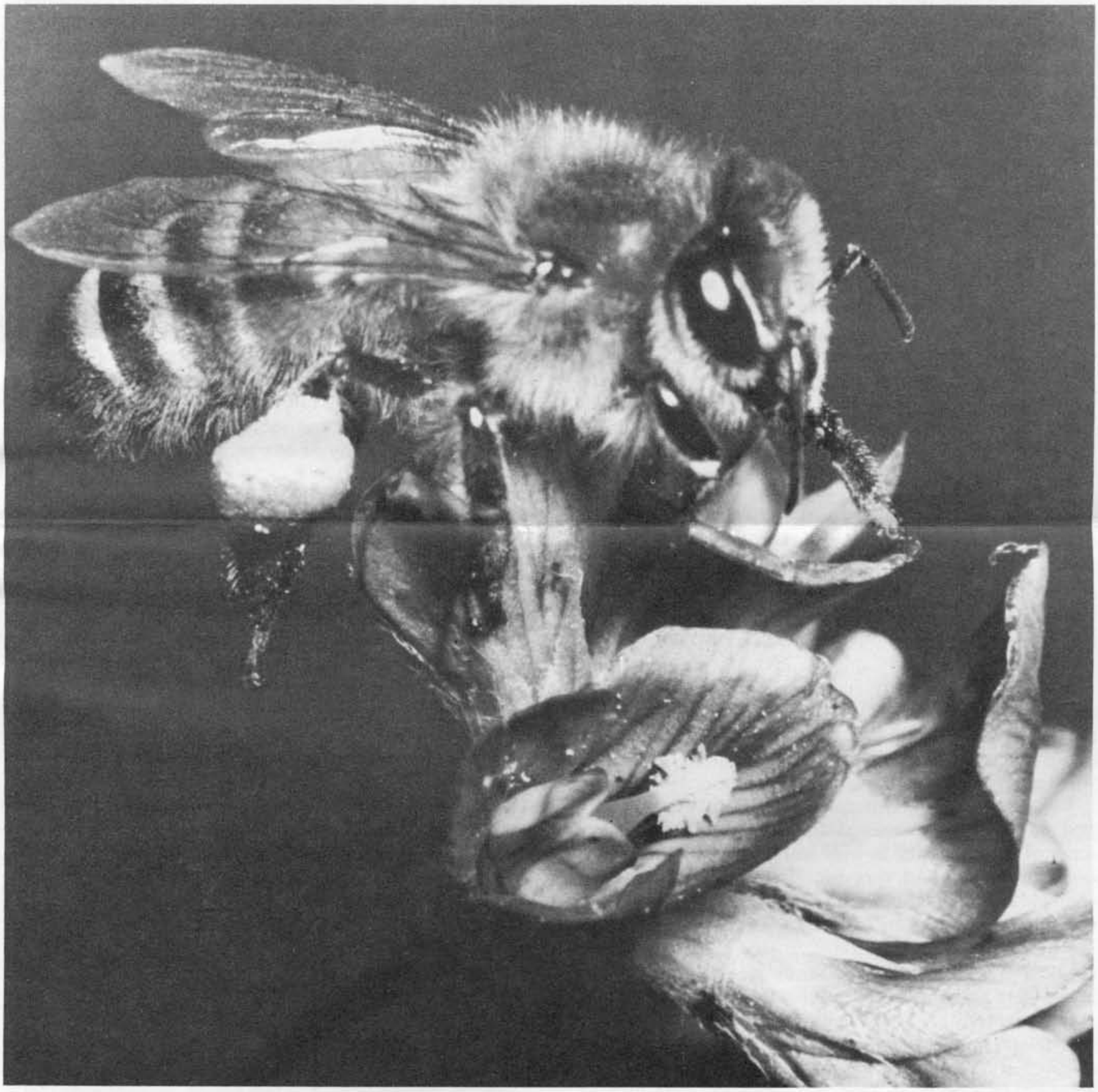
FRONTIERS
OF PLANT SCIENCE

SPRING 1984



A bee collecting nectar. See Page 2

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

Insecticides create problems for beekeepers in Connecticut

By John F. Anderson and William Glowa

Bees may be affected by insecticides intended for harmful insects that devour the foliage of crops, gardens and forests. In their work of collecting pollen and nectar, bees are especially apt to be affected by insecticides that land on flowers. Concern for the impact of insecticides on bees prompted the Station to seek the facts.

