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BITING MIDGES OR “SANDFLIES” IN THE NT

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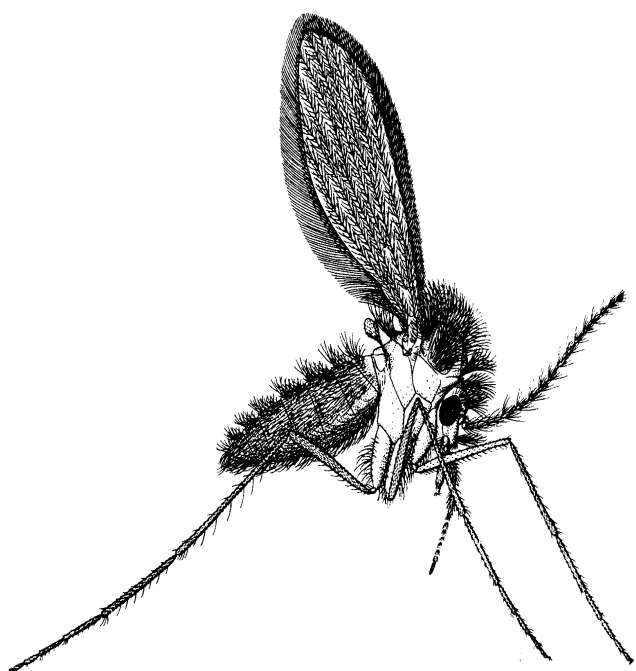
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Biting Midges or 'Sandflies' in the Northern Territory

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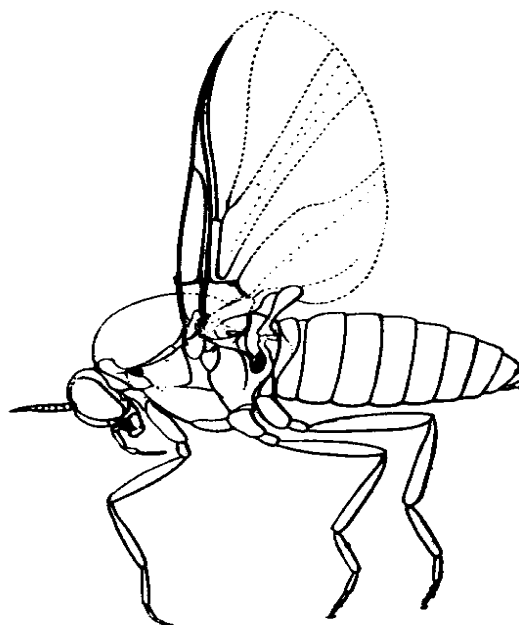
1.0 Introduction

Biting midges are small blood sucking flies in the family *Ceratopogonidae*. They are commonly referred to as "sandflies" in northern Australia. The term "sand fly" is a misused term for a number of families of small biting flies. This includes the true sandflies (Family *Psychodidae*) which are not pests of humans in Australia, as well as black flies (Family *Simuliidae*) which are serious pests in the inland areas of Qld and NSW following flooding, and the biting midges (Family *Ceratopogonidae*).¹



Phlebotomus – a female "Sand Fly"

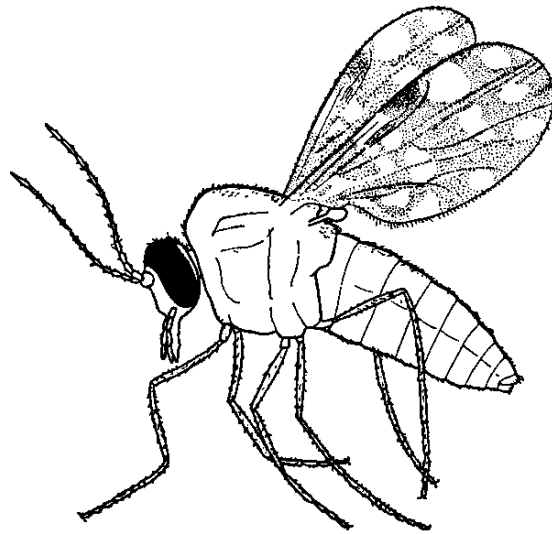
Insects of Medical Importance
British Museum 1956



Simulium – a female "Black Fly"

