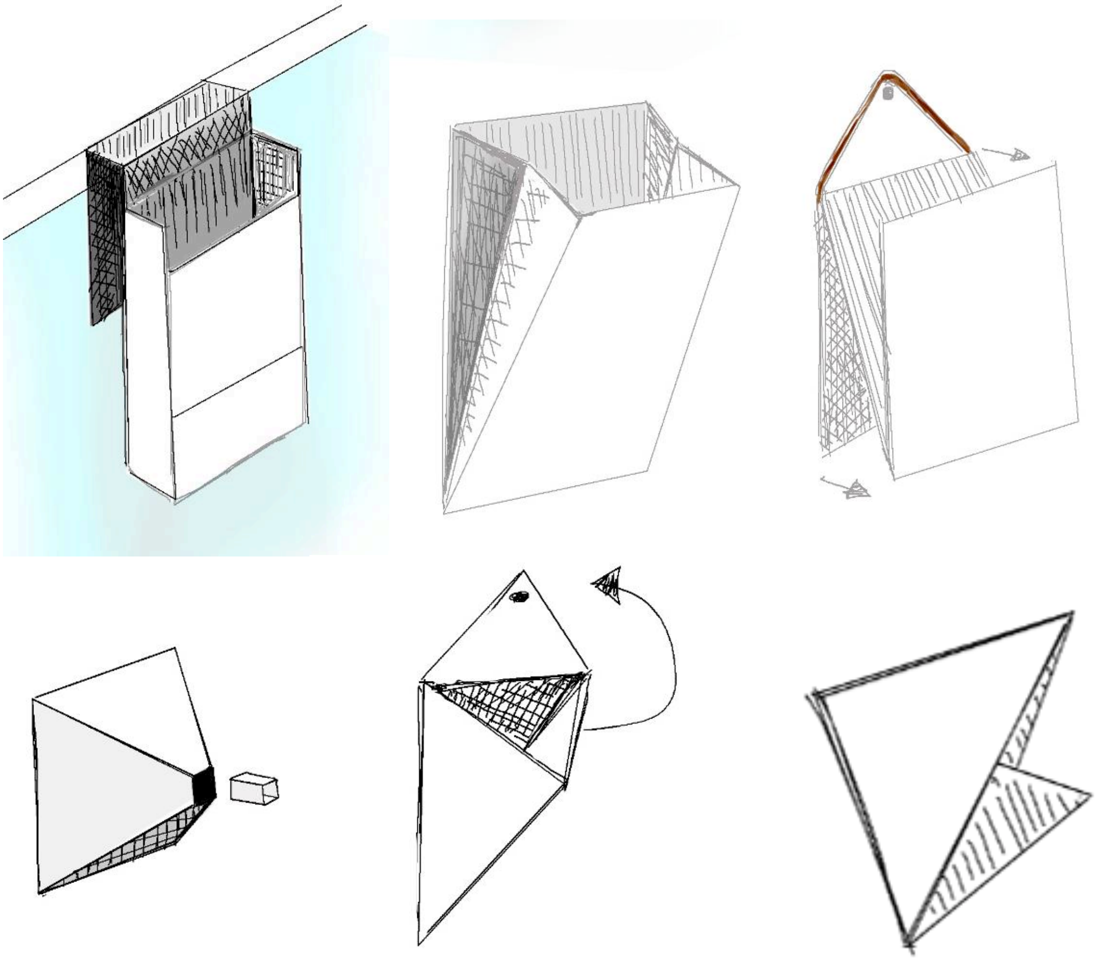

Figure 37. Concepts That Enclode the Sticky Surfaces (Schoeman 2012)

Another benefit of completely enclosing the sticky trap is that the glue would remain sticky and effective. Other sticky traps are often covered with a protective sheet, to keep the glue from drying. There would be no need to peel off any such sheets. Another unpleasant feature of sticky traps is the visibility of dead flies. Enclosing the trap would also hide these flies. However, enclosing all the sticky surfaces would make it very dark inside the trap. Constructing one of the trap sides, from clear biodegradable plastic, might sufficiently illuminate the inside of the trap. Placing the trap on a window, with the clear plastic side facing outward, would hide the flies from the users view and allow natural light to fill the inside of the trap.

