APPENDIX D

Management of Nuisance Flies:
Dairy Design and Operational Considerations

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INTRODUCTION

Nuisance flies are commonly associated with confined animal agriculture facilities such as dairies because they breed in the manure, animal feed, green waste, and rotting or composting vegetation found on these facilities. Nuisance flies are known to cause significant economic losses in the form of reduced weight gains and milk yields, increased hide damage, and higher production costs due to the nuisance and discomfort they cause to both animals and facility employees. Two species in particular, house fly (*Musca domestica*) and stable fly (*Stomoxys calcitrans*), are responsible for damage and control costs in excess of a billion dollars per year in the United States. In addition to the direct damage these flies inflict upon livestock, their presence as a byproduct of confined livestock operations has been repeatedly cited as a public nuisance, especially when the flies enter the vicinity of human habitations and urban environments. Law suits, zoning limitations and animosity between farmers and home owners have resulted. Furthermore, nuisance flies have been shown to carry a large number of animal and human disease causing pathogens such as *Escherichia coli* strain O157:H7, *Salmonella* bacteria, and *Moraxella bovis* (bovine pink eye).

Based on the economic loss to dairy operators, the threat of disease transmission to animals and people, and the need to maintain good neighbor relations, the goal of all commercial dairy operators is to limit the production of nuisance flies. Nuisance flies are limited by strict adherence to proper facility design and management considerations and by rapid correction of problem areas. While nuisance fly management is critical to the effective operation of any confined animal facility, it must also be understood that a goal of zero production of nuisance flies is unobtainable. At even the most sanitary animal facilities, there will always be some number of nuisance flies that manage to find an appropriate developmental site.

FLY DISPERSAL

As urbanization continues in formerly agricultural areas, the dispersal of flies from their developmental sites on dairies and other confined animal facilities into residential neighborhoods is becoming more of a problem. House flies and stable flies have been shown to disperse up to 10 or more miles, but dispersal from ¼ to 2 miles is more typical.

Dispersal distance is dependent upon many factors to include wind and weather conditions, the general topography of the region, the availability of vertical surfaces for resting, and the presence of attractive food sources. Where trees, tall crops, or man-made structures (e.g. homes) surround an animal facility, the dispersal distance will be short. When an animal facility is surrounded by low-growing crops or native vegetation, dispersal distance is typically longer as flies fail to find nearby vertical resting structures or feeding sites to halt the dispersal behavior. Long range dispersal has been demonstrated with stable flies carried on storm fronts moving many miles from their production sites. Because fly dispersal behavior is poorly understood and difficult to predict, control of fly development is currently the only effective means to prevent nuisance fly problems in surrounding urban areas.

Most other nuisance flies associated with dairy operations (e.g. garbage or blow flies) are not known to disperse great distances and rarely are considered a nuisance problem for residential neighbors of dairies. Residential neighbors may complain of garbage flies (shiny metallic-looking flies) that they contend come from the dairy, but in most cases these flies are locally generated in residential garbage and pet droppings.

MONITORING FLY NUMBERS

In any pest management approach, pest population information guides management decisions such as when and how to control the pest. Regular assessment of pest numbers is a cornerstone of an effective Integrated Pest Management (IPM) system. Pest population abundance must be regularly assessed or monitored so that changes in abundance over time can be readily determined. Pest monitoring methods typically provide a relative assessment of the pest population rather than an actual count of the number of pests in a given area. For this reason, it is important to use the same monitoring method consistently so that direct measurements can be made between different assessment periods. Monitoring results should be recorded and kept for several years in order to evaluate seasonal and long-term trends in pest population abundance. Understanding these trends will help to develop a proactive program for pest control and provide a means for evaluating fly management success.

A question that often arises is “what is an acceptable number of flies?” This is an important question. When pest abundance is low, the economic and health costs associated with the pest are typically also low. Low pest abundance also results in little nuisance. However, as the pest population increases in number it will pass an abundance value above which the pests will cause unacceptable economic and health costs or unacceptable nuisance, and control efforts directed against the pest must be increased. A pest abundance value over which economic or health costs caused by the pests would exceed the cost of controlling the pest is called the “economic injury threshold”. Similarly, a pest abundance value resulting in unacceptable nuisance to facility employees or neighbors or which exceeds county nuisance regulations is called the “nuisance threshold”. Both threshold values may be termed "action thresholds" meaning that the dairy operator must take immediate action to institute additional control measures to rapidly return fly numbers to acceptable levels. Action thresholds provide objective measures for abundance above which negative outcomes are expected. When abundance values rise above the action threshold, immediate control efforts utilizing adult targeted insecticides to suppress fly numbers are required

Action thresholds may vary depending upon many factors such as the distance to the nearest residential or urban area, the tolerance of neighbors, county regulations, and the risk of pathogen transmission. It is important that realistic action thresholds are chosen. If an unobtainable threshold value is required by the county, the dairy operator will have no incentive to monitor and manage nuisance fly numbers as compliance would be impossible.

