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Rural Flies in the Urban Environment?

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RURAL FLIES IN THE URBA

GUSTAVE D. THOMAS
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Editors

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RURAL FLIES IN THE URBAN ENVIRONMENT?

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Annual Meeting of the Entomological Society of America
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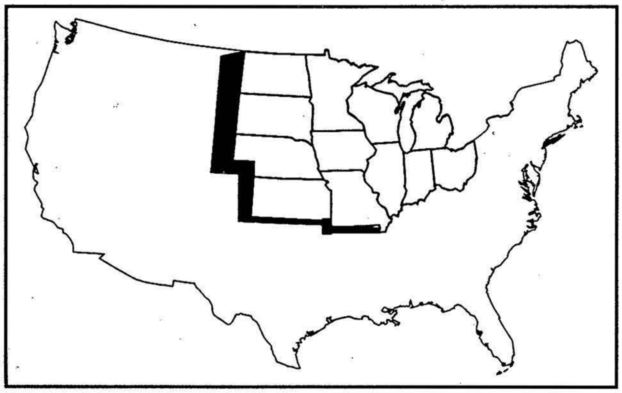

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CONTENTS

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FOREWORD

Flies, who cares about flies? Perhaps the more eccentric Dipterologists can be credited with a true affection for these animals but most people (including many Dipterologists) consider flies to be pests at best. Still, whether it be as pests to control or animals for research, everyone cares about flies. And with their ability to reproduce, a fly nuisance - whether in the rural or urban environment - can quickly become an economic and health problem. How fast can they reproduce? As an example, if there were one fertile female house fly and ideal conditions, over 15 billion flies could result in as little as two months. As you see, it wouldn't take long to have a place buzzing. Now flies aren't only villains, they have an important ecological niche: it's just that most people, urban and rural, would prefer to not be included in that niche.

Not that long ago, flies were considered an unavoidable product of animal husbandry: they were tolerated in most settings. Also, not that long ago, farms were mostly modest sized family owned and operated small businesses; relatives from town often came out to visit. But, agricultural practices in the United States have changed dramatically during the twentieth century. Fewer, larger farms are producing much of the nation's food and fiber. Modern technology has been incorporated into production agriculture. These production and demographic changes in agriculture have been accompanied by less frequent day-to-day interaction between urban and rural populations. Many urbanites, particularly the youth, have little or no contact with or knowledge of the way of life in modern-day production agriculture. The time when everyone had relatives on the farm and weekends were spent visiting those relatives is long past. Because metropolitan areas in the United States have been expanding at a dramatic rate, there has been direct competition between rural and urban interests for land. Also, market pressures often make it most profitable for meat producers to locate as close to urban centers as possible. A resultant growing interface between rural and urban centers, coupled with inadequate understanding of the people between the two centers, provides a potential for problems to develop. This book generally summarizes one area of contention - flies: few people tolerate flies in any setting anymore.

We thank Dr. Robert Hall, and all anonymous reviewers, for reviewing this book. We wish to thank all of the contributors to this book. Each paper presented at the symposium has been included. All authors were leaders in their assigned areas. The intent of the symposium was to review extant literature in the assigned areas: no new research results are presented in this text. Not all types of meat animal production were included: time for the symposium and vastness of the subjects were limiting. We have limited the coverage of flies to the muscoids, particularly house flies and stable flies, partly because of the good research base on these flies in agricultural environments and the expertise of the contributing authors. The research base on these flies in the urban environment is less complete: we feel the book will still serve as a useful reference and that any inferences and conjectures are based on good logic. We hope that any future research that may be stimulated by this book will be done with a holistic consideration of urban and rural interactions.

Gustave D. Thomas
Steven R. Skoda

THE INFLUENCE OF BEEF CATTLE FEEDLOTS ON THE URBAN FLY PROBLEM

Gustave D. Thomas

INTRODUCTION

"Fly problems" attributed to feedlot operations are receiving considerable attention as urbanization of agricultural lands proceeds at a rapid rate. In recent years, complaints to local, county and state authorities have resulted in litigation against feedlot operators because of flies, odors, and dust as a nuisance. Although many cases are settled out of court, a number of cases have reached state supreme courts. The feedlot industry has been affected by the problem of flies in the urban environment and operators have been forced to spend money to reduce the fly populations or in extreme cases the feedlot has been forced to cease operation. The two major fly species targeted for control are the stable fly, *Stomoxys calcitrans* (L.) and the house fly, *Musca domestica* L. The purpose of this paper is to examine the influence of beef cattle feedlots (Fig. 1) on the urban fly problem.

TOP TEN BEEF CATTLE FEEDER STATES

The four states with the largest number of cattle on feed (Texas, Nebraska, Kansas and Iowa) have 72% of the cattle on feed in the United States (Table 1). Cattle remain in the feedot for about 4 mo., so at any one time about 11,550,000 cattle are on feed in the top ten beef cattle feeder states in the United States. Each of the cattle produces ca. 23,000 grams (50 lbs) (Runov 1977) of wet manure daily. If we assume that the stable fly or house fly requires ca. 2 grams of manure to complete development, as does the face fly, *Musca autumnalis* DeGeer (Moon 1980), then 11,550,000 cattle could produce enough manure to allow production of 132,825,000,000 flies per day.

THE FLY SITUATION IN TOP FOUR CATTLE FEEDER STATES

A survey was conducted of the fly situation in seven of the top ten cattle feeder states. The individuals contacted were experts in livestock pest management or public health. The results of the survey of individuals in the four leading states of Texas, Nebraska, Kansas and Iowa will be discussed.

TEXAS

I discussed the situation in Texas with Dr. Bill Clymer, a private consultant for fly control at beef cattle feedlots in Amarillo, Texas. He contracts the fly control for 1 million head of beef feedlot cattle annually. He said the fly problems in many towns in Texas because of nearby beef cattle feedlots is a real problem that needs attention. It costs feedlot operators $0.40 to $1.00 per head per season to control flies. More pressure to control flies comes from nearby towns and subdivisions than from economic cattle performance considerations.

According to Dr. Clymer, there are 4 million head of beef feedlot cattle in a 200 mile radius of Amarillo. One feedlot 12 miles from Amarillo is often blamed for fly problems in Amarillo. Mainly because of public pressure, the feedlot spends a large amount of money for fly control. One particular year this feedlot sprayed weekly early in the season and daily most of the fly season.

NEBRASKA

Dr. Jack Campbell of the University of Nebraska was contacted about the fly situation in Nebraska. Dr. Campbell said that the urban fly problem as affected by cattle feedlots in Nebraska is so serious that feedlot operators are afraid to start new feedlots or add to present ones because of the fear of litigation.

Dr. Wayne Kramer of the Nebraska Department of Health was also contacted. Dr. Kramer receives many complaints about flies and odors in relation to large agricultural operations and in relation to the spreading and incorporation of paunch manure from animal slaughtering facilities. There is a trend for cattle operations to become larger with greater numbers of livestock and hence problems related to flies and odor are greatly magnified.

KANSAS

Mr. Leon Hobson of the Department of Health and Environment, Topeka, said they receive numerous complaints about flies from residents who reside near confined feeding facilities. A number of the fly complaints deal with small pens of animals (pleasure or domestic) that are located in proximity to neighbors (small towns, subdivisions, etc.). The complaints range from increased numbers of flies, to fly specs, to damage from fly specs, to can't go outside because of the large numbers of flies. In a significant portion of the cases excellent fly breeding areas are found on the property of the complainant. Thus, it is difficult to determine the origin of the troublesome flies. The normal procedure of the Department of Health and Environment is to investigate all complaints to determine their validity. To date, they have not taken any enforcement action against any facility because of flies. Instead, they routinely work with the facilities to improve fly control.

Dr. Alberto Broce, Kansas State University, said numerous cases exist of urbanites initiating legal action against livestock operations because of "flies in town" problems. The number of flies causing complaints from urbanites is several levels lower in magnitude than the levels causing economic damage to the feedlot operation. This results in costly efforts in attempting to suppress fly populations to extremely and often unattainably low levels.

Stable flies are more noticeable to urbanites and the complaint threshold lower because of their painful bite, because they constantly feed on the ears of dogs and because they soil houses with dark feces. Dr. Broce has investigated the origin of stable flies and house flies for several years in Manhattan where citizens consider the livestock operations around the city to be the source (Broce 1986). He feels strongly that many of the urban flies in Manhattan are breeding in urban settings.

IOWA

Dr. Ken Holscher of Iowa State University only received 2 complaints about flies during his seven years at the university. He talked with the state entomologist who said he had only received one complaint about flies in 15 years. It should be pointed out that Iowa has the "right to farm" law which makes it difficult to sue an existing feedlot. Also, many of the feedlots are farmer-owned and relatively small operations.

TWO EXAMPLES OF COURT CASES IN NEBRASKA

I would now like to discuss two court cases in Nebraska. First, the case of Glen and Eola Mae Botsch vs. Leigh Land Company (239 N.W. 2d 481). The feedlot was designed to meet EPA and Nebraska Environmental Control guidelines. However, the holding pond was located across the road from Botsch's farmstead. The district court agreed the situation was a nuisance because of odor and flies and shut down the feedlot. The feedlot remodeled and appealed to the district court to reopen. However, the appeal was denied by the district court. The suit was then tried in the Nebraska Supreme Court and the defendants won. The feedlot was allowed to reopen.

Next, let's look at the case of Lyle and Darlene Gee vs. Dinsdale Brothers, Inc. (298 N.W. 2d 147). The Gee home was across the road from the Dinsdale's feedlot which ordinarily had 2,500 to 3,500 cattle. After making complaints to a number of governmental agencies, the Gees sought temporary damages to their comfort and enjoyment of their property. They did not seek permanent damages resulting from the operation of the feedlot which they alleged constituted a nuisance. Their complaints related to odors, dust, flies and rodents coming from the feedlot. The jury in the district court returned a verdict for the plaintiffs in the amount of $50,000. The owners of the feedlot appealed to the Nebraska Supreme Court and lost.

The legal opinions of Nebraska are not unique (see Hayes in this volume). People in some states (e.g. Iowa and Kansas) are less apt to take legal action. As the urban-rural interaction becomes more intense, there may be even more pressure on the legal system to resolve conflicts of interest. Legal precedent in many states could be evaluated to begin to define a more uniform solution.

SUMMARY

There is definitely a beef cattle feedlot-urban interaction concerning flies. In Nebraska, there have been State Supreme Court decisions concerning this problem.

Many people feel that further research into this interaction is needed.

NOTES

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Table 1. Number of cattle on feed in the top 10 cattle feeding states for the period July 1, 1989 - June 30, 1990.[1]

State	Number of Cattle
Texas	7,820,000
Nebraska	7,560,000
Kansas	6,215,000
Iowa	3,485,000
Colorado	3,385,000
California	1,775,000
Oklahoma	1,230,000
Minnesota	1,115,000
Illinois	1,100,000
South Dakota	965,000
TOTAL	34,650,000

[1] Source: U.S. Dept. of Agric. Agricultural Statistics 1990. U.S. Government Printing Office, Washington DC.

Figure 1. A confined beef cattle feedlot.

THE INFLUENCE OF POULTRY OPERATIONS ON THE URBAN FLY PROBLEM IN THE WESTERN UNITED STATES

Jeffery A. Meyer

INTRODUCTION

The sale of farm products from California farms and ranches has consistently led the nation for over 40 years, with 1988 production valued at $16.6 billion (California Department of Food and Agriculture 1989). During 1988, animal commodities were worth $4.6 billion, with poultry commodities accounting for $850 million of that amount. The major poultry commodities produced in California (and their national ranking) are eggs (#1), turkeys (#3), and broilers and fryers (#9). Very little poultry meat is produced in the western United States (west of the Rocky Mountains), outside of California. Colorado, Oregon, and Washington produce eggs, but the number of layers is much below the number in California (Table 1).

For poultry production to be efficient and profitable, it is necessary to confine the animals at high densities in suspended cages or on the floor of semi-enclosed buildings. Monocultural practices such as these have often resulted in pest problems of great magnitude. One of the major pest problems associated with poultry production, especially egg production, is synanthropic flies. The two major synanthropic pest species associated with egg production in the western United States are the house fly, *Musca domestica* L., and the little house fly, *Fannia canicularis* (L.). Both fly species are key pests, with the house fly adapted to a hot climate and the little house fly preferring a cooler climate. It would be difficult to say which fly species is more of a nuisance, simply because their effects are indirect and there is no useful statistic for comparison. A seasonal evaluation of the number of fly complaints indicates that *F. canicularis* may be the more important nuisance pest, as judged by the greater number of complaints coinciding with the peak in the fly's population density (spring) in southern California (Fig. 1).

The population of California has risen rapidly over the past 40 years. The most rapid population growth has probably occurred since 1980, with five of the top 10 fastest growing counties in the United States located in California (U.S. Bureau of the Census 1988). All five of these counties are located in southern California, and not by coincidence, include Los Angeles County and the four counties that border it (Orange, San Diego, San Bernardino, and Riverside Counties).

Long & DeAre (1983) studied the phenomenon of population growth in southern California and came to the conclusion that urbanization had slowed steadily in this area, and that people were moving into the adjoining urbanized areas at a rapid rate. The result of these types of movements has been the formation of "massive supercities."

Another result has been the settlement of millions of people in the unincorporated areas of southern California that had been previously occupied by agriculture, including egg production. Complaints against flies and other nuisances from neighbors of egg production facilities have increased concurrently with the population growth.

STATE AND COUNTY FLY CONTROL LAWS

Nuisance fly problems in California are primarily resolved through the action of regulatory agencies. These agencies are either environmental health offices or mosquito/vector control districts; both are generally administered by local (county) governments. The legal basis for the regulation of nuisance fly development by these agencies comes from California's health and safety code #2271, "Breeding place of mosquitoes, flies or other insects; public nuisance." The law states that, "any breeding place for mosquitoes, flies, or other insects upon any land which exists by reason of any use made of the land on which it is found or of any artificial change in its natural condition is a public nuisance. The presence of mosquito, fly, or other insect larvae or pupae in any place shall constitute prima facia evidence that such place is a breeding place for mosquitoes, flies, or other insects." The state law is thus very restrictive, in that the presence of just one immature stage of a fly implies that a particular site is harboring a potential public nuisance.

Many of California's more urbanized counties have chosen to create their own fly control ordinances, with many specifically designed to regulate fly development on commercial poultry facilities. Southern California counties that have adopted such ordinances are Riverside (ordinance no. 527), San Bernardino (ordinance no. 2889), and San Diego (ordinance no. 7025). These ordinances tend to differ somewhat in their content, but all include specific standards relating to general operation, construction and maintenance of buildings, manure management and disposal, and fly control methodologies.

UNIVERSITY OF CALIFORNIA AGRICULTURAL SANITATION PROGRAM

The occurrence of rural flies in the urban environment is not a new problem for California. Egg producers being sued by angry neighbors have been reported periodically since the mid 1950's (Anonymous 1955). Undoubtedly, many more confrontations actually occur, but are settled out of court. In response to the inevitable coexistence of the egg industry with the growing human population, the University of California initiated the Agricultural Sanitation Program (Loomis 1964). This program was a very early attempt at infusing integrated control technologies into poultry production schemes. Five categories for program action included physical, mechanical, chemical, cultural, and biological control methods. One of the results of this program was the development of various frequent manure removal systems, which were designed to remove poultry manure from the house at a frequent enough interval to prevent successful fly development (Fairbank 1964, Bell et al. 1965). The concepts were workable and reliable, and are still in practice today.

Even with all the advancements made toward integrated fly control by the Agricultural Sanitation Program, the "tolerance threshold" (the fly density which stimulates homeowner action) declined as urbanization continued to increase. Integrated control technologies are available to maintain fly populations at reasonable population densities, but in some cases a "tolerance threshold" can be as low as one fly. Maintaining fly populations at these levels is almost impossible.

ORANGE COUNTY, CALIFORNIA: CASE HISTORY

The consequences of the urban/agricultural interface have been demonstrated several times in California, most dramatically in Orange County. In 1949, Orange County had approximately 700 egg production facilities. That number decreased to 461 by 1954, down to 98 by 1964, and decreased to a mere 28 farms by 1974 (U.S. Bureau of the Census 1954, 1964, 1974). The egg industry is essentially non-existent in Orange County today, having been "pushed out" by the tremendous urbanization phenomenon that began almost 40 years ago. Most experts agree that nuisances, especially synanthropic flies, were the main reason for the relocation of the egg industry to Riverside, San Bernardino, and San Diego Counties (Fig. 2). To help minimize the threat of fly production on the poultry industry, Orange County and the California State Department of Public Health funded a large scale applied research project designed to develop information, that "when skillfully applied, would consistently reduce fly production around poultry operations to an acceptable minimum." The study was completed in three years and produced two volumes of information that was subsequently extended to, and used by the poultry industry (Russell & Stone 1966a, b). The studies were directed toward controlling *Fannia* spp., and generally emphasized applied ecology, biological control, and cultural control. The urbanization process could not be stopped, however, and the industry had to subsequently relocate. The same pressures are now coming to bear again on the same industry that moved to Riverside, San Bernardino, and San Diego County 25 years ago.

SAN DIEGO COUNTY POULTRY FLY CONTROL ORDINANCE

Since fly populations are closely regulated on poultry facilities in California, the most reasonable avenue to take in helping to mitigate the fly problem may be through an improved regulatory process. An interesting case study of this idea can be found in San Diego County. As previously mentioned, San Diego County is one of the fastest growing counties in the United States, but supports a sizeable egg production industry; approximately equal to that of the state of Washington (Tables 1 & 2). The majority of the industry is positioned directly in the face of some of the more rapidly urbanizing sections of the county. Therefore, by 1985 the situation was deteriorating rapidly enough for the egg producers, that their industry would eventually have to relocate to avoid the problems associated with the urban/agricultural interface. In response to industry concerns, county government formed a poultry advisory committee, whose membership included representatives from the San Diego County Health Department, San Diego

County Farm Bureau, University of California, and Inland Empire Poultrymen, Inc. (poultry industry's organization). This committee was given the responsibility for developing a new fly control ordinance that would regulate fly development according to integrated control practices developed for the egg industry by the University of California. The practices would be implemented by the poultry producer and fly populations monitored by vector biologists employed by the San Diego County Health Department.

The ordinance seemed direct enough, but some checks and balances were necessary for each side, to insure fair treatment. Each poultry producer was required to prepare a fly control plan, which stated in writing the various components that would be included in the fly control program. Such plans would include information as to manure management and disposal, personnel associated with fly control, availability of fly control equipment (sprayers, manure removal machines, etc.), and back-up plans for unanticipated problems that might result in fly problems (broken equipment, lack of personnel, extended rainy periods that inhibit manure drying, etc.).

An additional integral component of the ordinance was the inclusion of a Fly Abatement and Appeals Board. The board was dictated to be composed of private citizens, poultry producers, and a person knowledgeable about fly biology and integrated control procedures. The board was designed to act as a "buffer" between the poultry producer and the health department, making judgements on the validity of fly control violations and recommending reasonable courses of action to abate problems.

The ordinance has been in place for five years and has been an overwhelming success. A great part of the success is due to the attitude adopted by the health department toward fly problems, attempting to supply advice in hopes of solving the problem before enforcing various aspects of the ordinance.

CALIFORNIA TURKEY FORUM

Although the majority of fly complaints in California are directed toward egg production operations, a consistent number of complaints are also filed against turkey production facilities. Turkey production facilities are generally concentrated in the San Joaquin Valley of California, which is much more rural than southern California. However, the problems seem to be as acute as those associated with egg production in southern California and have the potential of impacting turkey production efforts if not confronted in a direct manner. The turkey industry decided to develop their own organization, to deal with nuisance problems with a unified voice. Their efforts culminated in the formation of the California Turkey Forum. Again, the success of the forum has been through its attitudes toward working out cooperative arrangements between regulatory agencies and turkey producers. The organization's most significant accomplishment has been the formation of "guidelines for siting and operation of poultry facilities." As in San Diego County, the guidelines will eventually be formulated into a county ordinance and will have been developed by concerned citizens, the turkey industry, and county health departments. As in the case of San Diego County, the University of California maintained a significant presence in the organization, providing educational and research-based programs to further the efforts of improved fly control.