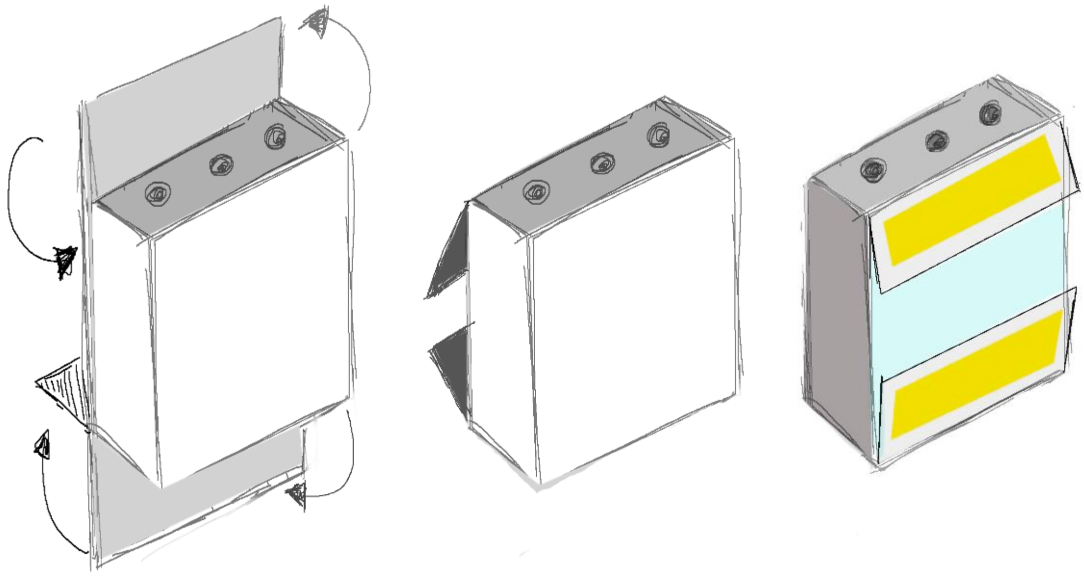

Figure 38. A Carton Box with a Clear Plastic Back and Adhesive Flaps that can Fold Back (Schoeman 2012)

As previously mentioned, Drosophila M. is attracted to long vertical shapes and light. Therefore the final concept will be long and vertical. The best placement for it would be in a tall and narrow window. Puncturing the perforated discs on the side of the trap with a sharp object, such as a pencil, can open the trap.

