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Effect of Dieldrin on Egg Hatchability and Chick Survival in Purple and Common Gallinules.

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Effect of Dieldrin on Egg Hatchability and Chick Survival in Purple and Common Gallinules

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ABSTRACT

An excellent opportunity to study nesting populations of game birds associated with insecticide use was available in the relationship of the purple gallinule Porphyrula martinica L., and the common gallinule, Gallinula chloropus L., to aldrin-treated rice fields of South Louisiana. In this area seed rice was treated prior to sowing at the rate of 0.25 lb. aldrin/100 lb. seed. When sown, the treated seed presented an available food source (contaminated with 2,500 ppm aldrin) to these birds during the early part of the nesting season.

Eggs and tissues of both species nesting in rice fields were known to be highly contaminated with dieldrin (the principal residue of aldrin), whereas dieldrin is rarely detected in similar samples from these species nesting in untreated marsh wildlife refuge areas.

The primary purpose of this study was to determine the effect of dieldrin residues in eggs of purple and common gallinules from rice fields on egg hatch, chick survival, and shell thickness. Eggs collected from marsh areas served as controls. In addition, an effort was made to ascertain if gallinules were indeed being contaminated as a result of their eating treated rice seed.

Average dieldrin contamination of eggs of the purple and common gallinule collected from rice fields in 1968 was 9.36 and 17.48 ppm, respectively. Much lower levels of dieldrin were detected in eggs collected from the same locations in 1969, (3.80 and 4.78 ppm in eggs

of purple and common gallinules, respectively) the cause apparently being due to reduced use of aldrin after the cancellation of the recommendation for pre-treating seed rice with this insecticide. All eggs collected in the rice fields contained p, p'-DDE except 2, with an average contamination of 0.19 and 0.70 ppm for purple and common gallinules, respectively, during 1968, and 0.15 and 0.18 ppm during 1969. Only 2 of 87 eggs from the marsh areas that were analyzed contained dieldrin, (0.17 and 0.28 ppm), although 46 contained p, p'-DDE at an average level of 0.22 ppm. Two eggs, both from Pass-A-Loutre Wildlife Refuge, also contained p, p'-DDT (1.03 and 1.54 ppm).

Whole body analyses of birds collected from rice fields during 1968 revealed a decline in dieldrin from 3.58 ppm in May to 0.21 ppm in September. This evidence supports the idea that gallinules do eat treated rice seed which are present early in the year during planting and that this was the principal source of dieldrin contamination.

No significant differences were found in egg hatchability, chick survival, or eggshell thickness when dieldrin-contaminated eggs of purple and common gallinules collected in rice fields were compared with that of control eggs of the same species collected in marsh areas. However, a significant interaction of survival of chicks was obtained between species and locations.

Dieldrin contamination of eggs of both species collected in 1969 had decreased 2 to 3-fold over levels detected in eggs collected during 1968. However, this decrease did not result in significant difference in egg hatch or chick survival between the two years.

Based on the data of this study it does not appear that dieldrin contamination of eggs of purple and common gallinules associated with aldrin-treated rice fields constitutes any serious threat to their reproductive potential.

INTRODUCTION

Since their introduction in the 1940's, organochlorine insecticides have become virtually universal contaminants of the world's environment, often including ecosystems in remote areas. Much concern has been expressed over the effect of these chemicals on bird populations, but relatively little data are available to justify many of the conclusions (Newsom 1967).

An excellent opportunity to study nesting populations of game birds associated with insecticide use was available in the relationship of the purple gallinule, *Porphyrula martinica* L., and the common gallinule, *Gallinula chloropus* L., to aldrin-treated rice fields of South Louisiana. In this area seed rice was treated prior to sowing at the rate of 0.25 lb. aldrin/100 lb. seed. When sown, the treated seed presented an available food source (contaminated with 2,500 ppm aldrin) to these birds during the early part of the nesting season.

Causey et. al. (1968) demonstrated that eggs and tissues of both species of gallinules nesting in treated rice fields did indeed contain high levels of dieldrin. Although egg contamination averaged 6.51 and 9.37 ppm in the purple and common gallinule, respectively, there was no effect on clutch size or egg hatchability.

The effect of organochlorine insecticide residues on avian reproduction is not fully understood. Some researchers have expressed concern that avian reproductive failures may be related more to chick

survival than to egg production, fertility or hatchability. Others have correlated reproductive problems with changes in calcium metabolism and decreases in eggshell thickness.

The primary purpose of this study was to determine the effect of dieldrin residues in eggs of purple and common gallinules on egg hatch, chick survival, and shell thickness. In addition, an effort was made to ascertain if gallinules were indeed being contaminated as a result of their eating treated rice seed.

LITERATURE REVIEW

Each year for nearly 20 years, thousands of pounds of persistent organochlorine pesticides have been applied to the environment in many countries (Stickel, 1968). In the 15 years from 1949 to 1964, approximately 974 million pounds of DDT were used in the United States. An additional 789 million pounds of the aldrin-toxaphene group were used in the 12 years from 1952 to 1964 (U. S. Department of Agriculture, 1965). As a result of their widespread use, much of the world environment has been polluted with one or more of these chemicals (Abott et al., 1966; Dustman and Stickel, 1966; Newsom, 1967; Weaver et al., 1965).

Adverse effects of pesticide residues on nontarget organisms have been generally recognized by biologists (Newsom, 1967). Much concern has been expressed over the consequences of these residues on wild animal populations (Carson, 1962; Boykins, 1966; Wallace, 1959). Of principal concern during the past 5 years, has been the effects of insecticide residues on wild bird populations, primarily because of population decline in certain species.

Evidence of insecticide residues in the tissues and eggs of wild birds is well documented (DeWitt and Buckley, 1962; DeWitt et al., 1964; El Sayed et al., 1967; Heath and Stickel, 1965; Hickey and Keith, 1965; Hunt and Keith, 1963; Keith and Flickinger, 1965; Lockie and Ratcliffe,

1964; Moore and Tatton, 1965; Stickel, 1968). Direct mortality resulting from acute toxicity of these residues has been recorded in local populations of such birds as the robin and western grebe (Hoffman et al., 1964; Hunt and Bischoff, 1960). However, more concern has been expressed over the possible effects of pesticide residues upon reproduction in contaminated populations than on acute mortality.

Striking declines in populations of bobwhite quail were noted in Georgia after land was treated with 2 pounds of heptachlor per acre (Rosene, 1965). Ferguson (1964) reported fluctuations in populations of wood thrushes, orchard orioles, yellow-breasted chats, brown thrashers, and eastern meadowlarks following a similar application of heptachlor in Mississippi.

Wright (1960) reported a decrease in proportion of young to mature woodcocks in DDT sprayed areas of New Brunswick.

