Fatal attraction

control of the housefly (*Musca domestica*)

Renate C. Smallegange

Laboratory of Entomology
Wageningen University
PO Box 8031
6700 EH Wageningen
Renate.Smallegange@wur.nl

Despite its long association with man, the housefly (*Musca domestica* Linnaeus) remains one of the most difficult pests to control. It is a ubiquitous insect that can be found in houses, stables, food processing factories and other domesticated areas and buildings. Although houseflies have not been shown to cause direct losses in animal production or performance, in large numbers these flies cause annoyance and nuisance. Moreover, they are potential transmitters of human and animal pathogens. Reliance on insecticides for fly control is decreasing because of increased environmental constraints and insecticide resistance. So far, biological control with natural enemies often has disappointing results. Light- and odour-baited traps are considered to be promising devices to control houseflies indoors, although they are not yet effective enough to reduce fly populations to acceptable levels. Therefore, possibilities to improve the effectiveness of these types of traps were examined.

Entomologische Berichten 64(3): 87-92

Keywords: behaviour, phototaxis, olfaction

Introduction

The housefly, *Musca domestica* Linnaeus (Diptera: Muscidae), is one of the most important hygiene pests worldwide. The flies are not only a nuisance, irritating people and animals and leaving regurgitation and faecal spots on surfaces, they are also vectors of pathogens which may cause serious diseases in humans and animals (Box 1). Therefore, a lot of money is spent on fly control. However, due to their high reproductive rate houseflies have rapidly developed resistance against various commonly used insecticides. Also other control methods (see examples below) are not effective enough to reduce fly populations to acceptable levels. Therefore, new or adjusted control methods are needed.

Light traps are fitted with only one attractive stimulus - light - which may be only effective during certain periods of the flies' life cycle (Box 2). This may explain the disappointing control results that are commonly achieved with these traps. Odour-baited traps have the same disadvantage, relying only on an olfactory stimulus. Combining several stimuli may increase the effectiveness of housefly traps. Therefore, visual and olfactory stimuli were studied, separately and in combination, for their attractiveness to houseflies at differ-ent moments of their life. Because the environment may affect attractiveness, different ambient conditions (illumination, odours) were taken into account.

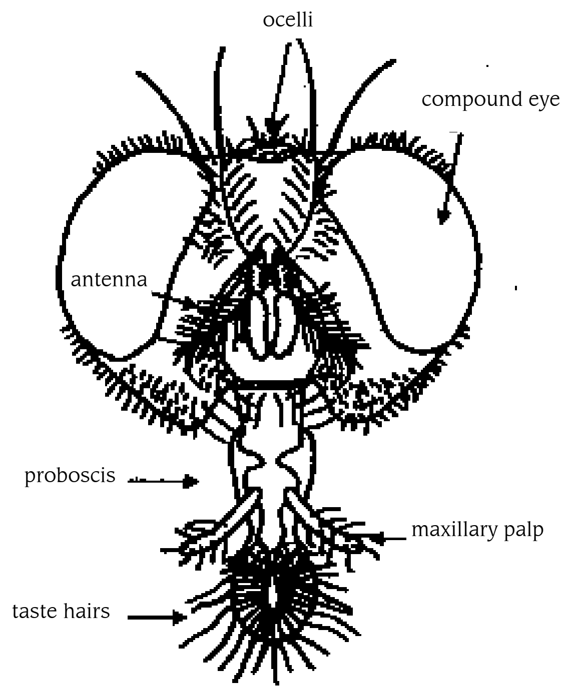

Figure 1. Frontal view of the head of the housefly (adapted from Pedigo 1989). Illustration: T.C. Everaarts.
Vooraanzicht van de kop van de huisvlieg (aangepast naar Pedigo 1989).