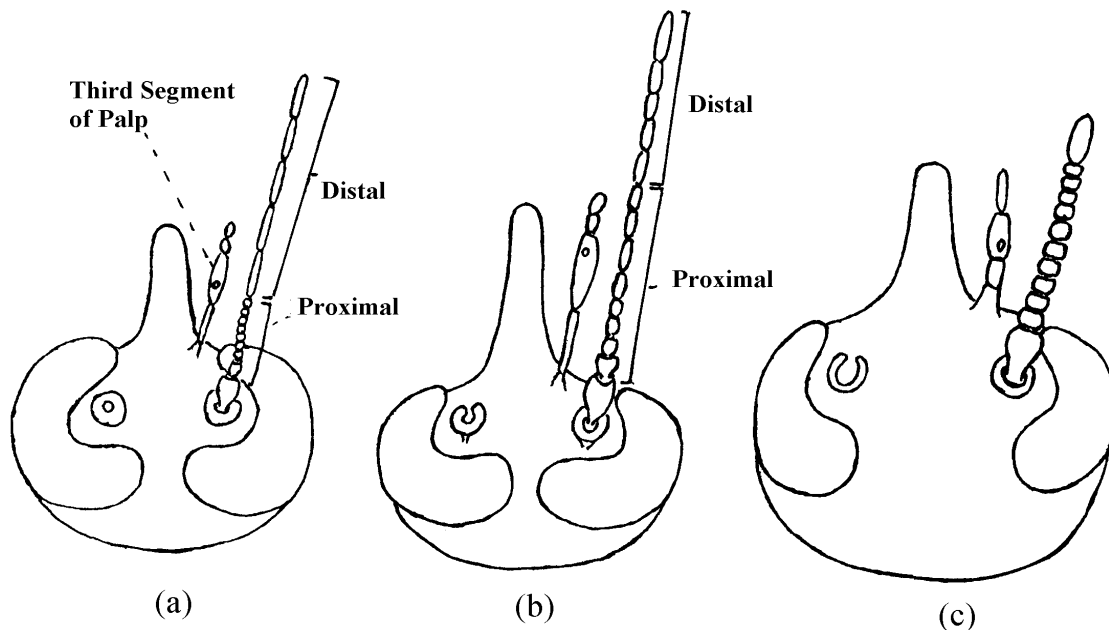
Insects of Medical Importance.
British Museum 1956

Biting midges are the major midge pest problem in Northern Australia.² A number of members of this family bite people in the Northern Territory. They include two species in the genus *Lasiohelea*, which are found biting in small numbers in shaded areas in or near dense forests during the day. A species of *Styloconops* is found in small numbers biting and swarming around the head on open sandy beaches during the day. The members of the *Culicoides* genus are more common, with many species and a wide range of breeding sites and biting habits.



Culicoides – a female “Biting Midge”

Entomology for Students of Medicine. Blackwell Scientific Ltd. 1962



Heads of *Ceratopogonidae* (Biting Midges) (a) *Lasiohelea* (b) *Culicoides* (c) *Styloconops*

Atlas of Common Queensland Mosquitoes. Queensland Institute of Medical Research, 1982

Thirty-three species of *Culicoides* have been recorded from the Darwin area.³ The *Culicoides* species include some species that don't bite vertebrates, some which preferentially bite cattle and other domestic animals, and the few species that are serious pests of people. The breeding sites include fresh water margins and cattle dung. Most of the serious human pest species breed in tidal and estuarine sites.

Culicoides midges are small, robust flies, approximately 1 mm in length with two wings usually showing a pattern of clear patches on a grey background. They have a short, forward directing proboscis or mouthparts for piercing skin and sucking blood.

Two species, *Culicoides flumineus* and *Culicoides* species near *subimmaculatus* can be severe human pests in mangrove areas across the Top End of the NT, but are rarely found outside mangrove forests.⁴

One species, *Culicoides ornatus*, sometimes referred to as the "mangrove midge", is found in association with mangroves across northern Australia, and is usually responsible for severe biting midge pest problems near the coast. This species is a major pest because it occurs in very high numbers and has a habit of invading nearby residential or recreational areas.

Culicoides ornatus is becoming an increasing problem across northern Australia due to urban development encroaching nearer to their major breeding places.^{5,6,7} They can impose serious restrictions on outdoor activities within flight range of their mangrove breeding sites due to the extremely annoying and painful bites, and to the discomforting after effects of the bites.

2.0 Bites of Biting Midges

It is only the female midges that bite. Biting midges do not transmit disease to humans in Australia. Their main human medical importance is as a biting pest.