DeWitt (1955) demonstrated a decrease in hatchability and survival of chicks in pheasants fed 0.02 percent (200 ppm) DDT by weight in their feed. Similar results were obtained using 0.001 percent (10 ppm) dieldrin. DDT concentrations of 0.01 percent (100 ppm) did not cause any adverse effect upon survival or growth of bobwhite quail.

Genelly and Rudd (1956) reported that egg production, fertility, hatchability, and survival of pheasant chicks fed up to 400 ppm DDT in their diet were not adversely affected. Egg production was higher in the 100 ppm DDT treatment than in the controls. However, dieldrin fed at 25 and 50 ppm produced a significant depression in egg production, fertility and survival of chicks.

DeWitt (1956a) reported high mortality in quail fed 1 ppm aldrin, dieldrin, and endrin in their diets. Young pheasants failed to survive on feed containing 5 ppm aldrin, dieldrin, or endrin. Winter diets containing 1 ppm dieldrin or endrin caused no ill effect on quail, but nearly all birds died on diets containing 0.5 ppm aldrin. Although egg production, fertility, and hatchability were relatively unaffected by inclusion of insecticides in the diets of breeding quail, chicks showed high mortality rates after hatch, even when fed as nearly an insecticide free diet as possible.

Causey et al. (1968), while conducting field tests to determine clutch size and hatchability of purple and common gallinules in association with aldrin-treated rice fields, found that neither parameter was adversely affected even when the eggs of these two species contained dieldrin averaging 6.51 and 9.37 ppm, respectively.

Graves et al. (1969) reported that feeding hens up to 5 ppm dieldrin for 16 weeks caused no deleterous effects of egg production, hatch, or chick survival over a 14-day period. Similar results have been reported for pheasants and chickens from feeding experiments with organochlorine insecticides (Atkins and Linder, 1967; Azevedo et al, 1965; Dunachie and Fletcher, 1966).

Walley et al. (1966) reported that during a 2-year study of nesting success in red-winged blackbird populations in areas treated annually with as much as 12 lb/acre of insecticides and in areas where little insecticide is used, no marked differences were reported in egg production, hatchability, or numbers of young fledged.

DDT residues in a nesting population of herring gulls seemed to cause a lowered hatchability rate but had no effect upon chick survival (Keith, 1966).

Experiments conducted to determine the effect on chick survival from eggs treated with dieldrin revealed that when a dosage of 960 ug/ egg (17 ppm) was injected prior to incubation, the chicks developed convulsions between 58 and 96 hrs after hatch (Koeman et al., 1967). The authors concluded that fast absorption of the yolk sac after hatching, such as is encountered in nature, may be hazardous when the birds have been exposed to toxic and persistent chemicals in the environment. Thus the significance of certain insecticide residues on reproduction in birds seemed to be more closely related to chick survival than to egg production, fertility, or hatchability.

Declines in populations of certain reptorial birds in recent years have been traced to drastic declines in their reproduction. These involve reproductive failures which are characterized by decreases in eggshell thickness and weight, egg breakage, and eating of eggs by adult birds, (Hickey and Anderson, 1968; Ratcliff, 1963, 1965, 1967). Regions of population declines coincide with areas where persistent organochlorine insecticides have been widely applied. Analysis of eggs and tissues confirmed the presence of high levels of insecticide residues in these species.

Population crashes in the United States and Western Europe of the peregrine falcon have been attributed to organochlorine pesticides (Hickey, 1969; Ratcliffe, 1967). Decreases in eggshell thickness were correlated with DDT and related organochlorine compounds in their environment.

Peregrine falcon eggs, adipose tissue, and prey species collected along the Peace, Slave, and Mackenzie rivers in Canada were analyzed and found to contain high levels of organochlorine pesticides. Eggs averaged (27.1 ppm) about twice that found in peregrine eggs in the stricken British population. Even with these high levels the Canadian peregrines appear to be reproductively normal (Enderson and Berger, 1970). Similar results have been reported for the peregrine population in Alaska, but fear has been expressed that this population may be at the threshold of pesticide tolerance (Cade et al., 1968).

The proportion of golden eagle eyries in West Scotland successfully rearing young increased from 31 percent in the period 1963-65 to 69 percent in the period 1966-68. Concurrently, the level of dieldrin in eagle eggs fell from 0.86 ppm (1963-65) to 0.34 ppm (1966-68). Eagles in East Scotland, where dieldrin levels in eggs are extremely low, consistently maintained a high breeding success between 1963 and 1968 (Lockie et al., 1969).

Enderson and Berger (1970) established a correlation between pesticide residues, thin eggshells, and poor hatching success in prairie falcons artificially fed starlings which had been fed a diet of 10 ppm dieldrin for 14 days.

Heath et al. (1969) reported that DDE in concentrations of 10 and 40 ppm in the feed of penned mallard ducks induced significant eggshell thinning and cracking and a marked increase in embryo mortality. DDD and DDT impaired reproduction, but less severely than DDE.

Japanese quail fed 100 ppm o, p' or p, p'-DDT in a low calcium content (0.56 percent) diet produced eggs with thinner shells and lower calcium content than controls (Bitman et al., 1969).

Delayed ovulation of Bengalese finches was demonstrated by Jefferies (1967), when he fed DDT dosages ranging from 11 to 54 ppm 6 weeks before pairing. Interval between pairing and egg laying averaged about 16 days among untreated birds and increased progressively to an average of 25 days among birds on highest dosage.

Albert (1962) reported experimental evidence indicating some reduction in sperm production in domestic fowl that were fed 0.3 percent DDT by weight in their food. However, the clinical symptoms of DDT poisoning appeared at about the same time that the reduction in sperm production was detected.

When bald eagles were fed DDT in the diet at the level of 10 ppm for periods of 60 and 70 days, there was no interference with spermatogenic activity. Degenerative testicular changes were produced only by levels of DDT that produced abnormal neurological signs and usually resulted in death (Locke et al., 1966). The authors concluded that DDT does not interfere with spermatogensis except at levels which are in themselves toxic to the bald eagle.

The mechanism which causes eggshell thinning is not well understood. Peakall (1970) demonstrated in the ringdove that dieldrin injected prior to egg laying produced no significant thinning of the eggshell or inhibition of carbonic anhydrase, an enzyme supposedly responsible for making calcium available to the eggshell in the oviduct. DDE severely depressed the activity of the enzyme and brought about a marked decrease in the eggshell thickness. A significant delay in breeding by birds fed dieldrin or DDE was also demonstrated.

Other mechanisms that may be involved in eggshell thinning include induction by insecticides of liver enzymes that lower the estrogen level and/or a decreased storage of calcium in bone marrow caused by insecticides (Peakall, 1970).

