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OCCUPATIONAL HEALTH HAZARDS EXPERIENCED

BY PEST CONTROL OPERATORS

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OCCUPATIONAL HEALTH HAZARDS EXPERIENCED BY PEST CONTROL OPERATORS

CHAPTER I

INTRODUCTION

It has long been recognized that man has been the only creature capable of greatly altering his environment. His standard of living and, indeed, his survival, are dependent upon his manipulating the environment. He has produced an ecological balance favorable for the growth of food crops and livestock, the protection of his natural resources, and all other values in his environment. Some authorities have agreed that pests have been among the most damaging pollutants in man's environment and have competed directly for human food and animal resources, and that pest control has been one of the major environmental manipulations necessary in a simplified ecosystem designed for the efficient, safe, and economical production of food crops (1). Through pest control, man has modified his environment to meet esthetic and recreational demands. Few people have disputed the fact that through man's modification of his immediate environment with chemical pesticides that detrimental as well as beneficial consequences have resulted.

The word "pesticide" was derived from two Latin words, "pestis" meaning plague and "cide" from the Latin word "caedo" meaning "I kill" (2, 3). Funk and Wagnalls (3) define pest as:

a) an annoying or vexatious person or thing; a nuisance

b) a destructive or injurious insect, plant, etc.

c) a virulent epidemic, especially of plague.

From these definitions one can readily see that the term pesticide encompasses quite a range of meaning. The Definitions Committee of the Association of Pesticide Control Officials, Inc. defined pests as any form of life which exists under circumstances that make it undersirable (4). The term pesticide is generally accepted to mean any substance intended for destroying, repelling, preventing, or mitigating any pest.

Pesticides have embraced a wide variety of chemical compounds for controlling undesirable forms of life which threaten man, his possessions, and portions of the natural environment that he values. In 1969, there were some 900 active pesticidal chemicals formulated into over 60,000 preparations in the United States. In 1968, production and sale of synthetic organic pesticides reached 1.2 billion pounds of which about 20 per cent was exported (5). Slightly more than half of all pesticides produced today have been used in farming with lesser amounts used to control public health vectors and other pests. At the current rate of increase of almost 15 per cent per year, a billion pounds of pesticides will soon be applied annually in this country.

Holding the largest shares of the pesticide market today have been the insecticides and herbicides. It has been predicted that insecticides will more than double in use by 1975 to more than $600 million annually while herbicide uses will increase to more than double that of insecticides during the same period (6). At the time of this writing the most used insecticides were those of the organic phosphorous group, the chlorinated hydrocarbon group, and the carbamate group.

Edson et al. (7) found, from a toxicity study of 197 pesticides, that only 4 per cent of the herbicides and 5 per cent of the fungicides fell into the most toxic category, an oral LD 50 to rats of 0 to 50 mg/kg, while 52 per cent of the organic phosphorous insecticides and 24 per cent of the other insecticides were in this classification.

All pesticides are poisonous to some plants and animals. This is the reason they are useful and the reason they are detrimental. Many, especially the chlorinated hydrocarbon insecticides, remain where applied to kill again and again or are passed through the food chain from one species to another in a mysterious process called magnification, which, to this time, has not been completely explained. Other groups of pesticides have a high toxicity for a short time and then loose their toxicity in part or total to present no particular persistance problem. The toxicity of certain pesticides has also been shown to be greatly altered by the interaction with other pesticides (8, 9). Pesticide-drug interactions have also been reported (10, 11) as well as pesticide-synergist-drug reactions (12).

For years consumers have been exposed to individual or combinations of pesticides either by do-it-yourself application or employment of a professional pest control operator (PCO), and it now appears that employment of professional pest control servicemen is sure to increase as the general public becomes more cognizant of the potential hazards of pesticide exposure. Because PCO's have the most prolonged, intensive exposure to pesticides, resultant toxic effects of these compounds are most likely to appear in professionals in this occupational field.

Although the number of professionals pursuing this occupation appears to be quite high, there seems to be no general concensus among authorities regarding the level(s) and kind(s) of exposure encountered by these persons. There also seems to be disparity concerning the use of known protective devices and procedures by the PCO's, as well as his training and supervision. There does, however, appear to be agreement that a large professional group has been at risk and that conditions inherent to the profession dictate that exposure is of great magnitude. This exposure can only be expected to increase in quality and quantity as low toxicity persistant pesticides are banned in preference to highly toxic, short-lived pesticides with a subsequent increase dependance upon the PCO by the homeowner. If this professional group is to be protected, it seems imperative that these parameters be evaluated.

CHAPTER II

LITERATURE REVIEW

Historical Background

A basic fact, certainly, has been that pests have always threatened destruction or diminishment to man's food supply, his health, comfort, some of his property, and some desirable aspects of his environment. An early history of pest control indicated that as early as 2500 BC ceramic cage traps were used for mouse control in Iran and that 500 years later the cat was prized for his ability to catch mice in the granaries of ancient Egypt. In 930 AD, Welch King Howell, the Good, regulated the prices of cats on the basis of their age and experience of catching mice (13).

An early written account of pest and pestilence was recorded in the Bible in the book of "Exodus" (14):

> ". . . all the dust of the land became lice throughout the land of Egypt. . . . and there came a grievous swarm of flies into the house of Pharoah and into his servants' houses, and into all the land of Egypt; the land was corrupted by reason of the swarm of flies. . . . and the locust went up over all the land of Egypt, and rested in all the coasts of Egypt; very grievous were they; before them there were no such locust as they, neither after them shall be such, for they covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land, and all the fruit of the trees which the hail had left; and there remained not any green thing in the trees, or in the herbs of the field, through all the land of Egypt. . . ."

It may be said, with some degree of accuracy, that the discovery and development of chemical pesticides and the legislation regulating their use which subsequently followed, parallelled the growth of modern agriculture. About the turn of the century when the great city migration began and fewer farmers were being called upon to provide more for more, farming operations changed, resulting in many new means to meet these increased demands. One means employed was the increased use of pesticides; until in 1969, approximately 600 million pounds were used in agricultural operations alone (6). Although usage of pesticides has reached this magnitude in the United States, insects by themselves have taken an annual toll of approximately $4 billion from crop and livestock production in the United States alone, and far more in the world's less agriculturally advanced areas (16). In terms of direct economic losses, rats have destroyed as much as $500 million to $1 billion in the United States annually (17). Other pests have inflicted similar economic losses. These figures clearly have indicated that the potential from the insect damage alone if left unchecked would be astronomical.

> "Insects aggressively invade the domains man marks out for himself. They infiltrate. They seize upon every possible opening. They are pervasive, persistant, penetrating, and persevering. They are quick to exploit the bonanzas human beings often arrange for them.
>
> Until barely a century ago, man ignored most of his insect enemies. Having been ignorant about them, often even ignorant of their existence, he barely realized their enmity. He occasionally spanked the mosquito when he felt its bits, scratched his lice and chiggers, and brushed off the fly that tickled his nose. If swarms of locusts destroyed his crops, he knew them only as enemies he could not combat and of whose origin he was unaware. When plagues and fatal fevers scourged his city and killed his family and friends, he considered the disaster to be an act of fate" (16).

Ironically, during personal interviews with the Oklahoma PCO's, many times the person interviewed spoke these same words relative to intoxication and violation of precautionary measures concerning safe use of pesticides - an act of fate.

Insects estimated to account for 75 per cent of the total animal population preceeded man as inhabitants of the earth by several million years as is evident by fossil findings dating back approximately 250 million years. Members of the same species of insects today remain practically unchanged from their fossil predecessor and to date, man has not been successful in eliminating a single specie while other animal and plant life have become extinct or are threatened with extinction (18).

Man has attempted to combat this and other competitors with the use of chemical pesticides. Among the first chemical pesticides used were the pesticides of inorganic origin. The insecticidal capabilities of the arsenicals have been known since 1681 (19). The use of Paris Green, an arsenical pigment, as an insecticide began about 1865. Paris Green was first used against the Colorado potato beetle, and for many years was the most widely used agricultural insecticide (20).

Approximately 20 years later (1892), lead arsenate was developed for use against the larva of the gypsy moth (20). A few years later, William C. Piver combined arsenic with calcium and mass produced a cheap product with which man fought the boll weevil infestation in the cotton growing regions of the United States (21). This increased usage and a growing demand by agricultural interests and manufacturers for

Federal Control of the arsenicals of interstate commerce in insecticides, fungicides, lead arsenate, and Paris Green led to the passage of the 1910 Insecticide Act (22). This act prevented the manufacture, sale, or transportation of adulterated or misbranded insecticides and fungicides and authorized regulation of sales of insecticides and fungicides.