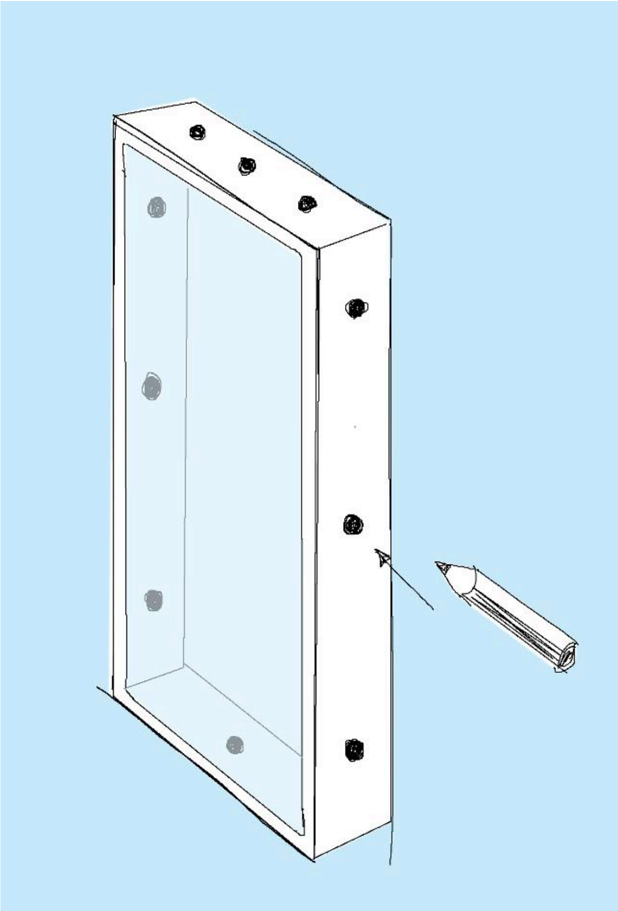

Figure 39. A Clear Biodegradable Film Covers the Back of the Trap (Schoeman 2012)

Popular Finnish graphic designs and illustrations could be placed on the front of the trap to give the trap a stronger aesthetic appeal. It should however be done in red to attract Drosophila M. (Wave 1964: 295). Two adhesive pads can be placed on the back of the trap to attach it to a window.

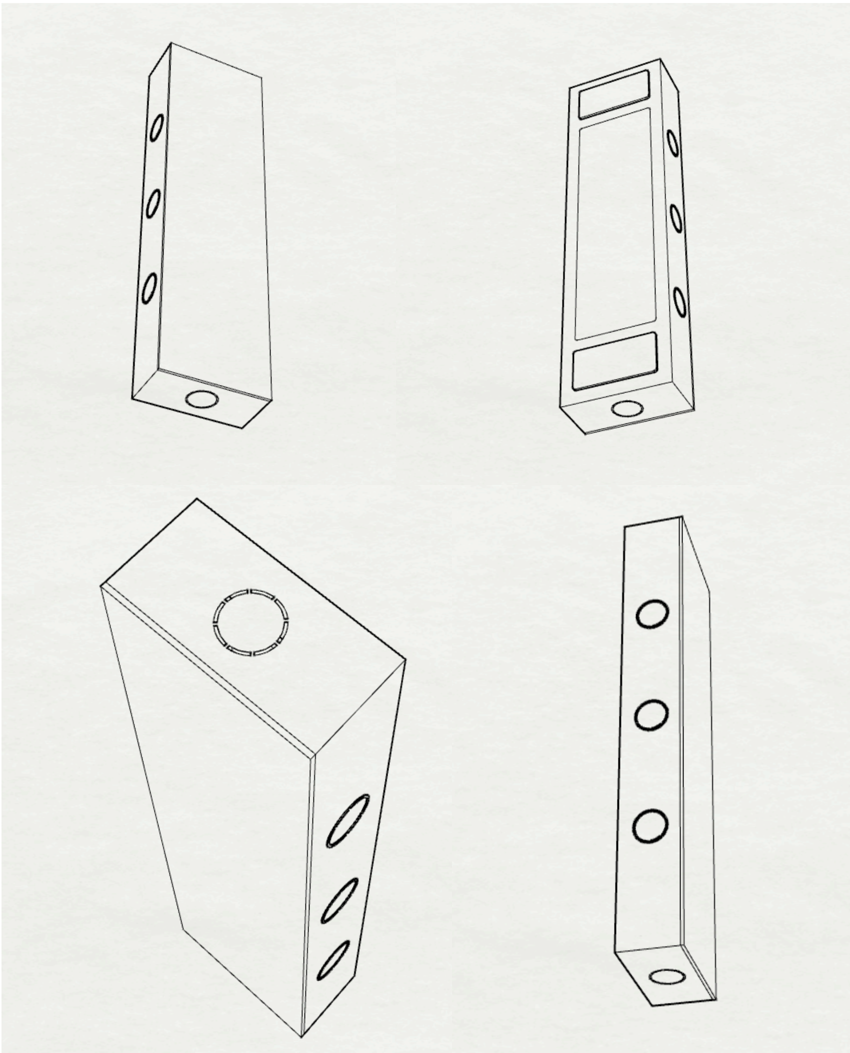

Figure 40. Final Concept Viewed from Different Sides (Schoeman 2012)

