pulsFOG®

VECTORS

VECTORS NUISANCES AND THEIR CONTROL

www.pulsfog.com

...to protect people, animals and crops

Life-endangering microbes have been roaming the Earth for thousands of years. Transmitted by insects to animals, humans and plants they often have disastrous consequences. With only a few exceptions, these pests and their vectors have not diminished after all, since the pest control measures taken against them affected their predators at the same time.

Together with the chemical industry, which is increasingly manufacturing substances with a more selective effect, we have the common goal of controlling those pests capable of causing economic damage and diseases - without disturbing the biological and ecological balance – to protect our living environment from its biological enemies.

From the very beginning, pulsFOG has been manufacturing machines and equipment capable of atomising biological and chemical products to create and distribute fine aerosols over large areas. Pulsfogging is used for any pest control task where reduced quantities of active substances should be uniformly distributed even in inaccessible places, without leaving undesirable residues.

It is the task of pest control management to adapt the target-oriented application method (selection of most efficient droplet size) to the various biospheres indoors and outdoors considering climatic conditions and the optimum timing including the selection of suitable active ingredients and formulations. In the hands of the pest control manager and user who is aware of his responsibility, our equipment is an respectful and effective tool.

pulsFOG®

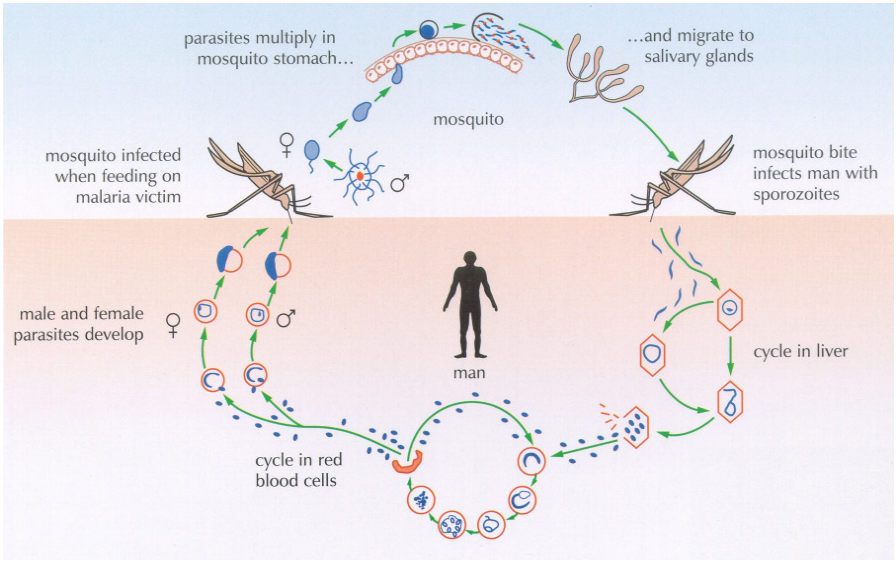
Content:

Pest And Vector Control Using Pulse-Jet Thermal Fogging Equipment

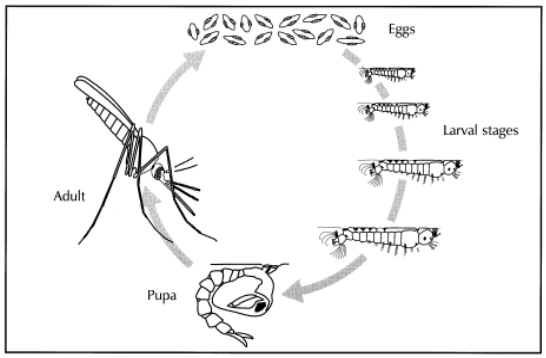
Flying Vectors	Mosquitoes

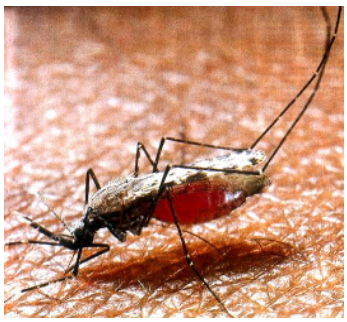
Mosquitoes are worldwide in distribution. They are dangerous as vectors of many Diseases. Especially in the tropical zones mosquitoes are increasingly infected by the malaria and dengue fever parasite. The parasite is introduced into the victim's body by the bite of a female mosquito seeking the blood feed she needs in order to produce viable egg.

The parasites find their way into the liver of the victim from where the developmental stages enter the blood again. If the victim is bitten by other mosquitoes the parasites are sucked up into the mosquito' stomach where they multiply sexually completing the life cycle with the effect of continuous distribution from victim to health man. Whereas the mosquito season in the moderate zones is generally from spring to autumn, mosquitoes are active all the year round in the hot, humid tropics. Most species hide during the day and become active only during the night.



Three main groups are subdivided: house mosquitoes (*Culex spp.*), yellow fever mosquitoes (*Aedes spp.*)and malaria mosquitoes (*Anopheles spp.*). There are less dangerous malaria and dengue fever species other lead to death. Recent estimates put incidence of malaria world wide at 400 million cases per year with up to 3 million deaths (90% in Africa). Today dengue fever as well is expanding around the world and may become a loss maker for the tourist industry.





Malaria Vector

The female anopheline mosquito plays an important part as vector in the life cycle of malaria parasite. She is the vector for the parasite and responsible for distribution. Destroying this vector lead to interruption of life cycle and to restriction of parasite spreading.

Dengue Fever Vector

The most important vector of dengue virus is Aedes Aegypti a mosquito originated in Africa and spread around the world. This mosquito transmits the dengue virus via bite only. Once infected it remains infective the rest of its lifespan (~ 15-60 days). The adult mosquitoes would bite only during the rainy season. It is dangerous as potential vector of dengue as it became adapted to urban life of people and even breeds and survives in home and garden if there is any water puddle present.

Mosquito Habitat And Their Control

Larval Stage

The larvae always develop in water. House mosquitoes (Culex spp.) breed close to dwelling houses in urban and rural areas, mainly in muddy waters. Yellow fever mosquitoes (Aedes) larvae breed in clean or lightly polluted water, e.g. in any temporary puddles of water left by recent rains. The eggs survive when the puddles evaporate.

pulsFOG K-22/10 BIO with large tubular frame

Control of Larval Stage

The recommendations differ according to species, developmental stage and habitat. All species can be preventively fought by controlling the larval stages in **wet habitat** e.g. in still or gently flowing water, where no or less fish are living. Such control measures need to be well prepared to ascertain exactly the time period of breeding process. Biological active substances based on bacillus thuringiensis israelensis and sphaericus or methoprene combined with a **pulsFOG-BIO** type ground applicator**,** mounted on all-terrain vehicles or boats, are an efficient weapon against mosquitoes larval stage. This Bio Unit produces a dense and heavy water fog cloud with a droplet spectrum <100 µm able to penetrate into large inaccessible areas of water vegetation. In case of even bigger areas there are other ULV (ultra low volume) application methods available using aircraft.

Adult Stage and its Control

Some mosquito species prefer an **indoor habitat**, where they rest during the day and attack at night and others remain outdoors. Indoor mosquitoes are easily fought using a **volatile** fogging formulation combined with a small portable fogger equipped with a nozzle system which provide

extremely small droplet sizes. Droplets < 10µm have the advantage to remain long-time airborne, dry like smoke, but improves the gas phase which penetrates even in hidden locations like corners and cracks where mosquitoes rest. Such fog or smoke does not cause wet or humid surfaces. Even the sensitive letter paper on a desk remains dry and gets not dirty. These small droplet sizes produced by a simple electricity independent motor technique make the **pulse jet thermal fogger** so efficient in third world countries. Volatile biocide formulations applied with small droplet sizes have a shorter period of efficacy. There are formulations available to prolong the efficacy of such active ingredients (e.g. encapsulated formulations).

Indoor habitats of mosquitoes are all residential buildings, offices, magazines, warehouses, storerooms, hotels, restaurants, public buildings but also underground sewage systems (canalisation).

Outdoor Adult Mosquitoes life nearby their breeding habitat in shadowy, humid areas, where they rest during the day. They become vector of the disease if they bite animals or men. While indoor treatments require „dry“ fog with ultra fine droplets (<10µm) to avoid stains on sensitive surfaces outdoor applications against flying mosquitoes require slightly bigger droplets **up to 20 µm,** which are less sensitive to air convection, less volatile and which ideally should carry in every droplet volume the lethal dose for one adult mosquito. The fogging equipment provides the appropriate nozzle sizes to produce these bigger droplets.

