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Predicting and Controlling Stable Flies on California Dairies

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The stable fly *(Stomoxys calcitrans)* is one of the most serious pests of confined livestock throughout the United States. In many areas it is becoming a more serious problem for pastured cattle as well, associated with hay waste residues from the large, round hay bales used to feed them (Broce, Hogsette, and Paisley 2005). Adult stable flies of both sexes require frequent (often daily) blood meals and prefer to feed on the lower body and legs of cattle. Stable flies have long, bayonet-type mouthparts called a *proboscis,* which they use to tear through the skin, causing blood to pool at the skin surface. These bites can be quite painful.

When stable fly numbers are high, they have been shown to reduce the weight gains and feed efficiency of confined and grazing beef cattle (Berry, Stage, and Campbell 1983; Campbell et al. 1987; Catangui et al. 1997; Campbell et al. 2001), and they may have a similar effect on milk production in dairy cows (see Drummond 1987). The overall annual economic loss to North American livestock producers due to stable flies is estimated at nearly $1 billion (Taylor and Berkebile 2006). Stable flies are also known to disperse from their site of development into the surrounding environment, where they can be significant pests of humans. Hogsette et al. (1987) demonstrated the pests' long-range dispersal, showing that stable flies carried on storm fronts could move many miles from their production site.

When researchers released large numbers of stable flies in the vicinity of dairy stalls, milk production went down by 1.49 kg/day (3.3 lb/day) (Freeborn, Regan, and Folger 1925). Bruce and Decker (1947; 1958) demonstrated an inverse correlation of $r = -0.82$ between fly numbers and milk production with a 0.65 to 0.70 percent loss in milk and butterfat production per fly per cow and other reports indicate an increase in milk production of between 0.45 and 1.42 kg/day (1.0 and 3.1 lb/day) for dairy herds with good fly control programs. Because depressed milk production continues for months beyond the fly season, control of stable flies was shown to increase overall milk production by 10 to 20 percent (Bruce and Decker 1958). However, cattle that were provided high-energy rations did not show a decrease in milk production, even under severe stable fly stress (Miller et al. 1973).

It is useful also to consider more recent work in Nebraska, measuring weight gains in beef cattle that were exposed to stable flies in controlled environments (reviewed by Campbell et al. 1987). These studies show that stable flies at and above the range of 2.5 to 5.0 flies per leg reduce both weight gains and feed conversion efficiency in feeder cattle. Feed conversion efficiency is an easy factor for a producer to overlook but it is quite important, in terms of costs of production, from a business perspective. The same effects probably occur in milking cows. Pending more definitive studies under a variety of circumstances, we can probably assume that stable fly attack rates above about 5 flies per leg may result in economic losses.

Immature stable flies seldom develop in fresh cow manure, but they can be abundant in wetted, old manure, decaying feed, and rotting or composting vegetation (straw, haylage, silage, or green waste), especially if mixed with urine or feces (Meyer and Petersen 1983; Skoda, Thomas, and Campbell 1991). In California, most stable fly development occurs in wetted, old manure located in protected areas of the cattle pen (such as beneath the fence line or the water trough) and in manure that has built up in flush lanes associated with free stall barns (Meyer and Schultz 1990).

Stable flies in Central and Southern California typically are most abundant in spring and early summer, with a small number of stable flies present year-round (Mullens and Meyer 1987). Stable flies have very poor survival rates at temperatures above 86°F (30°C) (Lysyk 1998), and midsummer mean maximum temperatures in Southern and Central California can reach 94°F (34°C) or more. Additionally, the lack of summer rains in California limits the availability of immature development sites during these hotter months. In moister and cooler areas of Northern California, stable fly production is probably a problem in midsummer, but no specific studies have been done to document this.

Stable flies can be expected to be more abundant during high rainfall years, presumably because of the widespread increase in available habitat for immatures (Greene 1989). Recent studies in California have shown that the intensity of stable fly biting during late spring and early summer correlates well to March rainfall, with greater rainfall in March resulting in more stable flies during the peak period of late spring and early summer (late April through June) (Mullens and Peterson 2005).