The arsenicals were not the only insecticides of the day; in fact, sulphur had been so used for many years and was the first chemical insecticide used by Greek physicians to treat cases of human scabies (13). Tobacco had been used as early as 1690 for pear lace bug control in France (13), and had been used to control sucking insects since 1763 (23). Another chemical used quite extensively during this time was pyrethrum which is derived from the flower of a type of chrysanthemum. About 1800, in the Near East, pyrethrum was found to kill insects (23), but it was not brought to the United States until about 1855 (13). Rotenone, derived from the roots of tropical plants, was discovered to be insecticidal in 1848 and like pyrethrum, is still in use today. These two chemicals offered the advantage of being toxic to insects and relatively safe for animals and people, but had the disadvantage of loosing their toxic properties quickly upon exposure to air (23). These latter two often have been spoken of as "quick knock-down" chemicals.

Due to the widespread use agriculturally of the arsenates, and the subsequent residues left on the treated fruits and vegetables, much public interest was raised in the 1920's (24). This public concern led to intensified research efforts to find safer insecticides and resulted in the development of the Summer Oils in 1924 by William H. Volck, and also speeded up the process of perfecting the botanical insecticides (21). Though oils have some general insecticidal properties, they have found widespread use as solvents and carriers for other insecticides (25).

In 1922, another milestone in pest control was reached when a practical, economical method for aerial application of insecticides was developed (26). Actually, the first attempt to control pests by air had been in 1918, and the first airplane especially equipped for aerial spraying was constructed in 1921 (27).

While these things were developing on a federal level, several states were dealing with their own specific problems with legislation. The first state pesticide law was passed in 1898 by the state of New York. In 1899, Oregon and Texas passed similar legislation as did California, Louisiana, and Washington in 1901 (28). At the same time many states had bounty laws which empowered certain officials with legal means to combat various pestiferous situations. For example, in Idaho, House Bill 25, 1907, empowered the board of county commissioners of any county in the state, on petition of 100 or more taxpayers, to levy a tax not exceeding 5 mills on the dollar of valuation for the purpose of exterminating crickets, grasshoppers, rodents, and rabbits; such tax was to form a "pest fund". At this same time in Oklahoma, county commissioners had the authority to levy an assessment not to exceed 5 mills per dollar valuation for the extermination of prairie dogs (29).

Perhaps the next major milestone in the development of pesticides, and certainly the pest control industry, was the discovery of the insecticidal capabilities of the chlorinated hydrocarbons, especially dichloro-diphenyl-trichloroethane (DDT). DDT was first described in 1874 by the German chemist, Othmor Zeidler, but it was not until 1939 that a dye company scientist, Paul Muller, discovered its insecticidal value. The same year DDT was used to control an infestation of the Colorado potato beetle in Switzerland and, thus, forestalled a threatened famine. In 1942, the first DDT was shipped to the United States for testing and the following year production of the insecticide began (30).

The first real test of DDT was in late 1943 and early 1944 when it was used to stop an outbreak of louse-borne typhus in war-torn Naples, Italy. The number of cases during this outbreak was held to 1,914. The success of this undertaking resulted in the American GI and his allies being accompanied throughout WW II with a 2-ounce can of Government Issue DDT (23).

About this same time, 1941, L. D. Goodhue and W. N. Sullivan of the Bureau of Entomology and Plant Quarantine develcped aerosol bombs as a means of dispensing small quantities of insecticides (31, 32). This method met with wide spread acceptance and today the aerosol bomb can be found in practically every home.

Soon after its discovery as an insecticide, DDT was used effectively in the control of many diseases by controlling the vector responsible (33). One such disease was malaria which has become practically non-existent in the United States due to the anti-mosquito campaigns initiated soon after WW II. DDT has also helped to control other major diseases such as yellow fever and encephalitis. As a result of these universal contributions made by DDT, its discoverer was awarded the Nobel Prize in 1948 (21, 33). Due to the widespread acclaim of this insecticide, other scientists began work with related compounds checking for their insecticidal capabilities, and this research led to the discovery of many other insecticides.

Benzene hexachloride is another chlorinated hydrocarbon which was discovered long before its insecticidal value was determined. It was first made in 1825 by Michael Faraday, an Englishman, but it was not until 1941 that A. P. W. Dupire in France applied for a patent on the use of the material as an insecticide. Studies with similar products soon yielded the insecticides toxaphene, methoxychlor, lindane, and tetrachloro-dipenyl-ethane (30).

Soon after, chloradane was discovered by using a reaction developed by two German chemists, Otto Diels and Kurt Alder. Alder and Diels were awarded the Nobel Prize in 1950 for this work and were also honored by having subsequent synthetic chlorinated hydrocarbons named after them, Aldrin and Dieldrin (30).

Another group of important pesticides were a result of research conducted during the days of WW II. This group was the organic phosphate insecticides and was discovered by Gerhard Schrader while searching for more powerful agents of chemical warfare. These insecticides are varying esters of organic phosphorous and are very similar to the poisonous nerve gases developed during WW II (30). These organic phosphates act by inhibiting chloinesterase, an enzyme found in many body tissues. Cholinesterase is necessary to prevent the accumulation of acetylcholine, an organic ester necessary for transmission of nerve impulses. This research ultimately resulted in the discovery of such chemical pesticides as malathion, diazinon, parathion, and O,O-Dimethyl-2,2-Dichlorovinyl Phosphate (DDVP). Another group of pesticides, the carbamates, soon followed the organic phosphates.

The carbamates also have a history reaching back into antiquity in that they are synthetic analogues of the alkoloid physostigmine found in the calabar or ordean bean of French West Africa. This drug was used for centuries by native witch doctors to determine guilt or innocence. The accused was fed the drug; if he died he was guilty and if he survived he was innocent. The drug was imported to England in 1840 and in 1926 a number of synthetic analogues were synthesized and since have been used medically with good results. In 1954, the insecticidal capabilities were demonstrated (34).

The carbamate insecticides like the organophosphorous insecticides have been very active inhibitors of the enzyme cholinesterase; however, the carbamates differ from the phosphates in that they are competitive rather than irreversible inhibitors of this enzyme (34).

As war-time chemical discoveries began to be adapted to civilian use during the later years of World War II and the use of pesticides increased, a need for new and stronger legislation was realized. This realization led to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) passed and signed into law June 25, 1947 (35).

This act retained many key portions of the 1910 Insecticide Act but also added two new ideas:

a) all pesticides intended for shipment in interstate commerce must have been registered with the Secretary of Agriculture before shipment, and

b) the Agriculture Department was given control over all precautionary statements in the labeling of pesticides.

This act had still no control over the user of the product and its major protection of the public came from the strict control over every feature of labeling.

Realizing that a need existed for similar control of other chemicals, Congress amended the law on August 7, 1959, to include nemotocides, defoliants, dessicants, and plant regulators. The coverage of the act was completed on March 27, 1962, by the inclusion of chemicals sold for control of moles, birds, predatory animals, and other forms of nonrodent wildlife pests (35).

Complimenting this act was the passage in 1954 of the Pesticide Chemicals Amendment to the Federal Food, Drug, and Cosmetic Act. This amendment revised procedures for obtaining tolerance which were a part of the basic food and drug law (35). It also provided for the Secretary of Agriculture to:

a) certify to the FDA that the chemical for which a petition for tolerance had been filed would be useful for the purposes described, and to

b) express an opinion as to whether the tolerance requested reasonably reflected the residues likely to remain upon the treated food crop when the chemical was used as directed.

This legislation provided the necessary legal backing for Secretary of Health, Education, and Welfare (HEW), Arthur S. Fleming, on November 9, 1959, to announce seizure of cranberries contaminated through misuse of aminotriazole (36), a carcinogen in rats (37).

This announcement preceeded by a few days the beginning of the market season responsible for an estimated 75 per cent of the total sales of the cranberry industry and made headlines nationwide (36). This incident and the publication of Silent Spring (38) in 1962 caused much reaction concerning the use of pesticides. The fire these two incidences started was given additional fuel when in March, 1964, millions of dead fish in the Mississippi River were reported to have been killed by pesticides draining from farmlands in the area (39). These incidents implicating pesticides served to awaken a sleeping America which heretofore had thought only of pesticides in a quite passive way. The interest generated spawned many governmental committees and study panels and likewise initiated several monitoring programs nationwide to assay to what extent pesticides were or were not pollutants.

A pilot study for monitoring agricultural pesticides was begun in 1964 in the Mississippi Delta and was expanded to several other states in following years (40). The Oklahoma air monitoring program of agricultural pesticides began July 1, 1968 (41), while monitoring Oklahoma's water, soil, and selected animal life began July, 1970 (42).