SUMMARY

The cooperative efforts of the poultry industries, the University of California and the regulatory agencies have been of tremendous value in avoiding litigation over nuisance complaints, and have generally improved the image of poultry production in California. However, cases have been documented in recent years, where poultry producers have been tried in both civil and criminal court, and convicted of offenses not related to violations of state or county laws. One relatively recent incident (Low 1987) involved an egg producer who was convicted of unfair business practices, for allegedly producing flies while his competitors did not. The producer was accused of having an advantage over his competitors by not having to divert resources to fly control. His conviction cost $25,000. The lesson to be learned is that the existence of animal agriculture will always be threatened when located in the path of urbanization. Right to farm laws, county ordinances, fly abatement and appeals boards, etc., will not ultimately protect the farmer from civil and criminal action regarding nuisances and production of public health threats.

In some ways, the pesticide regulatory process in the state of California has hindered the ability of the poultry industry to coexist in urbanized environments. The pesticide registration requirements of the California Department of Food and Agriculture (CDFA) are generally more restrictive than those of the U.S. Environmental Protection Agency. This regulatory process has severely limited the availability of new pesticides for the poultry industry (Meyer 1990). This problem is further complicated by a CDFA policy (part c of section 12825 in article 4) which prohibits registration of additional chemicals if a feasible alternative is currently registered. This particular policy eliminated the possibility of California poultry producers using cyromazine (Larvadex, CIBA-GEIGY Corp.) as a feed-through larvicide for filth-breeding flies. The compound was available in every other state, and has been shown to have unequaled efficacy (Axtell & Edwards 1983, Meyer et al. 1987). The addition of cyromazine to the available fly control chemicals would not only have given producers a highly efficacious insecticide that may have prolonged their existence in urbanized surroundings, but would have allowed for greater flexibility in managing resistance development.

NOTES

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Table 1. Poultry production statistics for various states in the western United States for 1988.[a]

	Estimated bird counts (x 1000)		
State	Layers	Broilers	Turkeys
California	31,467	212,199	26,500
Riverside Co. [b]	13,232	--	--
San Bernardino Co. [b]	4,086	--	--
San Diego Co. [b]	5,364	--	--
Washington	5,008	28,200	--
Colorado	3,056	--	--
Oregon	2,351	17,300	1,600

[a] Source: U. S. Dept. of Agric. Agricultural Statistics. 1989. U. S. Government Printing Office, Washington D.C.

[b] County data for 1987; 1988 information not available. Source: U. S. Bureau of the Census, 1987 Census of Agriculture.

Table 2. Human population of various states in the western United States, 1980 and 1988.[a]

State	No. people (x 1000)		
	1980	1988	% change
California	23,667	28,314	19.6
Riverside Co.	663	985	48.5
San Bernardino Co.	895	1,292	44.4
San Diego Co.	1,861	2,370	27.3
Washington	4,132	4,648	12.5
Colorado	2,889	3,301	14.2
Oregon	2,663	2,767	5.1

[a] Source: U. S. Dept. of Commerce, Bureau of the Census.

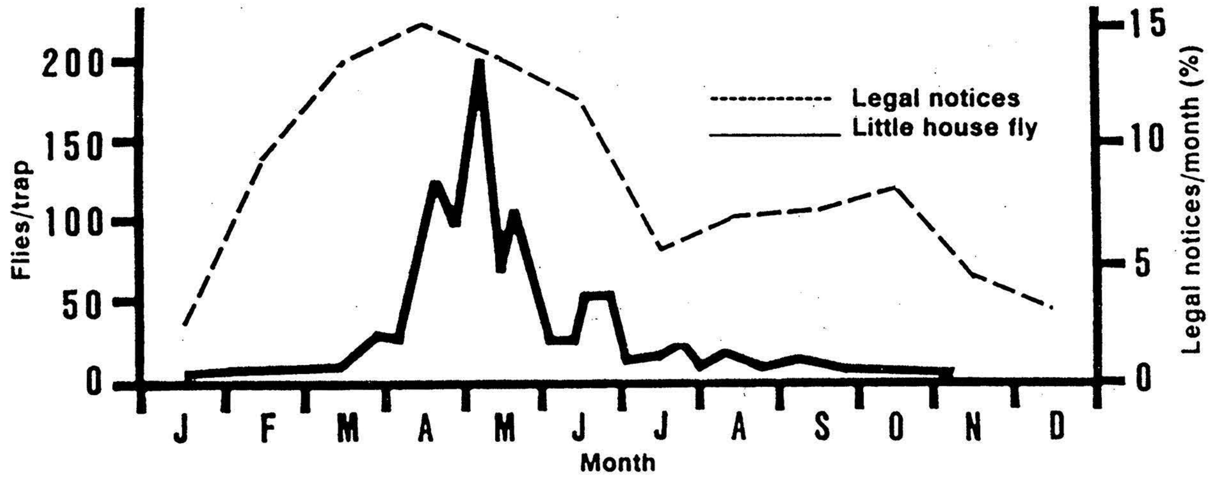

Figure 1. Seasonality of *Fannia canicularis* population density (1983 sample) and distribution (%/month) of legal notices filed in relation to excessive numbers of flies on poultry facilities.

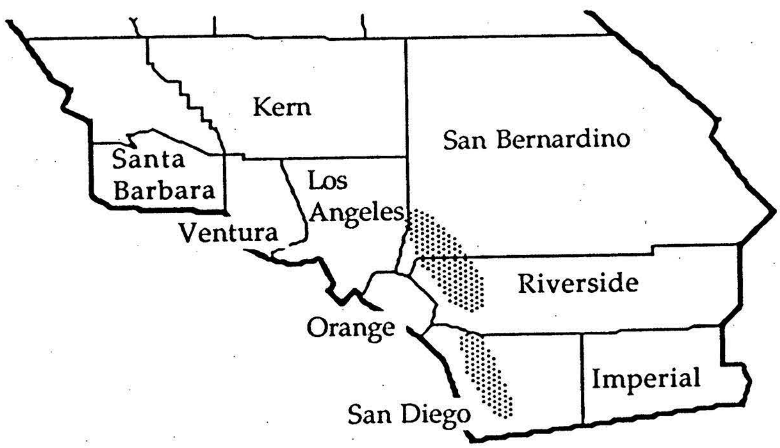

Figure 2. Southern California counties, with shaded areas outlining concentrations of caged-layer facilities.

THE INFLUENCE OF POULTRY OPERATIONS ON THE URBAN FLY PROBLEM IN THE EASTERN UNITED STATES

Jerome A. Hogsette

INTRODUCTION

The house fly, *Musca domestica* (L.), is well described as a major pest of poultry in general, but it is most pestiferous around caged layering hens (Horton et al. 1985, Axtell 1986, Hulley 1986). Flies can reproduce rapidly in manure and spilled feed, and both adult and immature stages are active year round because of the ameliorated temperatures maintained in layer houses. The role of the house fly as an urban or suburban pest resulting from flies breeding and developing on poultry farms and dispersing to nearby populated areas has just begun to be recognized. Some of the effects of urban sprawl on established agricultural installations, e.g., the necessity for increased and improved methods of fly control, have long been suggested (Georghiou & Bowen 1966), but now, with many farms completely surrounded by housing developments, the situation has changed considerably.

EGG PRODUCTION METHODS

Methods of egg production have changed greatly in the past few decades. In many locations, small buildings housing 15,000-20,000 layers have been supplanted by buildings housing 100,000 or more layers. In most cases, these 100,000-bird houses are built in groups of 5, 10, or more, and are completely automated. The size of these buildings, 120-150 m in length, makes poultry farms highly visible to the community.

The large size of poultry farms enables producers to maximize production and minimize costs. Unfortunately, it also concentrates some of the negative aspects of poultry production which were more easily managed on the smaller farms that were once spread across the countryside. Concentrations of manure are perhaps the most visible of these negative aspects. According to North & Bell (1990), an average 1.8-kg (4-lb) laying hen produces ca. 113 g (0.25 lb) of manure (wet) daily. This translates to 11,340 kg (25,000 lb) per day or 4,139 metric tons (4,563 tons) per year for each 100,000-bird house. Accompanying this large accumulation of manure is a concentration of manure odor. Odors produced when manure is allowed to accumulate and dry under the cages are marginally acceptable to many people. However, when manure is moved or spread, odors can be produced which nearby residents find intolerable. These odors can be highly attractive to flies.

Manure disposal has become a full-time chore on many farms. Although the value of poultry manure as a fertilizer has been well defined, most farm managers emphasize egg production and completely overlook the potential merits of promoting the manure. Manure and manure disposal are viewed as a profit loss portion of the egg business, and it appears that little is being done to reverse the situation. Manure disposal by spreading on land is becoming more difficult in some locations because not enough land is available to utilize the manure being produced. Improper disposal of manure on land has resulted in overnight outbreaks of large fly populations in places where flies were never before a problem. In many areas, statutes have been enacted which regulate manure application rates dependent on soil types and land use.

CONFRONTATIONS WITH SUBURBANITES

The idyllic connotation of chickens and egg production still persists in the minds of the general public, but it has long faded from the American scene. Few Americans still have direct ties to agriculture, and most are unaware of modern farming procedures and how farm products are produced. Confused but angry homeowners have often stated that they do not need the nearby poultry and dairy farms because they get their eggs and milk from the grocery store! It is difficult for them to appreciate the benefits of large agricultural facilities if flies and odors have become unbearable.

Many occupants of suburban developments are urban transplants. In some areas, they are primarily retirees. These individuals are looking forward to country living as they perceive it and they can be highly intolerant of agricultural odors and insects of any species. Any species of fly may be suspected of originating from a nearby livestock or poultry facility. According to ordinances in some cities and counties, homeowners can organize and petition to have a poultry or livestock facility declared a public nuisance and closed. Several states have enacted Right-To-Farm laws to protect farmers in these situations.

Many health departments are obligated to respond to fly and odor complaint calls in suburban areas. In locations where confrontations between suburban residents and agriculture have become routine, inspectors are usually well trained and can accurately evaluate the problems. In areas where these situations have just begun to occur, or where they occur on an irregular basis, health department staff may not be adequately trained, and can greatly confound the situation. The result can be a general breakdown in public relations between the producer and the community.

STATES WITH CRITICAL PROBLEMS

To obtain current, local information for this section, a telephone survey was conducted of state and federal research scientists and extension agents in entomology and poultry science disciplines in the eastern states. When contacts could not be made in a particular state, information was obtained, if possible, from personnel in adjacent states.

The potential for confrontations occurring between suburban residents and egg producers is greatest in states with the largest numbers of laying hens and the highest projected rates of population increase (Garwood 1987). Eight states, six of them east of the Mississippi River, fall into this category (Table 1).

In Florida, the most rapid human population growth is occurring between Orlando (Disney World) and Tampa. The largest concentrations of laying hens are found in the same area. Although dairies are undoubtedly contributing to the fly and odor problems, the local poultry producers usually get the blame. No farms have been closed yet, but lawsuits are not uncommon. The most routine reasons for complaints in the past five years have been excessive flies and odors resulting from improper management and disposal of manure. Several companies clean their houses weekly as a means of fly control. However, under Florida conditions, house flies can complete their life cycle in less than 6 days (Larsen & Thomsen 1940). In many instances, manure contains all three larval instars when it is removed from the houses. Producers are encouraged to harrow manure into the soil if fields are fallow, but enough 3rd-instar larvae can survive this process to produce large adult populations within 2 or 3 days (Mellor 1919). Fly populations are often large enough to be very pestiferous, even in sparsely inhabited areas. Long-term fly problems occur when manure is discarded by stacking large amounts in wooded areas. Since flies can disperse 20 km (Bishopp & Laake 1921) or more, production of large fly populations in isolated areas does not go unnoticed.

Most county health departments lack trained personnel and resources needed to inspect poultry facilities and manure disposal sites. However, USDA and University of Florida Cooperative Extension personnel are working closely with the counties to help train the inspectors.

New York and Pennsylvania both rank high in layer and projected human populations, but so far these two groups are located in different parts of their respective states. In New York, New York City accounts for most of the human population, and the poultry farms are in the less-populous upstate area. There are more fly nuisance problems with dairies than with poultry farms. In Pennsylvania, there have been isolated fly problems on poultry farms in the southeastern part of the state. Potentially, however, there could be more serious problems in the future if an increase occurs in land development.

In Ohio, large egg farms are located in the central portion of the state, many of them foreign-owned. Fly problems resulting from poultry farms have been serious, and several lawsuits have been filed in recent years. Poultry-related fly problems are considered serious in North Carolina, but are second to dairy. However, complaints resulting from flies or odors from poultry farms may average 50 to 100 per year. Prosecution is difficult if producers are using approved management practices and are trying to control flies. There has been recent litigation, but producers have lost only 1 case out of 25. In Georgia, poultry farms produce more serious fly problems than dairies. There are problems with flies breeding in layer houses, and with manure disposal. Some odor problems have been noted with lagoon systems. There have been many recent lawsuits, and producers can be closed in accordance with certain state and particularly stringent county laws.

OTHER STATES WITH FLY PROBLEMS

In Connecticut, moderate to serious poultry-related fly problems have been noted. Most of the farms are east of the Connecticut River, an area of rapid urban encroachment. Although land values are high, producers cannot afford to sell and re-establish in more western parts of the state. There has been some recent litigation and a state manure management advisory group is being formed. Some isolated fly problems with poultry farms have been reported from Maine and New Hampshire.

Poultry farms are a major cause of fly and odor problems in New Jersey, followed closely by dairies, and more distantly by horses. State nuisance laws are in effect--i.e., no one has the right to create a nuisance, either flies or odors. There have been some recent lawsuits filed. Similar fly and odor problems have been reported from Delaware and Maryland where farms have become surrounded by urban sprawl.

Poultry populations are growing rapidly in the mid-western states. Indiana has more layers than the neighboring states of Illinois, Michigan, Iowa, and Ohio, but the human population is slightly more than Iowa's, and much lower than those of Illinois, Michigan, and Ohio (Garwood 1987). Most poultry farms are located in the southern part of the state and fly problems exist year-round in the enclosed houses. There has been some recent litigation, but there are few pertinent state or local laws. In Minnesota, most poultry farms are still in rural areas, and few problems have been reported. More severe problems could occur, however, if future development occurs in agricultural areas of the state.

In Alabama, poultry-related fly problems are considered serious. Most farms are in the central and northern part of the state and complaints are numerous in the spring. Health department personnel are trained primarily in vector control, but have the authority to close farms. Once the health department enters the case, producers are at a disadvantage, because it is the producers' responsibility to prove that a fly nuisance does not exist (in most states, it is the State's responsibility to prove that a nuisance does exist). Several cases have been tried recently and won easily by the State.

Poultry-related fly problems are considered extremely serious in South Carolina. Problem farms are located in the upper Piedmont where high-rise, deep-pit houses comprise 80% of the problem. Health department personnel are well trained and authorized to close farms. Fly control laws are fairly stringent and several cases have been tried in recent years.

In Arkansas, Louisiana, and Mississippi, poultry farms are found in rural areas and fly problems related to poultry are localized and not serious. In Arkansas, health department personnel have little experience making inspections on agricultural facilities, and there are no specific fly control laws. However, a farm can be declared a public nuisance and closed. There have been cases tried recently, with the producers losing all of them. In Louisiana, fly control laws do exist and health department personnel are well trained. One case was tried recently. The producer lost, but cleaned up his farm and was allowed to stay in business. There are no fly control laws in Mississippi, and a single health official is responsible for fly problems statewide. There are occasional complaints, but the only cases investigated are those with many persistent complaints. There has been no recent litigation.

RESISTANCE AND THE COST OF FLY CONTROL

Resistance to organophosphorus and pyrethroid pesticides used as larvicides and adulticides was noted or suspected in 75% of the eastern states. Resistance to Larvadex® (Ciba-Geigy, Agricultural Division, Greensboro, NC), the feed-through growth-regulator, was noted or suspected in 67% of the states.

It is difficult to appreciate how much the producers, and ultimately the consumers, are paying for fly control without estimating an annual cost value. A hypothetical value, excluding labor and equipment, can be calculated by estimating the cost of Larvadex that would be utilized had it been included in all layer diets fed in the U.S. during 1990. This is assuming that essentially every producer is using some pesticide for fly control, and that some comparable form of fly control is being used when Larvadex is not being used, e.g., chemical larvicides and adulticides, manure removal, etc. Feed consumption can be derived by assuming that laying hens consume ca. 36 kg (80 lb) of feed per year (D. R. Sloan, Univ. Fla. Poultry Science Dept., Personal Communication). With an average of 270 million layers on hand in the U.S. (Florida Agricultural Statistics Service 1990), feed consumed during the 1990 production year (projected) would be 9.8 million metric tons (10.8 million tons). If Larvadex was added to all feed, not intermittently as recommended, at the rate of 454 g/900 kg (1 lb/ton) at a cost of $3.00/454 g, the total value of Larvadex, i.e., the cost of fly control in the U.S. for 1990, would be $32.4 million.

SUMMARY

House flies produced on poultry farms near urban and suburban areas are causing serious problems in many parts of the Eastern U.S., especially in states where both human and poultry populations are large (Table 1). A hypothetical value of $32.4 million was calculated for on-farm fly control costs in the U.S. during 1990. This is a high price to pay for an insect that causes no economic losses to the poultry industry, except for the possible spotting of eggs. Actually, the house fly is not really a pest of poultry, but a pest of people. The keys to fly control are good sanitation and manure management. Until the poultry industry considers manure as a valuable resource and not just a costly byproduct, the urban fly problem will continue to intensify.

NOTES

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Mention of a commercial or proprietary product in this paper does not constitute an endorsement or a recommendation for its use by the United States Department of Agriculture.

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Table 1. Rankings of 14 leading egg-producing states and the human populations in those states projected for the year 2000.

Layer rank	State	Projected human population rank
1	*California	1
2	Indiana	14
3	*Pennsylvania	5
4	*Ohio	7
5	*Georgia	11
6	*Texas	2
7	Minnesota	23
8	*Florida	3
9	Arkansas	32
10	*North Carolina	10
11	South Carolina	28
12	Alabama	24
13	*New York	4
14	Mississippi	31

Note: Asterisks indicate states with ranks of 14 or less in both categories.

THE INFLUENCE OF DAIRY OPERATIONS ON THE URBAN FLY PROBLEM

Richard W. Miller

INTRODUCTION

Suppose one were to ask a cross-section of people in the United States: "What do you picture when you hear the words dairy farm?" I think most people would visualize a farm in a rural area, perhaps with cows grazing in a pasture or housed in a barn. They might picture a family house, some barns, and a silo, but probably not a housing area or shopping center next door. However, this would not be an unusual scene in many areas of the United States, where suburbs have encroached upon previously rural areas (Figs. 1, 2, & 3).

The following two headlines from The Washington Post indicate that this is happening in Maryland, especially in counties that are within commuting distance to Baltimore and Washington, D.C.: "Increasing Development of Maryland Farmland Sparks Concerns" and "Maryland Farmland Disappearing at Rapid Pace." Many houses, sometimes quite large ones, are being built on land that was once cow pastures. One problem that results from the proximity of farms and developed areas is the nuisance caused by dispersal of flies from farms to surrounding homes or shopping centers.

SURVEY OF FLY PROBLEMS

In an attempt to assess the influence of dairy operations on the urban fly problem in the United States, I sent a questionnaire to extension dairy specialists in each state. The questions asked were: (1) Is the migration of flies from dairy farms to urban areas a problem in your state? (2) Approximately how many times in the past five years have you been contacted concerning the above problem? and (3) In the past five years have any dairy farmers in your state faced litigation regarding fly migration from their farms to urban areas?

Table 1 presents the results obtained from the questionnaire. Of the 41 people who responded to the questionnaire, 19 indicated that they did not consider the migration of flies from dairy farms to urban areas a problem in their states. Specialists from 22 other states replied that they did consider the migration of flies from farms to urban areas a problem in their states. Of these 22, 10 indicated that they had been contacted one to five times in the past five years, but only one of the respondents had experienced cases of litigation. Twelve individuals indicated that they had been contacted more than five times. Of these, six said farmers in their state had faced litigation proceedings.

