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Mercury, Dieldrin, DDT, DDE, and PCB Levels in Tissues From Fish and Wildlife in Utah

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MERCURY, DIELDRIN, DDT, DDE, AND PCB LEVELS IN TISSUES FROM FISH AND WILDLIFE IN UTAH

by

Fred A. Smith

A thesis submitted in partial fulfillment
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Mercury, Dieldrin, DDT, DDE, and PCB Levels in Tissues

From Fish and Wildlife in Utah

by

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Utah State University, 1973

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Fish and wildlife were randomly sampled in Utah from pre-selected areas and analyzed for levels of total mercury, dieldrin, DDT, and DDE. Levels were well within consumptive tolerance or guildeline limits except for mercury levels of fish in Willard Bay Reservoir. PCB's were also identified in a large proportion of samples.

None of the chukars, 6 percent of the pheasants, 4 percent of the waterfowl, and none of the fish sampled, excluding Willard Bay Reservoir, were above the 0.5 ppm guideline level for mercury established by the Food and Drug Administration. Seventy-seven percent of the fish sampled from Willard Bay Reservoir were above the 0.5 ppm guideline level. Only one duck (2 percent) was above the maximum permissible concentration for dieldrin. All of the chukars, pheasants, other waterfowl, and fish were well below human consumptive tolerance limits for dieldrin and DDT + DDE.

It is recommended that studies be initiated to more closely define possible sources of mercury and the health hazard involved in consumption of these fish.

(130 pages)

INTRODUCTION

A major concern of conservation agencies is potential contamination of the environment. The scope of the problem must be defined before concerted effort can be made toward this end.

With much of the recent research being done today on pesticides relating to their effect upon various species of the food chain, especially those of fish, raptoral birds of prey, and game birds, it is becoming increasingly evident that these problems also exist in Utah.

It has been suggested (Hunt and Keith, 1962) that a potential health hazard to sportsmen may result from eating game species. Reports of high levels of pesticides in pheasants, ducks, and starlings in our neighboring states indicate a need to evaluate Utah's situation regarding important game species (Brock, 1971; Buhler, Claeys, and Raynor, 1971; Hunt et al., 1969).

Residue levels have been examined in 20 pheasants approximately six months of age from farmlands near Delta, Millard County, Utah, during two years where DDT and dieldrin had been used for alfalfa weevil control. First year results showed high levels of these residues, ranging from 5 to 25 ppm dieldrin and 10 to 110 ppm DDT in the body fat (Low and Street, 1964). Because of opposition and partially based on such data these two insecticides were replaced by bidrin, a product of Shell Oil Company. After two seasons of non-use of the former insecticides, another sample of 20 birds of the same age range was examined. The levels were still as high as two years previous when use of these pesticides was discontinued. Although the direct or indirect effects of these pesticides on the pheasants were not determined, it does point out the persistence of these insecticides in the upland habitat.

In a preliminary investigation in California, (Hunt and Keith, 1962), it was found that DDT residues in pheasants were at a level considerably higher than residue levels allowed in commercial foodstuffs.

As indicated by a nationwide monitoring of organochlorine pesticides in wings of mallard ducks and black ducks in the 48 continental states by the Bureau of Sport Fisheries and Wildlife in late 1965, DDT was notably high in wings of ducks from New Jersey, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, Alabama, California, and Utah (Heath, 1969).

In a special report in Wildlife Service News (1970), Utah was indicated as an area relatively high in DDT and its metabolite residue levels and also as an area of relatively high dieldrin residue levels in nationwide monitoring of duck wings and starlings.

In 1969, the Government of Alberta, Canada (1970) closed its 60-day Hungarian partridge and pheasant season because of organic mercury residues 5 to 10 times higher than the allowable consumption level. Montana, Washington, Oregon, and Idaho are also conducting studies of mercury levels in game birds.

Objectives of this study were: (1) To determine the levels of mercury, dieldrin, DDT, and DDE in tissues from chukars, pheasants, deer, waterfowl, and fish collected from selected areas of Utah, (2) To evaluate and compare these levels with other published reports, and (3) To make recommendations for further studies and possible management measures.

REVIEW OF LITERATURE

Compounds

Mercury

History of effect on wildlife. The present concern regarding the potential hazards of mercury to wildlife began in 1955 when ornithologists in Sweden observed a marked decrease in populations of some seed eating birds. Borg et al., (1966) found high residues of mercury in livers and kidneys of birds found dead. They attributed the source to mercurial seed dressings.

Johnels and Westermark (1969) demonstrated that mercury levels in birds of prey from central Sweden in the period 1860 to 1870 was less than one-tenth of the levels in 1964 and 1965. In studies of feathers of museum specimens of pheasant (*Phasianus colchicus*), partridge (*Perdix perdix*), willow grouse (*Lagopus lagopus*), corn bunting (*Emberiza calandra*), perigrine falcon (*Falco peregrinus*), eagle owl (*Bubo bubo*), white-tailed eagle (*Haliaeetus albicilla*), long-eared owl (*Asio otus*), tawny owl (*Strix aluco*), buzzard (*Buteo buteo*), and hen carrier (*Circus cyaneus*), it was found that with the exception of *Lagopus lagopus*, an increase in mercury content was observed after the mid-1940's. This coincides with the beginning of liquid alkylmercury (methylmercury; ethylmercury) seed treatments replacing dusting of seeds due to reduced hazard to operator dressing the grain.

In the spring of 1966 regulations prohibiting use of alkylmercury compounds were imposed by the Swedish government. Alkoxyalkylmercury compounds were substituted and by 1967 mercury levels dropped sharply in many predatory bird species. During this same period of time it was found that Swedish fish had mercury levels up to 9.8 ppm.

The Government of Alberta, Canada, (1970) in 1969 initiated studies of mercury levels and found samples in pheasants and Hungarian partridge above their accepted tolerance of 0.1 ppm. In view of the potential hazard to human health, it was recommended that the hunting season for pheasants and Hungarian partridge be closed for 1969. Commercial catches of fish from Lake St. Clair were detained because tests made by the Canadian Wildlife Services indicated residues ranging from 5 to 10 ppm (Sport Fishing Institute Bulletin, 1970). Studies were then initiated throughout the United States revealing many situations similar to those of Sweden and Canada.

Sources of environmental contamination. Wallace et al., (1971) indicate that major sources of environmental contamination by mercury include chlor-alkali plant discharges; mercurial slimicides discharged from pulp and paper industries; mercury catalysts lost from acetaldehyde and vinyl chloride manufacturing processes; agricultural seed dressings; mining tailings and vapor released by the mining and smelting of mercury, tin, zinc, copper, and lead; loss of mercury in gold mining; combustion of paper products and fossil fuels and also from naturally occurring deposits of mercury. Known users of mercury that may also contribute mercury to the environment but in unknown amounts are laboratories (including hospitals).

Buildup in food chain. The only well known and documented accumulation of mercury by seed eating birds has resulted from direct consumption of mercurial seed dressings. Indirect accumulation may result from plant translocation of mercury to the seed. The predators of these birds may then accumulate mercury in concentrations greater than their prey (Wallace et al., 1971; Jernelov, 1969; Westoo, 1969).

Nelson (1971) states that the traditional food chain buildup may not occur with mercury. It has been found that uptake by animals was not related to trophic levels, but to such factors as metabolic rate and food habits. Predators usually contain more mercury than their prey but levels can be high near the base of the pyramid. He cites examples from Johnels, Olsson, and Westermark (1968), who reported residues of 1.4 to 17 ppm found in aquatic insects that normally had about 0.05 ppm. Pike from the same area (below a pulp mill) had 3.4 to 8.0 ppm in muscle. It is true, however, that concentrations of mercury in animals are thousands of times greater than those in the surrounding water.

Jernelov (1969) states the primary types of discharges of mercury are as follows:

1. As inorganic divalent mercury, Hg^{2+}
2. As metallic mercury, Hg^{o}
3. As phenylmercury, $C_6H_5Hg^+$
4. As methylmercury, CH_3Hg^+
5. As alkoxy-alkylmercury, $CH_3O\text{-}CH_2\text{-}CH_2\text{-}Hg^+$

He found that various organisms in lakes and rivers in Sweden were capable of manufacturing methylmercury. He further states that compounds numbered 1, 2, 3, and 5 above can all be converted in nature to methylmercury.

Matsumura, Gotoh, and Boush (1971) found that phenylmercuric acetate, a fungicide and slimicide, is metabolized quickly by soil and aquatic microorganisms. One of the major metabolic products was identified to be diphenylmercury. They state that in no case has a methylmercury derivative been found among the microbial metabolic products of phenylmercuric acetate in their aerobic situation.

Nelson (1971) states that although methylation of mercury will occur anaerobically, it appears to occur more efficiently in aerobic systems. In addition, microbial systems in the gut flora of hens have been shown to convert phenylmercuric hydroxide, methoxy ethylmercuric hydroxide, and mercuric nitrate to methylmercury. It has been shown by Westoo (1966) that mercury in fish muscle exists mainly as methylmercury. Grant (1971) states that fish concentrate methylmercury 5,000-fold greater than that in the surrounding water by respiring methylmercury directly through their gills or by ingestion of mercury absorbed on phytoplankton.

Toxicity. Toxicity of mercury to an animal or organism appears to depend primarily upon the chemical nature of the compound ingested, tolerance differences between species, feeding habits, concentration in the environment, and duration of exposure. Mercuric ions can interact with sulfhydryl groups of proteins, interfering with enzymes and producing changes in membrane permeability. This becomes particularly critical when enzymes are inhibited in the brain as these cells are not regenerated (Wallace et al., 1971).

Sixty ppb (parts per billion) ethylmercury has been found to be lethal to marine phytoplankton and as little as 0.1 to 0.6 ppb alkylmercury introduced into sea water will produce measurable inhibition of photosynthesis and growth (Harriss, White, and Macfarland, 1970).

Wier and Hine (1970) found that half of a group of goldfish continuously exposed to a concentration of 820 ppb mercuric chloride died within seven days. On exposure for only two days to only 3 ppb mercuric chloride produced a measured impairment in learning behavior.

Wallace et al. (1971) also state that synergisms in natural situations may play a role as in the case of copper which can appreciably increase the toxic effects of mercury.

Table 1 from Tucker and Crabtree (1970) indicate acute oral toxicity found in mallards, pheasants, and house sparrows from Panogen (methylmercuric dicyandiamide), Ceresan-L (methylmercury 2, 3-dihydroxypropyl mercaptide and methylmercury acetate), Ceresan-M (N-(ethylmercuri)-p- toluene sulfonanilide).

Inorganic and organic mercury differ greatly in the extent to which they are absorbed by the body and the degree of damage induced when absorbed. When taken orally, absorption of inorganic mercury is extremely low--less than 2 percent. Methylmercury is much more readily absorbed (90 to 95 percent) and more slowly excreted. Methylmercury is transported by the blood almost entirely by the red blood cells. Inorganic mercury by contrast is transported approximately 50 percent in plasma and is more readily excreted in urine. Measurement of mercury in the red blood cells would reflect the level of methylmercury in whole blood. The relatively slow excretion of methylmercury may be due to the fact it is excreted in the bile and then almost totally absorbed by the small intestine (Grant, 1971).

Methylmercury crosses the placental membranes and may be 20 to 30 percent higher in concentration in fetal red blood cells than in maternal red blood cells (Nelson, 1971). In animal experiments, mercuric mercury was found to concentrate in the placenta which acted as a barrier for absorption into the fetus (Berline and Ullberg, 1963).

Methylmercury and phenylmercury are among the most active c-mitotic agents known, being 200 to 1,000 times more effective than colchicine

Table 1a. Acute oral toxicity of Panogen in mallards, pheasants, and house sparrows. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards[a]	Male	--	56.1 (44.6-70.7)
Mallards[b]	Male	3-4 mo.	595 (350-1010)
Pheasants[b]	Male	4 mo.	566 (--)
House sparrows[b]	Male & Female	--	300-900

Acute symptoms: Regurgitation, polydipsia, general weakness, slowness of reactions, fluffed feathers, tetany when disturbed, coma. Affected survivors took up to a week to regain normal appearance.

PANOGEN

Alternative names: Panogen 42, methylmercuric cyanoguanidine, Morsodren

Chemical name: Methylmercuric dicyandiamide (=methylmercuric cyanoguanidine)

Primary use: Seed disinfectant, fungicides

[a]Sample purity 100 percent formulation.
[b]Sample purity 6.3 percent formulation.

Table 1b. Acute oral toxicity of Ceresan-L in mallards, pheasants, bobwhite quail, and fulvous tree ducks. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards	Male	3 mo.	>2000
Pheasants	Male	3-4 mo.	1190 (--)
Bobwhite quail	Male	2-3 mo.	1060 (841-1330)
Fulvous tree ducks	Male	3-6 mo.	1680 (--)

Acute symptoms: Ataxia, ataraxia, low carriage, hunching up with feathers fluffed, wing drop, neck pulled in, blinking, dyspnea, immobility. The mallards showed only ataxia for three days following treatment. Mortalities in the pheasants, bobwhites, and fulvous tree ducks took one to nine days after single oral adminstration. This is a very slow-acting compound, and complete recovery from symptoms among surviving pheasants took up to 21 days.

CERESAN-L

Alternative names: Granosan ("Granosan" also refers to Ceresan M, Ceresan M-DB, and Ceresan Red)

Chemical name: Formulation containing methylmercury 2, 3-dihydroxypropyl mercaptide and methylmercury acetate.

Primary use: Seed disinfectant, fungicide

Sample purity: 2.89 percent of former (chemical name) and 0.62 percent of latter ingredient (2.25 percent mercury)

Table 1c. Acute oral toxicity of Ceresan-M in mallards, mallard ducklings, pheasants, coturnix quail, pigeons, and prairie chickens. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards	Female	3 mo.	>2262
Mallard ducklings	Male & Female	7 days $\pm$ 1	>2262
Pheasants	Female	12 mo.	360 (--)
Coturnix	Female	2 mo.	668 (530-842)
Pigeons	Male & Female	--	755 (526-1080)
Prairie chickens	Male & Female	--	360 (233-566)

Acute symptoms: Mallards displayed regurgitation, polydipsia, salivation, goose-stepping ataxia, and slow reactions, but no deaths. Other species showed blinking, eyes closed, feathers fluffed, neck pulled in giving the animal the appearance of a "ball", anorexia, diminished righting reflex, lethargy, diarrhea, ataraxia. Mortalities usually occurred a few days to a few weeks post-treatment.

CERESAN-M

Alternative names: Granosan ("Granosan" also refers to Ceresan L, Ceresan M-DB, and Ceresan Red)

Chemical name: *N*-(ethylmercuri)-*p*-toluene sulfonanilide

Primary use: Seed disinfectant, fungicide

Sample purity: 7.7 percent formulation

at inhibiting spindle formation (Nelson, 1971). Inorganic mercury is about 200 times less active in this respect, although this factor may partially represent a difference in cell penetration of the two types of compounds (Wallace et al., 1971).

Symptoms of methyl- and ethylmercury poisoning in humans can occur weeks to months after acute exposure to toxic concentrations. The symptomology of chronic and acute cases of poisoning from both compounds is similar including numbness and tingling of hands and feet, ataxia, disturbance of speech, anemia, constriction of the visual fields, impairment of hearing and emotional disturbances. The symptoms are irreversible with severe intoxication indicating a threshold level of brain damage has been reached. Human infants born to mothers exposed to methylmercury have slightly different symptoms. Most children have mental retardation with cerebral palsy and convulsions (Wallace et al., 1971).

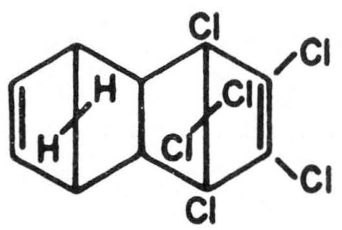
Current status-limitations of usage. In August of 1970, the United States Department of Agriculture, Agricultural Research Service, Pesticides Regulation Division (1970) cancelled registration of mercury products bearing claims and/or directions for use as slimicides, algicides, and use in laundering. This includes treatment of seeds.

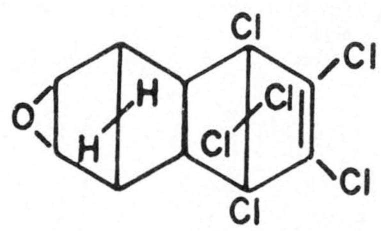
In March, 1972, the Environmental Protection Agency cancelled registration for products containing mercury. Some of these products suspended are registered for fungicidal use on cotton, farm and greenhouse equipment, ornamentals, turf, and on trees and shrubs to control anthracnose, leaf spots and blights. In addition, registrations for alkyl compounds and non-alkyl uses in rice seed, in laundry, and marine anti-fouling paint were suspended. Also the Environmental Protection

Agency administrator has given notice of intent to cancel the federal registration of all other mercury pesticide products including those used in mildew proofing paint, treatment of logs and lumber to prevent stain and mildew, and for control of stinking smut on wheat, snow mold on golf courses, and leaf stripe diseases on barley (Environmental News, 1972; Environmental Protection Agency, 1972).

Dieldrin

History and structure. Shortly after the advent of DDT many cyclodiene insecticides were developed, among them dieldrin, (1,2,3,4,10,10,-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a,-octahydro-1,4-endo,exo-58-dimethanonaphthalene) which is an epoxide of aldrin, (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene), (Metcalf, 1971).

ALDRIN: 

DIELDRIN: 

Aldrin and its epoxide, dieldrin, were synthesized in 1948. They became quite popular for control of grasshoppers, cotton and household insects.

In the monitoring of pesticides in wildlife samples, dieldrin is second only to DDT in being the compound observed most often. Though toxicity is greater and generally concentrations are less, persistence and modes of transport in the environment are essentially similar to those of DDT.

Scott, Willis, and Ellis, (1959) give some examples of mass poisoning by dieldrin as early as 1954 when the U. S. Department of Agriculture and the Illinois Agriculture Department began a program to eradicate the Japanese Beetle. These sprayings notably affected brown thrashers, starlings, meadow larks, grackles, and robins. Many dead ground squirrels, muskrats, and rabbits were found in treated areas. Almost 90 percent of the towns cats in Sheldon were killed during the first seasons spraying.

The President's Science Advisory Committee (1963), listed a great toll of wildlife had been taken by pesticides, including dieldrin. They also noted extensive fish losses, poisoning of shrimp, stunted oysters and elimination in one area of an entire years production of young salmon.

Toxicity. Table 2 from Tucker and Crabtree (1970), indicates the relative toxicity of dieldrin to mallards, pheasants, chukars, coturnix quail, pigeons, house sparrows, Canada geese, fulvous tree ducks, gray partridge, domestic goats, and mule deer.

Dieldrin is twice as toxic as DDT to rats and bluegills, 19 times as toxic to pheasants, 40 times as toxic to mallards, and 70 times as toxic to bobwhites (Fish and Wildlife Service, 1962).

In acute poisoning by cyclodiene insecticides from ingestion, inhalation or skin contamination, symptoms consist of hyperexcitability, tremors, ataxia, and convulsions within 30 minutes to 6 hours, followed by depression of the central nervous system which may terminate in

Table 2. Acute oral toxicity of dieldrin in mallards, pheasants, chukars, coturnix quail, pigeons, house sparrows, Canada geese, fulvous tree ducks, gray partridges, domestic goats, and mule deer. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards	Female	6-7 mo.	381 (141-1030)
Pheasants	Male	10-23 mo.	79.0 (33.3-187)
Chukars	Male & Female	8-11 mo.	23.4 (15.2-36.0)
Coturnix	Male	2 mo.	69.7 (40.0-121)
Pigeons	Male & Female	--	26.6 (19.2-36.9)
House sparrows	Female	--	47.6 (34.3-66.0)
Canada geese	Male & Female	Adult	50-150
Fulvous tree ducks	Female	--	100-200
Gray partridges	Female	3-10 mo.	8.84 (3.32-23.6)
Domestic goats	Male	6-8 mo.	100-200
Mule deer	Male	8-18 mo.	75-150

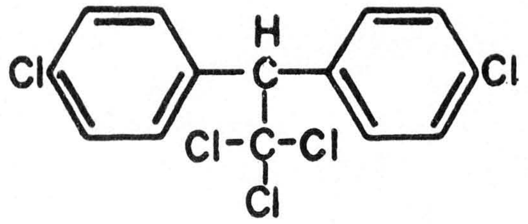
Acute symptoms: Tail feathers spread and pointed either upward or downward, hyperexcitability, jerkiness in gait, ataxia, dyspnea, myasthenia, fluffed feathers, immobility, terminal wing-beat convulsions or opisthotonos. Mortalities usually occurred one to nine days following treatment.