The goal of every pest management program is to keep pest population levels below these action thresholds in order to reduce operating costs. Abundance values below the action threshold do not require immediate adult fly suppression, but as the action threshold is approached non-chemical control efforts such as improved sanitation should be instituted to prevent fly numbers from reaching the action threshold.

There are many ways to monitor fly abundance. Casual, subjective observation of adult or larval fly numbers is a common method, but can be misleading and unreliable. More reliable methods include using passive methods such as fly spot cards or baited traps, or active methods such as on-animal fly counts, grill or area counts, or even animal behavior counts. The monitoring system will not indicate the actual number of flies at the dairy, but it will show the relative abundance of flies present during the count period (generally one week) for comparison to earlier count periods. A monitoring system should be determined following coordination with the county health inspector or other agent responsible for inspecting fly production at the dairy. Health inspectors are primarily concerned with the monitoring of house flies as these flies tend to be the predominant nuisance fly reported by neighbors of dairy operations.

For house fly, passive count methods that require very little time of dairy employees are generally the best. Some passive fly count methods include spot cards, sticky traps and bait traps. Spot cards are 3x5 or 4x6 white index cards that are placed on vertical structures at fly resting sites around the facility. Flies resting on the cards will regurgitate and defecate resulting in spotting on the card, and the number of spots on the cards will indicate the relative abundance of house flies for the count period. Sticky traps consist of a structure onto which a sticky substance is applied. Sticky traps can be used in conjunction with materials that are attractive for adult flies to increase fly capture. Flies stuck to the trap are counted at the end of the count period. Bait traps use commercial bait placed into a bucket or other confined arena to kill adult flies. Flies killed are then counted at the end of the count period. In all cases, flies should be monitored at a minimum of five locations (10 for spot cards) around the animal facility. The count from all similar monitoring devices is then combined for each count period to give a single count. The same locations around the facility must be used during each count period to provide a reliable comparison to earlier counts.

There has been substantial research on these monitoring methods for house fly over the last few years. Importantly, research at UC Riverside has shown that fly spot cards provide a good assessment of fly abundance when fly numbers are very high. Researchers at UC Riverside are also developing a computer program that will allow animal facility operators to scan spot cards on any flat bed scanner and then the program will count the spots and download the information into a database to show fly abundance trends over time. This program will also provide control recommendations dependent upon the rate of change in fly abundance over time. Research conducted at UC Riverside also showed that sticky traps were not useful under some dairy conditions due to wind and dust affecting trap performance and the difficulty of species identification for flies captured in the sticky glue. Research conducted outside California has shown that fly baits also provide an efficient means for monitoring fly populations. However, fly susceptibility to commercial fly baits is expected to change over time as resistance to the bait spreads through the fly population. For this reason, fly bait systems are not recommended for multi-year monitoring programs.

Monitoring stable fly abundance is done in three basic ways - counting flies on the animals, assessing frequency of fly repellent behaviors of the animals, or using stable fly traps. For a thorough discussion of stable fly monitoring techniques see UC ANR publication 8258: Predicting and Controlling Stable Flies on Dairies by Alec C. Gerry, Nyles G. Peterson and Bradley A. Mullens which is accessible for free from the UCANR catalog web site: http://anrcatalog.ucdavis.edu/pdf/8258.pdf

NUISANCE FLY BIOLOGY

To best manage nuisance flies, it is important to know a bit about their biology. Nuisance flies have a life cycle comprised of an egg, three larval, a pupal, and an adult stage. Eggs are laid by a mature female fly onto a substrate that would be appropriate for the development of the young larvae. A single female can lay hundreds of eggs during her life. Nuisance fly larvae (grubs) are generally white in color, with a tapering front end containing visible mandibles and a blunt rear end on which two dark spiracular plates are easily seen. They develop in moderately wet substrates, especially dung pats and manure or wet/rotting feed, hay and bedding straw where they feed on bacteria found on the substrate. It is important to note that fly larvae are not capable of developing in aquatic habitats – they need wet but not overly wet substrates. Substrates with moisture content below 40% or over 85% are not attractive to female flies for egg-laying, and larvae will die in substrates where the moisture content drops below 30%. These moisture content values become important when considering manure and green waste management plans.