Fog Application

The effect of biocides on pests is not only governed by the active ingredient itself but also by the formulation and application method (droplet sizes) selected. According to WHO specifications adult mosquitoes are effectively controlled with droplet sizes <16 µm. Additionally climatic conditions have to be respected (humidity and air velocity) to select a suitable droplet size and formulation. Mosquito larvaes living in wet habitat require larger and heavier droplets with a higher fall speed. Aerosols are generally determined as droplets or particles suspended in air with a size < 50µm (1µm=1/1000mm). Cold and thermal foggers are designed to produce the required

droplet spectrum. The pulsFOG machine produces an immense aerosol cloud which remains suspended in the air near ground level, drifting through the target area often inaccessible for men. Thermal fogging has proved to be the most effective method for the control of mosquitoes, flies and nuisance insects also in residential areas.

When to Fog

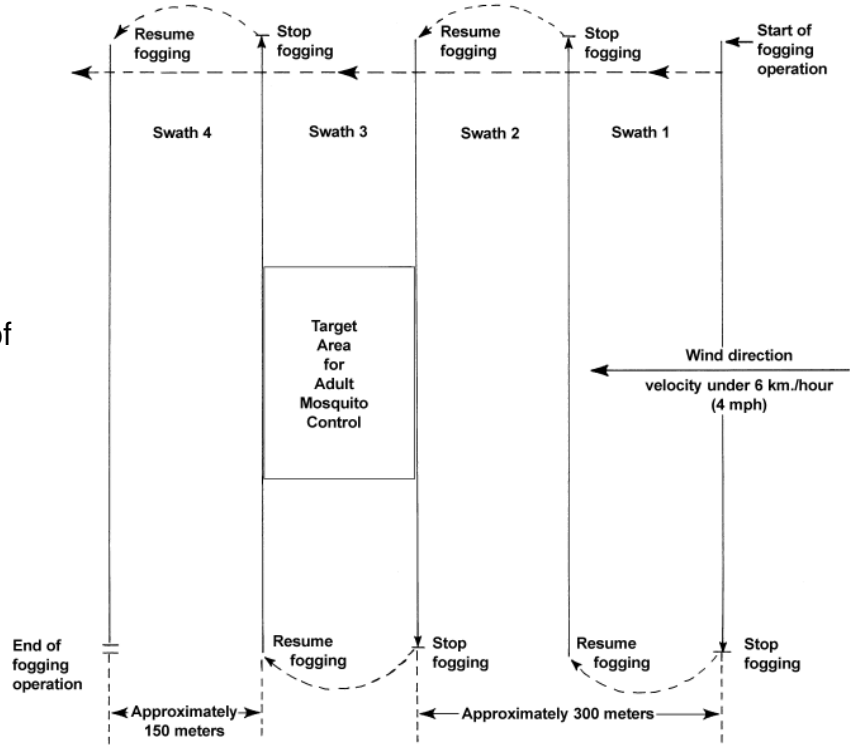
Fogging should begin in the insect-breeding season. The greatest effect will be achieved if the fogging operation is prepared for the insect's time of peak flight activity. This is usually in the late afternoon, evening, during the night and early morning.

Thermal fogs should be applied only when weather conditions are favourable for allowing the produced fog to remain close to the ground (high relative ambient humidity). In particular the wind velocity should not exceed 6 km/h. Daytime application under sunshine is not recommended because on warm days the hot air rises from the hot ground and causes the fog to move upward with the air currents.

Problem areas should be treated using a short-life biocide every 2 days in a period of 2 weeks to avoid that newly emerging adults continue to lay more eggs. After such a curative operation the entire mosquito population is reduced to a level where only regular maintenance fogging is required.

How to Fog

Note that an area much greater than the target area should be fogged to help protect against reinvasion from adjacent sections. Whenever possible the fogging machine should be operated starting upwind of the plot to be cleared of mosquitoes so that the fog will drift across the target area. Several overlapping fog swaths should be laid down at about 40-max.150m intervals starting about 300m upwind of the target area and ending about 150m downwind of the target. Swath widths will vary dependent to the number of obstacles



Overlapping fog swaths with a max. width

Determination of Application (vehicle) Speed

1. Establishment of location and size of fogging area
2. Establishment of fog swath distance (40m- max. 150m dependent on performance of applicator and existing obstacles in the target area)
3. Establishment of stretch of road for operator and equipment
4. Establishment of amount of total fogging solution (~ 2- 3 litres/hectare including biocide + fogging carrier).
5. Establishment of discharge rate of used applicator (adjustment of nozzle)
6. Establishment of operators vehicle speed (<5 km/h)

	Vehicle speed considering max. flow rate and max. throwing range of produced fog with different pulsFOG machines under optimal terrain conditions						
	Portable machines			Vehicle mounted machines			
Type of machine	**K-10 sp**	**K-22/O**	**K-30/O**	**K-22/10/O** small/large	**K-22/10 BIO** large	**K-30/20/O** small/large	**K-30/20 BIO** small/large
Max. flow rate[1] (l/h)	**30**	**60**	**120**	**75**	**75**	**120**	**190**
Max. throwing range[2] With oil as carrier (m)	**40**	**70**	**100**	**100**	**100**	**150**	**150**
Theoretical area output considering 3l/ha (ha/h)	**10**	**20**	**40**	**25**	**25**	**40**	**63**
Machine forward movement (vehicle speed) (km/h)	**2,5**	**2,85**	**4**	**3,3**	**3,3**	**4**	**4,3**

[1]) provided diesel fuel as biocide carrier is used. [2]) provided that wind speed is 3-6 km/h

After careful preparation of the fogging formulation and the pulsFOG machine the starting point with the fogger has to be selected considering the direction of wind.

Preparation of a Thermal Fogging Formulation

1. Selection and establishment of needed biocide
2. Establishment of dosage of biocide
3. Establishment of amount of fogging carrier (pure oil, pure water or oil/water emulsion)
4. Establishment of amount of eventually needed co-solvent or formulation improving agent (methylenechloride or pulsFOG Additive X-EC/100)
5. Establishment of the mixing steps
6. Production of a formulation sample and check of its stability during 30 min.

Note: prepare only the limited quantity of a final formulation for the immediate use

To avoid long storage of a ready to use fogging formulation in the chemical tank of the applicator it is advisable to **check the perfect function of machine before beginning any mixing** procedure of pesticide with the fogging carrier liquid. It may happen that the machine was not cleaned after the last treatment and there still is a remainder from another pesticide in the tank which may not be compatible with the new formulation. Chemical incompatibility of two mixed pesticides lead to separation of active ingredients or to an unwelcome reaction which again leads to choking and clogging of the discharge nozzle.
In other cases a dirty spark plug will hinder the correct starting of the engine! Such “technical” troubles should be avoided before the fogging formulation is prepared. Therefore always check perfect engine run and discharge of nozzle by fogging pure water first before mixing the pesticide.

Understanding Droplet Sizes, Volume Rates and Fogging Formulation

There are different methods to apply and to distribute Biocides as homogeny as possible on a given surface area or into a determined space volume. Following to well known international standards these application methods depend to the volume rates and the corresponding droplets sizes emitted.

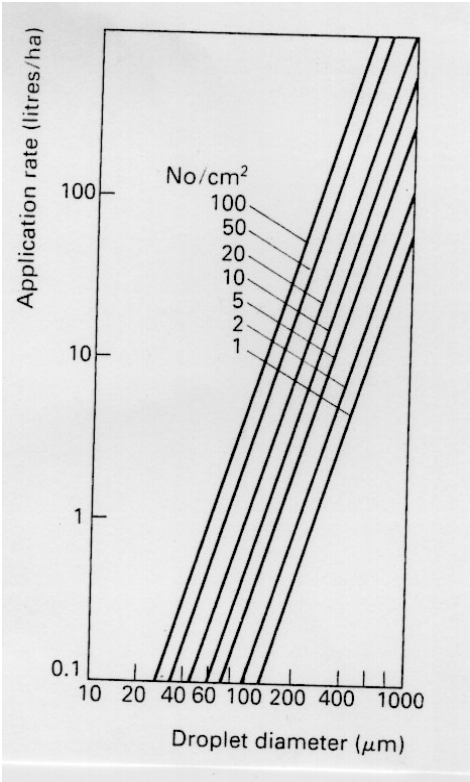
Application methods using different technical discharge equipment	
High volume (wet spraying, droplet size < 400µm)	> 600 litres/ha
Medium volume (spraying with 200 - 400µm)	200 - 600 litres/ha
Low volume (misting with 100 - 200µm)	50 - 200 litres/ha
Very low volume (atomising/fogging with droplets < 150µm)	5 - 50 litres/ha
Ultra low volume (atomising/fogging with droplets < 100µm) Ultra low volume (fogging with droplets < 20µm)	< 5 litres/ha < 3 litres/ha

Every pest requires an optimal droplet size (or better droplet spectrum) to be successfully attacked. This droplet size should content the lethal dose of active ingredient. The bigger the insect size the bigger the killing droplet needed. According to G.A. Matthews[2] there are the following recommendations:

Which Micron size is most effective?	
Flying insects	10 - 50µm
Insects of foliage	30 - 50µm
Foliage (e.g. fungal disease)	40 - 100µm
Soil (organisms living in soil)	> 200µm

1µm = 1/1000 mm
Note: a cigarette smoke particle
is smaller than 1µm!