Notes: The 30-day EMLD for fulvous tree ducks is 2.5 and for gray partridges, 1.25 mg/kg/day. That for mallards if 5.0 mg/kg/day for both sexes. This results in a cumulative toxicity index of 381/5 = 76 for mallards, indicating a high degree of cumulative action. In 60-day feeding tests, 2.5 ppm was lethal to partridges, but not to fulvous tree ducks.

respiratory failure. Evidence of renal damage indicated by proteinurea and hematuria has been reported as has anuria. (Driesbach, 1969.)

DDT

History and structure. In 1874, Ziedler synthesized and described the compound 2,2'-bis (p-chlorophenyl)-1,1,1-trichloroethane, that is now commonly called DDT. It was only after 1939, however, when Paul Muller discovered the insecticidal properties of DDT that it was produced in any great quantities (Metcalf, 1955).



Since World War II, DDT has been used avidly to control diseases spread by insect vectors, plant pests, and household and livestock pests. DDT has enjoyed great popularity due to its broad insecticidal action, longevity, and relatively low mammalian toxicity.

Even at an early age of usage, it was found that DDT was not infallible. Mutants of houseflies resistant to DDT were first reported in 1946 (Perry, 1960). Resistance of the fly to DDT was almost complete by 1948 and by 1952 the fly had become resistant to the chlorinated hydrocarbon group in general. The numbers of species resistant to the chlorinated hydrocarbon insecticides rose from 2 in 1946 to

37 in 1956. DDT was still applied in increasing amounts every year however (Chadwick, 1967).

On the continents of Europe and North America there appeared a pattern of diminishing reproductive success of carnivorous birds at the ends of food chains (webs). It was found that a widespread decrease of eggshell thickness and calcium carbonate content occurred during 1946 to 1950 in British peregrine falcons, sparrow hawks, and golden eagles. The data showed eggshell thickness declined 7 to 25 percent within a few years after 1946 (Ratcliffe, 1967). Similar changes occurred at the same time in North America for peregrine, osprey, and the bald eagle. The osprey population in New England and Long Island dropped from 150 pairs nesting in 1952 to only 5 pairs nesting in 1960 (Peakall, 1970).

In Clear Lake, California, after application of 120,000 pounds of DDD to the waters, 1949-57, to kill midge fly larvae, and 500,000 pounds of DDT to the area surrounding the lake, 1949-64, western grebes (Aechmophorus accidentalis) declined from 1,000 pairs before treatment to 15 pairs in 1959, only two years after the final application of DDD (Herman, Garrett, and Rudd, 1969).

Herman, Garrett, and Rudd (1969) also indicate there is a statistically significant inverse correlation existing between feeding success of the American woodcock (Philahela minor) as measured by the ratio of immatures to adult females and the quantity of DDT applied annually to the habitat in New Brunswick during a six year period.

Hunt and Keith (1962) report residues in ring-necked pheasants (Phasianus calchicus) exposed to DDT and dieldrin in the field averaged 14 ppm in breast muscle and 2509 ppm in fat. Eggs contained 568 ppm in the yolk; when artificially incubated, hatchability of eggs was unaffected but mortality of chicks was 46.6 percent from the field and 27.0 percent in controls. The study area also produced nearly twice as many crippled young as the control area.

Butler (1969) reports experimental and monitoring data indicate that existing widespread pesticide pollution is causing significant decreases in productivity of estuarine populations of fish and shellfish.

Sources of environmental contamination. The amounts of persistent pesticides produced and disseminated for control of insects is staggering. Edwards (1970) states that in the United States alone, more than a million tons of DDT and 600,000 tons of aldrin and dieldrin have been manufactured. Warnick (1970) reports that there were 1,047,670 pounds of pesticides used in Utah in 1969. Kearney, Nash, and Isensee (1969) indicate that California agriculturists are the largest utilizers of pesticides in the U.S.

Mechanisms by which pesticides are transferred in the environment include volatilization, photodecomposition, and mechanical removal by water and wind erosion. Once an incorporation of the pesticide into some biological system takes place other loss mechanisms are important. These include chemical decomposition, adsorption to soil colloids, microbial metabolism and plant uptake. When high concentrations of chlorinated hydrocarbons are applied as for termite control, toxic concentrations may remain two to three times the normal persistence. The normal persistence has been established as four to five years. (Kearny, Nash, and Isensee, 1969.)

Build up in food chain. Organochlorine pesticides have a potential capacity to be transferred along food chains between trophic levels. Within a food chain these compounds usually increase in concentration with increasing trophic level, reaching the highest concentrations with carnivores at the top. The greatest effect appears to be in fish and birds of prey at the top of the food chain. (Robinson et al., 1967; Woodwell, Wurster, and Isaacson, 1967; and Wurster, 1969.)

Butler (1969) states that despite the wide array of persistent pesticides used in the U.S., only DDT, dieldrin, and endrin are commonly present in their monitor samples.

Toxicity. Toxicity of DDT to mallards, pheasants, coturnix quail, pigeons, lesser sandhill cranes, and bullfrogs is presented in Table 3 (Tucker and Crabtree, 1970).

A fatal dose of DDT to humans is 0.4 gram/kg body weight. DDT acts chiefly on the cerebellum and motor cortex of the central nervous system causing a characteristic hyperexcitability, tremors, muscle weakness, and convulsions in acute cases. (Dreisbach, 1969.)

Several ppm to as little as 0.1 ppm DDT has been shown to render trout fry and salmon fry not viable after hatching (Wurster, 1969). Butler (1969) states that dietary levels of 2 to 5 ug/g of DDT caused 35 to 100 percent mortality within 2 to 10 weeks in populations of shrimp, crabs, and fish. Tests revealed that oysters were sensitive to as little as 0.0001 ug/g of DDT in their environment. Further, at this and lower concentrations, the oyster stores DDT and may concentrate it as much as 70,000 times the environmental level. The shrimp, crabs, and fish fed readily, but changes in behavior were observed. The crustaceans were unnaturally quiet when undisturbed. The shrimp were

Table 3. Acute oral toxicity of DDT in mallards, pheasants, coturnix quail, pigeons, lesser sandhill cranes, and bullfrogs. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards	Female	3 mo.	>2240
Pheasants	Female	3-4 mo.	1296 (745-2257)
Coturnix	Male	2 mo.	841 (607-1170)
Pigeons	Male & Female	--	>4000
Lesser sandhill cranes	Male & Female	Adult	>1200
Bullfrogs	Female	--	>2000

<u>Acute symptoms</u>: Ataxia, wing drop, jerkiness in gait, continuous whole-body tremors, falling, convulsions. Mortalities usually occurred from one to two days after single oral adminstration.

<u>Notes</u>: The acute tests reported above were based on DDT administered orally in gelatin capsules. However, DDT in corn oil was given via stomach tube to another group of cranes and was not lethal at 1200 mg/kg, the highest level tested. The 30-day EMLD for mallards of either sex is 50 mg/kg/day. This gives a cumulative toxicity index for mallards of >2240/50 = >44.8, indicating a high degree of cumulative action. Adult cranes given 1000 mg/kg/day for 10 days survived, but a 12-day exposure at this level was lethal. Adult mallards were fed 100 ppm DDT in the diet. The first to die did so at 43 days and the last at 417 days. Median lethal time was about one year. Thirty ppm was not lethal to mallards or bobwhite quail of either sex in a 90-day feeding study. DDT is more readily absorbed from materials with a high lipid content.

so inactive that silt collected on them. The animals also were more sensitive to mechanical and visual stimuli than animals in control groups.

Accumulations of DDT by predatory birds at the top of the food chains results in death at high levels of accumulation. At lower levels of accumulation there is an effect on calcium metabolism on avian reproduction. Wurster (1969) submits two mechanisms involving calcium metabolism related to avian reproduction:

1. Acute toxicity involves direct attack on the nerve axon with associated axon decalcification and symptoms of calcium deficiency. This mechanism can kill adult birds or chicks shortly after hatching.

2. Chlorinated hydrocarbons cause induction of hepatic enzymes that metabolize steroid hormones; estrogen breakdown is especially important, since estrogen influences calcium metabolism in birds.

Welch, Levin, and Conney (1969) have shown that chronic administration of DDT stimulated the metabolism to polar metabolites of estradiol 17B, testosterone, progesterone, and deoxycortisone by rat liver microsomes. There was also a marked increase in the uterine wet weight of immature female rats.

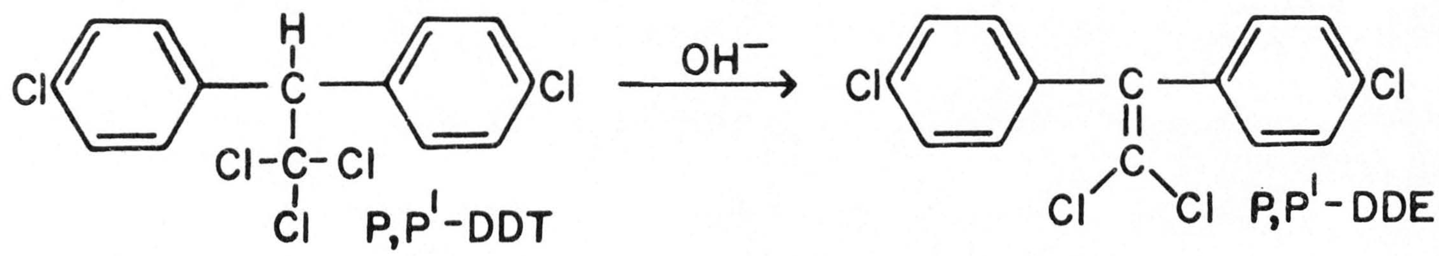
deFreitas, Hart, and Morley (1969) found that under chronic cold exposure under less than extreme conditions, causing a slower, exhaustive depletion of the animals energy at up to 300 ppm DDT in the diet, there is a significantly deleterious effect on survival in rats.

<u>Current status-limitations of usage</u>. The Environmental Protection Agency (1972) has banned general use of DDT, as of December 31, 1972. Public health and quarantine uses are not cancelled by this action. The order also does not affect exports for use in other countries. In addition, three minor crop uses for which it appears there are no

effective pest control alternatives presently available are not cancelled if certain conditions are met. These uses are for green peppers, onions and sweet potatoes in storage. (Pesticide Chemical News, 1972.)

DDE

Structure. In the presence of strong alkali, DDT is dehydrochlorinated to the noninsecticidal 2,2-bis(p-chlorophenyl)-1,1-dichloroethylene or DDE:



DDT in insects and mammals can also be dehydrochlorinated to DDE. (Metcalf, 1971.)

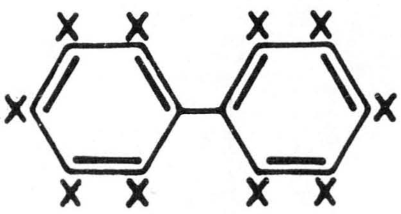
Relationship to eggshell thinning. Although DDE has been considered to be an inactive metabolite of DDT, recently correlations have been found indicating the thinning of eggshells in the brown pelican is related to the concentration of DDE in the eggs. Blus et al. (1971) state that in statistical analysis of prime suspects analyzed in pelican eggs (PCB's, DDT, DDE, DDD, Dieldrin, and mercury) by use of stepwise regression they found that DDE was the only residue that accounted for a significant amount of variability in each of three eggshell parameters.

Longcore, Samson, and Whittendale (1971), in feeding studies of DDE to black ducks, indicate that diets containing DDE at both 10 and 30 ppm caused significant shell thinning ($P < 0.01$) lower for the dosed groups. Survival of ducklings from dosed parents was 40 to 76 percent lower than survival of ducklings from undosed parents.

Blus et al. (1972) state that a concentration effect relationship seems to exist between DDE in eggs and shell thinning. It seems to follow a mathematically similar pattern in different species though it seems to operate at different levels i.e., a level of DDE in eggs that would result in population collapse among brown pelicans would not be expected to effect an overall population change among herring gulls. The significance of regression indicates that the shell thickness decreases in a predictable manner as the DDE concentration increases. The percentage change was greater per unit of DDE when the concentration of DDE was lower i.e., the lower concentrations were more effective. Their calculated percentage of thinning per ppm of DDE is 4.2 at 1 ppm, 3.0 at 5 ppm, 1.9 at 10 ppm and 0.4 at 100 ppm.

Polychlorinated biphenyls (PCB's)

Structure and history of the compound. There is now reason to believe that some of the results obtained in gas chromatography in the mid-sixties and later which were interpreted as chlorinated hydrocarbon pesticides were actually polychlorinated biphenyls or closely related compounds having the general structure:



The X's represent possible chlorine attachments. Jensen (1966) found that in practice there usually are 4 to 8 chlorines per molecule, giving 102 possibilities of different arrangements.

PCB's, which are many different compounds, produce many peaks on the gas chromatograph which coincide with the peaks produced by some organochlorine pesticides, thus complicating analysis. The materials giving rise to these unidentified peaks in the past occurred most frequently in extracts from aquatic raptoral species of birds and also fishes as reported by Roburn (1965), and Harrison (1966).

These unidentified peaks were first identified by Jensen (1966) in which he stated that these peaks corresponded to PCB compounds based on his analysis of a number of pike samples, an eagle, and human hair. He reported that initially gas-liquid chromatography, thin layer chromatographic patterns, and chemical inertness were used to identify the unidentified peaks.

The PCB's are produced and marketed under a number of commercial trade names, e.g., 'Aroclor', 'Clophen', and 'Phenoclor'. Monsanto Company, the only U.S. producer, manufactures 'Aroclor'. Monsanto Company (1965) states:

> The Aroclor compounds are among the most versatile chemically produced materials available. They vary from mobile, oily liquids to white crystals and hard transparent resins. They are nonoxidizing, inert, permanently thermoplastic, of low volatility, noncorrosive to metals, insoluble in water, and resistant to alkalies, acids, and corrosive chemicals. The viscous, more highly chlorinated liquid and resin members do not support combustion and they impart fire retardance to other materials. The crystalline Aroclor compounds are relatively insoluble but the liquid and resinous compounds are soluble in most of the common organic solvents, thinners, and oils.

In the system of designation of Aroclors, the first two digits indicate the type of material while the last two digits give the approximate weight percentage of chlorine in the product. An example: 'Aroclor 1254', indicates a chlorinated biphenyl with approximately 54 percent chlorine.

Uses and sources of environmental contamination. Polychlorinated biphenyls were introduced in 1929 for use in electrical transformers and condensers and these are among the primary uses today. PCB's are also used in marine anti-fouling paints (epoxy); in cardboard cartons; in some detergents; in natural and synthetic rubber; auto body sealants; protective coatings for wood, metal, and concrete; in paints and varnishes; in some adhesives; in waxes; plasticisers in wire and cable coatings and of vinyl chloride polymer films; in asphaltic materials; in hydraulic fluids; in thermostats; in cutting oils; as extreme pressure lubricants; in grinding fluids; in carbonless reproducing paper; and also for mixing with chlorinated insecticides to suppress their vaporization and extend their persistence (Thompson, 1971; Roberts, 1971).

Sources of environmental pollution are many as would be expected by the variety of uses of this group of compounds. Major sources of environmental contamination appear to be factory leakages; discharges through sewage treatment plants; burning of wastes; and possibly uses in conjunction with application of chlorinated pesticides to lower their vapor pressure and thus extend their life.

Risbrough et al. (1968b) found that residues of PCB's were considerably higher in animals of San Francisco Bay and San Diego Bay than those from the Farallon Islands, 27 miles west of the Golden Gate. Holden and Marsden (1967) found that seals taken from the east coast of Scotland, where estuarine pollution is greater, contained higher residues of PCB's than those from the west coast.

Build up in food chain. Jensen et al. (1969) studied two simple food chains, fish to eagles, and fish and mussels to seals. They found that PCB's were concentrated hundreds to thousands of times from prey to predator.

Prest, Jefferies, and Moore (1970) in studies of terrestrial species of birds throughout Britain found that residue levels were closely related to the birds' feeding habits. The highest concentrations were found in predatory birds, next in those having a mixed diet and lowest in those that feed on insects.

Toxicity. Tests of 6 PCB mixtures containing 32 to 62 percent chlorine by Dustman et al. (1971) showed that toxicity increased with the percentage of chlorine. In general, toxicity levels were similar to DDE. They found a difference in sensitivity between species also, bobwhites being the most sensitive followed by pheasants, mallards, and coturnix quail. Special tests with coturnix quail showed the combined toxic effects of DDE and Aroclor 1254 were additive but not synergistic. It was also found that PCB's supplied by different sources varied in toxicity. The PCB's tested were: 'Phenoclor DP-6, manufactured in France'; 'Clophen A-60, manufactured in Germany'; and 'Aroclor 1260, manufactured in the United States'. Phenoclor DP-6 and Clophen A-60 had 100 percent mortality and 91 percent mortality rates on domestic chicken at a dietary dosage of 400 ppm for 60 days. Aroclor had only 12.5 percent deaths at the same feeding level. Vos et al. (1970) later found that these differences were due to chlorinated dibenzofuran and chlorinated naphalene as contaminants in Phenoclor and Clophen.

Dahlgren (1972) fed adult pheasants Aroclor 1254 at 50 mg doses for 16 weeks or at 3.5 day intervals 7 times. The pheasants were alternately starved for 2 or 3 days and fed for 2 days until death. Controls treated similarly lived longer than treated birds. It was concluded that stresses causing loss of weight can be dangerous to birds having a body burden of PCB through mobilization of PCB stored in lipid reserves.

The toxicity of PCB's to insects was found to be related to chlorine content also but in a reversed order of that with birds. Lichtenstein et al. (1969) found that lower amounts of chlorine was more toxic to flies than PCB's with higher chlorine content. Toxicity of dieldrin and DDT was enhanced beyond an additive effect by the addition of lower chlorinated PCB's.

Table 4 from Tucker and Crabtree (1970) indicates the acute oral toxicity found in mallards and albino rats for aroclors.

Table 4. Acute oral toxicity of aroclors in mallards and albino rats. From Tucker and Crabtree (1970).

Species	Sex	Age	LD_{50} (95% conf. lim.) mg/kg
Mallards[a]	Male	10 mo.	2000
Mallards[b]	Male	10 mo.	2000
Mallards[c]	Male	10 mo.	2000
Mallards[d]	Male	10 mo.	2000
Albino rats[b] (S.T.)	Male	--	500-1000
Albino rats[d] (S.T.)	Male	--	2000-4000

Acute symptoms: Mallards showed no symptoms. Rats treated with Aroclor 1254 showed ataxia, blanched retinas, ptosis of eyelid, serous nasal exudate that appeared porphyrin-like, withdrawal, lack of preening. Rats treated with Aroclor 1268 showed reddish exudate on eyelids, ataraxia, ptosis of eyelid, possible blindness, withdrawal. Rat mortalities occurred between 4 hours and 4 days post-treatment. Some survivors showed symptoms for as long as 8 days.

[a] Aroclor 1242
[b] Aroclor 1254
[c] Aroclor 1260
[d] Aroclor 1268

METHODS OF PROCEDURE

Collection of samples

All wildlife samples were collected by representatives of the Utah Division of Wildlife Resources. The total number of samples collected was 366. The sampling according to species was 135 pheasants, 35 chukars, 50 waterfowl, 144 fish, and 2 deer. Table 5 indicates the number of samples taken by location sampled. Figure 1 shows counties sampled for pheasants. All samples were frozen and transported to Utah State University for analyses of total mercury, dieldrin, DDT, DDE, and PCB's.

Mercury

Preparation of samples. Breast muscle tissue was used exclusively for analyses of chukars, pheasants, and waterfowl. Filets were taken from the fish and the center section of this muscle tissue used for analysis.

It was felt at the beginning of the project that preliminary information was needed of levels in wildlife of Utah as soon as possible while setting up for mercury analyses at Utah State University. An initial group of samples were freeze dried in a Vertes shelf type freeze dry apparatus and sent out for comparative analyses to Gulf Atomic, San Diego, by neutron activation; Washington State Nuclear Research Center, Pullman, Washington, by neutron activation; and to the Bureau of Sport Fisheries and Wildlife Laboratory, Denver, by combustion and cold vapor atomic absorption. The mercury methods used by these laboratories were different from one another and from the method used at Utah State University, thereby limiting single method

Table 5. Species sampled for pesticide and mercury analysis in Utah, 1970-71, by number, location, and date collected.