STATES WITH MAJOR FLY PROBLEMS

For the remainder of this paper I will concentrate on the 12 states where the fly problems seem to be the most acute. The paper will describe situations in these states and present some examples of problems dairymen have encountered with flies dispersing from their farms to urban areas.

As Table 1 shows, states that appear to be experiencing the major problems with fly migration are located throughout the United States. Although dairies in these states differ in size and management practices, their capacity for the development of flies is a common problem.

A majority of the dairy cows in Kansas, Michigan, New Jersey, New York, North Carolina, and Pennsylvania are in herds averaging between 50 and 200 cows (Census of Agriculture 1987). Dairy herds in Colorado are somewhat larger than those just mentioned, and herds in Ohio are somewhat smaller. For the most part, these farms are family-owned and cows are housed in stanchion or free-stall barns, at least in the colder parts of the year.

Dairy herds in California, Florida, Hawaii, and New Mexico are generally much larger than those in the previously mentioned states, with a majority of the cows in herds of 500 or more. Cows in these states for the most part stay outside most of the time, only coming inside to be milked.

In certain areas in all of these states, developers have bought and developed land near existing farms, building primarily single-family homes. Families often have purchased these homes to get away from metropolitan areas and usually are not accustomed to odors and flies that come from the farms. Ground water contamination from farms has also been reported to be a problem in some areas of the country.

FLY DEVELOPMENT AREAS

Where do these flies develop on dairy farms? Meyer & Shultz (1990) list important locations for the development of the stable fly, *Stomoxys calcitrans* (L.) and house fly, *Musca domestica* L. on dairies in central California. These include calf hutches, along and under fence lines, around silage, in heifer pens, and in dry lots. These general areas are common to most dairies in the United States. If particular attention is not paid to controlling flies in these and other fly-breeding areas, large populations of house flies and stable flies may develop. When populations reach a high level, it is likely that they will disperse from the farms to surrounding areas. If these areas contain housing developments or other non-agricultural development, fly problems often surface.

Respondents made several points on the questionnaire and in follow-up phone discussions. The first of these is that homeowners usually blame poultry farms for fly production if both poultry farms and dairies are in the same area. It could be determined, however, that a fly problem is from the dairy farm if the flies found in the urban areas are stable flies, since this species rarely develops in large numbers on caged-layer farms.

Another point is that fly complaints often come from a small group of residents or even an individual resident with a low tolerance for flies. This is not to say that these individuals may not have a legitimate complaint. In a study conducted in Kansas (G. L. Greene, personal communication), five Alsynite® sticky traps were placed between a dairy farm and a nearby house (Fig. 2). Over a two-month period, a total of 700 to 7,200 stable flies were collected on each of these traps, with the trap nearest the house catching 6,400 stable flies. This study suggests that stable flies from a dairy farm can create a major nuisance if houses are close to the farm. Even if urban areas are located several miles from dairy farms, problems can arise, as it has been shown that both house flies and stable flies can disperse routinely for distances up to five miles (Eddy et al. 1962), and under special conditions stable flies can disperse considerably further (Hogsette & Ruff 1985).

Two particular situations that may result in high house fly and stable fly populations probably deserve specific consideration. The first of these is the area on a dairy farm where replacement calves are reared. Calf-rearing areas may be inside older barns converted to a calf-rearing facility or in a barn designed to house calves. These facilities must be cleaned frequently to prevent the development of large populations of flies. The use of the individual outdoor calf hutch appears to be increasing in popularity on dairy farms in the United States. Although outdoor hutches have proven to be beneficial in terms of rearing healthy calves, high populations of house flies and stable flies can develop in these pens, especially if the pens are bedded with straw. Schmidtmann (1988) showed that 25,000 to 40,000 stable flies and house flies could develop from the bedding of a single hutch during the summer.

In California these hutches are used on farms devoted to rearing dairy calves for herd replacements. Since these farms are often close to suburban areas, there is the potential for major house fly problems to develop.

A relatively new management practice of feeding cattle hay from large rolled bales has resulted in an ideal breeding medium for the stable fly. While the feeding from this type of bale is common in southern states (Hogsette et al. 1987), problems have been encountered in other parts of the country as well (Hall et al. 1982). Patterson and Morgan (1986) found up to 28,000 stable fly larvae per square meter of wastage around large round hay bales. Given the migration potential of stable flies, a major nuisance problem could easily develop.

The problem with fly dispersal from a dairy farm to an urban area was somewhat unique in Hawaii. The fly pest there is not the house fly or stable fly, but a species called *Musca sorbens* (Wiedmann), which is especially attracted to humans (Wilton 1963). This species breeds in animal manure -- in this particular case, fresh cow manure. The flies produced on one particular dairy dispersed to a nearby area where expensive homes were being built. The farmer received major complaints from the builder and residents of the homes. This problem appears to have been resolved on short-term basis through administration of diflubenzuron boluses to the cattle (J. L. Eschle, personnel communication).

SUMMARY

(1) The dispersal of house flies and stable flies from dairy farms to urban areas is a problem in many states.

(2) Breeding sites for these flies on dairy farms are fairly well defined.

(3) Other associated problems include odors and groundwater contamination.

(4) Because the trend of suburbs encroaching upon rural areas will likely continue, the problems discussed in this paper will need to be addressed in the foreseeable future.

NOTES

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Table 1. Assesment of fly migration problems from dairy farms to urban areas by state.

States where the migration of flies from dairy farms to urban areas is not thought to be a problem:

Alaska	Louisiana	South Dakota
Arkansas	Mississippi	Tennessee
Delaware	Montana	Vermont
Georgia	Nebraska	Virginia
Indiana	Oklahoma	West Virginia
Iowa	Oregon	
Kentucky	South Carolina	

States where dairy extension specialists have been contacted one to five times in the past five years:

Arizona	Minnesota	Washington
Connecticut	Missouri	Wisconsin
Idaho	New Hampshire	
Illinois	Rhode Island	

States where dairy extension specialists have been contacted more than five times in the past five years:

California	Kansas	New York
Colorado	Michigan	North Carolina
Florida	New Jersey	Ohio
Hawaii	New Mexico	Pennsylvania

States from which no response was received:

Alabama	Massachusetts	Texas
Maine	Nevada	Utah
Maryland	North Dakota	Wyoming

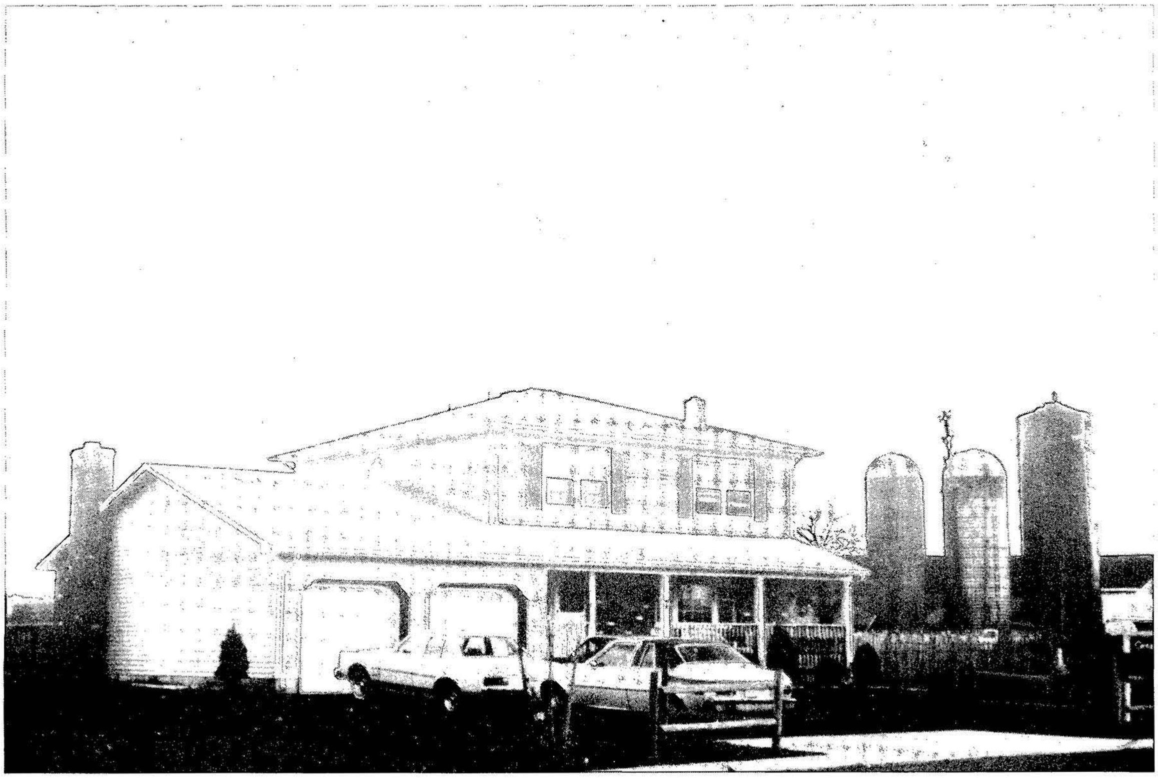

Figure 1. Relatively new home adjacent to dairy farm in New Jersey.

Figure 2. Proximity of house to dairy farm in Kansas.

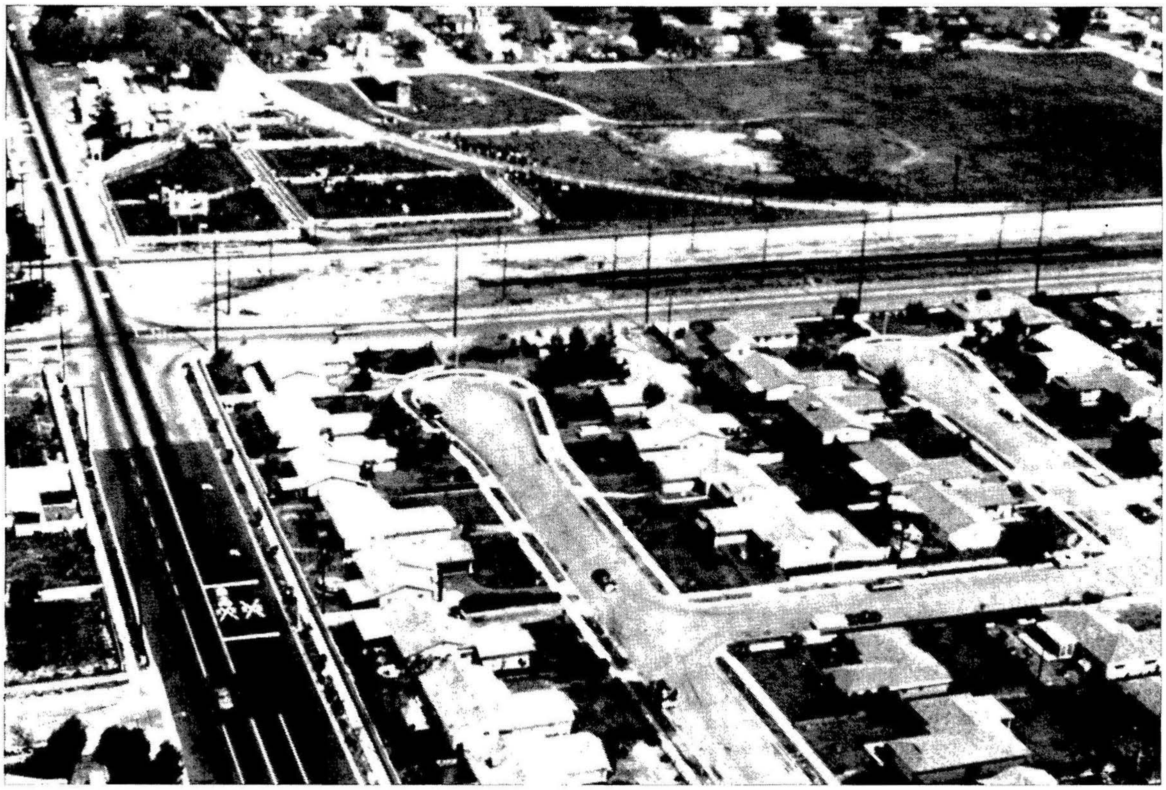

Figure 3. Housing area in foreground, dairy farm in background in California.

THE ECONOMICS OF THE FLY PROBLEM

John B. Campbell

INTRODUCTION

The two primary fly species that cause problems in the urban environment are the house fly, *Musca domestica* L., and the stable fly, *Stomoxys calcitrans* (L.). Feedlots, dairies, poultry, and swine units are major sources of flies that move from rural areas into urban neighborhoods. Slaughter houses may also be a source of fly breeding and may be located either in a rural or an urban area. However, flies may also breed in several urban environments; garbage, grass clippings, compost piles, dog kennels and any other areas that contain wet, decaying organic matter.

LAWSUITS

The economics of the fly problem for losses to various classes of livestock is certainly not well documented. Unquestionably, one important economic factor is the possibility of a lawsuit against a livestock production unit which cites flies, odor, and dust as a nuisance. The litigation is often a class-action suit which either requests punitive damages or, worse, that the unit be closed. In some states the suit may involve criminal charges if the litigation is initiated through a public health or environmental control agency.

Several years ago the Nebraska Supreme Court conducted a law review on this type of nuisance law suit. All litigations over a number of years were reviewed. The most notable aspect of the review, in my opinion, was that at no point in the document did it mention the possibility of changing conditions and management of an animal production unit to the point that it no longer constituted a nuisance.

In preparing this paper, I contacted knowledgeable people in the states of California, Florida, Georgia, Iowa, Kansas, New York, North Carolina, Texas, and, of course, Nebraska. There were many similarities in the problem of rural flies in the urban areas, but also some differences in the various states. One notable similarity was the fact that most lawsuits were initiated against large production units. The suits primarily were against poultry units in the southeast, against dairies in California and New York, and against feedlots and swine units in the Midwest.

In Iowa, eastern Nebraska, and other corn belt states, where much livestock feeding is done by farmers rather than commercial feeders, there are very few lawsuits. The same is true of major feeding areas where there are a number of large commercial feeding operations in one area such as southwest Kansas, northeast Nebraska, and southeast South Dakota. This indicates that areas economically dependent on livestock operations have fewer lawsuits. But, when a large unit is the only one in the area or urban housing begins to encroach into an agriculturally-zoned area, the larger operations are prime candidates for a lawsuit.

Iowa also has a right to farm law. This reduces lawsuits against existing confined livestock units. However, they do have considerable legal action when new units or expansion of existing units are in the planning stage.

TYPES OF INSECTICIDAL CONTROL

Because of the threat of lawsuits, livestock producers in the past few years have increased the amount of money they spend on fly control. In the case of stable flies at feedlots and dairies, this expenditure can be justified from the standpoint of weight gain (0.2-0.5 lbs/day) or milk production depression (40% reduction) caused by stable flies (Bruce & Decker 1958, Campbell et al. 1987). There is little evidence that house flies affect animal performance. Therefore, in areas where stable flies may not be present, the cost of house fly control efforts are made from the standpoint of aesthetic value, human comfort, possible vectors of disease, and to prevent complaints from neighbors.

Both house flies and stable flies breed in wet decaying organic matter. In confined cattle units, the breeding areas are usually wet animal waste or feed mixed with soil. However, the house fly also breeds in fresh manure. As a consequence, in hot dry areas, stable flies may not be present in confined cattle units; but house flies usually are present. Control efforts employed by managers of confined cattle units are generally the same for both species of flies.

In general, fly control consists of the application of quick knockdown area sprays into fly-infested areas with mist blowers, aircraft, hydraulic sprayers, or foggers. The insecticides are short residual and kill only the flies contacted by a spray droplet. Other methods of control employed to a much less degree include: insecticides incorporated into feed or mineral (feed additives), baits, and residual sprays. The feed additives are effective only in dry areas where house flies have fresh manure as a breeding source. Baits effect only house flies (stable flies feed only on blood). Overall, control of house flies with baits is impractical, but numbers around feed processing areas and the business office can be reduced.

Residual sprays are applied to fly resting areas. Stable flies rest in shady areas such as sides of buildings, bunks, shelter belts and windbreaks. The insecticide is absorbed by the resting fly. House flies rest inside of buildings, along the walls and ceilings, under eaves, and other protected places at night. These locations should be known when applying residual sprays.

THE ECONOMICS OF FLIES

The economics of stable flies at feedlots are difficult to determine. In Nebraska, the average cost of spraying and cleaning feedlots averaged $2,302 per feedlot in 1977 (McNeal & Campbell 1981). Nebraska feedlots average about 950 head per lot which means an average of $2.40 with an additional $1 per head for insecticide. We believe the $2.40 cost for cleaning feedlots should be divided equally between animal comfort (dry lots and mounds and reduced fly breeding areas) and house flies and stable flies which would assess $0.80 of the cleaning costs to stable fly control. The cost of insecticide should also be divided between house flies and stable flies ($0.50). This assessment would make the cost of control about $1.30 per head. Thus, in Nebraska, the cost of control would be $1.30 x 750,000 head on feed during the fly season = $975,000. Weight gain losses even with these control measures (based on 5 years of fly counting data and stable fly economic data) would indicate an average increase in cost of production of about $8.50 per head when both reduced weight gain performance and feed efficiency are considered (Berry et al. 1983, Campbell et al. 1987). The $1.30 cost of control plus $8.50 per head = $9.80 per head as a cost for stable flies in Nebraska. Using these figures, we estimate the annual loss to feeder cattle in Nebraska as a result of stable flies is $7.125 million per year.

There are about 10.5 million cattle on feed in the U.S. during the fly season (U.S. Environmental Protection Agency 1990). If the losses to those cattle are similar to losses in Nebraska, stable flies cost cattle feeders over $100 million annually.

At feedlots and dairies in the Panhandle of Nebraska, the stable fly is generally not abundant enough to be an economic factor but house flies often are perceived as a problem. There are about 100 feedlots and dairies in the Panhandle of Nebraska and 13,500 swine producing units throughout Nebraska where house flies are much more abundant than stable flies. Over one-half of the swine units and 75% of the Panhandle feedlots and dairies (6,825 livestock units) used sprays to control house flies an average of 13 times during the fly season (Campbell & Kamble 1981). We estimate each spray costs $25 if you figure cost of spray, labor, equipment and fuel costs. These figures mean that $2.23 million is spent for house fly control annually. We can't cite data that would indicate animal losses (weight, etc.) from the house flies, but they have potential for disease transmission, particularly in confined swine units. They are often the primary cause of lawsuits as urban growth infringes into agriculturally-zoned areas. Based on the number of swine in Nebraska (4 million on Dec. 1, 1987 [Nebr. Agric. Stat. 1987]), we can speculate that money spent on house fly control on swine at present (June 1 - October 1) would be in excess of $.50 per animal. If the costs of control in Nebraska is typical, it could be speculated that over $20 million is spent annually on control of house flies in the North Central States where 80% of the nation's hogs are produced.

In the poultry industry, there are about 280 million laying hens in the U.S. (U.S. Environmental Protection Agency 1990). It is estimated that the poultry industry spends $0.01 per bird for insect control. Because of the degree of house fly infestations at poultry facilities, it seems reasonable to assign half of that expense to fly control which amounts to at least $1.4 million annually. This figure is concerned only with the cost of insecticide and doesn't include the cost of equipment, labor, production losses or lawsuits. Much of the poultry production in the U.S. is in the southeast and California areas with fairly high human population concentrations. Rapidly expanding urban development often moves into poultry production areas. Since house flies are mobile and enjoy co-habitation with humans, these producers spend large amounts of money for fly control or face litigation.

Dairies, particularly class A dairies, also spend considerable money for control of house flies. Stable flies are generally present as well, so control costs would be divided between the two species. Class A dairies are inspected by local regulatory agencies regularly and fly control is generally a requirement of these agencies. There are about 10 million dairy cattle in the U.S. (U.S. Environmental Protection Agency 1990) and it seems reasonable that the cost of stable flies and house flies to dairy cattle would be similar to that of feedlot cattle ($9.80/head), in which case, these flies cost U.S. dairy operators in excess of $90 million annually.