Other materials have been introduced into the environment which have further complicated the significance of organochlorine insecticides. Polychlorinated biphenyls (PCB) used as plasticizers, flame retardants, insulating fluids, and as additives in other materials, have come into focus as being very similar to DDT in their effect on enzyme activity (Risebrough and Brodine, 1970). These investigators reported as much as 1980 ppm of PCB's in the fat of peregrine falcons from California. They further stated that Peakall had demonstrated that 20 ppm PCB injected into birds resulted in a 5.5 fold increase in estradiol metabolism in the liver as compared to a 3.5 fold increase when 40 ppm of DDT was injected. From this viewpoint of hormone balance, it appears that PCB's are potentially greater threats to birds than DDT.

Pesticide residues in the ecosystems of birds have been demonstrated to cause death, reproductive impairment, disruption of species balance, and behavioral alteration, but the overall significance of these residues is not well understood (Stickel, 1968). However, no experimental evidence is now available to support a conclusion that the continued existence of any species has been endangered by the use of insecticides (Newsom, 1967).

METHODS AND MATERIALS

Field Collection of Eggs

Entire clutches of eggs were taken from 37 purple gallinule nests (225 eggs) and 8 common gallinule nests (66 eggs) found in rice fields near Crowley, Louisiana, during the summers of 1968-69. The nests, constructed of woven and matted rice stems and leaves, were located by slowly wading through the flooded rice fields and looking for depressions in the rice which indicated the presence of a nest. During the same time eggs were also collected from 30 purple gallinule nests (169 eggs) and 33 common gallinule nests (170 eggs) located in marsh areas of Louisiana which included Pass-A-Loutre Wildlife Refuge in Plaquemines Parish, Pecan Island in Vermilion Parish, Sabine Wildlife Refuge in Calcasieu Parish, and Rockefeller Wildlife Refuge in Cameron Parish. These eggs were used as controls since these areas are isolated and removed from agricultural insecticide use. Nests in these areas were located with an airboat since wading in the marshy habitat was most difficult.

Clutches were coded, placed in game bird egg flats and immediately stored in a styrofoam ice chest for transport to the Louisiana State University campus at Baton Rouge. A bottle of warm water was placed in the chest during excessively long collecting trips to maintain a high ambient temperature similar to field condition.

Incubation of Eggs

Eggs were held in an electric incubator maintained at 37.7 C.° (99.8° F.) and approximately 90 percent relative humidity. Eggs were hand-turned and sprinkled with warm water 3 times daily. All eggs which did not hatch after 4 weeks were recorded as not hatching and discarded.

From each clutch containing more than 5 eggs, 2 or 3 eggs were taken for pesticide analysis. One egg was taken from all other clutches for analysis. Since gallinules begin incubation after the first egg is laid, clutches of eggs were candled to determine degree of embryonic development before incubation. When more than 1 egg was taken for analysis, the eggs showing the most advanced and least advanced embryonic development was chosen. These eggs were coded, placed in plastic bags and frozen until prepared for analysis. Eggs used for analysis were disregarded when computing percent hatch.

Measurements of Eggshell Thickness

Eggshell thickness was calculated by measuring with a micrometer pieces of shell taken from 4 points around the girth of each shell. These were then averaged to the nearest 0.001 in. for each shell. Thickness in each case represented the shell itself plus the dried egg membrane.

Rearing of Chicks

Newly hatched chicks were allowed to remain in the incubator for 24 hours. However, they were isolated in pint ice cream cartons to

maintain their identity. Chicks were then placed in cardboard boxes (approximately 30 cm high x 30 cm wide x 60 cm long) and hand-fed a ration of ground beef and "Little Friskies"® cat food soaked in warm water. As each member of a clutch hatched, it was placed in the box along with other members from that clutch. It was necessary to hand-feed each individual chick since a preliminary test revealed that newly hatched gallinule chicks would not eat by themselves. Chicks were fed every 2 hours, 12 hours a day for 14 days. The 14-day period was arbitrarily selected as a sufficient length of time for complete yolk absorption. Numbers of surviving and dead chicks were recorded by clutch during this period.

The eggshells remaining after the 1969 hatch were coded, placed in paper bags, and stored in herbarium cabinets until determination of shell thickness.

Field Collection of Bird Samples

Throughout the summer of 1968, gallinules were collected from rice fields to determine the amount of residues in the whole body. Specimens were taken during daylight hours with shotguns by walking in the young rice and flushing the birds. Once the rice had reached maturity, it was necessary to collect birds at night along irrigation ditches with the aid of headlights and shotguns since birds would not flush in dense cover.

Gallinules which were collected from Pass-A-Loutre Wildlife Refuge and Rockefeller Wildlife Refuge were captured at night using airboats, lights, and fish landing nests, since firearms are not allowed on these areas.

Laboratory Preparation of Samples

Eggs

Each egg was allowed to thaw, then cracked and the contents blended in a Sorvall Omni-Mixer cup at 5000 rpm for 3-5 minutes. A 2 g sample was quickly weighed into a tared 1 oz. medicine vial and stored in a freezer until analyzed. The remainder of the blended eggs was poured into another vial and stored in case the first sample was destroyed or lost in the analytical process.

Tissue Samples

Collected birds were picked clean of feathers and the heads and feet removed. Each carcass was finely ground in a Hobart blender and a 25 g sample weighed into a tared 1 oz. medicine vial and stored in a freezer until analyzed. The remaining tissue was placed in a plastic bag and frozen as an extra sample.

Clean-Up and Extraction

The following reagents were used in the clean-up and extraction of the eggs and tissue samples:

Petroleum ether -- Pesticide quality -- Matheson, Coleman, and Bell

Sodium sulfate -- Anhydrous, granular, reagent grade

Ethyl ether -- Redistilled

Acetone -- Reagent grade

Acetonitrile -- Redistilled

Ethyl alcohol -- 95 percent

Florisil -- Floridin Company, Tallahassee, Florida. 1200°F. (70.4°C.) activated, 60-100 mesh. Before use this material was heated for 2 hours at 1200°F. and stored at 130°F. (54°C.). Any florisil not used within 24 hrs of firing time was reactivated as described above.

Eggs

Egg samples were cleaned and extracted using the method described by Cummings et al. (1966) with the following modifications:

1) Two g samples from individual eggs were used.
2) Samples were ground in 250 ml beakers using small glass pestles.
3) Eluants were collected in 400 ml beakers and evaporated in a water bath.
4) The 15 percent ethyl ether-petroleum ether eluting solvent was changed to 20 percent.

5) The final volume of eluant was adjusted to a 1 g/ml concentration for injection into a gas chromatograph.

Tissue

Tissue samples were cleaned and extracted using methods described by Mills (1959) and Johnson (1962) with a modification of clean-up using the method of Cummings et al. (1966). The procedure was as follows:

1) Grind 25 g sample with sufficient amount of anhydrous sodium sulfate to absorb the moisture in the sample.
2) Transfer mixture to centrifuge bottle and add 100 ml petroleum ether.
3) Shake vigorously for 1 min and centrifuge in basket centrifuge for 5 min at 1500 rpm.
4) Pour off solvent layer into a beaker and re-extract sample twice with 50 ml petroleum ether.
5) Evaporate combined extracts in water bath to 25 ml and transfer 2 ml of the concentrated extract to a florisil column for clean-up.
6) Chromatograph as with the egg samples and dilute to volume for injection into gas chromatograph (1 g/ml).