Beekeepers reported suspected bee poisonings to the Experiment Station during 1981 and 1982. The State Bee Inspector collected dead bees for chemical analysis and examined the colonies to determine (1) if bees died from other causes, (2) the likely contamination source and, (3) the extent of the kill. Mortality was also based upon the beekeepers' observation of dead bees during the days of the poisoning incident (one qt represented about 5% of a 40,000 bee colony). Each beekeeper later provided information on the condition and size of the colonies at mid-winter. Samples of dead bees and, in some cases, brood-nest comb, were analyzed in the laboratory for chlorinated, phosphate and carbaryl insecticides. Forty-eight reported poisonings were investigated.

One reported poisoning was found by the inspector to have been caused by dysentery. No insecticide was found by chemical analysis in six other apiaries. In 41 samples, however, insecticides were found, suggesting that the identified chemicals were the cause of death of the bees.

We identified eight different insecticides in dead bees. Carbaryl was the most frequently found chemical (65%). Methyl parathion and methoxychlor were each found in 33% and 14% of the samples. Five other chemicals (endosulfan, chlordane, malathion, diazinon and acephate) were found in bees as well. In all, we documented the poisoning of 268 hives. Severity of kills ranged from less than 5% to 100% of the colony.

The insecticide methyl parathion appeared to be most destructive. Of a total of 113 hives containing methyl parathion or methyl parathion and another insecticide, about half were totally destroyed and another quarter were severely affected.

Bees were poisoned from May to October. Carbaryl and methoxychlor were contracted primarily (70% or more of the incidents) in May and June when both were used for the ground spraying of trees for gypsy moth control. Two bee yards were affected by carbaryl when it was aerially applied by helicopter to agricultural land. Methyl parathion applications to sweet corn shedding pollen and to fruit trees with an understory of blooming plants were responsible for bee deaths in July and August.

Insecticides killed bees in all eight counties. Carbaryl was detected in bees in seven counties. Curiously, bees contracted methyl parathion only in a five-town area of New Haven County in 1981 and 1982, although in 1983 this chemical also poisoned bees in other counties.

Bees were often simultaneously contaminated with two insecticides. For example, carbaryl was frequently found along with methoxychlor in the spring and with methyl parathion in the summer. In fact, in 1983 we identified three insecticides (endosulfan, methyl parathion, methomyl) in one group of dead bees. Effects of two or more insecticides on colony health needs further clarification.

Satisfactory solutions for protecting bees from insecticides during extensive outbreaks of the gypsy moth are often unavailable. Moving of hives is usually impractical because ground spraying is practiced throughout the infested area. Effectiveness of pollen traps is questionable. Brief closing of a hive may help when a single spray is applied, but more than one commercial applicator and houseowner usually work in an area, often sequentially applying sprays during 4 to 5 weeks. When large areas are sprayed occasionally to protect crops, moving or closing hives may be practical. Also sprays may be timed or directed to avoid flowers that attract bees or to avoid periods of the day when bees are visiting flowers.

The prevalence of colonies poisoned by insecticides in Connecticut was about 3% in 1982. Estimates of poisoned colonies elsewhere in the United States have ranged as high as 10% or more, but chemical analysis usually was not made. It is still too early in our investigations to compare the severity of our problems with those elsewhere.

In 1983, the Station published a directory of 625 beekeepers registered in Connecticut. This assists pesticide applicators in their efforts to find and inform beekeepers of their plans. The directory is available on request from The Connecticut Agricultural Experiment Station, Box 1106, New Haven, CT 06504.