If a certain pest requires a certain droplet size and a certain density of this size to be successfully killed the theoretic volume rate may be determined from the figure beside using cotton foliage as reference target area.



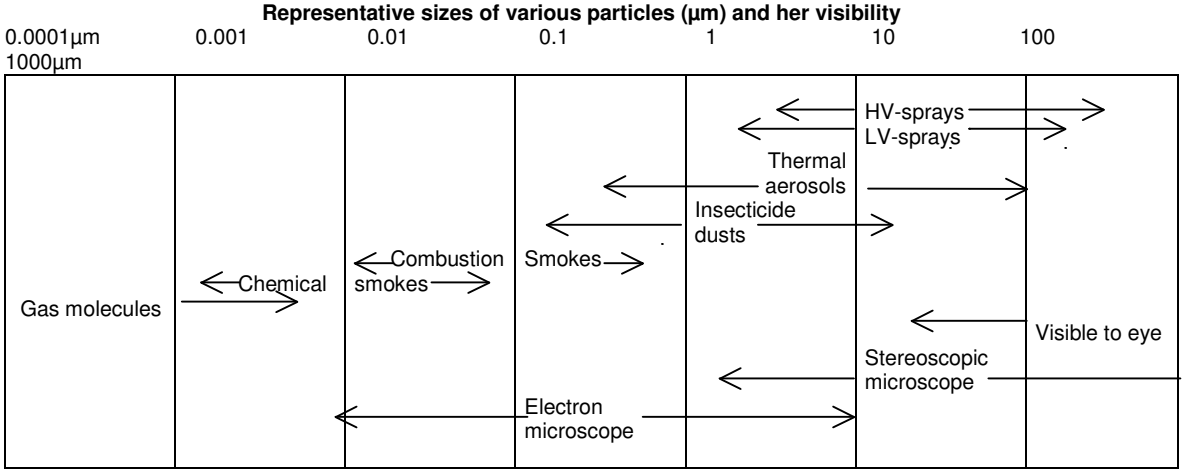
[2] Graham Matthews, Imperial College, University of London

Selecting the Suitable Application Formulation

pulsfogging offers with pure oil - but also with water based - fogging formulations a multitude of effective treatments due to a variety of different formulation possibilities and dosing nozzles providing different droplet sizes. **Pure oil** formulations provide droplet sizes (< 20µm) to attack successfully mosquitoes. **Oil-water** formulations produce droplet sizes up to 100µm and provide efficient attack to large insect sizes (e.g. locusts), as well as efficient fungal disease control on crops. Fog applications for targets in the soil are not possible.

Unlike a high volume (HV) spraying plant protection program with approx. 1000 l water/ha, a fogging program against adult mosquitoes uses only volume rates of approx.<3 l/ha. To decrease the volume rate from 1000 l to only 3 litres it is necessary to decrease simultaneously the droplet size to provide the original density of droplets on the target. A HV-sprayer will produce droplet sizes of less than 400 µm while a LV (low volume) and ULV(ultra low volume)- atomiser will produce droplets <150 µm and a thermal fogger a aerosol with droplets <50 µm. Compare: a smoke particle of a cigarette has a diameter of ~1 µm!

Representative sizes of various particles (µm) and her visibility



The reduction of droplet size in such categories leads to an evaporation problem. As smaller the droplet size produced from a given spray volume as bigger the total surface of the same volume and consequently as stronger the evaporation rate.

Lifetime of water droplets (temperature 20°C, relat. humidity 50%)[3]

Initial droplet size (µm)	Lifetime to extinction (s)	Fall distance (m)
50	14	0.5
100	57	8.5

The volatility of water is influenced by the ambient relative humidity and temperature but also by the pesticide and its formulation, additives and inert ingredients. The praxis has shown that additional supplements to the water are needed to delay successfully the evaporation of such small droplets. In the past, pure oil formulations of non volatile oil qualities for the fogging carrier solved the problem but more and

[3] **Published in: Matthews „Pesticide Application Methods“Longman Scientific & Technical UK Ltd, Harlow, UK**

more water based ULV and FOG formulations have shown advantages and are in progress.

Oil based fogging formulation

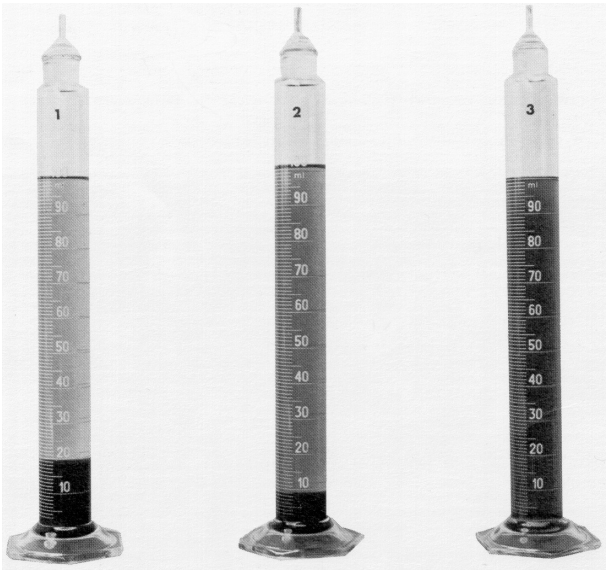
The fogging formulation includes the liquid pesticide and the fogging carrier, which is a locally available mineral oil (hydrocarbon solvent). Often used: diesel fuel (for lack of a better choice). The pesticide must be oil compatible to provide a **stable** solution or dispersion.

A powder suspension of pesticide in oil is less desirable as this type of formulation tends to clog the exhaust nozzle of pulse-yet motor. The working principle for this type of fogger is based on the evaporation of fogging liquid inside of the nozzle and the following condensation at cool ambient air. But suspension particles cannot be vaporised.

The oil quality used provides the characteristic of produced droplets: volatile, less- or non-volatile. The volatility of formulation influence the lifetime of droplet size. **Indoor** treatments require in many cases a short lifetime (**higher volatility**) to avoid undesirable oil residues on sensitive surfaces. The enclosed space of a building will prevent the drift away and loss of fog aerosols and its produced gas. The suitable droplet size for indoor treatments is less than 10µm.

A typical hydrocarbon used for **indoor** application is odourless kerosene. Some chemical or petrol companies make available fogging oils giving better solubility of pesticide and higher flash point to reduce a possible fire hazard (e.g. Shellsol D-100 or Sinarol types from Shell Oil Company).

Oils with less aromatic content or oils with a paraffin or aliphatic nature and also vegetable oils have a poor pesticide dissolving power. In such cases a non combustible co-solvent (e.g. methylenechloride or 1.1 trichloroethane) 5-10% admixed will help to dissolve the pesticide in the prepared mineral oil easily. The supplement of methylenechloride or trichloroethane also raises the flash point of fogging carrier and favours the development of smaller and more homogenate droplet sizes leading to an efficient gas phase.



1 **2** **3**

(1) Active ingredient badly diluted in kerosene. **(2)** Partly dissolved active ingredient (co-solvent not suitable). **(3)** Excellent dilution of active ingredient in kerosene with the help of methylenechloride as co-solvent.

Outdoor treatments require a **non volatile** fogging formulation to preserve the produced droplet size and its content as long as possible and to provide a farther drift leading to a residual coverage on habitat surfaces such as plant leaves where insects and other pests life. Fuel oils often used because everywhere cheap available are only the second choice. These oils are relatively volatile, highly flammable and very susceptible to thermal up drafts, which cause them to dissipate quickly leading to a loss of active ingredient on the target object.