A florisil recovery standard and reagent blank were run with each series of samples to determine the percent recovery of a known amount of insecticide injected onto the florisil and to monitor any solvent interference.

Gas Chromatography

Aerograph Pestilizer Models 680 and 682 gas chromatographs employing electron capture detectors were used for residue analysis. The chromatographs were operated simultaneously and both were connected to a Westronics Dual channel recorder Model 11A/MA21/DV7.5H containing Westronics 14063 chart paper. The 6 percent eluants were injected into the 680 model and the 20 percent eluants were injected into the Model 682.

Five ft fircular glass columns of 1/8 in. diameter packed with 5 percent Dow 11 on Gas Chrom Q were used in the chromatographs with nitrogen as a carrier gas. The operating conditions were as follows:

Detector Temp.	185°F (85°C)
Oven Temp.	185°F (85°C)
Inlet Temp.	205°F (107°C)
Gas Flow	reading 26 lb pressure at the tank gauge
Attenuation	4-6
Chart Speed	1/2 in/min

Injections of 1-4 ul quantities were made depending upon the amount of residue detected in the sample. A Hamilton 10 ul syringe (No. 701) was used in making the injections.

Standards of recrystallized aldrin, dieldrin, heptachlor expoxide, HEOD, p, p'-DDT and p, p'-DDE were injected prior to injection of the samples to determine the elution time characteristic of each chemical under the specified condition.

Thin Layer Chromatography

Random samples were selected for qualitative work with thin layer chromatography. The technique used was described by Damaska (1964). Extracts from the 20 percent eluting solution were further cleaned for thin layer chromatography by taking them through saponification and MgO-celite chromatography procedures outlined in FDA Pesticide Analytical Manual Volume I.

Endrin and dieldrin are not changed by this treatment.

Infrared Spectrophotometry

All the 20 percent eluants from the egg and tissue samples were concentrated into one sample each which was scanned with a Perkin-Elmer Model 21 Infrared Spectrophotometer. A 5/10 mm sealed micro-cell with NaCl windows was used to confirm the identity of dieldrin.

Residue Calculations

Peak heights resulting from residues detected in a sample were adjusted by dilution until they closely approximated the peak heights produced by an injection of a known amount of standard. Calculations were made by direct linear comparison of the similar sized peaks.

RESULTS AND DISCUSSION

Residue Analyses of Eggs

Results of analyses of egg samples collected in rice fields near Crowley during the summer months of 1968-69 are presented in Table 1. Eggs of both species of gallinules contained high levels of dieldrin. The average dieldrin contamination of eggs of purple and common gallinules collected in 1968 was 9.36 and 17.48 ppm, respectively. Average dieldrin contamination of eggs collected in 1969 was 3.80 ppm for purple and 4.78 ppm for common. DDE (p, p'-isomer) was present in all egg samples except 2, but at much lower levels than dieldrin (see Appendix Table 8 for individual clutch analysis).

Much lower levels of dieldrin were detected in eggs collected in 1969 than in 1968. The recommended practice of pre-treating rice seed with aldrin for rice water weevil (Lissorhoptrus oryzophilus Kuschel) control was discontinued after 1968 due to the development of high levels of resistance to the chemical by this insect (Graves et al. 1967). Although aldrin was not recommended in 1969, some seed companies sold treated seed since there was no alternative control for the rice water weevil. The reduction in the amount of aldrin-treated seed rice used in 1969 decreased the amount of contaminated rice available to birds arriving on the nesting grounds at this time. This accounts for the decrease in dieldrin contamination of eggs from 1968 to 1969.

TABLE 1.

Organochlorine insecticide residues in gallinule eggs from rice fields, Crowley, Louisiana, 1968-1969.

		ppm			
		Dieldrin		p, p'-DDE	
Species	Samples	Average	Range	Average	Range
			1968		
Purple	26	9.36	3.23-16.43	0.19	Trace[a]-0.46
Common	6	17.48	4.69-28.07	0.70	0.11-1.84
			1969		
Purple	33	3.80	1.56-13.62	0.15	Trace - 0.38
Common	12	4.78	1.16-10.70	0.18	0.11-0.38

[a]Trace recorded when residues were below 0.05 ppm.

Forty-six egg samples of the purple gallinule and 41 of the common gallinule from marsh areas were analyzed and only 2 samples were found to contain a detectable amount of dieldrin (0.17 and 0.28 ppm). Of these egg samples, 46 contained p, p'-DDE at an average level of 0.22 ppm with a range of 0.11-1.21 ppm. Two eggs collected at Pass-A-Loutre Wildlife Refuge also contained a detectable amount of p, p'-DDT (1.54 and 1.03 ppm). Results of analysis of individual clutches of eggs from the marsh areas are presented in Appendix Table 8.

Residue Analyses of Gallinules

Causey (1968) found rice seed in the gullets and gizzards of both common and purple gallinules. Gullet and gizzard contents from 10 purple and 10 common gallinules averaged 90.3 and 71 percent rice, respectively. The large amounts present led him to conclude that treated rice seeds were the source of dieldrin contamination of eggs. However, he did not analyze for residues any birds collected during or after the time that treated rice seed was available to them.

In order to determine if treated rice seed was indeed the source of dieldrin in eggs, samples of birds were collected periodically during 1968 from rice fields. Results of whole body analyses of these birds are presented in Table 2.

Birds collected during May averaged 3.58 ppm dieldrin and 0.08 ppm DDE, whereas birds collected during September averaged 0.21 ppm dieldrin and 0.07 ppm DDE. These data indicate that dieldrin residues found in tissues and eggs of these birds are a result of their having come in contact with the source of insecticide early in the season. This is further substantiated by the constant levels of DDE residues detected during this same period.

Rice has never been treated with aldrin or dieldrin during the growing season. It was treated prior to planting with aldrin at the rate of 0.25 lb aldrin/100 lb seed during 1968. Most of the rice fields are seeded during April. Birds arriving on the nesting ground during March and April have ample opportunity to feed upon this highly contaminated rice since they seek cover in ditches and canals adjacent to newly planted rice fields.

TABLE 2.

Dieldrin and p, p'-DDE residues in gallinules collected from rice fields, Crowley, Louisiana, 1968 (whole body minus head and feet).