One of the most comprehensive publications of all the study groups was the report of the Secretary's Commission on Pesticides and Their Relationship to Environment Health, Parts 1 and 2, in which the chairman reported to the Secretary that (6):

a) chemicals, including pesticides used to increase food production, are of such importance in modern life that we must learn to live with them;

b) in looking at their relative merits and hazards we must make individual judgments upon the value of each chemical, including the alternatives presented by the non-use of these chemicals. We must continue to accumulate scientific data about the effects of these chemicals on the total ecology; and

c) the final decision regarding the usage of these chemicals must be made by those governmental agencies with the statutory responsibilities for the public health, and for pesticide registration.

From these various studies and subsequent publications, and increased public concern, recent dramatic steps have been taken regarding pesticides. Perhaps the most dramatic have been aimed at the persistant chlorinated hydrocarbons, especially DDT. The beginning of the end of the DDT story came with the June 14, 1972, announcement that virtually all uses of DDT in the United States would be banned effective December 31, 1972 (43).

The rising concern reflected expanded interest in environmental protection by many citizens and has resulted in much legislation both passed and proposed. Perhaps the most far reaching legislation relative to pesticides has been the proposed Federal Environmental Pesticide Control Act first introduced in 1971, which would impose new controls and sanctions on both the use and users of pesticides by classifying pesticides into two categories, general use and restricted use (44). If passed, the restricted classification group could be applied only by applicators certified by the proper state authority. This legislation also provided for the prosecution of the individual who used a pesticide for a purpose other than that for which it was intended. It further provided for the appropriate regulatory agency to re-examine existing professional applicators.

Regarding this legislation the Agricultural Committee, the committee to which this proposed bill was assigned, probably quite closely represented the general feeling of most legislators about pesticides when they said:

> "As a result of the growing awareness of possible undesirable effects of pesticides and realization of the necessity of considering these disadvantages along with the beneficial effects realized through protection of public health and enhancement of agricultural productivity, the Agricultural Committee feels that the basic law regulating pesticides in the United States needs to be thoroughly overhauled in order to better serve the Nation in the light of these changing situations" (45).

In Oklahoma, currently the State Department of Agriculture has primary responsibility in regulating pesticides by the enforcement of several pesticide related laws (46, 47, 48, 49, 50, 51). These include the licensing of pest control operators, the requirement of dealers who sell phenoxy herbicides to obtain permits and keep records, the provisal for an analytical laboratory for pesticides and the authorization of the establishment of tolerance for pesticide residues in food stuffs.

The department's responsibility in controlling application of pesticides has been dependent primarily upon licensing as a means of control. In 1970, there were 257 licensed termite operators, 211 licensed general pest operators and 51 licensed fumigators in Oklahoma (52). With no state law providing for across-the-counter restriction of sales of pesticides to the general public, coupled with no legislation requiring accounting of total pesticides produced in or shipped into the state, the Oklahoma pesticide problem has become even more vague.

As man has become more affluent he has demanded certain luxuries. Included have been a pest free home and environment. He has provided this luxury by application of chemical pesticides bought from the grocer's shelf or by the employment of a professional applicator. Regardless of his method, he has greatly increased his exposure to the modern synthetic pesticides. At present, perhaps the most used are the insecticides of the chlorinated hydrocarbon group, the organic phosphate group, and the carbamate group.

Chlorinated Hydrocarbons

The exact physiological mechanism by which the chlorinated hydrocarbon compounds exert their toxic action is not known; however, their primary effect is on the nervous system (53).

The chlorinated hydrocarbons generally produce similar physiological effects in man and intoxication may result from oral, dermal, or respiratory entry into the body. Symptoms usually associated with an intoxication include headache, loss of appetite, nausea, vomiting, dizziness, tremors, convulsions, and coma following excessive exposure. Chlordane and benzene hexachloride (BHC) have been shown to cause dermatitis either by primary irritation or hypersensitization. The chlorinated hydrocarbon compounds and/or certain degradation products are stored in fat of the human body and are eliminated very slowly (54, 55).

Exposure to the chlorinated hydrocarbon compounds can be established by analysis of body fat and, for certain of these materials such as DDT, by urine tests. The most commonly detected chlorinated hydrocarbon metabolite is dichlorodiphenylacetic acid (DDA), a water soluble metabolite (56).

DDT, the class compound of the chlorinated hydrocarbons, can degrade one of two ways, either by dehydrochlorination, yielding the unsaturated dichlorodiphenyldichloroethylene (DDE) or by substitution of hydrogen for one chlorine atom, yielding the saturated dichlorodiphenyldichloroethane (DDD) which readily degrades further through a series of intermediates to the excretable DDA (57).

Wolfe and Armstrong (58) found that urinary excretion of DDA by formulating plant workers correlated quite well with exposure. Maximum excretion was reached on the average 10.6 hours after exposure began. This value agreed closely with previous findings for pesticide applicators exposed to liquid DDT sprays in the field (59).

A previous study reported that DDA excretion was maximal within 14 hours after exposure while levels of DDT and DDE in the blood were at a maximum within 30 hours of exposure (60). Morgan and Roan (61) reported that serum and fat DDE and DDD increased roughly in proportion to dosage. Hayes et al. (62) demonstrated that duration of exposure was the greatest single factor in relative amounts of stored DDE. Similar findings were reported by Davies et al. (63). Following a single intensive exposure, Edmundson et al. (60) reported highest levels of DDT and DDE in the blood and DDA in the urine of the pesticide formulators having the longer periods of experience in the trade. Wolfe and Armstrong (64) noticed that DDA excretions were lower for workers using protective gear than when no protection was used.

Laws and co-workers (65) found the metabolite p,p-DDT, which is of major importance as an excretory product in the general population, only slightly higher in urine of workers and showed no increase whatever corresponding to increasing exposure. Edmundson et al. (66) found that the length of time in the occupation relative to blood values appeared to be most important in the person's first few years in the trade.

Morgan and Roan (61) reported that ingestion of DDE increased serum DDE levels 30 times as fast per unit dose as did DDT ingestion, and that adipose DDE increased 13 times as fast in response to DDE dosing as it did during DDT ingestion.

Ortlee (67) used a method of Cueto et al. (68) to estimate DDT absorption by determining DDA excretion of persons on known daily oral dosages. They found no relationship between DDT exposure and the frequency and distribution of abnormalities with the exception of the urinary excretion of DDA and a few cases of minor skin and eye irritation. Wolfe and Armstrong (64) found a positive correlation between excretion levels and exposure. They further found no significant elevation in the cholinesterase level of men exposed to high DDT concentration for prolonged periods as compared with the level for unexposed persons. No neurological findings related to DDT exposure were detected and they concluded that it was unlikely that any illness or symptoms complex identifiable as chronic DDT poisoning existed in people exposed to DDT at the current dietary level.

Ortlee (67) calculated that workers with prolonged intensive exposure to DDT absorbed an average of about 200 times as much DDT as that absorbed by the general population from dietary sources.

Wolfe and co-workers (69), while studying agricultural spraymen, reported that generally the loading operation was the most hazardous part of agricultural spraying or dusting. During this study, they reported that observations of applicators of different pesticides suggest that considerably lower exposure was sustained by a careful operator than by a careless one. They found that the potential dermal exposure to each compound in every work situation studied was much greater than the potential respiratory exposure and that the agricultural use of dusts or fine aerosols rather than sprays greatly increased respiratory exposure. Wolfe et al. (70) have reported that higher spraying pressures are directly proportional to both higher dermal and respiratory exposure. They also have shown that indoor spraying subjects the sprayman to approximately seven times the dermal exposure than when doing outdoor spraying (243 mg/hr compared to 1755 mg/hr). The same test showed that respiratory exposure was much less outside than inside (0.11 mg/hr compared to 7.1 mg/hr). They further found that when indoor-outdoor spraying with DDT, ordinary cotton clothing gave almost complete protection to the body area covered.