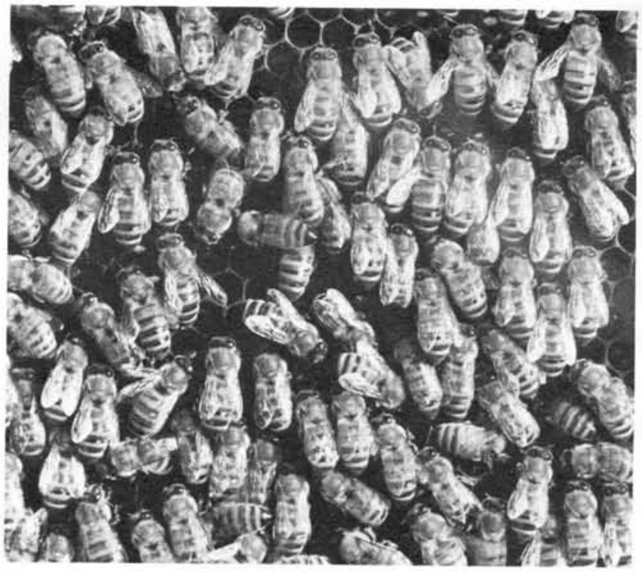


Fig. 1. Bees in a hive.

Station testing for EDB in food products and water

By Paul Gough

A new environmental contaminant has been found in food—EDB, ethylene dibromide.

In compliance with its charter, which directs it to conduct analyses for state agencies, The Experiment Station began testing various food products collected by the State Department of Consumer Protection. The samples began arriving in early February, while the Environmental Protection Agency in Washington was setting standards for residues in foods.

EDB was introduced as an insecticide in 1925, and was first produced commercially in 1946. It is used as an anti-knock ingredient in leaded gasoline and to control weevils in grain and fruit flies on citrus. It has also been used to control nematodes, tiny roundworms, in Connecticut soil.

EDB consists of two atoms of bromine with two atoms of carbon and four atoms of hydrogen in between. It has a molecular weight of 187.88 and is a heavy, colorless liquid with a chloroform-like odor at normal temperatures.

EPA standards for EBD are 150 parts per billion in raw food products and 30 parts per billion in cooked products. Experiments have shown that the material causes cancer in rats and mice at levels of 20,000 parts per billion. Until recently, it was believed that EDB did not remain as a residue in food products, but sensitive instruments that can measure quantities in the parts per billion range show that traces of EDB remain in some foods.

In general, the grain products being tested fall into two categories: raw products, such as cake mixes and flour; and cooked products, such as cookies and crackers. The method of analysis is slightly different, depending upon what type sample is being tested.

For raw products, 25 grams of a sample is combined with 50 ml of hexane and shaken. The samples are shaken once a day for four days, while the EDB dissolves into the hexane. A small amount of the hexane solution is injected into a gas chromatograph, which separates the components according to boiling point and size of molecule. As each component emerges, a detector produces an electronic signal that is recorded on a chart. The peaks on the chart are measured and compared to peaks from known amounts of EDB to calculate the amount of EDB in an unknown sample.

For cooked products, water and hexane are added to a sample in a flask, the contents heated, and the distillate condensed. The hexane solution is collected and analyzed for EDB.

The materials tested include spaghetti, corn muffins, flour, cake mixes, pancake mixes, and breakfast cereals. The results for the 229 food samples tested through April 1, 1984 show that all were within the EPA standards. Of these, 142 or 62% contained no detectable level of EDB and 214 or 93% had less than 10 parts per billion, well below the EPA standards. The table shows the types of products tested and the numbers of samples and the range of EDB detected.

Fig. 1. Measuring concentrations of EDB.

The State Departments of Environmental Protection and Health Services are also bringing samples of water to the Station. These samples are extracted by hexane and analyzed by chromatograph. In addition, any evidence of EDB is checked by mass spectrometry. A total of 221 samples of water have been tested. The amount of EDB in these water samples ranged from none detected to 1.7 parts per billion.

Experiments at the Experiment Station show that over 95% of the EDB in the mix dissipates when a cake is baked, and that the EDB in water dissipates quickly upon heating.

Table 1. Food and water samples tested for ethylene dibromide (EDB) to April 1, 1984. ND = no detectable level.

