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Relationship of Patterns of Use of DDT and Its Residues in Animal Feeds and Food Products

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RELATIONSHIP OF PATTERNS OF USE OF DDT AND ITS RESIDUES IN ANIMAL FEEDS AND FOOD PRODUCTS

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ABSTRACT

A study was undertaken to determine why DDT residue levels in milk produced on dairies in Northeast Louisiana was much higher than from dairies in other areas of Louisiana. The intensive agricultural practices and interrelationship of dairies and cotton farms in this area were thought to contribute to the contamination of milk.

A relationship expressed as a time/DDT-milk residue effect due to the seasonal application of DDT on cotton was examined. The relationship between milk contaminated with DDT and feed ingredients contaminated with DDT was also investigated.

Four dairies were selected for study. Herd milk samples from these four dairies revealed that all had DDT present in milk, ranging from 1.60 parts per million to approximately 6.00 parts per million (fat basis). All dairies investigated practice a combination of dry lot and pasture feeding.

A positive correlation between the seasonal use of DDT on cotton and maximum levels of DDT in herd milk of each dairy was found. Based on a corrected mean residue value for a twelve-month period, the range in total DDT residues in milk from the four dairies studied was as follows: Dairy A from 1.38 in May to 5.54 parts per million (fat basis) in September; Dairy B from 0.81 in May to 3.77 parts per million in November; Dairy C from 1.45 in June to 9.90 parts per million in October; and Dairy D from 0.39 in June to a maximum of

2.42 parts per million in August.

Residue analyses of feed ingredients revealed hay, silage and pasture grass to be highly contaminated with DDT considered a result of drift of DDT applied to adjacent cotton fields. Total DDT residues in hay fed to producing animals ranged from 0.17 to a maximum of 28.67 parts per million on Dairy C. The average concentration of DDT in hay fed to dairy animals on Dairy C during the course of this study was 5.24 parts per million.

Total DDT residues in silage fed as part of the dairy ration on Dairy C throughout the course of this study ranged from 0.03 to 6.50 parts per million. The average concentration of DDT in all silage fed as part of the dairy ration on this dairy during this study show that interrelated farming activities such as dairying and cotton production cannot be practiced without the occurrence of illegally excessive residues in the milk produced if chlorinated hydrocarbon insecticides such as DDT are used for cotton insect control. Where pastures, forage crops and silage crops for dairy and beef cattle feed are grown in close proximity to areas planted to cotton, inadvertent contamination of milk and meat cannot be avoided because of the contamination by drift of these insecticides onto the crops.

INTRODUCTION

DDT, a chlorinated hydrocarbon insecticide, has been found in milk as a residue. The sources are: 1) direct application to the animal, 2) inadvertent contamination as a result of drift and/or 3) feed contamination.

Source number 1 is minimal since there are no registered uses for DDT on dairy animals. Sources 2 and 3 may be serious. Since sources 2 and 3 may present serious residue problems in milk the Food and Drug Administration has established a tolerance of 0.05 parts per million on whole milk or 1.25 parts per million on fat basis.

Residues of chlorinated hydrocarbon insecticides in milk, eggs and meat products can be concentrated to illegally high levels as a result of the contamination of feed by minute amounts of the insecticide as well as from other sources. Cause of contamination of milk with dieldrin above the administrative guideline tolerance of 0.3 parts per million as a result of feed contamination was traced to the re-use of burlap sacks used to sack dairy feed. These sacks had previously been used for seed rice treated with the insecticide aldrin (Impson, et al., 1970).

Results of a pesticide residue monitoring program conducted by the Dairy Industry throughout Louisiana in 1968 and 1969 revealed DDT levels in milk to be approaching the tolerance level in certain areas of the state. This study was initiated to identify sources of DDT residues in herd milk in Northeast Louisiana and to develop recommendations for insecticide use patterns on cotton that would reduce and/or eliminate the occurrence of illegal residues in milk and red meat.

DDT as one component of an insecticide mixture has been recommended for control of certain cotton insects in Louisiana for more than 20 years. During this period the normal cotton insect control program has usually begun not later than mid-July and often as early as the first of June. Regularly scheduled applications have been made at 5 to 7 day intervals usually until mid-September. Such a schedule has involved 12 to 15 applications per season in most areas. Each application has usually included DDT at the rate of one pound active ingredient per acre for a total of 12 to 15 pounds of DDT per acre per season. Cotton growers in the area chosen for this study have adopted and used this method of control of cotton pests for more than 15 years.[a/]

[a/]Use of DDT on cotton was cancelled as of December 31, 1972. Consolidated DDT Hearings Opinion and Order of the Administrator, William D. Ruckelshaus, E.P.A. Federal Register Doc. 72-10340, July 6, 1972.

REVIEW OF LITERATURE

DDT and Its Presence in the Environment

DDT (Dichloro-diphenyl-trichloroethane), a chlorinated hydrocarbon insecticide has been used extensively in the United States for nearly twenty years. A standard formulation of commercial DDT is made up of approximately 80 per cent p,p'-DDT and 20 per cent o,p'-DDT. Between 1949 and 1964, approximately 974 million pounds of DDT were used in the United States (U.S. Dept. of Agriculture, 1965). Use in the United States declined to about 30 million pounds in 1968 and 1969. Estimates for use of DDT in 1970 and 1971 in the United States indicated a further decline (Hilton, 1971).

It is generally recognized that DDT and its metabolites have spread from sites of production and application throughout the global biosphere. Movement may be accomplished by atmospheric transport, surface runoff in drainage water, re-suspension from sediments, co-distillation with water, and biological magnification in food chains (Hilton, 1971).

Problems created by residues of DDT and its metabolites as well as other pesticides in raw agricultural commodities such as meat, milk and eggs, particularly in areas of diverse farming activity, pose potentially serious threats to the economic success of the agricultural enterprise. Milk has long been regarded as a "special

food" since it is regularly fed to infants, sick persons, and the aged. Until a tolerance for DDT was established no additives except Vitamin D were permissible. Prior to this time the tolerance for DDT in milk was zero (Sobelman, 1970).

Pesticide Residues in Dairy Products

It has long been recognized that residues of the chlorinated hydrocarbons can be detected in milk. The first recorded observation of DDT in milk and body fat was reported by Woodard and Ofner (1945), who through the use of the specific colorimetric method of Schechter and Haller (1947), identified DDT in the milk of lactating dogs.

It was expected that DDT would be excreted in milk from dairy animals. Cows could become contaminated from treatment with DDT or from contaminated feed since a fraction of the DDT ingested and/or absorbed is selectively deposited in the fatty tissues and excreted in milk. Alfalfa hay averaging 10.77 parts per million DDT was fed to a cow for two months beginning August 8th. The cow freshened August 31st. Results of analysis of whole milk from the cow on September 3rd showed a residue level of 0.22 parts per million. The DDT residue level peaked on September 25th at 0.92 parts per million. Results of fecal analyses done on August 12 and August 30 did not show any DDT residue. A similar analysis made September 30 indicated 0.04 parts per million DDT in the milk of a dairy animal fed alfalfa contaminated with DDT (Schwardt et al., 1947).

Dairy cows were fed alfalfa hay treated ten days prior to cutting with 0.25 pounds actual DDT per acre. The hay contained 7 to 8 parts per million DDT. This hay was fed for three months as part of their daily diet. After three months DDT residues in whole milk from these cows were 2.3 to 3.0 parts per million. Butter from the same milk contained 65 parts per million DDT (Smith et al., 1948).

Similar residues in milk were noted by Shepherd and his co-workers (1949) where alfalfa was treated with 2.4 pounds actual DDT per acre as an aerosol spray and fed to cows at a rate of one pound of hay per day per 100 pounds of body weight. Residues of DDT in milk were measured up to 10.1 micrograms of DDT per gram or 259.1 micrograms per gram of butterfat. Residues persisted for 160-170 days following feeding (Shepherd et al., 1949).

They also fed alfalfa treated with 0.6 pounds actual DDT per acre at a rate of 1.5 pounds per 100 pounds body weight. The milk contained 0.9 micrograms of DDT per gram and residues were detected for 30-40 days following feeding. In both feeding trials, DDT first appeared in the milk after a few days of feeding. Residues of DDT in milk were determined by the colorimetric method of Schecter and Haller (1947). Residues of DDT in the hay were based on total organic chlorine, according to the procedure of Carter and Hubanks (1946).

Henderson (1965) in a review of insecticide residues in milk reported very little concern by the dairy industry prior to 1959. Routine analyses of milk samples collected prior to 1965 by the Food and Drug Administration showed that contamination with pesticide residues was rather widespread. Procedures used to confirm these residues were based on the total organic chloride test, the colorimetric test of the Association of Official Agricultural Chemists (Schechter and Haller, 1947), or the housefly-bioassay method (Dewey, 1958).

The paper chromatographic test, a new technique developed by the Food and Drug Administration to detect pesticide residues was used to identify residues in milk collected in 1955 on a countrywide basis (Clifford, 1957). Pesticides found were DDT, DDD, DDE, lindane, BHC and methoxychlor.

A second survey was conducted in 1958 (Clifford et al., 1959) that consisted of 936 raw milk samples representing 48 dairies in fifteen metropolitan areas from all sections of the United States. Thirty-three per cent of these samples contained pesticide residues compared to 62 per cent in the 1955 survey. Based on results of these surveys, it was evident to the Food and Drug Administration that pesticide residues in milk were not at zero or non-detectable levels.

Seizure of butter and evaporated milk shipments consigned to Hawaii in late 1959 and early 1960 prompted immediate action by the dairy industry. DDT and its analogues were found in the evaporated milk at approximately 0.2 parts per million on a fluid milk basis as determined by the colorimetric test procedure. Concurrent with this, the Mill's paper chromatographic test was developed by the Food and Drug Administration. Use of this method provided a sensitive qualitative and semi-quantitative test procedure for rapid screening of milk supplies to determine pesticide residues (Henderson, 1965).

Reaction by the dairy industry to the obvious fact that the Food and Drug Administration regarded the problem as serious was swift. In the subsequent 2-year period (1961-1962), 31,548 samples of milk and dairy products were analyzed and the results were reported to the Technical Advisory Committee of the Dairy Industry Committee (Henderson, 1965). The report indicated aggregate residues of DDT, DDE, DDD and methoxychlor, in most instances, were well below 0.1 parts per million on the basis of whole milk, or 2.5 parts per million on the basis of fat.

Duggan (1967) reported results of analyses of 12,836 objective samples of milk and dairy products examined by the United States Food and Drug Administration. Samples represented domestic and imported lots during the period July 1, 1963 through June 30, 1966.

DDT, DDE, TDE, dieldrin, heptachlor expoxide, BHC, lindane, aldrin, heptachlor and methoxychlor accounted for 99.3 per cent of the pesticide residues. The average level for DDT and its analogues was 0.134 parts per million on a fat basis. Residues were found in 7,346 (57%) of the total samples examined. More than one pesticide chemical was found in 5,154 samples.

The introduction and general use of gas chromatography in 1964 made possible the detection and measurement of several different pesticides and the quantities of each in the parts per billion range. By this time public concern had become increasingly apparent toward the use of pesticides and their possible harmful effects. Data soon became available which indicated the residue problem to be more serious than had been previously thought.

Epps et al. (1967) reported on a preliminary monitoring study in Louisiana. DDT and its analogues were the most common residues found. The highest residue reported in milk was 3.37 parts per million.

In response to a petition submitted to the Food and Drug Administration by the California Department of Agriculture, a tolerance for DDT, DDD and DDE was established and published in the Federal Register of March 15, 1967. A tolerance of 0.05 parts per million was established for each or any combination of DDT, DDD and DDE in manufactured dairy products and milk, and 1.25 parts per million on the milk fat basis (Federal Register, 1967).

Residues in Marketable Food

In a report on regulation of pesticides in the United States, (U.S.D.A. and U. S. H.E.W., 1968) the following conclusions were drawn:

"1. Small amounts of chlorinated organic and organophosphorus pesticide chemicals are commonly present in foods as shipped in interstate and international commerce. Even smaller amounts of these chemicals are found in food when ready to eat. Herbicides and carbamate type pesticides are found infrequently in the total diet samples and cannot be recognized as a common component of the dietary intake of pesticide chemicals.

2. The current dietary intake of pesticide chemicals in the United States is below safe levels established by the United States and international authorities.