Midges must take a blood meal for their eggs to mature. They do not, as is sometimes believed, urinate on people to cause discomfort. In the process of biting and sucking blood, they inject a salivary secretion that produces a skin reaction of varying intensity, depending on an individual's reaction. Bites usually produce a classic allergic response, with the first bite producing no noticeable effect, and the subsequent bites producing the reactions. If the exposure to midges is reasonably continuous, a process of desensitization may follow. People continuously exposed are usually tolerant to the bites, and generally have no reaction or show a mild reaction with a small red spot.⁸

The average reaction for newly exposed people is a red spot that develops a small dome shaped blister with a hole at the top. In people who are more sensitive to bites, the reaction may result in a red swelling over an area of a few centimetres. The bite area can be extremely itchy, and scratching is very difficult to avoid. Reactions may last 3 - 4 days with slowly decreasing irritation. Sometimes scratching breaks the skin and allows secondary bacterial infections that lead to unsightly sores and residual scarring.

3.0 Treatment of Bites

Mild reactions from bites require little treatment other than the application of soothing lotions. Proprietary products such as Eurax, Stingose, Medcream, Katers Lotion, Democaine and Paraderm crème can give relief from bites or prevent secondary infection. Useful non-proprietary products include tea tree oil, eucalyptus oil, aloe vera gel, or methylated spirits. Painful reactions to bites can be appreciably reduced by the intermittent application of ice packs to the bite site.

More severe reactions may need medical advice and systemic treatment using antihistamine products such as Phenergan, Telfast or Vallergran. Check with your doctor or pharmacist for available products and safety information.

4.0 Breeding Sites of *Culicoides ornatus*

Culicoides ornatus is by far the most common biting midge pest around the coast of the Northern Territory.³

This midge breeds in the highest numbers in the dry season in the mangrove mud in the creek banks of upper tidal tributaries around the mean high water neap tide mark. This corresponds to an area reached by tides from 4.8 to 6.0 m in Darwin Harbor.^{4,9} The prime breeding sites are in a narrow zone in the upper section of the creek bank associated with the occurrence of pneumatophores of the mangrove species *Avicennia marina* on narrow creek banks. The prime dry season breeding site has an upper limit where the *Avicennia* reduces in height and predominance, and a lower limit where the creek opens out from the overhanging *Avicennia* canopy.⁴ Broad mangrove areas with many tidal tributaries will have a considerable area of breeding sites.

Other breeding sites of low to medium productivity occur at the front edge of the mangrove forest in the *Sonneratia* or woodland mangrove zone facing open water. These breeding sites are usually associated with mud substrates and not with sandy substrates. Narrow beach fringing mangrove areas are usually not appreciable sources of *Culicoides ornatus*, particularly in areas with sandy substrates.⁴

Another site exploited only in the wet season is in the *Ceriops* transition zone at the back of the creek bank forest. This is just below MHWS (Mean High Water Spring or average high tide mark) or 6.6m ACD (Admiralty Chart Datum) in Darwin harbor. This is where the mixed *Ceriops* starts in a transition from the taller creek bank mangroves to the smaller mangroves in drier, less frequently flooded areas only reached by tides from 6.5 to 6.8m.

The larvae are small active worm-like creatures that are confined to the surface mud. The larvae take in excess of 6 weeks to mature, when they change into a relatively inactive, air-breathing pupa. The pupa stage lasts only two to three days and the adults emerge around the time of neap tides.⁹

5.0 The Flight Activity of *Culicoides ornatus*

The numbers of adults emerging from pupa cases is related to the lunar cycle, with sudden rises in numbers inside their mangrove breeding sites of the order of 16 times the number occurring on the previous day. The peak in emergence occurs in the two days around the neap tide, although emergence of adults can continue for up to 4 days after the neap tide.⁴

The adults mate soon after emergence. The males are short lived while the females stay in the mangroves to develop and lay their first batch of eggs. The females then start to disperse from the mangroves in an active flight inland in search of blood meals. The dispersal starts about 2 days before the spring tide, and reaches a peak around the day of the spring tide. They show a marked abundance around spring tides with full moons, but are also numerous around spring tides of the new moon.³

The adults seek shelter in winds above 8 km/hour, so that there is little tendency for them to be borne long distances by strong winds. Light breezes from their breeding areas will however aid their dispersal flight. They are active fliers and despite their small size, are relatively hardy insects.