Type of product	No. of samples	EDB, ppb (range)
Cake, muffin, cookie, pancake mixes	79	ND-146
Milk and other dairy foods	15	ND
Infant foods	19	ND
Whole grains (wheat, corn, rice)	15	ND-7.5
Flour	14	ND-113
Cookies and crackers	13	ND
Bread and baked products	9	ND-0.8
Juices	8	ND
Ready-to-eat cereals	9	ND-0.43
Miscellaneous	48	ND-6.9
Total food samples	229	
Total well water samples	221	ND-1.7

Annual Amendments of Leaf Mold Sustain Higher Yields of Vegetables

By David E. Hill

Bountiful yields are the winter's dream of every vegetable gardener who plans for the forthcoming growing season. The hope of success makes all the efforts of digging, planting, weeding and watering seem worthwhile. Basically, the plant's needs are few: ample sunlight, water, and nutrients, supplied in a loose soil, and an environment free of insects, disease, and competing weeds assures success. Realistically, however, nature's ideal environment for growing is seldom found and the grower must manage the garden to overcome natural limitations. Two of the most serious limitations are the condition of the soil for growing plants and the water supply. We have shown that individual vegetable crops can be mulched with plastic film or organic materials to conserve soil moisture for use by vegetables and to discourage weeds that compete for water, nutrients, and light. We have also shown that mulching saves many hours of watering and can sustain a garden during periods of drought when water even may be rationed. But all efforts of water supply and water conservation go for naught if the soil's texture does not favor water retention and its structure limits plant growth. Very sandy soils that hold little available water for plant growth and fine textured soils that are dense, easily compacted, or crusted at the surface following summer rains present problems that need attention.

What can be done to improve moisture holding capacity, reduce compaction and crusting of the soil's surface? In my studies to improve the yields of vegetables growing in sandy, rubble-filled soil in inner-city community gardens, I found that 3 inches of well-decomposed leaf mold rototilled into the upper 6 inches of soil increased vegetable production 35-150% for most vegetables, compared to unamended plots. Yields were increased 10-75% in a loamy garden soil using only 1 inch of leaf mold. Amendments of 2-3 inches of leaf mold in a loamy soil, however, increased yields of broccoli, eggplant, and cucumber, 25-50%, but yields of snap beans, beets, peppers, carrots, and onions, increased only 5-40% compared to unamended controls. Thus, too much leaf mold in loamy soils reduces the benefits gained by adding organic matter, especially with vegetables grown from seed. The problem stems from increased moisture stored in the soil, which slows soil warming in the spring, delays germination, and induces rotting of seed.

Our earlier results on vegetable yields were from short-term experiments lasting 1-2 years. What are the effects of annual applications of 1 inch of leaf mold on the physical

Vegetable values, inflation and yields

The yields of vegetables in individual plots in our garden reflected the differences in management that we imposed upon the plants. Some differences were positive, others negative compared to untreated controls. Some increases and decreases were statistically significant, others were not. One can, however, total all yields of all vegetables grown in the garden, irrespective of management techniques, to determine the effect of season. We can compare our annual yields with one another because we have grown the same kinds of vegetables for 7 years and their cultivars are consistent. Early maturing crops have been followed diligently, except in 1982, with second crops that matured in late fall, and were harvested even during the snows of early winter.

We have also determined the economic value of our crops as they were harvested by assigning local supermarket prices at the time of harvest. Yield and values for the last 7 years are in the table.

It is clear that while annual yields have fluctuated between 965 and 1418 lbs/1000 ft^2, the value of these crops has consistently risen, except in 1982. Some of the increase in value can be attributed to inflation and some to greater yields. Inflation, raising the average price per pound of vegetables 22% between 1977 and 1979, accounted for an increased value of the garden despite a 10% decrease in yield. Between 1979 and 1981, the increased value of the garden was due to a 38% increase in yield as prices stabilized. The reduced yield and value of the 1982 crop was caused by flooding in June that delayed harvesting and precluded planting of fall crops. In 1983 yields declined 26% compared to 1981, but the value remained constant because of a corresponding increase in the average price of vegetables.

Year	Total Yield lbs/1000 ft^2	Value \$/1000 ft^2	Value \$/lb.
1977	1120	445	.40
1978	1000	456	.46
1979	1027	521	.51
1980	1215	600	.49
1981	1418	687	.48
1982	965	476	.49
1983	1052	685	.65

properties of the soil over a longer period of time? To answer this question we shall look at the changes in organic matter content and the bulk density in our vegetable garden plots. The topsoil in our unamended control plots had an organic content ranging from 6.8-7.9% in the spring at planting time to 5.9-6.3% following final harvest. Additions of 1 inch of leaf mold each year increased the organic content from 7.7-11.6% at planting time to 7.5-7.8% following final harvest. Despite loss of organic matter by oxidation during the growing season, the overall organic matter content increased from 5.9 to 7.8% in amended soils.