RECOGNIZING ADULT STABLE FLIES

Stable flies are about the size of a house fly (¼- to ⅜-inch body length). Both flies are common on dairies, but the physical appearance (especially the mouthparts), behavior, and posture of the two flies differ. Both flies rest on walls, hay bales, and other vertical surfaces, and may be especially noticeable when they are warming up in the morning in an area lit by the early sunlight. Stable fly mouthparts feature a long, bayonet-type proboscis that sticks out in front of the head (fig. 1). The proboscis has rasping teeth at its tip that the fly uses to abrade its host's skin and create a pool of blood on which it will feed over a period of about 2 to 4 minutes. At rest, a stable fly holds its body at an angle to the surface, with the head held higher (that is, farther from the resting surface) than the rear (abdomen) (fig. 1). In contrast, house flies have sponging-lapping mouthparts that are directed downward (not forward) and that cannot create a bleeding wound, although they will feed on available blood if they can get it. Also, a house fly rests with its body parallel to the surface on which it is resting (fig. 2).

Figure 1. An adult stable fly resting, following a blood meal. Note the angled position of the body and the extension of the proboscis (mouthparts) forward of the head. Photo by Brad Mullens, UC Riverside.

Figure 2. Adult house fly resting. Note that the body is parallel to the resting surface. A regurgitated droplet may be used for evaporative cooling in hot weather. Photo by Brad Mullens, UC Riverside.

Once they warm up, flies will begin to look for food and for locations where they can 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° to 85°F (20°–27°C). Stable flies typically feed on the animal's lower body, and particularly on the front legs of a cow. The presence of numerous flies in this location, coupled with leg-stamping behavior and bunching of cattle together in tight groups, is diagnostic for this species of fly (fig. 3). A stable fly feeds with its head pointing directly up (away from the ground) and with its body parallel to the direction of the hair of the host's legs. When trying to feed, the fly will dig its head into the host's hair coat; once blood is flowing, it will resist being dislodged unless strongly disturbed by something like vigorous stamping of the host's leg. House flies' feeding positions on an animal are more haphazard, and house flies are easily disturbed and set to flight.

HOW TO DETERMINE STABLE FLY ABUNDANCE

In any pest management approach, the pest's population level guides management decisions such as when and how to control the pest. Pest abundance must be regularly assessed or monitored so changes are easy to recognize. Pest monitoring methods typically provide a relative assessment of the pest population rather than an actual count of the number of individual pests in a given area. It is important that you use the same monitoring method consistently so you can make valid, useful comparisons between different assessment periods. Record your monitoring results and retain them for several years in order to evaluate seasonal and long-term trends in pest population abundance. A good understanding of these trends will help you develop a proactive program for pest control.

When pest abundance is low, the economic and health costs associated with the pest are typically low, too. However, as pest population numbers increase they will eventually pass an abundance value (the *economic injury threshold*) beyond which the pests will cause unacceptable economic or health costs, and control efforts directed against the pests will be warranted. The goal of every pest management program is to keep pest population levels below the economic injury threshold, and so keep operating costs low.

Figure 3. Stable flies feeding on the front legs of a cow. The presence of flies on the lower legs of cattle and resulting agitation of the cattle are diagnostic for stable fly. Photo by Brad Mullens, UC Riverside.

Monitoring of stable fly abundance takes three basic forms: counting flies on the animals, assessing the frequency of the animals' fly-repellent behaviors (e.g., tail flicks), and using stable fly trap counts.

Counting flies on cattle. It takes some skill to count flies on cattle, but this is a workable option for many dairy operators. It starts with the recognition that stable flies of both sexes are blood feeders and that they primarily attack low on the body of the host animal. Approximately 45 percent of the stable flies biting a cow will be on its front legs, with the remainder biting the hind legs and lower torso (belly, lower sides, and udder) (Lysyk 1995).