Ideally a plant compatible outdoor fogging oil should provide the following technical data:

Unsulfonated residue..> 92% **(„>“ = „more“)**
Aromatic content.....< 10% **(„<“ = „less“)**
Evaporation.....< 20% in the Lallata test, resp. evapor. rate < 1000 (ether=1)
Flash point.....> 75°C
Viscosity.....< 30cSt or 4Engler at 20°C
Molecular weight.....> 300
Note: flash point of diesel fuel = 59°C ! recommended flash point of WHO = >62°C

The well-known oil companies offer suitable mineral oil qualities under the common name **white mineral oil** (e.g. Risella-oil from Shell, WT 61 from BP, Exxsol D 100 from Exxon), which have either a paraffin, naphtenic or aliphatic nature.

Also, so-called **agricultural spray oils** (which include a emulsifying agent for a water supplement) are a good choice for fogging treatments if the viscosity is low (<25 cSt).

A ready for use **vegetable oil** is Codacide[4], which is extracted from rap seed and registered in UK. This environmentally friendly product includes all necessary emulsifying agents to provide good mixture with the pesticide and even with water. Other vegetable oils made from sun flower- or oil palm seed need a non-combustible co-solvent to reduce the viscosity, to lift the flash point and to improve the solubility of the pesticide.

Water based fogging formulation[5]

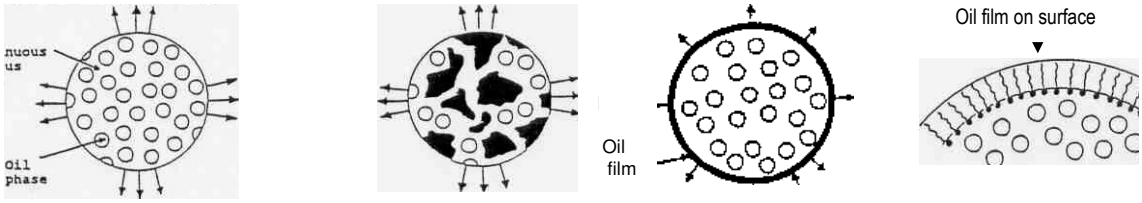
With the increasing need to reduce environmental contamination with hydrocarbon solvents such as diesel fuel, and also to reduce a possible fire hazard in hot countries, the use of water or of a water/ oil-emulsion as a fogging carrier should be given preference.

[4] **registered trade name of MICROCIDE LTD Shepherds Grove Stanton Bury St Edmunds Suffolk UK IP31 2AR**
[5] **Observe also: Groome, Martin and Slatter, Wellcome: Environmental Health (today AGREVO) UK: „Advances in the control of public health insects by the application of water-based Ultra Low Volume space sprays“**

The partly substituted oil by water also makes it possible to influence the droplet size and to adjust it to the desired range: as higher the water portion in a given fogging formulation as bigger the produced droplets (important in a plant protection program).

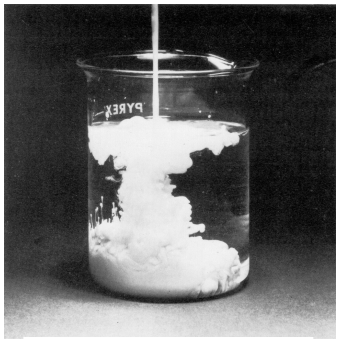
Pure water as fogging carrier without any oil as fog enhancer is only in some rare cases successfully applicable e.g. in greenhouses if there is no suitable carrier available or if there is no plant tolerance to the fogging carrier. Using pure water as pesticide carrier applied through a thermal fogger doesn't lead to a fog with condensed aerosols but only to a mist with droplets <100µm. Droplets in that range are practical in a residual application program but less efficient and not economic in a control program against adult mosquitoes.

The controlled supplement of oil to water forms a complete stable oil-film on the fog droplet surface. This oil film acts like an isolator or a skin and retards the evaporation of water inside of the droplet:



1 **2** **3** **4**

To provide a **stable emulsion** from oil in water the oil has to be premixed with a appropriate emulsifier (e.g. pulsFOG X-EC/100) and then added and agitated in the prepared amount of water. Oil as fog enhancer and evaporation inhibitor may be substituted by any type of **glycol**[6], which is a multihydric alcohol. Ethylene- and propyleneglycols are widely used as compounds in the chemical- paint- and cosmetic industries. They are available in most countries. Glycols have similar fogging properties as oils but are, -in contrary to oil-, completely **water-soluble.** The pulsFOG sales program contains a ready for use trade product (VK-2 special) based on diethyleneglycol which is registered in many countries.

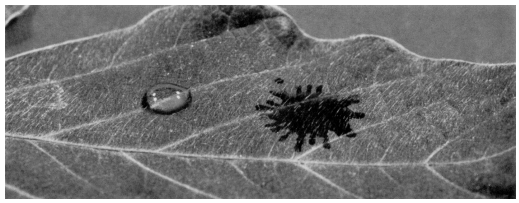


Fogging oil prepared with an Emulsifier added to water

Monoethyleneglycol is the cheapest representative of all the glycols. It has the lowest viscosity and highest evaporation rate (=600 compared to ether=1) and **polyethyleneglycol** has the highest viscosity and lowest evaporation rate (>2000 compared to ether=1). In between there are di- and triethyleneglycol. Advantages of a better environmental tolerance in relation to oil may be paid by a higher price.

[6]**Useful glycol types are: mono-, di-, tri- and polyethyleneglycol and 1.1 propyleneglycol**

Glycols, especially monoethyleneglycol with a higher volatility are certainly the **better choice** for **indoor applications** than a combustible oil or hydrocarbon.
Adding a glycol component to a water-based fogging solution reduces the droplet sizes simultaneously to the added quantity and narrows the droplet spectrum. The employment of glycol demands to add a wetting agent e.g. nonylphenolpolyglycolether[7]) to improve the biocide compatibility in the water/glycol component as recommended in the following table.



Efficacy of a wetting agent on the surface tension of a water droplet

	Fogging Formulation (litres / ha) for a mosquito control program considering the production of different droplet sizes									
Desired droplet spectrum	< 10 µm	< 25 µm			< 50 µm*			< 100 µm*		
Recommended composition	100 % oil	50% oil or glycol in water			25% oil or glycol in water			10% oil or glycol in water		
Agricultural spray oil (containing emulsifier)		1,5			0,75			0,3		
Other plant compatible oil without emulsifier	3**		1,5			0,75			0,3	
Emulsifier X-EC/100			0,06			0,03			0,01	
Glycol				1,5			0,75			0,3
Wetting agent Arkopal N-80				0,06			0,03			0,01
Water		1,5	1,5	1,50	2,25	2,25	2,25	2,7	2,7	2,7
Summary of fogging carrier (litres)	**3**	**3**	**3,06**	**3,06**	**3**	**3,03**	**3,03**	**3**	**3,01**	**3,01**
Biocide	Approx. 5% - 15 % biocide dependent on the instructions of supplier = 150 – 450ml in addition									
Total	**3,15 – 3,45 litres/ha** dependent on the selected formulation									

*droplet size recommended for application of larvicides
**should contain a cosolvent for better dilution with biocide

[7] **Trade product Arkopal N-080 from Aventis.**

Visibility of Produced FOG

While pure oil- or glycol formulations applied through a thermal fogger lead automatically to a white visible fog are water based formulations applied through the same fogging nozzle less visible. The reason is that water is only partly vaporised by the thermal energy and only this vaporised portion of the water will lead to a visible condensed fog. The not vaporised portion forms bigger droplet sizes which are required for a heavier fog with less drift away loss and better sedimentation of the pesticide on the target surface (leaves of plants and crops or the skin of a bigger insect e.g. locusts). Because water forms bigger droplet sizes and oil (and glycol) smaller sizes the supplement of these components offer a multitude of adjustment possibilities to achieve a desired droplet spectrum (observe the table above).

Street fogging using diesel oil as carrier for biocide


Avocado Treatment using water/glycol component As fogging carrier

The visibility of the FOG is important to supervise optically the spreading of the applied chemical and to direct the active substances on the limited area (surface) where the pest is located. But the visibility of the produced FOG is not a indicator for its biological efficacy! Both the water and oil based formulations are comparable effective.


Disinfection of a canteen kitchen with water based chemicals

In some cases a less or invisible FOG is preferred e.g. in public facilities, restaurants, kitchens, hotels, mainly in enclosed spaces. But also for open air applications more and more a less or even invisible aerosol is preferred e.g. in public health domains to prevent that people are irritated or shocked or only that the traffic or any organised event are not disturbed during FOG application. Water based fogging formulations with a water portion of more than 80% are the solution for this requirement.

