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Non-biting Muscidae and control methods

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Summary: *Many non-biting muscids (filth flies) are characterised by the habit of visiting manure or rotting organic material to feed and/or oviposit. As these flies also often have close associations with human beings, as well as human habitations and domestic animals, they are potentially both a nuisance and a contributory factor in the transmission of diseases. The authors examine the biology, economic importance and control of four of the most important non-biting muscids:*

- *housefly,* Musca domestica;
- *face fly,* Musca autumnalis;
- *Australian bush fly,* Musca vetustissima;
- *sheep head fly,* Hydrotaea irritans.

KEYWORDS: Biology – Bush fly – Control – Disease transmission – Economic importance – Face fly – Head fly – Housefly.

INTRODUCTION

Non-biting flies in the family Muscidae belong to the suborder Cyclorrhaph (Diptera) and are characterised by antennae having three segments, of which the last bears a bristle called the arista. Many of these flies breed in decaying organic materials (e.g. manure), and are therefore also known as filth flies. Flies which live in close association with humans (e.g. *Musca domestica*) are termed synanthropic, while flies associated with cattle (e.g. *M. autumnalis* and *M. vetustissima*) are termed symbovine. Flies highly dependent on human and animal habitation (e.g. *M. domestica*) are said to be endophilic. Flies which require a living host to complete their life cycle are referred to as obligate ectoparasites (e.g. *Hydrotaea irritans*), while others are termed facultative parasites (e.g. *M. domestica*). If the fly transmits pathogens from one animal to another, it can function as a vector. When development of the pathogen within the vector is essential for successful transmission, this is termed biological transmission (e.g. the transmission of *Parafilaria bovicola* by *M. autumnalis*), whereas mechanical transmission is said to occur if the fly simply functions as a carrier of the pathogen(s) (e.g. the bacteria causing summer mastitis and *H. irritans*). In addition to their vector status, many non-biting flies are important as a nuisance to farm animals and humans living nearby. Four of the most important of these species will be described below, although it should be noted that many other non-biting muscids are of veterinary importance.

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MUSCA DOMESTICA L.
COMMON NAME: HOUSEFLY

Distribution

The housefly has a world-wide distribution extending from the sub-polar regions to the tropics, being present in Asia, Africa, Australasia, the Americas and Europe. This species is commonly found in close association with humans and human habitations, and is thus synanthropic and endophilic.

Importance

The preference, habit and need of *M. domestica* for feeding and oviposition on decomposing and rotting organic matter bring this species into contact with excreta, carcasses and garbage on the one hand, and humans, their food and utensils on the other. This offers a large potential for the transmission of numerous diseases. In most cases, the fly is not obligatory for transmission, but it can act as a supplementary epidemiological factor, increasing the severity of disease transmission in both humans and domestic animals. In addition, the large numbers of flies which can be present constitute a considerable nuisance. This factor makes it difficult if not impossible to estimate the cost associated with presence of these flies.

Greenberg (9) lists more than 330 different associations between the housefly and pathogenic organisms. Keiding (12), listing important diseases which may be transmitted by *M. domestica* under certain conditions, includes the bacterial infections shigellosis, salmonellosis, cholera and *Campylobacter* infection. Houseflies carry the eggs and cysts of many intestinal worms, including *Ascaris* spp., hookworms and tapeworms. *M. domestica* has been shown to be involved in the spread of trachoma (although in this instance *M. sorbens* is more important) and epidemic conjunctivitis and, given the attraction of this species to skin infections and wounds, the housefly is also involved in infection of these sites.

Life history

The newly-emerged adult rises up through the substrate in which the pupa developed, with the aid of the frontal sac used to break out of the puparium. At this stage, the flies are negatively geotropic and positively phototropic. After emerging, they usually creep upwards to dark places and rest for 30-90 min until the cuticle and wings harden.

The adult is typically 6-7 mm long and grey in colour, with four dark longitudinal stripes on the dorsal thorax. The venation is distinctive, with the fourth longitudinal vein bent sharply upward near the end of the wing. Although the life span in the laboratory can be measured in weeks, in the field this is normally 3-10 days (18).