Many researchers use the front leg count to determine relative stable fly abundance, and dairy operators can use the same method. Pick a sunny day when the winds are not strong and a time of day when the temperatures are good for fly activity (75°–85°F [24°–29°C] is an excellent range). Approach a cow from the side in such a way as not to greatly disturb it. Most dairy cows are quite used to people and will tolerate a person getting as close as about 10 to 15 feet (3–5 m). Most people can count flies with the naked eye at this range. You can also count from a greater distance using binoculars. Estimate (very quickly) the number of stable flies on the outside of one front leg and the inside of the other (below the elbow). Stable flies are more likely to be the predominant fly out in the pens, while cattle near the feed bunks more often have a mixture of both house flies and stable flies. Try to count only the flies that are oriented in the head-up position (biting stable flies). Counting stable flies on at least 15 cows should give you a useful estimate of biting intensity, in average flies per leg. If you count at least once a week, you will be able to track fly numbers fairly well.

The reason for counting flies on multiple cows rather than just one is that cows in a given herd differ in the number of flies that will bite them. This is, no doubt, influenced by their behavior, their position within the herd, and probably the chemical attributes of their hair or skin. Some cows vigorously defend themselves against fly attack, while others are more docile. Under heavy attack, cattle will bunch together. This may contribute to heat stress and contact damage, and cattle doing this are not feeding or behaving normally. The cattle at the perimeter of these bunches are attacked more heavily by stable flies, while those in the center are protected. Cattle will jostle for position in the bunch to escape the painful biting. Isolated animals are also attacked in greater numbers. If possible, it is best to count stable flies on cows that are in loose groups.

Based on the studies described earlier we can assume that a stable fly abundance averaging 5 flies per leg will result in a production loss. That would make 5 stable flies per leg the economic injury threshold when using the front leg count method described above. This is probably a conservative estimate: an average of fewer than 5 flies per leg might also result in economic loss under some circumstances.

Assessing fly-repelling behaviors. Because the fly-repelling behaviors of cattle increase with stable fly attack rates, you can also use the prevalence of these behaviors to gauge fly abundance (Mullens et al. 2006). Fly-repelling behaviors include flicking the tail, stamping the feet, throwing the head back toward the legs or torso, and rippling the skin (panniculus reflex) (fig. 4). Horse flies and horn flies may trigger these behaviors as well, so it is important to determine that the cattle are in fact responding to stable flies. Because stable flies feed on the lower body and legs, the tail flicks are not very effective for fly defense, but they do indicate irritation. The other behaviors are more effective for dislodging flies. Tail flicks are probably the easiest behavior to count while looking out over a herd. A tail flick is a muscle-powered motion, not just a tail swinging while the cow walks.

As with the on-animal fly counts, it is best to examine fly-repelling behaviors for multiple (ideally, 15) cows in order to reduce the statistical impact of variations between individual cows. For each cow, count the number of tail flicks during a 2-minute period. A strong flick to either side is counted, while tail swings and weak tail movements are not. An average of 10 or more tail flicks per minute is estimated as equivalent to a count of 5 stable flies per leg (Mullens et al. 2006), so you can use this value as the economic injury threshold.

Figure 4. A cow exhibiting fly-repelling behaviors, including tail flicking, foot stamping, and head tossing to dislodge biting stable flies. Photo by Brad Mullens, UC Riverside.

Counting flies on traps. In the early 1970s, D. F. Williams (1973) discovered that a whitish, translucent type of fiberglass sheeting called Alsynite was favored by stable flies for landing. Traps based on this material were developed for monitoring stable flies. These Alsynite traps are covered with a clear plastic sheet with sticky glue that traps the flies that attempt to land on the Alsynite. Early traps used four 1-foot-square panels arrayed around the top of a support pole about 0.5 to 1 yard (roughly 0.5 to 1 meter) above the ground (fig. 5a). This design was later simplified by a Kansas researcher who used a cylinder instead (fig. 5b) (Broce 1988). These traps are now marketed as "Biting Fly Traps" and are available commercially from Olson Products Inc. of Medina, Ohio.