The increased organic matter content of the soil had a direct effect upon the weight of a known volume of soil, called bulk density by soil scientists. The unamended control had a typical density of 1.21 g/cc while the plots receiving 1 inch of leaf mold had a density of 1.09 g/cc. Reduced density of the soil enables plant roots to penetrate more readily and the added organic matter promotes aggregation of fine soil particles and reduces soil crusting following summer rains.

How have the vegetable crops responded to these changes brought about by annual additions of leaf mold? Table 1, the total yields of vegetables on amended vs. unamended plots for the period 1979-1983, is informative. Annual amendments of organic matter produced yield increases in each of the 5 years of study. The considerable variation in yields for both amended and unamended plots among years is the result of general weather conditions during the growing seasons. It should be noted, however, that the variability of annual yield is less for the leaf mold amended plots than for the unamended controls. Increasing the moisture holding capacity of soil by adding organic matter helps the plants during summer droughts by reducing periods of stress. In our best growing years (1979, 1981, and 1983), improvements in yield were modest, while in the poorer growing years (1980 and 1982), improvements were large. The average improvement in yields for the 5-year period was 10%.

How do individual vegetables respond to annual amendments of leaf mold? Table 2 shows wide variation. Broccoli and squash consistently yielded more throughout the 5-year period; increases outnumbered decreases in beans, peppers, cauliflower and cherry tomatoes. On the other hand, peas and beets yielded less on leaf mold amended plots. This is consistent with earlier observations. Poor yields are the result of poor germination. For peas this is not surprising because they are planted very early in soil that is cool. Delay in germination increases the chances of rotting. Protection of the seed with a fungicide would improve germination and yields. Beet seeds also germinate with more difficulty in cool soil. Only in the 2 years with large increases was the soil warmer and drier than in the years with decreases. Some vegetables have a "neutral" response toward increased organic matter, producing increases or decreases of less than 10%. Tomatoes were neutral in 4 of 5 years. Cabbage and carrots were also neutral.

In conclusion, annual additions of leaf mold provide lasting increases in organic matter content of soil with resultant decreases in bulk density. Many vegetables respond by increasing their size and yield. Large increases in yield are more likely to be seen during years of acute moisture stress while increases in years of adequate rainfall are more modest, but positive, for most vegetables. Seeds planted very early may require protection by fungicide or planting at higher densities to offset losses in cold, moist soil.

Table 1. Yield of all vegetables on plots amended with 1 inch of leaf mold compared to unamended controls during 1979-83.

Year	1-inch Leaf mold lbs/300 ft²	Unamended Control lbs/300 ft²	Increase %
1979	334	321	4.0
1980	356	300	18.7
1981	422	387	9.0
1982	297	246	20.7
1983	338	336	0.5
Average	350	318	10.1
Range	297-422	246-387	

Table 2. Number of years with greater than 10% increases or decreases of yields between leaf mold vs. control.

	Increases	Decreases	Neutral*
Beans	3	0	2
Beets	2	3	0
Broccoli	5	0	0
Cabbage	0	1	4
Carrots	1	1	3
Cauliflower	2	0	3
Lettuce	2	2	1
Onions	2	1	2
Peas	0	5	0
Peppers	3	1	1
Radishes	2	2	1
Rutabaga	2	1	2
Squash	5	0	0
Tomatoes	1	0	4
Tomatoes, cherry	2	0	3

*Increases or decreases between leaf mold amended plots vs. control are less than 10%.

Entranceway honors Gould

A brief ceremony on October 4, 1983 officially acknowledged the new sidewalks and entranceway to the Slate Building donated in memory of Sydney W. Gould. Mr. Gould, who died in January 1982, was appointed a Research Associate by the Board of Control in 1959. He worked for many years compiling plant genera. He developed the GEOCODE, an alphabetic method of listing geographical locations, and was the author of *Families of the Plant Kingdom* and *Authors of Plant Genera*.