For the first two days after emergence, the activity has a non-cyclic rhythm. Thereafter, under constant conditions, adults are diurnal with a bimodal activity rhythm, one mode commencing prior to dawn, the second in the early evening. Under natural conditions, activity is influenced by several physical variables including temperature, humidity, light intensity, air currents and barometric pressure. The housefly has a survival range from −10°C (up to 3 h) to +50°C. Activity commences at 6.7°C and ceases at 46.5°C, the optimal temperature for males and females being 34.2°C and 33.1°C respectively. Female flies are monogamous, while males are polygamous. The males are able to copulate on the day after emergence, whereas females must be older (at least 30 h). The first phase of sexual behaviour is probably swarming. Both males and females make short horizontal circular flights and frequent chases occur. Such swarms are extremely attractive to male and female flies. The major stimulus is probably visual, although sound cannot be ruled out. Courtship and mating behaviour take place after the male strikes at the female and landing has occurred. Chemical signals (pheromones) are involved in courtship behaviour and possibly in aggregation.

Egg-laying occurs largely on decomposing or fermenting substrates with an optimum temperature of 37.2°C. The female usually crawls into crevices and lays batches of approximately 120 eggs deep in the substrate. The laying of a single batch usually takes one day, and the interval between batches is two weeks, although this is temperature dependent. Oviposition does not usually occur below 15°C. The stimuli used by the female to find oviposition sites are olfactory, taste and thermal. The larvae survive in almost any substrate (from faeces to snuff), and breed in numerous types of decaying, fermenting or rotting matter. The only factors common to larval habitats are the presence of live microorganisms, and the correct moisture content and texture. Preferences for substrates vary between populations.

The number of generations per year varies from thirty (under tropical conditions) to ten or less (in temperate zones). The housefly has no true diapause and the species is presumed to overwinter through adults, with a slow generation rate.

The eggs are pearly white in colour and 1-1.2 mm long. They require high humidity (>90% relative humidity) to develop. Time required for development is temperature dependent, ranging from 36 h at 16°C to 8 h at 35°C. The survival limits are 13°C and 42°C, respectively. There are three larval instars. Feeding occurs in the first two stages and ceases midway through the third stage. When the larvae are 12-13 mm long, they migrate to regions with lower temperatures and humidities and eventually pupate, often in large aggregations. Larval development is also temperature dependent, ranging from 17-19 days at 16°C to 3-4 days at 35°C. No development occurs below 12°C, and 46°C is lethal. Time required for pupal development is approximately the same as that for total larval development at the temperatures given above.

Control

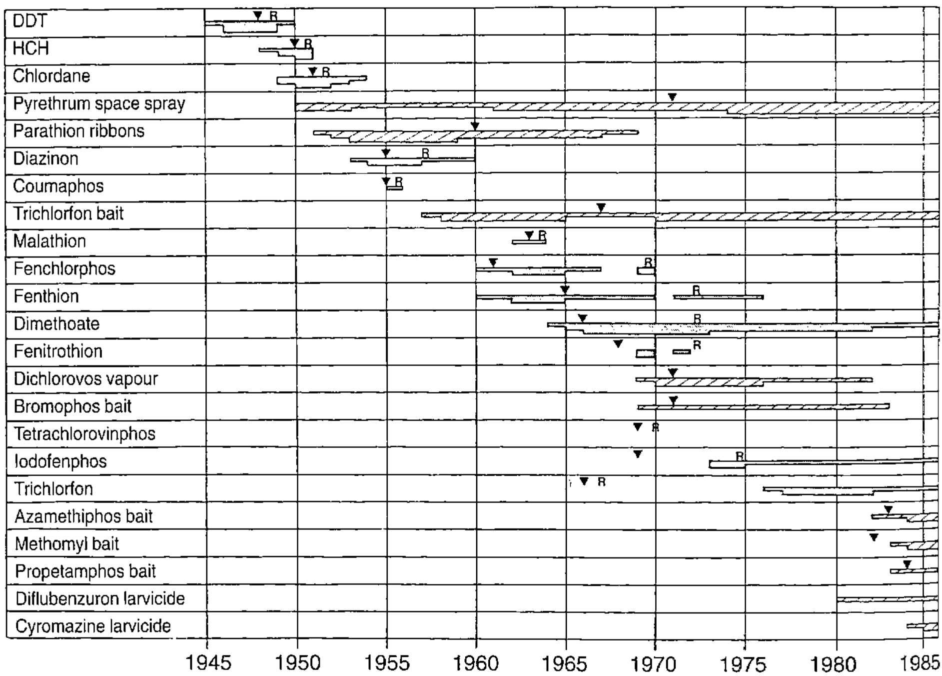
Five principal methods of control can be described for the housefly. The most important of these is the use of preventive measures. Pest infestations generally occur due to inadequate standards of hygiene and/or sanitation, and management of manure, feed and animal housing; it is therefore essential that these standards be improved. This requires eliminating fly breeding sites and preventing contact with food sources and utensils. This can involve the reduction of larval habitats through frequent manure removal or the use of housing systems designed for quick drying of dung.