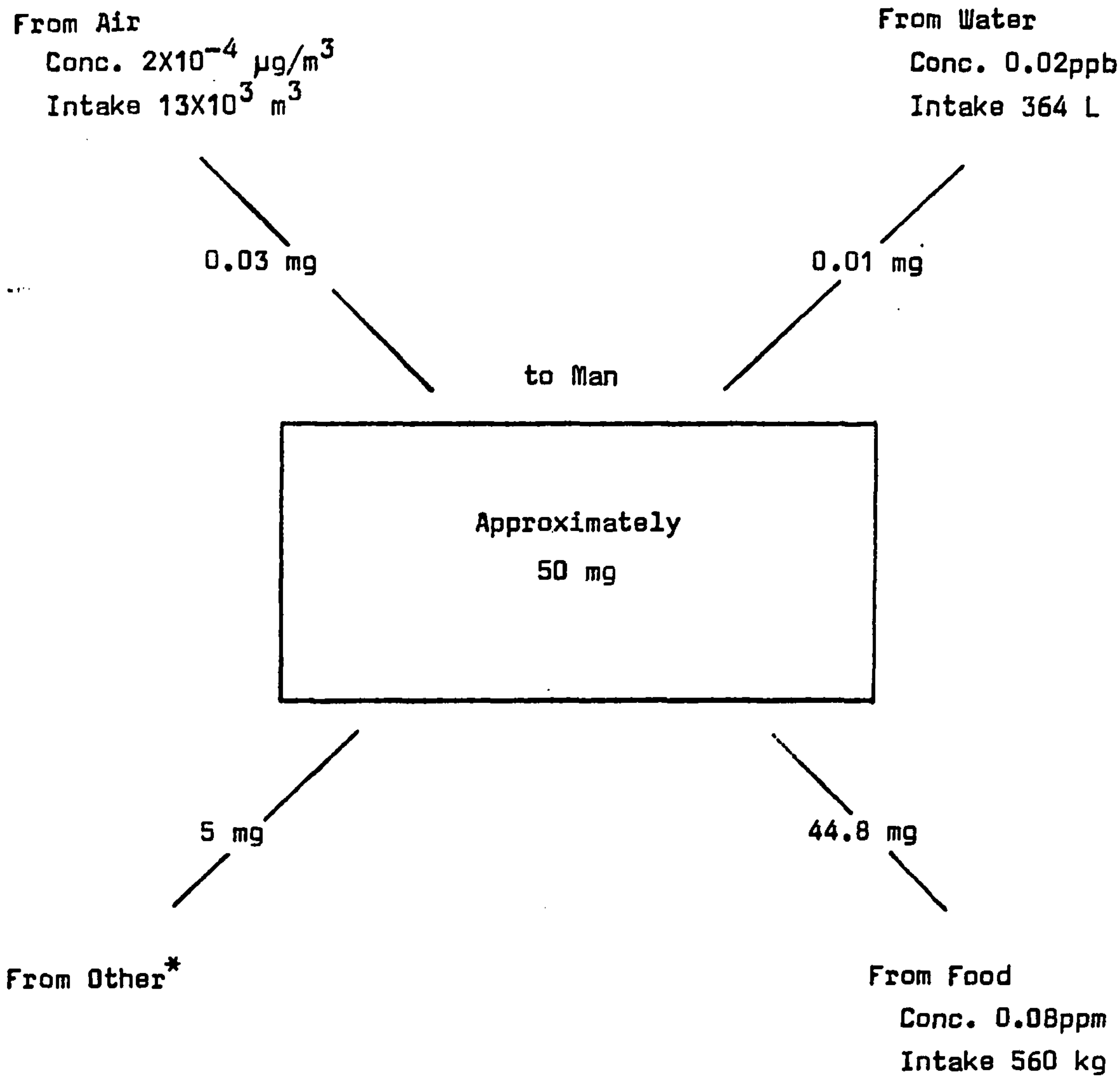
Durham et al. (71) reported no indication that any important difference in DDA excretion level existed among the general population, meat abstainers, or people with heavy environmental or light occupational exposure. They did, however, report a noticeable difference in DDA excretion for groups with widely different degrees of exposure. Durham et al. (72) found that about 75 per cent of the general population excrete less than 0.038/mg of DDT per day, while analysis of typical meals consumed by the average person contains about 0.038/mg of DDT per day (73). Campbell et al. (74) reported that animal derived foods may be a very important source of pesticides in the diet (see Table 1 and Figure 1).

It was shown by Duggan (75) that the average intake of 19-year old men in the general population during 1964 to 1967 was 0.028 mg per man per day for DDT and 0.063 mg per man per day for total DDT related compounds. An experimental intake 1,250 times the average daily intake

TABLE 1

FDA MARKET BASKET SURVEY,
BALTIMORE, MAY, 1962

	ppm			
Commodity	DDT+ DDD+DDE	Dieldren	Heptachler epoxide	Lindane
Dry beans and nuts	0.010	-	-	-
Grain products	-	-	0.002	0.011
Fruits and tomatoes	0.012	-	-	0.006
Above ground vegetables	0.030	-	Trace	-
Root vegetables (except potatoes)	0.120	-	-	0.015
Most common tolerance level	7ppm	0.25ppm	0.1ppm	10ppm



*Refers to contributions from direct contact through skin absorption or to those in food, air, or water resulting from individual household use.

Figure 1.—Estimated Annual Intake of DDT+DDE from All Environmental Sources.

of p,p'DDT administered to 24 volunteers for 21.5 months showed no definite clinical or laboratory evidence of injury from DDT (76). In one study, methoxychlor administered at levels up to 100 times the current allowable level, demonstrated no toxicities to man (77).

Chlorinated hydrocarbons have been detected in the tissues of stillborn and of infants dying in the very early neonatal period, and in the cord blood of normal neonates (78). Nine chlorinated insecticides have been detected in the blood of pregnant women and in the milk of lactating women (79). It has been demonstrated that pesticides pass across the placental membrane and that this is demonstrable at least as early as the 22nd week of gestation. In this same study a significantly lower level of DDT and DDE was observed in children under 5 years of age. Prenatal fetal concentrations of pesticides more closely resemble the adult population than does the 0 to 5-year-old group (80). Rappolt and co-workers (81) reported similar storage levels of p,p'DDE in human placentas and female autopsy material. In one study the storage of DDT in the body fat of the general population of the United States averaged 4.9 ppm while the storage of DDE was 6.1 ppm. In comparison, persons who had had occupational exposure within a year stored DDT at an average concentration of 17.1 ppm (62).

Findings from one recent study involving 35 men with 11 to 19 years continuous exposure to DDT failed to reveal any ill effects attributed to exposure to DDT. The overall range of storage of DDT and metabolites of DDT in the men's fat was 38 to 647 ppm as compared to an average of 8 ppm for the general population (65).

Other chlorinated hydrocarbons have been shown to be present in the body fat of people in the general population of the United States. The average storage of BHC was found to be 0.2 ppm and the average storage of dieldren was reported at 0.15 ppm in the United States (82). It would seem that the absence of other chlorinated hydrocarbons in most adipose analyses would indicate that their usage was not as great as those found. Indications are that different pesticides are concentrated differently (83), and that men and women differ in pesticide concentration (84). It has also been demonstrated in dogs that certain chlorinated hydrocarbon retention in fat, liver, and blood is considerably higher when ingested as a mixture with other chlorinated hydrocarbons (85). Analyses of soil samples from six states indicated that the most commonly occurring pesticides were members of the DDT group followed in turn by dieldren and chlordane (86).

In studies involving 70 autopsy cases, Morgan and Roan (87) found no definite association between chlorinated hydrocarbon pesticide levels and causes of death.

Organic Phosphates

The organic phosphate compounds are chemically related to the "nerve gases" and they exert their effect on the nervous system. The organic phosphates differ from the chlorinated hydrocarbons to inherent toxicity and, to some extent, in rate of absorption and excretion. They are similar in that they can cause intoxication by either oral, dermal, or respiratory entry into the body. The organic phosphates are cholinesterase inhibitors and thereby allow large amounts of acetylcholine to accumulate in the body. When cholinesterase depletion has reached about 20 per cent of normal, symptoms and signs of poisoning appear. Symptoms may include blurred vision, weakness, nausea, headache, abdominal cramps, chest discomfort, and diarrhea. Signs may include miosis, muscle twitching, salivation, sweating, tearing, cyanosis, convulsions, and coma (54, 55). Parathion, the class compound of the organic phosphate group, has to be converted by the body to an active form, diethyl P-nitrophenyl phosphate, before the effect occurs. Other members are direct acting (88). Exposure to these compounds can be estimated by measurement of cholinesterase activity of the blood. Certain of the insecticides of this group can also be determined by urine analyses (53). An over-exposure to parathion would result in the urinary accumulation of the metabolite paranitrophenol (56).

Before pure parathion becomes a strong inhibitor of cholinesterase, it must be metabolized, and this occurs mainly in the liver (54). Johnson (89) explained the mechanism of inhibition of an esterase by organophosphorus compounds as E + AB---(E..AB)---EA+B. The enzyme (E) treats the compound AB as an ester substrate and is phosphorlylated, liberating group B; the phosphorylated enzyme (EA) is stable and the enzyme is therefore inhibited.

Kidney function tests carried out on 42 pesticide exposed and 23 control subjects failed to identify chronic occupational differences in renal tubular function (90), while Mann et al. (91) reported that chronic exposure to pesticides in general and probably to parathion in particular imposes a liability to chronic, irreversible renal tubular dysfunction which increases with duration of exposure. Tocci et al. (92) observed that heavy exposure to pesticides does cause changes in kidney or liver function and in the concentrations of circulating amino acids in approximately 30 per cent of the people studied. However, the study failed to show if the changes in enzymes and amino acids were reflections of cellular damage or of beneficial cellular adaption. Cavagna et al. (93) demonstrated that hospital patients suffering from liver diseases were more sensitive to DDVP than were adults with normal liver function. Assuming certain inhaled volumes of air and the number of hours the patients were exposed, it was found that a reduction in plasma cholinesterase occurred for a calculated daily DDVP inhalation of about 1.7 mg by adults with normal liver function and 0.3 mg by adults with liver disease. Arterberry et al. (94) have shown that there is a reasonably good correlation between p-nitrophenol excretion and exposure to parathion, change in blood cholinesterase activity level, and the occurrence of poisoning.