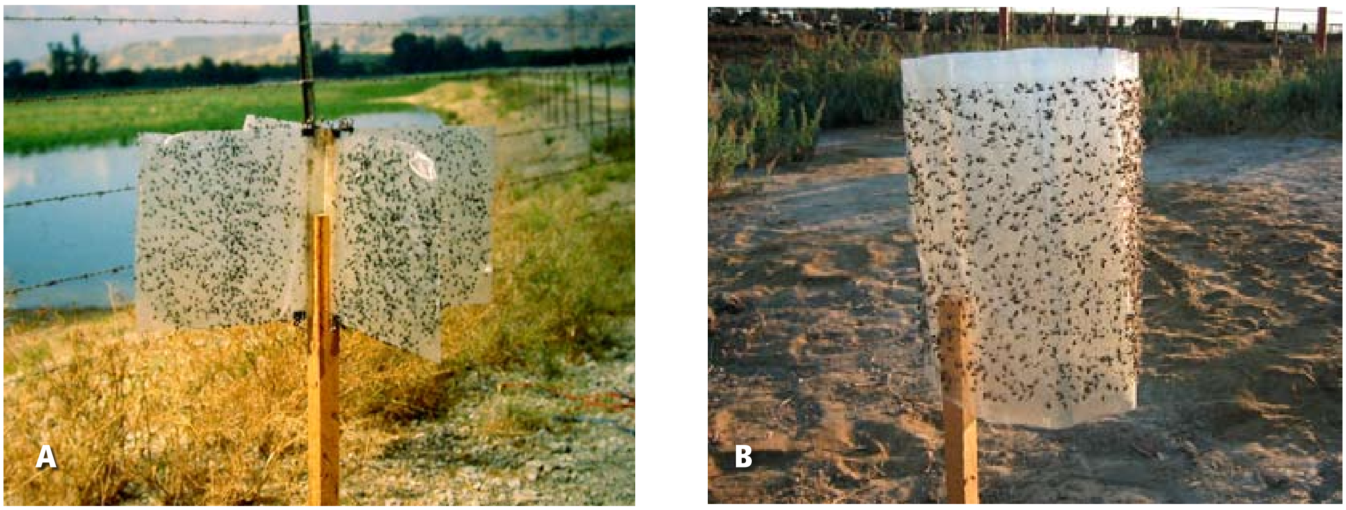

Figure 5. (a) Original Williams Alsynite trap for monitoring and reducing stable fly populations. Photo by Brad Mullens, UC Riverside. (b) Commercially available Alsynite trap (Olson Products). Photo by Alec Gerry, UC Riverside.

To use the traps, deploy several of them around the animals in areas where they cannot be damaged by the cattle. These traps quickly become useless if used in very dusty conditions. In our California studies, most flies are captured within 2 to 3 days of trap deployment, after which dust buildup prevents further fly capture. To differentiate stable flies from house flies on the traps, look for the distinctive stable fly mouthparts and, if necessary, differences in body coloration and wing vein patterns (fig. 6a, b). The number of flies per trap per unit of time (e.g., 24 hours) will yield an estimate of relative activity.

One limitation to using Alsynite traps to monitor stable flies is that no economic injury threshold value for this method has yet been determined. In addition, handling these traps can be messy, and most producers would probably find counting flies on animals or counting fly-repellent behaviors somewhat easier to perform and interpret.

REDUCING STABLE FLY DEVELOPMENT

Because high stable fly activity in Southern and Central California is limited to late spring and early summer with another much smaller activity peak in the fall, control efforts should be initiated following spring rains, before stable fly populations begin to increase. In Northern California, control efforts should be initiated by early summer in order to precede the midsummer peak in stable fly production. Although stable flies will develop off the dairy in wet organic material, sanitation efforts on the dairy can dramatically reduce the on-site abundance of these flies. In California we are fortunate in this regard that summer rains are unusual and sporadic, so the lack of late spring