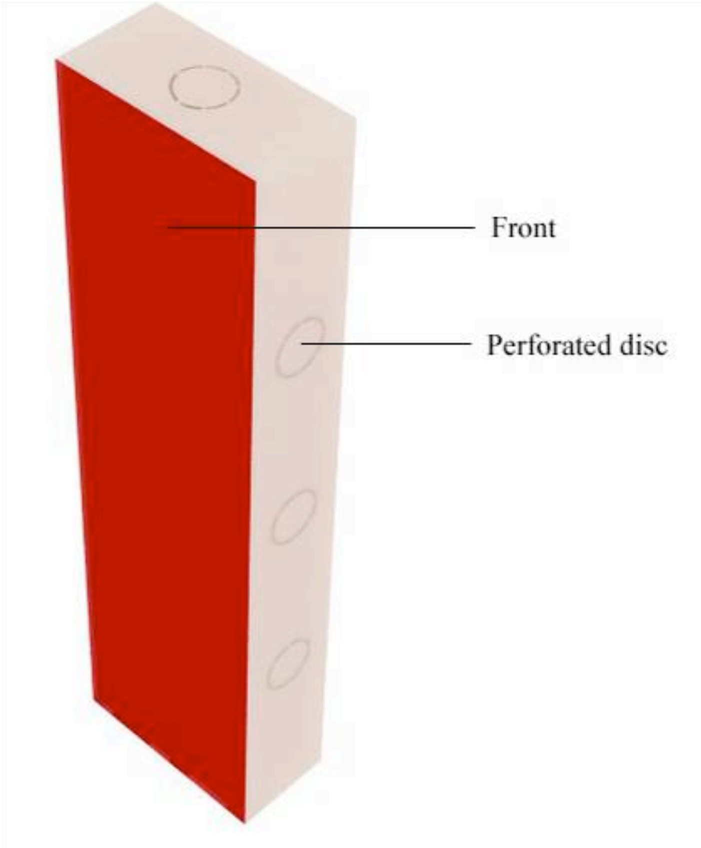

Figure 41. Front View Rendering of Final Concept (Schoeman 2012)