Suitable Biocide Formulations[8] for Fogging and ULV Applications

A biocide (pesticide) may be formulated in a dry or liquid state. The active substance is combined with inert ingredients, which include solvents, spreader stickers, wetting agents, dispersing agents and stabilizers. The inert ingredient is a material added to

[8] **Observe also: Powell, Linquist „Ball Pest & Disease Manual, Ball Publishing, Geneva, USA**

the active substance to carry or to dilute it. It has no direct pesticidal activity, but rather influence the behaviour of the toxic ingredient.

The formulation depends on the chemical ability of the active ingredient to be diluted in a solvent, which itself must be compatible to a pest habitat (e.g. leaves of crops), or which does not pollute the environment (e.g. ozone killer arising in the protective ozone layer). Some active ingredients are not soluble or do not meet the requirements above and have to be formulated in a powder, which in turn is able to be suspended in water. There are many different kinds of formulations also to be adapted to certain application methods (high volume spraying, low volume misting, ultra low volume atomising, fogging, dusting, gasification) or for a residual effect of the pesticide (e.g. wettable powder formulation against a fungus Disease):

Emulsifiable concentrates (EC) are liquid formulated pesticides prepared to be mixed with water. They form a emulsion (a kind of milk) with water because the active ingredient is originally not water soluble and must be pre-solved in a hydrocarbon (e.g. xylene). Most of these EC-formulations may be mixed as well in a oil carrier for ULV and Fogging applications. EC-pesticides are preferred for self made ULV- and Fog formulations both as a water based or a oil based preparation.

ULV-liquid (UL) is a commercially pre-formulated “ready for use” pesticide for small droplet applications with ground and air equipment. It is preferably designed for cold-fogging- or ULV-machines. The formulation contains a low-volatile solvent with a high molecular weight to provide good terminal velocity and spray deposit on the target surface. There are formulations which do not require to add any further carrier liquid. Other formulations require the supplement of a carrier liquid to increase the density of droplets/surface unit. Again other special preparations allow the supplement of water. A ULV-formulation may be used with a thermal fogger but it is recommended to check the flash point, which is sometimes to low for this equipment (except pulsFOG-BIO machines). Adding 5% of a non-flammable solvent (trichloroethane) or 20% of a mineral oil with a far higher flash point (>200°C) may solve the problem. Adding the pulsFOG emulsifier X-EC/100[9] will provide as well a desired emulsion with water.

ULV-suspension (SU) is a commercially pre-formulated “ready for use” pesticide powder suspended in oil with the same application conditions as above. A SU-formulation is a viscous oily liquid similar to a oil-based paint, which requires in most cases a oil supplement for the reduction of viscosity. In some special cases a water supplement is also possible. This formulation can be used in ULV or cold-fogging applications as well as in a thermal fogging application program but limited to large vehicle mounted foggers with bigger nozzle sizes.

Hot Fog-formulation (HN) is a commercially pre-formulated “ready for use” pesticide for thermal Fog applications, which sometimes contains the necessary oil carrier. In other cases the formulation requires a supplement of oil in a certain relation to the

[9] **Observe the technical description pulsFOG emulsifier X-EC/100**

pesticide: e.g. 1 : 9 (1 part pesticide to 9 parts oil carrier). These formulations are not prepared to be mixed with water but in this case as well: adding the pulsFOG emulsifier X-EC/100 may lead to the desired water mixture. Unfortunately there are some formulations in the market with a very low flash point and therefore highly combustible (e.g. Actellifog[10], Nuvan-7[11]). These formulations should be substituted with a EC-pesticide with the same active ingredient and available from the same manufacturers (observe a)) e.g Actellic 50 or Nuvan 50.

Flowables or **Suspended concentrates (SC)** are cream-like pesticide formulations, which are water-miscible. The active substance is combined with a very finely ground, solid particle, which is mixed in a liquid carrier. It is a suspension that flows much like a water-based paint. This formulation allows easy gauge of the capacity and doesn't need a balance for correct measurement as is necessary with wettable powders. Because of its micronized particles Flowables will not clog nozzles as much as wettable powders. Flowables are easier to use in all kinds of low volume applicators than wettable powders and should be preferred if the active ingredient is available only in both formulations. Flowables can not be mixed with an oil carrier. The pulsFOG thermal fogger range offers machine designs, which allow the fog application of Flowables (K-10sp, all standard- and BIO-types). PulsFOG also makes available special water-based fogging carriers for the use with such formulations[12]. Flowables are mostly used in the field of plant protection in case a residual effect against plant diseases is required.

Wettable powders (WP) are formulations of a toxicant mixed with inert dust (finely ground talc or clay) and a dry wetting agent. The particles are not as finely ground as a dust. A WP-pesticide must be carefully mixed in water to form a lump-free suspension. During application a permanent agitation in the chemical tank is necessary to prevent settling. These formulations are designed for a high volume spraying program with water. Using it in a low volume program the higher concentrated suspension with less water tends to clog the nozzle of applicator. WP's mixed with water and additionally with a water-based fogging carrier[5] are successfully applied with pulsFOG "Standard" units in greenhouses. However if there is the choice of both pesticide formulations (EC and WP) with the same active ingredient the EC-formulation is recommended for cold- and hot-fog applications. With the help of the pulsFOG emulsifier[9] a WP may be suspended in an oil-carrier for an outdoor ULV or Fog application. Fogging a WP/Oil suspension however requires a special technical design of the fogger such as the pulsFOG-BIO range represents it. The well-known biological pesticide "Bacillus thuringiensis", which is also used against the larval state of mosquitoes is formulated as a WP and easily foggable with the pulsFOG-BIO range.

[10] **Product from Zeneca (pirimiphos-methyl)**
[11] **Product from Novartis (dichlorvos)**
[12] **Observe the technical description of pulsFOG additive VK-2 special**

Soluble powder (SP) is a dry powdery pesticide formulation like a salt that dissolves completely in water. Adding the pulsFOG "VK-2 special"[5] fogging carrier allows unlimited indoor fogging application without any clogging problems. Because an SP-formulation is not oil-compatible a glycol component[10] must be used to enhance the fog condensation with a thermal fogger and to prevent early evaporation.

Microencapsulated pesticides with particles of ~10 µm have been developed for the slow release of volatile active ingredients. This type of biocide is formulated similar to a flowable. Due to the relative large particle sizes ULV and Fog discharge nozzles are choked quickly. Only the pulsFOG-BIO Fogging method but also standard spray applications with more water and larger droplet sizes allow an unhindered discharge. The retarded release of biocide active ingredient leads to the advantage of a prolonged efficiency of a short-lived agent.

Safety Instructions and Formulating Hints

Useful Accessories for a fogging operation

(1) pulsFOG light protection suit
(2) Mixing set, including:
one 10 l bucket with graduation
one 2 l graduated measure
one 250 ml graduated measure
one pair of chemical resistant rubber gloves, two wooden stirrers
(3) 5 l cleaning kit for the fogger
(4) Fuel measure
(5) Large Solution funnel,
(6) Solution funnel,
(7) Small pulsFOG tool bag
(8) Cleaning drill for nozzle
(9) Gas mask with filter A_2-B_2-P_3
(10) Cleaning rod with steel brush
(11) Ear protector
(12) pulsFOG spare parts set, small
(13) pulsFOG spare parts set, large

According to a test report published from the German association of engineers the most hazardous contamination with pesticides results from preparing, mixing and filling in the spray tank but not from the application itself. Therefore wear chemical resistant wear, gloves and protection mask with breathe filter A_2B_2-P_3 (German Standard).

Prepare only the limited amount of formulation needed **for the intended application** program. Even though there is after application a rest of liquid in the tank

drain this remainder into a container for safe storage and later use (some chemical companies and suppliers do not allow long storage of mixed biocides).