The remaining methods (chemical, electrical, mechanical and biological) are described below, but the chance of success is severely reduced if hygiene is not improved.

The traditional chemical methods include a variety of products (e.g. residual sprays, toxic baits, sprays for aerial use [space sprays and aerosols], fumigation products and larvicides). These methods usually function passively (except for space treatments) and depend largely on accidental contact of the insect with the substrate. Disadvantages include the fact that the products employed may also pose a hazard to humans and animals, and the fact that they are often non-selective (killing beneficial insects as well as pests). Lastly, in the long term, insects may become resistant to the chemicals used.

Over the past half centry, control systems for houseflies have depended heavily on the use of insecticides. Currently, many housefly populations have become or are becoming resistant to insecticides. Figure 1 shows the situation in Denmark (13) and illustrates that unless greater effort is expended on resistance management techniques, it is quite probable that insecticides will be misused and that possibilities for effective insecticide control will rapidly disappear in the near future.

Resistance against one or more of the five groups of chemical compounds used (organochlorines, organophosphates, carbamates, natural and synthetic pyrethroids, and insect growth regulators) is due to the fact that, given the variation within a population, one or more individuals will often possess a specific gene (or genes) allowing them to survive treatment and produce offspring with a greater chance of surviving. The percentage of such individuals within the population will determine whether or not a particular chemical control method will be successful.



DDT: dichlorodiphenyltrichloroethane
HCH: hexachlorocyclohexane
residual applications
other applications
▾ first confirmed case of resistance of practical importance
R resistance causing general control failure

FIG. 1

The history of resistance development in houseflies on Danish farms between 1945 and 1985

(13)

The width of each block indicates the extent of use on few, many or most farms (narrow, intermediate and wide blocks, respectively)

The following mechanisms can enable insects to avoid the killing or other negative effects of insecticides:

a) The insect may evolve physiological mechanisms which negate the effect of the chemical (e.g. reduced absorption through the cuticle).

b) The insect may develop an ability to detoxify the compound or its toxic metabolites.

c) The insect may develop endogenous biochemical processes which decrease sensitivity at the point of action of the insecticide (e.g. the 'kdr' or 'super kdr' gene which provides effective protection against DDT [dichlorodiphenyltrichloroethane] and varying levels of cross-protection against pyrethroids).

d) Behaviourial resistance may occur, whereby the insect develops the capacity to identify one of the compounds in the product and changes its behaviour in order to avoid contact with this compound.

Although research into resistance management is in the early stages, some guidelines have been suggested which can delay the development of resistance (13, 36). The principle is primarily to reduce the selection pressure with a particular insecticide or related insecticides. The guidelines include the following (12):

a) Avoid long-term use of compounds from the same group, as one of the important factors in resistance selection is the intensity and duration of the selection pressure. This requires the setting up of rotation schedules.

b) Avoid the use of persistent, long-acting insecticides in animal housing, where the fly has a rapid generation time.

c) Avoid treating the adult and larval stages by application of compounds from the same group.

d) Although insecticides are an essential component of control systems, non-chemical methods also form a vital part of control. It is preferable to apply an integrated pest management approach, involving hygiene, manure management and biological methods (see below).

Electrical methods include the combination of a visual attractant (e.g. ultraviolet lamp) with an electrocution screen. Such methods are reasonably effective in places with a low fly burden (e.g. in abattoirs, and especially against blowflies), but here again there is a drawback in that beneficial insects may also be killed.