The third and final (and largest) larval stage is called the “wandering stage”. During the wandering stage, fly larvae will leave the wet/warm developmental substrate to find a dry/cool and usually shaded area where they can pupate (develop into the pupal stage). The pupal case will vary in color from red to light brown to black depending upon the age of the pupa and superficially looks like a rodent dropping except that it is segmented and well rounded on both ends. Within the confines of the pupal case, the developing fly will undergo further changes to become a winged adult fly which will eventually emerge from the pupal case and may disperse from the site. The length of time required to complete the development from egg to adult is temperature dependent and may be as short as seven days during the summer months in California.

Some nuisance flies are blood feeders and can inflict a painful bite while feeding on animals or humans. Blood feeding (or biting) flies include the stable fly and horn fly. Other flies do not bite (non-biting flies), instead feeding on body secretions or liquefied organic matter. Non-biting flies include the house fly, face fly, and garbage fly.

The two most troublesome nuisance flies, house fly and stable fly, are similar in size (1/4 to 3/8 inch body length) and general appearance. Both are common on dairies. However, the bodies (especially mouthparts), behavior, and posture of the two flies differ. Both flies rest on walls, hay bales, and other vertical surfaces, and may be especially prominent when they are warming up in the morning in an area lit by the early sunlight. Stable flies have a long, bayonet-type proboscis (mouthparts) that sticks out in front of the head. The proboscis has rasping teeth at the tip that the fly uses to abrade the skin and create a pool of blood on which it feeds over a period of about 2-4 minutes. At rest, stable flies hold their bodies at an angle to the surface, with the head higher than the rear (abdomen). In contrast, house flies have sponging-lapping mouthparts directed downward (not forward), and which cannot create a bleeding wound, although they will feed on available blood if they can get it. Also, house flies rest with their bodies parallel to the surface on which they are resting. For more information on identification of nuisance flies, see Flies: Integrated Pest Management in and around the Home by Alec Gerry, John Klotz, Les Greenberg, and Nancy Hinkle which can be accessed for free at the UCANR catalog website: http://www.ipm.ucdavis.edu/PDF/PESTNOTES/pnflies.pdf

Once they are warmed up, flies will begin to look for food and locations to lay their eggs. During late spring and early summer, mid-morning is an excellent time for stable flies to blood feed on dairy cows. They will feed on blood once or perhaps twice per day, and are especially active at temperatures of 70-85 ^{o}F. Stable flies typically feed on the lower body, particularly the front legs of a cow. The presence of numerous flies in this location, coupled with leg stamping and bunching together in tight groups, is diagnostic for this species of fly. Stable flies feed with the head pointing directly up (away from the ground) and parallel with the direction of the hair of the legs. When trying to feed, their heads will be dug into the hair coat; once blood is flowing, they will resist being dislodged unless strongly disturbed by something like a vigorous stamp. The position of house flies will be haphazard if they are on an animal. House flies are also easily disturbed.

During the day, fly resting behavior provides a means to regulate body temperature. Flies will preferentially rest on light colored surfaces that are in direct sunlight on cold days or are in shade on hot days. At night, flies will move to overnight resting sites to be protected from wind and rain and where they will remain relatively inactive until the next day. House flies will congregate in large numbers inside animal holding structures along beams or in corners near the roof where temperatures are warmer. In contrast, face flies and horn flies remain on or near their animal host. Horn flies regulate body temperature by moving from the back of a cow just behind the head to the shaded belly region when temperatures are high.

In southern and central California, nuisance flies exhibit distinct seasonal activity periods. House flies and garbage flies are most abundant throughout summer and early fall when temperatures are at their highest, while stable flies are typically most abundant in spring and early summer. In contrast to house flies, stable flies have very poor survival at temperatures above 86 ºF. Additionally, stable flies typically develop in older manure or manure mixed with vegetation that was recently wet by rains or watering systems. The lack of summer rains in California would be expected to limit available immature development sites during these hotter months. In moister and cooler areas of northern California, stable fly production is probably a mid-summer problem, but specific studies have not been done. House flies will develop in fresh as well as old manure as long as the moisture content is between 40-85%. In California, all fly species are present year-round in small numbers.