3. The current legally sanctioned tolerances are substantially higher than the average amounts actually found in foods and for a vast majority of the individual lots where residues are actually present. The proportion of food containing residues at or above the

tolerance level is exceedingly small.

4. Many unsanctioned residues are found in foods, more as a result of environmental factors than from misuse. The lack of a legal sanction, or approval for residues in or on food does not insure that foods will remain free from such residues. Some of these are being found through the use of improved and more sensitive analytical procedures. Improved methods are employed in the programs as soon as they are available.

5. The tolerance and control system employed by the United States has been successful in maintaining a food supply within established and safe limits of pesticide chemicals needed in the production of food and fiber."

The report also stated, "It is noteworthy that the combination of foods in meat, fish, poultry and dairy products account for over half of the intake of chlorinated organic pesticide. There are few registered uses of pesticide chemicals known to result in residues in meat and poultry. No registrations have been granted which are calculated to result in residues in milk. Therefore there are environmental factors contributing unavoidable residues in these commodities."

Duggan et al. (1971) reported on pesticide residue levels in foods in the United States between July 1, 1963 and June 30, 1969. Seven chlorinated organic pesticides were commonly found in milk fat in addition to the DDT compounds. Imported dairy products contained

the same pesticide chemicals as domestic products. The data indicated that there have not been significant increases in the incidence or level of chlorinated organic pesticide chemicals in fluid milk or dairy products.

The DDE residue level does not exceed 0.1 parts per million (fat basis) in 85 per cent of the domestic samples of fluid milk and dairy products and 88 per cent of the imported samples of dairy products.

Pesticide levels in ready-to-eat foods remained at relatively low levels during the fifth year of the total diet study of the Food and Drug Administration (Corneluissen, 1970). During the period June 1968 to April 1969, samples from 30 markets were taken in 24 cities. Residues were found in 26 of 30 composite samples of dairy products. The most common residue was DDE at 0.028 parts per million and DDT at 0.129 parts per million on fat basis.

Residues in Foods of Animal Origin

Duggan and Lipscomb (1971) reported foods of animal origin continue to be the major source of chlorinated pesticide residues in the total diet during the period 1964 to 1969 in the United States. Residues for the most part were considered to have resulted from environmental and indirect exposure.

Results of the Food and Drug Administration market basket survey for the period June 1968 to April 1970 (Duggan and Corneluissen, 1972) indicated that foods of animal origin still continue to be the major source of chlorinated organic pesticide residues in the diet.

Foods in this class were identified as dairy products, meat, fish and poultry. These foods represent about one-fourth of the diet used in the study. They were the source of one-half of the intake of total chlorinated pesticide residues including DDT compounds. It was also reported that the residues in the above classes were due to indirect and environmental sources.

Increasing concern regarding pesticide residues in food products has developed in other countries. In Denmark, during the period 1962 to 1966, a total of 179 milk samples and 381 butter samples representative of the production of six dairies were collected and analyzed for pesticide residues (Bro-Rasmussen et al., 1968). All of the butter and milk samples were found to be contaminated by one or more of the insecticides. DDT, DDE, alpha BHC, dieldrin and lindane were found in concentrations of 0.02 to 0.10 parts per million on a butterfat basis.

A survey of the milk supply of Ontario, Canada was conducted between November 1967 and June 1969. Samples from bulk tanks indicated the average level of DDT and its analogues to be 0.134 parts per million in fluid milk (Frank et al., 1970).

Rammell and Thompson (1971) reported high levels of total DDT in market milk in New Zealand. The maximum level was noted from June to August. Minimum levels of DDT in milk were reported from December to February. A direct association was noted with the time of use of DDT for treatment of the grassgrub, Costelytra zealandica White, and ensuing residue levels of DDT in milk of dairy animals.

Between October 1969 and February 1970 and May-June 1970, 400 milk samples purchased from stores and dairies in 14 milk supply regions of West Germany were analyzed for chlorinated hydrocarbon pesticides (Tolle et al., 1971). Residues of at least two pesticides were found in every sample. Total DDT residues averaged 0.64 parts per million on fat basis. The residues in milk were higher in winter. The authors implicated feed concentrates as the important sources of pesticide residues.

Residues in Animal Feed

Considerable research has been conducted to define the "no effect or safe" level of feedstuffs contaminated with pesticide residues. Zweig et al. (1961) reported a maximum level of 0.5 parts per million DDT in feed fed for 31 days did not produce residues as much as 0.01 parts per million in milk. According to this report DDT concentration in milk was proportional to the DDT level in the feed. Analyses were performed by colorimetric and paper chromatographic methods.

In a study conducted by Williams and Mills (1964) sixteen lactating cows were fed mixtures of DDT, heptachlor epoxide, dieldrin, endrin and lindane at levels of approximately 0.05, 0.15 and 0.30 parts per million of each. The pesticides in an alcohol solution were added to the feed. The highest residues of DDT reported were less than 0.01 parts per million on a whole milk basis.

Laben et al. (1965) fed DDT to dry cows and heifers from the 90th to the 30th day before expected parturition. Levels fed were 30, 300 and 600 parts per million. Total DDT levels in the milk fat were 10, 231, and 812 parts per million respectively after calving. A decline of 9 to 11 per cent per week of total DDT was reported through the first lactation.

The DDT level in the milk fat of cows with lowest intake did not reach 1.0 part per million until after 17 to 26 weeks of lactation. These authors concluded that providing dry cows or heifers feed contaminated at or above this level is impractical, even if the feed is withdrawn a month before calving.

Feeding a single dose of about 14 parts per million DDT (77 per cent p,p'-DDT) caused a large increase in DDT residues in milk (Crosby et al., 1967). The total intake over a feeding period was about 350 parts per million DDT.

After dosing, the peak of total DDT residues was reached in 14 hours. The background level in milk fat was 0.21 to 0.36 parts per million DDT. Background levels of DDT in feed were 0.09 to 0.21 parts per million. After three weeks, DDT level in milk fat was stabilized at about 6.0 parts per million. Rate of decline of DDT was stabilized at about 10 per cent per week in milk fat when the feeding of DDT was discontinued.

Fries et al. (1969) suggested a daily intake of 5 milligrams of DDE would result in a concentration of residues in milk that would exceed the official tolerance. A daily dosage of 25 milligrams of p,p'-DDT however, could be tolerated without resulting in excessive residues.

Source of Residues in Animal Feed

The source of residues has been shown by several researchers to be of primary importance. Witt et al. (1966a) concluded that administration of DDT in the form of an "aged" residue in alfalfa results in higher residue levels than when DDT is administered in solution in corn oil. Absorption of DDT by the dairy cow from aged residues on alfalfa were about twice as efficient as absorption of DDT from an oil solution. The authors considered this may be due to the larger rumen exposure for alfalfa as compared to oil.

DDT administered in an oil solution produced predominately DDD and DDT residues in milk. DDT administered as an "aged" residue resulted in DDT, DDD and DDE in the milk. Intratracheal exposure of

p,p'-DDT, which bypasses the rumen, increased the amount of DDT in milk, but increases in the level of DDE and DDD were not significant. Intravenous administration of p, p'-DDT, which also bypasses the rumen, produced a large increase in the level of DDT in the milk, but some DDE and DDT also were produced.

In a similar study, Witt and several co-workers (1966b) reported on variations of pesticide residues in milk from Arizona. The metabolite DDE generally occurred in concentrations 6 to 12 times greater than the concentration of DDT. Results of earlier work by Witt et al. (1966a) indicated that rumen micro-organisms convert DDT to DDE rapidly and efficiently. DDD level in milk was generally low. In cases where it was high, the source of DDD was traced to large amounts of DDD in the silage. They concluded that since no DDD (TDE) was being used in the field, the ensiling micro-organisms were metabolizing DDT to DDD.

Fries et al. (1969) reported that rumen micro-organisms were very effective in converting both o,p'- and p,p'-DDT to the corresponding DDD isomers. This is important in relating toxicity of metabolites in a given milk sample. DDD is less toxic than DDT. Also, o,p'-DDT has been shown to exhibit estrogenic activity under some conditions.

Sources of Feed Contamination

Moubry et al. (1968) presented data on the source of pesticide residues in 40 dairy herds in Wisconsin between 1964-1967. During this period milk from these herds was found to contain residues of

DDT and several other chlorinated hydrocarbons in excess of tolerance. Feed had been contaminated from either direct application or drift of insecticides. Contamination of a dairy fly spray with other pesticides and dermal application of the wrong insecticide was also cited as sources of residues. The predominant residue in milk was DDD when cows ingested feed contaminated with DDT. If the cows had been treated dermally, DDT was the primary residue. They concluded that the amount of DDT, DDD and DDE present in milk varies in relation to each other depending upon whether exposure is by ingestion or dermal application.

Saha (1969), in a survey of the literature, reported that the probable residue level of total DDT in whole milk was about 3.8 per cent of the residue content of feed. The residue level in milk reached a plateau within a few days after cows ate contaminated feed. It thereafter stayed constant throughout the feeding period. A level of more than 1.3 parts per million of DDT residue in the feed resulted in residues in excess of the tolerance of 0.05 parts per million in whole milk.

Twelve holsteins were fed a constant pesticide intake during their first lactation. Levels of total DDT were 0.25, 0.50, and 1.00 parts per million, fed as "aged" residues on alfalfa hay. Total DDT in milk fat was 0.89, 1.34 and 2.45 parts per million, respectively (Whiting et al., 1969).

Pesticide drift from the target site to adjacent crops or animals has been shown to be an important source of contamination. Akesson and Yates (1964) reported on studies of drift of DDT and several other insecticides which were applied to alfalfa hay under California conditions. One and one-half pounds technical DDT per acre was applied by aircraft at wind velocity of from 4 to 7 miles per hour. Alfalfa hay cut 1200 feet downwind from this application produced no detectable insecticide residues in the milk of dairy cattle that were fed this hay. It was safe to cut the hay immediately after the insecticide application, with no waiting period.

These authors noted that this distance was based upon a single exposure between cuttings. If several applications were made in the same vicinity at approximately the same time, the drift residue on a particular alfalfa field downwind would probably be cumulative and thus the amount of deposit might exceed that upon which their calculations were based.

Huddleston et al. (1960) reported on DDT residues on New York dairy farms following the eradication program for the gypsy moth Porthetria dispar (L.). Contamination was widespread for one year as a result of a single aerial application of 1.0 to 2.6 pounds actual DDT per acre. DDT residues in raw milk in the area were 0.17 to 3.77 parts per million and 0.05 to 0.40 parts per million 7 and 325 days, respectively, after aerial application of DDT. Residues of DDT on

grass in the area treated with 1.0 pound of DDT varied from 24.4 to 337.2 parts per million and 0.0 to 0.6 parts per million at zero and 97 days, respectively, after application.

Henderson (1965) in a review of insecticide residues in milk and dairy products noted that one teaspoon of DDT spread over one acre producing two tons of hay caused contamination of 1 part per million. Residues in milk products were a result of either misuse or feed contamination. In most cases, feed contamination occurred without the prior knowledge of the dairymen.

Drift of DDT was also indicated as the principal source of residues in forage and grain feedstuffs on Pennsylvania farms (Cole et al., 1966). Samples from these farms revealed 54 per cent of forage samples were contaminated at levels from 0.003 to 0.15 parts per million. Sixty-two per cent of grain samples were contaminated with DDT at an average of 0.330 parts per million.

Danish dairy products were examined by Bro-Rasmussen et al. (1968) between 1962-1966. Two hundred sixty samples of feed and milk were examined from 20 farms. Analyses of feed mixtures and concentrates indicated DDT/DDE was responsible for 30 to 50 per cent of contamination problems. Since the organochlorines were not used on Danish feed crops, these workers concluded that contamination was caused by pesticide drift from other treated crops.

Ware and co-workers (1969) investigated the drift potential of various methods used to apply pesticides. At all distances downwind, aerial application of pesticides resulted in four to five times the amount of drift particles compared to drift resulting from a high-clearance ground sprayer.

Frost and Ware (1970) compared pesticide drift from aerial and ground applications. Methoxychlor was applied to cotton at 1.5 to 2.0 pounds actual in one to seven gallons emulsifiable concentrate per acre. They noted the drift residue from aerial application one-quarter to one-half mile downwind could be reduced 80 per cent by changing to a high-clearance sprayer. Alfalfa one-half mile downwind contained a total residue of methoxychlor of 0.14 parts per million as a result of aerial application.