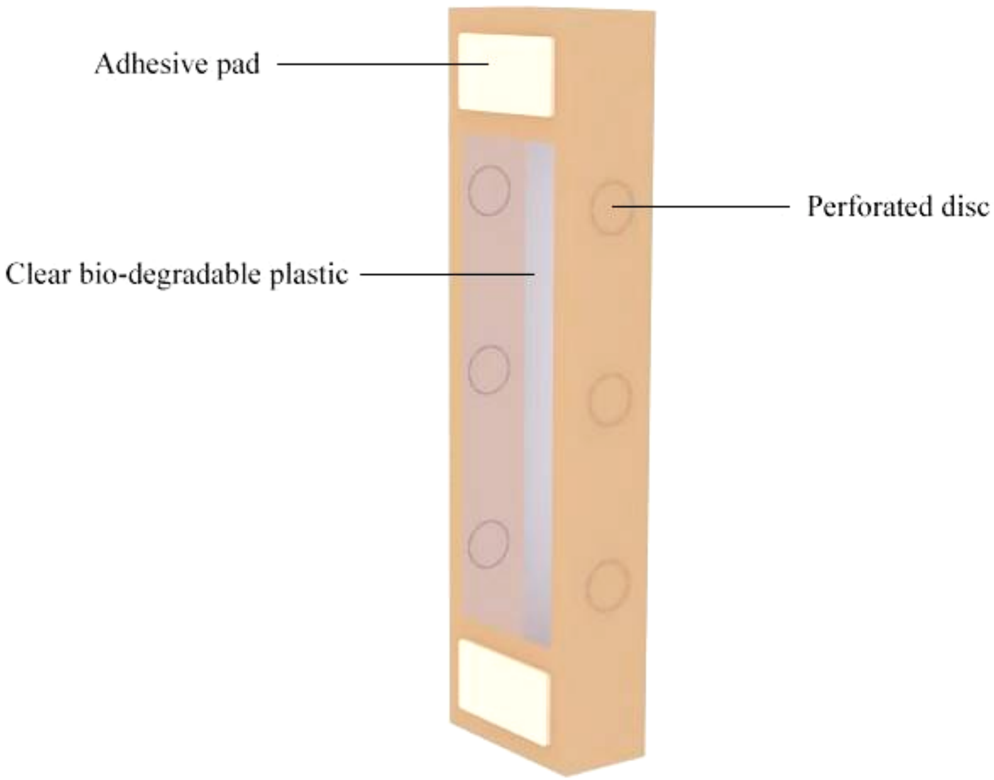

Figure 42. Rear View Rendering of Final Concept (Schoeman 2012)

5.4 Prototyping

Due to the lack of facilities and the lack of suitable wild-type flies during the season in which this paper was written, only one prototype was built, to determine whether fruit flies could escape from a dark funnel-entrance trap.

5.5 Evaluation

The next step would be to find a suitable adhesive and lure. Several companies can be approached and the design of the product can be re-evaluated as production methods are considered.

References

Agricultural Research Council (ARC). 2010. *The Sterile Insect Technique Programme In South Africa* [Online]. Available from: http://www.arc.agric.za/home.asp?pid=3763 [Accessed: 02.02.2012]

Barnes, B. 2000. *Fruit flies on wine grapes - infestation success, cultivar effects and impact on area-wide control.* Wynboer: A Technical Guide for Wine Producers. Stellenbosch

Bess, H.A., Van Den Bosch, R., Haramoto, F.H. 1961. *Fruit fly parasites and their activities in Hawaii*. Proceedings of the Hawaiian Entomological Society 17: 367-378

Botes, C. 2011. *M3 Fruit Fly Bait Station, Environmentally sound fruit fly control.* [Online] Available from: http://productdesignhub.com/2011/05/m3-fruit-fly-bait-station-environmentally-sound-fruit-fly-control/ [Accessed: 03.04.2012]

Chapman Kids Blog. [Online] Available from: http://chapmankids.net/blog/2006/12/12/the-scientific-method/ [Accessed: 03.04.2012]

Curtis, C. Klassen, W. 2005. *History of the Sterile Insect Technique.* Springer. Dordrecht

Dickson, M.H., Straw, A.D., Maimon, G. 2008. *A Simple Vision-Based Algorithm for Decision Making in Flying Drosophila*. Current Biology, Volume 18, Issue 6, 464-470, Elsevier Ltd, California

Demerec, M. 1950. *Biology of Drosophila.* John Wiley & Sons, Inc. New York

Edelfelt, A. 1885. *Louis Pasteur in his laboratory*, painting by A. Edelfeldt. Figure.1

Encyclopædia Britannica Online. Fruit Fly 2012. [Online] Available from: http://www.britannica.com/EBchecked/topic/221090/fruit-fly [Accessed: 02.02.2012]

Fatal Funnel Traps.com. [Online] Available from: http://fatalfunneltraps.com/fly-product.html [Accessed: 03.04.2012]

Flagg, R.O. 1979. *Carolina Drosophila Manual.* Carolina Biological Supply Co., Carolina

Hallman, G. J. Loaharan, P. 2002. *Generic Ionizing Radiation Quarantine Treatments Against Fruit Flies* (Diptera: Tephritidae) Proposed. Journal of Economic Entomology. Entomological Society of America

Hardie, R.C. 1985. *Functional Organization of the Fly Retina, Progress in Sensory Physiology Vol.5.* Springer, Berlin