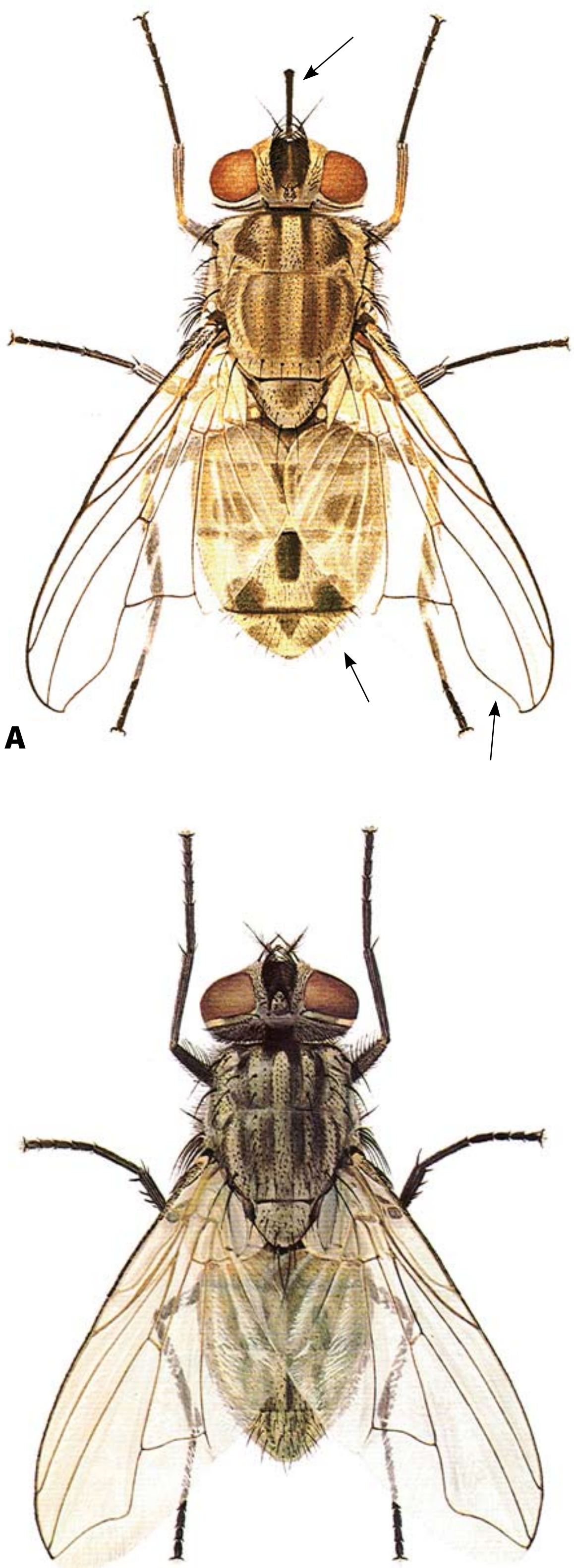

Figure 6. (a) Stable fly. (b) House fly. Arrows show diagnostic features that distinguish the two species; proboscis, wing vein shape, and abdominal markings. Color illustrations reproduced with permission from *Flies and Disease, Vol. I,* B. Greenberg, Princeton University Press, 1971; Franticek Gregor, Artist.

and summer rainfall limits the production of flies off the dairy during these months.

Appropriate sanitation of manure and moist, decaying feed is the principal means of fly control. As mentioned earlier, most stable fly production occurs in wetted, old manure in protected areas of the cattle pen, such as beneath fence lines and water troughs. Following spring rains, the manure buildup in these areas must be removed and either spread thin to dry within the cattle pen or trucked off-site. The presence of animals in the pen will ensure the disturbance and compaction of manure placed within the pens, and this will kill fly larvae that are already developing. After drying, the manure can be scraped up and stacked within the pen or placed into compost piles.

Cattle pens must be graded so that runoff and water trough overflow will drain immediately off the pen and into an appropriate drainage system. This will allow manure in the pen to dry more quickly, reducing the amount of fly development in the weeks following a rain or overflow event. If pens are improperly graded or have developed low spots over the years, the addition of new soil followed by grading and compaction should be taken care of during the dry summer months.