Stable flies are more abundant during high rainfall years due to the widespread increase in available immature habitat. Recent studies in California have shown that stable fly biting intensity during late spring and early summer was related to March rainfall, with greater rainfall in March resulting in greater abundance of stable flies during the peak abundance period in late spring and early summer (late April-June). House fly abundance is less a function of rainfall than it is of temperature and manure management failures.

DAIRY DESIGN

Because larval flies require manure or decaying organic material with moisture content between 30 and 85% for development, it is possible to minimize the production of nuisance flies through proper design of the dairy to reduce this larval habitat. Fly development can be substantially controlled by ensuring that these larval habitat remains dry or dries very quickly (within 3 days) to reach moisture content below 30%. The rapid drying is required because flies can complete their development from egg to pupae in as little as 5 days during the summer in California. Alternatively, manure may be held under conditions above 85% moisture such as in a manure lagoon.

Drainage Plan: A drainage plan must be developed to ensure that all wastewater and runoff is quickly transported to a settling pond or holding pond for evaporation and/or eventual use on forage crops. Drainage plans must meet California guidelines for wastewater management on dairy operations. A proper drainage plan will save hundreds of work hours and thousands of dollars of effort that would otherwise be spent to manually remove wet manure in order to prevent the development of nuisance flies.

All drylot pens should be designed with a minimum 3% grade so that runoff drains rapidly into a flush lane or other drainage system located outside the animal pen. Any water that pools within the pen will result in the breeding of nuisance flies. Drainage ditches located within the confines of the drylot pen generally fail due to animal movement across or into the drainage ditch reducing the integrity of the drainage system and causing pooling of runoff. Areas around watering and feeding stations must also be graded to rapidly drain water away from these structures and into adjacent flush lanes or drainage systems located outside of the cattle pen. Watering and feeding stations should be placed on graded concrete pads (with concrete aprons) for easier cleaning and better drainage. Watering stations should be designed to manage overflows due to float malfunctions. All overflow water should drain away from watering stations and immediately into nearby flush lanes or drainage ditches to prevent wetting of manure within the pen.

Cattle movement across drainage systems should be minimized. Where unavoidable, crossing areas should be restricted and should consist of a concrete base to maintain drain system integrity.

Flush lanes should be designed with a 3-5% grade and be level from side to side. Flush lane depth should be sufficient to prevent overflow during flushing. Flush lanes should be designed without bends or turns which result in poor water flow. Flush tanks should hold sufficient water to fully remove any solids in the flush lane.

Freestall barns should be constructed with roof-mounted rain gutters to divert rain runoff into an appropriate drainage system. This will reducing wetting of manure and bedding material in the freestall barn as well as reduce wetting of adjacent exercise or drylot pens. Cattle should be restricted from use of adjacent exercise pens during and immediately following a rainfall event in order to maintain the integrity of the pen grade.

Commodity storage areas should also be graded to prevent pooling of water or leachate along the base of commodity and silage piles. Commodity pads should be constructed of concrete or asphalt and should be designed to drain water away from each commodity or silage pile. A common practice is to grade the pad for drainage in only one direction resulting in pooling of water on the uphill side of a commodity or silage pile. With some foresight, the commodity pad can be designed with graded shallow drainage ditches located between each slightly elevated commodity and silage pile. Water should drain in all directions from each commodity and silage pile into adjacent graded drainage ditches allowing for the rapid removal of water from the commodity pad. The grades used for the silage piles and the drainage ditches need not be so steep as to impact the functioning of vehicles and equipment.

Sanitation: Regardless of the dairy design, sanitation measures will be required from time to time to remove wet manure and organic material in which nuisance flies will develop. However, by considering sanitation requirements when developing the dairy design, the cost of routine sanitation measures can be greatly reduced. Pens, lanes, alleys, and other areas where manure may collect should be designed with ease of cleaning and grading (mechanical scraping) in mind. The placing of water stations, feeding troughs, shade structures or any other structures in the center of the pen or in such a way as to obstruct machine scraping of a pen, lane, or alley should be avoided. The more obstacles that exist in the pen, the more labor will be required to meet appropriate sanitation requirements and the greater the likelihood that fly breeding will occur around these obstacles.

Feeding areas and watering stations should be separated to ensure that spilled feed stays dry and is not wet by leaks or overflow from watering stations. In addition, both feeding areas and watering stations should be located along the lowest graded edge of the pen to ensure rapid drainage of overflow water out of the pen and to reduce the mixing of feed with manure in the pen.

Flush lanes should be designed for ease of scraping by mechanical means as well as manually by flat shovel.