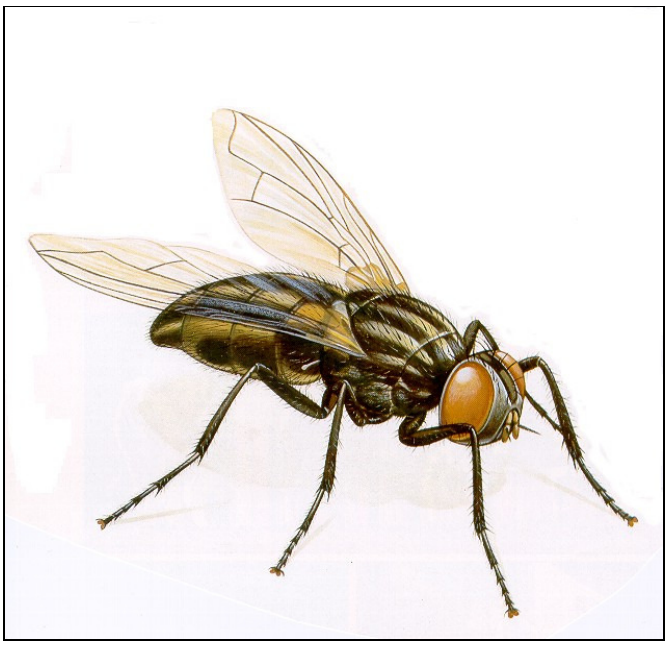
Read the pesticide label thoroughly and become as familiar with the product as possible. If there are no experimental values yet on its behaviour with a reduced quantity of water or with a supplement of oil first prepare a small quantity of test mixture in a clear glass vessel. Such a test mixture should remain stable for about 30 minutes, without any obvious separation. During this time, thickening is also impermissible. Chemicals with a strong separation effect (or settling-down effect of powders) cannot be used or must be improved by adding an appropriate emulsifier or wetting agent.
Be careful when combining pesticides in a single spray tank mix (e.g. a larvicide with a adulticide). This can help to save time and to increase a pest management effectiveness. But **make sure the pesticides are compatible with one another** by running a small trial before applying them. After properly diluting each with some water (for a water-based mixture) or oil (for a oil-based solution), mix them together and note whether their physical structures change in any way.

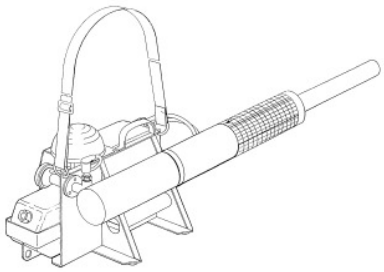
When mixing one pesticide with another, make sure the concentrated solutions do not come in contact with each other**.** First dilute the pesticide with a small amount of water (water-based fogging solution) or of oil (oil-based solution) in a small vessel. Partly fill a separate bucket with water or oil, put the first partially diluted pesticide into the bucket, mix it well, and then add the other partially diluted pesticide.

If a wetting agent, spreader sticker or a glycol component is desired in a water-based mixture, add this material last after the bucket is almost filled and agitate.

In case an adjuvant such as pulsFOG X-EC/100 is added to an oil-based carrier solution premix the adjuvant with the oil portion first then add the pesticide. In case water must be added to the oil always fill the premixed oil **in the water** and not the other way round! Constantly agitate the liquid during all mixing operations. Then fill the bucket content into the spray tank using a funnel with filter.

House Fly





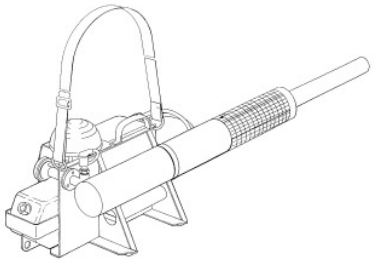
Important fly species include the common house fly (Musca domestica), the lesser house fly (Fannia canicularis), the face fly or autumn fly (Musca autumnalis), fruit flies or vinegar flies (Drosophila spp.), the blue bottle (Calliphora erythrocephala), the flesh fly (Sarcophaga carnaria) and the stable fly (Stomoxys calci-trans).

The stable fly differs from the other fly species in that it is the only one to require blood for egg production; therefore it bites and feeds on man, cattle and other livestock
Flies breed mainly in warm, dry areas. The adults feed on different kinds of vegetable and animal matter, but also on sweat and faeces. They lay hundreds of eggs in decaying organic matter in which the maggots remain throughout their development. Flies are prevalent every-where, in dwelling houses, in restaurants, in canteens, hospitals, cattle sheds and other livestock housing, slaughter houses, food factories.
But also outdoors there is no lack of them, on refuse dumps, in facilities for the disposal of sewage and effluent, in market places, streets, camping sites, etc.

In all countries of the world, flies are of importance as carriers of germs of different diseases which they transmit to man and animals (e.g. dysentery, typhoid, cholera, salmonellas).


Musca domestica

House Fly Larvae



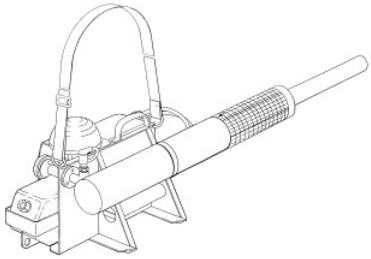
Control of adults
For the control of adult flies in private domestic premises, there are many biocides available to be used by householders.
For non-residual control of flies in dwelling houses, factories and in workrooms, use cold fog, thermal fog or mist formulations. In playgrounds, parks, streets, and on garbage dumps in residential districts, only a fog or ULV application will be effective. In stables and other livestock buildings, a residual effect is essential. Therefore treat walls, ceilings and Windows of these buildings with a residual insecticide (allow for occurrence of resistance) The use of an encapsulated formulation of short-lived biocide in sensitive areas are the preferential choice.
In rooms where foods are processed or stored, particular attention must be given to the risk of contaminating foods when applying insecticides for the control of flies.
Therefore, biological and non chemical protective measures to prevent build up of fly infestations should always be taken first, e.g. keep garbage bin areas clean and tidy; use garbage bins with close fitting lids; fit fly screens on Windows; do not leave foods exposed.
Only if these measures prove to be inadequate should insecticides be used.
In food areas, the insecticides are applied mainly as space Sprays and dry fogs. Outside these areas and especially in the area where garbage is kept, the insecticides should be used as residual sprays. A proven method is to use a bait spray combined with an attractant.


Fly control in livestock installation

Control of larvae
In breeding sites: Small bogs, cesspools and pits, liquid manure pits, effluent ponds, septic tanks, etc. frequently harbour fly larvae which, if left to breed freely, give rise to serious problems. Therefore, it is essential to eliminate these foci of infestation when and wherever possible, either by mechanical methods like drainage and filling in or by the use of insecticides
In order to minimize build up of fly populations in cattle sheds and other livestock buildings, it is important to control maggots in dung and liquid manure. Dung should be sprayed with an biological biocide such as a chitin synthesis inhibitor.


Vector control along the roads

Sandfly



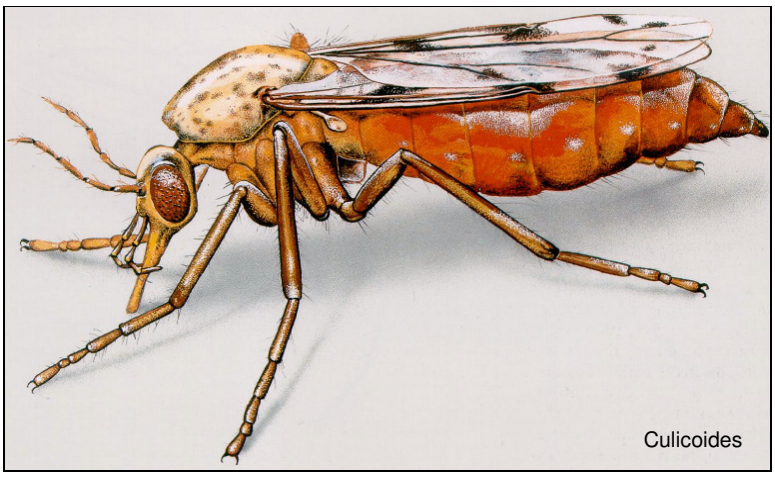
There are several different genera of sandflies. The most important are *Phlebotomus* (North Africa, Middle and Near East, West Asia, East Africa); *Sergentomyia* (U. S. S. R., Iran, Iraq, China, Africa, India, South America, Central America) and *Lutzomyia* (North, Central and South America). They are small, dark-coloured, bloodsucking Diptera.
They occur in swarms from spring to autumn, in tropical regions all the year round, and attack man and animals. Sandflies deposit their eggs mostly in danip recesses on the ground, in wild animal burrows, in crevices in walls and rocks, in silt, mud and decaying Vegetation; these sites are also the habitats of the larvae. The adults live mostly outdoors but sometimes they invade dwelling houses. Sandflies are not only nuisances. Their bites cause severe pain, and sandflies are vectors of several diseases including cutaneous leishmaniasis (Aleppo boil or oriental sore), visceral leishmaniasis (kala azar), mucosal leishmaniasis, and sandflv fever.