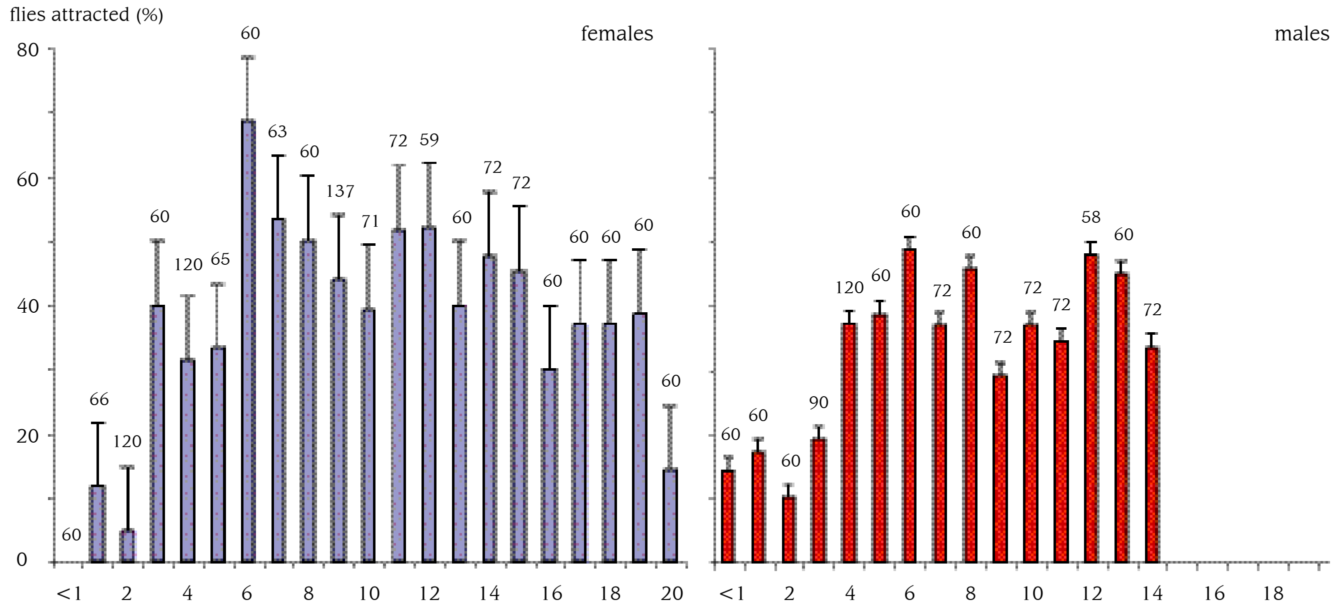

Figure 2. Mean attractiveness of six test lamps in the dark to houseflies of different ages (<1-20 days). Figures above columns indicate number of flies tested. Vertical lines show standard errors of the mean.
Aantrekkelijkheid van zes testlampen voor huisvliegen van verschillende leeftijd. De getallen boven de kolommen geven het aantal geteste huisvliegen weer. Verticale lijnen zijn de standaardfout van de gemiddelden.

Control methods

Gauze screens in front of windows and doors can be used to keep houseflies outside. Indoors, sticky fly-paper, electrocuting light traps and odour-baited traps may be used. Large sticky traps can be effective, but their use is limited by the rapid accumulation of dust on the sticky material (Kaufman et al. 2001). Odour-baited traps are not very popular because of their unpleasant smell. Furthermore, the light and odour-baited traps may also kill harmless and beneficial insects. In most cases only a negligible proportion of the fly population is caught by the traps because of competing environmental factors, such as ambient light conditions and odour sources (Bowden 1982, Browne 1990, Muirhead-Thomson 1991).

Sanitation and removal of possible breeding sites using efficient garbage and sewage disposal systems are probably the most effective control methods for houseflies breeding in domestic wastes and waste materials from animals. Garbage containers should have tight-fitting lids and should be cleaned regularly. Manure, straw and spilled feed should be removed at least twice a week. At waste disposal sites, the disposal should be covered with a layer of about fifteen centimetres soil or other inorganic material every week (Kettle 1995).

Application of insecticides may initially be effective, but muscids readily develop resistance to persistent insecticides either because enzymes enable the flies to break down the insecticides or because behavioural adaptations enable the flies to avoid the insecticides. Also cross-resistance has been reported, for example to juvenile hormone mimics. Not only the increase of tolerance and resistance of flies to insecticides but also the increasing costs of the use of insecticides and their toxicity to other organisms make them less desirable for fly control. Besides, it appears hard to discover new insecticides and the costs of their development are high (Scott & Georghiou 1985, Meyer et al. 1987, Pickens & Miller 1987, Kettle 1995, Pospischil et al. 1996, Keiding 1999, Scott et al. 2000).