Species	Date Collected	ppm Dieldrin	ppm p,p'-DDE
Common	May 20	2.49	0.09
Purple	"	4.97	0.11
Purple	"	1.76	0.05
Purple	"	1.50	0.05
Common	"	2.77	Trace [b]
Common	"	4.64	Trace
Purple	May 25	2.20	Trace
Purple	"	4.12	Trace
Purple	"	3.14	0.26
Purple	"	4.41	0.05
Purple [a]	"	8.86	0.17
Common [a]	"	2.07	0.17
Common	July 24	1.72	0.10
Purple	"	1.78	0.05
Purple	"	0.89	Trace
Common	"	1.71	Trace
Purple	"	0.57	0.13
Purple	"	2.01	0.18

a/ Birds taken in tremors.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 2. Continued

Species	Date Collected	ppm Dieldrin	ppm p, p'-DDE
Common	Sept. 10	0.13	0.10
Common	"	0.22	0.07
Purple	"	0.28	0.08
Purple	"	0.23	Trace
Purple	"	Trace	0.05
Purple	"	0.41	0.15

a/ Birds taken in tremors.

b/ Trace recorded if detected below 0.05 ppm.

The decline in dieldrin residues from May to September substantiates Causey's (1968) conclusion that gallinules do eat treated rice seed and that this is the main source of contamination.

One common and one purple gallinule that were collected on May 25 exhibited symptoms indicative of organochlorine poisoning. Dieldrin was present in the body of the purple gallinule at 8.86 ppm which was about twice that found in the gallinule with the next largest residue. However the common gallinule carried only 2.07 ppm dieldrin as a whole body burden. Dieldrin at this level was found in nearly all of the other birds collected during May and none of these exhibited any observable poisoning symptoms. Whether or not the symptoms observed were due to dieldrin poisoning is unknown, but Jefferies and Davis (1967) have reported that dieldrin residues of 16.88 ppm in the brain and 17.94 ppm in the liver are lethal amounts to song thrushes. They further state that other passerines with these or similar quantities may be suspected of having died from dieldrin poisoning. Robinson et. al. (1967) reported the mean concentration of dieldrin in poisoned Japanese quail and pigeons were: brains, 17.4 and 20.0 ppm, and livers, 40.0 and 45.6 ppm, respectively.

Whole body analyses of gallinules collected in marsh areas revealed very little dieldrin contamination (Table 3). Only two samples contained detectable amounts of dieldrin (1.79 and 0.32 ppm) and both were collected at Pass-A-Loutre Wildlife Refuge. DDE contamination averaged 0.12 ppm and was essentially the same as that found in the birds collected from rice fields (0.07 ppm).

TABLE 3.

Dieldrin and p, p'-DDE residues in gallinules collected in marsh areas, 1968 (whole body minus head and feet).

Species	Date Collected	ppm Dieldrin	ppm p, p'-DDE
Common	May 29	ND a/	0.78
Common	"	–	0.23
Common	"	–	–
Common	"	–	–
Common	"	1.79	0.43
Common	"	–	–
Common	"	–	0.50
Common	"	–	–
Common	"	–	Trace b/
Common	"	–	0.22
Common	"	–	–
Common	"	–	0.10
Purple	"	–	0.08
Common	"	0.32	Trace
Common	June 5	–	Trace
Common	"	–	–

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 3. Continued

Species	Date Collected	ppm Dieldrin	ppm p, p'-DDE
Common	June 5	–	–
Common	"	–	Trace
Common	"	–	0.11
Common	"	–	0.05
Common	"	–	Trace

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

Hatchability and Survival of Chicks

Data on hatch of eggs and survival of gallinule chicks observed during 1968 and 1969 are listed in Table 4 (see Appendix Table 8 for individual clutch results). Statistical analysis of these data revealed that hatch of eggs containing high levels of dieldrin from populations of common and purple gallinules in rice fields was not significantly different at the 5 percent level of significance from that of control eggs collected in the marsh areas (Table 5). The adjusted means for species versus location combinations for hatchability are quite similar (Table 6). These laboratory results on egg hatchability confirm those reported by Causey et al. (1968) who conducted field tests to determine hatchability of purple and common gallinule eggs. In addition, researchers studying other species of game birds have reported comparable hatchability figures from controlled experiments (Azevedo et al. 1965, Hunt et al. 1958).

Survival of common and purple gallinule chicks hatching from dieldrin-contaminated eggs collected in rice fields was not significantly different at the 5 percent level of significance from that recorded for control eggs of the same species collected in marsh areas (Tables 4, 5, and 6). However, there was a significant interaction between species and location (Table 5). The adjusted means for species by location combinations indicate that purple gallinules hatching from eggs collected in rice fields actually survived better than those hatching from eggs collected in the marshes, whereas just the reverse occurred in the case of common gallinules (Table 6). Since the differences in adjusted means for the two species

TABLE 4.

Hatchability of eggs and survival of chicks from eggs collected in marshes and rice fields, 1968-1969.

Species	Number of Clutches	Number Eggs Incubated	Eggs Hatched No.	Eggs Hatched Percent	Survival of Chicks (after 14 days) No.	Survival of Chicks (after 14 days) Percent
			Marsh Areas			
Purple	30	123	97	78	64	66
Common	33	129	111	86	90	81
			Rice Fields			
Purple	37	166	124	75	74	60
Common	8	48	41	85	25	61

TABLE 5.

Least-squares analysis of variance of hatchability of eggs and survival of gallinule chicks from eggs collected in marshes and rice fields, 1968-1969.

Sources	Degree of Freedom	Sum of Squares	Mean Squares	F
		Hatch		
Total	107			
Years	1	5.684	5.684	0.009
Species	1	514.738	514.738	0.823
Location	1	159.288	159.288	0.255
Years X Species	1	461.043	461.043	0.797
Years X Location	1	144.333	144.333	0.231
Species X Location	1	47.639	47.639	0.076
Error	101	63182.929	625.573	
		Survival		
Total	107			
Years	1	2615.315	2615.315	2.771 a/
Species	1	1328.925	1328.925	1.408
Location	1	109.823	199.823	0.212
Years X Species	1	463.509	463.509	0.491
Years X Location	1	32.639	32.639	0.035
Species X Location	1	3827.840	3827.840	4.056 b/
Error	101	95318.981	943.752	

a/ Approaches significance.

b/ Significant at the 5 percent significance level.

TABLE 6.

Least-square adjusted means for species versus location combinations for hatchability of eggs and survival of chicks.

	Species			
	Purple Gallinule		Common Gallinule	
Location	Hatchability	Survival	Hatchability	Survival
Marshes	68.22 ± 5.79	49.37 ± 7.12	72.24 ± 4.44	73.49 ± 5.46
Rice Fields	63.38 ± 4.11	60.80 ± 5.05	70.75 ± 8.98	54.98 ± 11.03

are reversed, a total difference of 29.44 results when the adjusted means for species by locations are combined (11.43 and 18.51 for purple and common gallinules, respectively). Thus a sufficient difference between species versus location was obtained to be significant.