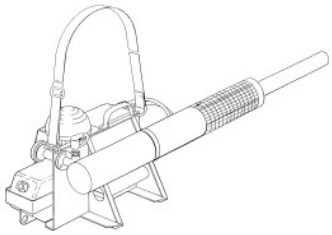
Street fogging

For the control of sandflies in huts or houses etc., it is recommended to spray walls with residual insecticides, which continue to act for several months. Sprays applied for the control of mosquitoes in anti-malaria campaigns have an additional bonus in the drastic reduction of sandflies. Sandfly infestation can be reduced also by spraying mosquito screens on windows.

For the control of sand flies outdoors e.g. in holiday camps, villages, small towns and work camps, fog applications are recommended using thermal or non-thermal aerosol formulations. Especially in outbreak of a leish-naniasis epidemic, rodent harbourages should be dusted with appropriate chemicals.

Biting Midge


Culicoides

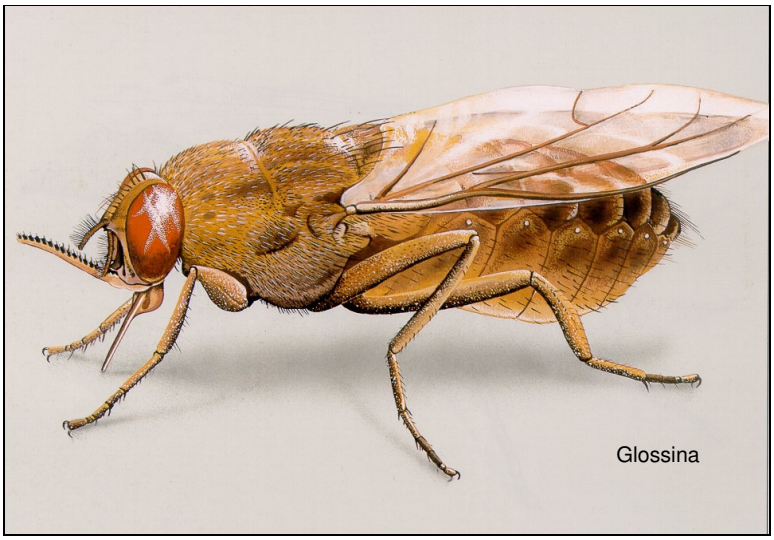


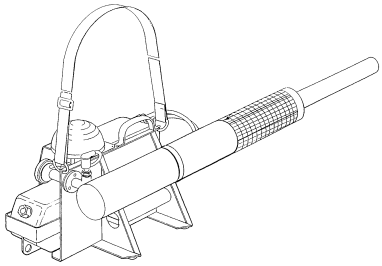
Biting rnidges (family *Cera-topogonidae),* also known by the name of punkies in some regions, sometimes are miscalled sandflies (this common name, however, is reserved for *Phlebotomus* species). They rank among the smallest of bloodsucking flies (0.5 to 1.5 mm). The most important species belong to the genera *Culicoides, Leptoconops, Forci-pomyia,* and *Austroconops.* Biting midges breed mainly in swamp areas, salt marshes, fresh water inlets, moist organic soils, etc.
The bloodsucking adults are mainly of importance for the great annoyance of their bites. However, some *Culicoides* species transmit certain filarial worms and arboviruses to man and animals.

Biting midges are controlled by applying larvicides where possible, by fogging in holiday resorts and residential areas, as well as by using repellents applied by persons on exposed parts of their body.

Amphibian vehicles
are the ideal carriers
for the application equipment
against vectors having their
habitat nearby water and
marshes

Tsetse Fly

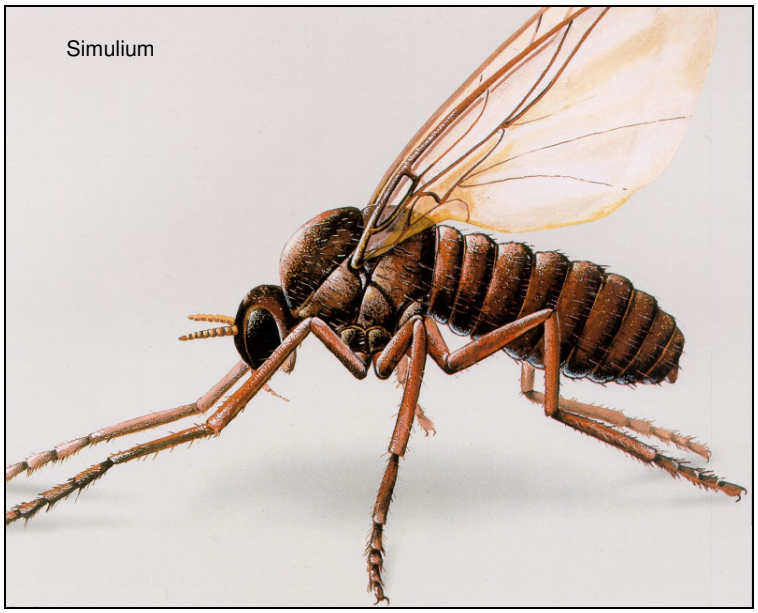




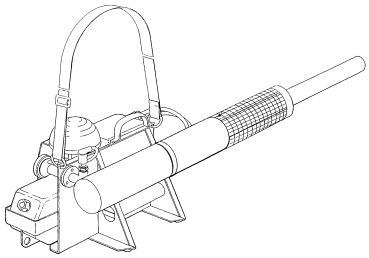
The different species of tsetse flies (Glossina spp.) occur in West, Central, Hast and South Africa. Some species live in the dry savannah regions, others in the wet Guinea savannahs. Their breeding sites and habitats are located close to rivers, streams and other bodies of water, mostly in trees, bushes and scrub, where cattle rest or pass by. Reproduction in tsetse flies is of a particular form known as adenotrophic viviparity, because the egg contains enough yolk for the embryo to complete its uterus by larva is nourished in the nutrients derived from the mother. Larval development is completed in the uterus, development, and the and the fully developed third-instar larvae are then deposited by the mother, burrow into the soil and pupate close to the surface. Tsetse flies transmit the causal organisms (Trypanosomaspp.) of sleeping sicknessto man and ofnagana disease to cattle. Reservoirs of the trypanosomes responsible for these diseases are antelopes and other wild animals which themselves do not become ill. When a tsetse fly bites and feeds on one of these animals infected with trypanosomiasis, it takes up with its blood meal a number of trypanosomes and inject them again into the next victim like people or domestic animals.

Control of tsetse fly is conducted during the dry period. One treatment with a pulsFOG machine is usually adequate to keep it under control for months. In some cases, however, it is necessary to make aerial applications in the early morning hours or late afternoon.

Trees and bushes are the preferred habitat of tsetse fly



Blackfly



Blackflies (Simulium spp.) are widespread especially in several countries of the African and American continents. They breed in unpolluted, rapidly-flowing waters which can range from small streams to huge rivers. The females lay their eggs on aquatic plants or on stones at water level. The adults have a considerable range of flight, usually many kilometres.

Blackflies are important not only as nuisances but also as vectors of onchocerciasis which can lead to blindness.

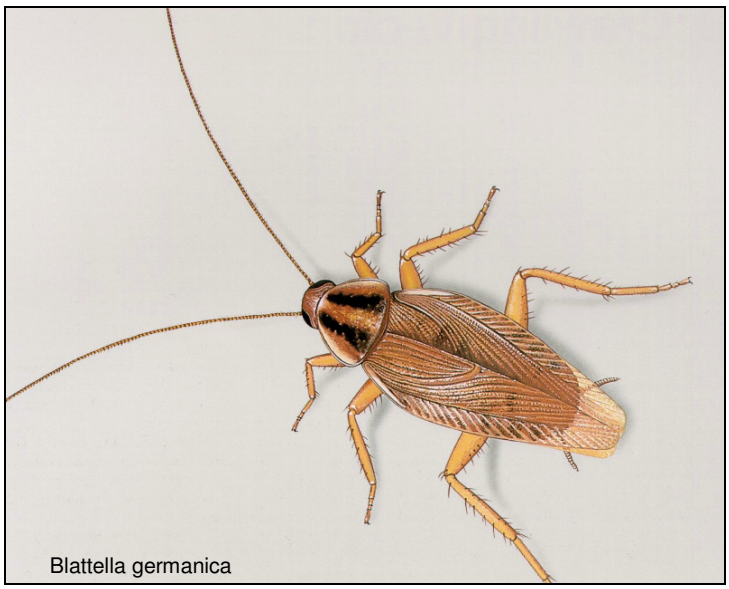
The causal organism of this disease, a filarial worm (Onchocera spp.) parasitizes man as its principal host.