Species	Number of Samples	Location	Date Collected
Chukar	3	Hogup Mtns., Box Elder Co.	11/70
	5	Confusion range, Millard Co.	11/70
	3	West side Promontory, Box Elder	11/70
	6	Morgan, Morgan Co.	11/70
	6	Southeast Myton, Duchesne Co.	11/70
	8	Echo Canyon, Morgan Co.	12/70
	2	Lakeside Mtns., Tooele Co.	10/70
Pheasant	13	Box Elder County	9/70-6/71
	18	Cache County	7/70-11/71
	10	Davis County	11/70
	14	Emery County	9/70-7/71
	16	Millard County	9/70-7/71
	13	Sevier County	10/70-7/71
	10	Uintah County	9/70-6/71
	14	Utah County	10/70-6/71
	7	Washington County	10/70-11/70
	18	Weber County	9/70-6/71
Waterfowl	10	Clear Lake WMA, Millard Co.	12/70
	13	Farmington Bay WMA, Davis Co.	11/70
	4	Brown's Park WMA, Daggett Co.	11/70
	2	Bear River, Cache Co.	11/70
	6	Ogden Bay WMA, Weber Co.	11/70
	8	Clearfield, Davis Co.	12/70
	2	Pocatello Valley, Box Elder Co.	11/70
	2	Promontory Point, Box Elder Co.	12/70
	1	Portage Creek, Box Elder Co.	12/70
	1	S. Blackhawk Club	10/70
	1	W. Layton Sloughs, Davis Co.	10/70
Fish	46	Willard Bay Res., Box Elder Co.	9/70-8/71
	13	Ogden Bay WMA, Weber Co.	3/71
	9	Farmington Bay WMA, Davis Co.	3/71
	20	Utah Lake, Utah Co.	4/71
	21	Deer Creek Reservoir, Utah Co.	4/70-5/71
	12	Wasatch Mtn. State Park, Wasatch Co.	12/70-5/71
	6	below State Park, Wasatch Co.	12/70-5/71
	10	Midway Hatchery, Wasatch Co.	12/70-5/71
	6	Bear Lake, Rich Co.	3/71
Deer	1	Springlen, Carbon Co.	10/70
	1	Huntington, Carbon Co.	10/70

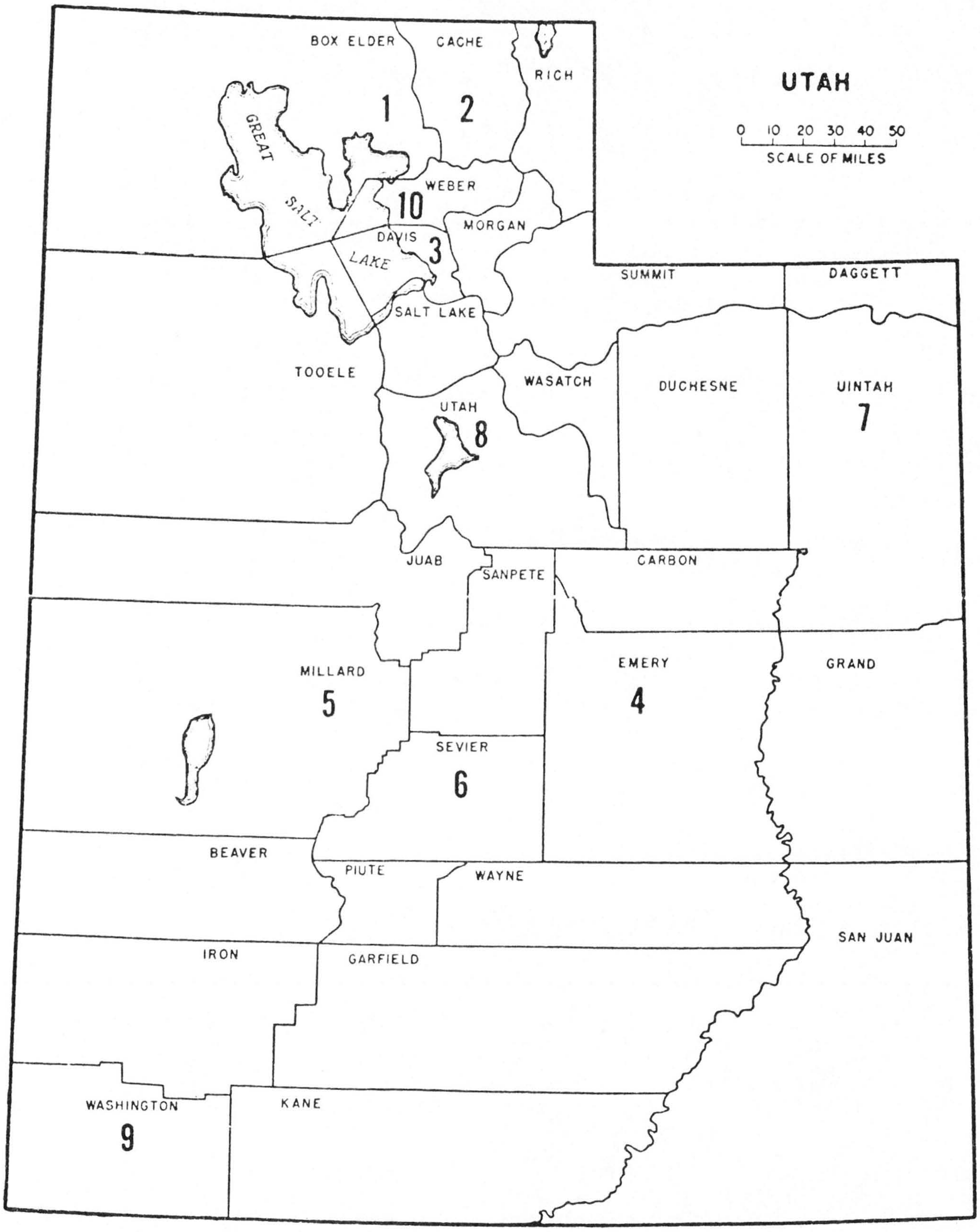


Figure 1. Counties in Utah (numbered) from which pheasants were collected for pesticides and mercury analyses, 1970-71.

bias. Table 6 indicates analyses for mercury of the same tissue by the four separate laboratories.

All samples analyzed at Utah State University were weighed frozen and wet digested by the method of the Fisheries Research Board of Canada as outlined by Uthe, Armstrong, and Stainton (1970) and revised by personal communication with F. A. J. Armstrong (1971)[1].

The digestion consisted of weighing duplicate samples of 1/2 gram or less of wet tissue in a boiling flask, adding 4 ml of concentrated H_2SO_4 and 1 ml of HNO_3 and placing in a shaking water bath at 50 C until a clear solution was obtained. The sample was then transferred into a 300 ml BOD bottle. The boiling flask was rinsed three times with 20 ml portions of distilled water into the BOD bottle. Fifteen ml of 6 percent w/v $KMnO_4$ was then added to oxidize all mercury to the mercuric ion state. The bottle was then stoppered and allowed to stand at least 24 hours before analysis.

Analyses of samples. Mercury analyses were performed on a Coleman Mercury Analyzer, model MAS-50. The Coleman Mercury Analyzer is a self-contained recirculating system measuring Transmittance at 253.7 nm of mercury vapor, and is based on the original method of Hatch and Ott (1968).

To the $KMnO_4$ oxidized sample is added 10 ml of 1.5 percent w/v Hydroxylamine hydrochloride to remove the excess permanganate. Ten ml of 10 percent w/v stannous chloride is then added to reduce the mercury to its metallic state, and air is bubbled into the sample circulating the mercury vapor through the MAS-50 mercury analyzer.

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[1]F.A. Armstrong, as per communication with author on February 25, 1971, at Environmental Health Sciences Center Mercury Symposium, Portland, Oregon.

Table 6. Analyses for mercury of the same tissues by four separate laboratories. Results in ppm total mercury, wet tissue.

Log Number	Lab A[a]	Lab B	Lab C	Lab D (U.S.U.)[a]
21. Pheasant	0.012	0.098	0.095	0.068
22. Pheasant	0.020	0.068	0.061	0.047
23. Pheasant	0.011	0.107	0.044	0.036
24. Pheasant	0.025	0.354	0.038	0.166
25. Pheasant	0.008	0.220	0.060	0.043
101. Chukar	0.020	0.130	0.063	0.051
102. Chukar	0.009	0.100	0.022	0.046
103. Chukar	0.008	0.120	0.029	0.020

Method utilized:

Lab A: Adapted flameless atomic absorption (Bureau of Sport Fisheries and Wildlife, Denver, Colorado).

Lab B: Neutron activation (Washington State Nuclear Research Center, Pullman, Wash.).

Lab C: Neutron activation (Gulf Atomic, San Diego, California).

Lab D: Flameless atomic absorption (Fred A. Smith, Utah State University).

[a]Mean values of duplicate analysis reported.

Standards were made up new daily from 1000 ppm stock solution as there was more than a 30 percent loss of mercury adsorbing to the walls of the container in just one day at the 0.3 ppm level.

Glassware was cleaned in hot soapy water, rinsed with concentrated nitric acid, rinsed three times with tap water and twice with distilled water. Pipettes were in addition soaked in chromic acid cleaning solution before the nitric acid and other rinses.

Dieldrin, p,p'-DDT, p,p'-DDE, and PCB's

Preparation of samples. Breast muscle tissue was used exclusively for analyses of chukars, pheasants, and waterfowl. Filets were taken from the fish and the center section of this muscle tissue used for analysis. Samples of adipose tissue from the abdominal cavity were taken for lipid analyses of 6 chukars and 18 pheasants.

Samples were weighed, 10 grams of muscle tissue or 0.5 grams of adipose tissue, and the sample ground in 25 grams of sodium sulfate in a mortar. The sample was then transferred to 100 ml centrifuge bottles. The mortar was rinsed with 50 ml of Skelley Solve B (Skelley Petroleum Company), and this was transferred to the centrifuge bottles. Samples were then centrifuged 10 minutes at 1000 rpm. Samples were extracted 5 times with 50 ml of Skelley Solve B, evaporated to approximately 10 ml, transferred to a 50 ml volumetric flask, and brought to volume with Skelley Solve B. Then 0.5 ml of the sample was taken for estimation of lipids by the dichromate oxidation procedure of Bragdon (1951).

The remainder of the 50 ml sample was then eluted through a 3 percent florisil column with 500 ml of 20 percent methylene chloride in Skelley Solve B. This volume was then evaporated down and transferred to a 10, 25, or 50 ml volumetric flask. From two to six ul was then injected into the gas-liquid chromatograph.

Analyses of samples. Analyses for dieldrin, p,p'-DDT, p,p'-DDE, and PCB's were performed at the Animal Science Department laboratory by gas-liquid chromatography. Instrumentation specifics are:

Instrument: MT-220 manufactured by Tracor
Detector type: Nickle-63 electron capture
Column length: 6' Column diameter: 1/4" O.D.
Column Packing: (a) 3% QF-1
(b) 1.5% OV-17, 1.95% QF-1
(c) 10% DC-200
Temperatures: Injection Port: 230 C
Detector: 340 C
Column: Isothermal
(a) 3% QF-1 at 180 C
(b) 1.5% OV-17, 1.95% QF-1 at 200 C
(c) 10% DC-200 at 200 C
Carrier gas: Prepurified nitrogen, the Matheson Co.
Flow rate of carrier gas:
(a) 3% QF-1 at 80 ml/minute
(b) 1.5% OV-17, 1.95% QF-1 at 80 ml/min.
(c) 10% DC-200 at 120 ml/minute

Initially PCB's were not included as one of the compounds to be analyzed in this study. As analyses for dieldrin, p,p'-DDT and p,p'-DDE progressed, however, it became increasingly evident peaks were being formed coinciding with peaks of the organochlorine pesticides being tested for.

Retention times of the various major peaks corresponded well with those of aroclor standards, and most closely with aroclor 1254. That these peaks were PCB's was confirmed by comparing retention times of unknowns and standards on the three columns listed above. Retention times corresponded well with those of aroclor standards on all three columns.

There was no attempt made to separate the PCB's into individual isomers but instead the entire group of isomeric peaks at the retention time range of the aroclor standards were used to quantitate by calculating ratios of areas under the groups of peaks of unknowns over those of standards.

Figure 2 depicts peaks formed from extracts from muscle tissue of a shoveler duck (#233) compared with peaks from an aroclor 1254 standard.

Statistical analyses

Statistical analyses was performed by personnel of the Utah State University Computer Center. A stepwise multiple regression was performed on results of chukars, pheasants, and waterfowl. An analysis of variance was made on fish.

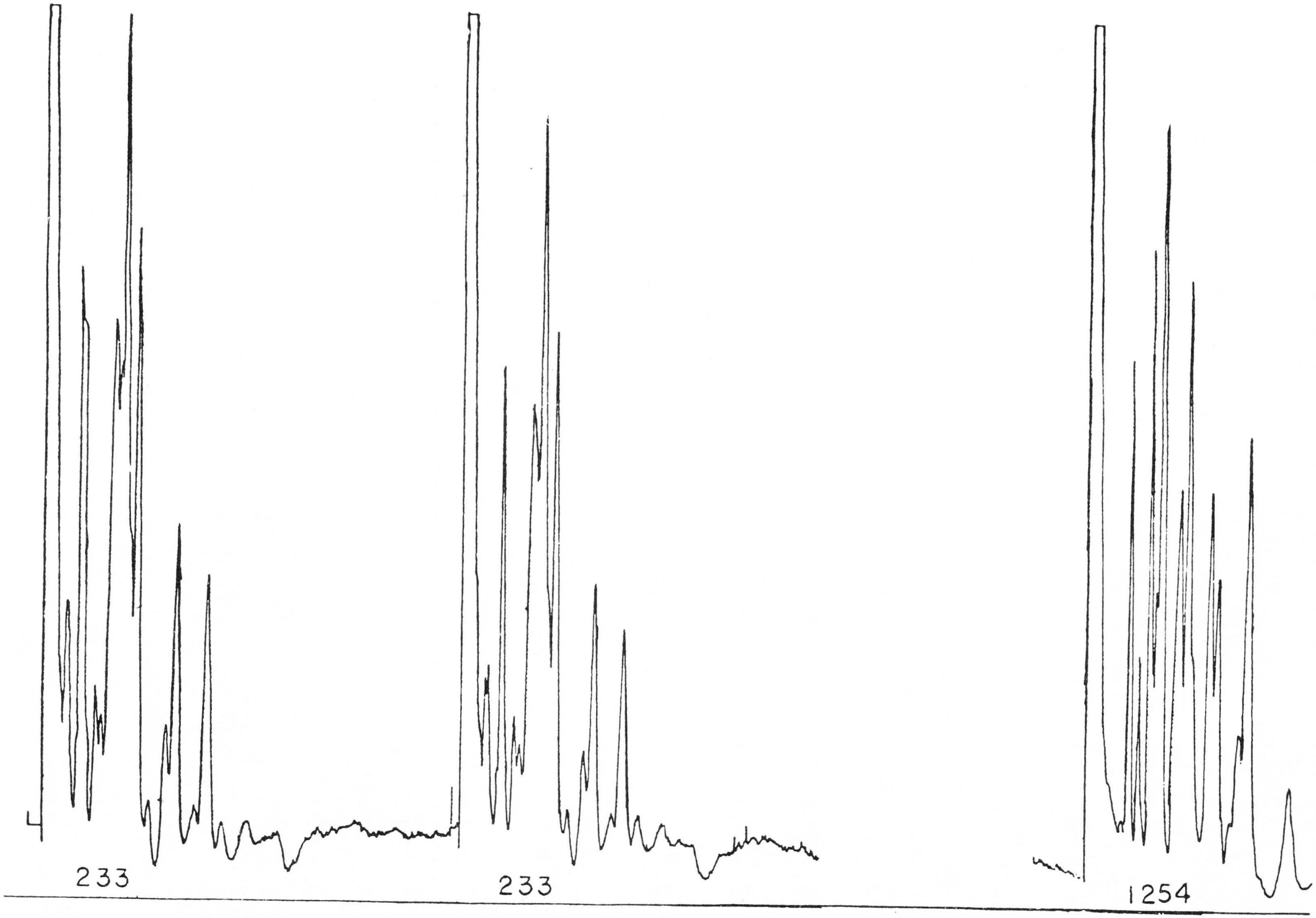

Figure 2. Gas chromatograph peaks formed by a hexane extract from muscle tissue of a shoveler duck (#233) compared with a peak from an aroclor 1254 standard.

RESULTS AND DISCUSSION

Compound

Mercury levels in species sampled

Chukars. Thirty-four chukar breast muscle tissues analyzed for mercury showed a mean value of 0.05 ppm and ranged from 0.01 to 0.11 ppm. None were near to or above the 0.5 ppm guideline level established by the Food and Drug Adminstration for human consumption. The tolerance level for heavy metals is zero, so a practical level based upon all known parameters was established and is referred to as a guideline level.

The 0.05 ppm mean and 0.01 to 0.11 ppm range of the 34 chukars analyzed is quite low. This would be expected from the habitat of the chukar. The chukar would not be exposed in any great numbers to mercurial treated seed dressing on agricultural lands except possibly on peripheral agricultural dry farm grain areas along the foothills. This appears to be supported by the statistical analysis which showed that location of sampling was the greatest contributor to the variabilty of results.

In a statistical analysis by stepwise multiple regression it was found that the three discreet variables considered (sex, age, location of sampling) contributed 40.7 percent of the variability. Location of sampling was the most important contributor, age next, and sex last. Location of the highest two chukars at 0.11 ppm was from the west side of promotory range in Box Elder County. These were a juvenile male and an adult female. One adult male from the Confusion range in Millard County and one juvenile female from southeast of Myton in Duchesne

County were at the 0.10 ppm level. Sixteen adult birds averaged 0.050 ppm and 18 juvenile birds averaged 0.049 ppm. Eleven male birds averaged 0.057 ppm and 23 female birds averaged 0.047 ppm mercury.

Table 7 indicates means and ranges of mercury levels in chukar breast muscle tissue by location sampled. It also presents R square changes of the stepwise multiple regression statistical analysis. Complete tables of all analyses performed are given in Tables 29 to 35, Appendix. Analyses of adipose tissues from six chukars are given in Table 30, Appendix. Mercury level values for chukars number 105 through 117 have been previously reported (Smith, 1971a, 1971b).

Pheasants. Pheasant breast muscle tissues for 135 birds showed a mean value of 0.157 ppm mercury and ranged from 0.01 to 2.08 ppm. Eight pheasants (5.9 percent) of the total sampled were at or above the 0.5 ppm guideline level established by the Food and Drug Adminstration. Of the eight pheasants reported at or above the 0.5 ppm guideline level (0.79, 0.53, 0.72, 1.06, 0.76, 1.09, 0.49, 2.08 ppm), only one of these high samples (0.72 ppm) was collected during the hunting season in November. This was from a total of 35 birds collected in November. Six high specimens were collected in the months of June and July and one (0.53 ppm) specimen was collected in September.

Alberta's study (Government of Alberta, 1970) of pheasants and Hungarian partridge found that mercury levels varied between 0.238 to 0.794 ppm when collected in early summer. Birds collected in the fall were considerably lower, the four highest being from 0.10 to 0.365 ppm. Buhler, Claeys, and Raynor (1971) found also in their study of mercury levels in pheasants of Oregon, that the periods of maximum concentration were in good agreement with the planting dates for mercury treated

Table 7. Mercury levels for chukars in Utah, 1970-71. All results reported as ppm total mercury in wet muscle tissue.

Location	Number of Samples	Mean	Range Minimum	Range Maximum
Confusion range (Millard Co.)	5	0.060	0.020	0.100
West side Promontory (Box Elder Co.)	3	0.060	0.040	0.110
3 mi. east of Morgan (Morgan Co.)	6	0.040	0.040	0.070
Southeast of Myton (Duchesne Co.)	5	0.030	0.010	0.100
Echo Canyon (Morgan Co.)	8	0.040	0.020	0.060
Lakeside Mountains (Tooele Co.)	2	0.040	0.030	0.050

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Location sampled

<u>R square changes</u>

40.7 percent contribution of 3 Y variables
delete sex (1)
40.4 percent contribution of 2 Y variables
delete age (2)
34.7 percent contribution of location

seed crops. Brock (1971) found this same parallel in his study of mercury levels in Idaho pheasants.