The mechanical methods include probably the three oldest methods of fly control commercially available: swatters, sticky paper and door/window screens. The advantages and disadvantages of these methods are well known. All such methods are efficient and cheap, and they present no risk to human or environmental health.

Biological control methods may be subdivided into the following broad categories:

– Systems have been developed using natural predators, competitors or parasites (bacteria, fungi, nematodes, predatory beetles and parasitic wasps) to reduce whole populations of insect pests. Rutz and Patterson (27) provide further details of such systems.

– Insecticides have been combined with the stimuli which play a natural role in steering or releasing the behaviour of the fly. This has therefore led to a second generation of chemical control systems, with the development of the SFAs (solid fly attractants). These are based on odours from housefly oviposition or food sites, and combine fermenting proteins with the insecticide. Another development involves PTDs (pheromone toxicant devices), which take advantage of the sex pheromones used by the insect for communication during courtship and include cis-9-tricosene, which has now been incorporated into several insecticide bait products for houseflies.

MUSCA AUTUMNALIS DE GEER
COMMON NAME: FACE FLY

Distribution

Musca autumnalis occurs in the palaearctic and oriental regions, being recorded in Europe, Russia, China, North Korea and Japan, as well as in North Africa, Iran and Pakistan. This fly was introduced into North America in the early 1950s (20) and has since spread rapidly; the species is now found in all the southern provinces of Canada and throughout the United States of America (USA) except for Florida, Texas, New Mexico and Arizona.

Importance

Face flies feed on lacrimal secretions, wounds, blood and dung, facilitating the mechanical transmission of diseases. *M. autumnalis* is known to mechanically transmit the bacterium *Moraxella bovis*, which causes infectious bovine keratoconjunctivitis ('pink eye'). The face fly has also been implicated in the transmission of infectious bovine rhinotracheitis, and has been shown to act as an intermediary host of *Thelazia* spp. eyeworms (including *T. gulsoa*, *T. rhodesi* and *T. skrjabini* in cattle, and *T. lachrymalis* in horses). The fly has also been confirmed as an intermediary host of the nematode *Parafilaria bovicola*, a parasite of the connective tissues of cattle which causes lasinophilic muscular infiltrations. Cheville *et al.* (6) showed that the face fly was capable of the uptake and excretion of *Brucella abortus*.

Figures for the damage caused by *M. autumnalis* are conflicting. Steelman (31) gave an estimate of losses for the USA of US$68 million in 1976, whereas the United States Department of Agriculture reported losses of US$150 million (40). Drummond *et al.* (8) estimated losses at US$53.2 million in 1981.

Life history

Pickens and Miller (24) have described the biology of the face fly in detail. The sex ratio of emerging adults is approximately 1:1. Adult face flies usually emerge in the morning hours and, like many muscids, shelter in surrounding vegetation while the wings harden. Sexual maturity occurs earlier in males than in females (2-5 days and 3-6 days, respectively). Mating stimuli include vertical objects in the vicinity (such objects also stimulate mating swarming behaviour in houseflies). Females lay the first batch of eggs in fresh dung, with peaks at six and eleven days; they have a preference for cattle dung (sheep and horse manure being unsuitable). Egg-laying can only occur after the female has fed on cattle secretions, and continued egg-laying requires repeated blood meals. Dispersal is considerable in this species, and can reach 11-12 km in five days. Males are only present on cattle for a short period in the life cycle. Eggs hatch after 20 h and three instars are present, taking 3-5 days depending on the temperature. Pupation occurs up to 10 m from the dung pat and the time required before emergence is 7-10 days.

As days shorten and temperatures decrease below 16°C, young females which have not yet mated cease oogenesis and build up considerable reserves of body fat. Face flies enter hibernation in prominent buildings and hollow trees. This diapause may occasionally be interrupted during the winter when temperatures increase, at which time the flies may become a considerable nuisance. As the temperatures increase and days lengthen in spring, diapause ends and mating takes place before leaving the hibernation sites. Oogenesis recommences after the female has fed on the host, and egg laying is synchronised within the population.