Wet, decaying feed or silage is another common site of stable fly production. Feed, silage, and other organic materials should not be allowed to accumulate near pens or anywhere else where rain runoff, water trough overflow, misters, or urine will wet the material. Torn or open silage bags can also produce stable flies. Any organic material outside the pen that does get wet should be removed immediately and either spread thin to dry within the cattle pen or placed directly into a compost system. Special attention should be directed toward the manure and feed buildup surrounding or under calf hutches and against feed bunks. In cooler and wetter areas of California, indoor calf pens with straw bedding, especially once wetted with manure and urine, can produce a large number of stable flies.

Many dairies today are using free stalls to house their milking cows rather than keeping them exclusively in open dry lots. Cows housed in free stalls are provided bedding material that may consist of old manure, hay, wood shavings, ground nut shells, or other materials. The use of any organic material as bedding (especially old manure and straw or hay) may result in the production of large numbers of stable flies as the area is wetted with urine and water from the adjacent flush lanes. To prevent stable fly development during the spring and summer, remove the bedding material entirely every other week and replace it with new material. To kill developing larvae, spread the old bedding material thin to dry in a cattle pen, compost it, or remove it off-site to a waste treatment facility. Straw bedding generates more stable flies than does sawdust bedding or sand/gravel (a poor bedding material anyway) in outdoor calf hutches (Schmidtmann 1991).

Another opportunity for stable fly development associated with free stalls is in manure buildup within the flush lane system. Manure buildup is typically caused by incomplete flushing or improper grading of the flush lanes. The flush lane should be designed so that all manure buildup within the flush lane is removed by simply increasing the water flow through the flush lane system or by mechanically or manually scraping the flush lane each week.

By proactively addressing these sanitation concerns and removing potential stable fly breeding sites on the dairy, you should be able to keep adult stable fly numbers low. Continued sanitation of this breeding habitat throughout summer will also help to reduce the abundance of house flies, which also breed in wet manure and spilled feed (Thomas et al. 1996).

REDUCING ADULT STABLE FLIES

In terms of time and money spent on control, sanitation of larval development sites is the most cost-effective approach to controlling stable flies. However, there may be times when sanitation efforts alone will not be enough to keep adult stable fly numbers below the economic injury threshold. For example, during particularly wet years or years with significant March rainfall, stable fly production in areas off the dairy may be high.

In this publication, we suggest 5 stable flies per leg as the tentative economic injury threshold, meaning that the dairy will suffer monetary losses when stable flies reach or exceed this number. If you are assessing fly-repelling behavior of cattle, the equivalent economic injury threshold is 10 tail flicks per cow per minute. The appropriate economic injury threshold for Alsynite trap catches is unknown and probably varies, but control efforts should be initiated whenever the number of trapped stable flies begins to rapidly increase.

When adult stable fly numbers exceed the economic injury threshold, it is time to apply adult fly controls to reduce your economic losses. Although complete elimination of stable flies is an unrealistic goal, you can still reduce the number of stable flies attacking cows through three mechanisms: (1) the use of Alsynite or similar target traps, (2) the use of insecticides applied to treated cloth targets or stable fly resting sites, and (3) the use of insecticides and repellents applied directly to cattle.

Target traps have proven an effective way to achieve some reduction in adult fly numbers in limited situations such as smaller dairies, zoo pens, or dog kennels. Larger dairies probably have too many flies to control efficiently using these traps as the only means of control. Recent studies have shown plastic sheeting materials such as Coroplast (Great Pacific Enterprises Inc., Granby, Quebec, Canada and Dallas, Texas) and polyethylene terphthalate or PET (marketed as “Bite Free,” by Farnam Companies Inc., Phoenix, Arizona) to be superior to Alsynite in attracting stable flies (Beresford and Sutcliffe 2006; Taylor and Berkebile 2006). Coroplast sheets can be cut into approximately 0.5-yard (roughly 0.5-meter) squares to be mounted onto wooden stakes just above ground level. The Coroplast sheet is then covered with Tangle-Trap insect adhesive (Tanglefoot Co., Chicago, Illinois) that has been thinned with mineral spirits until it is thin enough to be applied with a paint brush. While Alsynite and similar traps collect large numbers of stable flies, they can be expensive and messy due to the need to replace the clear, sticky covering every few days.