Durham et al. (95) found that of orchard spraymen using parathion in an airblast type of spray machine, skin contamination was potentially a more important route of absorption but not necessarily of poisoning, than the respiratory route. They stated that this conclusion may not be valid for other compounds or even for parathion under different conditions of use. These findings confirmed earlier findings of Durham and Wolfe (96). They also reported indications that after dermal exposure to parathion, greater excretion of p-nitrophenol was associated with higher temperature (95). Baetjer and Smith (97) had found parathion to be more toxic to mice at higher environmental temperatures. Wolfe et al. (70) have also reported that comparative studies made at two temperature ranges indicated that exposure to DDT was increased when spraying at higher temperatures. Several other studies have shown that exposure to parathion by the respiratory route was by far the most hazardous (98, 99, 100). During one such study, Hartwell and Hayes (100) observed that cholinesterase activity increased or returned to normal when respiratory protection was provided to exposed workmen with depressed cholinesterase activity, even though work was continued in the environment where the level of exposure was the same. Later Wolfe et al. (101), while studying exposure of spraymen to different pesticides, observed that potential dermal exposure to each compound was much greater than potential respiratory exposure.

Durham et al. (102) found that mental alertness was impaired by exposure to organic phosphate insecticides. In 187 study cases of suspected organic phosphate poisoning, there were no cases in which mental effect was noted in the complete absence of physical signs or symptoms of illness. Metcalf and Holmes (103), while studying neurological alterations in humans with organophosphorus exposure, concluded that the possibility existed that long term exposure to organic phosphate compounds can induce irreversible or only slowly reversible brain dysfunction.

DuBois (104) observed that under conditions of prolonged exposure to an organophosphate that cause cholinesterase inhibition in rats some acquired resistance would be expected to develop. Williams et al. (105) observed no cholinesterase inhibition when parathion was administered at graded levels up to 3.5 ppm in the total diet of volunteers. In another study, 122 volunteers were studied to determine the toxic effects of insecticides on people with and without respiratory diseases. The insecticide used was paration and results indicated that hazards of insecticidal poisoning to persons with environmental or incidental exposure were negligible (106). DDVP has been shown to be safe for warehouse workers when applied as a thermal aerosol twice a week or less often at a rate of 2 mg/ft^3 or less (107). Witter (108) noticed no physiologically significant exposure to DDVP by fogging machine operators applying 4 per cent DDVP for 8 hours a day twice weekly for 4 months. Culver et al. (109) estimated a worker's exposure to malathion and chlorthion during aerosoling for mosquitoes to be 100 to 200 times less than the acute LD 50's reported for animals. They also concluded that malathion and chlorthion could be used safely in aerosol form against adult mosquitoes in populated areas.

Chavarria et al. (110) observed that dichlorves as an anthelmintic caused no clinical side effects except for brief mild headaches in a few when administered to 108 hospitalized adults. Cerf and coworkers (111) have also reported encouraging results with dipterex against several helmimths with good patient toleration.

Carbamates

The physiological effect of the carbamate insecticides also involves inhibition of the enzyme cholinesterase; however, generally, the carbamate cholinesterase complex is less stable than is the organic phosphate-enzyme combination. Absorption of the carbamates may also be determined by measurement of blood cholinesterase activity (53).

Kolbezen et al. (112) have demonstrated that there is a direct relationship between the toxicity of the carbamate compounds and their ability as cholinesterase inhibitors. Carbamates have been found to be effective against a wide range of insect pests (112, 113, 114), and have been found safe to use on various fruits and vegetables (115).

Winteringham (116) gave the following reaction to represent the inhibition of cholinesterase by a carbamate:

$$Enz + I \rightarrow Enz{:}I \rightarrow Enz. + P$$

The free enzyme (Enz.) and inhibitor (I) combine to form a carbamylated enzyme (Enz:I) with subsequent hydrolytic regeneration of free enzyme (Enz.) and carbamate decomposition products (P). Carbofurin is a direct inhibitor of acetylcholinesterase and produces signs and symptoms within a half hour after absorption (117). Suicidal death due to the ingestion of a quantity of a carbamate compound probably less than 8 ounces, has also been reported (118).

It appears that the most widely used carbamate is carbaryl, commercially known as Sevin. Best and Murray (119) have shown that workers in an environment containing Sevin dust in air absorbed and metabolized the insecticide, as demonstrated by high levels of urinary excretion of the metabolite, 1-naphthol. During this study workers blood cholinesterase analyses indicated absorption of the insecticide although no employee showed any signs or symptoms of increased activity of the parasympathetic nervous system.

Matsumura and Ward (120) reported that the degradation of carbaryl by the human and rat liver was very similar. They also reported differences in male and female rats of water soluble metabolite production. Differences in mammalian species susceptibility to Sevin had been demonstrated earlier by Carpenter et al. (121), and differences in species susceptibility to one other carbamate compound has since been observed by Tucker and Crabtree (122). Working with rats, Goldberg et al. (123) observed the male to be about three times as sensitive than females to a carbamate compound and that mice were more sensitive than rats to the chemical. El-Aziz et al. (124) also found age and sex were important factors affecting the toxicity of six carbamate insecticides to certain species in one study.

Vandekar (125) observed rash and signs of poisoning in both spraymen and occupants of houses sprayed with carbamate compounds. Deformities have been observed in fetuses of hampsters as a result of injection interperitoneally with various carbamate compounds (126), and teratogenic action of carbaryl in beagle dogs has also been reported (127). Edington and Howell (128) have reported changes in the nervous system of rabbits given sodium diethyldithiocarbamate and the same compound has also been found to interfere with blood copper-level and have a marked effect on pregnancy in rabbits (129).

Williams and co-workers (130) have reported that rats pretreated with chlordane or aldrin showed decreased acute oral toxicity to certain carbamates. Meksongsee et al. (131) have demonstrated a potentiation of toxicity of carbamate insecticides with ethanol in mice. These findings were similar to earlier findings of Goldberg et al.(123).

Vandekar and co-workers (132) have demonstrated that carbamates produce a greater LD50/ED50 ratio than organophosphorous compounds. From these findings they have concluded that in occupational over-exposure to carbamates, it is reasonable to assume that an early warning of poisoning by the appearance of unmistakable and incapacitating symptoms may be expected long before a lethal dose is absorbed.

Summary

It appears that current dietary and incidental exposure of the general public to pesticides is negligible. It has been well established that generally, the occupationally exposed person will demonstrate a deposition-excretion level of pesticides in excess of that of the non-exposed person. The organic phosphate insecticides are generally much more toxic than the chlorinated hydrocarbons or the carbamates. Pesticides of each type may exhibit their toxic action upon man through oral, dermal, or respiratory entry into the body, of which dermal seems to be the most important. The hazards of pesticide exposure can be greatly reduced by the careful operator and by the use of certain safety precautions and devices. The toxicities of certain pesticides can be altered when in combination with other pesticides or drugs. It further appears that the professional PCO through his constant contact with pesticides, either individually or in combination, is subjected to more constant exposure than any other occupational group. Due to a greater public awareness of the detrimental effects of pesticide overuse or misuse it seems safe to conclude that the consumer will turn to employment of pest control professionals, thus increasing the total number occupationally exposed or increasing the exposure of those presently pursuing that occupation. This realization points up the need for a study to determine: a) the kind(s) and level(s) of exposure experienced by these professionals, b) the experience and special training possessed by these professionals, c) the amount of supervision provided the employees, and d) the usage of protective devices by the employees.

CHAPTER III

PURPOSE AND SCOPE

Since proposed federal pesticide legislation promised to cause sweeping changes regarding the knowledge and ability required of those applying certain pesticides, obviously the application of these pesticides will change accordingly (44). This legislation provides for the prosecution of those using certain pesticides for uses other than the use for which it was intended. It further provides for the State Regulatory Agency, in this state, the Department of Agriculture, to provide compatible acceptable state legislation providing for the re-examination of all existing professionals. These are the persons presently licensed by the State Regulatory Agency to perform Pest Control Services.

Because this legislation provides that application of pesticides be limited to competent persons, a study was initiated to determine the amount(s) of and kind(s) of exposure experienced by today's PCO's. Other areas chosen for investigation were worker's experience, training, and amount of supervision. This was accomplished by a collection of pertinent data from the 68 member firms of the Oklahoma Pest Control Association during the months of April through August, 1972.