Spencer (1971) commented on the problem of interrelated cotton and alfalfa production in Arizona. Excessive residues of DDT in alfalfa hay prompted him to suggest a zoning action.

Residues of DDT up to 70 parts per million were found at distances of one to 100 meters from treated rape fields within three days after spraying (Heinisch et al., 1972). The original detectable residue decreased approximately 80 per cent within 10-14 days. A maximum residue concentration was reached at a distance of 30-50 meters and not adjacent to the treated fields. The authors noted residues may have been detected farther than 100 meters. They suggested the possibility of forage contamination from drift.

Attempts have been made to define "safe" withholding period for dairy animals grazing on pastures treated with and/or exposed to drift of organochlorine insecticides. Garon and Decker (1960) exposed cows to pastures seven days after application of three pounds actual DDT per acre. After grazing for 13 days, the cows had a maximum of 4.0 parts per million DDT in their milk. The DDT residue on pasture grass during this period was 6.7 to 7.8 parts per million. This represents about 0.5 parts per million residue in milk per part per million intake. Cows grazed on treated pastures from 14 to 20 days after application had 1.6 parts per million DDT in their milk on a fat basis.

Harrison et al. (1963) reported that DDT emulsion sprays gave the highest and most persistent residues on pastures. In their study one application was made at 2.0 pounds actual per acre to a rye grass/clover pasture about 1/2 - 1" in height. DDT was measured at 2441 parts per million on the grass. Their data indicated that rainfall alone cannot be depended upon to wash pastures free of these residues.

New growth of the rye grass and clover helped reduce residues. After four days, they noted a 44 and 48 per cent reduction. After 14 days, the reduction in residues was 87 to 95 per cent.

A six-week withholding period was suggested in later work by Harrison and Collet (1965). Cows introduced to pasture when the DDT residue on grass was 1.2 parts per million experienced a build-up in the butterfat of less than 0.5 parts DDT per million. The original treatment rate was two pounds per acre in one application. Seven days after application, residues were as high as 56.8 parts per million DDT. After 28 days, this residue had declined to 8.0 parts per million.

Persistence of Residues in Soil

Residues of the organochlorine insecticides are known to persist in soil for a number of years. Newsom (1967) pointed out that residues from a single application to turf may persist for from 4 to 12 years at levels amounting to 5 to 15 per cent of the initial application. Laben (1968) commented on the importance of the transfer of pesticide residues from soil and water to crops in dealing with very low contamination levels in food of animal origin.

Ware et al. (1968) measured DDT residues in soil in Arizona in 1967 and 1968. They found a maximum of 404 parts per billion of DDT and its analogues in the soil in August. In May the total residue level in soil had decreased to 25.0 parts per billion.

Stevens et al. (1970) sampled soils nationwide in 1965, 1966 and 1967 to determine existing pesticide residue levels in soils. Samples were collected from three different areas; (1) areas in which pesticides had been used regularly, (2) areas which had a record of at least one pesticide application, (3) areas with no history of pesticide use. Residues of DDT were found in soils from areas (1) and (2). Only one sample from one non-use area contained a small amount of DDT.

Gish (1970) sampled 20 agricultural soils in Louisiana. Samples were from pastures, cotton and sugarcane fields. DDT and its analogues were found in all samples. Values in parts per million (dry weight basis) ranged from 0.0083 to 2.5700 with the larger amounts from cotton fields having a history of heavy use of DDT.

Ware et al.(1971a) concluded that the soil burden of DDT and its analogues had not significantly decreased following a two-year moratorium on use of DDT in Arizona. They suggested a possible half-life of 10 to 12 years for DDT in soils. The primary residue was DDE.

Rammell et al. (1971) referred to results of a study by Walton which indicated that residue levels in milk rise and fall in response to the amount of topsoil ingested by the cow. Dairy cows in New Zealand may consume 90-450 kilograms of soil annually with peak ingestions in autumn and winter.

Two hundred fifty kilograms of soil would amount to about 1 per cent of the weight of fresh herbage ingested by the cow during a one-year period. A concentration of 50 parts per million of DDT in the

soil would therefore be required to give a concentration equivalent to 0.5 parts per million on a fresh herbage basis.

Translocation of Insecticides in Plants

It has been established that most of the chlorinated hydrocarbon insecticides are translocated from the soil and penetrate plant tissues to a limited degree. Lichtenstein and Schulz (1960) reported DDT translocation was not detected in aerial parts of pea plants when grown in DDT treated soil, however.

Ware et al. (1968) indicated DDT was not translocated in alfalfa to any significant degree through the roots to above ground portions. They concluded that the residues on alfalfa originated from wind blown contaminated dust, rain-splashed soil or drift.

Nash (1968) studied the plant absorption of dieldrin, DDT and endrin from soils. Wheat seedlings grown in Lakeland sandy loam soils treated with C14 labeled DDT concentrated 3 to 10 per cent in the shoots of the level of residue in soil.

DDT, in soil at levels of 4 parts per million did not translocate to the above ground portions of alfalfa from the root zone during 279 days of exposure (Ware, 1968).

Harris and Sans (1969) studied the uptake of organochlorine insecticide residues from agricultural soils by crops used for animal feeds. Soils were a sandy loam, clay and muck. Residues of DDT and its metabolites were present in all three soils. Oats, corn

carrots, potatoes, sugarbeets and alfalfa contained little or no residues of DDT.

Ware et al. (1970) exposed alfalfa roots to C^{14}-DDT labeled impregnated soil by three methods: (a) emulsion injected around the roots, (b) seeds germinating in treated soil, and (c) plants surrounded by a layer of treated soil. They concluded that DDT translocation from contaminated soil to above-groupd parts of alfalfa is not a route of significant forage contamination.

Seasonal Variation of Residue Levels

Due to the inadvertent contamination with DDT of feedstuffs such as grain and forage utilized by dairy animals, one of the most interesting correlations has been the seasonal occurrence of contamination and resultant increases of residues in milk. Witt et al. (1966) commented on this in a study in Arizona conducted over a period of 4 years and 3 months. They found that the residue level in milk exhibited a seasonal cycle, with a maximum in the fall and a minimum in the late spring and early summer. They correlated this with practices in pesticide application and the harvesting, storage and feeding of drift-contaminated forage.

Ware and his co-workers (1968) noted a seasonal variation with soil residues. They correlated this with DDT use, primarily on cotton.

Damaskin (1972) indicated a direct relationship between DDT residues in forage/fodder and milk in an agricultural area. A seasonal variation was noted. A sharp decrease in the use of DDT resulted in a considerable decrease of the DDT level in feed and food products. Bro-Rasmussen and his co-workers (1968) noted a seasonal variation. The highest level of DDT/DDE occurred in the September-December period. Rammell and Thompson (1971) found milk to contain the highest levels of DDT in June-August. The minimum residue level was reached during the period December to February.

Attempts to Reduce Residue Levels

There has been a limited amount of work in attempting to de-contaminate animal feeds following their contamination. Archer and Crosby (1968) investigated the removal of DDT and related chlorinated hydrocarbon residues from alfalfa hay. Commercial dehydration removed 50 per cent of the original residues on green chopped alfalfa. This would be practical, if the initial concentration of residues were at a level of 1.0 to 2.0 parts per million.

Later work by Archer and Crosby (1969) revealed that DDT levels may be substantially reduced in alfalfa products by vapor washing or volatilization. Practical scale demonstrations indicated that the decontamination methods as demonstrated in the laboratory may be economically feasible.

Alfalfa sprayed with large concentrations of DDT was air dried in the dark, in sunlight and under ultra violet lamps. Loss of DDT residues after 11 days was approximately 50 to 70 per cent (Archer, 1969).

Ware et al.(1971b) noted a difference in total DDT residues in green alfalfa, hay and alfalfa cubes from the same source. Residues in cubes were 63 per cent higher than those in windrow hay from which cubes were derived. The cubing process involves compressing to a density approximately four to five times that of baled hay. On three fields sampled, the total DDT residues were greater in cubes $>$ field hay $>$ laboratory hay $>$ green alfalfa.

Upon contamination of a dairy cow with DDT, excretion has been found to be a function of time that depends primarily on the initial concentration of residue in the milk. DDT decline in milk fat has been estimated to be at about 9 to 11 per cent per week by Laben et al. (1965), assuming of course that the source of contamination has been eliminated.

Cows were exposed to a moderately high pesticide contaminated environment and then transferred to one of very low intake (feed 0.01 ppm DDT) (Whiting et al., 1972). The initial mean value of total DDT in the milk fat was 1.79 parts per million. After two months, the level of DDT in the milk fat was 0.96 parts per million. After 8-10 months, the total DDT in the milk fat was 0.17 to 0.21 parts per million. There was considerable individual variation among animals. Seven of 10 had total DDT levels in milk fat ranging from 0.93 to 2.50 parts per million. Two had levels of 0.41 and 0.70 parts per million. The milk from one animal had a concentration of DDT in the milk fat of 3.30 parts per million. Individual variation was also noted at the final observation.

Miller (1967) investigated the effect of thyroprotein and a low-energy ration on removal of DDT from lactating dairy cows. His data did not indicate any appreciable difference between cows that received normal rations and those receiving thyroprotein. Milk from cows on a low energy ration declined to 1.25 parts per million (fat basis) in 114 days compared to 189 days for cows on a regular ration.

Stull et al. (1968) subjected six lactating dairy cows to DDT contamination by intravenous dosing at a rate equivalent to 4 parts per million dietary intake for 14 days. Thyroprotein was administered at a rate of 1 gram per 11 kilograms body weight for 28 days. Milk and milk fat yield increased and body weight decreased in animals

receiving thyroprotein. The concentration of DDT in milk rose during dosing of DDT to 30 parts per million and declined to approximately 7 parts per million prior to the administration of thyroprotein. The DDT level in milk of animals receiving thyroprotein declined to 4 parts per million. Milk from animals in the control group declined to 2 parts per million DDT. They concluded thyroprotein was of no practical value in elimination of DDT residues from milk.

Fries et al. (1969) concluded that any procedure which increases total milk production regardless of its effect on energy balance would probably increase the total DDT excreted and hasten depletion of the body stores.

More recently, activated charcoal has been suggested, either alone or in combination with phenobarbital as treatments to speed excretion of pesticides from milk of dairy cows. Cook (1969) commented on the effect of feeding a pesticide absorbent, such as activated charcoal. He reported that chlorinated hydrocarbons are absorbed from the stomach into the blood stream and recycled back to the stomach in the saliva and digestive juices. It was postulated that feeding an absorbent, such as activated charcoal, would trap the pesticide in the gut of the animal and increase excretion through feces to rid the animal of contamination.

Fries et al. (1970) did not detect any significant effects on removal of DDT and its metabolites from milk of animals fed activated charcoal. Cows were fed one kilogram per day of activated carbon for 14 days. There was no effect on feed consumption. A decrease was noted in milk production. Feeding activated carbon was not recommended as a prophylactic treatment.

Sodium phenobarbital treatments significantly increased the rate of decline of DDD, but not of DDT in contaminated milk. DDE was reduced significantly by phenobarbital. Feed consumption, milk yield and fat content were not affected (Fries et al., 1971).

METHODS AND MATERIALS

Herd milk and feed samples were collected from four dairies in Northeast Louisiana during the period April 1970 to December 1971. Dairies selected were located either adjacent to or in close proximity to cotton acreage. All practiced a combination of dry lot and pasture feeding.

Dairy A

At the beginning of this study the milking herd of Dairy A consisted of 150 Holstein cows. At its conclusion the milking herd consisted of 138 Holstein cows.

Six fields were utilized for the production of feed ingredients on Dairy A. These were hay fields, grain sorghum and corn for silage and rye grass which was utilized for winter grazing. Occasionally supplemental hay was purchased. Crops were rotated on most of these fields in 1970 and 1971. For example, corn was planted in one field in 1970 and was followed by grain sorghum in 1971.

Neighboring cotton fields were located to the North, South and West of the six permanent fields utilized by this dairyman for production of his feed ingredients. An example of proximity of the location of cotton to one field used for hay production on Dairy A is evident in Plate 1. In this case the fields were separated by a gravelled road about 14 feet wide.