Plant Science Day is August 8

The annual Plant Science Day open house will be held from 10 a.m. to 4 p.m. on Wednesday August 8 at the Experiment Station's Lockwood Farm in the Mt. Carmel section of Hamden. Field plots will be open for inspection, staff will give short-talks, and exhibits will be open throughout the day. The annual Samuel W. Johnson Lecture will be held at 11:35 a.m.

Infected *Ixodes* ticks found where Lyme disease occurs

By Louis A. Magnarelli and John F. Anderson

Lyme disease is a newly described human illness that usually starts with expanding skin lesions at the sites of tick bites. In the ensuing weeks or months, victims may develop arthritic, neurologic, or cardiac disorders. The infectious agent is a spirochete (bacterium) that is transmitted in the northeastern United States by a tick, *Ixodes dammini*. We have been investigating the distribution of this tick, prevalence of infection, and the presence of antibodies in patients and wildlife to assess the risk of this disease in the state.

Our research on ticks began in 1976, and within 3 years, we learned that these ectoparasites were distributed throughout most of southern Connecticut. During 1982, Dr. Willy Burgdorfer of the National Institute of Allergy and Infectious Diseases and co-workers discovered spirochetes in *Ixodes dammini* and proposed that this organism caused Lyme disease. For the past 2 years, we have been conducting investigations primarily at sites in Lyme and East Haddam, communities where these ticks and human infections of Lyme disease are prevalent. Ticks were also collected from other areas of the state to compare infection rates.

Ticks were removed from wild animals such as white-footed mice, raccoons, and white-tailed deer, but we also examined specimens obtained from the public. Juvenile and adult ticks and blood from wild mammalian hosts were tested for spirochetes.

Spirochetes were isolated by placing tick tissues and the blood of wild mammals into a liquid growth medium. The culture tubes were then incubated and checked periodically for one month to determine if the disease-causing bacteria were present.

Additional tests were conducted to determine if people and wild and domestic animals had antibodies to the Lyme disease spirochete. Species-specific reagents and a fluorescent microscope were used to observe positive reactions (Fig. 1).

Wild and domestic mammals are suitable hosts for all mobile stages of *I. dammini*. We collected infected ticks from 10 species (Table 1) and detected antibodies to spirochetes in all five species that we have a test for. Similar studies of mammalian serum samples from northwestern Connecticut, a region where *I. dammini* is rare, revealed no antibodies to the Lyme disease spirochete. Of the 109 ticks dissected and examined from East Haddam and Lyme during April through July 1982, 42 harbored spirochetes. Larvae, nymphs, and adults were infected. Twenty-eight of these positive adults were collected while they were still crawling on hosts and had not yet ingested blood. Because of this, we concluded that spirochetes acquired by nymphs can be carried into the next life stage after moulting. It remains unclear, however, whether females can pass spirochetes into their eggs and thereby infect their offspring. Infected ticks were found (Fig. 2) in the following communities: Chester, East Haddam, East Lyme, Haddam, Hamden, Lyme, Marlborough, North Guilford, North Madison, Northford, Voluntown, Waterford, and Westbrook.

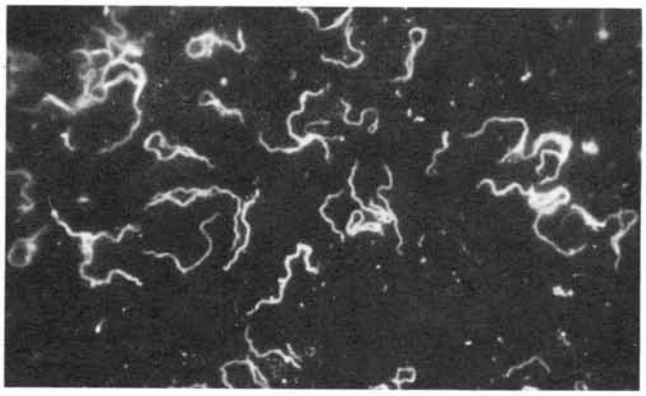


Fig. 1. Spirochetes (1,650X) fluorescing in antibody test. Photograph by Willy Burgdorfer.