CHAPTER IV

MATERIALS AND METHODS

The population selected for this investigation was the 68 member firms of the Oklahoma Pest Control Association. Since it contained both those firms licensed by examination, as well as "grandfather" license holders, it was considered representative of the pest control operators in Oklahoma.

Since all licensed firms have long been required by the state regulatory agency to report monthly activities, monthly reporting was chosen as the method of data gathering most appropriate for the study. This prior reporting experience provided a responsive population and allowed for quick initiation of the study to coincide with the busy months of the season.

In order to obtain the desired information, a specially constructed form herein called the monthly data sheet was designed resembling as closely as possible the standard monthly report forms provided each license holder by the state regulatory agency (see Appendix A).

One section of the data sheet was designed to collect information pertaining to the amount(s) and kind(s) of pesticides used as well as the pest controlled with these pesticides. Another section was designed to accumulate data relative to kind(s) and amount(s) of exposure experienced by employees as well as the employees' education, training, experience, and supervision. Questions four and eleven of this section were designed to serve as a check for inconsistencies in reporting. Question four called for the major area of employment of the employee, while question eleven asked for the pesticide type to which the employee was exposed. Since chlorinated hydrocarbons are exclusively specified by the state regulatory agency for termite control, any response other than chlorinated hydrocarbons for this area of employment was considered inconsistant.

The monthly data sheet did not solicit information regarding sociological parameters and since it was apparent that this information could be used beneficially by the investigator, especially as related to age and education of the respondents, a preliminary report form was devised to solicit this information (see Appendix B). It was constructed to obtain quick, objective responses and consisted of eleven questions. Question six of this form was included to serve as a check for inconsistant reporting when used as a cross check against the previously mentioned monthly data sheet, especially questions four and eleven. Since certain pesticide types are limited to certain licenses, a relatively quick check for inconsistencies was provided when the two forms were compared.

Both the report form and the monthly data sheet were revised several times to make them as clear and complete as possible and every precaution was taken to make certain that all terms used were the same as those used universally by PCO's in his everyday jargon. Although the case of the untruthful respondent is always a possibility, it was concluded that this would be minimized due to the design of the research instrument. Another area of particular concern was that of the possibility of the responses being provided by persons performing clerical tasks only. To minimize this possibility, certain technical information was solicited.

When final revisions appeared to be appropriate for solicitation of the desired information, it was decided that much would be gained by endorsement of the study by the state regulatory agency and the association membership. This was obtained at the March 14, 1972, meeting of the Western Chapter of the Oklahoma Pest Control Association when the members present voted unanimously to recommend full support of the study at the next regularly scheduled statewide meeting of the association. At this same meeting a representative of the state regulatory agency publicly endorsed the study and on April 6, 1972, members in attendance at the statewide meeting also voted unanimously to cooperate with the investigator throughout the study. Shortly after this dual endorsement, the preliminary report form and several copies of the monthly data sheet were mailed to all members of the association as of April, 1972. The mailout material also contained a cover letter outlining the need for and the intent of the study. The letter asked for return of the preliminary report form by return mail and requested the return of the data sheet monthly during the peak season of 1972. In order to indicate the method of reporting more clearly, an example was included in each mailout.

The instructions provided asked for the return of all data sheets by the 10th of the month following the reporting month. Those firms not responding by the 10th of the month were routinely sent a reminder requesting again the desired information. Firms failing to respond to this request were contacted by phone and offered assistance, if desired, in completion of the appropriate report form(s). When this procedure failed, the firm was visited personally by the investigator or the Oklahoma State Health Department Pesticide Coordinator.

CHAPTER V

RESULTS AND DISCUSSION

The results of this investigation were obtained from information collected by two separate data gathering devices , and the data were analyzed accordingly.

An analysis of these data yielded one general finding of interest which seems pertinant to mention here. This finding was the large number of licensed firms which were pursuing the pest control business only part time as evidenced by letterheads, advertisements, and company names. Although this information was not specifically solicited, it does seem meaningful since most such firms apparently used their other business outlets to utilize full benefit from permanent employees, thus removing the pest control technician from the area of exposure at least part of the year. Most firms were in businesses closely related to the pest control profession such as landscaping, tree and yard care, and/or some phase of home construction or remodeling. There were, however, some firms engaged in other businesses which seemed to have no specific connection with the pest control business. These businesses included a barber supply, a pawn shop, and a liquor store. Detailed analyses were performed on each data gathering instrument.

Preliminary Report Form

Of the total respondents (N=52), the mean number of years of experience possessed by the owners/operators was 17.7 years. The range of experience was from 5 months to 44 years. The 52 responses represent a 76 per cent return of the preliminary report form. Fifty-six per cent of the respondents indicated that they were licensed as PCO's after 1955, the first year licensing was required by state statute. Firms in operation at that time were granted licenses under the "grandfather" clause, while those beginning later were required to satisfactorily complete both a written examination, as well as perform one or more actual jobs in the area in which licensing was desired. All 52 respondents indicated that they were licensed to perform termite work while 50 were licensed in the area of general pest control. These two licenses permit the firm to engage in both termite and general pest control while the other license granted by the state regulatory agency, that of fumigation, was held by only 17 of the respondents. That particular license differs from the others previously mentioned since it enables a licensee to use a definite method rather than perform in a distinct area. These data are presented in Table 2.

TABLE 2

LICENSE STATUS OF OKLAHOMA PCO's 1972

License	Number of Operators	Percentage
Termite	52	100
General Pest	50	96
Fumigator	17	33

As previously mentioned, 1955 had a significant meaning since it was in that year that licensing of PCO's was first required in Oklahoma. Table 3 shows the percentage of operators licensed after that date

TABLE 3

TIME OF LICENSING

Year First Licensed	Number of Operators	Percentage
1955	23	44
After 1955	29	56

and those licensed by virtue of the "grandfather" clause. The number of firms allocated to each category indicated that, indeed, the sample population was representative and contained a like number of the "grandfather" license holders, as well as those who had been tested for licensing. This breakdown also indicated that a large number of the respondents had been associated with the business at least since 1955. This stratification also served to provide built-in sub groups against which certain other findings could be compared.

Table 4 shows that 46 per cent of the owners/operators were 51 years of age or older and that 84 per cent were 41 years of age or older. This investigator interpreted this to be quite meaningful since only 16 per cent were of the age which would indicate potential educational exposure after the age of modern day pesticides began.

From Table 5 it is quite evident that the highschool education is the most frequently reported educational level attained and 23 per cent of the owners/operators had attained at least one college degree

TABLE 4

AGE DISTRIBUTION OF OWNERS/OPERATORS

Age Group	Number of Operators	Percentage
20-30	2	4
31-40	8	15
41-50	18	35
51 above	24	46

TABLE 5

EDUCATIONAL ATTAINMENT OF OWNER/OPERATORS

Educational Level Attained	Number of Operators	Percentage
Less than Highschool	8	15
Highschool	32	63
Bachelor's Degree	6	11
Master's Degree	6	11
Doctor's Degree	0	0

and only 15 per cent failed to complete highschool. A closer look at the raw data indicates that attainment of masters' degrees by the operators taking the examination for licensing exceeded the operators licensed by the "grandfather clause" six to one. There seems to be no meaningful implications in comparison of other educational levels between these two strata. Most college degrees, however, did tend to be either in a scientific or management field.

Table 6 indicates that a total of 90 per cent of the operators

TABLE 6

REQUIREMENT OF PROTECTIVE DEVICES

Response	Number of Operators	Percentage
Yes	31	60
Try to	16	30
No	3	6
No response	2	4

either require or at least try to require individual protective devices for their employees. Only three operators indicated that they did not require protective devices and two firms failed to mark either choice. This particular question seemed for some reason to stimulate many respondents to make personal comments. Most comments indicated a desire for employees to use protective devices, but comments also reflected a realization that quite possibly they were not used. A graphical presentation of the specific protective devices required by the respondents can be found in Figure 2. These findings indicate that a majority of the respondents required employees to use four or more protective devices. The investigator considers this to be meaningful as it reflects an awareness on the part of the operator of the potential hazard of working in close proximity to certain pesticides. This investigator has several times witnessed PCO's failing to wear necessary protective devices in an attempt to convey a sense of complete safety of the