Control

Various methods of insecticide control have been used (e.g. pour-ons, sprays, ear tags, dust bags, repellents, attractants, ultra low volume sprays and feed additives) (24). All are only partially effective. The common reason given is the considerable mobility of the fly, which allows rapid migration of flies from untreated areas. Another possible contributing factor is the feeding site of *M. autumnalis*, i.e. the eye. Not only is this a difficult area to treat, but lachrymal fluid acts to dilute optimal concentrations. Traps do have a degree of success, but tend to capture far more males than females; moreover, the available traps are economically unfeasible.

Biological control has frequently been attempted (19) but has generally not proved applicable. However, recent work in Sweden (using release of *M. autumnalis* flies infected with the nematode parasite *Heterotylenchus autumnalis*) shows considerable promise in controlling transmission of *P. bovicola* (7).

MUSCA VETUSTISSIMA WALKER
COMMON NAME: AUSTRALIAN BUSH FLY

Distribution

The Australian bush fly (*Musca vetustissima* Walker) occurs in the Australasian region (Australia, Tasmania and southern Papua New Guinea). The species is found in open country, avoiding heavily forested areas.

Importance

The bush fly is an extremely irritating nuisance fly. It feeds on secretions from the eyes, ears, nose, mouth and wounds of animals and humans. *M. vetustissima* can aid in the formation of skin sores and prevent these from healing. In addition to the nuisance effect, the bush fly is important because of its possible relationship to pathogen transmission. This species is also an intermediate host of the equine stomach worms *Habronema muscae* and *Draschia megastoma*.

Life history

The biology of the bush fly has been studied and described in detail by Hughes *et al.* (10), and Lancaster and Meisch (19). Kettle (14) also describes the life history of this species. The eggs of *M. vetustissima*, measuring 1.7 × 0.3 mm, are of the typical muscid shape and are laid in animal dung. They will hatch in water, but not if totally immersed in dung. The eggs are very susceptible to desiccation, and exposure to 90% relative humidity for 1 h prevents hatching. Survival is highest at 96-100% relative humidity. Development is rapid and eggs hatch after 7 h at 32°C, while none hatch below 14°C or above 43°C. When fully developed, the larva emerges from the egg and enters the dung.

Larval growth is very rapid. The development of the three instars is completed in 8 h, 10 h and 49 h, respectively, in moist cattle dung at 32°C. No flies are developed below 12°C or above 46°C. The larvae prefer moist dung and require access to air; they will develop in the dung of cattle, sheep, horses, camels, emu, dogs, swine and humans. Bush fly larvae initially feed near the surface, immediately below the dry crust formed over the surface of a typical moist cow dung pat. As the dung dries out, sub-surface tunnelling occurs and the larvae penetrate the entire pat. Larvae are then gradually confined to a central position near the lower surface of the dung. The pre-pupal larvae leave the dung between midnight and dawn over a span of three successive days, to seek a suitable site in the soil adjacent to the dung to bury themselves and pupate.

In addition to dependence on temperature and access to air, the survival of the bush fly larvae is affected by the physical environment of the dung, the quality of the food provided, and the presence of competitors and natural enemies. Extremes of moisture content are also detrimental. For example, high densities of larvae in the dung may reduce the size of the pupae and the resulting flies.

The pupa is sub-cylindrical with rounded ends, and is typically found near the dung pat and 20-30 mm below the soil surface. Bush flies emerge from the puparia within a few hours around dawn over a period of a few days. The pupal stage varies between three and eighteen days over the range of 18°C and 39°C, with a development threshold of 12°C and 41°C. The survival of pupae is affected by the water content of the soil and the success of parasites, such as parasitic wasps and nematodes.

The bush fly is a typical greyish, non-bristly muscid with two longitudinal bands on the thorax. The wings are clear with very white squamae. The first abdominal segment is black. The size of the adult varies greatly. The mouthparts are of the lapping type and the prestomal teeth allow the fly to rasp soft tissues of animals to make blood flow. Development of adult flies depends on their uptake of an adequate protein-rich diet from the body fluids (e.g. blood, pus, milk, tears and saliva) of animals. The life span of bush flies depends on temperature, being inversely related to temperature between 12°C and 29°C. In the laboratory, bush flies are able to live for several months. However, the mean intrinsic life span in the field is probably much shorter, as this is reduced by many outside causes, such as access to water and food. Adult bush flies are prey for some other flies and wasps, and nematodes such as *Habronema* also cause mortality.