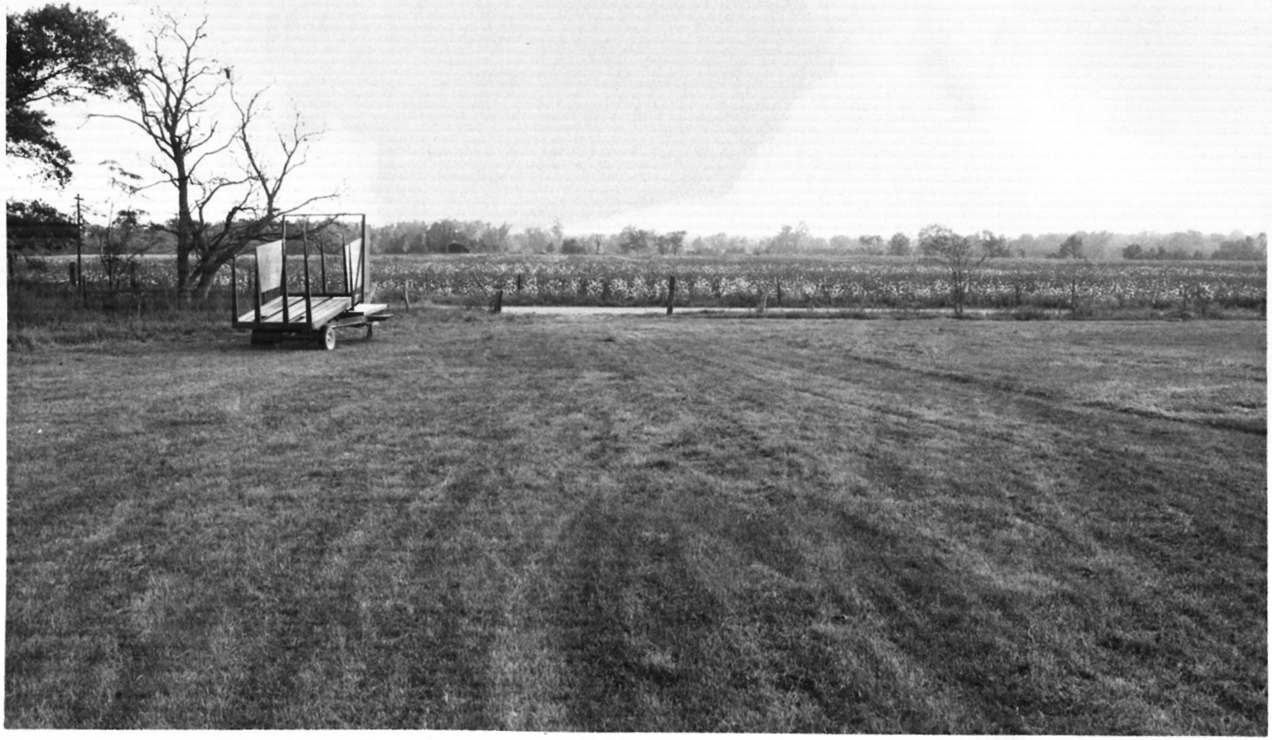


Plate 1. Location of hay pasture on dairy A showing its proximity to cotton.

DAIRY B

The milking herd of this dairy consisted of 101 Holstein cows when this study was begun and 125 animals at its conclusion. The dairyman produced most of his feed ingredients, such as hay, grain sorghum and corn. Rye grass pastures were utilized for winter grazing. Every field was bordered by a neighboring cotton field. An example of this can be seen in Plate 2. Grain sorghum cut for silage was adjacent to cotton, as can be seen in the background.

DAIRY C

Dairy C had 105 Holstein cows in milk production at the beginning of this study and 115 cows at the conclusion. Feed ingredients produced on this dairy were hay, corn, grain sorghum and wheat. Fields utilized for production of these feed ingredients were located from one to three miles from the dairy. The loafing pasture, which was utilized as a resting area for animals between milkings, also presented a problem since it was bordered on the West side by a cotton field (Plate 3). There was a limited amount of grazing of common grass in this pasture by animals in the milking herd.

Plate 2. Location of a grain sorghum field (foreground) on dairy B showing its proximity to cotton fields (background).

Plate 3. Location of loafing pasture next to the milking barn of dairy C showing its proximity to cotton fields.

Outlying fields used by this dairyman for production of his feed ingredients were usually surrounded on at least 3 sides by cotton. The severity of this situation is evident in Plate 4. This field was used for production of corn in 1970 and grain sorghum in 1971. It is bordered to the North, South and West by cotton. As indicated in Plate 4, the only separation is a common dirt field road approximately 10 feet wide utilized by both the cotton producer and the dairyman.

DAIRY D

The milking herd of Dairy D consisted of 70 Holsteins throughout the period of investigation. Commercial feeds were supplemented by grazing pastures and forage sorghums. There was no hay or silage produced or utilized on this dairy.

Three pastures were used for either grazing or production of forage sorghum. Field 1 was adjacent to the milking barn and was bounded on the western boundary by a cotton field, separated by a stream and windbreak. Approximately 2000 feet on its northern boundary was another cotton field. An open pasture separated the two fields. Fields 2 and 3 were adjacent to each other and were bordered on their eastern boundaries by a cotton field. A dirt road and fence separated the test fields from the cotton field.

Plate 4. Location of a grain sorghum field on dairy C showing its proximity to cotton fields.

Milk Samples

Milk samples consisting of four to five ounces were collected daily by the dairyman from his bulk tank and composited on a monthly basis. The milk samples were kept frozen until delivered to the laboratory.

Feed Samples

Daily feed samples consisting of one quart were collected by the dairyman and frozen. Each feed ingredient was identified and kept separate in this manner. These samples were also composited once a month. Typical ingredients were corn or grain sorghum silage, hay, commercial feeds and green chops. The green chops usually consisted of corn and/or grain sorghum fed free choice immediately after cutting. Commercial rations included pelleted concentrate feed, usually consisting of corn and cottonseed or soybean meal. The rate of feeding of the commercial feed was one pound of pellets to 3 pounds of milk produced per animal.

Another commercial ration fed was Built-in-Roughage (BIR). It usually consisted of silage and/or hay and grain concentrates plus proteins and minerals. The BIR, silage and hay was fed free choice. Occasionally, corn and milo were fed as whole grain.

Laboratory Preparation of Samples

Milk

The milk samples were thawed upon delivery to the laboratory. The samples of milk were then thoroughly shaken and set aside until the fat had separated. Seventy-five grams of fat were collected for clean-up and extraction. Duplicates were held for a check sample.

Feed Ingredients

Silage, hay, and grass samples were thoroughly ground in a Hobart blender prior to clean-up and extraction. Commercial feeds were partitioned in a Riffle Splitter and fifty grams were collected as a representative sample. Duplicates of each were held for a check sample.

Clean-Up and Extraction

The following reagents were used in the clean-up and extraction of milk and feed samples:

Petroleum ether - Pesticide quality - Matheson, Coleman and Bell

Sodium chloride - A. R.

Ethyl alcohol - 95 per cent

Potassium oxalate - crystals

Celite 545 - Fisher - C212

Ethyl ether - redistilled

Sodium sulfate - Anhydrous, granular, reagent grade

Magnesium oxide - (Sea Sorb 43)

Acetone - reagent grade

Acetonitrile - nanograde

Florisil - Floridin Company, Tallahassee, Florida; activated at 650°C - 60/100 mesh. Before use, Florisil was oven dried (open pan) at 130°F for five hours.

Milk samples were cleaned and extracted using the method described by the Pesticides Analytical Manual, Volume I, Section 211.12. Feed samples were cleaned and extracted using the method described by the Pesticides Analytical Manual, Volume I, Section 212.13 (U.S. H.E.W., 1968).

The final volume of eluant was adjusted to 1 gram per ml concentration for milk fat analysis and 5 grams per ml concentration for feed analysis. A florisil recovery standard and reagent blank were run with each series of six samples to determine the per cent recovery of a known amount of insecticide from the florisil and to identify any solvent interference.

Gas Chromatography

Aerograph Pestilizer Models 680 and 682 gas chromatographs were utilized for determination of residues of DDT and its primary metabolites. Both employ electron capture detectors. The lower level of sensitivity was 0.01 parts per million.

Standards of recrystallized p,p'-DDT, o,p'-DDT, p,p'-DDD, and p,p'-DDE were injected prior to injection of the samples to determine

the elution time of each chemical under the specified conditions. Injections of 1-5 ul quantities were made depending upon the amount of residue detected in the sample. Proper dilutions of a sample were prepared when the residue in a particular sample exceeded the elution retention of the chromatograph.

Only the 6 per cent eluant was required for injection. A Hamilton 10 ul syringe (No. 701) was used in making the injections.

Residue Calculations

Peak heights resulting from residues of DDT and its primary metabolites detected in a sample were adjusted by dilution until they closely approximated the peak heights of a known standard determined by injection of each. Calculations were made by direct linear comparison of peaks.

The following formula was employed for final determination in parts per million:

$$\text{ppm} = \frac{\frac{A \times B}{C} \times D}{E}$$

where

A = height of sample peak for an injection of n uls of sample

B = ng pesticide represented by standard peak

C = height of standard peak

D = dilution factor (D = 1 if no dilution)

E = mg of sample represented in n uls of original extract

Thin Layer Chromatography

Qualitative confirmation of samples was done by the thin layer technique described by Damaska (1964). Samples that contained less than 0.05 parts per million total DDT were not confirmed by this method.

RESULTS AND DISCUSSION

DAIRY A

Residue Analyses of Milk

Results of analyses of Dairy A milk samples collected between April 1970 and December 1971 are presented in Table I. All calculations are on the fat basis. Results show amounts of each primary metabolite of DDT for each observation expressed as total DDT and its relates.

Statistical analysis of these data showed that 74 per cent of the variation of total DDT in milk of Dairy A could be accounted for by linear, quadratic and cubic effects by month (Figure 1). Data to plot both the observed and predicted values for each observation are based on the monthly mean. Regression coefficients were established to test the relationship of each mean observation to determine whether a linear, cubic or quadratic relationship existed. The "t" test was used to test for significance at the 10 per cent probability level. All three relationships were significant.

It is evident that a definite relationship exists between the time DDT is applied to cotton and the occurence of maximum residues of DDT in milk.

Feed Samples

Feed samples for Dairy A were not analyzed. Samples were collected each month to establish the general feeding practice through

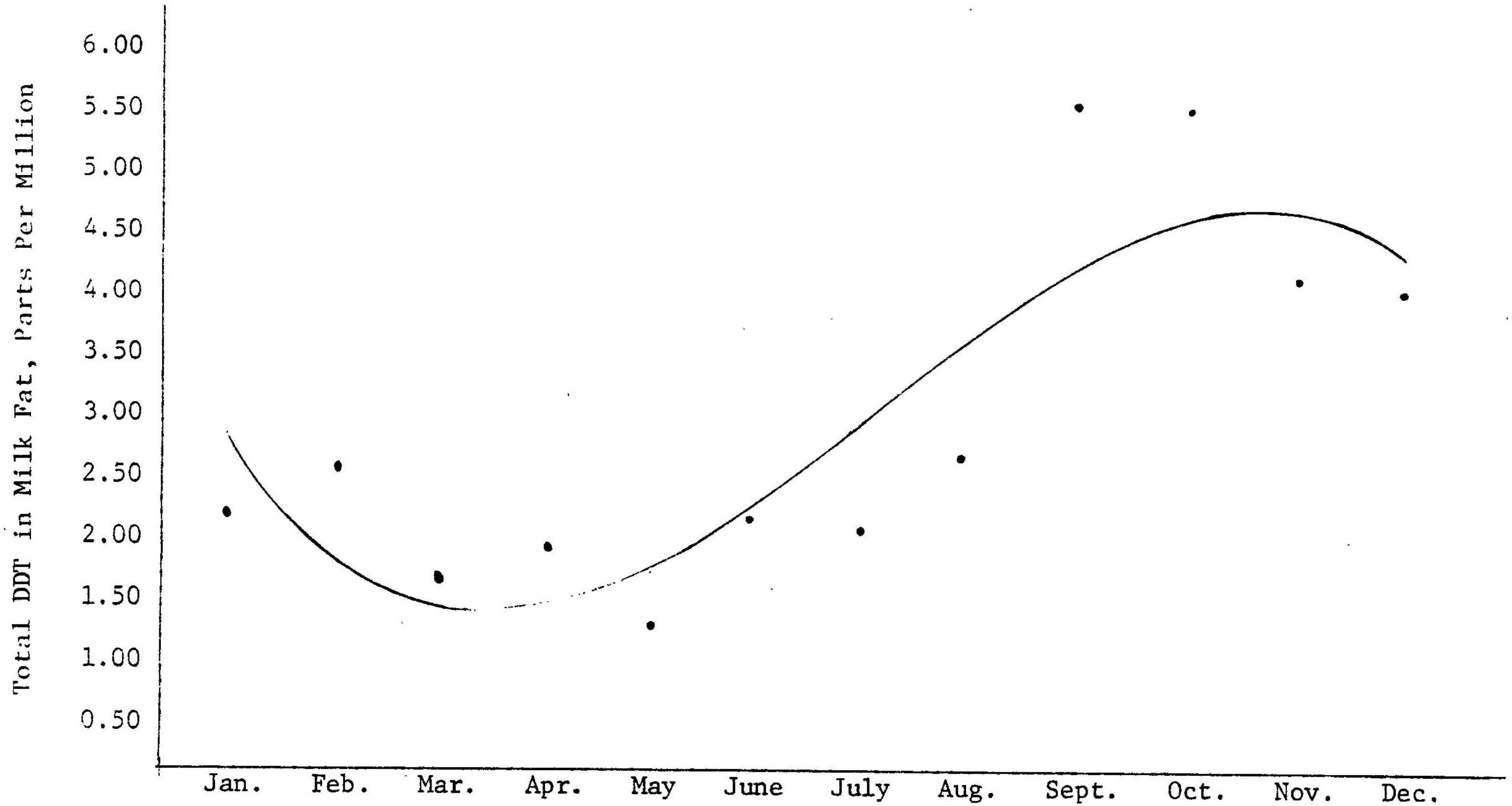
TABLE I

Residues of DDT in Milk on Milk Fat Basis From Dairy A During the Period April 1970 to December 1971.