Fly control is also a major concern of the horse industry. Only about 20% of the 5.75 million horses in the U.S. are professional (race, work, etc.) The remaining 80% are used in recreational, 4-H, and other private enterprises (American Horse Council 1977). The annual cost of insect control for horses is estimated to be about $125 million annually (Knapp 1985). A good portion of this would be spent for fly control, particularly stable fly control. In spite of this expenditure, privately-owned horses probably are major contributors to the urban fly problem. Thousands of horses are boarded and pastured at the fringe of urban housing areas. Many of these owners spend money for protection of the horse, via wipes, etc., but are unaware of the breeding areas of flies in the bedding and spilled horse feed around the stables.

SOURCES OF FLIES

Unfortunately, some livestock units become the victims of the conception by urban residents that all flies in the area are generated by the livestock. In fact, as indicated previously, the source of the urban flies may be urban NOT rural environments.

In addition, there are often small livestock production units situated in proximity to the big unit that is the subject of the lawsuit. These small units may have a few cows and calves, sheep or goats, dogs, and a horse or two. Fly breeding, sometimes major in scope, can occur at all of these places. Because livestock do not represent a major income source, much of the livestock handling and feeding facilities and equipment is makeshift. Consequently, spilled feed from winter feeding or drainage areas from the facility may provide breeding areas for high numbers of flies. The flies tend to migrate away from these smaller units because of the few numbers of animals. But it is almost never the small unit that gets sued. Perhaps because of the old adage, "you can't get blood from a turnip."

The economics of the rural fly problem in the urban environment is largely unknown, but the advent of lawsuits adds costs that could be considered hidden. Lenders are more cautious in loaning money for new or expanded livestock facilities. This may be reflected in higher interest rates. Liability insurance, particularly for commercial operations, is higher because of the fear of a nuisance judgment or the unit being forced to close.

If flies do migrate from a rural animal production unit to urban homes, the home owners may need to repaint the house if fly specks cause an unsightly condition. The estimate for repainting an average-sized home is about $800. If the home owner uses sprays to control the flies, the treatment costs would be approximately $15 per treatment for a residual spray and seasonal control might require as many as 10 treatments. Area sprays would be cheaper, costing about $10 per treatment, but less effective and requiring twice as many treatments.

House flies, by themselves, are not as noticeable in urban residential areas as are stable flies. Stable flies bite and, although many urban dwellers don't know the difference between species (they call the stable fly the biting house fly), the complaints increase dramatically if the stable fly is present. The problem isn't centered so much on the cost of treatment as it is on the fact that urban dwellers know very little about dealing with the problem. They are not aware of the biology or behavior of flies, types of control methods available, equipment needed for insecticide applications or characteristics of insecticides.

As a consequence, the urban dweller who experiences a problem with flies complains to the city, county, or state health agencies. The personnel of these agencies may be little better informed on how to handle the problem than the citizen making the complaint. The result is that little or no action is taken by these agencies and the urban dweller may finally resort to litigation simply out of frustration. In general, the homes built on the outlying urban areas are expensive, owned by citizens in the higher income brackets who expect problems to be solved by governmental agencies and if that doesn't happen, they are often willing to initiate a nuisance lawsuit.

SUMMARY

In summary, there is no data base that indicates the cost of the flies in the urban environment. But for the victims of the lawsuits I have cited, the cost can be as serious as going out of business.

As indicated previously, the cost of fly control is high for virtually every aspect of animal agriculture. Unfortunately, much of the cost is aimed at controlling flies rather than at breeding source reduction. In some countries of the world, notably China and a few African countries, sanitation (fly breeding source reduction) is the mainstay of a national governmental effort at fly reduction. It seems probable that if we in the U.S. increased educational efforts on this aspect of fly control, we could decrease the amount of money spent on fly control and decrease the numbers of flies simultaneously.

This is a national problem as indicated by the responses from states I contacted. The Agricultural Research Service is in the process of reviewing both the problem and the current research on the problem. I think we, as veterinary entomologists, should review the fly situation with the national production organizations (i.e., American Cattlemen, American Dairy Council, 4-H Councils, National Pork Producers, and the national poultry groups). We might do this through one or more of our regional research committees such as NCR-99, S-181, or through our Livestock Insect Workers' Conference.

NOTES

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LEGAL ASPECTS OF RURAL FLIES IN THE URBAN ENVIRONMENT

Dora K. Hayes

The cover of this book shows an artist's conception of the problem presented by the urban interface involving suburban encroachment on farms. Here, the cows have been "urbanized," but they still retain bovine properties. This is true also for chickens, pigs and sheep. Details of this problem in the urban-rural interface of beef, dairy and poultry operations have been discussed by others in this publication.

Legal problems related to urban-rural flies revolve around three aspects of the problem: flies; odor; and public and private nuisance. Fly-related nuisances may involve the physical presence of flies and/or the odors associated with sites in which nuisance flies are found. The laws and the suits often do not distinguish between them.

Four aspects of rural flies in the urban environment are considered in this paper. They are: (l) the United States Federal Code; (2) state and local codes regarding flies, odor and nuisance; (3) judicial interpretations of relevant state agricultural statutes and regulations regarding flies, odor and nuisance; and (4) the state "Right-to-Farm" laws.

THE UNITED STATES FEDERAL CODE

The United States Federal Code contains few provisions on fly control. For the dairy farmer, there is the Grade A Pasteurized Milk Ordinance (U.S. Food and Drug Administration 1978) which not all states have adopted in governing health aspects of milk production. This Grade A Pasteurized Milk Ordinance is specific about the techniques for minimizing fly populations; the emphasis is on keeping flies out of the areas where milk is handled and in reducing breeding sites. The mere presence of large populations of flies is an insufficient basis for closing down an operation, even though a large fly population constitutes a real nuisance to the operators and is annoying to casual visitors.

For the poultry farmer, the only requirement imposed by the United States Code is that the product be clean. The U.S. Public Health Service has published a "model" code for states and municipalities that regulates the processing of eggs and egg products, but this deals primarily with protecting the eggs or products made from eggs (U.S. Food and Drug Administration 1970). This code contains a wealth of detail about the processing and the standards the final product must meet, but little about the conditions at the locations from which the poultry operator supplied the eggs.

The Food and Drug Administration Acts (U.S. Food and Drug Administration 1980) deal with consumer safety and only tangentially with contamination caused by flies, i.e., adulteration by contamination with flies or fly droppings. Operators who commit minor violations are not usually prosecuted, since the legal ends of the act are deemed to be met by giving the operators an opportunity to adopt sanitary conditions.

As of June 1990, no citation to any case in which the United States Supreme Court had ruled for or against a farm or farms for fly-related health violations was found. We need, therefore, to look to the states and municipal statutes, ordinances and case law.

STATE AND LOCAL CODES

It is generally recognized that flies present a nuisance and a health hazard. The problems of flies, odor and nuisance have been addressed by state laws and by county and local ordinances. The possible magnitude of the fly problem is illustrated by Hogsette (1987) with stable flies who indicated that: "Landing rates of 80-100 flies per minute are not uncommon during outbreaks..." [of stable flies]. It is therefore expected that state and local governments have found flies to be a problem requiring legislative attention.

States where statutes might be expected to be stringent will probably be in areas where the suburbs are encroaching onto farmland. In the United States, populations are growing most rapidly in Florida, Texas and New Mexico. The ten fastest growing suburban areas are shown in Table 1 (U.S. Bureau of Census 1988). The largest numerical increases in Consolidated Metropolitan Standard Areas occurred in California around Los Angeles and San Francisco, in Texas around Dallas and Houston, and in metropolitan New York.

The greatest populations of cattle are found in Texas, Kansas, Nebraska, California, Iowa, Missouri, Oklahoma and Florida, with major marketing occurring in Omaha, Nebraska, South St. Paul, Minnesota and Sioux City, Iowa (U.S. Department of Agriculture 1989). Thus, it is evident that with human population centers, major concentrations of cattle may also occur.

Poultry eggs are primarily produced in California, Indiana, Pennsylvania, Georgia, Florida and Texas. Most milk production is in Wisconsin, California, New York, Minnesota and Florida (U.S. Department of Agriculture 1989). Thus, California, Florida, Texas and New York would be expected to have adopted laws dealing with fly-related food and health problems. As stated by Thomas earlier in this publication, the states of Kansas and Nebraska have heavy concentrations of feedlot operations and would be expected to have strong laws and ordinances dealing with related health problems as well.

A computer search of West Publishing Company's General State Data Bases of Annotated and Unannotated Statutes (1988) showed that California, Idaho, New York, Illinois, Louisiana, Massachusetts, New York and Texas had enacted laws on milk inspection regulation. Since not all states are covered by that data base, the list could not be complete. Maryland, for example, has a state regulation on conditions of farm sites within the state where milk is produced, but there is no reference to this regulation.

Colorado has public health laws regulating public nuisances which cover the presence of flies and fly-related hazards (Michie Co., 35-3.5-102). In California, Sacramento County (Sacramento County Code, Sec. 6.8.010 -090) has a Chapter of the County code dealing with fly and rodent abatement. In one case in Sacramento County, from 1986 to 1989, a turkey farm was prosecuted successfully and fined, first $250.00 and then

$500.00 as a public nuisance for producing flies.

JUDICIAL INTERPRETATIONS OF RELEVANT STATUTES AND REGULATIONS

Decisions as evidenced by case law in the various state appellate or supreme courts have included cases from Nebraska (239 N.W. 2d 481 195 Neb 509), Kansas (65 P.2d 601 160 Kan. 697), South Dakota (107 N.W. 2d 337 79 S.D. 28), New York (304 N.Y.S.2d 841 33 A.D.2d 32), Illinois (328 N.E. 2d 338 28 Ill App. 3d 115), Alabama (288 So. 2d 761. 292 Ala. 3), Iowa (196 N.W. 2d 557), Missouri (461 S.W.2d 784.) and New Hampshire (231 A. 2d 622 198 N.H. 237). Most of the cases primarily involved nuisance and odor, but in South Dakota (107 N.W. 2d 337 79 S.D, 28) a neighboring farmer complained that a locally operated dump produced flies. The courts granted a substantial damages award to the plaintiff.

The farmer or operator often settles out-of-court so that a case is not reported as a fully adjudicated decision after a trial. One settlement may be to terminate the farmer's activity. Being forced to shut down a farming operation may or may not be in the best interests of the farmer. If the farm can be sold for a large sum to permit further expansion of suburbia, the individual farm operator can profit substantially, although the farm must naturally discontinue operations.

STATE "RIGHT TO FARM" LAWS AND POSSIBLE APPLICATIONS

The number of states with zoning and "right-to-farm" laws is increasing (Fulton 1989). All states provide some protection for the farmer who was "there first" before suburbia burgeoned or other operations were initiated; all states except South Dakota have passed "right-to-farm" laws. The legal language of the right-to-farm laws is susceptible to differing interpretations. Grossman & Fisher (1983) published a major review article on "right-to-farm" laws. Hamilton & Bolte (1988) similarly analyzed nuisance law and livestock production.

The legal language of the "right-to-farm" laws is illustrated by a quotation from the West's Wisconsin Statutes Annotated (1988, 823.(08).(1)): "the law should not hamper agricultural production or the use of modern technology." While this seems to be clear, 823.08(2) (a) states that "closure shall not be available as a remedy unless the agricultural practice is a threat to public health and safety." Again, the farm operation appears safe. In (b), "The court may assess only nominal damages if the agricultural use or practice found to be a nuisance was conducted at the same location...prior to the time that any plaintiff acquired an interest in any property damaged by the agricultural use and practice". However, (c) of that same section states, "The court may order the defendant to adopt agricultural practices which have potential for reducing the offensive aspects of the activity or was found to be a nuisance." Here then, is latitude for the courts to examine the activities of the farmer and possibility to order some modifications, even though the operation itself was initiated before the new neighbors moved in and is protected by the "right-to-farm" language in the statute. In addition, in 823.08.(3)(a)

"...the relief granted, if any, shall not substantially restricted (sic) or regulate such uses or practices, unless such relief is necessary to protect public health or safety." This aspect of the law requires legal interpretation for the protection of the public if flies, odor and nuisance are found to endanger public health and safety. The judicial process required to flesh-out the meaning of the law may be very costly indeed for the farmer or poultry operator.

In the past 10 to 12 years, the prime impetus for regulating land use has shifted from local government to the states (Fulton 1989). Oregon, Maine, Vermont, Rhode Island, Delaware, Florida and New Jersey have passed statewide land-use planning laws. Massachusetts and Maryland are planning for Cape Cod and the Chesapeake Bay, respectively. These ideas and laws are more controversial in California. However, land use planning codes can be positive for the farmer. In his article, Fulton (1989) quotes Hansell, an Oregon farmer, who says, "How would you like it if I moved my hog operation in next door to you?" Of course, nothing was said about moving a suburb next to Hansell.

SUMMARY

In summary, there is no federal law that prohibits a farmer from running an operation that produces fly-related health hazards. At state and local levels, criminal and civil charges are usually brought against feedlots, dairies and poultry farms under public nuisance laws. Health laws vary from state to state in light of local conditions necessary to provide minimum sanitary standards and the right of the public to a safe environment. The nuisance of the flies themselves, odor and dust are commonly viewed as a public nuisance and numerous cases brought against agricultural operations have asserted those perceptions. As a counter-balance to the nuisance laws, "right-to farm" laws exist in all states except South Dakota, but vary widely from state to state and may or may not have "grandfather clauses" protecting existing businesses from the applications of accepted health standards. While they generally protect farmers from nuisance suits when reasonable agricultural activity is involved, they do not appear to provide absolute protection of fly and odor-producing operations against an ever-encroaching suburban community which has rediscovered that a part of living next to animals and poultry in "rural, bucolic America" can mean living next to large fly populations.

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Table 1. Fastest growing areas in the United States regardless of size (more than 30% increase).[a]

Location	Number of People (thousands)
Naples, Florida	100
Ocala, Florida	100
Ft. Pierce, Florida	200
Ft. Myers, Florida	200
Melbourne, Titusville, Palm Beach, Florida	300
West Palm Beach, Florida	700
Austin, Texas	200
Orlando, Florida	900
Ft. Walton Beach, Florida	40
Las Cruces, New Mexico	100

[a] Table abstracted from data in the U.S. Bureau of the Census (1988).

RURAL FLIES IN THE URBAN ENVIRONMENT - A Pest Consultant's View

Bill C. Clymer

INTRODUCTION

Fly problems have plagued our society since time immortal. As our population moved from the rural scene to the present suburban and metropolitan areas, attitudes changed and the nuisance factor became even more important. When our population had a rural base, flies were often accepted as "part of the territory". However, today's rural family has the same attitude about fly problems as their urban cousins. The trend for more leisure time and outdoor cookouts has also increased the awareness of the fly problem. Fly development does take place in urban situations, but many of the problems originate in the rural environment.

THE CONSULTANT'S INVOLVEMENT!

Living in the "middle" of cattle feeding country necessitated a major involvement in the problems generally associated with commercial cattle feeding. Many different problems exist relating to insects in the feedyard, however, fly management and control are considered to be one of primary importance. At the present time I consult for 10 feedyards with a one time capacity of over 650,000 head of cattle. The normal "turn-over" is 2.2 times per year with an average of 1.43 million head of cattle being fed annually. In addition to my regular clients, I consult for about 20 additional feedyards (ca. 500,000 head) on an as needed basis. Dairy, swine, poultry, and horse operations are also frequent clients. Occasionally cities, municipalities and home owners are also consulting clients. Numerous litigation matters concerning fly problems are also a part of the consulting business.

WHY ARE RURAL FLIES AN URBAN PROBLEM?

Many confinement livestock operations are in close proximity to urban situations. It is not uncommon for an agricultural facility to be located out in the country and have a housing development appear as its new neighbor. The town of Hereford, Texas has a population of ca. 10,000 with 12 large feedlots within an eight mile radius. Although many people in the town derive their income directly from the cattle feeding industry, the constant fly problem has become a major issue.

The small town of Sulphur, Oklahoma depends primarily on agriculture and tourism as its livelihood. Approximately three years ago, a 500,000 poultry egg layer operation was built within six miles of the city limits. The resulting fly problem that developed resulted in numerous legal battles and high operational costs for the poultry operation. The possibility still exists that an injunction will be filed against the poultry producer to stop his operation. Many long time friends are now on opposite sides of the problem.

Another example of this type of situation exists on the island of Hawaii. A large dairy operation had been in operation for many years on a rural area of the island. About four years ago the development of a major residential area was initiated. The "dream homes" being built in the development start at $750,000 per home. Many are in the two million dollar range. The dairy has suddenly found that it may no longer be able to operate at a profitable level due to the increased cost of fly control. Legal action has been discussed against the dairy by its new neighbors. The problem has since been greatly reduced through close supervision and management.

Our distribution of population is considered to now be 97% urban. Many former urban dwellers are moving into rural areas and find that flies are a part of the rural scene. Another major consideration in the fly problem is the change in general attitudes toward the use of litigation when any problems arise. We have become a "pro-suit" society.

ATTITUDE OF MANAGERS OF LIVESTOCK OPERATIONS TOWARD THE PROBLEM

Managers and owners are very aware of the problem, both from the actual economic loss caused by heavy fly populations and the potential nuisance problem that exists. The large feedlots that were previously mentioned are generally referred to as "custom" yards. This means that they feed cattle for other people. Many of their clients may be urban dwellers. The last thing a manager wants to happen is to have a potential client come to the feedyard to visit the facility and leave with a car full of flies. Managers must continually "sell" their yard to compete with other custom yards in the area. Public image is very important in the community.

Besides the people problem created by flies, they may also be responsible for numerous health problems in the cattle. Eye infections as well as respiratory infections increase as fly pressure increases. Cattle weight gains decrease as stable fly problems increase. Feedyards, as well as other commercial livestock operations, operate on a very small profit margin and any decrease in efficiency may result in a nonprofit situation.

Last but not least, the morale of the employees is very important. It is not uncommon for employees to become unhappy with their job if a constant fly problem exists. This same situation may apply to the families of employees who live in close proximity to the facility.

COST OF FLY PROBLEMS TO URBAN DWELLERS

The largest problem encountered by the urban dweller is generally the nuisance factor. In this era of backyard cookouts, outdoor weddings, sunbathing and many other outdoor activities, flies can ruin an otherwise delightful outing. Heavy fly populations may result in specking of windows and paint. Repainting and washing may be required.

In areas of heavy fly pressure, decreased property values may result. If problems continue, large sums of money may be spent on legal fees. The "goodwill" between friends and neighbors may be lost as a result of continual problems.

COST OF FLY PROBLEMS TO LIVESTOCK OPERATIONS

Sanitation and waste management comprise the largest single cost for fly control. Costs are totally dependent on the size of the operation, annual rainfall, and the amount that the facility is willing and able to spend on clean-up. Costs may vary from zero to well over $150,000 per operation.

Facility design is very important but often is one of the last things considered when planning an efficient operation. Proper design of any facility concerning waste management and fly control will substantially reduce the problems at a later date.

Many facilities depend on chemicals for their fly control. As the size of the facility increases, the cost per head decreases. This cost varies from zero to over $5 per head for the season. An average cost for a feedlot would be between $0.25 and $5.00 per head per month. A 20,000 head feedyard would spend an average of $5,000 to $15,000 per year for fly control. A yard of 75,000 head may spend between $18,750 and $56,000 per year. The various products that may be used include fly baits, residual sprays, contact sprays, larvicidal products, feed additives, self-treatment devices, and a few "wonder drugs" that show up from time to time. Products are used according to the label but care should always be exercised to prevent accidental contamination of agricultural products and the environment. Numerous types of equipment are required in a fly control program. Such things as box scrapers, front end loaders, several dump trucks, caterpillars, shovels, and a fly swatter may be required. Other costs include labor, employee benefits, and upper level management.