Houseflies have many natural enemies, like entomopathogenic fungi (e.g. *Entomophthora muscae*) and nematodes, parasitic wasps (e.g. various pteromalid species), predatory beetles (histerid and staphylinid species), mites and flies (e.g. *Hydrotaea aenescens* (Wiedemann)) and birds. Only in a

Box 1. Transmission of pathogens

Houseflies are not only a nuisance to humans and animals, they may also transport disease-causing organisms. Their movements between human and animal food, organic wastes, garbage, faeces, manure and other sources of filth on which they may feed and breed make them ideal transmitters of human and animal pathogens. About a hundred different pathogens have been found in and on houseflies. There are three ways in which houseflies may transmit pathogens. The surface of their body, particularly the legs and proboscis, may be contaminated. Because a housefly sucks food after it has been liquified in regurgitated saliva, pathogens may be deposited onto food with the vomit drop. Thirdly, pathogens may pass through the gut of the fly and be deposited with its faeces.

Pathogens that may be transmitted by houseflies are, for example, viruses causing diarrhoea, cholera bacteria, *Salmonella* species and *Escherichia coli* bacteria causing enteric infections, haemolytic streptococci, agents of typhoid, diphtheria, tuberculosis, leprosy and yaws. In addition, they may carry cysts of Protozoa, including those causing amoebic dysentery, and the eggs of nematodes. Finally, houseflies may be vectors and intermediate hosts of certain cestodes of poultry and horse nematodes (Hewitt 1910, 1912, Ostrolenk & Welch 1942, West 1951, Saccà 1964, Kettle 1995, Grübel et al. 1997, Tan et al. 1997, Kurahashi et al. 1998).

Box 2. Biology of the housefly

The housefly undergoes a complete metamorphosis in its development from egg to adult (figure 3). The rate of development depends on food availability and temperature. A female housefly may lay four to six batches of eggs consisting of 75-150 eggs each. The eggs are deposited in clumps in cracks and crevices of a moist medium to protect them from desiccation. Manure and spilled food are known to be the principal breeding media for houseflies (Hewitt 1910, West 1951, Kettle, 1995, Cossé & Baker 1996). The pearly-white eggs measure about 1.2 mm in length. They hatch within 24 hours after oviposition. Within approximately a week the whitish, legless, saprophagous larvae (maggots) develop through three larval stages. The full-grown larvae migrate to drier conditions and bury themselves into the substrate where they pupate. After approximately five days the adult emerges from the reddish-brown to almost black puparium.

Adult houseflies may live 15-30 days. Males may already mate on the day of their emergence. Mating readiness of females (which are monogamous, contrary to males) is highest when they are three days old (Saccà 1964). Oviposition takes place a few days after copulation.

During warm weather the life cycle from egg to egg takes two to three weeks. Because of this high rate of development and the large numbers of eggs produced, large populations can build up rapidly. In temperate regions ten to twelve generations per year can occur. In colder regions breeding is restricted to the warmer months, resulting in four to six generations per year. Overwintering takes place in the larval or pupal stage (Hewitt 1910, 1912, West 1951, Kettle 1995).

The housefly is one of the most common of all insects. It is an endophilic and eusynanthropic species, i.e. it lives closely with humans and is able to complete its entire life cycle within residences of humans and their domestic animals. It thus became distributed world-wide. It can be found in human dwellings, dairies, poultry houses, horse stables, food processing factories and other domesticated areas and buildings (Hewitt 1910, 1912, West 1951, Hansens 1963, Lillie & Goddard 1987, Kettle 1995).

few cases successful control with natural enemies has been achieved, mostly in combination with other control methods (integrated fly control) (Hewitt 1910, 1912, West 1951, Saccà 1964, Geden et al. 1993, Glofcheskie & Surgeoner 1993, Kettle 1995, Skovgård & Jespersen 1999).

Light and odours to lure houseflies into traps

Vision

Adult houseflies are positively phototactic, i.e. they are attracted towards light (West 1951). It is also known that the photoreceptors in the compound eyes of the housefly (figure 1) are sensitive to ultraviolet (340-365 nm) and blue-green (450-550 nm) light (Mazokhin-Porshniakov 1960, Goldsmith & Fernandez 1968, Bellingham & Anderson 1993). Therefore, electrocuting traps with fluorescent lamps emitting light in the ultraviolet range are commonly used for indoor control of houseflies. Although they are considered promising pest-management devices (Lillie & Goddard 1987), unfortunately the numbers of houseflies caught by these traps are often too low to have a noticeable impact on the fly population (Bowden 1982, Pickens & Thimijan 1986, Muirhead-Thomson 1991). Perhaps the disappointing effectiveness of light traps is due to the 'wrong' wavelengths emitted by the lamps. Hence it seemed worthwhile to search for a more appropriate wavelength to be used in light traps to improve control of housefly populations indoors.