The causes of the significant interaction could be explained by: (1) the disparity in the number of common and purple gallinule nests at each location (only 8 common gallinule nests in rice fields as compared to 33 in marshes, for example); (2) a large amount of variability in survival for both species; and/or (3) the possibility that survival of chicks of one species is affected in a reverse manner from that of the other species.

Although some unknown aspect of species specificity or behavior may be responsible for the significant interaction on chick survival obtained with these 2 species, this would seem to be unlikely since they are closely related. Two noticeable differences between the 2 species were found. Purple gallinules were much more plentiful than common gallinules in the rice fields, yet populations of both were very large in the marshes. In addition average dieldrin residues in eggs of common gallinules were greater than those present in purple gallinules during both years of this study.

The dieldrin residues in eggs of purple and common gallinules associated with rice fields were rather high (Table 1). Residue levels in eggs of both species collected during 1968 exceeded those in eggs collected in 1966 by Causey et al. (1968). The residue levels in eggs collected during 1969 had decreased greatly apparently due to the cancellation of the recommendation for pre-treating seed rice with

aldrin. This drastic decrease in the amount of dieldrin present in gallinule eggs during 1969 (from an average of 17.48 in 1968 to 4.78 in 1969 for common gallinules, for example) did not result in significant differences in egg hatch or chick survival when compared with data obtained during 1968 (Table 5). However, survival data of purple and common gallinules between these years did approach significance (Table 5) which indicated that decreased dieldrin contamination of eggs in 1969 may have resulted in increased survival. Locke et al. (1960) correlated the improved nesting success of golden eagles in West Scotland during the period 1966-68 over those observed during 1963-65 with a decrease in dieldrin in their eggs from 0.86 (1963-65) to 0.34 ppm (1966-68).

The survival (60-88 percent) of purple and common gallinules in this study was high considering success in rearing similar wild birds in captivity. Lynch[1/] reported that his success in rearing gallinules, rails, and mallard ducks was never greater than 50-75 percent.

Graves et al. (1969) found that 4.8 ppm dieldrin in eggs of chickens had no effect on egg hatch or chick survival during a 14-day period. Bala[2/] (1970) found that feeding 10 ppm dieldrin in the diet of chickens did not reduce significantly egg hatch or chick survival. De Witt (1955), however, reported that 10 ppm dietary dieldrin adversely affected egg hatchability and chick survival in quail and pheasant.

[1/] Personal Communication (1969) John J. Lynch, U. S. Fish and Wildl. Serv., Lafayette, Louisiana.

[2/] Personal Communication (1970) Bala A., Louisiana State University, Baton Rouge, Louisiana

Statistical analysis of eggshell thickness taken from 158 purple and common gallinule eggs collected from rice fields and marsh areas indicated no correlation in shell thickness and dieldrin contamination in these species when considered separately or when combined. A significant correlation between shell thickness and p, p'-DDE + p, p'-DDT concentrations was obtained with common gallinules. This correlation had a curvilinear relationship however, indicating an increase in shell thickness with increases in concentration of these residues (Table 7). Significant eggshell thinning has been reported in mallard ducks fed DDE in concentrations of 10 or 40 ppm or DDT at 25 ppm (Heath et al., 1969). Japanese quail fed 100 ppm o, p'-DDT or p, p'-DDT in a low calcium content diet produced eggs with thinner shells and lower calcium content than usual (Bitman et al., 1969). Significant reduction in eggshell quality has also been recorded in prairie falcons fed dieldrin contaminated starlings (Enderson and Berger, 1970). In addition, sparrow hawks fed a combination of dieldrin and DDT produced eggs with significantly thinner shells. One ppm dieldrin and 5 ppm DDT in the diet were sufficient to produce this effect (Porter and Wiemeyer, 1969). Peakall (1970), however, reported that dieldrin injected (20 ppm) prior to egg laying in the ringdove produced no significant thinning of the eggshell.

General Considerations

Stickel (1969) noted that declines in avian reproductive success under insecticidal treatment are almost always partial, are usually small, and rarely are eliminative. This seems to be true even when

toxicant levels are high enough to kill a significant percentage of parents. The effects on reproduction of sublethal dosages over a long period of time are complicated by natural variability and are extremely difficult to measure.

Considering the data obtained during this study, the reproductive potential of purple and common gallinules associated with aldrin-treated rice fields does not appear to be seriously threatened by the presence of rather high levels of dieldrin in their eggs. However, this does not mean that there may not be an adverse effect on reproduction from these residues. Variation was great enough in this study that rather small effects could not be measured with accuracy.

SUMMARY

Residue analyses of eggs of purple and common gallinules collected in rice fields averaged 9.36 and 17.48 dieldrin during 1968 and 3.80 and 4.78 ppm during 1969, respectively. DDE (*p*, *p*'-isomer) was present in all egg samples except two, but at much lower levels than dieldrin.

Dieldrin residues detected in eggs during 1969 were much lower than during 1968. This decrease was due to discontinuing the recommendation of treating rice seed with aldrin for rice water weevil control.

Analyses of 41 common and 46 purple gallinule eggs from marsh areas revealed only 2 samples with a detectable amount of dieldrin (0.17 and 0.28 ppm). Forty-six of the egg samples contained *p*, *p*'-DDE at an average level of 0.22 ppm. Two eggs from Pass-A-Loutre Wildlife Refuge contained a detectable amount of *p*, *p*'-DDT (1.54 and 1.03 ppm).

Whole body analyses of gallinules collected during 1968 revealed an average contamination of 3.58 ppm dieldrin for birds collected during May and 0.21 ppm for those collected during September. The decline in dieldrin residues from May to September substantiates Causey's (1968) conclusion that gallinules consume treated rice seed early in the nesting season and that this is the main source of contamination.

There were no significant differences in hatch, survival of chicks, or eggshell thickness between the dieldrin contaminated purple and common gallinule populations in rice fields and the population of purple and common gallinules in marsh areas, where dieldrin contamination is extremely low. Hatchability data confirm the results reported by Causey et al. (1968) who conducted field tests to determine hatchability of these two species.

A significant interaction of survival of chicks was obtained between species and location. The differences in adjusted means for location were reversed for the two species and thus a sufficient difference for statistical significance in species versus location interaction was obtained. The cause of the significant interaction could be explained by: (1) the disparity in the numbers of common and purple gallinule nests of each location (only 8 common gallinule nests in rice fields as compared to 33 in marshes); (2) a large amount of variability in survival for both species; and/or (3) the possibility that survival of chicks of one species is affected in a reverse manner from that of the other species.

Dieldrin contamination of eggs of both species collected during 1968 exceeded that in eggs collected in 1966 by Causey et al. (1968). The residue levels in eggs collected during 1969 had decreased greatly (2 to 3-fold); however, this decrease did not result in significant difference in egg hatch or chick survival when compared with data collected during 1968.