In the last few years, much interest has been shown in the use of beneficial insects and other biological organisms as a means of fly control. Parasitic wasps are the most popular method but other such things as predaceous beetles, disease organisms, and juvenile hormones are also being used. At the present time, the costs of this type of program is about equal to or is slightly higher than the standard chemical methods. However, the program has little risk to the surroundings and is still very much in its infancy. The next few years should see a very rapid increase in this type of program.

ACCEPTANCE OF FLY CONTROL PROGRAMS

Commercial confinement operations, such as feedyards, consider the cost of fly control a part of "doing business". This often increases the cost of the operation significantly and may put the operation in a negative profit situation. Community acceptance is a very important part of any operation, whether it be the neighbor that happens to be an attorney or the manager's wife.

Most communities that have "rural flies" are willing to accept the fact that total elimination of flies is an impossibility. Many of the people inhabiting these areas derive much of their income from the industry. It is not uncommon to find that the "rural flies" are actually "city born and bred". This fact should always be considered when assessing a problem.

SUMMARY

As we become more sophisticated in our production programs, we should remember this "little" problem will probably always be with us. There will continue to be more public pressure with fewer products for control. We will see more emphasis on biological control as well as a trend to pest management instead of "just control". As long as we have communication between the various parties concerned, the majority of the problems can be managed effectively.

NOTES

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DISPERSAL OF HOUSE FLIES AND STABLE FLIES

Alberto B. Broce

INTRODUCTION

Other contributors in this publication have discussed the problems that occur when rural flies produced in livestock operations move into town or into the urban-rural interface. I will review what we currently know about the dispersal of house flies and stable flies, and how their dispersal capabilities magnify the problem of rural flies in urban environments. I will also discuss the breeding of these flies in urban habitats, which often leads to situations in which livestock operations are mistakenly considered the source of these flies.

DISPERSAL OF HOUSE FLIES

Since the turn of this century scientists have stated, although often without showing evidence, that house flies and stable flies exhibit great abilities for dispersal. Knowledge of their dispersal habits has been obtained through different means: from circumstantial evidence of fly occurrence in places where breeding habitats are lacking, from the release and recapture of marked individuals, and from the capture of self-marked wild flies.

Hodge (1913) collected house flies and stable flies up to 9.6 km away from the shore at Lake Erie on the cribs of the water works. He observed that these occurrences increased when the wind was blowing from the land and that winds blowing from the lake carried these flies away. Parker (1916) conducted one of the earliest studies using the release of marked house flies. He reported that they dispersed about 3 km under urban conditions in Montana and considered this fly to be in essence a "migratory insect", not restricting itself to localized areas, moving rather, from the field of one stimulus to that of another.

In 1917, Ball (cited by Bishopp & Laake (1921)) concluded that the only explanation for house flies on the Rebecca Shoal Light Station off the coast of Florida was for these flies to have flown there from downwind, over water, from lands situated 38 (the Marquesas Keys) to 152 km (Cuba) away. Bishopp & Laake (1921) showed, in studies conducted near Dallas, Tex., that house flies marked with powdered chalk and paint pigments could be recaptured at distances of up to 21 km away, and that they could move 9.6 km in less than 24 h. In one of the earliest uses of radioactive tagging in the study of dispersal of insects of medico-veterinary importance, Lindquist et al. (1951) trapped house flies 19 km from the release point in an agricultural area near Corvallis, Ore. Quarterman et al. (1954a) combined radioactive and dye tagging of wild flies to determine the dispersal of house flies in a rural area near Savannah, Geor. They found that house flies moved up to 8 km from the release point in 24 h; and that, although flies tended to congregate more at places where food and breeding materials were more abundant, the availability of these materials did not prevent flies from leaving any given location, and that the flies movement ranged over a large area.

Studies on the habits of house flies under urban conditions conducted by Quarterman et al. (1954b) in Savannah, Geor., and Schoof et al. (1952) in Phoenix, Ariz., indicated that fly dispersal was rapid and in all directions, with most of the marked flies recaptured within 1.6 km and some as far away as 12 km.

Hanec (1956), in a study of factors affecting dispersal of house flies in a dairy community in Manitoba, concluded that released flies did not disperse at random "...but orientated to the wind or wind-borne odors...", and that flies migrated in appreciable *numbers* among farms. Dispersal patterns of house flies from dairies in Maryland were studied by Pickens et al. (1967). They found that flies tended to disperse upwind when wind speed was steady 3.2 - 11.2 kmph, but randomly when the winds were variable. Their data suggest that flies tend to disperse more readily from dairies with fewer breeding habitats than from those with abundant breeding sites. Lysyk & Axtell (1986) found that the degree of house fly movement among farm habitats in North Carolina was related to the sanitation level of each habitat. Released flies tended to accumulate in farm areas where fly breeding habitats abounded. These various studies indicate that house fly dispersal is, in general, random. But because flies tend to stay longer in areas with ample feeding and breeding habitats, the populations build as compared to areas devoid or limited of these habitats.

DISPERSAL OF STABLE FLIES

The systematic study of the dispersal habits of stable flies was initiated more recently than that of house flies. Bishopp & Laake (1942) stated (without discussing experimental evidence) that marked stable flies were recaptured as far as 83 km from the release point. Eddy and coworkers demonstrated in 1962 that stable flies are good fliers, and that marked flies could move 8 km in less than 2 h (Eddy et al. 1962). Bailey et al. (1973) reported that studies with stable flies in flight mills demonstrated they can fly 29 km in 24 h. However, the authors observed a maximum dispersal of 3.2 km in the field.

Todd (1964) indicated, in describing the problem of stable flies in New Zealand, that uncovered ensilage stacks are the main breeding sites in rural areas, while open compost heaps and piles of grass clippings are the most important in urban areas. He observed that cattle on a farm with no fly breeding grounds located 1.6 km from known sources of flies were not disturbed by stable flies. He also indicated that these flies seldom disperse farther than necessary to secure a blood meal. However, Scholl (1986) found that most of the stable flies dispersing from feedlots in Nebraska were virgin nullipars with evidence of previous bloodmeal; he suggested that lack of food may not be the only force driving stable flies to disperse.

Numerous published reports have documented massive movements of stable flies over large distances. These dispersal patterns are believed to be usually associated with weather disturbances, such as fronts. Perhaps this is exemplified best by the conditions along the coast of the Florida Panhandle. King and Lenert (1936) noted that stable flies (also called biting house fly, dog fly) are a serious problem along Florida's Northwest coast from August through November. The numbers fluctuate from day to day, but the greatest prevalence occurs when the wind is blowing from a northerly direction. They also reported finding stable flies breeding in a *Sargassum* seaweed accumulated in piles at the edge of the water, and that cattle producers believed that flies produced in these breeding habitats then migrated inland for 16 to 24 km, or possibly as much as 40 km. Simmons & Dove (1941) reported that stable flies can become quite numerous and annoying to people fishing more than 19 km offshore of the Florida Panhandle.

Studies on the problem of stable flies in the Florida Panhandle by Williams & Rogers (1976) demonstrated that dispersing stable flies fly close to the ground and seldom higher than 1 m. They observed that stable flies use open "corridors" such as rights-of-way rather than wooded areas, and indicated that their movement toward the Gulf beaches is associated with winds from the north. More recently, Hogsette & Ruff (1985) investigated the migration of these flies in the Florida Panhandle in relation to weather patterns by marking wild stable flies with attractant self-marking devices (Hogsette 1983). Their results indicated that populations of stable flies on the beaches fluctuated in relation to cold fronts passing through this area. The numbers of stable flies caught on Williams Alsynite® plastic traps (Williams 1973) increased from 26 to 427 flies/trap/day before and after the passage of a front. Of great biological and economical significance was the trapping on the beaches of flies which had been self-marked on farms located 225 km away.

Stable flies are also a sporadic but serious pest of humans along the ocean beaches of New Jersey; their presence on the beaches has always been associated with westerly winds (Hansens 1951). Voegtline et al. (1965) indicated that stable flies can become quite annoying on beaches near Marquette, Mich., during certain days in the summer, and that fly biting activity (number of flies alighting on a human subject at a given time) was best correlated with increases in barometric pressure ("...warm, dry days, with breezes from the land, tended to have higher barometric pressure..."). These authors felt that wind direction, in itself, did not affect fly biting activity, rather that wind direction was correlated with some other weather variable having a more direct influence on fly feeding activity. Even so, the data on fly biting activity presented in their paper showed a good correlation with winds from the south or the southwest (from the land). Similarly, records made by Jack Parker (pers. comm.) on stable fly annoyance at Silver City Beach, Mich., on Lake Superior (near the Porcupine Mts. Wilderness State Park), show that "fly days" occur most often when wind is blowing from the south - southwest, as exemplified by data for June-July, 1983 in Fig. 1. However, "fly days" do not always occur when wind is blowing from these directions and "fly days" have occurred when wind has blown from other southerly directions, suggesting there might be other factors governing fly dispersal, such as weather conditions and abundance of flies at their source. Ottawa National Forest, Mich., is bordered by the Lake Superior coast on the north (on which Silver City Beach is located) and extends ca. 45 km on a southerly direction from Silver City Beach. Because it is unlikely that flies originated in the forest, it is safe to speculate that the source of flies dispersing into the beaches must be at least 45 km from Silver City Beach. Analysis of historical meteorological data, similar to those collected at Silver City Beach, should help understand the massive dispersal of stable flies.

The situation along the Lake Superior coastline in Michigan appears to be similar to those on the coasts of the Florida Panhandle and New Jersey. Likewise, there must be many other instances of massive dispersal of stable flies like those just described. Gerald L. Greene (pers. comm.) has observed significant increases in stable fly numbers in Western Kansas feedlots right after rainstorms. Similarly, Donald E. Mock[1] (1988) reported massive populations of stable flies covering the sides of houses and structures in northcentral Kansas at sites located miles away from any livestock operation during a period of hot weather which meteorologists associated with a stalled high pressure system. These observations suggest that the massive dispersal of these flies in association with weather disturbances may not be restricted to land areas bordering bodies of water. As suggested by Hogsette & Ruff (1985), stable fly movement over great distances probably is more noticeable along these coasts because this migration is terminated by a large body of water. Obviously, it is difficult to determine the source of flies which have migrated over large distances. Likewise it is very difficult to accuse livestock operations of producing flies in these situations.

Livestock producers operating in the vicinity of urban centers are well aware of the economic threat posed to them by flies in town or at the urban-rural interface. While stable flies and house flies are of concern to the livestock operator because of the damage these flies may inflict upon his animals, these flies can also be an additional source of problems when they disperse into town, or whenever flies in town are perceived as having immigrated from these animal operations. Studies dealing directly with movement of flies from rural to urban environments are few, but much needed. Schoof & Siverly (1954) demonstrated that in the urban-rural interface in Phoenix, Ariz., house flies moved from a poultry ranch, a hog farm, and a meat-packing plant into the urban area. Imai (1985) studied a house fly problem in Osaka Bay (Japan) and found a close correlation between the frequency of public complaints about house flies in the urban areas and fly densities at a landfill site located 0.5 km across a bay from the urban areas (urban areas monitored extended up to 5 km from the landfill site).

Fly population levels eliciting negative responses from urbanites (and potentially, legal action) are several levels of magnitude lower than the levels causing economic damage to the animals. This results in costly efforts by producers attempting to suppress fly populations to extremely, and often unattainably, low levels.

Although high numbers of house flies can be quite annoying to urbanites, stable flies are more noticeable and their complaint threshold is much lower. Stable flies are more noticeable to urbanites because of behavioral differences between these flies. First, stable flies are quite annoying to people when outdoors, because of their blood sucking habits and painful bites. Second, their feeding upon pet dogs in backyards often results in noticeable bleeding ulcers on the tips of the dog's ears. Third, these flies are noticed by the soiling of outside wall surfaces by their dark feces.

FLY BREEDING IN URBAN ENVIRONMENTS

Although it is clear that flies can and do migrate from livestock operations into urban areas, there is another part to this problem: the production of flies within urban areas and the perception by urbanites that these flies come from agricultural production areas. I have investigated the problem of urban flies in Manhattan, Kans., for several years, in an attempt to evaluate the degree to which they are a problem in this urban area, and also in an attempt to determine the origin of these flies in the city[2].

A preliminary survey of citizens of Manhattan indicated their perception that these flies originate in the various animal facilities at the edge of town. These include various Kansas State University animal facilities, such as dairy, sheep, and horse barns, a research feedlot, poultry houses and swine facilities, and animal holding facilities of the School of Veterinary Medicine. In addition, within town there are a zoo and barn facilities for holding ca. 40 bulls for artificial insemination purposes (Fig. 3A-D).

Surveys of compost and grass clipping piles in backyards of homes throughout Manhattan, using 0.25 m^2 emergence cone traps, showed a high percentage of these piles of decomposing vegetation to be producers of both house flies and stable flies (Fig. 2A-B). Fly production ranged from 0 to 122 stable flies and 0 to 676 house flies/trap (0.25 m^2)/week, representing a considerable source of the urban flies. The suitability of grass clippings as breeding habitat for stable flies is a well-documented fact (Schoof et al. 1954, Todd 1964, Ware 1966). With the practice of organic gardening becoming more popular we might expect this source of urban flies to increase, unless composting is done in a way that prevents the production of these flies.

The population levels of stable flies in Manhattan were monitored during 1982, 1983, 1985, and 1988 by placing Alsynite cylinder traps (Broce 1988) throughout the city. Some traps were purposely placed near the university horse and feedlot facilities and by the "Community Gardens", a public gardens area with numerous compost piles. No correlation was found between the numbers of stable flies per trap and the proximity of the traps to animal facilities on the periphery or within town (Fig. 3A-D). Traps located in the vicinity of the Community Gardens always caught the most flies.

Results of 1982 and 1983 surveys indicated a tendency for traps in yards with dogs to have more stable flies. To study this, in 1985, 11 areas in town were selected with 2 homes in adjacent blocks which either had or did not have dogs in their backyards. Results indicated that traps in backyards with dogs caught more stable flies than in those yards without dogs (Fig. 2C). Because stable flies do not seem to breed in dog feces, it has to be assumed that these flies developed somewhere else. Most likely, stable flies are attracted by the dogs or, stable flies in backyards with dogs remain there for longer periods of time than in those yards without dogs, thus increasing their chances of being trapped.

The distribution of stable flies within the urban settings may be affected by their breeding habitats and the presence of their main source of blood in town, dogs. However, there may be other unknown factors affecting their distribution. In 1988 I located pairs of houses in adjacent blocks; these houses had dogs in their backyards. Trapping with Alsynite cylinder traps indicated that stable fly distribution was highly clumped (Fig. 3D). The effect of breed of dog on stable fly distribution should be investigated, as it is clear that not all dogs react equally to the feeding of stable flies.

In a related study conducted in the summer of 1983, stable flies were found to adversely affect the training of Greyhound dogs in Abilene, Kans., by causing massive ear ulceration and modifying the dog's behavior to the point of decreasing their racing performance. The breeding and training of Greyhounds is located at the urban-rural interface in Abilene and it represents a multimillion dollar business for the community. Stable flies do not breed within the kennel confines, but move into these facilities from surrounding urban areas (with numerous home vegetable gardens and the corresponding compost piles) and from agricultural operations (swine, dairy, and feedlot) in the vicinity.

SUMMARY

These comments have not been made in an attempt to remove the blame or responsibility of livestock operations in producing flies which may become urban flies. There are clearly many instances of this being the case. In order to allocate responsibility for flies in urban areas one must conduct release-recapture studies. However, the fact that flies such as stable flies can disperse or migrate over long distances must also be considered. The report by Scholl (1986), which asserts that dispersing stable flies are in very early stages of ovarian development and have taken a blood meal, should be of great value in designing experiments to determine the origin of flies in urban areas by the identification of the host upon which they have fed.

NOTES

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1/ "Stable Flies", Kansas Insect Newsletter. No. 13, June 24, 1988.

2/ Portions of these data were presented at the "Workshop on Stable Fly Biology and Control in Cattle Feedlots", Garden City Branch Station, Kans. Agric. Expt. Stn., April 17, 1986.

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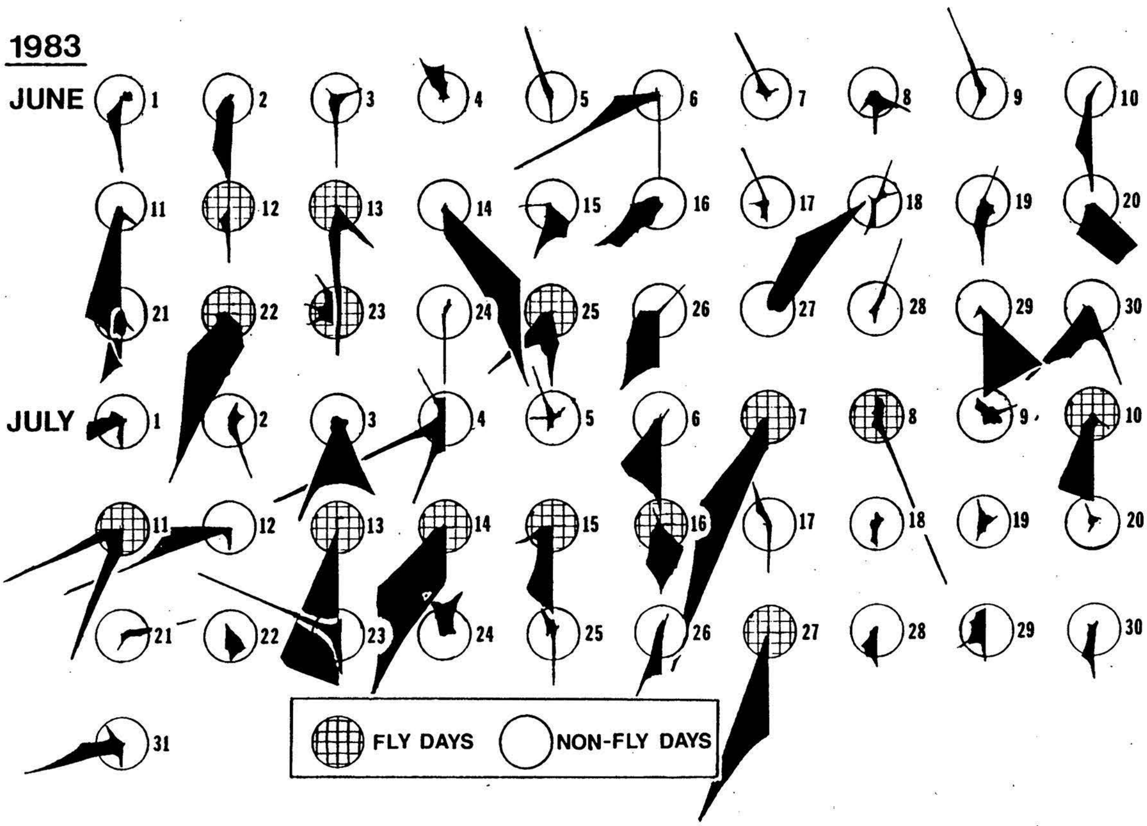

Figure 1. Frequency of wind direction at Silver City Beach, Mich, during June - July, 1983. Cross-hatched days indicate "fly days".