On a statistical analysis by stepwise multiple regression it was found that the five discreet variables considered (sex, age, habitat, location sampled, date collected) contributed to 33.3 percent of the variabilty. Age was the most important contributor to the variability followed by location sampled, habitat, date, and sex. Fifty-five adult pheasants analyzed averaged 0.170 ppm and 79 juvenile pheasants averaged 0.099 ppm mercury. Seventy-three male pheasants analyzed averaged 0.187 ppm and 60 females averaged 0.099 ppm mercury. Box Elder County had one bird of 13 birds sampled (0.53 ppm) over the 0.5 ppm guideline level; Cache County had two (0.79, 0.72 ppm); Millard County had three (1.09, 2.08, 0.49 ppm); and Uintah County had two (1.06, 0.76 ppm) pheasants above the 0.5 ppm mercury guideline level. All birds sampled in the remaining six counties, a total of 75 birds, were below the 0.5 ppm guideline level.

Means and ranges in pheasant breast muscle tissue reported by county sampled are shown in Table 8. It also presents R square changes of the stepwise multiple regression statistical analysis. Figure 3 indicates the change of mercury concentration in pheasants on a chronological basis. Mercury values for pheasants number 1 through 20 have been previously reported (Smith, 1971a, 1971b).

<u>Waterfowl</u>. Waterfowl breast muscle tissue analyzed from 48 waterfowl for mercury showed a mean value of 0.165 ppm and ranged from 0.037 to 0.743 ppm. One bufflehead (0.695 ppm) collected from the Bear River at Richmond, Cache County, and one pintail (0.743 ppm) collected at Clear Lake Waterfowl Management Area, Millard County, were above the

Table 8. Mercury levels for pheasants by counties sampled, Utah, 1970-71. All results reported in ppm total mercury in wet muscle tissue.

County	Number of Samples	Mean	Range	
			Minimum	Maximum
Box Elder	13	0.112	0.010	0.530
Cache	17	0.178	0.010	0.790
Davis	10	0.103	0.070	0.170
Emery	14	0.062	0.010	0.210
Millard	16	0.330	0.040	2.080
Sevier	12	0.108	0.040	0.210
Uintah	10	0.281	0.010	1.060
Utah	14	0.076	0.010	0.140
Washington	7	0.083	0.040	0.220
Weber	18	0.118	0.020	0.320

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Habitat 4. Area sampled 5. Date

R square changes:

33.3 percent contribution of all 5 Y variables
delete sex (1)
32.9 percent contribution of 4 Y variables
delete date (5)
28.7 percent contribution of 3 Y variables
delete habitat (3)
24.7 percent contribution of 2 Y variables
delete area sampled (4)
8.1 percent contribution of age

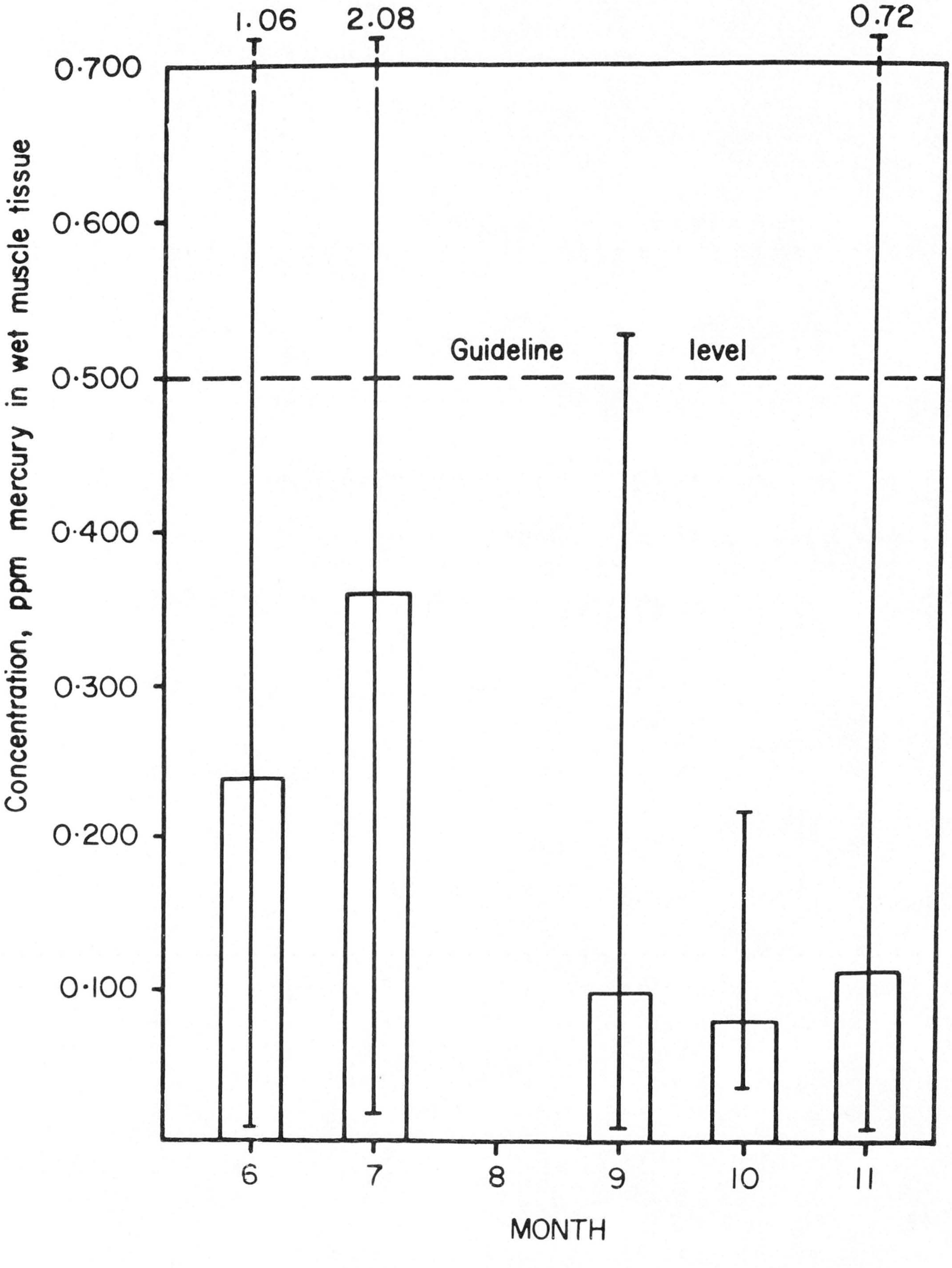

Figure 3. Mercury levels in pheasants collected in Utah, June through November, 1970-71.

0.5 ppm guideline level. This is 4.1 percent of the total sampling. Another bufflehead (0.487 ppm) collected from the Bear River at Richmond and another pintail (0.473 ppm) collected at Clear Lake Waterfowl Management Area were near the 0.5 ppm guideline level. None of the baldpate, gadwall, teal, mallard, coot, or shovelers collected from Farmington Bay, Ogden Bay, Clearfield, Promontory Point, or Browns Park Waterfowl Management Areas, a total of 44 birds, were near or above the 0.5 ppm guideline level.

The mean for divers (0.591 ppm) was somewhat higher than that of dabblers (0.154 ppm). This could be due to the smaller sampling of divers (2) than dabblers (43). Baskett (1970) and Johnson and Morris (1971) in their results of mercury levels of waterfowl showed somewhat higher values for divers also. Henderson and Shanks (1971) believe there is a closer correlation of mercury levels in animals with the sediment than with the concentration in water. Divers, feeding on or among the sediments, would then have more exposure to mercury than surface feeders.

In a statistical analysis by stepwise multiple regression it was found that the three discreet variables considered (sex, age, feeding habit) contributed to only 12.2 percent of the variability. Nineteen adult waterfowl analyzed averaged 0.132 ppm and 23 juveniles averaged 0.206 ppm mercury. Twenty-three males averaged 0.142 ppm and 18 females averaged 0.217 ppm mercury.

Means and ranges in waterfowl breast muscle tissue reported by species and feeding habit are shown in Table 9. Also presented are R square changes of the stepwise multiple regression statistical analysis.

Table 9. Mercury levels for waterfowl by species and feeding habit, Utah, 1971. All results reported as ppm total mercury in wet muscle tissue.

Species	Number of Samples	Mean	Range	
			Minimum	Maximum
Bufflehead	2	0.591	0.487	0.695
Pintail	6	0.346	0.099	0.743
Gadwall	5	0.055	0.037	0.067
Mallard	4	0.135	0.087	0.208
Coot	5	0.078	0.051	0.161
Green-winged teal	11	0.101	0.037	0.187
Shovelers	10	0.181	0.069	0.332
Geese	2	0.073	0.061	0.085
Feeding Habit				
Surface feeding birds	43	0.154	0.037	0.743
Divers	2	0.591	0.487	0.695

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Feeding habit

R square changes

12.2 percent contribution of all 3 Y variables
delete sex (1)
9.4 percent contribution of 2 Y variables
delete feeding habit (3)
5.4 percent contribution of age

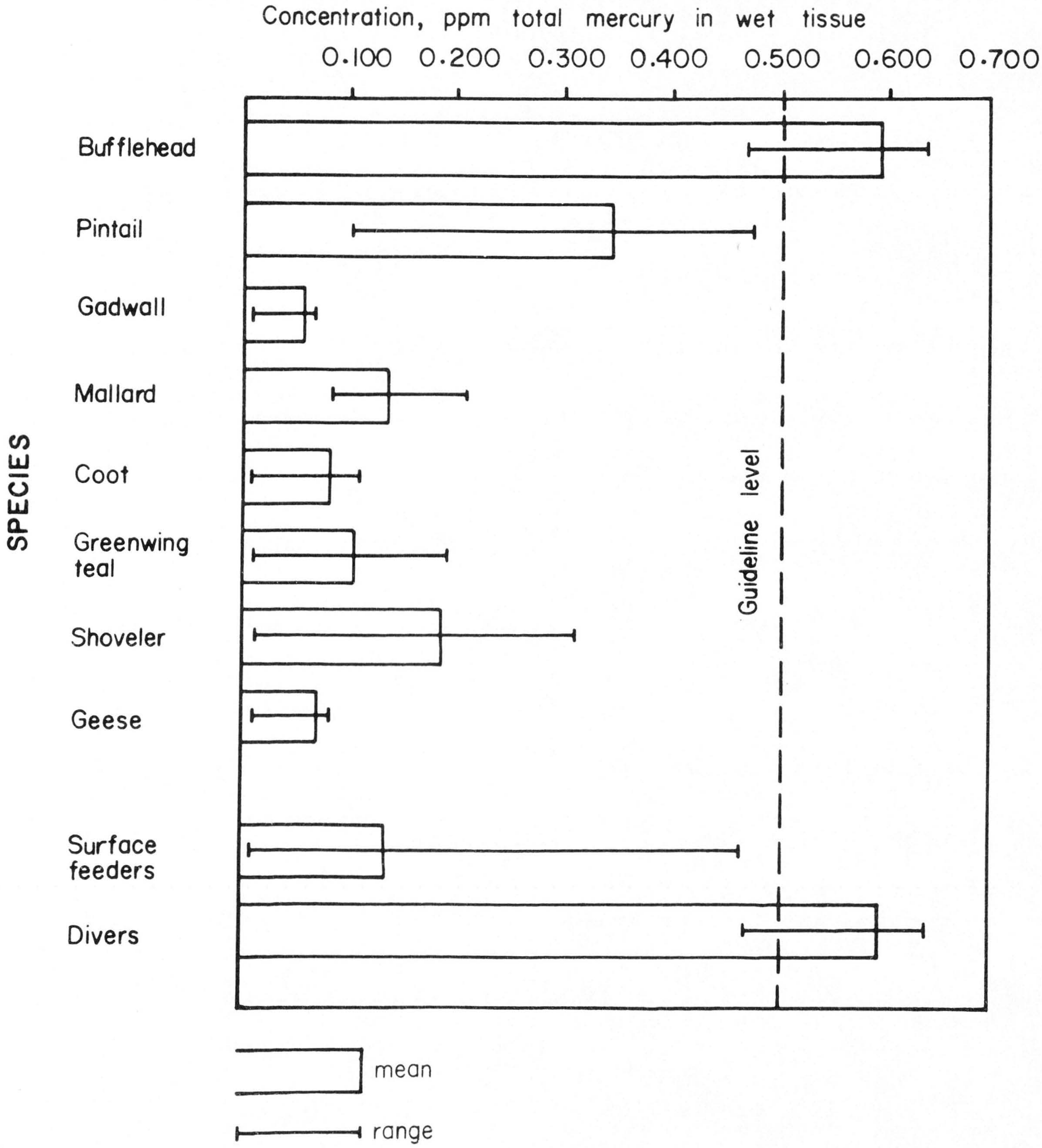

Figure 4. Mercury levels of waterfowl collected in Utah, 1970.

Fish. This mercury survey on fish was restricted to areas where the potential of finding higher mercury and pesticide levels may have been greatest. These areas include those on the Wasatch Front, Deer Creek Reservoir, Utah Lake, and Bear Lake.

Carp and bullhead from Utah Lake; trout and yellow perch from Deer Creek Reservoir; and Bonneville whitefish and cisco from Bear Lake were all well below the 0.5 ppm guideline level established by the Food and Drug Administration for commercially marketed fish.

Carp, black bass, and walleyed pike from Willard Bay Reservoir, Box Elder County, had unusually high mercury levels with 77 percent of all fish sampled being above the 0.5 ppm guideline level. In samples of walleyed pike and black bass, the range was 0.160 to 7.300 ppm mercury in muscle tissue. The Weber and Ogden Rivers, tributaries to Willard Bay, were sampled above and below Ogden to determine if there was an industrial contribution of mercury to the rivers. No measurable quantities of mercury were found in the waters. Sediment samples of the rivers were analyzed for mercury and one sample taken at the mouth of Weber Canyon was found to contain 0.01 ppm mercury. No mercury was found in the other seven samples taken. Water from Willard Bay Reservoir was found to contain 0.0001 ppm or 0.1 ppb (parts per billion). Saline water in the channels and mud flats on the south and west sides of the dikes of Willard Bay Reservoir were found to range from 0.002 to 0.015 ppm mercury. Salt crusts on the mud flats in August ranged from 0.002 to 0.03 ppm mercury.

Willard Bay Reservoir is a relatively new man-made reservoir built on the saline mud flats east of the shores of the Great Salt Lake. It is fed from the Weber and Ogden Rivers, west of Ogden, Utah, by a canal running to the reservoir. A major contribution of mercury to Willard Bay Reservoir may be made from insoluble mercury salts or sulfides in the muds deposited from the time of Lake Bonneville. Another source of contamination may possibly be the Weber River. The Land Pollution Reporter (1971) states that a recent report by the U.S. Geological Survey indicates the greatest concentration of mercury found in a soil sample was from Summit County, Utah, containing 4,600 ppb (parts per billion) or 4.6 ppm mercury. Summit County is the area of the headwaters of the Weber River. Evidence that there is a contribution of mercury to the Willard Bay Reservoir by the Weber River is indicated by comparing levels in carp from Ogden Bay Waterfowl Management Area with Farmington Bay Waterfowl Management Area. Ranges for Farmington Bay Waterfowl Management Area carp with an average age of 4.4 years have levels of 0.040 to 0.230 ppm mercury. Ranges for Ogden Bay Waterfowl Management Area carp, at an average age of 4.9 years, is 0.060 to 0.670 ppm mercury. Mean levels of carp from Ogden Bay is 0.355 ppm compared to a mean of 0.130 ppm for carp from Farmington Bay. Farmington Bay Waterfowl Management Area is fed by the Jordan River while Ogden Bay Waterfowl Management Area is fed by the Weber River.

Willard Bay Reservoir is rather shallow (average 20 feet) with little stratification taking place. It has a pH in the range of 8.1 to 8.3 at 25 C. It has been found that optimum conditions occur for methylation of mercury in aerobic alkaline conditions. Dimethyl mercury is volatilized to a greater extent under these conditions. Some investigators indicate a greater loss to the atmosphere and less accumulation by the acquatic life of dimethyl mercury under these conditions (Nelson, 1971).

Ranges and means of Willard Bay Reservoir fish are presented separately in Table 10. Statistical analysis of variance showed a species effect, i.e., the species of fish sampled had a direct relationship to the mercury content in muscle tissue. Predators such as black bass and walleyed pike were found to have the greatest accumulation of mercury.

Dieldrin levels in species sampled

Chukars. Breast muscle tissue from 29 chukars analyzed for dieldrin showed a mean value of 0.017 ppm and ranged from none to 0.092 ppm. Dieldrin was found in 24 of the 29 samples inspected. None of the muscle tissue of these birds was found to have levels near the 0.30 ppm maximum permissible concentration in edible portions of fish established by the Food and Drug Adminstration. Of the six adipose tissue samples analyzed, the mean was 0.198 ppm with a range of 0.056 to 0.830 ppm. Table 11 shows means and ranges of dieldrin levels in chukar muscle tissue by location sampled. It also shows R square changes of the stepwise multiple regression statistical analysis. In the statistical analysis, it was found the three discreet variables considered (sex, age, location sampled) contributed to 22.3 percent of the variability. Location was the most important, contributing 17 percent to the 22.3 percent total variability. The three highest chukars were a juvenile female from the Confusion range in Millard County (0.062 ppm) and two adult females (0.057, 0.092 ppm) from Morgan, Morgan County. Fourteen adult birds averaged 0.016 ppm and 15 juvenile birds averaged 0.006 ppm. Eleven male birds averaged 0.007 ppm and 18 female birds averaged 0.014 ppm dieldrin in breast muscle tissue.

Table 10. Mercury levels in fish by area and by species, Utah, 1970-71. All results reported as ppm total mercury in wet muscle tissue.

Area	Number of Samples	Mean	Range Minimum	Range Maximum
Willard Bay (Box Elder Co.)	46	1.360	0.120	7.300
Utah Lake (Utah Co.)	20	0.152	0.030	0.470
Deer Creek Reservoir (Wasatch Co.)	21	0.150	0.020	0.430
Bear Lake (Rich Co.)	6	0.162	0.100	0.330
Ogden Bay W.M.A.[a] (Weber Co.)	13	0.355	0.060	0.670
Farmington Bay W.M.A.[a] (Davis Co.)	9	0.130	0.040	0.230
Species (all areas except Willard Bay Reservoir)				
Carp	30	0.221	0.040	0.820
Bullhead	10	0.113	0.030	0.240
Yellow perch	5	0.286	0.130	0.430
Bonneville cisco	2	0.225	0.120	0.330
Bonneville whitefish	4	0.130	0.100	0.160
Brown trout	10	0.146	0.130	0.430
Rainbow trout	25	0.141	0.020	0.390
Whitefish	6	0.065	0.020	0.100
Species (Willard Bay Reservoir)				
Walleyed pike	25	1.424	0.160	3.890
Carp	6	0.802	0.520	1.210
Black bass	10	2.070	0.270	7.300
Sunfish	1	0.120	--	--
Brown trout	1	1.330	--	--

[a]W.M.A. Waterfowl Management Area

Table 11. Dieldrin levels in chukars from Utah, 1971. All results reported as ppm dieldrin in wet muscle tissue.