Dieldrin residues in eggs of purple and common gallinules in association with rice fields were rather high. Nevertheless, it is obvious from the data reported that even the large amounts of dieldrin present in eggs of these 2 species nesting in the rice fields do not exert a drastic adverse effect on egg hatch, survival of newly hatched chicks, or eggshell thickness, and would not appear to be any real threat to their reproductive potential. However, this does not mean that there may not be an adverse effect on reproduction from these residues. Further investigation of this problem should emphasize a considerable increase in sample size (number of clutches and eggs) in order to overcome the variability present.

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APPENDIX

TABLE 7.

Simple correlation of eggshell thickness versus dieldrin or DDE contamination in eggs of purple and common gallinules (combined and individual species analysis).

Variables	No. Observations	Average	Correlation
		Combined Analysis	
Dieldrin	158	1.49 ± .19	-0.04
DDE	158	0.26 ± .03	0.05
Thickness	158	0.86 ± .04	
		Purple Gallinules	
Dieldrin	109	1.82 ± .23	-0.02
DDE	109	0.19 ± .01	-0.08
Thickness	109	0.80 ± .05	
		Common Gallinules	
Dieldrin	49	0.79 ± .27	0.22
DDE	49	0.41 ± .09	0.33[a]
Thickness	49	1.00 ± .14	

[a] Significant at the 95 percent confidence limit.

TABLE 8.

Hatchability, survival, and residue analyses of individual clutches of purple and common gallinules.

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live No. Young	14-Day Mortality	ppm Dieldrin	ppm DDE
(Sabine Refuge, 1968)								
Common	6	1	5	0	5	0	ND[a]	-
Purple	4	1	3	0	1	2	-	0.12
Common	6	1	5	0	5	0	-	-
Common	3	1	0	2	0	0	-	0.13
Purple	5	1	4	0	4	0	-	0.15
Purple	4	1	3	0	1	2	-	-
Purple	3	1	1	1	0	1	-	Trace [b]
Common	4	1	1	2	0	1	-	-
Common	7	2	4	1	4	0	-	-
Common	6	1	4	1	4	0	-	-

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
(Sabine Refuge, 1969)								
Purple	6	2	4	0	1	3	-	0.11
Purple	5	1	4	0	1	3	-	-
Purple	3	1	1	1	1	0	-	-
Purple	5	1	3	1	3	0	-	0.12
Purple	5	1	3	1	2	1	-	0.15
Purple	3	1	0	0	0	0	-	-
Common	8	3	4	1	4	0	-	-
Common	5	1	4	0	4	0	-	Trace
Purple	5	1	1	4	0	1	-	0.30
Common	5	1	3	1	2	1	-	0.18
Common	6	2	3	1	3	0	-	0.16
Purple	6	2	3	1	3	0	-	0.15

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Purple	6	2	4	0	3	1	-	-
Purple	6	2	0	4	0	0	-	-
Purple	8	2	6	0	5	1	-	0.15
Purple	7	2	4	1	4	0	-	0.16
Purple	7	2	4	1	4	0	0.28	1.21
Purple	6	2	3	1	3	0	-	0.12
Purple	6	2	4	0	4	0	-	0.38
Purple	3	1	1	1	1	0	-	-
Purple	8	3	3	2	3	0	-	-
Purple	6	2	4	0	4	0	-	-
Common	5	1	4	0	4	0	-	0.21
Common	7	2	5	0	5	0	-	-

a/ Not detected at 0.025 ppm

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Common	6	2	4	0	4	0	-	-
Common	5	1	4	0	4	0	-	Trace
Purple	7	2	5	0	4	1	-	0.24
(Rockefellow Refuge, 1968)								
Common	6	1	5	0	5	0	-	0.15
Purple	5	1	4	0	2	2	-	Trace
Common	5	1	4	0	2	2	-	-
Common	7	1	6	0	5	1	-	-
Common	2	1	1	0	1	0	-	0.16
Common	6	2	4	0	1	3	-	0.27
(Pass-A-Loutre Refuge, 1968)								
Common	6	1	1	4	1	0	-	Trace

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live No. Young	14-Day Mortality	ppm Dieldrin	ppm DDE
Common	4	1	2	1	2	0	-	0.18
Purple	6	1	5	0	1	4	-	0.14
Common	6	1	4	1	3	1	-	0.24
Common	5	1	4	0	4	0	-	-
Common	4	1	3	0	2	1	-	-
Common	4	1	2	1	2	0	-	-
Common	8	1	6	1	6	0	-	-
Common	4	1	3	0	3	0	-	-
(Pass-A-Loutre Refuge, 1969)								
Common	2	1	0	1	0	0	-	-
Purple	5	1	4	0	4	0	-	0.21
Purple	4	1	2	1	1	1	-	0.19

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Common	5	1	4	0	4	0	-	-
Common	4	1	3	0	3	0	-	1.54 DDT
Common	6	2	4	0	1	3	-	1.03 DDT
(Pecan Island, 1969)								
Purple	7	2	5	0	2	3	-	0.18
Purple	7	2	2	3	0	2	-	0.50
Purple	6	1	4	1	2	2	-	Trace
Purple	6	1	3	2	0	3	0.17	0.27
Common	7	2	5	0	5	0	-	-
(Crowley, 1968)								
Purple	3	1	2	0	1	1	3.23	0.13
Purple	7	1	6	0	2	4	12.87	0.37

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Purple	3	1	1	1	1	0	16.43	0.11
Purple	4	1	1	2	1	0	13.01	0.46
Purple	4	1	2	1	1	1	5.19	0.14
Purple	9	2	6	1	0	6	7.70	-
Purple	5	1	4	0	4	0	3.44	0.34
Purple	2	1	1	0	1	0	3.96	0.46
Common	12	2	8	2	2	6	19.67	0.11
Common	6	2	4	0	3	1	4.69	0.14
Purple	4	1	2	1	1	1	5.35	0.14
Purple	8	2	6	0	0	6	6.98	0.11
Purple	7	2	2	3	2	0	9.85	0.18
Purple	8	2	2	4	2	0	10.11	0.37

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Purple	2	1	0	1	0	0	14.64	0.15
Purple	4	1	3	0	3	0	5.23	-
Purple	8	2	4	2	2	2	13.18	0.16
Purple	7	2	2	3	1	1	9.63	0.38
Purple	9	2	6	1	5	1	8.14	Trace
Purple	9	2	7	0	1	6	14.45	0.19
Common	10	2	8	0	5	3	28.07	1.84
(Crowley, 1969)								
Purple	8	2	5	1	2	3	4.80	0.29
Common	7	2	4	1	3	1	4.39	0.15
Purple	8	2	5	1	3	2	4.37	0.32
Purple	6	2	4	0	3	1	3.55	0.25