If a freestall barn design is to be used, it should be designed to minimize the time and labor required to remove and replace bedding material. If straw is to be used, bedding material will need to be replaced weekly from June to November and every two weeks thereafter to reduce fly (especially stable fly) breeding. The use of bedding material other than straw is encouraged and should result in a reduction in fly development. However, all bedding materials should be checked regularly for fly development and should be replaced throughout the freestall barn when any fly development is noted or at least every two weeks from June to November. A common practice is to use dry manure scraped from cattle pens (often mixed with rice hulls or other greenwaste) for bedding – this is an appropriate use of this material, but can allow for development of nuisance flies when this bedding material is wet by urine or water. Other bedding options are sawdust, wood shavings, rubber mats, and nut shells. Sand is another alternative bedding material, but has fallen from favor due to maintenance issues.

Compost sites should be identified in the dairy design and should be located in an area separate from the commodities area. Compost sites should be designed with ease of turning the compost pile in mind. Compost piles are turned by "walking" the pile, slowing moving the pile with each turn in a single direction across an open area, or by shifting the pile back and forth with each turn.

Animal comfort systems: The ideal ambient temperature for most dairy cows is between 41-77 ºF. Because summer temperatures in California regularly exceed the upper ideal temperature resulting in cow stress or even mortality, the provision of shade structures and misting or sprinkling systems is common in this state. If designed well and regularly maintained, these systems should not result in substantial fly production. However, if designed poorly or maintenance is not regularly performed these systems will result in significant fly production at the facility.

Shade structures typically provide animals with a location in the drylot pen where they can escape the mid-day heat. Shade structures should be placed at high grade locations in the drylot pen to avoid shading low spots where wet manure might accumulate. Shade structures should also be positioned in a north-south orientation to allow for penetration of sunlight to the ground beneath the structure for at least a few hours each day to dry manure deposited beneath the shade structure. These structures should be constructed with a minimum of support poles placed in the drylot pen. Support poles placed in the pen will be obstacles to cattle movement and to mechanical scrapers, resulting in undisturbed manure around these structures that will serve as a fly developmental site. Manual removal of manure buildup around these poles will be required weekly from June through November to prevent fly development. If possible, support poles for shade structures should be incorporated into an existing fence line to eliminate the creation of a potential new fly breeding site. Shade structures should be positioned so that they provide shade to the pen during afternoon hours when temperatures are greatest. But care must be taken not to shade areas where wet manure or feed buildup is most common (e.g. along feed lanes, near watering stations, along drainage systems).

Fans and sprinkling or misting systems are also used on some dairies to reduce animal heat stress. These systems must be designed carefully and maintained regularly to prevent fly production in wetted manure. These systems can be incorporated into shade structures or placed along feed lanes and watering stations to encourage feeding and water consumption. Sprinkling and misting systems must be calibrated to provide enough water to cool animals while not resulting in wet manure or feed. Misting and sprinkling systems that result in wet manure or wet feed, especially along fence lines, will result in substantial fly production during the summer months. These systems should only be run during the hottest hours of the day so that areas beneath them can fully dry during the late afternoon and evening hours.

Calf Rearing: Research has shown that calf areas, most often calf hutches, are often the greatest source of fly breeding on dairy farms. The wetted manure and feed that accumulates beneath calf hutches is ideal for the development of house flies. Reducing fly development beneath these hutches is very difficult. One option is to place calf hutches over flush lanes to remove excreted manure daily. Calves can also be housed in structures that are placed directly on the ground so that excreted manure is disturbed and compacted reducing fly development. In some parts of the U.S., large, plastic covered, half-hoop structures called coveralls, are replacing calf hutches and this design appears to result in reduced fly production relative to traditional elevated calf hutches.

The reliance on insecticide use beneath calf hutches is discouraged, however if calf hutches are used then these structures should be designed and placed on the facility to be easily lifted mechanically (usually by forklift) for sanitation and insecticide treatment when necessary. Lime is often placed on the ground beneath calf hutches and this will provide some reduction in fly development for a few days until the lime is covered by fresh manure from the calf above. If using straw bedding material, a reduction in fly numbers can be achieved by replacing the straw with sawdust.