Location	Number of Samples	Mean	Range	
			Minimum	Maximum
Confusion range (Millard Co.)	5	0.018	0.004	0.062
West side Promontory (Box Elder Co.)	3	0.005	0.004	0.006
3 mi. east of Morgan (Morgan Co.)	6	0.032	0.003	0.092
Southeast of Myton (Duchesne Co.)	5	0.006	none	0.021
Echo Canyon (Morgan Co.)	8	0.002	0.001	0.006
Lakeside Mountains (Tooele Co.)	2	0.003	0.002	0.004

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Location

R square changes:

22.3 percent contribution of 3 Y variables
delete sex (1)
17.1 percent contribution of 2 Y variables
delete age (2)
17.0 percent contribution of location

Pheasants. Dieldrin was found in low concentrations in 111 of 125 breast muscle samples inspected. Mean of samples was 0.007 ppm with a range of none to 0.084 ppm. None of the muscle tissue from these birds were found to have levels near the 0.30 ppm maximum permissible concentration in edible portions of fish established by the Food and Drug Administration. The mean for the 18 adipose tissues analyzed was 0.162 ppm with a range of none to 1.577 ppm. Table 12 shows the means and ranges for counties sampled. It also shows R square changes of the stepwise multiple regression statistical analysis. In the statistical analysis it was found the five discreet variables considered (sex, age, habitat, location collected, date collected) contributed to 21 percent of the variability. Date of collection contributed to 10.4 percent and location 9.1 percent to the 21 percent total variability influenced by the five discreet variables. The adult male pheasant with 0.084 ppm dieldrin in breast muscle tissue was collected near Lawrence, Emery County. Millard County had one juvenile female pheasant with 0.046 ppm and Washington County had a juvenile female with 0.031 ppm dieldrin. Forty-eight adult birds averaged 0.007 ppm and 64 juvenile birds averaged 0.006 ppm. Fifty-nine male birds averaged 0.006 ppm and 53 female birds averaged 0.007 ppm dieldrin in breast muscle tissue.

Waterfowl. Dieldrin was found in 39 of 48 waterfowl samples analyzed (81 percent). The mean was 0.033 ppm with a range of 0.000 to 0.348 ppm. A green-winged teal with 0.348 ppm was collected from Clear Lake Waterfowl Management Area, Millard County, which was over the 0.3 ppm maximum permissible concentration. A juvenile male bufflehead collected from the Bear River in Cache County contained 0.177 ppm and a juvenile female pintail collected from Clear Lake Waterfowl Management

Table 12. Dieldrin levels in pheasants from Utah, 1971. All results reported as ppm dieldrin in wet muscle tissue.

County	Number of Samples	Mean	Range Minimum	Range Maximum
Box Elder	12	0.004	0.000	0.007
Cache	15	0.005	0.001	0.010
Davis	8	0.008	0.002	0.014
Emery	11	0.014	0.002	0.084
Millard	10	0.010	0.003	0.046
Sevier	8	0.005	0.002	0.015
Uintah	5	0.004	0.000	0.009
Utah	14	0.004	0.001	0.008
Washington	6	0.009	0.002	0.031
Weber	14	0.005	0.002	0.024

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Habitat 4. Location sampled 5. Date

R square changes:

21.0 percent contribution of 5 Y variables
delete sex (1)
20.3 percent contribution of 4 Y variables
delete date (5)
9.9 percent contribution of 3 Y variables
delete habitat (3)
9.3 percent contribution of 2 Y variables
delete location (4)
0.2 percent contribution of age

Area contained 0.184 ppm dieldrin in breast muscle tissue. Table 13 presents means and ranges of dieldrin levels in breast muscle tissue of waterfowl by species and feeding habit. It also presents R square changes of the stepwise multiple regression statistical analysis. In the statistical analysis it was found the three discreet variables considered (sex, age, feeding habit) contributed to only 10.4 percent of the variability. Nineteen adult birds averaged 0.016 ppm and 23 juvenile birds averaged 0.049 ppm. Twenty-four male birds averaged 0.039 ppm and 18 female birds averaged 0.027 ppm dieldrin in breast muscle tissue.

Fish. Dieldrin was found in 22 of 39 muscle tissue samples analyzed (56 percent). Levels in muscle tissue ranged from 0.000 to 0.038 ppm. None of the 22 positive samples inspected showed levels near the 0.30 ppm maximum permissible concentration. Table 14 presents dieldrin levels in muscle tissue by location and species sampled.

It is notable that though dieldrin is found in a high percentage of all samples analyzed in this study, there appears to be an exception in the case of the carp, black bass, and walleyed pike in Willard Bay Reservoir. No measurable amount of dieldrin was found in any of the 17 fish muscle tissue samples from Willard Bay Reservoir analyzed for dieldrin.

DDT and DDE levels in species sampled

Chukars. DDT was found in 25 of 29 samples (86 percent) of chukar breast muscle tissue tested. The mean value for the 25 positive birds was 0.016 ppm with a range of 0.002 to 0.064 ppm. The highest bird with 0.064 ppm DDT was an adult female from Morgan, Morgan County.

Table 13. Dieldrin levels in waterfowl from Utah, 1971. All results reported as ppm dieldrin in wet muscle tissue.

Species	Number of Samples	Mean	Range	
			Minimum	Maximum
Bufflehead	2	0.102	0.026	0.177
Pintail	6	0.049	0.010	0.184
Gadwall	5	0.016	0.000	0.061
Mallard	4	0.019	0.015	0.022
Coot	5	0.029	0.006	0.053
Green-winged teal	11	0.062	0.000	0.348
Shovelers	11	0.008	0.000	0.024
Geese	2	0.003	0.000	0.007
Feeding habit				
Surface feeders	44	0.031	0.000	0.348
Divers	2	0.102	0.026	0.177

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Feeding habit

R square changes:

10.4 percent contribution of 3 Y variables
delete sex (1)
8.2 percent contribution of 2 Y variables
delete feeding habit (3)
5.9 percent contribution of age

Table 14. Dieldrin levels in fish from Utah, 1970-71. All results reported as ppm dieldrin in wet muscle tissue.

Area	Number of Samples	Mean	Range Minimum	Range Maximum
Willard Bay Reservoir (Box Elder Co.)	17	0.000	0.000	0.000
Utah Lake (Utah Co.)	19	0.010	0.000	0.030
Deer Creek Reservoir (Wasatch Co.)	2	0.031	0.015	0.017
Species				
Carp (Utah Lake)	10	0.012	0.000	0.023
Carp (Willard Bay)	6	0.000	0.000	0.000
Black bass (Willard Bay)	6	0.000	0.000	0.000
Walleyed pike (Willard Bay)	5	0.000	0.000	0.000
Bullhead (Utah Lake)	9	0.007	0.004	0.010
Rainbow trout (Deer Creek Res.)	2	0.031	0.015	0.017

None of the muscle tissue samples inspected was near the maximum permissible concentration of 5.0 ppm as established by the Food and Drug Adminstration for edible portions of fish. Only 2 of 29 birds contained over 0.04 ppm DDT. The figure 0.04 ppm is arbitrarily selected as being greater than the majority of the levels found. Of the six adipose tissue samples analyzed the mean was 0.243 ppm and the range from 0.087 to 0.441 ppm DDT. Recommended tolerance of DDT, DDE, and DDD for meat, fish, and poultry on a fat (lipid) basis is 7.0 ppm. All of the adipose samples analyzed were below this recommended tolerance level. Table 15 indicates means and ranges of DDT levels in chukar breast muscle tissue by location sampled. It also presents R square changes of the stepwise multiple regression statistical analysis. In the statistical analysis it was found the three discreet variables considered (sex, age, location sampled) contributed to only 8.8 percent of the variability. Location was the greatest contributor with 5.8 percent being contributed to the 8.8 percent total variability of results due to these three discreet variables. Fourteen adult birds averaged 0.018 ppm and 15 juvenile birds averaged 0.011 ppm. Eleven male birds averaged 0.013 ppm and 18 female birds averaged 0.015 ppm DDT in breast muscle tissue. It is not known what amounts of pesticides in the habitat of the chukars may have been applied. The literature is abundant in indicating the ability of DDT to be transferred in the environment by volatilizing and being moved by wind and water to other areas.

DDE was found in 25 of 29 samples inspected. For the 25 positive samples the mean value was 0.009 ppm with a range of 0.001 to 0.075 ppm. The highest chukar at 0.075 ppm was an adult female collected from southeast of Myton, Duchesne County. Range of six adipose tissues analyzed was from none to 0.155 ppm DDE. Means and ranges by location

Table 15. p,p'-DDT levels in chukars from Utah, 1970. All results reported as ppm p,p'-DDT in wet muscle tissue.

Location	Number of Samples	Mean	Range Minimum	Range Maximum
Confusion range (Millard Co.)	5	0.024	0.012	0.036
West side Promontory (Box Elder Co.)	3	0.022	0.015	0.035
3 mi. east of Morgan (Morgan Co.)	6	0.028	0.011	0.064
Southeast of Myton (Duchesne Co.)	5	0.006	0.000	0.021
Echo Canyon (Morgan Co.)	8	0.003	0.000	0.006
Lakeside Mountains (Tooele Co.)	2	0.001	0.000	0.003

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Location sampled

R square changes:

8.8 percent contribution of 3 Y variables
delete sex (1)
5.8 percent contribution of 2 Y variables
delete age (2)
5.8 percent contribution of location sampled

Table 16. p,p'-DDE levels in chukars from Utah, 1970. All results reported as ppm p,p'-DDE in wet muscle tissue.

Location	Number of Samples	Mean	Range Minimum	Range Maximum
Confusion range (Millard Co.)	5	0.007	0.004	0.018
West side of Promontory (Box Elder Co.)	3	0.004	0.003	0.007
3 mi. east of Morgan (Morgan Co.)	6	0.010	0.003	0.042
Southeast of Myton (Duchesne Co.)	5	0.017	0.000	0.075
Echo Canyon (Morgan Co.)	8	0.002	0.000	0.012
Lakeside Mountains (Tooele Co.)	2	0.001	0.001	0.002

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Location sampled

R square changes:

10.2 percent contribution of 3 Y variables
delete sex (1)
5.5 percent contribution of 2 Y variables
delete age (2)
5.2 percent contribution of location

Table 17. p,p'-DDT levels in pheasants from Utah, 1970-71. All results reported as ppm of p,p'-DDT in wet muscle tissue.

County	Number of Samples	Mean	Range Minimum	Range Maximum
Box Elder	13	0.024	0.007	0.119
Cache	14	0.016	0.005	0.070
Davis	9	0.023	0.006	0.071
Emery	13	0.014	0.000	0.038
Millard	10	0.026	0.010	0.051
Sevier	8	0.011	0.001	0.036
Uintah	6	0.007	0.000	0.018
Utah	14	0.012	0.001	0.028
Washington	6	0.018	0.007	0.030
Weber	18	0.018	0.000	0.043

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Habitat 4. Location sampled 5. Date

R square changes:

23.5 percent contribution of 5 Y variables
delete sex (1)
23.4 percent contribution of 4 Y variables
delete date (5)
15.2 percent contribution of 3 Y variables
delete habitat (3)
14.2 percent contribution of 2 Y variables
delete location (4)
4.3 percent contribution of age

(85 percent). For the 94 positive samples the mean value was 0.015 ppm with a range of 0.002 to 0.678 ppm. Only 3 of 113 samples analyzed were above 0.03 ppm DDE. The 18 adipose tissue samples inspected showed a range of none to 3.090 ppm DDT and a range of none to 2.297 ppm DDE. One sample, a male adult pheasant from Emery County showed no DDT in its tissue but had 0.678 ppm of DDE. Butler (1969) states that the presence of a high percentage of DDT indicates direct exposure to pollution. Conversely when the metabolites (DDE, DDD) are present alone or at disproportionately high levels, this would indicate the residues have been transmitted through the food web.

Hunt and Keith (1962) have found levels in pheasants of California exposed to DDT and dieldrin in the field averaging 14 ppm in the muscle tissue. Alberta, Canada (1970) states that 459 samples of pheasants, partridge, and other game birds, ducks and waterfowl, antelope and other game animals, plus various fish analyzed 1966 through 1969 indicate there is no general problem with DDT. They indicate the only problems concerning wildlife are in local areas where DDT has been used in the past for mosquito and biting fly control. High levels in lipid (Low and Street, 1964) of pheasants have been found in the Delta area of Millard County. Values ranged from 10 to 110 ppm in lipid. Five samples recently analyzed from this area show low levels of DDT and DDE in the muscle tissue.

Means and ranges by counties sampled for DDE levels in pheasant breast muscle tissue is presented in Table 18. It also gives R square changes from the stepwise multiple regression statistical analysis. In the statistical analysis it was found the five discreet variables considered (sex, age, habitat, location sampled, date sampled) contributed

Table 18. p,p'-DDE levels in pheasants from Utah, 1970-71. All results reported as ppm of p,p'-DDE in wet muscle tissue.

County	Number of Samples	Mean	Range	
			Minimum	Maximum
Box Elder	12	0.006	0.003	0.013
Cache	14	0.011	0.000	0.120
Davis	9	0.011	0.002	0.032
Emery	13	0.058	0.000	0.678
Millard	10	0.008	0.002	0.022
Sevier	8	0.004	0.000	0.008
Uintah	6	0.004	0.000	0.011
Utah	14	0.007	0.000	0.020
Washington	6	0.004	0.002	0.007
Weber	18	0.004	0.000	0.012

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Habitat 4. Location sampled 5. Date

R square changes:

19.1 percent contribution of 5 Y variables
delete sex (1)
19.1 percent contribution of 4 Y variables
delete date (5)
8.1 percent contribution of 3 Y variables
delete habitat (3)
7.8 percent contribution of 2 Y variables
delete location sampled (4)
1.2 percent contribution of age

to 19.1 percent of the variability. Date sampled contributed 11 percent to the 19.1 percent total variability due to the five discreet variables considered. Forty-seven adult birds averaged 0.021 ppm and 63 juvenile birds averaged 0.007 ppm DDE. Fifty-nine male birds averaged 0.017 ppm and 53 female birds averaged 0.008 ppm DDE in breast muscle tissue.

Waterfowl. The literature is very replete with pesticide levels concerned with the aquatic situation. This includes primarily waterfowl and fish in the wildlife category of interest in this study. Wildlife Service News (1970) indicated duck wings and starlings collected in Utah were relatively high in DDT and metabolites and also dieldrin. Relatively high was defined as having two year mean residue levels in duck wings equal to or greater than 0.8 ppm DDT and metabolites and equal to or greater than 0.1 ppm dieldrin.

DDT was found in 42 of 48 samples (87 percent) of muscle tissue tested. The mean value for the 42 positive birds was 0.023 ppm with a range of 0.003 to 0.240 ppm. The highest bird, a juvenile male gadwall, was collected at Farmington Bay Waterfowl Management Area. Only 3 of 48 samples were above 0.05 ppm DDT. All of the 48 samples analyzed were below the maximum permissible concentration of 5.0 ppm as established by the Food and Drug Administration for edible portions of fish. Table 19 presents means and ranges of DDT levels in breast muscle tissue by species and feeding habit. It also presents R square changes from the stepwise multiple regression statistical analysis. In the statistical analysis it was found the three discreet variables considered (sex, age, feeding habit) contributed to 21.1 percent of the variability. Age contributed 11.8 percent and sex 7.2 percent to

Table 19. p,p'-DDT levels in waterfowl from Utah, 1971. All results reported as ppm of p,p'-DDT in wet muscle tissue.

Species	Number of Samples	Mean	Range Minimum	Range Maximum
Bufflehead	2	0.041	0.016	0.067
Pintail	6	0.012	0.003	0.033
Gadwall	5	0.060	0.000	0.240
Mallard	4	0.007	0.004	0.012
Coot	5	0.010	0.004	0.023
Green-winged teal	11	0.014	0.000	0.065
Shovelers	11	0.022	0.000	0.084
Geese	2	0.004	0.000	0.009
Feeding habits				
Surface feeders	44	0.020	0.000	0.240
Divers	2	0.041	0.016	0.067

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Feeding habit

R square changes:

21.1 percent contribution of 3 Y variables
delete sex (1)
13.9 percent contribution of 2 Y variables
delete feeding habit (3)
11.8 percent contribution of age

the 21.1 percent total variability due to the three discreet variables considered. Nineteen adult waterfowl averaged 0.009 ppm and 23 juvenile waterfowl averaged 0.022 ppm DDT. Twenty-four male birds averaged 0.028 ppm and 18 female birds averaged 0.013 ppm DDT in breast muscle tissue.

DDE was found in 43 of 48 samples (90 percent) inspected. Two samples were abnormally high with levels of 6.70 and 8.82 ppm in breast muscle tissue and are not incorporated into the mean. For the 41 positive samples considered, the mean value was 0.046 ppm with a range of 0.003 to 0.580 ppm DDE. There were 6 of 48 samples above 0.05 ppm with four of these six having levels of DDE greater than 0.4 ppm. The somewhat high incidence of DDE than DDT in the same tissue would indicate that waterfowl are picking up these residues through the food web. Table 20 presents means and ranges of DDE levels in breast muscle tissue by species and feeding habit. It also presents R square changes from the stepwise multiple regression statistical analysis. In the statistical analysis it was found the three discreet variables considered (sex, age, feeding habit) contributed to only 3.9 percent of the variability. Eighteen adult waterfowl averaged 0.048 ppm and 23 juveniles averaged 0.041 ppm DDE in breast muscle tissue. Twenty-three male birds averaged 0.042 ppm and 18 female birds averaged 0.049 ppm DDE in breast muscle tissue.

Johnson and Morriss (1971) monitored pesticide levels in waterfowl of Iowa. They found DDT residues in 37 mallards ranging from none to 0.062 ppm in muscle tissue. DDE levels in the same 37 mallards were higher ranging from 0.06 ppm to 0.097 ppm. Other species sampled on a limited basis showed DDT not present in the muscle but DDE was present in quantities ranging from 0.005 to 0.042 ppm. A table from

Table 20. p,p'-DDE levels in waterfowl from Utah, 1971. All results reported as ppm of p,p'-DDE in wet muscle tissue.

Species	Number of Samples	Mean	Range	
			Minimum	Maximum
Bufflehead	2	0.003	0.000	0.006
Pintail	6	0.008	0.004	0.014
Gadwall	5	0.010	0.000	0.038
Mallard	4	0.007	0.003	0.011
Coot	5	0.019	0.010	0.030
Green-winged teal	11	0.036	0.008	0.170
Shovelers	11	0.690	0.000	6.70
Geese	2	0.295	0.011	0.580
Feeding habits				
Surface feeders	44	0.212	0.000	6.70
Divers	2	0.003	0.000	0.006

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Feeding habit

R square changes:

3.9 percent contribution of 3 Y variables
delete sex (1)
3.7 percent contribution of 2 Y variables
delete feeding habit (3)
1.2 percent contribution of age

Edwards (1970) shows tissue levels of DDT and related compounds in ducks with mean values of 0.20 to 0.73 ppm in muscle tissue.

Using maximum permissible concentrations of DDT in edible portions of fish of 5.0 ppm as a tolerance guideline, only one shoveler at 6.70 ppm total DDT residue, exceeded this limit. The other high value with a concentration of 8.82 ppm DDE was found in the breast muscle tissue of a pelican.

Except for one shoveler with a high level, all ducks and geese had levels much lower than the 5.0 ppm tolerance level. No adipose tissue samples were analyzed, which would have contained higher levels of DDT and DDE. By roughly equilibrating a ratio of 1 ppm muscle concentration to 9 ppm total DDT in adipose of the same tissue based on the analysis of ducks by Johnson and Morriss (1971) there would still have been only three ducks which would have shown levels slightly above 5 ppm total DDT plus DDE levels.

Fish. DDT was found in 33 of 39 samples (85 percent) of muscle tissue tested. The mean value for the 33 positive fish was 0.020 ppm with a range of 0.003 to 0.087 ppm. All of the samples were far below the maximum permissible concentration of 5.0 ppm as established by the Food and Drug Administration for edible portions of fish. Table 21 indicates means and ranges of DDT levels in fish muscle tissue by area sampled and by species.

DDE was found in 37 of 39 samples (95 percent) inspected. For the 37 positive samples the mean value was 0.042 ppm with a range of 0.011 to 0.175 ppm. Means and ranges of DDE levels in muscle tissue by area sampled and by species is presented in Table 22. DDE levels were higher than DDT levels indicating accumulation through the various trophic levels of the food web.

Table 21. p,p'-DDT levels in fish from Utah, 1970-71. All results reported as ppm of p,p'-DDT in wet muscle tissue.

Area	Number of Samples	Mean	Range	
			Minimum	Maximum
Willard Bay (Box Elder Co.)	17	0.024	0.000	0.087
Utah Lake (Utah Co.)	19	0.012	0.000	0.036
Deer Creek Reservoir (Wasatch Co.)	2	0.016	0.015	0.017
Species				
Carp (Utah Lake)	10	0.011	0.000	0.036
Carp (Willard Bay)	6	0.087	0.000	0.025
Black bass (Willard Bay)	6	0.029	0.000	0.087
Walleyed pike (Willard Bay)	5	0.037	0.022	0.051
Bullhead (Utah Lake)	9	0.012	0.003	0.020
Rainbow trout (Deer Creek Reservoir)	2	0.016	0.015	0.017

Table 22. p,p'-DDE levels in fish from Utah, 1970-71. All results reported as ppm of p,p'-DDE in wet muscle tissue.