Mass movements of adults can occur to 0.5 to 1.5 km from the mangrove margin of their major breeding sites, although they will move greater distances up creeks and rivers with dense tree cover which form avenues of humidity for dispersal. The dispersal is a purposeful one, with the midges actively flying away from the mangroves. Often higher numbers can be found up to 1.0 km from the mangroves compared to numbers in the mangroves or at the mangrove margin. Elevated hills or escarpments within 1.5 km of prolific biting midge breeding sites often exhibit higher biting midge numbers compared with lower adjacent areas. Minor pest numbers can be detected up to 3 km from the nearest mangrove margin.

Most *C. ornatus* bite in the morning and evening. There is a peak in biting activity in the one hour either side of sunset, with a smaller peak in the one-hour after sunrise of about half the sunset peak. However there is a low level of activity throughout the night.

6.0 Seasonal Abundance of *Culicoides ornatus*

The annual peak of *Culicoides ornatus* adults in the NT is in the August to October period in the late dry season, with lowest numbers in January and February during the wet season. Populations start to build up from the end of the wet season to the late dry season with a slight decrease in the coldest months of June and July. Populations start to decline rapidly after the first heavy rains occur. However pest numbers can still be present during the seasonal lows in the mid dry season and the mid wet season.

There are three different breeding sites in the mangroves, with varying seasonal productivity from the different breeding sites. Mangroves with small tidal tributaries that contain the prime creek bank breeding sites are dry season breeding sites. The greatest productivity from these creeks occurs in the August to October period. They are not significant sources of midges in the wet season.⁴ The back of small mangrove creeks in the *Ceriops* transition zones has moderate productivity in the wet season.^{4,9} Areas with extensive *Sonneratia* zones will have moderate productivity at least in the dry season⁴ and probably all year around.

Highest numbers of *Culicoides ornatus* occur for the four days around the full moon, with high numbers to a lesser extent, four days around the new moon.

7.0 Protection from Bites of *Culicoides ornatus*

7.1 Avoidance

Culicoides ornatus bite primarily in the early morning or evening around sunrise and sunset. Attacks can occur in the daytime in shaded areas adjacent to the mangroves near major mangrove breeding areas or in dense creek vegetation that is continuous with the mangrove breeding places. They will continue to bite throughout a still, humid day and warm humid night, particularly in sheltered areas outside the mangroves but close to their breeding areas. Often there is only a little biting activity in the mangroves during the day during and just after the spring tide, as all midges have usually dispersed landward.

Landward areas that are close to and within one kilometre of broad areas of mangroves with many tidal creek tributaries, especially near densely vegetated creeks that run into the mangroves, should be avoided. This particularly applies to the two days either side of the spring tides in the August to November period. Spring tides on full moons have roughly twice as many biting midges as spring tides on new moons.³

Minimum pest problems occur in the June-July period during the mid dry season or in January and February in the middle of the wet season. During any month the least pest problems occur in the two to three days either side of the neap tide, particularly neap tides following a new moon. A calendar marked with the 4 days around full moons and new moons, with highlights of seasonal peaks of abundance, can serve as a good midge avoidance reminder.

Biting midges are active under calm conditions and are generally inhibited by wind. Wind protected areas adjacent to and within 1.5km of large expanses of mangroves should be avoided around the spring tide period. People in open areas exposed to winds will experience less pest problems compared to other areas.

Elevated houses and high rise buildings have less pest problems than ground dwellings. Although midges probably fly over dense tree canopies and can fly in appreciable numbers at least 3 metres above the landscape surface, they are generally more numerous lower to the ground surface.¹¹

The worst pest problems around Darwin include areas include landward areas adjacent to the mangroves and tidal areas of Sadgroves and Reichardt Creeks, Hudson Creek, Elizabeth River, and Buffalo Creek.

The north shore of Frances Bay near Sadgroves Creek in the Charles Darwin National Park is a particularly troublesome area. This is due to the dendrite pattern of numerous narrow mangrove creeks and an extensive *Sonneratia* zone nearby. Urban areas of Stuart Park, the Narrows, and near Winnellie, which are closest to the Sadgroves creek mangroves, can experience seasonal moderate to minor pest problems. There are some minor pest problems near the lower reaches of Ludmilla creek and Alawa near Rapid Creek. Darwin city itself is relatively free from midges due to the relative lack of mangroves, the exposed cliffs, and the fact that the prevailing SE and NW winds do not blow from mangrove areas.