Spirochetes were isolated from three nymphs, six adults, and from the blood of a raccoon and a white-footed mouse collected at East Haddam during June and July of 1982. Laboratory analyses revealed no differences between these bacteria from the mammals and those recovered from ticks. Although the pathogenic effects of spirochetes on wild and domestic animals are unknown, these and other mammalian hosts may be reservoirs for spirochetes.

White-footed mice were frequently infested with *I. dammini* larvae or nymphs. Blood tests detected antibodies to spirochetes in 34 (10%) of 329 serum samples from mice. The majority of these animals were collected during June and July, a period when immature ticks and

Table 1. Number of mammals found carrying spirochete-infected *Ixodes dammini* in southeastern and southcentral Connecticut during 1982-1983.

Host	Number of animals*	Number with infected ticks	Antibodies present
Chipmunk	3	3	X
Cottontail rabbit	1	1	NT**
Domestic cat	1	1	NT
Domestic dog	4	1	X
Raccoon	14	2	X
Red squirrel	1	1	NT
Short-tailed shrew	7	1	NT
White-footed mouse	106	31	X
White-tailed deer	167	71	X
Woodland jumping mouse	1	1	NT
Totals	305	113	

*Ticks tested for spirochetes from each animal.
**NT = Not Tested.

human infections of Lyme disease were prevalent. Larval ticks are probably ingesting spirochetes from rodents and other animals during the summer and early fall. After overwintering in larvae or nymphs, these bacteria are transmitted to other animals when the ticks resume feeding during the spring and summer. With increased human exposure to *I. dammini* during warmer months, there is a greater risk for Lyme disease.

Serum samples from people suspected of having Lyme disease are forwarded to us by the Virology Laboratories of the Connecticut Department of Health. We analyze these sera for antibodies to the Lyme disease spirochetes and report our findings to the Department of Health. During 1982-1983, we tested samples from 513 people and detected antibodies in sera from 147 of these. Most of these people live in heavily tick-infested areas of south-central and southeastern Connecticut.

Although *I. dammini* is widely distributed throughout southern Connecticut, populations are most abundant east of the Connecticut River. Our findings indicate a close correlation among the distributions of this tick, wild and domestic mammals with antibodies to spirochetes, and human cases of Lyme disease. Therefore, if populations of *I. dammini* continue to increase, the occurrence of Lyme disease in humans may also rise. Studies are currently underway to find insecticides that will control this tick.

Suggested Readings

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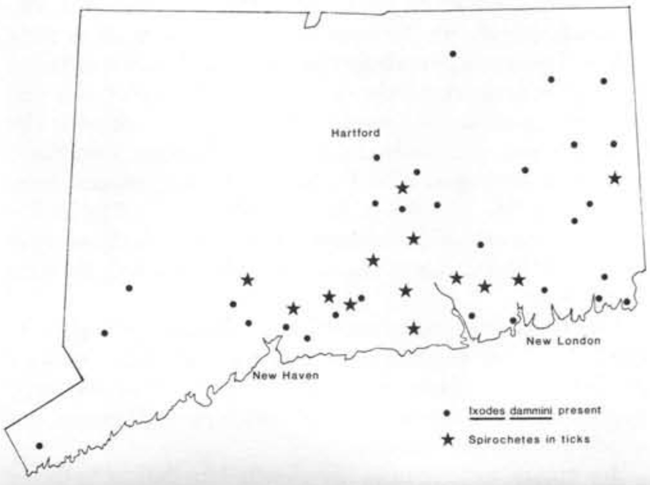

Fig. 2. Geographic distribution of *Ixodes dammini* in Connecticut. (Revised from Anderson and Magnarelli 1980).

Testing of vanilla ice cream reveals compliance with regulations

By Lester Hankin

The Experiment Station has tested the nutritional, microbial, and flavor quality of 88 samples of vanilla-flavored ice cream, ice milk, and dietary frozen desserts and has compared the results with State Regulations.

These Regulations require that ice cream contain at least 10% butterfat, whereas ice milk may contain between 2 and 7%. Dietary frozen dessert must contain less than 2% butterfat. Vegetable fat is not permitted. French vanilla must contain at least 1.4% eggs. Ice cream and ice milk also must meet certain microbial standards.