Experiments were done to investigate the attractiveness of ultraviolet, blue, green and white lamps to houseflies of different age, sex and origin under controlled circumstances in the laboratory in a flight chamber (210 cm long, 60 cm wide and 60 cm high) and, closer to possible practical use, in a bigger room (310 cm long, 200 cm wide, 240 cm high). It was shown that both physiological and environmental parameters (age, sex and origin of flies, energy output of light, ambient illumination) affect the number of houseflies attracted to a light source. Flies younger than three days for example, were hardly, if at all, attracted to the test lamps, whereas older flies were positively phototactic (figure 2). In the dark, more flies were attracted to the light sources and

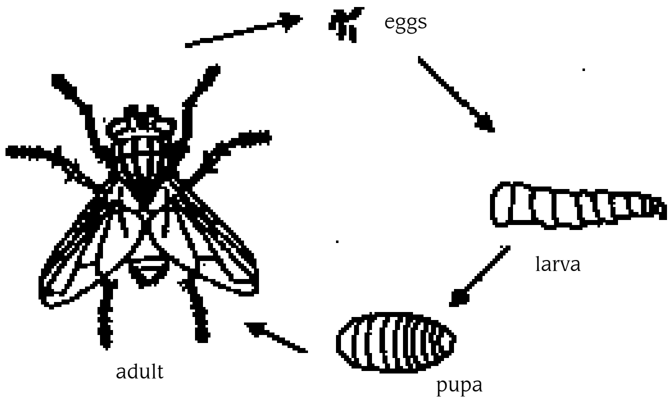

Figure 3. The life cycle of the housefly, *Musca domestica* (adapted from Pedigo 1989). Illustration: T.C. Everaarts.
De levenscyclus van de huisvlieg, Musca domestica.

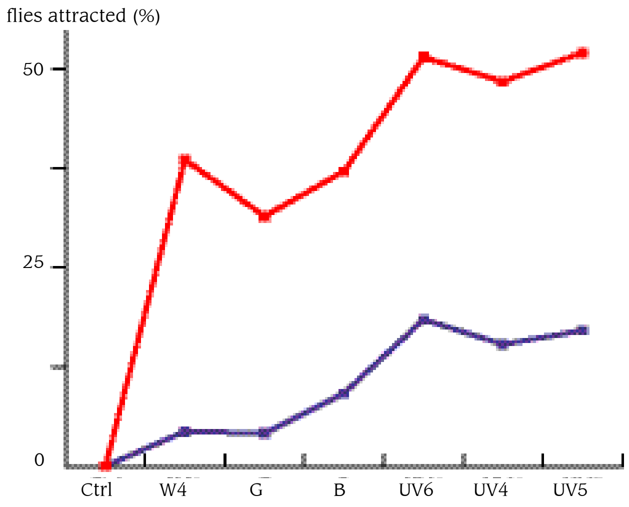

Figure 4. Mean attractiveness of six test lamps in the light (purple) and in the dark (red) to houseflies. Ctrl = no test lamp burning, UV = ultraviolet light, B = blue light, G = green light, W = white light.
Aantrekkelijkheid van zes testlampen voor huisvliegen in een verlichte (paars) en in een donkere ruimte (rood). Ctrl = geen brandende testlamp, UV = ultraviolet licht, B = blauw licht, G = groen licht, W = wit licht.

Table 1. Total number of landings of females and males of well-fed houseflies in the control cylinder (clean air) and in the odour-loaded cylinder (odour) with (+ UV) or without ultraviolet light in an illuminated flight chamber. Duration of experiments was ten minutes. Asterisks indicate significant differences (Fisher's exact test, two-tailed, p<0.05). Note the sample size difference between clean air and the sample size of the other odour sources.
Aantal landingen van doorvoede vrouwtjes en mannetjes huisvliegen op geurbronnen (schone lucht en lucht met een geur) zonder of met (+ UV) ultraviolet licht. De experimentduur was steeds tien minuten. Een asterisk geeft een significant verschil aan (tweezijdige Fishers exact-test, p<0,05). De steekproefgrootte verschilt tussen schone lucht en de andere geurbronnen.