7.2 Clothing and Netting

Full-length trousers, socks and shoes, and long sleeved shirts will usually provide considerable protection from midge attack. Pale clothing is generally less attractive than dark clothing. Any exposed part of the body will still be subject to midge bites, with most bites occurring on the legs. Protective clothing should be supplemented with the application of repellants on exposed skin.

Clothing impregnated with permethrin or bifenthrin insecticide offers considerable protection for people continually exposed to biting midges. Impregnation involves soaking the clothing in a prescribed volume and concentration of certain formulations of the insecticide. Protective clothing such as overalls and mosquito nets impregnated with permethrin or bifenthrin will remain effective through one or two washes at the most, and will need reapplication. The insecticides in these treatments can kill the insects after they land on them, but they can also have the effect of interfering with the normal biting behaviour. Impregnated clothes with the additional use of insect repellents can provide extremely good protection.

Normal insect nets and screens are usually not adequate to restrict entry to midges unless the mesh is very fine. Tents screens in particular should have mesh diameter approximately half that of normal mosquito netting. Clothing, screens, netting or tents can be impregnated with permethrin or sprayed with permethrin, bifenthrin or repellents containing Deet to increase their efficiency.

Houses should have outward opening doors and insect screens to prevent entry when opening doors during midge activity.

7.3 Repellents

Most repellents have limitations because of their short duration of effectiveness (about 2-4 hours) and their irritability to mucous membranes around the eyes and mouth. Care is needed with young children to avoid the spread of repellent to their eyes or mouth. Repellents are also removed by perspiration.

Repellents that contain Deet (diethyl toluamide) or Picaridin as the active constituent offer considerable protection. Mixtures of natural oils or oils with natural ingredients such as herbs or antiseptics are not as effective as repellents containing Deet or Picaridin. In general effective repellents require above 10% Deet and 9% Picaridin. Repellents in lotions are more effective than alcohol based spray-ons, while gels are the most effective formulations. Repellents can also be applied to mosquito netting or insect screens, although a sample application on a small piece of netting is wise as some repellents affect synthetics. Repellents containing relatively high amounts of Deet can melt some plastics, although those containing Picaridin don't have the same effect.

Other methods of repelling biting midges include the use of coils, repellent oil lamps, and electric vapor pads impregnated with insecticide. These work satisfactorily in closed situations such as rooms, or sheltered patio and veranda situations out of the wind, where a cloud of vapour or smoke can build up. However they cannot provide satisfactory protection in windy and exposed situations.

Smoke from a fire with green leaves will give some protection in emergency situations. Burning aromatic and oil producing foliage of plants such as *Hyptis* (horehound), *Calytrix* (turkey bush), *Melaleuca* species (paperbark) and *Eucalyptus* species (gum trees) can give appreciable protection.

Rubbing the skin with the leaves of some of these plants can also provide some protection, but this is not as good as recommended repellents.

The so-called "electronic mosquito repellers" that emits a frequency that is supposed to repel biting midges by imitating the noise of males do not work and offer no protection against biting insect attack.

There is an urban myth that taking Vitamin B1 or thiamin can act as a repellent. There is no scientific evidence that Vitamin B1 acts as a repellent, or helps to reduce the reaction to insect bites by developing some immunity to the bites.¹³ Other topical applications such as a Dettol™ and baby oil mixture do offer some physical barrier to biting midges, but are not as effective as Deet or Picaridin based repellents. The best protection from biting insects remains the avoidance of the problem areas at times of abundance and the use of protective clothing in combination with efficient repellents.

7.4 Use of Lights

Biting midges can be attracted to lights. Houses in biting midge problem areas should have dull outside lighting, with little internal light visible from outside. Lightproof curtains that can be drawn at night offer a good alternative. Outside lights should be away from insect screens, as the midges attracted to the light can then penetrate the screens. Outside lights should be yellow (or red, which is even better) to reduce their attractiveness to biting insects. Attractive lights such as large incandescent bulbs or white or ultra violet fluorescent tubes positioned a distance away from a house or building can deflect biting midges to some extent. However rows of streetlights positioned between mangroves and residential areas are not effective barriers to midge dispersal inland.¹¹

7.5 The reduction of vegetation

The reduction of vegetation around houses or recreation areas can reduce problems by removing shelter for the midges. A buffer of clear open space between the mangroves and residential areas can reduce biting midge numbers in a residential area, as long as the buffer is wide and subject to winds. However clear open buffers by themselves offer little protection unless they are at least 1 km wide. Mowing a wide margin around houses to eliminate dense grass can help reduce the available areas where midges can harbor.