Date	parts per million p,p'-DDE	p,p'-DDD	p,p'-DDT	DDTR[a]
April 1970	0.83	0.38	0.46	1.67
May 1970	0.87	0.14	0.31	1.32
June 1970	1.01	0.97	0.28	2.26
July 1970	1.07	1.63	0.27	2.97
Aug. 1970	0.97	0.91	0.24	2.12
Sept. 1970	1.15	2.73	0.78	4.66
Oct. 1970	1.78	3.68	0.89	6.35
Nov. 1970	1.38	2.52	0.79	4.69
Dec. 1970	1.69	0.83	1.16	3.68
Jan. 1971	1.24	0.58	0.34	2.16
Feb. 1971	1.55	0.63	0.37	2.55
Mar. 1971	1.21	0.22	0.27	1.70
April 1971	1.37	0.18	0.56	2.11
May 1971	1.13	0.10	0.20	1.43
June 1971	1.36	0.40	0.25	2.01
July 1971	0.87	0.07	0.19	1.13
Aug. 1971	1.52	1.06	0.49	3.07
Sept. 1971	2.05	3.38	0.99	6.42
Oct. 1971	1.43	1.89	1.34	4.66
Nov. 1971	2.17	1.11	0.42	3.70
Dec. 1971	2.16	1.63	0.69	4.48

a/ Total DDT and relates.

Figure 1. Monthly Variation in Total DDT Residues on Milk Fat Basis from Dairy A



Analysis of Variance for Regression

Source	Degrees of Freedom	Mean Square	F Value	Prob., F
Regression (linear, quadratic, and cubic)	3	58123.05	7.54	0.01

the course of this study. A list of feed ingredients collected each month is shown in Table II. Typical feed ingredients fed each month were comparable to those utilized by Dairy C, which were analyzed for residues of DDT.

DAIRY B

Residue Analyses of Milk

Results of analyses of milk samples collected from this dairy between April 1970 and December 1971 are presented in Table III.

A general trend in increase of total DDT occurred toward the end of each year. This increase of total DDT indicates a positive relationship exists between treatment of cotton with DDT adjacent to fields located on this dairy that was used for production of hay, grain sorghum and corn.

An analysis of variance indicated a linear relationship existed between application of DDT to cotton and DDT residues in the dairy feeds grown in adjacent fields over a calendar year (Figure 2). The seasonal variation of DDT residues in milk, as accounted for monthly, was only 33 per cent. Results of the "t" test indicated significance at the 5 per cent probability level.

Feed Samples

A list of feed samples collected from Dairy B is shown in Table IV. No residue determinations were made on these samples. Typical feed ingredients fed each month on Dairy B were similar to those fed on Dairy C.

TABLE II

Feed Ingredients Fed Monthly on Dairy A During the Period April 1970 to October 1971.

Date	Feed	Date	Feed
April 1970	Mixed Feed	Oct. 1970	Silage
	Pellets		Pellets
	Hay	Nov. 1970	Silage
	Silage		Mixed Feed
May 1970	Pellets	Dec. 1970	Pellets
	BIR		BIR
June 1970	BIR		Silage
	Pellets	Jan. 1971	BIR
	Silage	Feb. 1971	BIR
July 1970	Pellets		Pellets
	BIR		Silage
	BIR	March 1971	Silage
	Silage		Pellets
August 1970	BIR		Mixed Feed
	Pellets	April 1971	(none available)
	Green Chops	May 1971	Pellets
	Silage		BIR
Sept. 1970	Pellets	June 1971	BIR
	BIR		Mixed Feed
	Silage		Hay (alfalfa)

TABLE II (contd)

Date	Feed	Date	Feed
July 1971	Pellets	Oct. 1971	Pellets
August 1971	Green Chops		Hay
	Hay		Silage
Sept. 1971	Pellets	Nov. 1971	Pellets
			Hay

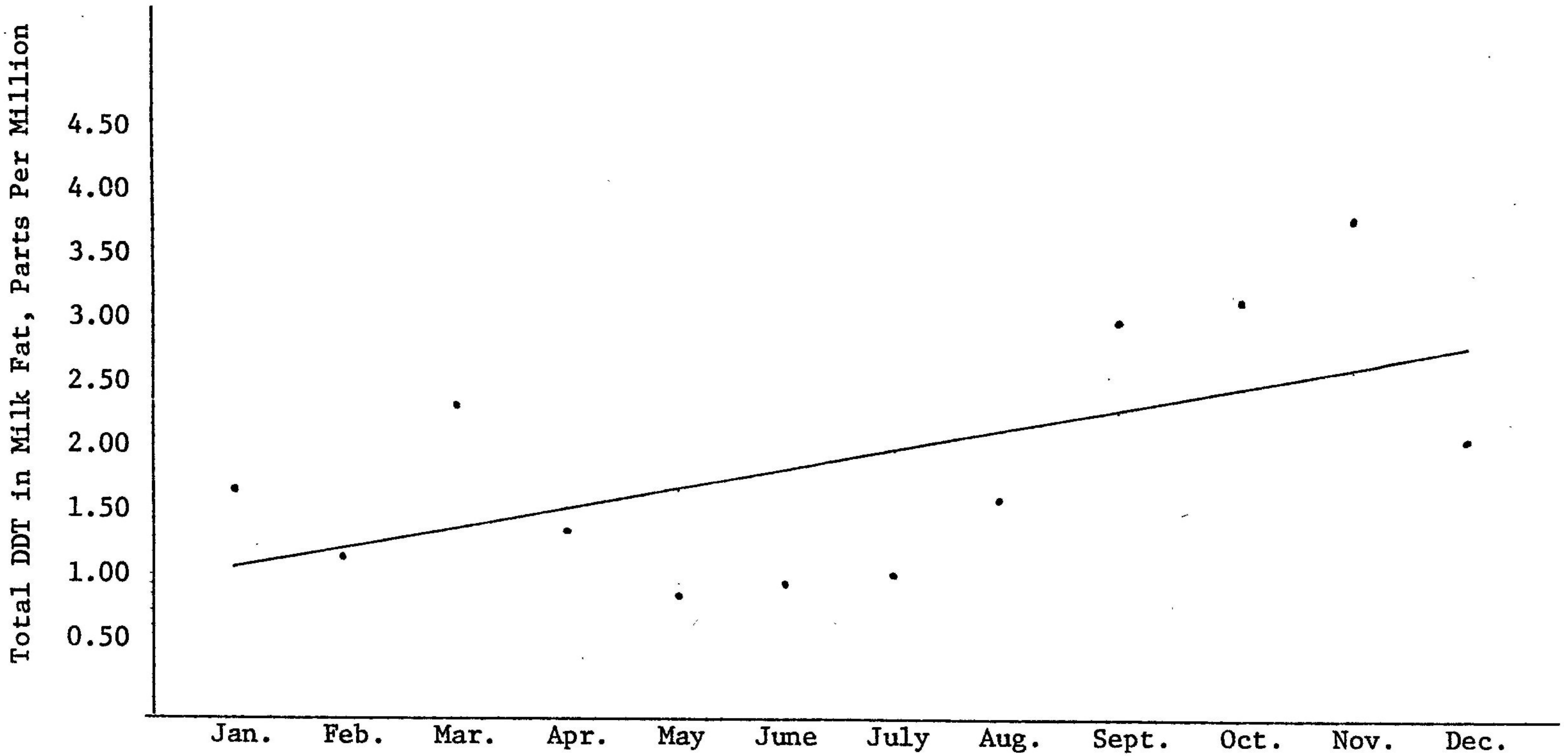
TABLE III

Residues of DDT in Milk on Milk Fat Basis From Dairy B During the Period April 1970 to December 1971.

Date	parts per million p,p'-DDE	p,p'-DDD	p,p'-DDT	DDTR[a]
April 1970	0.54	0.07	0.44	1.05
May 1970	0.53	0.10	0.40	1.03
June 1970	0.65	0.11	0.28	1.04
July 1970	0.68	0.09	0.24	1.01
Aug. 1970	0.66	0.21	0.25	1.12
Sept. 1970	0.79	1.17	0.47	2.43
Oct. 1970	1.13	2.31	0.85	4.29
Nov. 1970	1.09	1.71	0.64	3.44
Dec. 1970	1.27	0.47	0.23	1.97
Jan. 1971	1.13	0.24	0.29	1.66
Feb. 1971	0.84	0.14	0.23	1.21
March 1971	1.06	0.79	0.49	2.34
April 1971	0.92	0.13	0.42	1.47
May 1971	0.40	0.08	0.11	0.59
June 1971	0.56	T [b]	0.15	0.71
July 1971	0.72	0.05	0.21	0.98
Aug. 1971	0.89	0.85	0.26	2.00
Sept. 1971	1.00	2.00	0.57	3.57
Oct. 1971	0.87	0.62	0.54	2.03
Nov. 1971	2.04	1.61	0.46	4.11
Dec. 1971	1.45	0.37	0.42	2.24

[a] Total DDT and relates
[b] Trace

Figure 2. Monthly Variation in Total DDT Residues on Milk Fat Basis from Dairy B



Analysis of Variance for Regression

Source	Degrees of Freedom	Mean Square	F Value	Prob., F
Regression (linear)	1	35072.45	4.90	0.05

TABLE IV

Feed Ingredients Fed Monthly on Dairy B During the Period April 1970 to November 1971

Date	Feed
April 1970	Commercial grain
	Silage
	Pellets
	Milo
May 1970	Hay
	Silage
	Mixed Feed
	Pellets
June 1970	Silage
	Pellets
	Mixed Feed
July 1970	Silage
	Hay
	Pellets
	Mixed Feed
August 1970	Mixed Feed
	Pellets
	Silage
Sept. 1970	Pellets
	Silage
	Mixed Feed
Oct. 1970	Silage
	Milo (whole grain)
	Mixed Feed
	Pellets
Nov. 1970	Silage
	Mixed Feed
Dec. 1970	Mixed Feed
	Pellets
	Alfalfa Hay
	Silage
Jan. 1971	(none available)
Feb. 1971	Silage
	Pellets
	Mixed Feed
March 1971	Silage
	Pellets

TABLE IV (contd)

Date	Feed	Date	Feed
May 1971	Hay	Sept. 1971	Mixed Feed
	Pellets		Silage
June 1971	Mixed Feed	Oct. 1971	Silage
July 1971	(none available)		Mixed Feed
Aug. 1971	Mixed Feed	Nov. 1971	Cottonseed Meal
	Silage		Pellets
Sept. 1971	Pellets		Silage

DAIRY C

Residue Analyses of Milk

Data relative to DDT residues from monthly collections of milk samples from this dairy are presented in Table V. DDT residues in milk were high throughout the course of this study. Lowest value of total DDT occurred in June of both 1970 and 1971. The maximum total DDT occurred in November and December in 1970 and 1971 respectively. No reason can be given with the available data for the reduction that occurred in total DDT in the milk sample of November 1971, compared to the October sample and the corresponding milk sample in December 1971.