McKenrick, H. University of Florida, Department of Entomology

Markow, T. O'Grady, P. 2006. *Drosophila : a guide to species identification and use.* Elsevier Academic. London

Myllykoksi, H. (M.Sc.). 2012. University of Tampere [Interview]. Tampere, Institute of Biomedical Technology. 27.02.2012

Research Institute of Molecular Pathology. 2007. *For The Fruit Fly, Everything Changes After Sex*. ScienceDaily. [Online] Available from: http://www.sciencedaily.com-/releases/2007/12/071210163142.htm [Accessed: 02.04.2012]

Rurification. [Online] Available from: http://rurification.blogspot.com/2011/10/fruit-fly-trap.html [Accessed: 03.04.2012]

Russel Integrated Pest Management. *Fly Catcher or McPhail Trap*. [Online] Available from: http://www.russellipm-agriculture.com/insect.php?insect_id=201 [Accessed: 03.04.2012]

Science Photo Library. *Drosophila Fly Head ESM*. [Online] Available from: http://www.sciencephoto.com/media/369771/enlarge [Accessed: 03.04.2012]

Slack, Laura 2006: *What is product design?* Roto Vision SA. Switzerland

Spring Star Incorporated. *Fruit Fly Trap.* [Online] Available from: http://springstar.net/glassfruitflytrap.html [Accessed: 03.04.2012]

Straw,A. 2011. *The neural basis of locomotory visual guidance in Drosophila.* Research Institute of Molecular Pathology. [Online] Available from: http://strawlab.org/publications/ [Accessed: 02.04.2012]

Terro. *Fruit Fly Trap* [Online] Available from: http://www.terro.com/products.php?product=fruit_fly_trap [Accessed: 03.04.2012]

Thompson, C.R. 2004. *DPI Entomology Circular 325.* Florida Department of Agriculture and Consumer Services, Division of Plant Industry. University of Florida. Publication Number: EENY-193 [Digital image] Photograph: Lotz, J. [Online] Available from: http://entnemdept.ufl.edu/creatures/beneficial/d_longicaudata.htm [Accessed: 02.04.2012]

Trece Incorporated. *The Pherocon Trap* [Online] Available from: http://www.trece.com/agmon.html# [Accessed: 03.04.2012]

Vihma, S. 1992: *Objects and Images, Studies in design and Advertising.* University of Industrial Arts Helsinki UIAH, A 12. Finland

Vioryl, Biological Pest Control Systems. *Eco Trap.* [Online] Available from: http://www.vioryl.gr/eng/dakos.html [Accessed: 18.02.2012]

Wave, H.E. 1964. *Effect of bait-trap color on attractancy to Drosophila melanogaster.* Journal of Economic Entomology. Entomological Society of America

Weir, P.T. Dickson, M.H. 2012. *Flying Drosophila Orient to Sky Polarization.* Current Biology. Elsevier Ltd. Volume 22. Issue 1: 21-27

References for Illustrations

Figure 1. Illustration of Basic Work Strategy. Schoeman, J.J. 2012

Figure 2. Adult female Diachasmimorpha longicaudata (Ashmead), an Braconid endoparasitic wasp which parasitizes the Caribbean fruit fly, ovipositing into a fly larva, Division of Plant Industry. Lotz, J. Available from: http://entnemdept.ufl.edu/creatures/beneficial/d_longicaudata01.htm [Accessed: 25.04.2012]

Figure 3. Painting: Louis Pasteur. Edelfelt, A. 1885. The Musée d'Orsay. Paris. Havala, O. 2009. Availible from: http://fr.wikipedia.org/wiki/Fichier:Albert_Edelfelt_-_Louis_Pasteur_-_1885.jpg [Accessed: 25.04.2012]

Figure 4. An Illustration of the Classification of Drophila and Trypetidae. Schoeman, J.J. 2012