7.6 The use of attractant traps

There are a number of insect attracting traps on the market. They generally use light or carbon dioxide as an attractant and either trap the insect in a container, electrocute, or drown the insects. Some are more useful than others but can not be relied to give considerable protection from bites for unprotected people in close proximity to the traps. In most cases they attract biting insects to the general vicinity and these are then diverted to people, who are more attractive targets. Some traps can help to reduce the overall population, as long as there are enough traps, the biting insect population is relatively small, and the area is isolated from re-invasion from other areas. However most trapping techniques can not cope with the huge populations of midges at one time, and those not trapped still result in a pest problem.

8.0 Evaluation of Biting Midge Problems

The Medical Entomology Branch of the Department of Health and Community Services has conducted numerous investigations into biting midge problems in the Top End of the NT.^{2,3,5} Potential problems have been investigated by trapping midges overnight using special carbon dioxide (CO₂) baited traps. The number of midges collected can be counted or estimated by weight or volume and identified to species under a microscope in the laboratory.

The number of bites by biting midges that constitute a pest problem will largely depend on an individual. It has been suggested that over 60 bites per hour for most experienced biting midge workers are the thresholds of acceptability. For people unaccustomed to biting midge bites, even 1 to 5 bites per hour may be considered unbearable.

There is an approximate relationship between the number of midges collected in a CO₂ trap and the number of bites that can be expected at the peak biting period. For an unprotected person, the number of bites in an hour at the peak biting time is approximately one quarter of the number collected in a CO₂ trap over one night at the same position. Thus CO₂ collections of over 240 per carbon dioxide trap per night are likely to represent a pest problem (equal to over 60 bites per hour) to unprotected people with prior experience of biting midges. Collections of over 1000 per trap per night represent over 250 bites in an hour and would constitute a major pest problem. Trap collections of over 5,000 per trap would constitute a severe pest problem.³

The numbers of *C. ornatus* collected by CO₂ traps in different locations can indicate the magnitude of the human pest problem in each location. Trapping on a constant day in relation to the tide cycle over every month in a year can give an indication of the seasonal population fluctuations. Trapping at different distances from the mangroves and in different vegetation types can give an indication of the dispersal of midges into various areas.

9.0 Control of *Culicoides ornatus*

9.1 Insecticide fogging for Adult Midges

Insecticide fogging is the application of aerosol size particles directed against active flying insects. Insecticide fogging operations in residential areas by vehicle or hand held equipment are usually not very effective measures to eliminate pest problems, due to the rapid re-infestation of midges from nearby breeding and harborage areas. Sometimes re-infestation occurs very soon after the fog has cleared, although up to 12 hours protection can be achieved in some localized situations.

For effective midge control, the entire midge breeding and harboring area near residential development needs to be fogged each day over the 3-4 day period of peak emergence. This has to be timed to coincide with the time just after the midges have emerged and before they begin to disperse out of their breeding areas. This area would also have to be relatively isolated from other such areas to prevent re-invasion. Fogging also has to be carried out during the peak activity period in the evening and early morning.

For vehicle ground based operations, the fog has to be able to drift into the target area on favorable winds of the right velocity and in the right direction. This often reduces the opportunity for effective fogging. Fogs do not usually penetrate more than 50m into dense forested areas such as mangroves, monsoon forests and other thick vegetation.

One of the major problems is determining the level of control required. A reduction of *C. ornatus* numbers by 99% may be required to reduce a large pest problem to an appreciable level. This may be impossible to achieve for various operational purposes, and if there were still any remaining pest problem, the control would not be cost effective.

In the Darwin situation, the mangrove breeding and harboring areas are generally inaccessible, too wide, or too extensive for ground based application methods to effectively reduce midge numbers, although some temporary relief would be possible in some areas.

Aerial application of insecticides aimed at adult midges in breeding and harborage areas has given the best results in overseas investigations, but in some instances there has been immediate re-infestation. It is a difficult practice, as the breeding grounds have to be closely delineated and fogging must be based

on an accurate forecast of adult emergence times. The fogging has to be with sufficient regularity to kill all the emerging dispersing females over the night and fog drift to nearby residential areas has to be avoided. Fogging is not carried out regularly for midge control in Australia and requires more local research. Fogging involves large continuing costs, which is often beyond the resources of many local authorities. Insecticide resistance and the killing of other insects pose additional potential problems.