Statistical analyses of these data indicate a positive relationship exists between DDT in milk and seasonal application of DDT to cotton. An analysis of variance was conducted and regression coefficients were established. Linear, cubic and quadratic relationships were tested. These data are presented in Figure 3.

Seventy per cent of the variation of DDT in the milk from this herd was related to seasonal occurrence. Based on observation of the means for each sampling point definite linear and quadratic relationship is established for one season (Figure 3). Results of the "t" test indicated this relationship to be significant at the 5 per cent probability level.

TABLE V

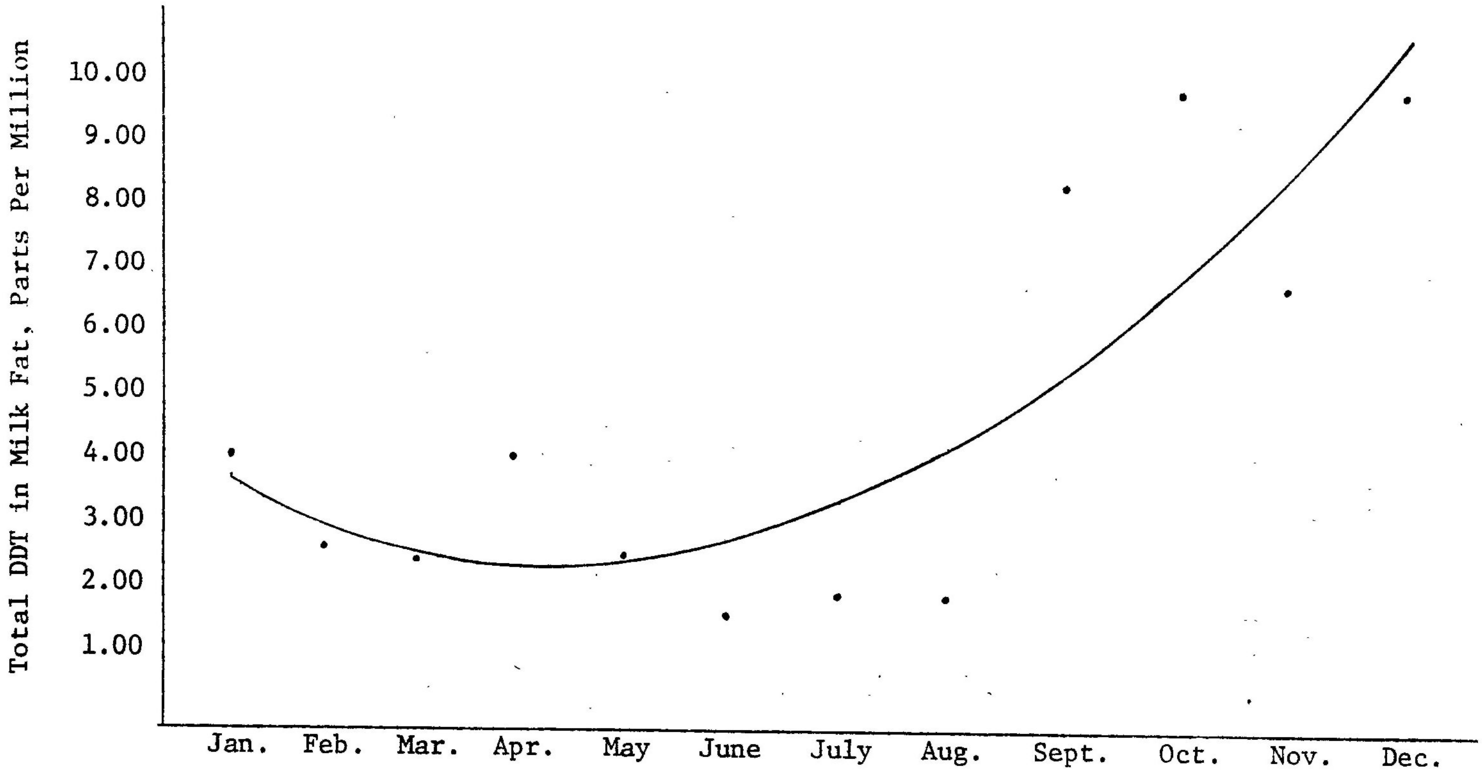
Residues of DDT in Milk on Milk Fat Basis From Dairy C During the Period April 1970 to December 1971.

Date	parts per million			
	p,p'-DDE	p,p'-DDD	p,p'-DDT	DDTR [a]
April 1970	1.09	1.90	1.86	4.85
May 1970	1.05	1.15	0.73	2.93
June 1970	0.89	0.41	0.50	1.80
July 1970	1.19	0.86	0.64	2.69
August 1970	1.25	0.62	0.48	2.35
Sept. 1970	1.71	3.73	0.84	6.28
Oct. 1970	1.37	2.91	1.16	5.44
Nov. 1970	2.35	4.80	1.41	8.56
Dec. 1970	1.75	1.37	0.98	4.10
Jan. 1971	1.51	2.06	0.49	4.06
Feb. 1971	1.23	1.05	0.31	2.59
March 1971	1,22	0.83	0.40	2.45
April 1971	1.40	0.82	0.66	2.88
May 1971	1.15	0.27	0.49	1.91
June 1971	0.83	0.16	0.11	1.10
July 1971	0.96	0.16	0.17	1.29
Aug. 1971	1.17	0.28	ND [b]	1.45
Sept. 1971	2.00	7.03	1.40	10.43
Oct. 1971	2.15	10.40	1.80	14.35
Nov. 1971	2.04	2.10	0.76	4.90
Dec. 1971	3.91	9.58	2.02	15.51

[a] Total DDT and relates

[b] Not detected

Figure 3. Monthly Variation in Total DDT Residues on Milk Fat Basis from Dairy C



Analysis of Variance for Regression

Source	Degrees of Freedom	Mean Square	F Value	Prob., F
Regression (linear and quadratic)	2	392634.97	10.55	0.01

Residue Analyses of Feed

Results of analyses of feed samples collected from Dairy C from April 1970 through November 1971 are presented in Table VI. An analysis of variance was conducted to check the significance of DDT levels in feed to DDT residues in milk. Feeds were classified as hay, silage, mixed feed, and/or Grain Pellets and BIR for purpose of analyses.

The data in Table VI shows that hay is the most highly contaminated of all feeds analyzed. DDT contaminated silage was found to significantly affect the DDT content of milk from August to December (Table VII). Because of the limited number of observations, data on silage analyses from Dairy D was included.

The DDT content in mixed feed, and/or Pellets or BIR rations did not significantly affect the occurrence of DDT in the milk of animals of Dairy C which received these feeds.

The influence of silage contaminated with DDT, at a specific time period, on levels of DDT in milk is evident. The "steady state" of high DDT residues in hay is responsible for the high residues of DDT in milk of Dairy C herd throughout the year. Use of silage from August through December probably explains the increase in total DDT residues in the milk (Figure 4).

TABLE VI

Residues of DDT in Feed From Dairy C During the Period April 1970 to November 1971.

Date	Feed	parts per million p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	DDTR[a/]
April 1970	Silage	0.01	0.01	0.02	ND[b/]	0.04
	Mixed Feed	ND	ND	0.97	0.32	1.29
May 1970	Silage	ND	T[c/]	0.18	0.04	0.22
	Hay	1.12	2.29	21.96	3.30	28.67
	Mixed Feed	ND	ND	0.34	0.15	0.49
June 1970	Silage	ND	0.14	0.23	0.04	0.41
	Hay Ration	0.35	ND	7.78	1.10	9.23
	Mixed Feed	ND	ND	0.07	0.02	0.09
July 1970	Silage	0.03	ND	0.13	ND	0.16
	Hay	0.09	ND	1.19	0.28	1.56
	Mixed Feed	ND	ND	0.05	0.03	0.08
Aug. 1970	Hay	0.13	0.25	4.36	0.77	5.51
	Silage	0.04	0.01	0.33	0.02	0.40
	Mixed Feed	0.01	ND	0.05	ND	0.06
Sept. 1970	Mixed Feed	ND	T	0.34	0.04	0.38
	Hay	0.07	0.18	3.15	0.37	3.77
	Silage	ND	ND	1.52	0.24	1.76
Oct. 1970	Silage	0.16	0.29	1.38	0.19	2.02
	Hay	0.12	ND	2.11	0.47	2.70
	Mixed Feed	ND	ND	0.05	0.02	0.07

TABLE VI (contd)

Date	Feed	parts per million				
		p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	DDTR[a]
Nov. 1970	Silage	0 .12	0.43	1.71	0.25	2.51
	Hay	0 .21	ND	3.14	0.80	4.15
	Mixed Feed	ND	ND	0.18	T	0 .18
Dec. 1970	Hay	T	T	2.16	0.40	2.56
	Silage	0 .14	0.93	0.53	ND	1.60
	Mixed Feed	0 .01	T	0.14	0.03	0 .18
Jan. 1971	Hay	0 .60	1.17	7.78	1.50	11.05
	Mixed Feed	ND	ND	0.27	0.07	0 .34
	Silage	T	0.41	0.36	T	0 .77
Feb. 1971	Mixed Feed	ND	T	0.05	0.01	0.06
	Hay	0 .12	ND	2.48	0 .47	3.07
	Silage	0 .05	0 .17	0.90	0 .17	1.29
March 1971	Hay	ND	ND	5.57	0 .27	5.84
	Silage	ND	0 .14	0 .17	ND	0 .31
	Mixed Feed	ND	0 .02	ND	ND	0 .02
April 1971	Mixed Feed	ND	T	ND	ND	T
	Hay	ND	0 .58	3.88	0 .45	4.91
	Silage	ND	0 .09	0.10	ND	0 .19
May 1971	Silage	ND	0 .07	0.06	ND	0 .13
	Hay	0 .11	ND	1.44	0 .37	1.92
	Mixed Feed	ND	ND	T	ND	T

TABLE VI (contd)

Date	Feed	parts per million				
		p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	DDTR[a]
June 1971	Silage	0.02	0.07	0.06	0.01	0.16
	Hay	0.03	ND	0.11	0.03	0.17
	Mixed Feed	ND	ND	0.02	ND	0.02
July 1971	Silage	0.01	ND	0.02	ND	0.03
	Hay	0.04	ND	0.20	0.06	0.30
	Mixed Feed	0.02	0.03	0.13	0.01	0.19
Aug. 1971	Mixed Feed	ND	ND	ND	T	T
	Hay	T	ND	0.48	0.11	0.59
	Silage	ND	ND	0.26	0.05	0.31
Sept. 1971	Mixed Feed	ND	ND	ND	ND	ND
	Hay	0.04	ND	0.15	0.56	0.75
	Silage	ND	ND	6.10	0.40	6.50
Oct. 1971	Mixed Feed	ND	ND	ND	ND	ND
	Hay	0.33	ND	6.06	0.35	6.74
	Silage	T	ND	2.87	0.16	3.03
Nov. 1971	Silage	0.25	ND	2.67	0.12	3.04
	Hay	0.26	ND	5.54	0.26	6.06
	Mixed Feed	0.01	ND	0.33	0.02	0.36

a/ Total DDT and relates.

b/ ND - Non Detectable

c/ Trace

TABLE VII

Residues of DDT in Silage Rations Fed to Dairy Animals
and the Effect on DDT Levels in Milk

No. of Observations	Month	Parts Per Million: Silage	Parts Per Million: Milk Fat[a/]
1	January	0.77	4.06
1	February	1.29	2.59
1	March	0.31	2.45
2	April	0.11	3.86
2	May	0.16	2.42
2	June	0.28	1.45
3	July	0.08	1.99
3	August	0.78 [b/]	1.90
3	September	6.61 [b/]	8.36
2	October	2.52 [b/]	9.90
3	November	2.38 [b/]	6.73
1	December	1.60 [b/]	9.81