Area	Number of Samples	Mean	Range	
			Minimum	Maximum
Willard Bay (Box Elder Co.)	17	0.073	0.020	0.175
Utah Lake (Utah Co.)	19	0.015	0.000	0.056
Deer Creek Reservoir (Wasatch Co.)	2	0.012	0.011	0.013
Species				
Carp (Utah Lake)	7	0.020	0.000	0.056
Bullhead (Utah Lake)	9	0.007	0.000	0.013
Rainbow trout (Deer Creek Reservoir)	2	0.012	0.011	0.013
Carp (Willard Bay)	6	0.070	0.045	0.104
Black bass (Willard Bay)	6	0.042	0.020	0.058
Walleyed pike (Willard Bay)	5	0.112	0.067	0.175

PCB's levels in species sampled

Chukars. PCB's were found in measurable quantities in all 29 breast muscle tissue samples of chukars analyzed. A juvenile female collected from southeast of Myton, Duchesne County, contained 7.7 ppm and was not incorporated into the mean. For the other 28 positive samples the mean was 0.059 ppm with a range of <0.05 to 0.30 ppm. Of the six adipose tissues analyzed the mean was 2.1 ppm with a range of 1.9 to 2.5 ppm. Means and ranges by location sampled is presented in Table 23. It also gives R square changes from the stepwise multiple regression statistical analysis. Values given as <0.05 ppm are arbitrarily considered as 0.03 ppm; and those given as <0.10 ppm as 0.05 ppm when incorporated into the mean value. In the statistical analysis it was found the three discreet variables considered (sex, age, location sampled) contributed to 41.6 percent of the variability. Location contributed 25.2 percent and age 16.3 percent to the 41.6 percent total variability due to the three discreet variables considered. Fourteen adult chukars averaged 0.070 ppm and 14 juveniles averaged 0.047 ppm PCB in breast muscle tissue. Eleven male birds averaged 0.059 ppm and 18 females averaged averaged 0.055 ppm.

Pheasants. PCB's were found in 47 of 52 samples inspected (90 percent). For the 47 positive samples the mean value was 0.075 ppm with a range of 0.02 to 0.40 ppm. Of the 18 adipose tissue samples analyzed, the mean value was 2.1 ppm with a range of 0.000 to 4.2 ppm. Table 24 indicates means and ranges by county sampled. It also shows R square changes of the stepwise multiple regression statistical analysis. In the statistical analysis it was found the five discreet variables considered (sex, age, habitat, location collected, date collected)

Table 23. PCB levels in chukars from Utah, 1970. All results reported as ppm of PCB in wet muscle tissue.

Location	Number of Samples	Mean	Range	
			Minimum	Maximum
Confusion range (Millard Co.)	5	0.030	all	<0.05
West side of Promontory (Box Elder Co.)	3	0.030	all	<0.05
3 miles east of Morgan (Morgan Co.)	6	0.030	all	<0.05
Southeast of Myton (Duchesne Co.)	5	1.706	0.03	7.70
Echo Canyon (Morgan Co.)	8	0.039	<0.04	<0.10
Lakeside Mountains (Tooele Co.)	2	0.040	0.04	0.04

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Location sampled

R square changes:

41.6 percent contribution of 3 Y variables
delete sex (1)
41.5 percent contribution of 2 Y variables
delete age (2)
25.2 percent contribution of location

Table 24. PCB levels in pheasants from Utah, 1970-71, by counties sampled. All results reported as ppm of PCB in wet muscle tissue.

County	Number of Samples	Mean	Range	
			Minimum	Maximum
Box Elder	8	0.069	0.050	0.100
Cache	12	0.047	0.000	0.120
Davis	0	NA	NA	NA
Emery	4	0.050	0.050	0.050
Millard	0	NA	NA	NA
Sevier	2	0.110	0.020	0.200
Uintah	5	0.104	0.050	0.200
Utah	9	0.057	0.020	0.200
Washington	0	NA	NA	NA
Weber	10	0.057	0.000	0.120

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Habitat 4. Location 5. Date

R square changes:

44.8 percent contribution of 5 Y variables
delete sex (1)
44.6 percent contribution of 4 Y variables
delete date (5)
23.2 percent contribution of 3 Y variables
delete habitat (3)
20.9 percent contribution of 2 Y variables
delete location (4)
3.2 percent contribution of age

NA-no analysis performed.

contributed to 44.8 percent of the variability. Date collected contributed 2.14 percent and location 17.7 percent to the total 44.8 percent variability due to the five discreet variables considered. Twenty-seven adult pheasants averaged 0.065 ppm and 20 juveniles averaged 0.084 ppm. Thirty-three male birds averaged 0.066 and 15 female birds averaged 0.091 ppm PCB in breast muscle tissue.

Waterfowl. PCB's were found in all 46 breast muscle tissue samples inspected (100 percent). The mean for these samples was 0.261 ppm with a range of 0.004 to 1.000 ppm. High birds were a juvenile female green-winged teal (1.000 ppm) collected from Ogden Bay Waterfowl Management Area, Weber County; a juvenile female shoveler (0.80 ppm) collected from Promontory Point, Box Elder County; and an adult male shoveler (0.70 ppm) collected at Clearfield, Davis County. Means and ranges by species and feeding habit and R square changes are presented in Table 25. In the statistical analysis it was found the three discreet variables considered (sex, age, feeding habit) contributed to only 2.4 percent of the variability in results. Nineteen adult waterfowl averaged 0.219 ppm and 23 juveniles averaged 0.315 ppm. Twenty-three males averaged 0.229 ppm and 18 females averaged 0.319 ppm PCB in breast muscle tissue.

Fish. PCB's were found in 36 of 39 samples (93 percent) inspected. For the 36 positive samples the mean was 0.156 ppm with a range of 0.05 to 0.97 ppm in muscle tissue. High fish was a black bass (0.97 ppm) collected from Willard Bay Reservoir. A black bass and a walleyed pike from Willard Bay Reservoir had concentrations of 0.33 ppm in their muscle tissue. Means and ranges by area sampled and by species is presented in Table 26.

Table 25. PCB levels in waterfowl from Utah, 1971. All results reported as ppm of PCB in wet muscle tissue.

Species	Number of Samples	Mean	Range Minimum	Range Maximum
Bufflehead	2	0.350	0.100	0.600
Pintail	6	0.123	0.004	0.200
Gadwall	5	0.250	0.050	0.500
Mallard	4	0.087	0.050	0.100
Coot	5	0.120	0.100	0.200
Green-winged teal	11	0.252	0.050	1.000
Shovelers	11	0.418	0.000	0.800
Geese	2	0.450	0.300	0.600
Feeding habits				
Surface feeders	44	0.268	0.050	1.000
Divers	2	0.350	0.100	0.600

Stepwise multiple regression statistical analysis.

Y variables: 1. Sex 2. Age 3. Feeding habit

R square changes:

2.4 percent contribution of 3 Y variables
delete sex (1)
2.1 percent contribution of 2 Y variables
delete feeding habit (3)
1.7 percent contribution of age

Table 26. PCB levels in fish from Utah, 1970-71. All results reported as ppm of PCB in wet muscle tissue.

Area	Number of Samples	Mean	Range	
			Minimum	Maximum
Willard Bay (Box Elder Co.)	17	0.195	0.090	0.970
Utah Lake (Utah Co.)	18	0.108	0.000	0.200
Deer Creek Reservoir (Wasatch Co.)	2	0.103	0.100	0.150
<u>Species</u>				
Carp (Utah Lake)	10	0.115	0.000	0.200
Bullhead (Utah Lake)	8	0.100	0.100	0.100
Rainbow trout (Deer Creek Reservoir)	2	0.120	0.100	0.150
Carp (Willard Bay)	6	0.078	$<$0.100	$<$0.200
Black bass (Willard Bay)	6	0.312	0.090	0.970
Walleyed pike (Willard Bay)	5	0.196	0.000	0.330

Fish from Willard Bay Reservoir have higher levels of PCB (mean 0.195 ppm) than those of Utah Lake fish (mean 0.104 ppm). It is conceivable that there is a contribution of PCB's to the Weber and Ogden Rivers from Ogden industry which shows this effect on the higher PCB levels in the Willard Bay Reservoir fish.

Though no tolerance limit has been set for PCB's, Reynolds (1971) states that PCB's can cause:

1. Pathological changes in laboratory animals.
2. Can produce teratogenic effects in chick embryos at lower dosage levels.
3. Along with other chlorinated pesticides such as DDT, can account for interference with calcium metabolism in many species.

Dustman, et al., (1971) state that in general toxicity of PCB's were similar to that of DDE. PCB's have an additive effect when combined with DDE. PCB's can also:

1. Reduce egg production.
2. Affect hatchability of chicks.
3. Reduce resistance to disease.
4. The lower percent chlorine PCB's such as aroclor 1242 can cause eggshell thinning.
5. PCB's can enhance the toxicity of dieldrin and DDT to insects.
6. Can affect offspring of high dosed pheasants in their performance in visual cliff tests.

Table 27. Sex and age data by compound and species of wildlife from Utah, 1971. All results reported as ppm in wet muscle tissue.

Analyses	Species	Category	Number of Samples	Mean
Mercury	Chukar	Adult	16	0.050
		Juvenile	18	0.049
		Male	11	0.057
		Female	23	0.047
	Pheasant	Adult	55	0.170
		Juvenile	79	0.131
		Male	73	0.187
		Female	60	0.099
	Waterfowl	Adult	19	0.132
		Juvenile	23	0.206
		Male	23	0.142
		Female	18	0.217
Dieldrin	Chukar	Adult	14	0.016
		Juvenile	15	0.006
		Male	11	0.007
		Female	18	0.014
	Pheasant	Adult	48	0.007
		Juvenile	64	0.006
		Male	59	0.006
		Female	53	0.007
	Waterfowl	Adult	19	0.016
		Juvenile	23	0.049
		Male	24	0.039
		Female	18	0.027
DDT	Chukar	Adult	14	0.018
		Juvenile	15	0.011
		Male	11	0.013
		Female	18	0.015
	Pheasant	Adult	48	0.013
		Juvenile	64	0.020
		Male	59	0.015
		Female	53	0.019
	Waterfowl	Adult	19	0.009
		Juvenile	23	0.022
		Male	24	0.028
		Female	18	0.013

Table 27. Continued

Analyses	Species	Category	Number of Samples	Mean
DDE	Chukar	Adult	14	0.011
		Juvenile	15	0.004
		Male	11	0.004
		Female	18	0.010
	Pheasant	Adult	47	0.021
		Juvenile	63	0.007
		Male	59	0.017
		Female	53	0.008
	Waterfowl	Adult	18	0.048
		Juvenile	23	0.041
		Male	23	0.042
		Female	18	0.049
PCB's	Chukar	Adult	14	0.070
		Juvenile	14	0.047
		Male	11	0.059
		Female	17	0.055
	Pheasant	Adult	27	0.065
		Juvenile	20	0.084
		Male	33	0.066
		Female	15	0.091
	Waterfowl	Adult	19	0.219
		Juvenile	23	0.315
		Male	23	0.229
		Female	18	0.319

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Because of the isolation of the chukars from most agricultural crops by its habitat, the mercury levels found by this study could possibly be considered as a natural background level. There should be no health hazard involved to humans from consuming the muscle tissue of the chukar in Utah.

This study indicates, as do the previously mentioned studies, that mercury levels in pheasant muscle tissue in the fall hunting season is lower and essentially safe to eat by consumers. The major source of mercury contamination of pheasants is ingestion of mercurial treated seed. Due to the current restrictions imposed upon mercurials for seed treatments, it is believed that the mercury situation as has been reported these past few years in the case of pheasants will disappear. Mercury levels during the future hunting seasons would be expected to be lower even than this study shows.

The higher than the 0.5 ppm guideline levels for mercury found in some grain feeding waterfowl such as the pintail should become lower in the next few years because of the restriction of the use of mercurial seed dressing by both Canada and the United States. This has been shown to be the case with seed eating birds just a year after restrictions were imposed upon mercurial treated seeds in Sweden (Westoo, 1969). Mercury concentrations in divers may continue at levels seen by this study.

Utah Lake carp and bullhead; Deer Creek Reservoir trout and yellow perch; and Bear Lake Bonneville whitefish and cisco are well below the 0.5 ppm guideline level and should present no health hazard upon consumption.

Optimum conditions for a high rate of formation (and loss) of dimethyl mercury in Willard Bay Reservoir, very high mercury levels in the fish, and an apparent lack of any industrial contribution of mercury to Willard Bay Reservoir tends to support the belief that the source of mercury in the lake was there when Willard Bay Reservoir was built, as well as receiving contributions from the Weber River. Further study is necessary, however, to firmly establish where the contributions of mercury to Willard Bay Reservoir come from.

The Food and Drug Adminstration has established maximum permissible concentrations of 0.30 ppm for dieldrin and 5.0 ppm total DDT residues in edible portions of fish. Using these tolerances as guides and based upon the levels found in muscle tissue of chukars, pheasants, waterfowl, and fish, there appears to be no health hazard to humans due to dieldrin or DDT + DDE concentration in these species.

It is evident that PCB levels are generally higher than the organochlorine pesticide levels in chukars, pheasants, waterfowl, and fish. Studies of interactions of PCB's with dieldrin, DDT, DDE, and other pesticides are incomplete. Definite conclusions or predictions cannot at this time be made on a potential additive effect of all of these compounds in reproductive or physiological effects upon the species studied. It would be difficult to evaluate the impact of PCB's plus organochlorine pesticides upon reproduction in the field as population fluctuations are due to many intricately woven factors. Much research is now being done to evaluate possible synergistic or additive effects of combinations of the compounds investigated in the project. Possibly at a later time, the data given here may be re-evaluated regarding effect on species and sportsmen in the light of whatever new physiological effects are found to be caused by combinations of these compounds.

Recommendations

If the allowable daily intake (ADI) for mercury is accepted based on Berglund and Berlin (1969), at the 0.5 ppm guideline level, a person could safely eat almost two pounds of muscle tissue per week assuming this was his only intake of mercury (see Table 28, Appendix, page 92). It should be kept in mind that livers of birds may contain as much as seven times the concentrations of mercury as the breast muscle. If any warning need be given consumers, it would be to recommend that the viscera be discarded upon cleaning the bird to ensure a safe allowable daily intake. As the concentration of mercury in pheasants is greater after the spring planting of grains, poachers would be susceptible to much higher mercury tissue levels.

Willard Bay Reservoir fish, with a mean of 1.36 ppm mercury and a range of 0.16 to 7.18 ppm are not within safe human consumption limits. Seventy-seven percent of all fish sampled from Willard Bay Reservoir were above the 0.5 ppm guideline level established by the Food and Drug Administration for commercially marketed fish. On the basis that over 3/4 of all fish sampled exceeded this 0.5 ppm guideline level it is recommended that:

1. Studies be initiated to more closely define possible sources of mercury and the health hazard involved in consumption of these fish.

2. That a more thorough investigation into all potential sources of this mercury in Willard Bay Reservoir fish be initiated.

3. A survey of mercury levels of fish down the entire Weber River drainage, including Wanship and Echo Dams, should be undertaken at once.

4. Monitoring of diving ducks should continue for sometime. If their source of mercury is the bottom sediments, their levels should continue to be approximately the same as shown by this study.

5. That a survey of levels of mercury in local ducks of Ogden Bay Waterfowl Management Area be initiated.

The limitations of usage on dieldrin and DDT should result in a gradual lowering of these levels in the coming years in contrast with those found by this study. It is felt, therefore, that further studies of this type or magnitude will not be needed except possibly in small problem areas which may arise.

SUMMARY

All three objectives of the study were accomplished. They are summarized as:

1. Levels of total mercury, dieldrin, DDT, and DDE in muscle tissues from chukars, pheasants, deer, waterfowl, and fish collected from selected areas of Utah were determined.

2. These levels have been evaluated and compared with other published reports.

3. Recommendations for further studies and possible management measures have been made.

In addition, PCB's were identified in many samples and were, therefore, included in the analyses to determine their levels also in the wildlife of Utah.

It was found that levels of dieldrin and DDT + DDE were well within human consumptive tolerance limits. Total mercury levels in pheasants, chukars, and waterfowl were below the 0.5 ppm guideline level established by the Food and Drug Adminstration. Fish from Utah Lake, Bear Lake, and Deer Creek Reservoir were below the 0.5 ppm guideline level for mercury.

Three-fourths of all fish analyzed for total mercury from Willard Bay Reservoir were above the 0.5 ppm guideline level. Inflows into Willard Bay Reservoir were analyzed and showed there was a residual source of mercury in the waters and soils of the reservoir and that a constant source was coming in from the Weber River.

PCB levels in muscle tissue showed levels generally higher than those of dieldrin and DDT + DDE.

This study shows there was no health hazard to a person consuming fish and wildlife from Utah due to pesticide levels with the exception of mercury concentrations in fish from Willard Bay Reservoir.

Further monitoring of fish from the Weber River drainage, local waterfowl from the Ogden Bay Waterfowl Management Area, and fish from the Willard Bay Reservoir is necessary to more closely define the scope of this mercury situation in Utah.

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APPENDIX

Allowable daily intake (ADI)

Berglund and Berlin (1969) state that in the adult man the brain toxic concentration (concentration in the brain which causes toxicity) is near 8 ppm or a total of 12 mg of mercury. Considering the brain as 20 percent of the body burden gives a body burden at toxic levels of 60 mg of mercury. The daily excretion is one percent and the body burden half life is 70 days. Equilibrium of the body concentration of mercury at toxic level will be maintained by 0.6 mg mercury per day intake. Applying a safety factor of ten gives an allowable daily intake of 0.06 mg mercury per day or 0.42 mg mercury per week. Using these data, it is possible to calculate from a given mercury tissue level of any animal the amount an individual can eat in one week to stay within this allowable daily intake as in Table 28.

Table 28. Based upon applied allowable daily intake (ADI) from Berglund and Berlin (1969). Amounts of muscle tissue an individual could consume per week at concentrations up to 5.0 ppm mercury.

Mercury tissue level	0.3 ppm	0.5 ppm	1.0 ppm	2.0 ppm	3.0 ppm	4.0 ppm	5.0 ppm
Can eat per week	1400 gm 2.9 lb	840 gm 1.75 lb	420 gm 14 oz	210 gm 7 oz	140 gm 4.6 oz	105 gm 3.5 oz	84 gm 2.8 oz

Table 29. Total analyses in chukars from Utah, 1970. All results reported in ppm in fresh muscle tissue.