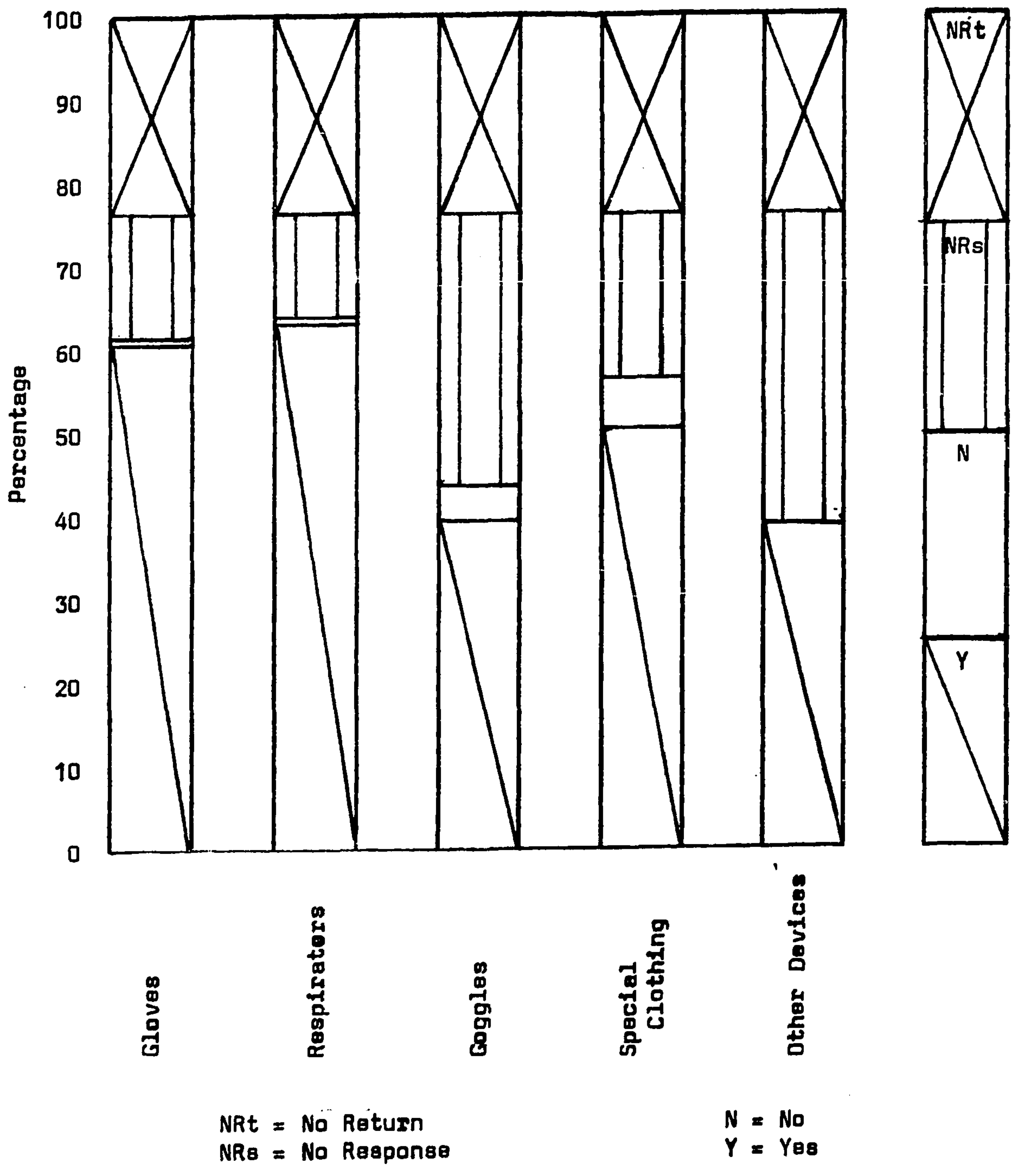


Figure 2.--Protective Devices Required by Oklahoma PCO's.

pesticide and procedure used and thus gain customer acceptance.

In summary, the Oklahoma owner/operator averaged 41 years of age or older and had an average of 17.7 years of experience with a range of 5 months to 44 years. There were more owners/operators who had at least one college degree than there were operators without high-school. A large majority of the licensed firms in the state pursued other business interests, most of which were closely related to some phase of pest control. Ninety per cent of the operators required or tried to require the use of protective devices, and a majority of these required or tried to require four or more such devices. These findings were quite similar to a recent study conducted with Indiana PCO's (133). In that study, owners' age ranged from 28 to 76 with a mean age of 48.4 They also had an average of 19.4 years of experience in pest control work with a range of 3 to 45 years.

Monthly Data Sheet

Forty-nine firms representing a 72 per cent return responded during the course of the investigation. Fifteen firms reported only once during the reporting period while 24 reported three or more times and ten firms reported twice. An analysis of data from these sub groups did not seem to bias the results and findings are reported accordingly.

Table 7 clearly shows that the PCO's pesticide of choice for termite control was chlordane followed distantly by aldrin while heptachlor was used by only one of the reporting firms. Even though the ratio of chlordane to aldrin was approximately 3.5:1, a closer look at the raw data indicates that most of the large volume use companies

TABLE 7

PESTICIDE OF CHOICE FOR TERMITE CONTROL

Pesticide	Number of Operators	Percentage
Chlordane *	38	78
Aldrin *	11	22
Heptachlor	1	2

* One operator indicated a dual choice.

prefer chlordane; consequently the amount of chlordane reaching the environment is significantly greater than the amount of aldrin.

Table 8 shows the pesticide used for general pest control.

TABLE 8

PESTICIDE OF CHOICE FOR GENERAL PEST CONTROL

Pesticide	Number of Operators
Diazinon	35
Vapona	16
Dieldren	12
Dursban	9
Chlordane	8
Baygon	7
Pyrethrum	4

"General pest" here is defined to be all insects and other related arthopods commonly known to be pestiferous to man, but not including termites, tree and lawn pests, and rodents. Diazinon was clearly the pesticide of choice, followed by vapona, dieldren, dursban, chlordane, baygon, and pyrethrum. Eight other pesticides were also listed as being used for general pest control but in amounts not considered significant. It would appear to this investigator that many PCO's were using mixtures of various pesticides for general pest control. The most common mixtures appeared to be an organic phosphate and pyrethrum for a quick "knock down and kill" and a chlorinated hydrocarbon for a long residual. Two findings which seemed of particular interest to this investigator were that no PCO reported the use of lindane, even though the lindane vapor lamp still flourishes in the state, and dieldren appeared to be used almost exclusively for poisonous spider control.

The pesticide of choice for mice control is shown in Table 9.

TABLE 9

PESTICIDE OF CHOICE FOR MOUSE CONTROL

Pesticide	Number of Operators
DDT	9
Warfarin	2
Fumarin	1
Others	1

Even though DDT has become quite difficult to obtain, it still was preferred by a majority of the PCO's reporting. It appeared that the professional controls rodents almost exclusively by use of anticoagulants baits. The rodent problem did not seem to be of great significance as evidenced by the extremely small number of firms reporting rodent control as a part of their routine control service.

The carbamate compound, sevin, appeared to be the pesticide of choice for tree and/or shrub pest control, with malathion and diazinone being second and third, respectively. These findings can be seen in Table 10. It was interesting to note that even though few firms

TABLE 10

PESTICIDE OF CHOICE FOR CONTROL OF TREE AND SHRUB PESTS

Pesticide	Number of Operators
Sevin	22
Malathion	7
Diazinon	2

actively pursue the tree spraying business, those that do are, indeed, using large quantities of pesticides and on a volume basis are applying more pesticides into the ambient environment than any other pest control activity. It also seems meaningful that a large number of PCO's engaged in tree and/or shrub spraying used a mixture of sevin and malathion or sevin and diazinon.

The five leading pests controlled by the PCO's during the period of investigation are presented in Table 11. Table 12 presents similar findings from a previous study (6). When specific household pests were listed individually, termites appeared to be the leading pest controlled followed quite closely by roaches, spiders, silverfish, and fleas. Lawn and tree pests, collectively, appear to occupy a position

TABLE 11

MOST FREQUENTLY CONTROLLED PESTS

Pest
Termites
Roaches
Tree and Shrub Pests
Spiders
Silverfish
Fleas

TABLE 12

THE TEN MOST IMPORTANT PESTS CONTROLLED BY PEST CONTROL OPERATORS IN 1965

Pest
German Roach
House Mouse
Norway Rat
Subterranean Termites
House Ants
American Roach
Carpenter Ant
Oriental Roach
Fleas
Brown Dog Tick

equal to that of many household pests and, on an overall analyses of the raw data, appear to be ranked in third position of most controlled pests. This investigator considers the ranking of termite control in the number one position, probably due to the high unit of profit per dollar investment coupled with the increased number of pre-treats being performed as a result of a recent surge in building. In 1970, there were 5,288 pre-treats reported to the state regulatory agency (52).