[a/]Mean Value - Dairy C

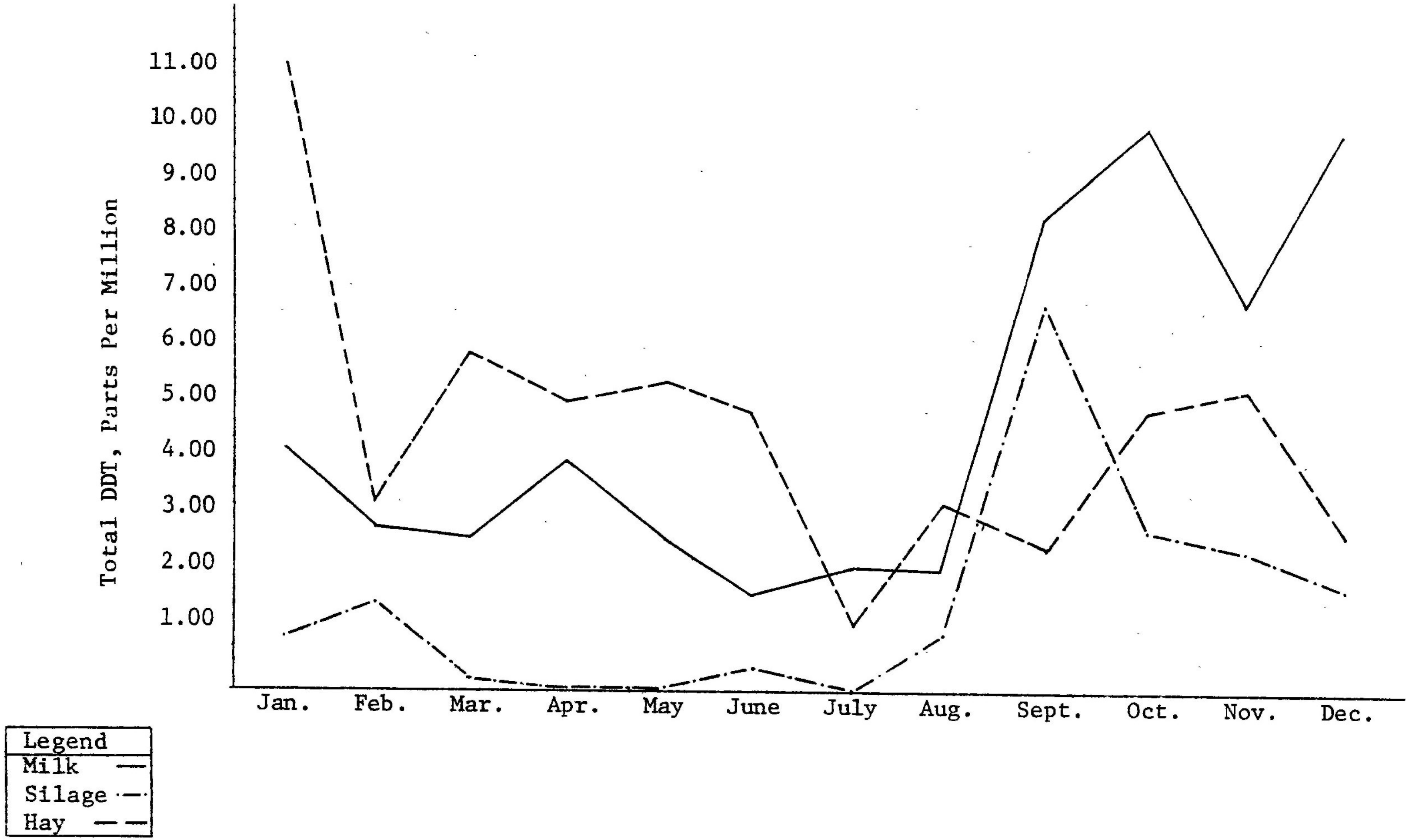
[b/]Approaches significance at 8 per cent.

[c/]Analyses of variance by month for silage.

Analysis of Variance

Source	DF	Mean Square	F Value	Prob. F
Month [c/]	11	33707	2.38	0.08

Figure 4. Seasonal Variation of DDT Residues in Milk from Dairy C as Influenced by the Level of DDT Contamination in Hay and Silage



DAIRY D

Residue Analyses of Milk

Results of analyses of milk samples collected from Dairy D from April 1970 through December 1971 are presented in Table VIII. The lowest level of DDT in milk in 1970 was in July and was 0.53 parts per million total DDT. The maximum high occurred in September 1970 and was measured at 1.60 parts per million total DDT. The lowest level of DDT in milk in 1971 was in June and was measured at 0.09 parts per million total DDT. The maximum high occurred in August 1971 and was measured at 4.18 parts per million total DDT.

A positive relationship between the time DDT is applied to cotton and the increase in total DDT in milk from Dairy D is evident. As expected the increase is shown from August through December (Figure 5). This relationship is significant at the 5 per cent probability level, as determined by the "t" test. The variation of the DDT level in herd milk in Dairy D as influenced by the seasonal application of DDT on cotton is 43 per cent.

Residue Analyses of Feed

Results of residue analyses of feed samples collected monthly from Dairy D are given in Table IX. The data from silage from Dairy D were included with silage data from Dairy C in order to analyze for significance (Table VII). Analysis of variance was not conducted on the other feed ingredients.

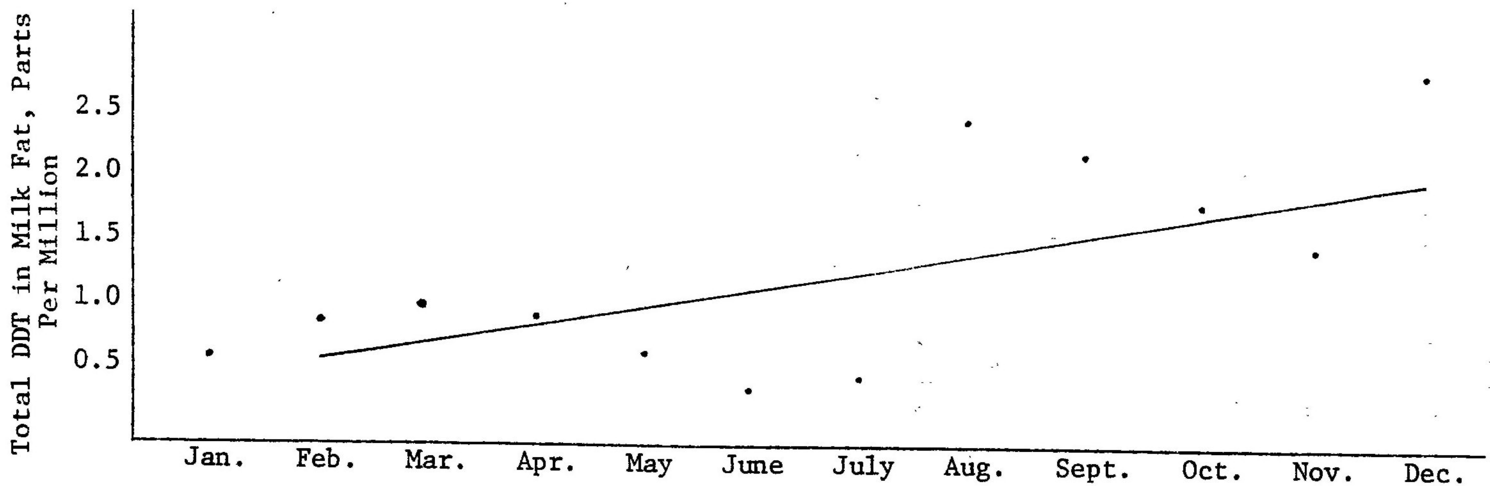
TABLE VIII

Residues of DDT in Milk on Milk Fat Basis From Dairy D During the Period April 1970 to December 1971.

Date	parts per million			
	p,p'-DDE	p,p'-DDD	p,p'-DDT	DDTR [a]
April 1970	0.63	0.11	0.31	1.05
May 1970	0.54	0.11	0.17	0.82
June 1970	0.32	0.10	0.26	0.68
July 1970	0.34	0.08	0.11	0.53
Aug. 1970	0.36	0.14	0.16	0.66
Sept. 1970	0.55	0.65	0.40	1.60
Oct. 1970	0.46	0.44	0.32	1.22
Nov. 1970	0.40	0.19	0.19	0.78
Dec. 1970	0.34	0.09	0.18	0.61
Jan. 1971	0.28	0.10	0.19	0.57
Feb. 1971	0.53	0.12	0.22	0.87
March 1971	0.27	0.11	0.60	0.98
April 1971	0.43	0.05	0.16	0.64
May 1971	0.30	ND [b]	0.09	0.39
June 1971	ND [b]	T [c]	0.09	0.09
July 1971	0.26	0.08	0.04	0.38
Aug. 1971	0.73	2.45	1.00	4.18
Sept. 1971	0.90	1.45	0.39	2.74
Oct. 1971	0.88	0.95	0.42	2.25
Nov. 1971	1.04	0.48	0.63	2.15
Dec. 1971	1.16	1.37	1.02	3.55

[a] Total DDT and relates
[b] Non Detectable
[c] Trace

Figure 5. Monthly Variation in Total DDT Residues on Milk Fat Basis from Dairy D



Analysis of Variance for Regression

Source	Degrees of Freedom	Mean Square	F Value	Prob., F
Regression (linear)	1	22766.42	9.94	0.03

The data in Table IX shows that commercial feeds (pellets and BIR rations) were very low in total DDT residues with the exception of the BIR feed sample of October 1970 which contained 1.12 parts per million total DDT.

Pasture grass samples taken in November 1970, August 1971, and September 1971 contained a relatively high level of total DDT compared to total DDT in samples of pasture grass taken in July 1970 and April 1971 (Table 9). Grazing by dairy animals of Dairy D on pastures during the time that DDT is used on cotton adjacent to these pastures is considered to have been responsible for the increase in DDT content of herd milk of Dairy D (Figure 5).

TABLE IX

Residues of DDT in Feed From Dairy D During the Period April 1970 to October 1971.

Date	Feed	parts per million				
		p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	DDTR[a]
April 1970	Commercial Pellets	ND[b]	ND	0.03	ND	0.03
May 1970	Commercial Pellets	ND	ND	0.02	ND	0.02
June 1970	BIR	ND	T[c]	0.05	ND	0.05
July 1970	Commercial Pellets	ND	ND	0.01	ND	0.01
	BIR	ND	T	0.01	ND	0.01
	Pasture Grass[d]	ND	ND	0.07	ND	0.07
Aug. 1970	BIR	ND	ND	0.02	ND	0.02
Sept. 1970	BIR	ND	ND	0.02	ND	0.02
Oct. 1970	BIR	ND	T	1.12	T	1.12
Nov. 1970	Pasture Grass[d]	0.17	0.58	0.62	0.24	1.16
	BIR	ND	ND	0.50	ND	0.50
Dec. 1970	BIR	ND	ND	0.03	ND	0.03
	Commercial Pellets	ND	ND	0.02	ND	0.02
Feb. 1971	Commercial Pellets	T	T	0.04	ND	0.04
	BIR	T	0.02	0.09	0.02	0.13
March 1971	Commercial Pellets	ND	ND	0.14	ND	0.14
	BIR	ND	ND	0.07	ND	0.07

TABLE IX (contd)

Date	Feed	parts per million				
		p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	DDTR[a]
April 1971	BIR	ND	ND	0.06	ND	0.06
	Pasture Grass[d]	T	ND	0.02	ND	0.02
May 1971	BIR	ND	ND	0.08	ND	0.08
June 1971	BIR	0.04	ND	0.12	T	0.16
July 1971	BIR	ND	ND	0.07	0.01	0.08
Aug. 1971	BIR	ND	ND	0.06	ND	0.06
	Pasture Grass[d]	ND	ND	1.49	0.16	1.65
Sept. 1971	Commercial Pellets	ND	ND	0.03	ND	0.03
	BIR	ND	ND	0.08	ND	0.08
	Pasture Grass[d]	ND	ND	6.75	4.83	11.58
Oct. 1971	Commercial Pellets	ND	ND	0.06	ND	0.06
	BIR	ND	ND	0.15	T	0.15

[a] Total DDT and relates.