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Location	Date Collected
101	0.06	NA[c]	NA	NA	NA	F	J	Hogups Box Elder County	11-1-70
102	0.02	NA	NA	NA	NA	F	A	Hogups Box Elder County	11-1-70
103	0.03	NA	NA	NA	NA	F	A	Hogups Box Elder County	11-1-70
104	0.02	0.062	0.036	0.018	<.05	F	J	Confusion Range Millard County	11-3-70
105	0.10	0.004	0.012	0.004	<.05	M	A	Confusion Range Millard County	11-3-70
106	0.07	0.006	0.025	0.005	<.05	F	A	Confusion Range Millard County	11-3-70
107	0.04	0.006	0.021	0.004	<.05	F	J	Confusion Range Millard County	11-3-70
108	0.08	0.014	0.027	0.005	<.05	M	A	Confusion Range Millard County	11-3-70
109	0.11	0.004	0.015	0.003	<.05	M	J	West side Promontory Box Elder County	11-15-70
110	0.04	0.006	0.035	0.007	<.05	M	J	West side Promontory Box Elder County	11-15-70
111	0.11	0.004	0.016	0.003	<.05	F	A	West side Promontory Box Elder County	11-15-70
112	0.04	0.029	0.036	0.006	<.05	M	A	3 mi. east of Morgan Morgan County	11-17-70
113	0.04	0.092	0.064	0.042	<.05	F	A	3 mi. east of Morgan Morgan County	11-17-70
114	0.06	0.003	0.011	0.003	<.05	M	A	3 mi. east of Morgan Morgan County	11-17-70

Table 29. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Location	Date Collected
115	0.06	0.003	0.012	0.003	<.05	F	A	3 mi. east of Morgan Morgan County	11-17-70
116	0.07	0.057	0.025	0.005	<.05	F	A	3 mi. east of Morgan Morgan County	11-21-70
117	0.04	0.009	0.023	0.003	<.05	F	J	3 mi. east of Morgan Morgan County	11-21-70
118	0.07	0.000	0.000	0.000	7.70	F	J	Southeast of Myton Duchesne County	11-4-70
119	0.10	NA	NA	NA	NA	F	J	Southeast of Myton Duchesne County	11-4-70
120	0.04	NA	NA	NA	NA	F	J	Southeast of Myton Duchesne County	11-4-70
121	0.03	0.000	0.000	0.000	0.30	F	A	Southeast of Myton Duchesne County	11-4-70
122	0.01	0.000	0.000	0.000	0.30	M	A	Southeast of Myton Duchesne County	11-4-70
123	NA	NA	NA	NA	NA	M	A	Southeast of Myton Duchesne County	11-4-70
124	0.02	0.000	0.021	0.075	0.03	F	A	Southeast of Myton Duchesne County	11-4-70
125	0.03	0.000	0.011	0.010	0.20	F	J	Southeast of Myton Duchesne County	11-4-70
126	0.03	0.002	0.003	0.002	0.04	F	J	Echo Canyon Morgan County	12-24-70
127	0.03	0.002	0.003	0.001	0.04	M	J	Echo Canyon Morgan County	12-24-70
128	0.06	0.002	0.000	0.001	0.04	M	J	Echo Canyon Morgan County	12-24-70

Table 29. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Location	Date Collected
129	0.05	0.006	0.006	0.012	0.10	M	J	Echo Canyon Morgan County	12-24-70
130	0.06	0.001	0.002	0.000	0.04	F	J	Echo Canyon Morgan County	12-24-70
131	0.03	0.002	0.005	0.001	0.04	F	J	Echo Canyon Morgan County	12-24-70
132	0.06	0.001	0.003	0.001	0.04	F	J	Echo Canyon Morgan County	12-24-70
133	0.02	0.002	0.003	0.001	0.04	F	J	Echo Canyon Morgan County	12-24-70
134	0.05	0.004	0.000	0.001	0.04	M	A	Lakeside Mountains Tooele County	10-15-70
135	0.03	0.002	0.003	0.002	0.04	F	A	Lakeside Mountains Tooele County	10-15-70

[a]M=Male, F=Female
[b]A=Adult, J=Juvenile
[c]NA= No analysis performed

Table 30. Total analyses of adipose tissues in chukars from Utah, 1970. All results reported in ppm in lipid.

Log #	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Location	Date Collected
126	0.078	0.140	0.099	2.0	F	J	Echo Canyon Morgan County	12-24-70
128	0.058	0.290	0.116	2.0	M	J	Echo Canyon Morgan County	12-24-70
129	0.830	0.350	0.000	1.9	M	J	Echo Canyon Morgan County	12-24-70
130	0.056	0.087	0.087	1.9	F	J	Echo Canyon Morgan County	12-24-70
131	0.094	0.441	0.155	2.4	F	J	Echo Canyon Morgan County	12-24-70
133	0.072	0.151	0.143	2.5	F	J	Echo Canyon Morgan County	12-24-70

[a]M=Male, F=Female
[b]J=Juvenile

Table 31. Total analyses in pheasants from Utah, 1970-71. All results reported in ppm in wet muscle tissue.

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
1	0.79	0.002	0.012	0.002	0.05	M	A	2	Cache Co.	7-17-70
2	0.29	0.003	0.015	0.003	0.10	M	A	2	Cache Co.	7-18-70
3	0.04	0.003	0.020	0.003	0.05	M	J	2	Cache Co.	9-7-70
4	0.01	0.003	0.020	0.003	0.05	M	J	2	Cache Co.	9-9-70
5	0.01	0.001	0.010	0.002	0.05	M	J	1	Cache Co.	9-9-70
6	0.02	0.002	0.070	0.004	0.05	M	J	1	Cache Co.	9-7-70
7	0.01	0.003	0.023	0.003	0.12	F	J	1	Cache Co.	9-9-70
8	0.17	0.005	0.014	0.003	0.10	M	J	2	Box Elder Co.	9-6-70
9	0.08	0.002	0.012	0.013	0.10	M	J	1	Box Elder Co.	9-5-70
10	0.12	0.000	0.022	0.006	0.05	M	J	1	Box Elder Co.	9-6-70
11	0.06	0.002	0.016	0.010	0.05	M	J	2	Box Elder Co.	9-23-70
12	0.53	0.002	0.010	0.004	0.05	F	A	2	Box Elder Co.	9-23-70
13	0.01	0.002	0.012	0.006	0.10	M	A	2	Box Elder Co.	9-23-70
14	0.21	0.002	0.011	0.003	0.05	F	A	1	Weber Co.	9-8-70
15	0.10	0.005	0.020	0.003	0.12	F	A	1	Weber Co.	9-8-70
16	0.02	0.002	0.010	0.003	0.05	F	J	1	Weber Co.	9-8-70
17	0.03	0.002	0.011	0.003	0.05	F	J	1	Weber Co.	9-8-70
18	0.32	0.003	0.012	0.003	0.05	F	J	1	Weber Co.	9-5-70
19	0.03	0.004	0.021	0.003	0.05	M	J	1	Weber Co.	9-5-70
20	0.01	0.003	0.015	0.003	0.12	F	A	1	Uintah Co.	9-30-70
21	0.10	0.003	0.002	0.004	0.20	M	A	1	Uintah Co.	9-30-70
22	0.07	NA[d]	NA	NA	NA	F	A	1	Uintah Co.	9-30-70
23	0.14	NA	NA	NA	NA	F	J	1	Uintah Co.	9-30-70
24	0.35	NA	NA	NA	NA	M	J	1	Uintah Co.	9-30-70
25	0.22	NA	NA	NA	NA	F	A	1	Uintah Co.	9-30-70
26	0.03	0.000	0.018	0.004	NA	F	A	3	Uintah Co.	11-20-70
27	0.05	0.005	0.016	0.004	NA	F	J	1	Weber Co.	11-7-70
28	0.05	0.024	0.040	0.008	NA	F	A	1	Weber Co.	11-8-70

Table 31. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
29	0.03	0.020	0.026	0.008	NA[d]	F	A	3	Weber Co.	11-11-70
30	0.03	0.024	0.043	0.011	NA	F	J	1	Weber Co.	11-8-70
31	0.04	0.003	0.119	NA	NA	F	J	2,3	Box Elder Co.	11-12-70
32	0.07	0.005	0.045	0.011	NA	F	J	1	Box Elder Co.	11-10-70
33	0.04	0.006	0.017	0.004	NA	F	J	1	Box Elder Co.	11-17-70
34	0.12	0.003	0.009	0.004	NA	F	J	1	Box Elder Co.	11-8-70
35	0.08	0.005	0.019	0.004	NA	F	J	1	Box Elder Co.	11-8-70
36	0.22	0.005	0.015	0.007	NA	F	J	1	Washington Co.	10-8-70
37	0.05	0.005	0.017	0.003	NA	M	J	1	Washington Co.	10-8-70
38	0.07	0.031	0.018	0.004	NA	F	J	1	Washington Co.	10-27-70
39	0.04	0.005	0.030	0.005	NA	F	J	1	Washington Co.	11-11-70
40	0.07	0.002	0.007	0.002	NA	F	A	1	Washington Co.	11-11-70
41	0.04	NA	NA	NA	NA	F	A	1	Washington Co.	11-11-70
42	0.09	0.005	0.022	0.005	NA	M	A	1	Washington Co.	10-27-70
43	0.10	0.010	0.025	0.007	NA	M	J	1	Millard Co.	9-30-70
44	0.03	0.008	0.025	0.015	NA	M	J	1	Emery Co.	9-30-70
45	0.03	0.005	0.014	0.003	NA	F	J	1	Emery Co.	9-30-70
46	0.12	0.004	0.020	0.004	NA	F	J	1	Millard Co.	9-30-70
47	0.11	0.003	0.013	0.008	NA	F	J	1	Millard Co.	9-30-70
48	0.12	0.003	0.010	0.004	NA	M	A	1	Millard Co.	9-30-70
49	0.015	0.010	0.022	0.018	NA	M	J	1	Millard Co.	9-30-70
50	0.10	0.005	0.025	0.005	NA	M	J	1	Millard Co.	9-30-70
51	0.07	0.010	0.022	0.010	NA	F	J	1	Millard Co.	9-30-70
52	0.07	0.004	0.017	0.004	NA	F	J	1	Millard Co.	9-30-70
53	0.04	0.046	0.050	0.022	NA	F	J	1	Millard Co.	9-30-70
54	0.18	0.004	0.051	0.002	NA	M	A	1	Millard Co.	9-30-70
55	0.09	0.005	0.014	0.002	NA	F	A	1	Sevier Co.	10-29-70
56	0.10	0.002	0.008	0.003	NA	F	J	1	Sevier Co.	10-29-70

Table 31. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
57	0.11	NA[d]	NA	NA	NA	F	J	1	Sevier Co.	10-28-70
58	0.07	0.004	0.015	0.005	NA	M	J	1	Sevier Co.	10-28-70
59	0.09	0.003	0.011	0.003	NA	M	J	1	Sevier Co.	10-28-70
60	0.09	0.010	0.011	0.009	NA	F	J	1	Emery Co.	9-30-70
61	0.03	0.003	0.009	0.004	NA	F	J	1	Emery Co.	9-30-70
62	0.04	0.013	0.038	0.008	NA	M	J	1	Emery Co.	9-30-70
63	0.02	0.006	0.014	0.002	NA	F	A	1	Emery Co.	9-30-70
64	0.03	0.002	0.009	0.002	NA	M	A	1	Emery Co.	9-30-70
65	0.09	0.005	0.008	0.002	NA	F	J	1	Emery Co.	9-30-70
66	0.08	0.003	0.015	0.003	NA	M	A	1	Emery Co.	9-30-70
67	0.07	NA	NA	NA	NA	F	J	1	Emery Co.	9-30-70
68	0.07	0.012	0.071	0.032	NA	F	J	1	Davis Co.	11-19-70
69	0.10	0.014	0.030	0.021	NA	F	A	3	Davis Co.	11-16-70
70	0.12	0.002	0.010	0.002	NA	M	J	1	Davis Co.	11-19-70
71	0.17	0.004	0.013	0.003	NA	M	A	3	Davis Co.	11-16-70
72	0.15	0.007	0.011	0.006	NA	M	J	1	Davis Co.	11-19-70
73	0.07	0.010	0.020	0.005	NA	M	J	3,1	Davis Co.	11-11-70
74	0.08	0.014	0.011	0.010	NA	F	A	3,1	Davis Co.	11-11-70
75	0.09	0.004	0.036	0.020	NA	F	J	1	Davis Co.	11-20-70
76	0.09	NA	NA	NA	NA	F	J	1	Davis Co.	11-21-70
77	0.09	0.001	0.006	0.002	NA	M	J	1	Davis Co.	11-14-70
78	0.09	NA	NA	NA	NA	M	J	1	Sevier Co.	10-28-70
79	0.07	0.015	0.036	0.008	NA	F	J	1	Sevier Co.	10-28-70
80	0.05	0.006	0.003	0.004	NA	M	J	1	Sevier Co.	10-28-70
81	0.07	0.005	0.022	0.005	NA	M	A	3	Weber Co.	10-10-70
82	0.09	0.003	0.002	0.004	0.20	F	J	1	Sevier Co.	10-28-70
83	0.04	0.002	0.001	0.000	0.02	M	A	1	Sevier Co.	10-28-70
84	0.12	0.006	0.019	0.004	NA	M	J	1	Weber Co.	11-5-70

Table 31. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
85	0.10	0.005	0.022	0.005	NA	M	A	1	Weber Co.	11-7-70
86	0.08	0.006	0.023	0.004	NA	M	J	1	Weber Co.	11-12-70
87	0.06	0.006	0.024	0.005	NA	M	J	1	Utah Co.	10-20-70
88	0.14	0.008	0.022	0.005	NA	M	A	1	Utah Co.	10-20-70
89	0.10	0.003	0.003	0.003	0.20	M	A	1	Utah Co.	10-20-70
90	0.07	0.005	0.022	0.005	NA	F	J	1	Utah Co.	10-20-70
91	0.04	0.005	0.028	0.005	NA	F	J	1	Utah Co.	10-20-70
92	0.04	0.001	0.001	0.000	0.02	F	A	1	Utah Co.	10-21-70
93	0.04	0.002	0.002	0.000	0.02	F	A	2	Utah Co.	10-21-70
94	0.11	0.003	0.001	0.001	0.05	M	A	2	Utah Co.	10-21-70
95	0.11	0.005	0.025	0.020	NA	M	A	2	Utah Co.	10-21-70
96	0.11	0.002	0.002	0.000	0.02	F	J	2	Utah Co.	10-20-70
97	0.07	0.000	0.001	0.000	0.40	F	J	1	Salt Lake Co.	11- -70
98	0.06	0.010	0.005	0.011	NA	F	J	1	Cache Co.	11-11-70
98A	0.01	0.007	0.010	0.000	NA	F	J	2	Cache Co.	11-14-70
99	0.13	0.010	0.005	0.000	NA	F	J	1	Cache Co.	11-7-70
99A	0.72	0.009	0.007	0.088	NA	F	A	1	Cache Co.	11-7-70
100	0.08	0.005	0.011	0.019	NA	F	J	1	Cache Co.	11-7-70
500	1.06	0.009	0.010	0.011	0.05	M	A	1	Uintah Co.	6-27-71
501	0.07	0.000	0.000	0.000	0.10	M	J	1	Uintah Co.	6-27-71
502	0.76	0.004	0.000	0.000	0.05	M	A	1	Uintah Co.	6-27-71
503	0.04	0.007	0.008	0.000	0.05	M	J	1	Cache Co.	7-1-71
504	0.02	0.005	0.006	0.022	0.05	M	J	1	Cache Co.	7-1-71
505	0.07	NA	NA	NA	NA	M	J	1	Cache Co.	7-1-71
506	0.13	0.004	0.007	0.000	0.05	M	A	1	Box Elder Co.	6-29-71
507	0.03	0.007	0.016	0.021	0.05	M	A	1	Utah Co.	6-29-71
508	0.25	0.009	0.006	0.000	0.05	M	A	3	Weber Co.	6-28-71
509	0.11	0.006	0.006	0.011	0.05	M	A	1	Utah Co.	6-29-71

Table 31. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
510	0.06	0.012	0.008	0.012	0.00	M	A	1	Weber Co.	6-28-71
511	0.09	0.005	0.006	0.017	0.05	F	J	1	Utah Co.	6-29-71
512	0.27	0.006	0.008	0.000	0.05	M	A	1	Weber Co.	6-28-71
513	0.01	0.004	0.006	0.000	0.05	M	A	1	Utah Co.	6-30-71
514	0.01	0.007	0.008	0.011	0.05	M	A	1	Box Elder Co.	6-30-71
515	0.30	0.000	0.000	0.000	0.10	M	A	1	Weber Co.	6-28-71
516	0.21	0.007	0.012	0.000	0.05	F	A	1	Emery Co.	6-6-71
517	0.04	0.013	0.016	0.025	0.05	M	A	1	Emery Co.	7-3-71
518	0.10	0.084	0.000	0.678	0.05	M	A	1	Emery Co.	7-6-71
519	0.01	0.006	0.010	0.000	0.05	M	A	1	Emery Co.	7-6-71
520	0.13	NA[d]	NA	NA	NA	M	J	1	Millard Co.	7-8-71
521	1.09	NA	NA	NA	NA	M	J	1	Millard Co.	7-8-71
522	2.08	NA	NA	NA	NA	M	J	1	Millard Co.	7-8-71
523	0.49	NA	NA	NA	NA	M	J	1	Millard Co.	7-8-71
524	0.31	NA	NA	NA	NA	M	A	1	Millard Co.	7-8-71
525	0.12	NA	NA	NA	NA	M	J	1	Millard Co.	7-8-71
526	0.21	NA	NA	NA	NA	M	J	1	Sevier Co.	7-14-71
527	0.16	NA	NA	NA	NA	M	A	1	Sevier Co.	7-10-71
528	0.17	NA	NA	NA	NA	M	A	1	Sevier Co.	7-7-71
529	0.16	NA	NA	NA	NA	M	J	1	Cache Co.	11-4-71
530	0.30	NA	NA	NA	NA	M	J	2	Cache Co.	11-12-71
531	0.32	NA	NA	NA	NA	M	A	2	Cache Co.	11-10-71

[a]M=Male, F=Female
[b]A=Adult, J=Juvenile
[c]1=irrigated cropland, 2=dry farm wheat, 3=marsh or adjacent marsh
[d]NA=no analysis performed

Table 32. Total analyses of adipose tissues in pheasants from Utah, 1970. All results reported in ppm in lipid.

Log #	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Habitat[c]	Location	Date Collected
20	0.075	0.118	0.067	1.9	F	A	1	Uintah County	9-30-70
21	0.037	0.000	0.000	0.5	M	A	1	Uintah County	9-30-70
28	0.100	0.114	0.171	1.9	F	A	1	Weber County	11-8-70
30	0.045	0.102	0.076	1.9	F	J	1	Weber County	11-8-70
32	0.049	2.840	0.678	2.0	F	J	1	Box Elder County	11-10-70
35	0.116	0.254	0.394	1.0	F	J	1	Box Elder County	11-8-70
37	1.577	1.771	1.897	4.6	M	J	1	Washington County	10-8-70
42	0.053	0.070	0.085	0.9	M	A	1	Washington County	10-27-70
50	0.129	0.088	0.237	2.0	M	J	1	Millard County	9-30-70
54	0.034	0.079	0.047	0.0	M	A	1	Millard County	9-30-70
62	0.116	0.125	0.062	2.0	M	J	1	Emery County	9-30-70
63	0.224	0.367	0.207	3.9	F	A	1	Emery County	9-30-70
68	0.058	0.396	1.795	4.2	F	J	1	Davis County	11-19-70
75	0.019	3.090	2.297	4.0	F	J	1	Davis County	11-20-70
78	0.086	0.043	0.090	2.1	M	J	1	Sevier County	10-28-70
80	0.093	0.115	0.104	0.7	M	J	1	Sevier County	10-28-70
93	0.103	0.146	0.321	2.3	F	A	2	Utah County	10-21-70
95	0.000	0.331	3.703	1.9	M	A	1	Utah County	10-21-70

[a]M=Male, F=Female
[b]A=Adult, J=Juvenile
[c]1=irrigated cropland, 2=dry farm wheat

Table 33. Total analyses of waterfowl collected in Utah, 1970. All results reported in ppm in wet muscle tissue.