MANURE MANAGEMENT

Animal Pens: Proper management of the manure that accumulates in animal pens will significantly reduce the number of nuisance flies. In order to minimize fly production at this site, manure must be continuously disturbed and compacted by the movement of animals until the manure is sufficiently dry (< 30% moisture) to prevent the development of fly larvae. Intact manure pats should be regularly removed or harrowed into the soil to prevent fly development. Animal density within the pen should be maintained at sufficient numbers to regularly disturb manure pats while not being so great that the pen surface remains wet from urine and feces. Manure that is not disturbed by animal movement or mechanical action, such as manure that accumulates beneath fence lines, water and feed structures, or along concrete curbs and edges, must be manually removed (via shovel) and incorporated back into the pen to prevent fly development. Any other locations in the pen where water is pooling and manure is not drying rapidly (within 3 days) must be graded to ensure proper runoff. A visual inspection of the pens and removal or incorporation of wet manure and manure buildup must occur weekly from June to November and monthly thereafter to prevent the development of flies. All manure removed from an animal pen should be composted or removed from the facility. Thin spreading this manure will allow late stage fly larvae and fly pupae in the manure to complete development.

Wastewater Systems: Fly larvae cannot live in an aquatic habitat. Flies therefore cannot develop in wastewater holding areas (e.g. settling ponds, evaporation ponds or manure separators) as long as these areas remain inundated with water. However, fly development can occur in debris floating on the surface of wastewater ponds and this debris should be removed from wastewater systems and composted or harrowed into a drylot pen. Flies can also develop in manure solids separated from wastewater systems. Separated manure solids should accumulate for no longer than 3 days prior to being composted or harrowed into drylot pens.

Flush lanes should be cleaned by flushing at least daily. Poor flush lane design or insufficient flushing will nevertheless result in the build up of manure deposits and fly development if not removed. Flush lanes should be examined and scraped clean at least once per week from June to November and monthly thereafter. Care must be taken to ensure that all manure is removed to include the manure that tends to cling to the concrete curb at the edge of the flush lane. A complete cleaning of the flush lanes may require manual labor with a flat bottom shovel to ensure that all manure is removed.

Compost: Compost piles should be turned when peak internal temperatures are reached. Temperatures above 120 ºF are lethal for immature flies. Flies will lay eggs on the cooler outer portion of a compost pile if the moisture content is greater than 40% and fly development will continue if moisture content remains above 30%. A compost pile should be turned following a rainfall event or deliberate wetting of the compost pile. Turning the pile will move the wet outer compost material into the middle of the pile and the hot internal composed material will be moved to the outside of the pile where it will quickly dry as it cools. A compost pile should not be wet after turning the pile as this will cool the surface material providing ideal conditions for fly development.

Proper manure composting either with or without an additional carbon source has been shown to substantially reduce fly production relative to other manure management techniques. Piling manure reduces the available surface area of the manure for fly development, and composting of the pile allows for rapid drying and decomposition of the manure. While piling manure with developing larvae will probably not kill the larvae as they can migrate from the center of the pile to the edge, it will result in mortality of fly pupae which are not mobile. Piled manure that is not turned will dry more slowly allowing for greater fly development in the outer portion of the pile and renewed fly development following a rainfall event. Spreading or harrowing manure in the pen or in a nearby field will allow for rapid drying, but will also allow for the survival of late stage fly larvae and pupae already present in the manure.

ORGANICS MANAGEMENT

Commodities: Even dairies with excellent manure management programs will produce a substantial number of flies if their commodity management is poor. Commodities management is especially important for dairy operators as stable flies will commonly be found developing in this material. Feed, silage, or other organic material should not be allowed to accumulate near pens or anywhere else where rain runoff, water trough overflow, misters, or urine will wet this material. Wet feed and silage may allow for the production of an enormous number of flies. Wet commodities should be removed and fed to cattle or composted, and the grade of the commodities pad should be re-evaluated to determine why water or leachate is pooling along feed and silage piles. Commodities stored in large enclosed "Ag-Bags" may allow for stable fly production at the open end of the bag if exposed material is not routinely (every few days) removed from the open end of the bag and fed to cattle. A sealed Ag-Bag should not produce flies.

Greenwaste: All greenwaste (e.g. grass clippings, bedding straw) should be removed offsite or composted each week from April through November. Like poor commodities management, poor greenwaste management will lead to the production of a large number of stable flies.

Animals: Dead animals must be rapidly removed and properly disposed of. Flies (mostly blow flies) will begin to visit and colonize dead and decomposing animals within the first few hours following death. Blow flies that develop in decomposing animal tissue may also lay eggs in the wounds of otherwise healthy animals. Fly infested wounds may not heal and may become infected resulting in illness and even death of the animal.