9.2 *Barrier spraying*

The application of insecticides to create an artificial barrier or an insect killing zone around houses where biting insect harbor before biting offers some promise as a new control method. The application of residual insecticides to exterior walls, screens, patio plants, nearby hedging plants or lawns and other close vegetation may kill midges attracted to houses or people.¹⁴ Insecticides that can be used include permethrin, deltamethrin and bifenthrin. Bifenthrin has the advantage over other similar insecticides, as it appears to have less of a repellent or agitation effect on insects, is less irritant to people, is ultra violet resistant, and binds very well to surfaces to give a good residual effect.¹⁴ As with all synthetic pyrethroids, it must only be applied as per the label and kept out of fish habitats.

9.3 *Insecticide Control of Larval Habitats*

Breeding site treatment by applying insecticides to kill larvae before emergence of adults is a possible control method but there have been very few examples of successful larval treatment in mangrove areas. Larval habitat treatment involves considerable costs and organization, which is impractical in extensive breeding areas such as those surrounding Darwin. Insecticides would need to have good residual qualities and be able to penetrate dense mangrove tree cover and mud in a tidal situation. Most insecticides with these qualities would generally kill non-target insects. The problem of accurately delineating all the significant breeding sites and the seasonal fluctuation of breeding sites pose additional problems.

9.4 *Elimination of Breeding Habitats*

Reclamation of mangroves has been successful in eliminating biting midge breeding sites in various localized situations. This usually requires large amounts of fill material which is neither cheap or readily available. For *Culicoides ornatus*, the reclamation needs to extend from near the average high tide level to below the outer mangrove forest. This may involve significant engineering considerations posed by deep mud and erosion of the filled area.

Reclamation would not be practicable in most of the Darwin area because of the extensive areas involved. The destruction of large areas of mangroves would be environmentally undesirable and unacceptable to public opinion. This potential solution would only be practicable in localized areas if the breeding site was small, in close proximity to residential development, was regarded as an area of reduced environmental importance, and the filling could create a stable shore environment.

There should be conclusive evidence that the site to be reclaimed is a significant source of biting midges and that the midges are significant pests to nearby residential development. Mangroves can be an indicator of biting midge breeding sites, but the presence of mangroves does not confirm any site as the breeding place. Other specific factors such as substrate types are involved in productive breeding sites.

9.5 *Buffer zones*

There is some evidence that creating a buffer zone between urban residential development and mangrove areas can reduce the dispersal of biting midges into residential areas. Clearing of vegetation and mowing to allow wind disruption, or extensive streetlights or roads with active traffic in the buffer zone may enhance the buffer to some extent.³ However extensive testing of a modified buffer with lights and

different vegetation types in Darwin have shown that unmodified buffers and lights by themselves are not effective barriers to *C. ornatus* dispersal from mangroves to urban areas. The effectiveness of buffers is generally related to the width of the buffer and the presence of blood sources or other attractions such as light in the buffer zone. However semi-urban residential or industrial development between mangroves and urban areas can reduce midge dispersal inland. In general, unmodified buffers need to be in the order of 1.5km, and modified buffers in the order of one kilometre to offer significant reduction in numbers.

10.0 Planning Guidelines To Prevent Biting Insect Problems

The Medical Entomology Branch is involved in the planning process to reduce the effects of biting insects. Guidelines have been prepared for preventing biting insect problems in new urban and semi rural residential developments, industrial, and other developments.

In 1974 the planning for the new satellite town of Palmerston near Darwin included a buffer of at least 1-km from the mangrove boundary to urban residential development.¹² Palmerston is one of the few urban areas in Australia that has been specifically designed to minimize biting insect problems.

Good urban planning is required to;

- reduce the risk of biting insect pests
- recognize and avoid areas of biting insect breeding or harborage
- avoid costly and environmentally undesirable rectification methods
- avoid costly and ongoing biting insect control programs

The Medical Entomology Branch gives advice on what may constitute a potentially significant biting insect breeding site. In some instances detailed entomological investigations are necessary to gather sufficient information before the detailed planning stage. The avoidance of biting insect problems can be achieved in the initial planning process by consideration of development location, easements, buffer zones, and sub division design.

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