odour source	clean air	odour	clean air	odour + UV
females (n = 50)				
clean air (n = 150)	0	3	3	12
banana	2	11	1	8
mango	2	14	2	9
moist yeast	0	19*	4	19*
marmite	2	28*	3	20*
tainted pork	2	19*	1	10
tainted beef	0	28*	3	18*
tainted chicken	1	41*	2	7
chicken manure	1	39*	5	18
bread + water	0	2	1	5
bread + milk	1	1	0	7
bread + beer	0	4	3	2
bread + vinegar	1	2	3	4
males (n = 50)				
clean air (n = 150)	3	3	6	18
banana	1	6	1	7
mango	3	12	2	11
moist yeast	1	6	1	13*
marmite	2	19*	4	7
tainted pork	1	27*	2	10
tainted beef	3	26*	3	7
tainted chicken	1	14*	9	5
chicken manure	3	11	3	4
bread + water	6	17	6	19
bread + milk	7	19	3	8
bread + beer	7	25*	5	14
bread + vinegar	0	23*	5	15

the flies were caught faster than when the room was illuminated by a white tube (figure 4). Overall, ultraviolet light attracted most flies. Within the ultraviolet region no preference was found. So, ultraviolet light seems to be the best choice for use in light traps, but does not attract flies of all ages and is not effective under all circumstances.

Next, the possibility to increase the attractiveness of an ultraviolet lamp to houseflies by manipulating its flicker frequency was examined. Fifteen light flicker frequencies were tested in a dark room. The frequency of light an eye can no longer distinguish as discontinuous is called the flicker fusion frequency. The flicker fusion frequency of houseflies lies around 270 Hz (Vogel 1956). Considering the total number of flies caught after 21/2 hours, 'flickering' light (below 270 Hz) was found to be less or equally attractive as 'non-flickering' (above 270 Hz) light for both females and males. There was one exception: a flicker frequency of 10 Hz seemed to cause an escape response in both males and females towards a 'non-flickering' (40,000 Hz) light source (figure 5). However, lamps with a frequency of 40 and 175 Hz attracted females and males respectively, the most rapidly: 50% of the flies were caught within the first fifteen minutes of the experiments.

Olfaction

The experiments described in the previous paragraph clearly indicate that light traps alone do not suffice. Especially ambient illumination decreases the efficiency. In addition it was found that immature flies are hardly attracted to a light source. A means to improve the success of light traps may be to load them with attractive odours.

The phenomenon that adult houseflies are positively anemotactic, i.e. that they tend to fly upwind (West 1951), may be induced by airborne odours. Rostrally between the eyes the head of a housefly bears two antennae, each consisting of three segments (scapus, pedicellus and funiculus), the latter bearing a feather-shaped arista (figure 1). The funiculi are covered with olfactory hairs which enable the fly to 'smell' (Hewitt 1910, 1912, West 1951).

Natural substances which may serve as oviposition substrates and/or food sources were shown to be attractants for houseflies, especially putrefying and fermenting substrates emanating amines, aldehydes, ketones and alcohols, and dairy products and sugar-containing substances (e.g. Awati & Swaminath 1920, Brown et al. 1961, Künast & Günzrodt 1981, Cossé & Baker 1996). However, commercially

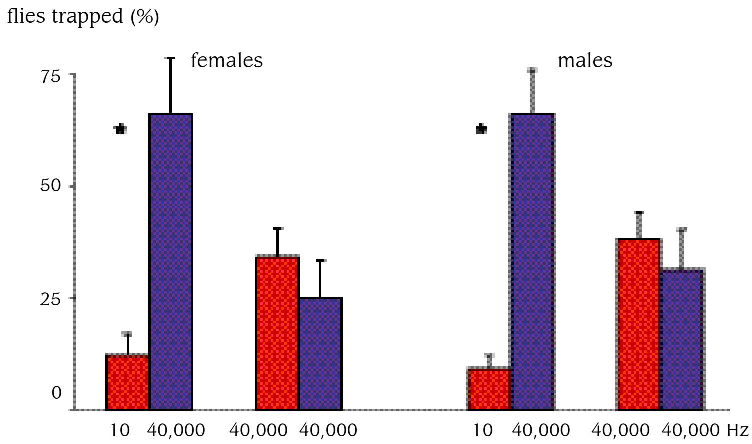

Figure 5. Mean attractiveness to houseflies of two ultraviolet lamps flickering at two frequencies (10 or 40,000 Hz). Each column represents the mean of four two-choice experiments in a dark room with 25 flies each. Vertical lines show standard errors of the mean. Asterisks indicate a significant difference in attractiveness between the two light sources (Fisher's exact test, two-tailed, p<0.05).
Gemiddelde aantrekkelijkheid voor huisvliegen van twee met verschillende frequenties knipperende ultraviolette lampen (10 of 40.000 Hz). Elke kolom geeft het gemiddelde van vier dubbele-keuze-experimenten in een donkere kamer, elk met 25 vliegen. Verticale lijnen per kolom zijn de standaardfout van het gemiddelde. Een asterisk geeft een significant verschil aan (tweezijdige Fishers exact-test, p<0,05).

available odour baits show variable and often contradictory results (Browne 1990).