Another section of the monthly data sheet indicated that ten of the 49 participating firms had no employees while the upper range was 11, with a mean of 2.7 employees per firm. The total number employed by the participating firms was 135. A presentation of these data can be seen in Table 13. A very interesting revelation concerning these

TABLE 13

NUMBER OF EMPLOYEES PER FIRM

Number of Employees	Number of Firms	Percentage
0	10	20
1-2	21	43
3-5	11	22
6-10	6	12
11 above	1	2

data is that over 65 per cent of the employees have 3 or more years experience. The 19.3 per cent of the employees with less than 1 year experience also seems quite high; however, no distinction between transient employees and firm growth was attempted in this study. Employee data gathered were limited to employees with exposure to pesticides. By definition, exposure was defined as intimate contact with one or more pesticides either in technical or diluted form under normal daily routine work conditions. This method excluded many part-time personnel who were used to perform tasks prior to application of pesticides, and were actually not part of the work force during application. Another point of particular interest was the quite large number of firms employing family members. This might account for the large number of persons with many years of experience.

Responses to column six through ten of the monthly data sheet indicated that there seemed to be no correlation between length of employment, experience, and amount of training, with the job performed by the employee. Generally, it can be stated that the owner/operator delegated little supervisory authority to personnel although some did sell and a large number mixed chemicals. Employee attendance of technical schools or other association meetings was practically non-existent.

Columns twelve through fifteen solicited information relative to the length of time of exposure and supervision of the employees. An analysis of the data indicated that employees were exposed to pesticides an average of 18.9 days per month. A large majority of the employees worked 5.5 or 6 days per week while some worked only 2 or 3 days per week.

Sixty-seven per cent of the employees worked alone at least part time and 44 per cent were supervised at least part time. Of those employees supervised, there seemed to be no common denominator which determined supervision. The supervisors employed had an average of 15.4 years experience ranging from a low of 1 year to 40 years. Supervision in this context was determined to be contact or consultation between supervisor and employee one or more times during the normal work day. There seemed to be no significant difference in amount of supervision provided employees regardless of their area of specialization or the pesticides to which they were regularly exposed.

CHAPTER VI

SUMMARY AND CONCLUSIONS

An investigation was conducted during the peak season of 1972 to determine the kind(s) and amount(s) of exposure experienced by PCO's in Oklahoma, as well as other parameters perculiar to this particular professional group. The 68 member firms of the Oklahoma Pest Control Association were chosen as the population for the study. Data were obtained by use of specially designed report forms provided the firms by the investigator. Based on the results of this investigation, the following conclusions were reached.

The Oklahoma PCO was repeatedly exposed to varying amounts of pesticides individually and in combination while engaged in normal performance of his routine duties. On an average, the Oklahoma PCO experiences exposure 18.9 days per month and usually worked alone. A large percentage of owners try to require protective devices for their employees but realize that often these protective devices are not used. The chlorinated hydrocarbon, chlordane, appeared to be the most extensively used pesticide and was generally applied in concentrations of 1 per cent or less. Practically all of the chlordane used was used for the control of subterranean termites. Diazinon was the most extensively used of the organic phosphates and was normally applied in concentrations of 0.5 per cent or less. Quite often it was used in combination with DDVP and pyrethrum. Most diazinon was used for the control of the German roach. Sevin was the most extensively used carbamate compound and was often used in combination with organic phosphates and/or chlorinated hydrocarbons. Sevin was used primarily for control of tree and shrub pests usually in percentages ranging from 0.3 to 0.5 per cent. This investigation indicated that potentially tree and/or shrub spraying contributed more environmental pesticide contamination than any other activity studied.

Eighty-four per cent of the owners/operators were 41 years of age or older which indicated that the possibility existed that these persons received very little if any education dealing with pesticides during their formal education. Twenty-three per cent of the owners/operators have attained at least one college degree and 73 per cent of the employees have a highschool education. Although it appeared that the employees as a group were highly trainable, attendance at specialized schools or regularly scheduled technical meetings was practically non-existent. Sixty-five per cent of the employees have been employed three years or longer while the average length of experience of the owner/operator was 17.7 years. Length of employment, education, and prior experience did not appear to be a criteria for determining employee job assignments or degree of supervision.

These findings point to the need for future studies dealing in depth with this occupational group. Therefore, the following are recommended:

a) Retrospective epidemiological investigations of pesticide related morbidity and mortality of occupationally exposed persons. For example, the incidence of illness and/or death in this occupational group should be studied for comparison with similar rates for the general population.

b) Prospective epidemiological investigations of occupationally exposed persons to determine toxic effects due to long term exposure. This could be accomplished by monitoring various parameters in a cohort of exposed persons from time of initial employment for several years.

c) Laboratory studies involving in-depth biochemical analyses of body fluids and tissues to determine measures of toxic reactions in occupationally exposed persons as evidenced by cell abnormalities, detoxifying enzyme levels, and tissue deposition levels.

d) Studies probing the adequacy and effectiveness of existing licensing and regulatory legislation governing this occupational group in Oklahoma by studying the state of the art in Oklahoma and comparing these findings with those from other states.

e) Investigations exploring the effectiveness of existing PCO technician training techniques currently used in Oklahoma with those utilized by other states.

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UNIVERSITY MICROFILMS.

APPENDIX A

Monthly Data Sheets

Monthly Data Sheet

Part A

Please complete and return on or before the 10th of the month following reporting month.

Firm reporting ______________________

Address ______________________

Month you are reporting ______________________

Person preparing report ______________________

PLEASE PROVIDE THE FOLLOWING ABOUT PESTICIDES USED DURING THE MONTH YOU ARE REPORTING. AN EXAMPLE HAS BEEN PROVIDED TO INDICATE METHOD OF REPORTING. BEGIN ON LINE ONE.

TYPE (NAME) OF PESTICIDE	POUNDS OR GALLONS OF PESTICIDES USED DURING MONTH	CONCENTRATION	PEST CONTROLLED
Example: DDT	15 pounds	50%	Mice
1.			
2.			
3.			
4.			
5.			
6.			

Monthly Data Sheet-Part B

Please provide the following information for all employees (including part-time employees) who were actually exposed to (worked with) pesticides during the month reported. An example has been provided to illustrate the method of reporting more clearly. Begin on line one and report all exposed employees by name. Column 0 asks for the employee's name; once the initial (first) report has been made for an employee and all information in columns 0 thru 15 has been completed, following monthly reports need only include information in columns 0 (name) and columns 11 thru 15 (information which may change from month to month) for that employee. However, always provide information in all columns (0-15) for any employee hired since last reporting date. If more space is needed, use additional forms.

0	1	2	3	4			5		6		7		8		9		10		10b	11						12	13	14	15
Name of Employee	Education (highest grade completed)	Length of time employee has been employed with your company (in years or months)	Total number of months or years experience in Pest Control Business	Check major area of employment. May be more than one.			Does employee supervise others?		Does employee also sell?		Does employee mix chemicals?		Does employee attend Pest Control Assn. meetings?		Did employee attend recent technician school?		Has employee attended a similar school in another state?		If yes, for how many days?	Major pesticide type that employee worked with during month...may be more than one.						Actual number of days this month that employee was exposed.	Number of days this month that employee worked alone.	Number of days this month that employee was supervised.	If supervised, give number of years of Pest Control experience of supervisor.
				Termite	General Pest	Fumigation	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		CHLORINATED HYDROCARBONS	CARBAMATES	FUMIGATION GASES	WEED KILLERS	ORGANIC PHOSPHATES	OTHERS (specify)				
Example S. Jones	12	4 yr	4 yr	x	x			x	x		x		x		x			x		x	x					22	22	0	
1.																													
2.																													
3.																													
4.																													
5.																													
6.																													

APPENDIX B

Preliminary Report Form

Preliminary Report Form

1. Name of Company ______________________________

2. Name of Owner/Operator of Business ________________

3. Address of Owner/Operator ______________________

4. Total years of experience in Pest Control Business of Owner/Operator ______________________________

5. First year that Owner/Operator was licensed as a PCO in Oklahoma _____

6. Check appropriate license (s) held by Owner/Operator.

   Termite ______________

   General Pest ___________

   Fumigator ____________

7. Age of Owner/Operator (check appropriate age group)

   20-30 years ___________

   31-40 years ___________

   41-50 years ___________

   51 and above ___________

8. Educational background of Owner/Operator

   Highschool ____________

   Bachelor's degree ______ ____________________ ____
   Major area of study year

   Master's degree ______ ____________________ ____
   Major area of study year

   Doctor's degree ______ ____________________ ____
   Major area of study year

9. Average number of employees that you employ ______________

10. Do you require that your employees use protective devices and/or special clothing while working with pesticides? ___Yes ___No ___ Try to

11. If number 10 was answered yes, check any of the things listed below that you do require.

   Gloves ____ Yes ____ No   Special Clothing ____ Yes ____ No

   Respirators ____ Yes ____ No   Other things ________________ Specify

   Goggles ____ Yes ____ No