Figure 5. Drosophila Lifecycle. Flagg. 1979.Available from: http://www.cs.uofs.edu/~kapplerk2/drosophila.php [Accessed: 25.04.2012]

Figure 6. Female Drosophila Melanogaster Flies Start Laying Eggs Shortly After Mating. Research Institute of Molecular Pathology .IMP-IMBA. Graphics Department. 2007.Available from: http://www.sciencedaily.com/releases/2007/12/071210163142.htm [Accessed: 25.04.2012]

Figure 7. A fruit fly suspended in a magnetic field alters its flight path depending on cues it receives from light polarization. Weir, P. 2012. Available from: http://www.sciencenewsline.com/biology/2012011815310066.html [Accessed: 25.04.2012]

Figure 8. A fruit fly (Drosophila melanogaster) in a virtual reality display system. Straw. 2011. Available from: http://strawlab.org/ [Accessed: 25.04.2012]

Figure 9. Drosophila Melanogaster. Mr.Checker. 2012. Available from: http://en.wikipedia.org/wiki/File:Drosophila_melanogaster.jpg [Accessed: 25.04.2012]

Figure 10. Drosophilidae compound eye edit1. Original author Dartmouth College retouched by Papa Lima Whiskey. Available from: http://commons.wikimedia.org/wiki/File:Drosophilidae_compound_eye_edit1.jpg [Accessed: 25.04.2012]

Figure 11. The M3 fruit fly bait station. Botes. 2011. Available from: http://www.behance.net/gallery/M3-Fruit-Fly-Bait-Station/1569453 [Accessed: 25.04.2012]

Figure 12. The Fly Catcher or McPhail trap. Russel Integrated Pest Management. 2012. Available from: http://www.russellipmagriculture.com/insect.php?insect_id=201 [Accessed: 25.04.2012]

Figure 13. The Eco Trap. Vioryl. 2012. Available from: http://www.vioryl.gr/eng/dakos.html [Accessed: 25.04.2012]

Figure 14. Pherocon® AM, AM/NB Trap. Trece Incorporated. 2012. Available from: http://www.trece.com/agmon.html# [Accessed: 25.04.2012]

Figure 15. The Fatal Funnel. Fatal Funnel Traps.com. 2012. Available from: http://fatalfunneltraps.com/fly-product.html [Accessed: 25.04.2012]

Figure 16. Terro Fruit Fly Trap. Urban Garden Solutions. 2012. Available from: http://www.urbangardensolutions.com/Terro-Fruit-Fly-Trap-p/senf2500.htm [Accessed: 25.04.2012]

Figure 17. The Fruit Fly Trap. Spring Star Incorporated. 2012. Available from: http://springstar.net/glassfruitflytrap.html [Accessed: 25.04.2012]

Figure 18.Fruit Fly Trap. Downtowngal. 2012. Available from: http://commons.wikimedia.org/wiki/File:Fruit_fly_trap.jpg [Accessed: 25.04.2012]

Figure 19. A Jar Filled with a Liquid Lure and a Small Amount of Soap. Rurification. 2012. Available from: http://rurification.blogspot.com/2011/10/fruit-fly-trap.html [Accessed: 25.04.2012]

Figure 36. Forms for Sticky Paper Traps. Schoeman, J.J. 2012

Figure 37. Concepts That Enclode the Sticky Surfaces. Schoeman, J.J. 2012

Figure 38. A Carton Box with a Clear Plastic Back and Adhesive Flaps that can Fold Back. Schoeman, J.J. 2012

Figure 39. A Clear Biodegradable Film Covers the Back of the Trap. Schoeman, J.J. 2012

Figure 40. Final Concept Viewed from Different Sides. Schoeman, J.J. 2012

Figure 41. Front View Rendering of Final Concept. Schoeman, J.J. 2012

Figure 42. Rear View Rendering of Final Concept. Schoeman, J.J. 2012

Other materials

Bramston, David 2009: *Basic Product Design 02, Material Thoughts.* AVA Publishing SA. Switzerland