Treated cloth targets are also capable of attracting and killing large numbers of stable flies. These targets are pieces of dark black or blue cloth 1 yard square (roughly 1 meter square) that are fixed to stakes and soaked with a premise spray insecticide. Treated cloth targets are not yet available commercially, but trapping with this equipment is being researched, especially in the southern United States (Foil and Younger 2006). They may ultimately be useful for reducing adult stable fly activity in open environments such as beef pastures or feedlots.

While typically the least desirable tools in an integrated pest management program, insecticide applications can be used to achieve some reduction in total numbers of adult stable flies at the dairy. With any insecticide it is both important and legally necessary that you follow all label directions regarding site of application, dilution, and application frequency. There are two broad categories of insecticide that may be used to reduce adult stable flies: knockdown insecticides and residual sprays. Knockdown insecticides are non-persistent (short-lived) insecticides (e.g., synergized pyrethrin) that are applied using foggers or mist blowers to areas where stable flies are concentrated. Knockdown insecticides should be applied during early morning hours when the stable flies are less active and are concentrated in overnight resting locations such as barns, tree lines, and shade structures. You may have to repeat treatments every few days, since these insecticides will not persist more than a day or two. Residual sprays are persistent insecticides (e.g., synthetic pyrethroids such as permethrin) that are applied to structures on which stable flies tend to rest. Residual sprays should be applied to building walls, fence lines, shade structures, surrounding vegetation, or any other location where stable flies have been observed resting. To slow the development of insecticide resistance, you should limit the use of residual sprays and rotate the chemical classes that you use. For example, alternate between the use of pyrethroids and 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 biological characteristics. Adult stable flies are blood feeders that may also feed on natural sugar sources such as nectar, but there is no evidence that commercially available fly baits are attractive or effective for stable flies.

The intensity of stable fly biting on cattle may be reduced if you spray insecticides or insect repellents directly onto the cattle. Insecticidal sprays should be directed so they will soak the animal's feet, legs, and belly, where stable flies typically bite. However, because stable flies spend so little time on the host (feeding takes only 2 to 5 minutes), many may feed before they can be killed by the insecticide. For this reason, insecticidal sprays may not reduce stable fly attacks on animals. In addition, insecticide residues on the legs will be quickly lost if the cattle walk through vegetation or water. Furthermore, very few insecticides are approved for this type of use, especially on lactating animals. Our experience to date with on-animal treatments of pyrethroid insecticides (the most widely available materials) has not resulted in any dramatic reductions in adult fly populations on animals. Work is, however, proceeding on additional toxic and repellent materials for on-animal use.

Biological control through the release of commercially available "natural enemies" that attack stable fly pupae is an appealing prospect. California surveys have shown that stable flies are naturally attacked by a variety of parasitoid wasps, especially in the genera *Muscidifurax* and *Spalangia.* On California confinement dairies, most of the natural parasitism of this type is by wasps in the genus *Spalangia* (Meyer et al. 1990). Natural enemy activity is something to be encouraged, and care must be taken to apply pesticides in such a manner as to cause no harm to natural enemy populations. Spraying a broad-spectrum pesticide directly onto a fly development site may cause substantial harm to natural enemies, which tend to be on the surface of the developmental site, but yield poor to mediocre control of stable flies as the fly larvae are somewhat protected beneath the surface at the developmental site. For this reason, the application of pesticides to widespread larval development sites is discouraged.

Parasitoid releases in some regions of the United States 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 substantial reductions in fly activity, but the concept is constantly under review and subject to further experimentation as more effective natural enemies and better techniques are developed. Other natural enemies such as fly-pathogenic fungi, bacteria, viruses, or nematodes may attack immature or adult stable flies and may be found naturally in the environment. Substantial interest is focused now on fungi as potential biological control agents for both house flies and stable flies; more research in this area may help improve biological control of stable flies on the large, open dairies that predominate in California.

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