[b] Non Detectable

[c] Trace

[d] Classified as silage for statistical analysis

DAIRIES A, B, & C

Variation of Milk Residues by Month

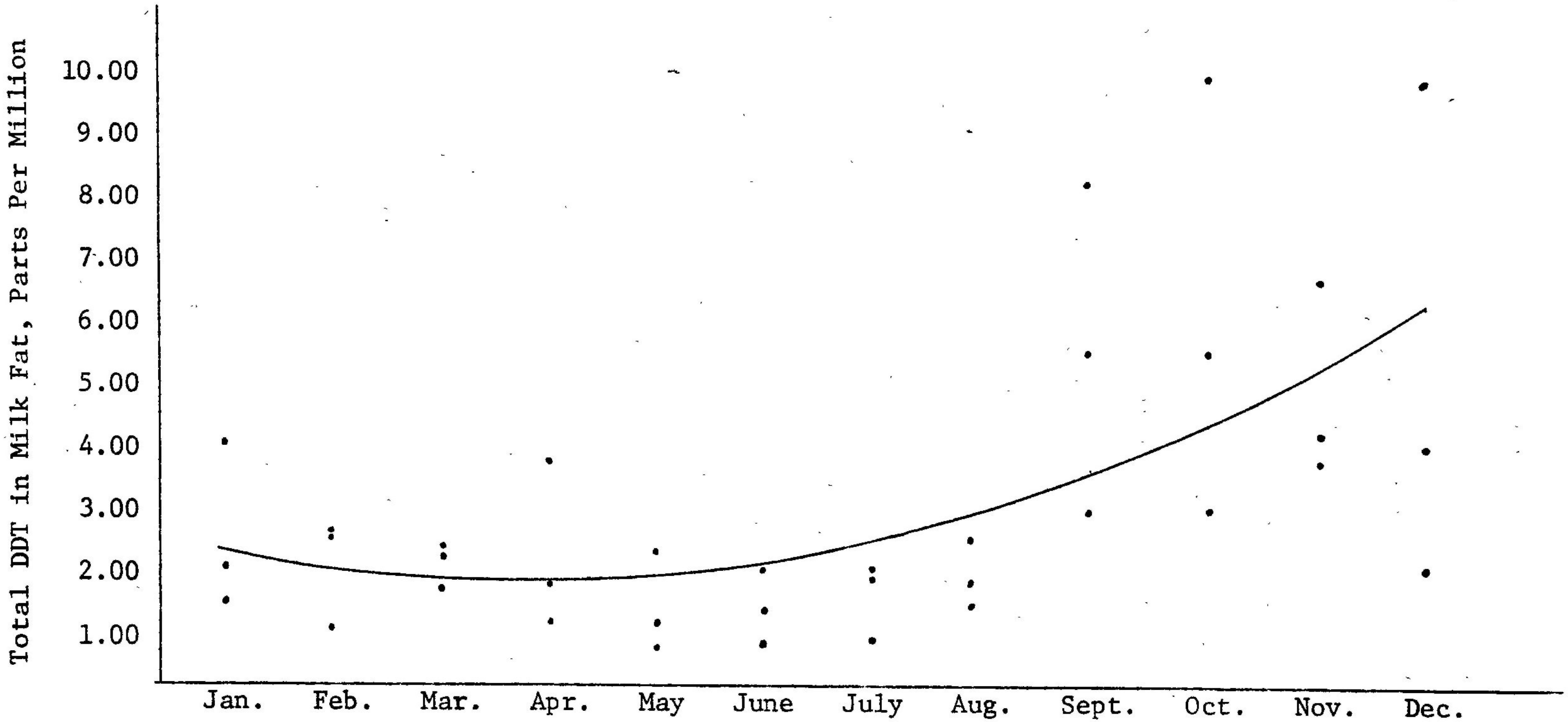
Because of the similarity of feeding ingredients and practices of Dairies A, B, and C, linear, cubic, and quadratic relationships were analyzed for these three dairies. Significant linear and quadratic relationships were established (Figure 6). Results of the "t" test indicated this relationship was significant at the 5 per cent probability level.

Approximately 38 per cent of the variation of DDT in milk from these three dairies may be accounted for by seasonal occurence of the use of DDT on adjacent cotton farms. The least amount of DDT in milk occurred in May and June. The maximum level of DDT in milk occurred in December.

GENERAL CONSIDERATIONS

This study was initiated to identify sources of DDT residues in herd milk in Northeast Louisiana and to develop recommendations for insecticide use patterns on cotton that would reduce and/or eliminate the occurrence of illegal residues in milk and red meat. During the period covered by this study DDT was the insecticide most widely used in mixtures along with various other insecticides for control of the boll weevil *Anthonomus grandis* Boheman, and boll-

Figure 6. Monthly Variation in Total DDT Residues on Milk Fat Basis from Dairies A, B, and C



Analysis of Variance for Regression

Source	Degrees of Freedom	Mean Square	F Value	Prob., F
Regression (linear and quadratic)	2	360254.14	9.94	0.0007

worm Heliothis zea (Boddie) in Louisiana. In a normal cotton insect control program in Louisiana, regularly scheduled insecticide applications at intervals of about 5 days usually begin in July and may continue until late September. About 12 to 15 lbs. of active ingredient DDT is applied to cotton per acre annually.

Application of DDT to nearby and/or adjacent cotton fields is considered the cause for the inadvertent contamination of milk produced on these dairies. Drift of DDT to hay, pasture grass utilized for grazing by dairy animals and corn and grain sorghum which are used either as green chop feed or ensiled is considered responsible for this contamination. DDT was not used on any of these four dairies during the course of this study.

This relationship may be expressed as a time/DDT-milk residue effect because of the seasonal treatment of cotton (July-September) and an increase in DDT residues in milk. A positive relationship has been established.

Cotton farmers and dairy farmers have a mutual interest in controlling contamination of the environment generally and milk especially. Cotton farmers and aerial applicators have been advised to take every precaution to avoid contamination of neighboring crops by drift of insecticide sprays. Dairymen have been advised to plant silage and hay crops as early as possible and harvest before the peak period of cotton insecticide application. Hay and silage harvested after cotton spraying begins should not be used as feed ingredients unless analysis indicates it to be free of excessive pesticide residues. Delay in the use of DDT until after

July 15 would allow dairy farmers to have most of the forage crops harvested and would reduce the possibility of contamination of forage crops. Cotton farmers in milk producing areas who control insects prior to July 15 should not use DDT or other chlorinated hydrocarbon insecticides. In 1970, the following precaution was included in recommendations for control of cotton pests: "CAUTION: Do not apply DDT, Strobane or Toxaphene to cotton fields adjacent to pastures or forage crops" (La. Coop. Ext. Service Insect Control Guide).

Adoption of the diapause control program (La. Coop. Ext. Service Insect Control Guide, 1971) should reduce pesticide residue in feed crops in cotton producing areas. It utilizes organophsophorus insecticides applied after the crop matures to reduce populations of overwintered boll weevils thereby delaying the guildup of populations the following season. Consequently, applications of insecticide can be delayed usually for four to six weeks. Thus the total amount of insecticide required for control of cotton pests is reduced substantially. Also, a higher percentage of that used is the organophosphates instead of mixtures containing compounds more likely to persist on treated crops and to contaminate meat and milk of animals to which they are fed.

The results of this study indicates that hay and silage are the most highly contaminated feed ingredients. Total DDT residues in hay fed to dairy animals on Dairy C ranged from a low of 0.17 parts per million at one monthly

observation to a high of 28.67 parts per million at another monthly observation. The average concentration of DDT in hay fed to dairy animals on Dairy C during this study was 5.24 parts per million.

Total DDT residues in silage fed as part of the daily ration on Dairy C throughout the course of this study ranged from 0.03 to 6.50 parts per million. The average concentration of DDT in all silage fed as part of the daily ration on Dairy C was 1.24 parts per million.

Residues of DDT in silage reflect a strong seasonal variation. Silage cut early in the year is low in total DDT residues and when fed does not contribute significantly to total DDT in milk. Silage cut in August and later is more likely to be contaminated with DDT as a result of drift from application to cotton and when fed does contribute significantly to total DDT levels in the milk of cows to which it is fed (Figure 4).

These data indicate that the silage cut late in the year (September-November) was most recently contaminated from drift of DDT because of the high ratio of o,p'-DDT and p,p'-DDT, to p,p'-DDE in these samples. Results of analyses from field samples of grain sorghum intended for silage on Dairy C clearly demonstrates this relationship. A sample taken in July 1970 contained 0.09 parts per million p,p'-DDT and only a trace of o,p'-DDT. A sample collected from the same field in August 1970 contained 1.20 parts per million p,p'-DDT and 0.25 parts per million o,p'-DDT.

Herd milk from this dairy was sampled and analyzed monthly for 21 months. DDT levels (milk fat basis) ranged from a low of 1.10 to 15.51 parts per million. The average contamination of DDT in milk during this period was 4.85 parts per million.

Residue data from Dairy D on pasture grass samples taken from the same fields indicate the seasonal occurrence of residues of DDT apparently resulting from drift. The total DDT residues in green forage sorghum on Dairy D in July 1970 was 0.07 parts per million of p,p'-DDT. Rye grass samples collected from these same fields in November 1970 contained 0.33 parts per million p,p'-DDT and 0.12 parts per million o,p'-DDT or a total DDT residue of 0.45 parts per million.

Residue data obtained from field samples from Dairy D in 1971 are even more conclusive. Rye grass from Field 1 sampled in April 1971 showed a total DDT content of 0.02 parts per million p,p'-DDT. Grass samples from this same field in August 1971 showed the following residues upon analyses: 1.49 and 0.16 parts per million p,p'- and o,p'-DDT, respectively, or a total DDT residue of 1.65 parts per million. A sample of pasture grass collected in September 1971 from the same field contained 6.75 and 4.83 parts per million p,p'- and o,p'-DDT, respectively, or a total DDT residue of 11.58 parts per million.

Based on results from this study, need for a change in use practices of chlorinated hydrocarbon insecticides is indicated. In 1971, Louisiana State University through its Agricultural Extension Service and Agricultural Experiment Station recommended that chlorinated hydrocarbon insecticides not be applied to cotton fields within one-half mile of pastures, forage or silage crops (La. Coop. Ext. Service Insect Control Guide). Unpublished data by Newsom (1971) indicated high levels of residues of total DDT and toxaphene in Bermuda grass hay intended as supplemental feed for beef cattle. Stull et al. (1971) correlated pesticide levels in milk with pesticide levels in dairy cows. They reported fairly close agreement with the pesticide concentration of DDT in milk fat to the concentration of DDT in the body fat of a lactating dairy cow.

The tolerance of DDT in red meat is presently 7 parts per million on body fat basis. Based on data obtained from analyses of milk from dairy animals it is highly probable that beef cattle from the same areas would be contaminated with DDT residues at levels so high as to exceed tolerances. Recent data obtained by the United States Department of Agriculture at slaughter houses in Louisiana show high levels of DDT as well as other chlorinated hydrocarbon insecticides present in beef and pork products (U.S.D.A., 1973).

The tolerance for chlordane and endrin, two chlorinated hydrocarbon insecticides which are registered for use on cotton, is zero in milk and red meat. Toxaphene which is also registered for use on cotton has an interim tolerance of 0.05 parts per million in

whole milk and an established tolerance of 7 parts per million in red meat (fat basis). Use of these insecticides for control of cotton insects where cotton fields are located adjacent to or near hay pastures and forage and grain crops will undoubtedly result in contamination of these feed grains and possibly cause illegal residues in milk and red meat of animals fed these contaminated feed ingredients. Therefore these chlorinated hydrocarbon insecticides should not be used in cotton fields which are in close proximity to hay pastures and forage and grain crops which will be used as feed ingredients for beef, swine and dairy animals.

CONCLUSIONS

1. Milk produced from four dairies in Northeast Louisiana in close proximity to cotton fields was contaminated with DDT. Drift of DDT from adjacent cotton fields onto dairy pastures, forage, hay and/or grain crops used for dairy feed is considered to be primarily responsible for this contamination.
2. Residues of DDT in milk exhibited a seasonal cycle. Maximum levels occurred in the four month period of September to December and minimum levels occurred in May and June.
3. Hay, silage and pasture grass was most heavily contaminated with DDT. Commercial dairy rations were low in residues of DDT.
4. Chlorinated hydrocarbon insecticides such as DDT, as well as chlordane, endrin and toxaphene cannot be used in cotton fields which are located in close proximity to feed grain crops without the probability of illegal residues of these insecticides occurring in beef, swine, or dairy animals that consume these feed ingredients.

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EXAMINATION AND THESIS REPORT

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Major Field: Entomology

Title of Thesis: Relationship of Patterns of Use of DDT and Its Residues in Animal Feeds and Food Products

Approved:

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