The ice cream laws are regulated by the Connecticut Department of Consumer Protection. From May to August, 1983, inspectors collected samples of vanilla ice cream and ice milk sold in Connecticut. These were tested in the analytical chemistry laboratory of The Connecticut Agricultural Experiment Station in New Haven. Tests included chemical and microbial analyses, determination of calories, nutrients, and weight per gallon, and evaluation of taste.

The samples represented 68 different brands. There were 79 ice creams, eight ice milks, and one dietary frozen dessert. In one case 12 samples, most with different brands, were made by the same processor.

Seven samples failed to meet the State minimum requirement of 4.5 pounds per gallon. Microbial analysis revealed only one sample failed to meet the State maximum standard of 100,000 per gram for all bacteria. Seven exceeded the maximum of 10 coliform bacteria per ml.

The butterfat content of the ice creams averaged 12% but ranged from 9.1 to 17.3%. The ice milks averaged 3.6% butterfat. No sample was adulterated with vegetable fat. **Continued Page 8**

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Protein content of ice cream, which averaged 3.3%, depends largely on the amount of casein in milk or milk solids. The average carbohydrate content, which includes lactose from dairy products, was 22% for ice cream and 27% for ice milk. The amount of sweetener, which is the total amount of carbohydrate less the lactose from dairy products, averaged 27% for ice cream but ranged from 13.2 to 21.9%. The range for ice milk was 19.2 to 26.7% with an average of 21%. Sweeteners can include sucrose and hydrolyzed corn starch, usually labeled as corn sweeteners.

Calories in ice cream and ice milk depend primarily on the fat content. We found ice cream averaged 207 calories per 100 grams, about the number of calories in two large apples. Ice milk averaged 154 calories per 100 grams. An ounce is about 29 grams.

Ice cream and ice milk are clearly labelled as to flavor components. For our ice cream samples, 41 were labelled "vanilla", which means they contained only natural vanilla; 27 were labelled "vanilla flavored", which means they contained mostly natural vanilla but some artificial flavor; and 11 were labelled "artificially flavored", which means they contained all or mostly all artificial flavor.

Taste or flavor is largely a personal preference. On a scale of 10 being best flavor and 1 the worst, we found the average score was 7.6, but it ranged from 4 to 9. Scores below 6 usually show inferior taste and criticisms can include unnatural flavor or taste of old ingredients. Five of the ice creams had scores below 6.

Findings for all samples are summarized in Table 1. Our results show that vanilla ice creams and ice milks sold in Connecticut are generally of good quality.

Results of tests on all ice creams and ice milks by brand name are listed in Bulletin 818 of this Station, available free from Publications, The Connecticut Agricultural Experiment Station, P.O. Box 1106, New Haven, CT 06504-1106.

Table 1. Analysis of ice cream and ice milk sold in Connecticut.

Category	Ice Cream	Ice Milk
Exceeded microbial standard	1	0
Exceeded coliform standard	6	1
Short weight	6	1
Did not meet fat requirement	1	0
Butterfat, average %	11.9	3.6
Calories, average per 100 grams	207	154
Sweeteners, average %	18.2	21.2
Flavor, average score (1 to 10 best)	7.6	
TOTAL SAMPLES	79	8

Ice cream is a favorite dessert or snack for persons of all ages. It is a delicious, nutritious, wholesome food made of dairy products, sweeteners, and flavoring. Air is incorporated during freezing. New Englanders consume about 5 gallons of ice cream annually, while for the United States as a whole the per capita consumption is about 4 gallons. Vanilla-flavored ice cream is the most popular and accounts for more than 45% of sales. Chocolate is a distant second at about 10%. About 74% of all ice cream is purchased in supermarkets and over 83% is purchased in half-gallons.

The origins of ice cream can be traced to 18th century Europe. Frozen ices can be traced to the 16th century, with some references dating to the Romans. In the United States, the introduction of ice cream is credited to Mrs. Alexander Hamilton who, it is said, served it to George Washington. The first commercial ice cream plant was opened in Baltimore, Maryland in 1851. Four inventions were essential to sustain this new industry: condensed milk by Gail Borden of Wolcottville, Connecticut; the cream separator; the Babcock test for fat; and mechanical refrigeration.

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Vol. 36 No. 2 Spring, 1984 ISSN 0016-2167 Paul Gough, *Editor*