Hoping to find volatile compounds that may be used as odorous baits in fly traps, several odours were tested in the flight chamber for their attractiveness to female and male houseflies, either immature or mature, well-fed or food-deprived. The odours of chicken manure, tainted chicken, beef and pig meat, 'fly food' (a mixture of skimmed-milk powder, sugar and yeast that was used to rear the flies in the laboratory), and bread soaked in water or milk were found to be attractive to well-fed as well as to food-deprived flies, both immature and mature. Males and females appeared to be attracted to different odours; males were attracted to soaked bread, whereas moist yeast and chicken manure were only attractive to females. Tainted meat attracted both sexes (table 1).

Of course, flies are never found in an environment without ambient odours. Therefore, it had to be determined whether olfactory baits will still attract flies in an environment loaded with other attractive volatiles. Several 'natural' products were tested for their attractiveness in the presence of an attractive background odour. Indeed, under these circumstances many products did no longer lure flies.

The expectation was that adding ultraviolet light would increase the attractiveness of an attractive odour. Surprisingly, however, ultraviolet light suppressed the attractiveness of most of the tested odours, except those of moist yeast, marmite and tainted beef which were still attractive to females (table 1).

Practical application of the results

In cattle stables, which are usually sparsely illuminated, and in restaurants, bars, kitchens and other rooms in buildings that are not illuminated during the day, ultraviolet light traps (with emission peaks around 340-365 nm) may be used to lure houseflies. Lamps with flicker frequencies higher than the flicker fusion frequencies of humans and animals should be used in these places, for example 175 Hz. In small dark environments where no humans or animals are likely to be present, like manure pits, it may be possible to use a push-pull system: lamps flickering at 10 Hz are likely to induce an escape response in female and male houseflies towards a trap with ultraviolet lamps with a flicker frequency above the flicker fusion frequency of the flies.

Since light only attracts flies older than two days, and odours may attract flies of all ages, odours may be used in traps in lighted rooms (houseflies do not respond to odours in the dark). Tainted meat (pork, beef, and chicken) appeared to attract young and mature, well-fed and 'hungry' males and females. However, because these products have an unpleasant smell for humans they are less desirable for use in human dwellings. Yeast and marmite may be better options. In addition, it is questionable whether the odorous substances are still attractive in rooms in which the same or other attractive odours are already present. In order to get a standard bait, the components in the substances which induce attraction should be identified and an effective synthetic mixture developed. A synthetic mixture of manure components, for example, showed some attractiveness, but was less effective than natural (chicken) manure. It may be that these components applied in the right ratio and doses exceed the attractiveness of ambient odours and no longer pall on humans. It is likely that different application areas with different background odours require different (mixtures of) attractants.

Additional studies

It is clear that more work is needed. Synthetic odorous attractive mixtures should be developed and the appropriate doses must be established by testing the mixtures under natural circumstances. Also, the practical use of light traps that are adjusted based on the suggestions mentioned in the previous paragraph may be examined. Not only the practicability of the traps, but also the number of traps that should be applied in a room and the optimum siting of the traps have to be determined. The effects of light- or odour-baited traps on other invertebrates, humans and their domestic animals should be examined during these studies. Pilot studies indicated that it is important to modify the design of the traps to improve their efficacy.

Noticing the limitations of visual and chemical stimuli, combining several methods to prevent and control fly infestations (integrated fly control) seems to be the best defence. The aim should be to apply environment-friendly control methods that affect only houseflies or other hazardous flies.

Acknowledgements

The studies described in this paper were part of a research project called 'Environmentally friendly control of flies using combined visual and chemical stimuli' (STW-grant GBI33.2997). All studies were performed at the Department of Animal Physiology, in collaboration with the Department of Neurobiophysics, of the University of Groningen, The Netherlands. The project was funded by the Technology Foundation of the Netherlands Organisation for Scientific Research (STW-NWO).

References

Awati PR & Swaminath CS 1920. Bionomics of houseflies. III. A preliminary note on attraction of houseflies to certain fermenting and putrefying substances. The Indian Journal of Medical Research 7: 560-567.

Bellingham J & Anderson M 1993. Variations and sexual differences in the spectral sensitivity of the compound eye of the housefly *Musca domestica* (L.) and the lesser housefly *Fannia canicularis* (L.). Proceedings of the International Conference on Insect Pests in the Urban Environment 1: 480.