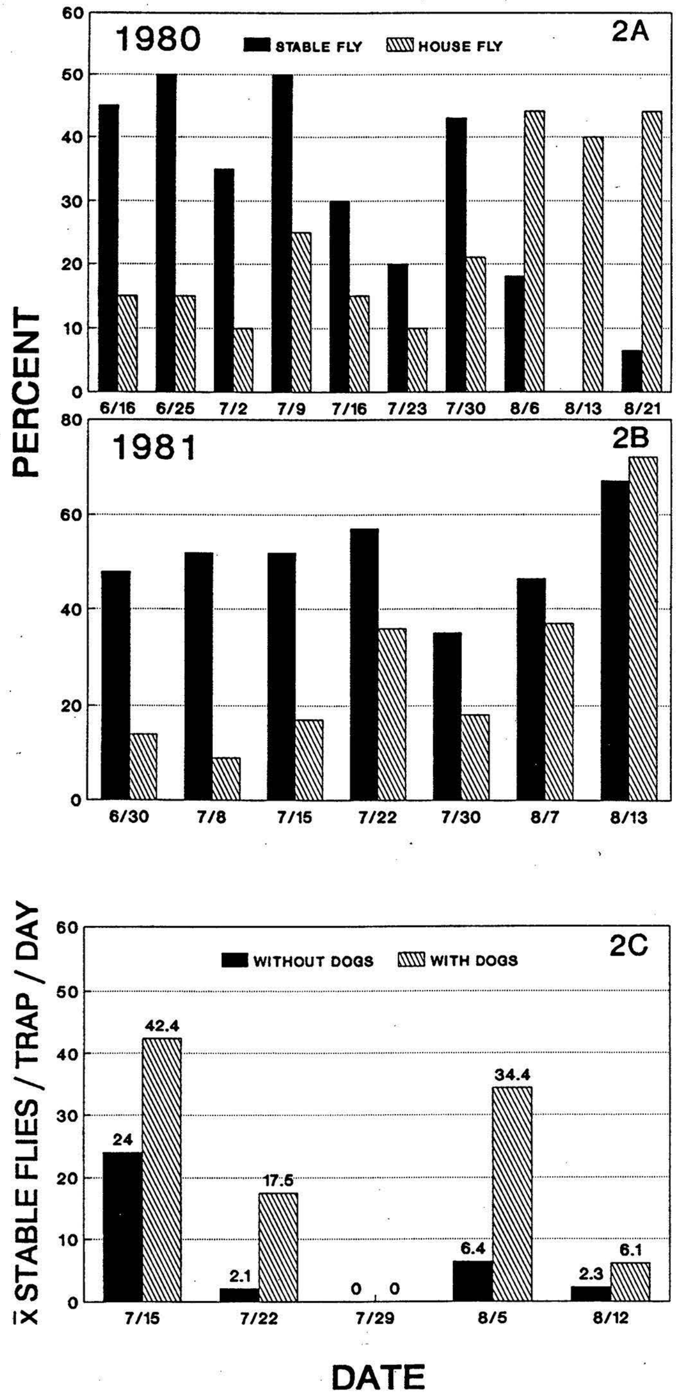

Figure 2A-B. Percent of grass clippings and compost piles in Manhattan, Kans., in which house flies and stable flies were found breeding during the summers of 1980 and 1981.

2C. Mean numbers of stable flies caught on Alsynite cylinder traps in eleven Manhattan, Kans., backyards with and without dogs. Summer of 1985.

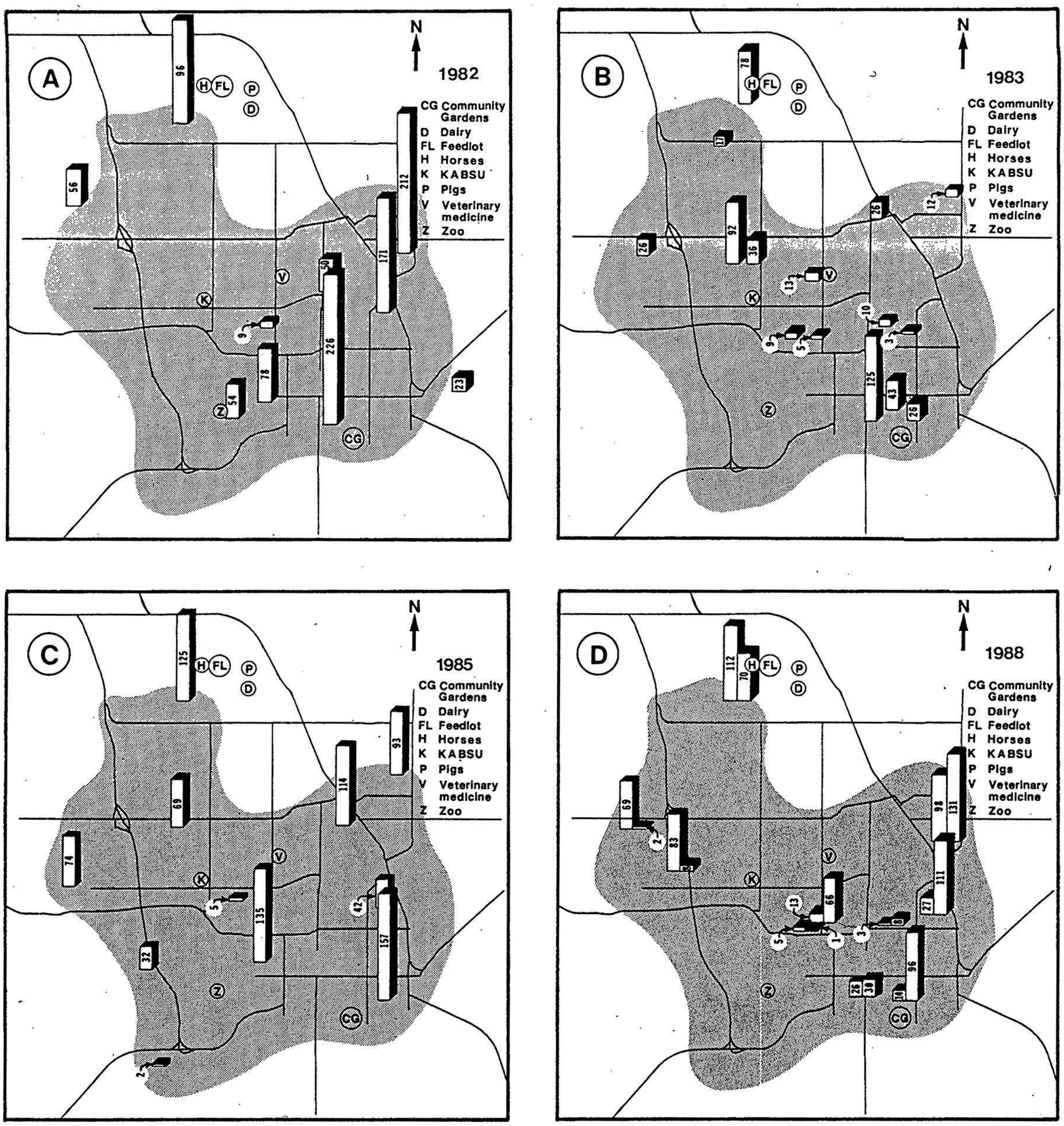

Figure 3A-D. Mean numbers (within bars) of stable flies caught on Alsynite cylinder traps/day in Manhattan, Kans., backyards during the summers of 1982, 1983, 1985, and 1988. Trapping on 1988 (D) was conducted in backyards of pairs of houses on adjacent city blocks.

BREEDING SITES OF STABLE FLIES AND HOUSE FLIES

Steven R. Skoda and Gustave D. Thomas

INTRODUCTION

The accepted common name for *Stomoxys calcitrans* (L.) is the stable fly, a name that connotes ruralism (Stoetzel 1989). Other names historically used for *S. calcitrans,* including dog fly and power-mower fly, relate that this fly can be part of the urban environment. The house fly, *Musca domestica* L., is well known as a cosmopolitan pest and, as the name implies, may be a pest in homes. Volumes of literature have accumulated for both the house fly (West & Peters 1973) and the stable fly (Morgan et al. 1983). There is, however, a paucity of literature regarding breeding sites under field conditions and most of the available literature is from research conducted in the rural environment. We consider a breeding site an area where an insect can successfully complete development through the immature stages and emerge as an adult. The purpose of this paper is to illustrate the known and potential breeding sites of stable flies and house flies.

SYNOPSIS OF BREEDING IN RURAL ENVIRONMENTS

Early reports showed that the stable fly can utilize decomposing vegetation (i.e. oats straw, hay, and other material kept as feed or bedding for livestock) as breeding sites (Bishopp 1913). Breeding is most frequent in vegetation that is actively fermenting; often at the area where vegetation contacts the soil. Some post World War II storage practices for animal feed, such as grass silage (Guyer et al. 1956) and large round bales (Hall et al. 1982) have been shown to provide breeding sites for stable flies.

Much of the post World War II field research on stable fly breeding has been done around confined beef or dairy installations. In the arid San Joaquin Valley of California, Walsh (1964) found the most consistent breeding of stable flies around feedlot waterers. Rasmussen & Campbell (1981) stated that stable fly breeding areas in Nebraska feedlots exhibit a rather wide range of physical conditions and further research was needed to evaluate factors influencing breeding. Meyer & Petersen (1983) categorized 16 breeding sites of stable flies in feedlots in eastern Nebraska and found manure under fencelines and in drainage ditches, open silage, and spilled feed to be consistent breeding sites. In a three year study of stable fly breeding sites in Nebraska feedlot pens, the area along the soil-to-concrete interface of the feed apron yielded about 80% of the stable fly immatures (Skoda et al. 1991) (Fig. 1). The mound area and manure under fencelines also yielded significant percentages of stable fly immatures.

The studies by Guyer et al. (1956), Walsh (1964), and Meyer & Petersen (1983) showed that, in cattle feedlots, house flies and stable flies utilized similar breeding sites.

Much of the recent research on house fly breeding has been done at poultry facilities. Hulley (1986) reported significant correlations of manure temperature and moisture level with house fly breeding. Stafford & Bay (1987) found most house fly larvae in manure with a 60-79% moisture level and at 27-28° C. But they stated that the house fly showed a wide tolerance of moisture and temperature conditions. Fatchurochim et al. (1989) found similar results for moisture preferences and tolerances of house flies developing in chicken manure.

Studies in rural environments have shown that stable flies and house flies can breed in similar materials. The house fly may be tolerant of a wider range of materials (i.e. more dense material and carrion can be used) and conditions than the stable fly. A laboratory study by Larsen & Thomsen (1940) showed that, under similar conditions, house flies complete development from egg to adult about 40-50% faster than stable flies.

POTENTIAL FOR BREEDING IN URBAN ENVIRONMENTS

Animal Waste

Small pets, dogs and cats, are very common in cities. These pets are often housed outdoors and their fecal waste, particularly when mixed with grass or bedding materials (such as straw or woodchips), is a good breeding site (Haines 1953, Schoof et al. 1954). Horses, popularly kept for recreational uses, are often stabled near suburban localities or small towns. Reports in the literature, from the early to mid-1900's, considered horse manure to be a primary breeding site for stable flies; waste material generated at horse stables can be a good site for fly breeding (Newson 1977, Kennedy & Merritt 1980). Animals in zoos, especially the larger exotic animals that are often housed in situations resembling cattle feedlots, also generate waste that can be a source of flies (Dipeolu 1976). Based on research at poultry confinements, we suspect that roosting sites for large flocks of birds can provide breeding sites, especially for house flies, in urban settings.

Urban Refuse

Garbage receptacles around human dwellings, restaurants and grocery stores, if not cleaned regularly, can be breeding sites for flies; particularly the house fly (Simmons & Blakeslee 1942, Schoof et al. 1954). Fly breeding has been reported in waste generated at meat processing plants (Greenberg & Bornstein 1964). Modern regulations preclude fly breeding problems within the facilities but waste produced by the facilities, and the disposition of this waste, could present a problem outside of the facilities. Nettles (1934) reported an unusual outbreak of stable flies associated with trickling filters at a waste treatment plant. Although modern operation of these facilities reduces the chances, the potential for fly breeding is there. Waste at sanitary landfills has the potential to be a fly breeding site (Poorbaugh 1978). Because of urban expansion in some regions and because landfills need to be located near the towns they serve, the location of future sites of landfills must be considered carefully.

Vegetative Materials

Coastal areas provide breeding sites for flies when large amounts of marine vegetation wash ashore and begin to ferment (King & Lenert 1936). Most cities have grassed waterways or water impoundments within their boundries; these can provide breeding sites for flies if litter accumulation along bank or backwater areas is not checked (Pickard 1968, Newson 1977). The stable fly is also known as the power-mower fly because of its ability to breed in fermenting grass trapped in housings of lawn mowers (Ware 1966). Grass piles, garden mulch, and neglected areas within botanical gardens can serve as breeding sites for stable flies and house flies, particularly if these materials are not composted or otherwise stored out of the weather (Newstead 1906, Broce 1986) (Fig. 2). The amount of grass and other vegetation in piles in the urban environment may be on the increase due to the popularity of 'organic' gardening and commercial lawn care.

Areas of Urban and Rural Interaction

As the urban communities of the United States expand they are encroaching on rural communities. It is not unusual to see towns and suburbs that are bordered by livestock confinement facilities that could serve as sources of flies. Grain elevators in towns, if areas of spilled grain are not cleaned regularly, can develop areas used as breeding sites by flies.

Rural sources are often implicated for fly problems in town. But, in a study in Manhattan, Kansas, Broce (1986) investigated potential rural and urban stable fly breeding sources. He placed Alsynite® traps at various livestock facilities, the Kansas artificial breeding service unit, the city zoo, and community gardens. Community gardens, a two-block area of vegetable gardens for the general public, was included because of numerous compost piles in the area. The abundance of flies in Manahattan did not correlate with proximity to livestock operations. Traps located in the proximity of the community gardens always trapped high numbers of flies. Although results of this study were not conclusive, Broce stated that he felt strongly that many stable flies in Manhattan were breeding in urban settings.

CONCLUSIONS

Much of the research on stable fly and house fly breeding has historically been done in rural agricultural settings. This is because the commodities affected have a tangible economic value, obvious sources of breeding were present, and concentrations of adult flies could be seen.

These flies could also be of significance in urban situations. The potential of adult flies to vector disease organisms is well documented. Although people of developed countries are exposed to more information in the education process of today, there may be a lack of assimilation of information regarding the importance of flies and disease (i.e. these were problems in history but it couldn't happen today). Some regulations to reduce potential breeding sites through sanitation, and thus reduce adult fly populations, are in effect. Perhaps there is a trend of today's urban citizenry growing complacent towards insect problems (i.e. the people responsible for insect control have done all they could); anticipating the 'cure-all' of insecticide applications. The impetus for the regulations promoting sanitation can be historically traced to epidemics (not only promoted by flies but in combination with other filth related organisms) related to unsanitary conditions. In this time of reduced government funding for programs, the importance of these regulations must be reemphasized. Also, the many documented cases of insecticide resistance coupled with concern for the environment is reducing the availability of insecticides for fly control and making other avenues of control necessary.

There are several categories of potential fly breeding sites in urban environments: 1) animal waste, 2) urban refuse, 3) vegetative materials, and 4) areas of urban and rural interaction. Each category has probably existed as a potential fly breeding source since humans became civilized, perhaps accounting for the synanthropy of stable flies and house flies. The trend towards more 'organic' gardening and the thriving business of commercial lawn care may increase the number of piles of vegetation in urban areas. This category of fly breeding site may be an area on which to concentrate efforts of control in the future.

Research that investigates the medical, economic and aesthetic importance of flies in the urban environment should be done. This could coincide with more research, similar to that of Broce (1986), that should be conducted to evaluate modern urban breeding sites of flies and the relationship to other filth frequenting organisms.

But more research is not the only solution to reducing fly breeding in urban areas. Each of the categories of potential fly breeding sites in urban environments can be collectively categorized as organic waste. In agricultural settings, sanitation (removing and disposing waste materials) is the primary factor in reducing fly breeding sources. Disposal is often accomplished by spreading waste material on fields; organic waste is good fertilizer. Sanitation is and should remain the primary factor in reducing fly breeding in the urban environment. Disposal of much of the organic waste could be accomplished by spreading on fields if people could be convinced of the usefulness (such as reducing health risk, fertilizer value, reduced land area needed for landfills, etc.). New regulations and more education programs may need to be developed so that compost piles are managed properly, concepts of integrated pest management are practiced by urbanites, and alternative waste management schemes are explored.

NOTES

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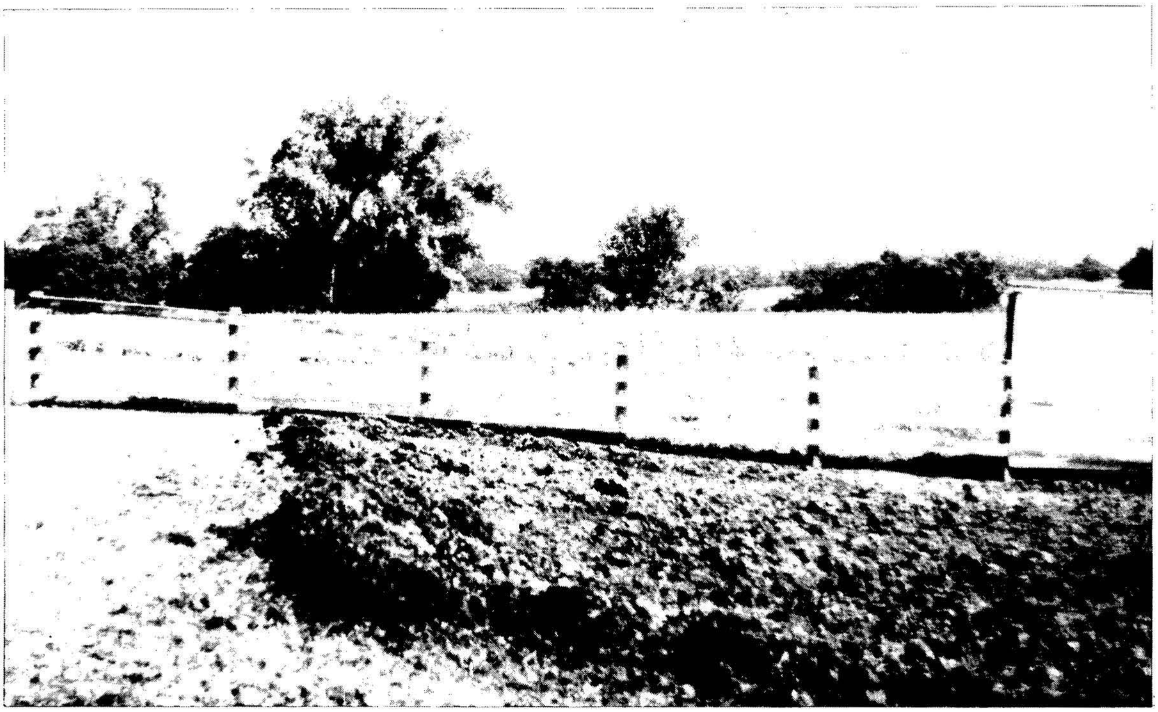

Figure 1. A feed apron at a confined beef feedlot, a good fly breeding area.

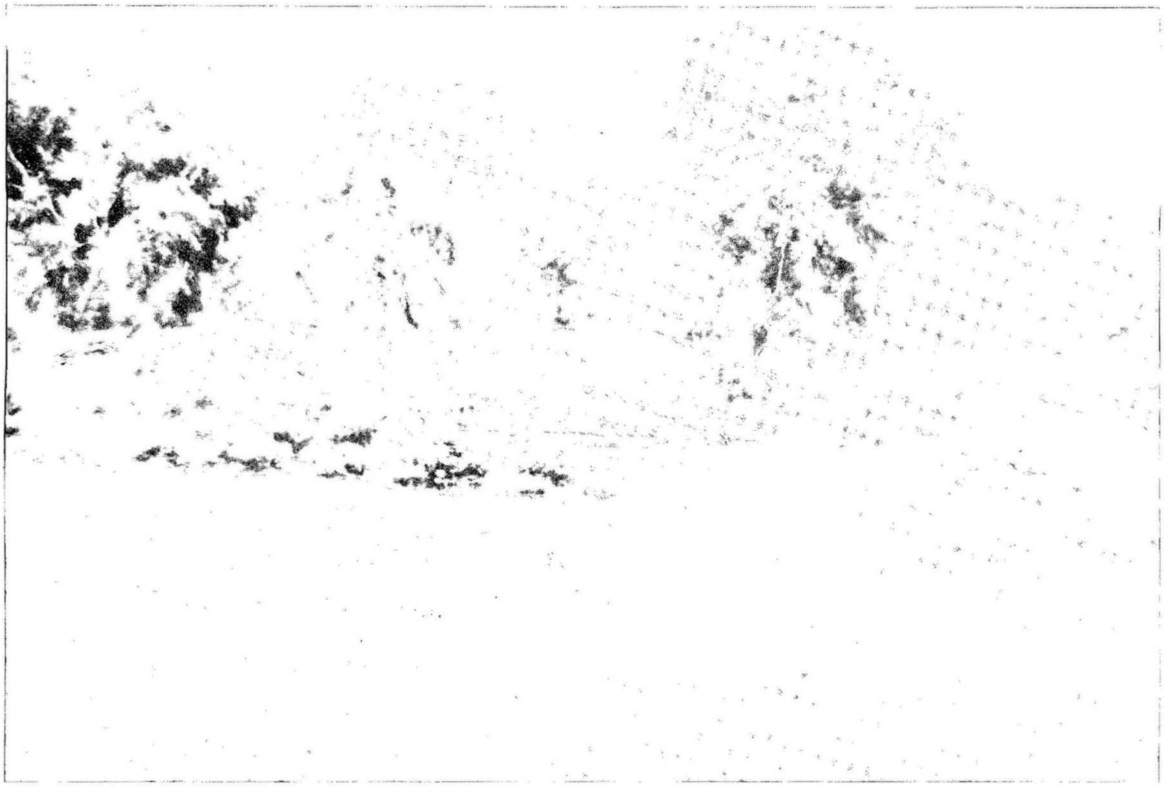

Figure 2. A grass pile, made by a lawn care service, exposed to the weather and a potential fly breeding area.