Female bush flies do not mate until three days after emergence, and they may re-mate after two batches of eggs have been fertilised. In the field, females gravid in their first, second and third ovarian cycles are frequently recognised. The number of eggs found in gravid field-caught flies ranges from 4 to 48.

Bush fly eggs are normally laid in crevices in freshly dropped dung or at the interface between the dung and the soil. Once the dung has formed even a thin dry crust, it becomes less attractive. Dung of cattle, sheep, horses, camels, dogs, humans and emu have been recorded as natural oviposition sites. Bush flies are strongly attracted by the odour of fresh dung. During daylight hours, eggs will be laid in dung after landing and feeding. The eggs are extruded singly, usually in the same site, and the female fly partly embeds her eggs into the surface of the moist dung. Female flies laying eggs are strongly attractive to other gravid females.

Bush flies actively suck body fluids (e.g. tears, saliva, blood, serum and pus) from the eyes, mouth and wounds of large animals, including humans. The activity level of the flies is dependent on temperature. Below 10°C, *M. vetustissima* is often unable to fly, and when air temperatures rise above 35°C the activity declines. During the night, the fly rests in vegetation. The bush fly shows shade-avoiding behaviour, unless temperatures are above 35°C, when the flies will enter open shade or buildings to avoid heat.

There is no diapausing stage in the life cycle of the bush fly, and temperatures near or below 0°C are lethal. In the southern part of Australia, the bush fly population dies out during the winter. The population is highest in the north in the autumn, following the summer rains. Flies move south on warm winds. In general, the bush fly population increases after the wet season, when cattle are feeding on rapidly-growing grasses and producing rich dung.

Control

The development and implementation of control measures for the bush fly is a great challenge. Due to the wide dispersal of *M. vetustissima*, local and chemical control measures, as well as mechanical disruption of development, are ineffective. One major obstacle to control has been the ready availability of bovine dung, and the virtual absence of dung-degrading beetles adapted to attacking the dung of imported cattle. To obtain a well-balanced complex of co-adapted species, many species of beetles have been introduced to Australia. *Onthophagus* spp. may be cited as dung beetles which have demonstrated an ability to compete successfully with bush flies for bovine dung in certain areas (3, 37). Other scarabaeine dung beetles have proved to be effective in killing bush fly larvae, while mites (e.g. *Macrocheles* spp.) prey on the eggs and larvae of dung-breeding flies.

Residues in dung following treatment of livestock with anthelmintics containing ivermectin and abamectin affect the development of bush fly larvae (39, 26). This could be considered beneficial to bush fly control, although the simultaneous adverse impact on the beneficial fauna (e.g. dung-degrading beetles and predators) probably negates this effect.

HYDROTAEA IRRITANS FALLEN
COMMON NAMES: SHEEP HEAD FLY, PLANTATION FLY

Distribution

The sheep head fly *Hydrotaea irritans* Fallen is confined to the palaearctic region and is commonly found on cattle from the west coast of the United Kingdom to Russia, and from northern Sweden as far south as Israel.