Bowden J 1982. An analysis of factors affecting catches of insects in light-traps. Bulletin of Entomological Research 72: 535-556.

Brown AWA, West AS & Lockley AS 1961. Chemical attractants for the adult house fly. Journal of Economic Entomology 54: 670-674.

Browne LE 1990. The use of pheromones and other attractants in house fly control. In: Behavior-modifying chemicals for insect management (LR Ridgway, RM Silverstein & MN Inscoe eds.): 531-537. Marchel Dekker, Inc.

Cossé AA & Baker TC 1996. House flies and pig manure volatiles: wind tunnel behavioral studies and electrophysiological evaluations. Journal of Agricultural Entomology 13: 301-317.

Geden CJ, Steinkraus DC and Rutz DA 1993. Evaluation of two methods for release of *Entomophtora muscae* (Entomophtorales: Entomophtoraceae) to infect house flies (Diptera: Muscidae) on dairy farms. Environmental Entomology 20: 1201-1208.

Glofcheskie BD & Surgeoner GA 1993. Efficacy of muskovy ducks as an adjunct for house fly (Diptera: Muscidae) control in swine and dairy operations. Journal of Economic Entomology 86: 1686-1692.

Goldsmith TH & Fernandez HR 1968. The sensitivity of housefly photoreceptors in the mid-ultraviolet and the limits of the visible spectrum. Journal of Experimental Biology 49: 669-677.
Grübel P, Hoffman JS, Chong FK, Burstein NA, Mepani C & Cave DR 1997. Vector potential of houseflies (*Musca domestica*) for *Helicobacter pylori*. Journal of Clinical Microbiology 35: 1300-1303.
Hansens EJ 1963. Fly populations in dairy barns. Journal of Economic Entomology 56: 842-844.
Hewitt CG 1910. The housefly, *Musca domestica* Linnaeus. A study of its structure, development, bionomics and economy. Publications of the University of Manchester, Biological Series: 1-195.
Hewitt CG 1912. House-flies and how they spread disease. The Cambridge manuals of Science and Literature. Cambridge University Press.
Kaufman, PE, Rutz, DA & Frisch, S 2001. Sticky traps for large scale house fly (Diptera: Muscidae) trapping in New York poultry facilities. Journal of Agricultural and Urban Entomology 18: 43-49.
Keiding J 1999. Review of the global status and recent development of insecticide resistance in field populations of the housefly, *Musca domestica* (Diptera: Muscidae). Bulletin of Entomological Research 89: S7-S67.
Kelling FJ 2001. Olfaction in houseflies. Morphology and electrophysiology. PhD thesis, University of Groningen, The Netherlands.
Kettle DS (ed) 1995. Medical and veterinary entomology. Second edition. CAB International, Cambridge University Press.
Künast C & Günzrodt C 1981. Vergleichende Laboruntersuchungen über Lockstoffe und Köder bei der Stubenfliege (*Musca domestica* L.). Anzeiger der Schädlingskunde, Pflanzenschutz, Umweltschutz 54: 131-135.
Kurahashi H, Hayashi T, Moribayashi A, Kobayashi M & Agui N 1998. The house-fly - a mechanical vector for verotoxin-producing *E. coli* O157: H7 associated with some outbreaks of food poisoning in Japan. Abstract of the 4th International Congress of Dipterology: 116.
Lillie TH & Goddard J 1987. Operational testing of electrocutor traps for fly control in dining facilities. Journal of Economic Entomology 80: 826-829.
Mazokhin-Porshniakov GA 1960. Colorometric study of the properties of colour vision of insects as exemplified by the house fly. Biofizika 5: 295-303.
Meyer JA, Georghiou GP & Hawley MK 1987. House fly (Diptera: Muscidae) resistance to permethrin on southern California dairies. Journal of Economic Entomology 80: 636-640.
Muirhead-Thomson RC 1991. Trap responses of flying insects. The influence of trap design on capture efficiency. Academic Press.
Noorman N 2001. Pheromones of the housefly. A chemical and behavioural study. PhD thesis, University of Groningen, The Netherlands.
Ostrolenk M & Welch H 1942. The common house fly (*Musca domestica*) as a source of pollution in food establishments. Food Research 7: 1920-200.
Pedigo LP 1989. Entomology and pest management. Prentice Hall, Inc.
Pickens LG & Miller RW 1987. Techniques for trapping flies on dairy farms. Journal of Agricultural Entomology 4: 305-313.
Pickens LG & Thimijan RW 1986. Design parameter that affect the performance of UV-emitting traps in attracting house flies (Diptera: Muscidae). Journal of Economic Entomology 79: 1003-1009.
Pospischil R, Londershausen M, Szomm K & Turberg A 1996. Resistance in German housefly populations (*Musca domestica* L., Diptera) - summary of recent studies. Proceedings of the 2nd International Conference in Insect Pests in the Urban Environment: 255-262.
Saccà G 1964. Comparative bionomics in the genus *Musca*. Annual Review of Entomology 9: 341-358.
Scott JG, Alefantis TG, Kaufman PE & Rutz DA 2000. Insecticide resistance in house flies from caged-layer poultry facilities. Pest Management Science 56: 147-153.
Scott JG & Georghiou GP 1985. Rapid development of high-level permethrin resistance in a field-collected strain of the housefly (Dipterea: Muscidae) under laboratory selection. Journal of Economic Entomology 78: 316-319.
Skovgård H & Jespersen JB 1999. Activity and relative abundance of hymenopterous parasitoids that attack puparia of *Musca domestica* and *Stomoxys calcitrans* (Diptera: Muscidae) on confined pig and cattle farms in Denmark. Bulletin of Entomological Research 89: 263-269.
Smallegange RC 2003. Attractiveness of different light wavelengths, flicker frequencies and odours to the housefly (*Musca domestica* L.). PhD thesis, University of Groningen, The Netherlands.
Tan SW, Yap KL & Lee HL 1997. Mechanical transport of rotavirus by the legs and wings of *Musca domestica* (Diptera: Muscidae). Journal of Medical Entomology 34: 527-531.
Vogel G 1956. Verhaltensphysiologische Untersuchungen über die den Weibchenbesprung des Stubenfliegen-Männchens (*Musca domestica*) auslösenden optischen Faktoren. Zeitschrift für Tierpsychologie 14: 309-323.
West LS 1951. The housefly. Its natural history, medical importance, and control. Comstock Publishing Company.