BIOTIC AGENTS TO CONTROL HOUSE FLIES AND STABLE FLIES

James J. Petersen

INTRODUCTION

Though biological control of filth flies has attracted considerable attention in recent years, with the exception of the fungus *Entomophthora muscae* (Cohn) (Mullens et al. 1987a), little progress has been made with pathogens or predators. As a result, most of the research efforts have been directed at the study of parasites, specifically entomogenous nematodes and pteromalid wasps. At least in part, interest in these agents has been stimulated because both groups are commercially available.

NEMATODES

A review of the literature suggests that little if any natural control is provided by nematodes against house flies, *Musca domestica* L., and stable flies *Stomoxys calcitrans* (L.). Studies with the commercially available nematodes *Steinernema feltiae* Filipjev, *S. glaseri* (Steiner), *S. bibionis* Steiner, and *Heterorhabditis heliothidis* (Khan, Brooks and Hirschmann), have shown promising results against a number of insects in moist environments (Gaugler 1981). Similar studies have been conducted with house flies to evaluate the possibility that one or more of these nematodes may have potential in the biological control of these flies.

In laboratory studies, Geden et al. (1986) reported that second and third instar house fly larvae were highly susceptible to *S. feltiae* and *H. heliothidis* when hosts were confined in petri dishes containing nematode treated filter paper. The authors further showed that these nematodes were less effective when applied to house fly media and poultry manure (Table 1); *S. glaseri* was ineffective against immature house flies. Georgis et al. (1987) showed that *S. feltiae*, *S. bibionis* and *H. heliothidis* survived poorly in chicken manure with few surviving after 24 h (Table 2). They concluded that poor survival and limited movement of the nematodes in poultry manure appeared to make the nematodes unlikely candidates for biological control of filth flies in this type of habitat.

When adult house flies were offered *S. feltiae* in a 5% sucrose bait on cotton balls, mortality averaged 67% at dosage rate of $1x10^5$ nematodes per ml of bait (Geden et al. 1986). In similar studies, Renn et al. (1985) reported that dosages of $1x10^6$ nematodes per 4 ml of water of *H. heliothidis* and *S. feltiae* resulted in 100 and 93% knock down of adult house flies in 48 h, respectively.

Under field conditions, Belton et al. (1987) were able to reduce house fly populations in a poultry house by applying *H. heliothidis* at rates of $5x10^5/m^2$. However, Wicht & Rodriguez (1970) failed to get significant reductions of *M. domestica*

and *Fannia femoralis* (Stein) under similar conditions using *S. feltiae*. Similarly, applications of 8-9x10^6 nematodes per sq. meter of *H. heliothidis* and *S. feltiae* failed to reduce populations of *Fannia canicularis* (L), *F. femoralis* or *Muscina stabulans* (Fallen) (Mullens et al. 1987b). Further, these authors reported that they were unable to demonstrate parasitism of larval house flies using *S. feltiae* (all strains) even under wet conditions that permitted nematode applications in close proximity to the hosts.
The data from these studies strongly suggest poor survival and limited movement of these nematodes in poultry manure making them unlikely candidates for control of filth flies in this habitat. These types of studies have not been reported for fly habitats on beef cattle feedlots or dairies.

PTEROMALID WASPS

The pteromalid wasps are of considerable interest as pupal parasites of house flies and stable flies. Since up to about 90% of normal pest fly populations die before reaching the pupal stage as Smith et al. (1985) reported for stable flies, and because the pupal stage is generally free from attack by most parasites, pathogens, and predators, pupal parasites are advantageous. As pupal parasites, these wasps have several advantages: first, any control effected by pteromalids can have a significant impact on adult fly populations; second, most of the wasp species can be mass produced economically; and third, several pteromalid species are commercially available.

There is considerable confusion as to the effectiveness of these agents. Much of this confusion results from the sampling procedures (natural or introduced hosts); where, when and how samples are taken; and the methods used to determine the incidence of parasitism.

Accurate sampling of parasite activity in the field is essential if reliable estimates of the effectiveness of these agents are to be made. Three methods are generally employed. One is the sampling of naturally occurring host pupae. This probably is the preferred method but is time consuming and has several disadvantages (Simmonds 1949, Shepard et al. 1983, Petersen 1986). First, sampling host populations usually remove a portion of the population before the sampled pupae are exposed to attack for the full duration of their susceptible period. Second, the degree of parasitism can be greatly affected by sudden increases in host populations in specific sampling locations. Third, parasitized hosts accumulate in the sampling site because of the protracted developmental period of the parasites compared with that of the hosts. This results in overestimates of parasitism.

A second method involves the introduction of pupal traps, usually sawdust in wire hardware cloth cages (Hogsette & Butler 1981), in larval habitats. This method eliminates the problem of parasite accumulation but does not prevent removal of hosts while still subject to attack. This method also is unreliable in that placement is often difficult and may not attract pupating fly larvae.

The third method employs the placement of laboratory reared flies in the field (Rutz & Axtell 1979). The advantages of this method include reliability and ease of sampling, exposure of hosts for a specific period, and controlled sampling of specific sites within the habitat. The major disadvantage of this method is that the placement of the sentinels is artificial and may give biased results because placement may favor one species over another, or may be outside the searching range of the parasites (Rutz & Axtell 1980, Merchant et al. 1987) (Table 3).

Further, any time naturally occurring fly pupae are sampled for parasite activity, biases can be introduced by the method used to determine percent parasitism (Petersen & Meyer 1985) (Table 4). If only intact puparia which produce flies or parasites are included in the determination, the probability is high that overestimation will occur because of the accumulation of parasitized pupae in the environment. If only intact puparia are included in the count, the parasite accumulation error is somewhat offset by the accumulation of host pupae that have died for unknown reasons. The most accurate but time consuming method is to include in a representative sample all encountered intact puparia, puparia with parasite emergence holes, and eclosed puparia. This method permits a good estimate of parasite activity over the history of the sampled pupal population. Normally, fly pupae in a particular population do not accumulate for more than a few days to 3 weeks, thus, the total sampling method gives an estimate of relatively recent parasite activity.

INCIDENCE OF NATURAL PARASITISM

Because of the previously mentioned sampling problems, comparing the results of various research studies is difficult but some generalizations can be made. Tables 5 and 6 summarize surveys of natural parasite activity in poultry houses and bovine confinements in the U.S., respectively. These studies show that parasite activity varies greatly over time. Petersen & Meyer (1983) reported that parasite activity generally increased over the season at Nebraska feedlots. They showed that there is a difference in relative abundance of a given species of the parasite guild in a given area or habitat. This type of information is important if these agents are to used effectively in control programs.

APPLIED CONTROL IN POULTRY HOUSES

Attempts to control flies associated with poultry have met with mixed results, but generally have been more encouraging then attempts to control flies associated with bovine confinements (Table 7). Pickens et al. (1975) reported 82-90% reduction of house flies and *Fannia* spp. following releases of *Pachycrepoideus vindemiae* (Rondani) but the facilities were very small (3 by 3 by 3 m) and artificial. Legner & Dietrick (1974) released *Spalangia endius* Walker, *Muscidifurax raptor* Girault and Sanders, *M. zaraptor* Kogan and Legner, and *Tachinaephagus zealandicus* Ashmead at 1-2 wk intervals for 20 months. They reported increased parasitism of *Fannia*, *Muscina*, and *Ophyra* spp. but not *M. domestica*. The *Muscidifurax* spp. were responsible for most of the parasitism achieved and *T. zealandicus* was not recovered. Further, they concluded that parasite releases did not apparently effect the relative abundance of native parasite species, and that releases during the spring months had a greater effect on fly population reduction than did similar releases in the summer.

Morgan et al. (1981a,b) reported high levels of parasitism following releases of high numbers of *M. raptor* and *S. endius* in Florida poultry houses (Table 7). They concluded that *M. raptor* did not seek house fly pupae below the surface of the habitat and did not function well in hot weather. Also, Morgan et al. (1975) reported that sustained releases of *S. endius* could completely suppress populations of house flies. Results of studies by Rutz & Axtell (1979, 1981) were not as successful as those reported by Morgan and coworkers (Table 7). They reported that releases of *M. raptor* resulted in significant increases in overall parasitism and some adult fly reductions. They concluded that *M. raptor* numbers can be increased in poultry houses and recommended earlier season releases with larger numbers of parasites than were employed in the studies.

APPLIED CONTROL AROUND BOVINE CONFINEMENTS

Where success has been achieved, it usually has been with low numbers of cattle and high numbers of parasites. Morgan et al. (1976) achieved 20-100% parasitism of house flies in a 13 by 7 m facility by releasing 18,000 *S. endius* weekly for 5 weeks (Table 8). Similar results were achieved following weekly releases of *S. endius* at a facility with 11 animals (Morgan 1980). At a pasture feeding station for dairy cattle, Morgan & Patterson (1977) reported a 96% parasitism rate of house flies again using large numbers of *S. endius*.

Reported attempts to control flies on larger facilities have not been as successful. Stage & Petersen (1981) observed an 8% increase in parasitism of house flies following the release of *M. raptor*, *S. endius* and *Nasonia vitripennis* (Walker), but the increased parasitism was not attributed to the released parasites (Table 8). Further, despite the release of 2.2×10^6 *N. vitripennis*, the researchers were unable to recover this species from house fly puparia. In a second study on 400-800 animal confinements, Petersen et al. (1983) released $7.2\text{-}10 \times 10^5$ *S. endius* weekly for 13 weeks. They were able to increase the percent parasitism attributed to *S. endius* by only 5%.

SUMMARY

The studies herein suggest that pteromalids have the potential to be effectively used as part of an integrated fly control program. However, these studies also show that much more information is needed if these agents are to to be used economically and with reliability. It is apparent that better communication is needed with commercial producers of these agents to assist the producers in providing a better product and in keeping them informed of latest developments. Also, it is apparent that there is no single species of natural enemy suitable in all situations. Considerable research is needed for different environments (i.e., temperature, humidity) and host source (i.e., poultry, hogs, cattle), to determine the best suited species for a given set of circumstances. Quality control is another factor that requires attention. Unpublished research from our laboratory suggests that parasites retained in colony for 2-3 years may loose their competitiveness when released in the field (Barry M. Pawson, pers. comm.). Further, species recognition and elimination of contaminant species in commercially produced wasps is an area that needs considerable attention (Stage & Petersen 1981). Other factors need to be addressed including timing of releases, numbers of parasites and numbers of release sites at a particular location, frequency of releases, parasite dispersal and persistence, limiting environmental factors (i.e., temperature thresholds, humidity), manipulation of the environment to improve parasite survival and effectiveness, and improved methods of releasing parasites. Though some of this information has been developed in the last 3-4 years, much remains to be done to answer these questions, without which, it is unlikely that the full potential of these parasites will be realized.

NOTES

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Table 1. Percent parasitism of third instar house flies by entomogenous nematodes in the laboratory (after Geden et al. 1986).

Species	Exposure surface[a]		
	Filter paper	Rearing media	Poultry manure
S. feltiae	93	56	28
H. heliothidis	98	26	22
S. glaseri	0	-	-

[a]Dosage rate of 5000 nematodes per host.

Table 2. Survival of infective juveniles of entomogenous nematodes applied to poultry manure (after Georgis et al. 1987).

Exposure time (h)	% survival[a]		
	S. feltiae	*S. bibionis*	*H. heliothidis*
3	68	74	57
12	34	49	26
24	0	7	0

[a]Treatments consisted of $1x10^5$ infective nematodes in 5 ml of water applied to 90 mm diam. petri dishes containing a 3-mm layer of poultry manure.

Table 3. Percent relative abundance of pteromalid wasps attacking house flies using three sampling procedures in North Carolina (after Rutz & Axtell 1980) and Indiana (after Merchant et al. 1987).

Location	Species	Native pupae	Sentinel pupae	Pupal traps
No. Carolina	*S. endius*	9	4	-
	S. nigroaenea	18	1	-
	S. cameroni	16	7	-
	M. raptor	56	81	-
	P. vindemiae	<1	7	-
Indiana	*S. endius*	3	4	<1
	S. nigroaenea	11	<1	15
	S. cameroni	87	96	85

Table 4. Comparison of three methods to determine the percent parasitism of field collected house fly pupae (after Petersen & Meyers 1985).

% fly	Puparia sampled[a]		
eclosion	Total	Intact	Live
0-86	15.5	17.2	32.2
<5	12.9	12.8	20.9
>20	15.7	23.2	49.8

[a]Total = all puparia in sample (including eclosed); Intact = all intact puparia; Live = only puparia producing adult flies or parasites.

Table 5. Percent relative abundance of pteromalid wasps parasitizing house flies in poultry manure.

Species	Florida[a]	Indiana[b]	No. Carolina[c]	California[d]
S. endius	26	3	4	32
S. nigroaenea	36	11	1	1
S. cameroni	38	86	7	6
Muscidifurax spp.	<1	<1	81	60
% parasitism	0-42	0-40	0-35	46

[a]After Butler et al. 1981.
[b]After Merchant et al. 1987.
[c]After Rutz & Axtell 1980.
[d]After Legner & Dietrick 1974.

Table 6. Percent relative abundance of pteromalid wasps parasitizing house fly and stable fly pupae during the summer on bovine confinements.

	House flies			Stable flies		
Species	No. Carol.[a]	Ariz.[b]	Nebr.[c]	Missouri[d]	Nebr.[c]	Kansas[e]
S. nigra	0	0	1	68	2	2
S. nigroaenea	<1	4	31	11	34	25
S. cameroni	12	17	11	0	14	12
Muscidifurax spp.	59	76	56	17	49	42
P. vindemiae	29	0	<1	0	0	0
Other	<1	4	<1	4	2	19
% parasitism	2 (1-6)	54 (7-96)	14 (0-32)	6 (0-50)	8 (0-23)	

[a]After Rueda & Axtell 1985.
[b]After Legner & Olton 1971.
[c]After Petersen & Meyer 1983.
[d]After Smith et al. 1987.
[e]Gerald L. Greene, personal communication.

Table 7. Attempts to control house flies on poultry installations with pteromalid wasps.

Location	Size (No. birds)	Parasite species	Application rate (x10^5)	% Control achieved
Maryland	24	*P. vindemiae*	0.05/wk/14wk	82-90
California	6,000	*S. endius*	0.35 over 5 mo.	3-46
		M. raptor	0.37	
		T. zealandicus	0.59	
California	-	*S. endius*	0.11/48x over 20 mo.	0
		Muscidifurax spp.	0.25	
		T. zealandicus	0.35	
Florida	6,700	*S. endius*	2.5/wk/10wk	93-100
Florida	30,000	*M. raptor*	3/wk/18wk	27-85
		S. endius	1/wk/7wk	
Florida	30,000	*S. endius*	2.6-3.5/wk/5wk	45-100
No. Carolina	20,000	*M. raptor*	4/wk/22wk	28-45
No. Carolina	30,000	*M. raptor*	1.5/wk/18wk	32

Sources in descending order: Pickens et al. 1975; Olton & Legner 1975; Legner & Dietrick 1974; Morgan et al. 1975; Morgan et al. 1981a; Morgan et al. 1981b; Rutz & Axtell 1979; and Rutz & Axtell 1981.

Table 8. Attempts to control house flies of confined livestock installation with pteromalid wasps.

Location	Size (No. cattle)	Parasite species	Application rate (x10^5)	Control achieved (%)
Nebraska	400	*M. raptor*	1	21 (incr. 8)
		S. endius	0.85	
		N. vitripennis	22	
Nebraska	400-600	*S. endius*	0.72-1/wk/13wk	18 (incr. 5)
Florida	11 + 80 wk 7	*S. endius*	3.8-12/wk/10wk	71(incr. 44)
Florida	13 by 7 m stall	*S. endius*	0.18/wk/5wk	93(20-100)
Florida	feed station	*S. endius*	5.3/wk/13wk	80-100
Denmark	6 farm	*M. raptor*	0.05-0.18	increase
		S. cameroni	0.05-0.18	

Sources in descending order: Stage & Petersen 1981; Petersen et al. 1983; Morgan 1980; Morgan et al. 1976; Morgan & Patterson 1977; and Mourier 1972.

CHEMICAL, CULTURAL, AND MECHANICAL CONTROL OF STABLE FLIES AND HOUSE FLIES

Gerald L. Greene

INTRODUCTION

With the large numbers of animals in confinement (7 million cattle on feed on the high plains), it is easy to see why the potential fly problems are so great. An animal will produce approximately a metric ton of manure per year and if four flies were produced from one gm of manure, then the manure from one animal could produce 4 million house flies. Control methods are critical to the success of confined livestock operations to reduce or prevent losses and irritation to the animals. When the animal facilities are close to urban or residential areas, there is an added threat of forced closing. This paper will discuss the controls available today and look at controls that may be revived if current controls fail due to efficacy, loss of chemicals, pollution, or public demand for reduced insecticide use.

CHEMICAL CONTROL

Control of flies with chemicals has been one of the main methods used for fly control for the last 100 years and is widely practiced today. One of the early reports of control (Osborn 1896) of insects affecting domestic animals lists some very interesting insecticidal substances (arsenic, carbolic acid, calomel, benzene, kerosene + milk, oil of turpentine, coal tar, cotton-seed oil, dust and ashes, pyrethrum powder, sulfur, and tobacco). An additional group of pre-DDT insecticides include: anabasine, barium, calcium arsenate, lead arsenate, cryolite, fluorine compounds, rotenone, ryanodine, sabadilla, tartar emetic, turpentine, and veratrine alkaloids. These materials were generally ineffective and were replaced by synthesized chemicals as they were introduced after 1945. However, not all early reports were negative. Brain (1918) reported good fly control at an armed service depot with 3,300 to 10,900 animals present: sprays consisting of caustic soda, paraffin, hyrol, mixed into boiling water and applied where flies were present, along with baits of arsenite of soda, black sugar and boiling water, resulted in a nearly fly free installation. The main fly control was by reduction of fly breeding through excellent sanitation and burying of the animal manure, thus greatly assisting the chemical control. Cory (1917) sprayed dairy cattle with creosote, coal tar, and pine tar which increased milk production by 3 lbs/day, but the milk was tainted. Formalin was added to milk to kill house flies (*Musca domestica* L.) by Smith (1911).

In spite of the large number of products available, flies are still present at livestock installations and migrate into urban areas. Chemical methods have been used repeatedly with variable results. The effectiveness of the chemicals is of less question than is contacting the fly. Control failure is probably more often a result of not contacting the fly than of chemical failure. That is particularly true of the stable fly, *Stomoxys calcitrans* (L.). House fly control failure may result from resistance to the insecticide (McDuffie 1960, Meyer et al. 1987, and Scott & Georghiou 1985).