Importance

H. irritans is a haematophagous, non-biting muscid; however, given sufficient time, the prestomal teeth may penetrate the skin. This species feeds on secretions of the eyes, ears, nose, mouth and udders of the host, and on wounds. As *H. irritans* is often present in large numbers, it can cause a considerable nuisance to both animals and humans. For example, the numbers of such flies feeding from wounds caused by biting flies on bare-faced Scottish blackface sheep are often so great that sheep develop 'broken head syndrome' by repeatedly rubbing the head against posts and stones in an attempt to dislodge the flies (15). In addition, *H. irritans* has also been implicated in the mechanical transmission of several disease agents of veterinary importance, principally the bacteria which cause summer (heifer) mastitis. Summer mastitis is a multibacterial infection of the udder which occurs in non-lactating cattle during the summer months, with most cases yielding at least five bacterial species (21). Often, but not always, these include *Actinomyces (Corynebacterium) pyogenes* and *Peptostreptococcus indolicus*. If the infection is not detected immediately, the udder quarter is usually lost and the animal is often slaughtered. Although the disease is almost indistinguishable clinically from mastitis found at other times of the year, the epidemiological pattern suggests the involvement of a fly vector (see below). In some years, the disease can cause considerable financial losses in north-western Europe. In Denmark, for example, the annual losses to the dairy industry from this source have been estimated at DKK100-200 million (21). Cases have also been reported in Japan (28), Australia (29) and the USA (J.E. Hillerton, personal communication). However, given the above distribution of *H. irritans*, other vectors must be involved in these cases. The fly has also been implicated in transmitting other important diseases, including infectious bovine keratoconjunctivitis in cattle (caused by *Moraxella bovis*) and myxomatosis in rabbits.

Evidence implicating *H. irritans* as the vector of summer mastitis

The hypothesis that summer mastitis is a vector-transmitted disease is relatively old (5). The major arguments are presented below.

Temporal factors

Of the 40-50 fly species visiting cattle in northern Europe, *H. irritans* is one of the few for which the population dynamics curve matches the summer mastitis incidence curve.

Spatial factors

The macrogeographical distribution of summer mastitis areas is overlapped by that of *H. irritans*. Microgeographically, there is a positive correlation between local fly density and disease incidence (38).

Fly behaviour

Climatic changes which increase fly activity (high air temperature and low wind speed) have been related to increased incidence of summer mastitis (23). Moreover, during food searching behaviour, the fly makes frequent contact with the infection site on the host and is frequently found feeding on the udder.

Vector control measures

Insecticide treatment of the udder, in particular, or simply the application of a mechanical barrier to the teat, produces a dramatic reduction of both numbers of *Hydrotaea* and incidence of summer mastitis (1). Pour-on treatment, although reducing numbers of flies and summer mastitis occurrence, does not have such a dramatic effect (22).

Bacteriological investigation of potential vectors

A. pyogenes has been recovered from *H. irritans* by several researchers (30, 4).

Artificial transmission experiments

Experiments have shown that *A. pyogenes* can survive in *H. irritans* for up to 16 days (41), and both this bacterium and *P. indolicus* can be transmitted by the fly to an artificial substrate (34). Actual transmission experiments have been attempted at least three times (32, 33) and the success ratio was high. Unfortunately, the descriptions were sparse and numerous attempts to replicate the experiments have failed.

Life history

Emergence of adult flies is temperature dependent, and the first flies are usually found on cattle at the beginning of June. *H. irritans* exhibits protandry, with males emerging before the females. In the laboratory, the difference is about two days at 21°C. At the beginning of the season, more males are found on cattle than females. Male densities peak before the end of July, after which numbers decline rapidly. Female numbers peak towards the middle/end of August.

Egg development takes place in six stages (O, I-V) according to Berlyn (2), or seven (1 = O; 2, 3 = I; 4-7 = II-V) according to Kirkwood (16). The developmental cycle can be used to subdivide the life history of the female into three phases. The first phase is from emergence to stage I. This proceeds in the absence of a blood meal and the flies do not constitute a nuisance to animals or humans. The second phase is from stage I to stage III, when females require protein meals for further ovarial development, actively seeking blood and thus causing high levels of infestation. Much work has been carried out on the stimuli releasing the host-searching behaviour of this species (see 'Control' below). The final phase consists of stages IV and V, when few females are found on cattle and the females probably switch to seeking oviposition sites. Mating occurs after females reach stage III, but mating sites are unknown. Egg-laying takes place in three peaks in Northern Europe (mid August, early September, late September) at intervals of 2-3 weeks, suggesting three ovarial cycles. Females have a preference for laying eggs around the edges of low-lying, grass-covered fields with humid soil and low grass height (up to 10 cm) (25). The eggs are pearly white in colour and 1-1.5 mm long. Under humid conditions, emergence of the second instar occurs in approximately five days, depending on the temperature. The second instar is white in colour, active and saprophagous. After two weeks, the larvae reach the third instar stage. At this stage, they are 5 mm long, parchment yellow in colour, and prey on other fly larvae which become immobile immediately after being struck by the mouth parts of *H. irritans* larvae. Prey are sucked empty within 30 min of capture. In the absence of other prey, cannibalism is common. The larvae remain growing until January, by which time they have reached their maximum size of 10-12 mm. Pupation occurs in the upper ground layer (5 cm) in early May, and lasts for 25-32 days depending on the temperature.