MAINTENANCE

Even the best designed and managed dairy will produce nuisance flies when watering stations or misting and sprinkling systems break down and wet manure areas. A small water leak that keeps manure wet can result in an enormous number of flies. All water systems should be checked weekly to look for breaks, leaks, and overflows. Watering stations should be checked to ensure that water lines are not leaking, that floats are working properly, and that overflows are not occurring. Mist and sprinkler lines, if present, should be checked to ensure that there are no leaks or cracking pipes. Mist and sprinkler lines should be checked while in operation to evaluate water spray rate. Manure beneath mist lines should be evaluated for dryness to ensure that mist lines are not leaking or dispensing too much water. Areas beneath mist or sprinkler systems should be dry by the end of each day.

Wastewater systems including flush lanes, drainage ditches, manure separators, settling basins and evaporation ponds should also be checked weekly. Inlets and outlets must be checked regularly to ensure proper flow of wastewater. Screens, if used, should be checked and cleaned regularly. Wastewater discharged to clean flush lanes should spread evenly across the lane and remove all manure or feed in the lane. If material is not being removed from the lane, water flow will need to be increased.

Drylot pens and earthen drainage systems should be evaluated annually for proper grade and integrity. If pens or drainage systems are improperly graded, or have developed low spots where runoff can accumulate, the addition of new soil, followed by grading and compaction should be accomplished during the dry summer months.

FLY MANAGEMENT PLAN

It is not possible to develop a fly management plan that can be used by all dairies in California. Each dairy will have specific environmental, geographical, and regulatory considerations that must be accounted for. The level of management required may be greater for some dairies with nearby residential neighbors or community park lands.

Environmental conditions such as temperature, rainfall, humidity, and wind speed all affect house fly abundance and dispersal. Geographical and man-made structural barriers will also affect the direction and distance that flies are likely to disperse from a facility.

A fly management plan must be part of every dairy operation. This plan should be specifically designed for that operation and is best developed in coordination with the county health department and the agency or persons responsible for the management of nuisance flies at the dairy (private contractor or dairy manager). A framework for management of nuisance flies can be obtained from the information provided in this report.

Sanitation Measures: In terms of time and money spent on control, sanitation of larval development sites is the most cost effective means to control flies. Sanitation measures are all those design and management techniques listed in the preceding sections. Sanitation measures reduce fly development sites around the dairy and thus act to control adult fly numbers by limiting the production of immature flies so that emergency fly management measures are rarely needed.

However, there may be times when sanitation efforts alone may not be enough to keep adult fly numbers below the action threshold. For example, during particularly wet years or years with significant March rainfall, stable fly production in areas off the dairy may be high. Unexpected summer rains might similarly result in significant house fly production if wetted manure cannot be dried within a few days.

Dispersal Barrier: Although this method is untested, creating a barrier of vertical structure (e.g. tree lines) at the periphery of a dairy operation may help to stop dispersing flies before they become a nuisance to neighboring residential areas. Flies stopping at dispersal barriers near the dairy may return in great number to the dairy and never reach more distant residential areas. The height and density of vertical structures needed to "capture" dispersing flies is unknown. However, from experience it is clear that tree lines planted in depth (at least 2 rows) using tree species that have dense foliage extending to ground level during summer months will result in the greatest "capture" of dispersing flies. Whether treatment of these structures with a residual chemical insecticide would provide greater control of dispersing flies is unknown.

Trees and vertical structures on the dairy will also help to keep flies from dispersing off the facility when they are looking for resting sites. However, these structures should only be placed in locations where they will not impact other operations of the dairy to include general sanitation and manure management.

Biological Management: Many beneficial arthropods are naturally found in the same manure and organic materials where fly larvae develop. These beneficial insects help to control fly populations through predation on or direct competition with nuisance flies. Biological control through releases of commercially available "natural enemies" that attack fly pupae is an appealing prospect. California surveys have shown that house and stable flies are naturally attacked by a variety of parasitoid wasps, especially in the genera Muscidifurax and Spalangia. On California confinement dairies, most natural parasitism is done by wasps in the genus Spalangia.

Fly natural enemy activity is something to be encouraged, and care must be taken to apply pesticides in such a manner as not to harm these natural enemy populations. Spraying a broad-spectrum pesticide directly onto a fly development site may cause substantial detrimental impact to natural enemy populations which tend to be present on the surface of the developmental site, while resulting in poor to mediocre fly control as fly larvae are somewhat protected beneath the surface at the developmental site. Also, the life cycle of nuisance flies is much faster than that of fly predators and parasitoids, sometimes resulting in an explosion in the number of flies shortly after widespread insecticide application which results in the destruction of available natural enemies. Thus, application of pesticides to widespread larval development sites is discouraged.