There are many types of chemical control strategies with numerous variations possible that were outlined in Mock & Greene (1989) for stable fly control in livestock confinement facilities: 1) Environment spray treatments--residual, space (area) or larvicidal applications; 2) Traditional direct animal applications--sprays, dips, repellents, cattle oilers, and pour ons; 3) Non-traditional direct animal applications--ivermectin injections, ear tags and animal collars, oral larvicides, insect growth regulators and *Bacillus thuringiensis* Berliner.

Mock & Greene (1989) mention 1789 products registered by the U.S. Environmental Protection Agency for stable fly control, and thirteen insecticides registered for stable fly control on beef cattle or beef cattle premises. There are 772 commercial products available. Therefore, is it any wonder a manager would wonder if the best materials were being used.

Repellents and attractants have been tested with some effectiveness reported (Annon. 1958, Bruce & Decker 1957, Carlson & Beroza 1973, Defoliart & Morris 1967, Granett et al. 1951, Gilbert et al. 1970, Kawai 1962, Meifert et al. 1978, Morrill 1914, Richardson & Richardson 1922, Rogoff et al. 1964). Recent use of house fly attractant baits have shown mixed results, even though many cattle feedlot managers believe house flies are controlled. Probably the most effective repellent was reported by Bishop (1913) which consisted of covering horses with burlap, rather than use of chemicals.

CULTURAL CONTROL

The first change to make to reduce rural fly numbers is often to correct the confinement structure. The design of livestock facilities often has failed to consider fly breeding areas. Fence lines are a major source of fly development followed by drainage ditches. Haylage in small feedlots and spilled feed was a major source of stable fly breeding in a large feedlot in eastern Nebraska (Meyer & Petersen 1983). McNeal & Campbell (1981) reported potholes and lot corners as the predominant fly breeding areas in western Nebraska, with feed aprons, fence lines and drainage ponds contributing 15 to 17% of the breeding area, respectively. The rainfall is much less in western than eastern Nebraska which may account for some of the differences. In western Kansas we seldom find fly breeding in spilled feed as it dries before flies can develop. We see major fly breeding along feed aprons and in manure mounds only when there are wet areas, similar to reports from western Nebraska (McNeal & Campbell 1981) and eastern Nebraska (Skoda et al. 1991). Stored manure supplied 31.7 and 25.3% of the total stable flies and house flies at dairies in eastern Nebraska (Meyer & Petersen 1983).

Changing the feedlot structures to reduce manure accumulation or preventing water contact with the manure so that it dries, is one of the best fly controls available. Preventing manure accumulation under fences and keeping the residue dry along feed aprons and in manure piles goes a long way toward preventing fly breeding in the dryer high plains. More attention should be placed on fly prevention when building, repairing, or altering animal feeding facilities. Attention to construction and maintenance of feeding systems could reduce fly numbers many fold. The electric fence has been seen to create fly problems numerous times: animals will not disturb fly breeding under the fence which is often a wet area and produces numerous flies. When cattle numbers are high in the pens, typical of high plains cattle feedlots, manure is trampled and fly breeding prevented, except in very wet or inaccessible areas.

A severe stable fly outbreak during 1912 in Texas (Bishop 1913) resulted from flies breeding in straw piles that were wet from heavy rains. Bishop states that "the proper care of the straw is the most important step in control." Eliminating spilled feed and wet areas in livestock facilities reduces fly populations. The first attack on flies is to eliminate breeding locations. Fly prevention by burying animal manure and covering it to prevent fly production along with continual use of fly baits and sprays, was reported by Brain (1918). He demonstrated that flies could be controlled with good sanitation and continual fly control effort in warm climates, even before modern insecticides.

MECHANICAL CONTROL

Mechanical control could have a renewed emphasis for fly control with the increased fly resistance to chemicals, the loss of registered insecticides, and the interest in preventing chemical contamination. A maggot trap developed by Hutchinson (1915) and discussed by Cory (1918) was an attempt to control flies by killing the pupating larvae. Their trap consisted of a rack built over a concrete basin. As the horse stalls were cleaned, the cleanings were stacked on the slatted wood rack and sprayed with water. The mature larvae migrated from the manure (straw) rack and were drowned in water or a collection cistern. The mortality reported by Cory (1918) ranged from 84 to 99% of the house fly larvae. Fly counts were much lower near the maggot trap locations than in other residential areas. Hewitt (1914) used covers over manure piles to catch flies as they emerged. Prepupae moved two ft from the manure pile and nine inches deep, so the emerging flies were not all caught in the traps. At the end of Hewitt's paper, Z.P. Metcalf stated that Asheville, NC required manure be placed in tight receptacles and dampened lightly and Asheville had less flies than similar towns in the South.

Fly traps have received considerable study and even more extensive application prior to the use of DDT. One of the early fly traps used was a round screen cage with an inverted screen funnel at the bottom (Bishop 1916, Parker 1916). The legs were a couple inches longer than the screen providing room to set a pan of fly attractant under the cage. The attractant material was anything available that would attract flies, such as milk, fruit juices, yeast, vinegar, banana, beer, etc. This type trap was used by home owners in many towns and in the country. They may be revived for fly control due to environmental interests. They provide a very visual example of fly catch resulting in a feeling of success for the trap owner.

The Hodge fly trap (Hodge 1913) was one of the early fly traps developed for livestock buildings. It was designed to fit into a window and the flies would enter in response to the outside light. They entered the trap through small holes in the screen folds and could not find their way out. He shows 37 1/2 qt of flies caught in one week. A similar trap was proposed by Washburn (1912) and coined "The Minnesota Fly Trap". It used the inverted V screen with small holes in the V to let flies enter the trap, but not escape. The trap was baited with bread and milk or stale meat. They reported both house flies and stable flies were caught. The screen trap was used extensively in the U.S. until insecticides were developed in the 1940's and the introduction of muscalure and sugar laced with insecticides; these are predominantly used for house fly control in cattle feedlots today.

Additional traps have been designed for research use and may have control possibilities. The Alsynite® trap (Williams 1973) has sticky material on it to catch stable flies. They are attracted to the Alsynite, but there is controversy on what is the attraction mechanism. This is currently being debated and trap design studied (Broce 1988). The trap has been used for insect survey and control with insecticide application (Meifert et al. 1978, McNeal & Campbell 1981, Hogsette 1983, Thomas et al. 1989, 1990, Hogsette & Ruff 1990). A pyramid trap developed for house fly, stable fly and horn fly attraction has been developed by Miller & Pickens (1987). Thimijan et al. (1973) reported on an electromagnetic radiant energy trap to catch house fly, stable fly and face fly in barns.

Exclusion devices for working horses were suggested by Bishop (1913). "The most effective and inexpensive covering observed during the recent outbreak was a blanket made of double thickness of burlap so arranged as to completely cover the back, sides and neck, and the covering of the legs by means of trousers slipped on over the feet. The latter can be made of burlap or old trousers. When fastened together over the shoulders and back or attached to the harness, the animal is almost completely protected from the flies. Leather nets or other coverings should also be applied to the head."

SUMMARY

Chemical control of flies has evolved from use of natural products to complex chemicals which may have limited use due to fly resistance, environmental concern, or failure to reach the fly.

Attractants and repellents for house flies and stable flies have been reported. Controlling house flies using attractants to draw flies to chemicals or traps is common practice.

Cultural control or sanitation by removal of animal and plant residue to prevent fly development is the most important and first method of fly control to be used for fly reduction.

Mechanical control with traps and exclusion devices have been reported to give good fly control and may have increased use in the future.

Control of flies at livestock facilities will reduce the fly problem in urban areas and must receive added emphasis if we are to prevent an increased urban fly problem in the future.

NOTES

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MODELING OF STABLE FLY AND HOUSE FLY POPULATIONS

Danel G. Haile

INTRODUCTION

Modeling has been used for many years in a variety of forms to study fly population dynamics and control strategies. Also, a considerable amount of research on biology and population ecology of house flies and stable flies has been completed or is in progress to provide information for model development. A number of submodels and preliminary models have been constructed, but no comprehensive models are generally available. This paper will not attempt to review all of the previous modeling work related to stable fly and house fly research, but will discuss some of the more recent developments in modeling research and its relationship to the problem of rural flies in the urban environment.

MODEL TYPES AND GOALS

In general, all models have the common goal of synthesis of knowledge to better understand the interrelationships involved in a complex system. There are many types of models that can be used to study a complex biological system, such as that of fly population dynamics and control. These include conceptual, statistical and mathematical models, as well as, computer simulation models based on a life history analysis. Computer simulation models have become increasingly useful for analysis of pest systems because of their ability to incorporate a relatively unlimited number of relationships and submodels to produce biologically realistic results. The capacity of these models to include a variety of control technologies and study integrated management strategies is important. Field experiments with complex integrated management strategies are difficult, time consuming and expensive. Models cannot replace field experimentation but they can provide invaluable information to guide field research and limit the number and length of field trials. To this end, a number of federal and state institutions in the United States are involved in research to develop or provide data for computer simulation models of fly population dynamics and control.

MICROCOMPUTER-BASED MODELS

Computer simulation methods have been available for several decades, but recent advances in microcomputer technology have greatly enhanced the potential for use of models in the development and implementation of advanced approaches to pest control. With microcomputer equipment and programming languages, modeling software is easier to develop, debug, modify and validate. Currently, there are some limitations on the size and complexity of models that can be implemented on microcomputers as a result of memory or speed constraints. However, these limitations become less and less important as technology and software in the computer industry continually improve. Also, a majority of modeling projects can be accomplished satisfactorily, if the present or expected limitations are considered in design and implementation of the model. This is particularly true considering that today's microcomputers are more than equivalent to mainframe computers of a decade ago, and that advances in speed and power of microcomputers are proceeding at a rapid pace. One additional advantage of microcomputer based models is the potential for distribution to large numbers of interested groups or individuals that have compatible machines. This potential for additional users of a model requires additional work on the user interface for the software. Additional programming is needed for presentation of menu choices, data input and error trapping to make the program interactive and "user friendly". Although this additional programming is time consuming, the benefits of having the model available for others to use makes the effort worthwhile. Also, interactive software is beneficial to the model developers and research users in debugging, modification and validation of the model and in conducting extensive simulation experiments with the final model. The widespread proliferation and acceptance of personal computers also enhances interest and acceptance of models as an analytical tool that can be applied to practical problems.

MODELS AND THE URBAN FLY PROBLEM

Specific uses of models in connection with the urban fly problem are largely no different than any other research effort to improve methods for control of fly populations. If the numbers of flies can be effectively and economically reduced, there will be no urban fly problem. The most useful models will be developed in conjunction with or will utilize the results of basic research on fly bioecology and control. Research programs that coordinate model development with experimental work obtain the maximum benefit for both efforts. Most current modeling efforts in the United States can be categorized as research to develop or improve knowledge for more efficient or effective control of fly populations. Beyond fly control, research models, or future models designed for a specific purpose, have some potential uses relative to the urban fly problem. First, models that include predictions of fly migration can provide information for evaluation, planning or control of agricultural or urban development projects where an impact from flies is expected. Models can also provide a demonstration or educational tool concerning the urban fly problem and possible solutions. Last, models could be used in litigation of lawsuits involving fly populations. In lawsuits, models with sufficient validity could provide convincing evidence concerning whether or not a problem exists and the potential effects and costs of control measures that may or may not be in use.

FUTURE FOR DEVELOPMENT OF SIMULATION MODELS

Development of comprehensive modeling software is a time consuming process that requires a considerable commitment of resources. A team approach is generally required with the minimum team comprised of a biologist, systems analyst and computer programmer. The process of model development includes review of the literature, development of submodels, design of model structure, programming, refinement and validation. This process requires extensive feedback between the different steps to obtain a model of sufficient validity for its intended purpose. The accuracy of model predictions will depend on the quality of data used for model development and validation comparisons, as well as, the quality of data for input variables. The overall validity of a model is established by a variety of check points during construction and programming to provide reasonable confidence in the output of the model. Final validity is generally confirmed by comparison of model output (in terms of generally measured population variables) with real data from experiments that are independent of studies used in model development. Depending on the resources available and the purpose of the model, field or laboratory research may provide additional data to improve the model or to provide data for validation comparisons.

SUMMARY

The future of modeling efforts for stable fly and house fly populations (as well as other species) will depend upon the amount of resources available for further development. With the present competition for research resources, rapid development in this area will be very difficult. The goals of modeling research, however, are certainly valid and justifiable, and continued efforts will provide useful tools for understanding and managing fly problems. Future simulation models of insect pests will eventually be incorporated into more extensive system models or artificial intelligence programs covering all aspects of livestock and poultry production.

NOTES

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CURRENT AND FUTURE STATUS OF RESEARCH ON STABLE FLIES AND HOUSE FLIES IN THE UNITED STATES

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INTRODUCTION

When considering the current and future status of research on stable flies and house flies, it may be useful to first reflect on the changing demographics of the U.S. population and how this has affected the constituency and objectives of agricultural research in general. Fifty years ago and before, agricultural research by Federal, State, and private institutions was targeted almost solely for the benefit of individual farmers. Now, however, there are significantly fewer individual farms and 85% of the food and fiber required for the United States is produced by less than 10% of the population. Therefore, agricultural research targets were expanded so that they included not only individual producers but also agribusiness interests and some research to assist the consumers. Agricultural research must satisfy the needs of a blend of constituents that includes small and large producers, agribusiness, consumers, and even the urban/suburban resident. Thus, research on stable flies and house flies has as its objective not only increasing the productivity of livestock, but also preventing annoyance by these flies for entire communities.

CURRENT STATUS OF RESEARCH

As with so many agricultural problems, research to discover cost effective solutions to stable fly and house fly management is conducted by Federal, State, and industry research organizations. At the Federal level, the Agricultural Research Service (ARS) is the principal agency addressing the problems associated with management of stable flies and house flies. Research is conducted at five laboratories located in Beltsville, Maryland; Gainesville, Florida; Lincoln, Nebraska; Kerrville, Texas; and College Station, Texas. State agricultural experiment stations in 24 states throughout the country are conducting research on fly problems supported, in part, by the Cooperative State Research Service (CSRS). In private industry, over 25 companies are devoting some of their research efforts to the control of flies.

The areas of research emphasis vary among Federal, State, and industry institutions, reflecting their respective missions and objectives. Within ARS, emphasis is currently being given to integrated strategies for fly management by combining appropriate components such as manure management, adult trapping, biological control, and chemical control, including feed-through compounds. This applied research is supported by fundamental investigations in quantitative ecology, chronobiology, electrophoretic fingerprinting, basic fly physiology, and computer modeling using the dynamic life table approach. State agricultural experiment stations, too, have emphasized the integrated pest management of flies on the farm as well as in the urban environment. The academic institutions also conduct pesticide research, often in cooperation with the commercial sector, which addresses alternative compounds and formulations, pesticide degradation, and the genetics of pesticide resistance in house flies. Industry interests continue to lean to products, including repellents, new and better pesticide formulations, and novel and improved pesticide delivery systems. However, some segments of private industry have also taken a keen interest in biological control with pathogens as well as with large-scale rearing and distribution of parasites.

FUTURE RESEARCH ON THE MANAGEMENT OF STABLE FLIES AND HOUSE FLIES

Although there are many opportunities for new research approaches, particularly through the application of some of the more sophisticated technologies now available, only those areas of highest priority can receive attention within the limits of available resources. Of course, emphasis on research priorities will vary to some degree, depending on whether the sponsoring entity is Federal, State, or private enterprise.

In 1988, ARS held an in-house workshop to identify its own high priority research needs relating to rural flies in the urban environment. Workshop participants recognized six areas of future research that are still valid today, in the following priority order: (1) problem definition and quantification; (2) non-chemical control; (3) chemical control; (4) modeling; (5) targeted fundamental research; and (6) control systems. Within these broad areas of investigation, many opportunities exist for future research that will contribute to stable fly and house fly management strategies in the United States. A brief overview of some of these opportunities for the future may be valuable.

Problem Definition and Quantification

Although research on stable flies and house flies has been of high priority to veterinary entomologists for several decades, there is still an enormous deficiency in our fundamental biological knowledge. Characterization of breeding sites and overwintering mechanisms has not been fully investigated using quantitative ecological approaches. Of particular relevance to understanding stable fly population dynamics are the unknown triggering mechanisms that stimulate migration and dispersal. Research should also be conducted to determine nuisance or tolerance factors for house flies and stable flies under different circumstances and environments.

Non-Chemical Control

Biological control holds great promise as an environmentally benign tool in fly management. For endemic species of parasites and predators, mass rearing technologies will be required. Furthermore, selection of the most effective biotypes to improve fecundity and searching behavior, enhance longevity, and, perhaps, pesticide resistance for compatible use with chemical control agents is necessary. Foreign exploration for exotic parasites and predators specific for house flies and stable flies still holds promise. The use of pathogens in fly control is a vast, uptapped opportunity; but first, there is a need for general evaluation of the microbial flora of various larval habitats. Modifying genes to make existing insect pathogens more effective or inserting toxic genes into normally non-toxic organisms is now possible through genetic manipulation. Before pathogen use is feasible, there must be major developments and progress in production, formulation, and delivery on a commercial scale.

Chemical Control

The avermectins have only wetted our appetites for microbially-produced pesticides that are effective at microgram concentrations. New products based on novel molecular structures will undoubtedly be discovered, particularly by scientists in industry. Such new products will require new formulations and delivery systems that could employ radically different designs. However, great care must be taken to prevent the development of resistance in target populations and to assure that these new products have a minimal effect on non-target beneficial organisms that utilize the same habitat. An alternative is to increase research on fly attractants and repellents. Attractants could be employed to enhance chemical control products for specialized applications and repellents to prevent flies from becoming pests in unique habitats of the urban setting.

Modeling

Models and computer simulations that accurately predict pest population dynamics and identify when to effectively apply different control strategies are in various stages of development as research tools. The future, however, will see these tools incorporated into expert systems that will provide the producer with a tailored farm management system. Ideally, expert systems will eventually include all components of farm management and will identify economic ramifications for consideration at the various decision points.

Targeted Fundamental Research

Fundamental research provides the key to future strategies and novel methods of fly management. Biochemical and physiological research, particularly in the area of peptide neurohormones, holds great promise for isolating and characterizing selective chemical molecules that disrupt metabolic pathways or internal chemical communications systems. This physiological research may also identify new chemical receptor sites that, when blocked, could interfere with normal insect functions. Physiologically based activities that seem to be particularly vulnerable to disruption include oviposition, diuresis, and visceral muscle tone. Manipulating the fly genome could theoretically provide new genetic means of fly population management. Genetic control strategies might include introducing genes to selectively sterilize males and females, inserting promotor genes that turn on detrimental genes in a population under certain environmental conditions, or attaching deleterious genes that disrupt reproduction to transposible genes that can spread throughout a population. Fundamental opportunities in host immunity to ectoparasites also exist.

Control Systems

Integrated control will be the flagship for fly management well into the decade of the '90s. By incorporating the best and most applicable results of each research area previously discussed, systems approaches to fly management will be developed for use under virtually any situation, rural or urban. Control systems will put all of the technologies together in order to effectively manage fly populations, thereby resulting in minimum nuisance to the urban environment.

Cost/Benefit

I would like to add that in order to be universally adopted, future technologies must be cost-beneficial for the producer. Today, profit margins are very slim, and fly control strategies will be implemented only if there is a financial return on the investment. There must be convincing evidence that the producer will benefit from an investment in fly management either by increased profits or by being able to at least remain in business in hopes of better times ahead. It is our responsibility to provide the tools for pest fly management that are both effective and reasonably priced.

SUMMARY

Although, historically, agricultural research was conducted solely for the benefit of individual farmers, today agricultural research must satisfy the needs of a blend of constituents that includes the urban/suburban resident. Research on the management of stable flies and house flies is conducted by Federal, State, and industry institutions, each reflecting their respective missions and objectives. Numerous opportunities for future research exist in six prioritized areas: (1) problem definition and quantification; (2) non-chemical control; (3) chemical control; (4) modeling; (5) targeted fundamental research; and (5) control systems. In order to be adopted, future technologies must be cost-beneficial for the producer.

NOTES

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