Control

Several methods of control have been used to reduce both sheep head fly numbers and the risk of summer mastitis. These methods vary from keeping animals indoors during the risk period to the older method of physical protection of the teats using various substances, such as Stockholm tar. The results of the latter methods are generally disappointing, apart from trials performed in Denmark using bandage sealing (17). More modern methods involve the use of long-acting antibiotics, which are suitable for dry cows and older heifers (but less so for calves), and various insecticides employed in the form of collars, pour-ons and ear tags (11). Control using antibiotics can be effective, but risks of bacterial resistance are always present. Insecticides provide adequate control for many cattle-visiting flies, but are less effective in general for udder-visiting *H. irritans*, possibly due to a decrease in the concentration of the insecticide on the udder, a major site visited by this fly. In the Netherlands, application of the anti-summer mastitis box (where the insecticide is directly sprayed up onto the udder area) provides a high degree of control. The mechanism is attached to the drink pump, and is automatically activated when the animal drinks. Although such methods may be effective, care should be taken to delay or prevent the build-up of resistance to the insecticide; such resistance against pyrethroids has been found in the USA and in Canada in the biting horn fly *Haematobia irritans*. As *Hydrotaea* is univoltine (one generation per year), such processes may well be delayed. However, as Jespersen and Vagn-Jensen (11) observe, lack of control of biting flies may well increase udder damage and allow an increase in *Hydrotaea*-transmitted mastitis.

One possible course of action for the future may be to take into consideration those host stimuli which attract the fly, to achieve optimal control. Recent findings have indicated that the attractiveness of cattle for flies varies due to differences in host-produced attractant and repellent odours (35). These findings may speed up the identification and application of such odours to achieve control.

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MUSCIDÉS NON PIQUEURS ET MÉTHODES DE LUTTE. – G. Thomas et J.B. Jespersen.

***Résumé** : La caractéristique de nombre de muscidés non piqueurs (mouches à ordures) est de se nourrir de fumier et de matières organiques en décomposition et/ou d'y pondre leurs œufs. Comme ces mouches vivent également en contact étroit avec l'homme, l'habitat humain et les animaux domestiques, elles constituent à la fois une nuisance et un facteur potentiel de transmission des maladies. Les auteurs présentent la biologie, l'importance économique et les moyens de lutte contre les quatre principaux muscidés non piqueurs :*

- *mouche domestique,* Musca domestica,
- *mouche d'automne,* Musca autumnalis,
- *mouche de la brousse australienne,* Musca vetustissima,
- *« mouche de la tête du mouton »* (sheep head fly), Hydrotaea irritans.

MOTS-CLÉS : Biologie – Importance économique – Lutte – Mouche d'automne – Mouche de la brousse – « Mouche de la tête » – Mouche domestique – Transmission des maladies.

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MÚSCIDOS NO PICADORES Y MÉTODOS DE LUCHA. – G. Thomas y J.B. Jespersen.

Resumen: *La característica de numerosos múscidos no picadores (moscas de la basura) consiste en alimentarse de estiércol y de materias orgánicas en descomposición y/o de aovar en ellos. Como por otra parte estas moscas viven en contacto estrecho con el hombre, el hábitat humano y los animales domésticos, son dañinas y factores potenciales de transmisión de enfermedades. Los autores presentan la biología, la importancia económica y los modos de lucha contra los cuatro principales múscidos no picadores:*

– *mosca común,* Musca domestica,

– *mosca autumnal (o mosca de la cara),* Musca autumnalis,

– *mosca de la selva australiana,* Musca vetustissima,

– *mosca de la cabeza,* Hydrotaea irritans.

PALABRAS CLAVE: Biología – Control – Importancia económica – Mosca autumnal – Mosca común – Mosca de la cabeza – Mosca de la selva – Transmisión de enfermedades.

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