The release of commercially purchased parasitoids in some U.S. regions (and Europe) have met with success, especially in areas that are somewhat confined (e.g. calf barns). Some of these sites are similar to the pasture-type dairies found in northern California. To date trials releasing parasitoids on large confinement dairies in southern and central California have not resulted in a substantial reduction in fly activity, but the concept is constantly under review and subject to further experimentation as better natural enemies or techniques are developed.

Other natural enemies such as fly-pathogenic fungi, bacteria, viruses or nematodes may attack immature or adult stable flies and are found naturally in the environment. There is currently substantial interest in fungi as potential biological control agents for both house flies and stable flies; it is hoped that more research can help with improved biological control on the large, open dairies that predominate in California.

Chemical Management: Chemical insecticides are the least preferred form of nuisance fly management. As noted above, chemical applications tend to kill beneficial insects such as fly predators and parasitoids that would otherwise have provided some level of fly control. In addition, the rapid generation time of most nuisance fly species has resulted in the development of resistance in many fly populations to the effects of most of our available chemical insecticides. The continued use of chemical insecticides only serves to maintain this high level of chemical resistance in nuisance fly populations.

While typically the least desirable method in an integrated pest management (IPM) program, insecticides can be used to achieve some reduction in total numbers of adult flies at the dairy. With any insecticide it is important, and legally necessary, to follow label directions regarding site of application, dilution, and application frequency. There are two broad categories of insecticides that may be used to reduce adult stable flies - knockdown insecticides and residual sprays. Knockdown insecticides are non-persistent or short-lived insecticides (e.g. synergized pyrethrin) applied using foggers or mist blowers to areas where stable flies are concentrated. Knockdown insecticides should be applied during early morning hours when stable flies are less active and are concentrated in overnight resting locations such as barns, tree lines, and shade structures. Treatments may need to be repeated every few days as these insecticides will not persist more than a day or two. Residual sprays are persistent insecticides (e.g. synthetic pyrethroids such as permethrin) applied to structures on which flies tend to rest. Residual sprays should be applied to building walls, fence lines, shade structures, surrounding vegetation, or any other location where flies have been observed resting. To slow the development of insecticide resistance, the use of residual sprays should be limited and rotation of chemical classes should be practiced. For example, alternate the use of pyrethroids with organophosphate insecticides.

Commercially available fly baits are meant to be used as scatter baits or in bait stations, and consumed by flies. These baits are meant for house flies, and not for stable flies, which are a different species with different biology. Like other insecticide applications, the use of fly baits should be limited to periods when adult house fly numbers exceed the action threshold. The continued used of fly baits throughout a season and especially over successive seasons will result in the rapid development of resistance and subsequent failure of the bait. When adult fly numbers have been lowered by the use of baits or other management techniques, all fly bait material should be removed from the dairy and properly disposed. Flies in California are uniformly resistant to baits containing the insecticide methomyl (e.g. golden marlin, blue streak) and these baits should be avoided. Check the bait label to identify the insecticide or “active ingredient” in the bait.

PEST MANAGEMENT SERVICES

Many dairy operators hire private pest management contractors to provide services such as the monitoring and management of nuisance flies. This is generally a wise investment as these contractors should have considerable expertise in this area. Prior to entering into a relationship with a contractor, the dairy operator should investigate the contractor’s knowledge of fly biology, production, and management on confined livestock facilities. Fly monitoring and management strategies should be discussed in depth to ensure that the contractor is able to provide the level of service required by the dairy operator to meet social or legal obligations. Pest management contractors should employ Pest Control Operators (PCO’s) licensed by the state of California to apply pesticides in the event that pesticide applications are needed for fly management.

The relationship between the dairy operator and the contracted pest management service must be based on the mutual goal of sustainable fly management. The contractor that advocates the continued use of chemical applications (because it requires less time and is easier for the contractor) must be avoided. The routine use of chemical applications will only lead to greater resistance in the fly population resulting in future control failures. A good contractor will constantly evaluate the design and day to day operation of the dairy and will provide suggestions that improve the overall sanitation of the dairy, thus effecting a permanent reduction in the breeding of nuisance flies. To support this relationship, the dairy operator must be willing to listen to the recommendations of the pest management contractor and make appropriate changes to the design or operation of the dairy when feasible.

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