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Species	Location	Date Collected
203	0.487	0.177	0.067	0.000	0.60	M	J	Bufflehead	Bear River Cache Co.	11-10-70
204	0.695	0.026	0.016	0.006	0.10	M	A	Bufflehead	Bear River Cache Co.	11-10-70
205	0.101	0.016	0.003	0.004	0.04	M	A	Pintail	Browns Park WMA[c] Daggett Co.	11-18-70
206	0.045	0.009	0.007	0.008	0.10	M	A	Baldpate	Browns Park WMA Daggett Co.	11-18-70
207	0.037	0.004	0.004	0.005	0.05	M	A	Gadwall	Browns Park WMA Daggett Co.	11-18-70
208	0.208	0.022	0.012	0.011	0.10	M	J	Mallard	Browns Park WMA Daggett Co.	11-18-70
209	0.051	0.016	0.011	0.030	0.20		J	Coot	Farmington Bay WMA Davis Co.	11- -70
210	0.038	0.053	0.023	0.010	0.10			Coot	Farmington Bay WMA Davis Co.	11- -70
211	0.093	0.022	0.007	0.005	0.10	M	J	Mallard	Farmington Bay WMA Davis Co.	11- -70
212	0.053	0.061	0.049	0.000	0.20	M	J	Gadwall	Farmington Bay WMA Davis Co.	11- -70
213	0.037	0.038	0.014	0.013	0.10	F	A	Green-winged teal	Farmington Bay WMA Davis Co.	11- -70
214	0.096	0.050	0.006	0.008	0.05	M	A	Green-winged teal	Farmington Bay WMA Davis Co.	11- -70
215	0.037	0.002	0.011	0.009	0.10	F	J	Green-winged teal	Farmington Bay WMA Davis Co.	11- -70

Table 33. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Species	Location	Date Collected
216	0.077	0.022	0.004	0.010	0.10	M	A	Green-winged teal	Farmington Bay WMA[c] Davis Co.	11- -70
217	0.059	0.023	0.006	0.010	0.10			Coot	Farmington Bay WMA Davis Co.	11- -70
218	0.082	0.045	0.004	0.020	0.10			Coot	Farmington Bay WMA Davis Co.	11- -70
219	0.151	0.015	0.004	0.010	0.05	M	A	Mallard	Farmington Bay WMA Davis Co.	11- -70
220	0.099	0.026	0.011	0.010	0.10	F	A	Pintail	Clearlake WMA Millard Co.	12-21-70
221	0.184	0.024	0.002	0.003	0.20	F	J	Shoveler	Clearlake WMA Millard Co.	12-21-70
222	0.743	0.026	0.011	0.014	0.10	F	J	Pintail	Clearlake WMA Millard Co.	12-21-70
223	0.064	0.111	0.065	0.021	0.40	M	J	Green-winged teal	Clearlake WMA Millard Co.	12-21-70
224	0.227	0.033	0.007	0.012	0.20	F	A	Pintail	Clearlake WMA Millard Co.	12-21-70
225	0.085	0.348	0.008	0.028	0.10	M	J	Green-winged teal	Clearlake WMA Millard Co.	12-21-70
226	0.432	0.184	0.033	0.000	0.20	F	J	Pintail	Clearlake WMA Millard Co.	12-21-70
227	0.063	0.017	0.008	0.007	0.10	M	A	Gadwall	Clearlake WMA Millard Co.	12-21-70
228	0.473	0.010	0.006	0.006	0.10	F	J	Pintail	Clearlake WMA Millard Co.	12-21-70
229	0.087	0.017	0.004	0.003	0.10	M	J	Mallard	Clearlake WMA Millard Co.	12-21-70

Table 33. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Species	Location	Date Collected
230	NA[d]	0.007	0.009	0.011	0.30	M	A	Canada goose	Portage Box Elder Co.	12-29-70
231	0.085	NA	NA	NA	NA	F	A	Snow goose	Pocatello Valley Box Elder Co.	11-5-70
232	0.061	0.000	0.000	0.580	0.60	M	A	Snow goose	Pocatello Valley Box Elder Co.	11-5-70
233	NA	0.000	0.000	0.000	0.80	F	J	Shoveler	Promontory Point Box Elder Co.	12- -70
234	0.090	0.000	0.000	6.70	0.00	M	A	Shoveler	Promontory Point Box Elder Co.	12- -70
235	0.067	0.000	0.240	0.038	0.40	M	J	Gadwall	Farmington Bay WMA[c] Davis Co.	10-29-70
236	0.054	0.000	0.000	0.000	0.50	M	A	Gadwall	Farmington Bay WMA Davis Co.	10-9-70
237	0.332	0.004	0.025	0.007	0.10	F	J	Shoveler	Clearfield Davis Co.	12-5-70
238	0.069	0.016	0.040	0.044	0.60	M	A	Shoveler	Clearfield Davis Co.	12-5-70
239	0.236	0.005	0.012	0.059	0.70	M	A	Shoveler	Clearfield Davis Co.	12-5-70
240	0.173	0.012	0.032	0.019	0.60	F	J	Shoveler	Clearfield Davis Co.	12-5-70
241	0.230	0.000	0.084	0.024	0.20	M	J	Shoveler	Clearfield Davis Co.	12-5-70
242	0.079	0.009	0.017	0.014	0.40	F	J	Shoveler	Clearfield Davis Co.	12-5-70
243	0.127	0.000	0.024	0.027	0.40	F	J	Shoveler	Clearfield Davis Co.	12-5-70

Table 33. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age[b]	Species	Location	Date Collected
244	0.290	0.013	0.011	0.480	0.60	F	J	Shoveler	Clearfield Davis Co.	12-5-70
245	0.161	0.006	0.008	0.026	0.10			Coot	Layton Sloughs Davis Co.	10-4-70
246	0.203	0.002	0.006	0.043	0.40	F	J	Green-winged teal	Ogden Bay WMA[c] Weber Co.	11-11-70
247	0.156	0.020	0.014	0.022	0.30	F	A	Green-winged teal	Ogden Bay WMA Weber Co.	11-11-70
248	0.045	0.017	0.008	0.026	0.04	F	J	Green-winged teal	Ogden Bay WMA Weber Co.	11-11-70
249	0.187	0.071	0.000	0.170	1.0	F	J	Green-winged teal	Ogden Bay WMA Weber Co.	11-11-70
250	NA[d]	NA	NA	NA	NA	M	J	Green-winged teal	Ogden Bay WMA Weber Co.	11-11-70
251	0.121	0.000	0.019	0.048	0.18	M	A	Green-winged teal	Ogden Bay WMA Weber Co.	11-11-70
252	0.252	0.000	0.000	8.82	0.00			Pelican	Unit 1 Lake Farmington Bay WMA Davis Co.	7-7-71

[a] M=Male, F=Female
[b] A=Adult, J=Juvenile
[c] WMA=Waterfowl Management Area
[d] NA=no analysis performed

Table 34. Total analyses in fish from Utah, 1970-71. All results reported in ppm in wet muscle tissue.

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
281	0.59	0.000	0.014	0.095	<.10	F		Carp	Willard Bay Res. Box Elder Co.	9-9-70
282	0.95	0.000	0.000	0.048	<.20	F		Carp	Willard Bay Res. Box Elder Co.	9-9-70
283	0.52	0.000	0.000	0.045	<.20	F		Carp	Willard Bay Res. Box Elder Co.	9-9-70
284	1.21	0.000	0.013	0.065	<.10	M		Carp	Willard Bay Res. Box Elder Co.	9-9-70
285	1.01	0.000	0.000	0.065	<.10	F		Carp	Willard Bay Res. Box Elder Co.	9-9-70
286	0.53	0.000	0.025	0.104	0.12	F		Carp	Willard Bay Res. Box Elder Co.	9-9-70
287	7.30	0.000	0.008	0.055	0.18	M		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
288	0.68	0.000	0.087	0.058	0.97	F		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
289	0.88	0.000	0.017	0.036	0.09	M		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
290	1.15	0.000	0.049	0.038	0.19	F		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
291	1.31	0.000	0.000	0.048	0.33	M		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
292	1.19	0.000	0.011	0.020	0.11	M		Black bass	Willard Bay Res. Box Elder Co.	9-9-70
293	3.15	0.000	0.030	0.067	0.22			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70
294	3.29	0.000	0.022	0.067	0.20			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
295	3.89	0.000	0.037	0.089	0.23			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70
296	3.44	NA[b]	NA	NA	NA			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70
297	2.62	0.000	0.045	0.175	0.33			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70
298	1.97	0.000	0.051	0.162	0.00			Walleyed pike	Willard Bay Res. Box Elder Co.	9-9-70
299	0.71	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
300	1.56	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
301	0.86	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
302	1.83	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
303	1.49	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
304	1.99	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
305	1.32	NA	NA	NA	NA	M	4	Walleyed pike	Willard Bay Res. Box Elder Co.	3-23-71
306	0.82	NA	NA	NA	NA	F	3	Black bass	Willard Bay Res. Box Elder Co.	3-23-71
307	0.27	NA	NA	NA	NA	F	3	Black bass	Willard Bay Res. Box Elder Co.	3-23-71
308	0.28	NA	NA	NA	NA	F	6	Carp	Ogden Bay WMA[c] Weber Co.	3-24-71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
309	0.67	NA[b]	NA	NA	NA	M	5	Carp	Ogden Bay WMA[c] Weber Co.	3-24-71
310	0.27	NA	NA	NA	NA	F	4	Carp	Ogden Bay WMA Weber Co.	3-24-71
311	0.49	NA	NA	NA	NA	M	4	Carp	Ogden Bay WMA Weber Co.	3-24-71
312	0.15	NA	NA	NA	NA	F	3	Carp	Ogden Bay WMA Weber Co.	3-24-71
313	0.23	NA	NA	NA	NA	F	4	Carp	Ogden Bay WMA Weber Co.	3-24-71
314	0.51	NA	NA	NA	NA	F	3	Carp	Ogden Bay WMA Weber Co.	3-24-71
315	0.18	NA	NA	NA	NA	F	4	Carp	Farmington Bay WMA Davis Co.	3-24-71
316	0.06	NA	NA	NA	NA	F	3	Carp	Farmington Bay WMA Davis Co.	3-24-71
317	0.18	NA	NA	NA	NA	M	4	Carp	Farmington Bay WMA Davis Co.	3-24-71
318	0.16	NA	NA	NA	NA	F	5	Carp	Farmington Bay WMA Davis Co.	3-24-71
319	0.11	NA	NA	NA	NA	F	2	Carp	Farmington Bay WMA Davis Co.	3-24-71
320	0.15	NA	NA	NA	NA	F	5	Carp	Farmington Bay WMA Davis Co.	3-24-71
321	0.06	NA	NA	NA	NA	M	5	Carp	Farmington Bay WMA Davis Co.	3-24-71
322	0.08	NA	NA	NA	NA	F	5	Carp	Ogden Bay WMA Weber Co.	3-24-71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
323	0.06	NA	NA	NA	NA	F	7	Carp	Ogden Bay WMA[c] Weber Co.	3-24-71
324	0.04	NA	NA	NA	NA	F	6	Carp	Farmington Bay WMA Davis Co.	3-24-71
325	0.23	NA	NA	NA	NA	F	7	Carp	Farmington Bay WMA Davis Co.	3-24-71
326	0.38	NA	NA	NA	NA	F	6	Carp	Ogden Bay WMA Weber Co.	3-24-71
327	0.41	NA	NA	NA	NA	F	6	Carp	Ogden Bay WMA Weber Co.	3-24-71
328	0.47	0.030	0.036	0.051	0.20	F		Carp	Orem pier, Utah Lake Utah Co.	3-24-71
329	0.25	0.007	0.010	0.009	0.10	F		Carp	Airport dike, Utah Lake, Utah Co.	4-15-71
330	0.34	0.016	0.000	0.024	0.20	F		Carp	Orem pier, Utah Lake Utah Co.	4-15-71
331	0.12	0.012	0.012	0.056	0.00	M		Carp	Orem pier, Utah Lake Utah Co.	4-15-71
332	0.10	0.006	0.009	0.009	0.10	F		Carp	Airport dike, Utah Lake, Utah Co.	4-7-71
333	0.16	0.000	0.000	0.000	0.10	F		Carp	Airport dike, Utah Lake, Utah Co.	4-7-71
334	0.12	0.011	0.017	0.021	0.10	F		Carp	Orem pier, Utah Lake Utah Co.	4-15-71
335	0.10	0.011	0.012	0.015	0.10	M		Carp	Orem pier, Utah Lake Utah Co.	4-15-71
336	0.11	0.023	0.008	0.034	0.20	F		Carp	Orem pier, Utah Lake Utah Co.	4-15-71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
337	0.15	0.006	0.010	0.006	0.05	F		Carp	Orem pier, Utah Lake Utah Co.	4-15-71
338	0.09	0.006	0.010	0.009	0.10	M		Bullhead	Orem pier, Utah Lake Utah Co.	4-7-71
339	0.03	0.010	0.018	0.013	0.10	F		Bullhead	Orem pier, Utah Lake Utah Co.	4-7-71
340	0.12	0.007	0.006	0.009	0.10	M		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
341	0.09	0.006	0.011	0.006	0.10	M		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
342	0.11	NA[b]	NA	NA	NA	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
343	0.12	0.009	0.020	0.000	0.10	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
344	0.11	0.004	0.003	0.005	0.10	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
345	0.08	0.006	0.012	0.007	0.10	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
346	0.14	0.008	0.014	0.010	0.10	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
347	0.24	0.005	0.014	0.007	0.00	F		Bullhead	Airport dike, Utah Lake, Utah Co.	4-7-71
348	0.43	NA	NA	NA	NA	M		Yellow perch	Deer Creek Reservoir Wasatch Co.	4-20-70
349	0.13	NA	NA	NA	NA	M		Yellow perch	Deer Creek Reservoir Wasatch Co.	4-20-70
350	0.26	NA	NA	NA	NA	F		Yellow perch	Deer Creek Reservoir Wasatch Co.	4-20-70

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
351	0.38	NA[b]	NA	NA	NA	F		Yellow perch	Deer Creek Reservoir Wasatch Co.	4-20-70
352	0.23	NA	NA	NA	NA	F		Yellow perch	Deer Creek Reservoir Wasatch Co.	4-20-70
353	0.12	NA	NA	NA	NA			Bonneville cisco	Bear Lake Rich Co.	3-9-71
354	0.33	NA	NA	NA	NA			Bonneville cisco	Bear Lake Rich Co.	3-9-71
355	0.16	NA	NA	NA	NA			Bonneville whitefish	Bear Lake Rich Co.	3-9-71
356	0.11	NA	NA	NA	NA			Bonneville whitefish	Bear Lake Rich Co.	3-9-71
357	0.10	NA	NA	NA	NA			Bonneville whitefish	Bear Lake Rich Co.	3-9-71
358	0.15	NA	NA	NA	NA			Bonneville whitefish	Bear Lake Rich Co.	3-9-71
359	0.26	NA	NA	NA	NA			Brown trout	Snake creek below Wasatch Mtn. State Park, Wasatch Co.	5-26-71
360	0.09	NA	NA	NA	NA			Rainbow trout	Deer Creek Reservoir Wasatch Co.	5-20-71
363	0.37	0.024	0.017	0.013	0.15			Rainbow trout	Deer Creek Reservoir Wasatch Co.	5-20-71
365	0.14	NA	NA	NA	NA			Rainbow trout	Deer Creek Reservoir Wasatch Co.	5-20-71
367	0.10	0.038	0.015	0.011	0.10			Rainbow trout	Deer Creek Reservoir Wasatch Co.	5-20-71
370	0.15	NA	NA	NA	NA			Rainbow trout	Deer Creek Reservoir Wasatch Co.	5-20-71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
375	0.38	NA[b]	NA	NA	NA			Brown trout	Snake Creek above Wasatch Mtn. State Park, Wasatch Co.	5-26-71
377	0.16	NA	NA	NA	NA			Brown trout	Snake Creek above Wasatch Mtn. State Park, Wasatch Co.	5-26-71
600	0.44	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. south end Box Elder Co.	8- -71
601	2.64	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. south end Box Elder Co.	8- -71
602	0.21	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. south end Box Elder Co.	8- -71
603	0.12	NA	NA	NA	NA			Sunfish	Willard Bay Res. south end Box Elder Co.	8- -71
604	0.39	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. west end Box Elder Co.	8- -71
605	0.32	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. west end Box Elder Co.	8- -71
606	0.28	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. west end Box Elder Co.	8- -71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
607	0.16	NA[b]	NA	NA	NA			Walleyed pike	Willard Bay Res. west end Box Elder Co.	8- -71
608	0.25	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. northeast end Box Elder Co.	8- -71
609	0.31	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. northeast end Box Elder Co.	8- -71
610	1.12	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. northeast end Box Elder Co.	8- -71
611	0.89	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. northeast end Box Elder Co.	8- -71
612	0.48	NA	NA	NA	NA			Walleyed pike	Willard Bay Res. northeast end Box Elder Co.	8- -71
613	1.33	NA	NA	NA	NA			Brown trout	Willard Bay Res. northeast end Box Elder Co.	8- -71
614	6.82	NA	NA	NA	NA			Black bass	Willard Bay Res. northeast end Box Elder Co.	8- -71
615	0.39	NA	NA	NA	NA			Black bass fingerling	Willard Bay Res. southeast end, canal entrance, Box Elder Co.	8- -71

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
2BGBT	0.06	NA[b]	NA	NA	NA			Brown trout	Snake Creek below Wasatch Mtn. State Park, Wasatch Co.	12- -70
2CGBT	0.06	NA	NA	NA	NA			Brown trout	Snake Creek below Wasatch Mtn. State Park, Wasatch Co.	12- -70
2DGBT	0.08	NA	NA	NA	NA			Brown trout	Snake Creek below Wasatch Mtn. State Park, Wasatch Co.	12- -70
2EGBT	0.13	NA	NA	NA	NA			Brown trout	Snake Creek below Wasatch Mtn. State Park, Wasatch Co.	12- -70
3ARBT	0.04	NA	NA	NA	NA			Rainbow trout	Midway hatchery Wasatch Co.	12- -70
3BRBT	0.07	NA	NA	NA	NA			Rainbow trout	Midway hatchery Wasatch Co.	12- -70
3CRBT	0.11	NA	NA	NA	NA			Rainbow trout	Midway hatchery Wasatch Co.	12- -70
3DRBT	0.11	NA	NA	NA	NA			Rainbow trout	Midway hatchery Wasatch Co.	12- -70
3ERBT	0.06	NA	NA	NA	NA			Rainbow trout	Midway hatchery Wasatch Co.	12- -70
4ARBT	0.13	NA	NA	NA	NA			Rainbow trout	Deer Creek Res. Wasatch Co.	12- -70
4BRBT	0.11	NA	NA	NA	NA			Rainbow trout	Deer Creek Res. Wasatch Co.	12- -70

Table 34. Continued

Log #	Mercury	Dieldrin	p,p'-DDT	p,p'-DDE	PCB	Sex[a]	Age	Species	Location	Date Collected
4CRBT	0.04	NA[b]	NA	NA	NA			Rainbow trout	Deer Creek Res. Wasatch Co.	12- -70
4DRBT	0.13	NA	NA	NA	NA			Rainbow trout	Deer Creek Res. Wasatch Co.	12- -70
4ERBT	0.08	NA	NA	NA	NA			Rainbow trout	Deer Creek Res. Wasatch Co.	12- -70
5AWF	0.06	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70
5BWF	0.08	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70
5CWF	0.02	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70
5DWF	0.10	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70
5EWF	0.06	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70
5FWF	0.07	NA	NA	NA	NA			Whitefish	Deer Creek Res. Wasatch Co.	12- -70

[a] M=Male, F=Female
[b] NA= no analysis performed
[c] WMA=Waterfowl Management Area

Table 35. DDD analyses in fish from Utah, 1971. All results reported in ppm of wet muscle tissue.

Log #	p,p'-DDD	Species	Location	Date Collected
328	0.16	Carp	Orem pier, Utah Lake, Utah County	3-24-71
330	0.012	Carp	Orem pier, Utah Lake, Utah County	4-15-71
331	0.000	Carp	Orem pier, Utah Lake, Utah County	4-15-71
334	0.016	Carp	Orem pier, Utah Lake, Utah County	4-15-71
335	0.006	Carp	Orem pier, Utah Lake, Utah County	4-15-71
336	0.015	Carp	Orem pier, Utah Lake, Utah County	4-15-71
337	0.000	Carp	Orem pier, Utah Lake, Utah County	4-15-71
338	0.005	Bullhead	Orem pier, Utah Lake, Utah County	4-7-71
339	0.000	Bullhead	Orem pier, Utah Lake, Utah County	4-7-71
332	0.005	Carp	Airport dike, Utah Lake, Utah County	4-7-71
333	0.000	Carp	Airport dike, Utah Lake, Utah County	4-7-71
341	0.000	Bullhead	Airport dike, Utah Lake, Utah County	4-7-71
343	0.000	Bullhead	Airport dike, Utah Lake, Utah County	4-7-71
344	0.000	Bullhead	Airport dike, Utah Lake, Utah County	4-7-71
345	0.004	Bullhead	Airport dike, Utah Lake, Utah County	4-7-71
346	0.006	Bullhead	Airport dike, Utah Lake, Utah County	4-7-71

VITA

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Master of Science

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Papers Published: (1) Thesis (2) Mercury Levels in Wildlife of Utah and the Western States, Utah Chapter of the Wildlife Society, March 19-20, 1971. Salt Lake City, Utah. (3) Preliminary Studies of Mercury Levels in Tissue from Game Birds and Fish in Utah, Environmental Health Sciences Center Mercury Symposium, February 25-26, 1971. Oregon State University, Portland, Oregon.

Manuscript in Preparation: (1) Characterization of PCB Residues in Ducks and Fish with Combined Thin Layer, Gas--liquid Chromatography Mass Spectrometry.