Large areas in Africa (especially in West Africa), that are suitable for agricultural use, have been rendered uninhabitable by onchocerciasis. The disease, also commonly known as river blindness, is prevalent also in parts of Mexico, Guatemala and Venezuela.

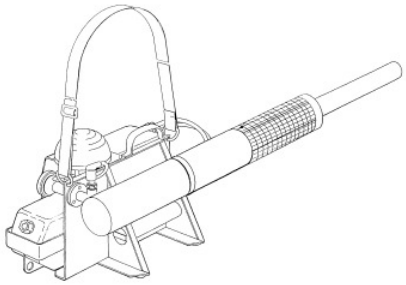
Effective residual control of blackflies is obtained by treating their breeding sites in flowing waters with larvicides applied from helicopters, fixed-wing aircraft or boats using also pulsFOG BIO machines which provide larger droplet sizes up to 100 µm. Non-residual control of adults as nuisances can be obtained by standard fogging with thermal fog or non-thermal fog formulations), using ground applicators or aircraft.

Vector control with amphibian vehicle

Cockroaches

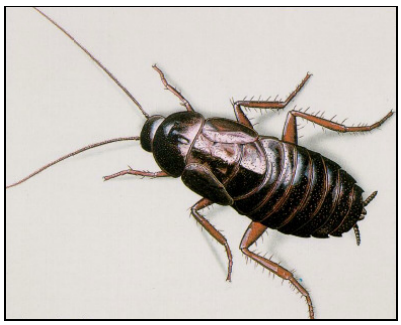


Blattella germanica

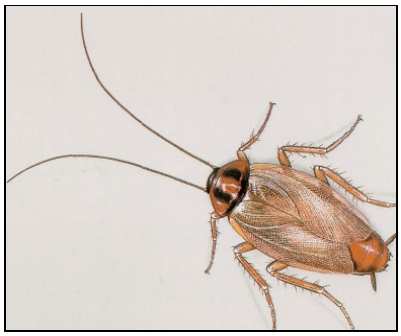


Many cockroach species are known. Three important ones are the following: The American cockroach (Periplaneta americana) which takes one year to complete its development. Just as long as the somewhat smaller dark brown Oriental cockroach (Blatta Orientalis). The still smaller yellowish-brown German cockroach (Blattella germanica) has the shortest life-cycle; it completes its development in 2 to 3 months. This explains why it is the most common species in many countries. Cockroaches originated in the tropics but now they occur in virtually all regions. They thrive best in a warm .

environment where the air is moist. In hotels, restaurants, kitchens, hospitals and homes, food processing plants, supermarkets, commercial establishments, breweries, Stores, aircraft, ships, etc. Cockroaches tend to avoid light. They hide during the day, which is the reason why they are seen so seldom despite their frequent presence and abundance.
Cockroaches are omnivorous creatures. They are especially fond of starchy and sweetened foods, meat, dairy products and vegetable products



Blatta orientalis



Periplaneta americana


Vector control in sewage system


Crack and crevice treatment

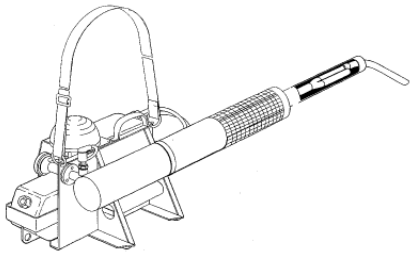
Cockroaches are successfully controlled in animal Stables with a thermal fogger and in underground sewage channels with a specially designed machine for this treatment (model pulsFOG K-10sp SAN)

Foremost among the many kinds of damage caused by cock-roaches is the contamination of human food. As a result, a wide range of disease-causing organisms (e.g. streptococci, salmo-nellas, etc.) can be transmitted by cockroaches to man and animals. But the economic losses sustained as a result of their direct feeding damage are also most substantial.

Cockroaches are controlled by thoroughly spraying and fogging their breeding places, harbourages and run-ways with residual insecticides applied with standard type knapsack sprayers or in large rooms with foggers. For the treatment of cockroach harbourages that are not easily accessible and not reached with a spray e.g. false ceilings, walled-in passageways, voids or heating ducts, it is recommended to make an additional application of a fog concentrate especially in the evening and night when they are active. Spray applications with residual insecticides: Thoroughly treat all likely cockroach hiding places like cracks, crevices and joints; also behind and beneath cupboards, shelves, refrigerators, sinks, etc.; along the bases of kitchen equipment, behind facings of cookers and dishwashing machines; ducting, elevator shafts, stairways, storerooms, and enclosed spaces where refuse containers are located. Avoid contact with spray mist, spray at a low pressure. For general treatments against all occurring insect pests including cockroaches (in industrial premises, etc.) where a residual action is not required, it is recommended to use a thermal fog or cold fog with appropriate machines such as pulsFOG. In rooms where foods are processed or stored, sprays must be applied with absolute care. It is rnost essential to avoid contamination of foods or of surfaces on which foods are handled and processed. Therefore, applications of insecticides in such rooms must be limited to crack and crevice treatments and spot treatments with hand sprayers.

CRAWLING VECTORS

Ants



More than 6,000 species of ants with greatly differing habits (nest construction; mode of formation of a new colony; nutrition) are known. Most have beneficial aspects, for example as scavengers or, like the wood ant, *Formica rufa* in Europe, by feeding on insects. Other species must be classified as pests because they feed on seeds and plants, and invade houses and other premises. In particular, Pharaoh's ant *(Monomorium pharaonis)* which invades houses and hospitals, feeds on a variety of edible materials preferably proteins and fats, and what is more may transmit disease germs.
A nest is established by a newly mated, winged queen. She remains there after she has laid her eggs. When the grub-like larvae hatch from the first batch of eggs, the queen feeds them until they pupate. Adult workers emerge from the pupae and these then nurse, tend and feed the larvae hatching from new batches of eggs laid by the queen, as well as the queen herself. In some species, winged sexual forms are produced; the males and females emerge on a nuptial flight, mate, and the fertilized females establish new nests. Ants forage for food in houses, stores, gardens, etc. Their food varies according to species, and includes sweet materials, fatty foods, meat, also plant parts like roots, leaves and fruits.

The control of ants is made difficult by their highly developed social organization and the location of their nests in places where it is not easy to gain access. Outdoors, on industrial premises, in gardens, parks, etc., successful control of ants depends upon effective treatment of nests so that eggs, larvae, pupae and queens will all be destroyed. PulsFOG designed a specially fogging machine (the ANT EATER) to treat the underground nests through the runaways and channels used by the ants.

Pharaoh's ants feed on animal proteins too, so special baits are required for their control

K-10 SP SAN (Ant Eater)

pulsFOG patents are issued, applied for or pending worldwide under the following numbers:

Europe

EU	0060938 // 94112785.4 // 0092057 // 92 115 438.1
GER	P2835338 // P3214932.8 // P3100414.8 // P3521941.6 // P2938958.0 // P3230184.7 // P3306546.2
GB	2028170 // 2066 367 // 2125317
F	7920407 // 8020747
I	982677 // 967324
CH	660668
NL	8004432 // 149990
USA+	4.298.167 // 4.504.214 // 08/274.267 // 992 039
Canada:	4.556.383 // 1.144.227 // 1.195.229 // 5.224.651
Japan:	1 223491 // 133094/80 // 195755/81 // 5-245 415
Brazil:	PI7508223 // PI7904982 // PI8006095 // PI8200067

Under the registered pulsFOG trade mark the following trade names of pulsFOG products are used:

pulsFOG BIO
(water cooled thermal fogger with 2 tanks for water and pesticide)

DECOFOG
(Portable thermal fogger with special design for decontamination)

COLFOGGER
(Heavy duty coldfogger mounted on wheels with a flow rate more than 30 l/h)

Turbo ULV
(portable electric coldfogger with 5 l tank)

TracFOG
(Coldfogger with PTO drive)

TURBOMATIC
(Autostationnary electric coldfogger on turntable, computer controlled)

MINIMATIC
(Autostationnary electric coldfogger, computer controlled)

nutriFOG
(Fogging additive with foliar fertilizing properties, bio-active, for the conversion of plant protective chemicals into a fogging formulation in glasshouses)

VK-2 special
(Fog enhancer for water based fogging formulations)

TÜVRheinland® CERT ISO 9001

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