Accepted 29 February 2004.

Samenvatting
Fatale aantrekkingskracht - bestrijding van de huisvlieg (*Musca domestica*)

De huisvlieg, *Musca domestica* Linnaeus, komt in de gehele wereld voor. Huisvliegen zijn niet alleen lastig en irritant, ze kunnen diverse ziektes overbrengen op mensen en dieren. Huidige bestrijdingsmethodes hebben vaak negatieve neveneffecten of zijn niet zo effectief als nodig is om een vliegenpopulatie tot een acceptabel niveau terug te brengen. Een biologische manier om het huisvliegenprobleem aan te pakken is om ze af te schrikken of juist naar een val te lokken, door gebruik te maken van prikkels die een rol spelen in het opwekken van het natuurlijke gedrag. Hierom is de mogelijkheid om huisvliegen met licht (verschillende golflengtes en knipperfrequenties) en/of geurprikkels (chemische stoffen en natuurlijke producten) te lokken onderzocht. De gedragsstudies zijn gedaan met vrijvliegende vliegen in een laboratorium (in een windtunnel en in een kamer), waarbij rekening werd gehouden met onder andere de fysiologie van de vliegen en diverse omgevingsfactoren.

Uit het onderzoek blijkt dat huisvliegen van een tot twee dagen oud niet of nauwelijks met licht kunnen worden gelokt, maar wel met bepaalde geuren. Huisvliegen ouder dan twee dagen kunnen zowel met licht als met geuren worden gelokt. Vooral ultraviolet licht heeft een grote aantrekkingskracht. De knipperfrequentie van het licht is daarbij niet belangrijk. Het is makkelijker om vliegen in een donkere dan in een verlichte ruimte met licht te lokken.

De mogelijkheid om vliegen met geuren te lokken is afhankelijk van leeftijd, sekse en fysiologie. Bovendien kunnen aanwezige omgevingsgeuren een negatieve invloed hebben op het lokvermogen van geuren. Anders dan verwacht verlaagt het combineren van een geur met ultraviolet licht de aantrekkingskracht van de geur.

Deze resultaten maken duidelijk dat de bestrijding van huisvliegen sterk afhangt van de situatie in de ruimte waar bestrijding gewenst is. In het algemeen kan overdag - de periode waarin de huisvlieg actief is - in donkere ruimtes gebruik worden gemaakt van ultraviolet licht om huisvliegen naar een val te lokken. In verlichte ruimtes zijn geuren waarschijnlijk een beter lokmiddel.