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Common	7	2	3	2	1	2	1.16	0.13
Purple	4	1	1	2	1	0	6.02	0.14
Common	9	3	5	1	3	2	10.71	0.17
Purple	4	1	2	1	2	0	2.71	0.16
Purple	4	1	2	1	2	0	0.56	Trace
Common	9	3	6	0	5	1	2.53	0.11
Purple	5	1	1	3	1	0	1.56	0.18
Purple	7	2	2	3	2	0	3.19	0.12
Purple	5	1	4	0	2	2	3.67	0.16
Purple	5	1	4	0	4	0	1.25	0.27
Purple	8	2	5	1	2	3	0.69	0.38
Common	6	2	3	1	3	0	3.30	0.38

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 8. Continued

Species	Total No. Eggs	No. Analyzed	No. Hatch	No. Did Not Hatch	Live Young	No. 14-Day Mortality	ppm Dieldrin	ppm DDE
Purple	6	2	2	2	2	0	3.61	0.32
Purple	7	2	4	1	2	2	1.63	Trace
Purple	8	2	5	1	5	0	2.09	Trace
Purple	6	2	4	0	3	1	4.39	Trace
Purple	9	3	6	0	3	3	2.37	0.15
Purple	8	2	4	2	4	0	3.83	Trace
Purple	7	2	2	3	1	1	5.57	Trace
Purple	7	2	5	0	2	3	13.62	0.12

a/ Not detected at 0.025 ppm.

b/ Trace recorded if detected below 0.05 ppm.

TABLE 9.

Eggshell thickness and insecticide content of individual eggs that were measured.

Species	Average Shell Thickness	ppm Dieldrin	ppm DDE + DDT
Purple	0.79	ND[a]	0.15
Purple	0.73	-	0.15
Purple	0.68	-	0.15
Purple	0.76	-	0.15
Purple	0.74	-	0.15
Purple	0.73	-	0.15
Common	0.83	-	-
Common	0.98	-	-
Common	0.97	-	-
Common	1.03	-	-
Common	0.89	-	-
Common	1.03	-	-
Common	0.97	-	-
Common	0.97	-	-
Common	1.05	-	-
Purple	0.73	-	-
Purple	0.75	-	-
Purple	0.75	-	-
Purple	0.75	-	-
Purple	0.62	3.67	0.16

a/ Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm Dieldrin	ppm DDE + DDT
Purple	0.86	3.83	-
Purple	0.74	-	0.13
Purple	0.77	-	0.13
Purple	0.70	0.28	1.21
Purple	0.74	0.28	1.21
Purple	0.73	0.28	1.21
Purple	0.74	0.28	1.21
Common	1.12	-	-
Common	1.12	-	-
Purple	0.78	-	-
Purple	0.68	5.57	-
Purple	0.68	4.39	-
Purple	0.72	4.39	-
Common	1.07	3.30	0.38
Common	1.07	3.30	0.38
Common	1.04	3.30	0.38
Common	1.05	4.39	0.15
Common	1.02	4.39	0.15
Common	0.96	4.39	0.15
Purple	0.76	4.80	0.29
Purple	0.75	4.80	0.29
Purple	0.72	4.80	0.29

a/ Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm	
		Dieldrin	DDE + DDT
Purple	0.61	3.67	0.16
Purple	0.67	3.67	0.16
Purple	0.68	3.67	0.16
Common	1.00	-	1.42
Common	1.65	-	1.42
Common	0.98	-	1.42
Common	1.10	-	1.42
Common	0.96	-	0.21
Common	0.98	-	0.21
Common	0.96	-	0.21
Purple	0.66	3.55	0.25
Purple	0.76	3.55	0.25
Purple	0.67	3.55	0.25
Purple	0.67	3.55	0.25
Purple	0.73	3.55	0.25
Purple	0.70	-	0.21
Purple	0.75	-	0.21
Purple	0.81	-	-
Purple	0.74	-	-
Purple	0.70	-	-
Purple	0.77	-	-
Purple	0.74	-	0.11

[a] Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm Dieldrin	ppm DDE + DDT
Purple	0.75	-	0.11
Purple	0.77	-	0.11
Common	0.85	-	-
Common	0.87	-	-
Purple	0.70	1.25	0.27
Purple	0.65	1.25	0.27
Purple	0.65	1.25	0.27
Purple	0.67	1.25	0.27
Common	1.00	-	1.99
Common	0.96	-	1.99
Common	1.06	-	1.99
Purple	0.80	-	0.15
Purple	0.76	-	0.15
Purple	0.78	-	0.15
Purple	0.84	-	0.15
Purple	0.67	2.09	-
Purple	0.69	2.09	-
Common	1.04	-	-
Common	1.03	-	-
Common	1.03	-	-
Common	0.72	-	-
Purple	0.85	-	0.24

a/ Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm Dieldrin	ppm DDE + DDT
Purple	0.87	-	0.24
Purple	0.81	-	0.24
Purple	0.85	-	0.24
Common	1.09	-	1.42
Common	1.08	-	1.42
Purple	0.74	1.63	-
Purple	0.97	1.57	0.18
Purple	0.81	1.57	0.18
Purple	0.84	-	0.19
Purple	0.70	2.37	0.15
Purple	0.69	2.37	0.15
Purple	0.80	5.57	-
Purple	0.88	3.83	-
Purple	0.79	0.69	0.38
Purple	0.75	3.67	0.16
Purple	0.71	13.62	0.12
Purple	0.71	13.62	0.12
Common	1.11	-	-
Purple	0.75	-	.21
Purple	0.74	4.39	-
Purple	0.76	4.39	-
Purple	0.71	2.09	-

a/ Not detected at 0.025 ppm.

TABLE 9: Continued

Species	Average Shell Thickness	ppm Dieldrin	ppm DDE + DDT
Purple	0.71	3.61	0.32
Common	1.03	-	-
Common	0.95	1.16	0.13
Purple	0.74	6.02	0.14
Common	1.10	-	1.99
Common	1.00	1.16	0.13
Purple	0.82	4.37	0.32
Purple	0.82	4.37	0.32
Purple	0.85	4.37	0.32
Common	1.22	10.70	0.21
Common	1.02	2.53	0.11
Purple	0.74	-	0.19
Purple	0.78	-	0.19
Purple	0.81	0.69	0.38
Purple	0.86	0.69	0.38
Purple	0.89	0.69	0.38
Purple	0.69	-	0.12
Purple	0.70	-	0.12
Purple	0.72	-	0.12
Purple	0.77	3.83	-
Purple	0.70	3.83	-
Purple	0.76	3.83	-

a/ Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm	
		Dieldrin	DDE + DDT
Purple	0.72	3.19	0.12
Purple	0.73	3.19	0.12
Common	1.02	-	0.18
Common	0.95	-	0.18
Common	1.00	-	0.18
Purple	0.72	-	0.15
Purple	0.73	-	0.15
Purple	0.73	-	0.15
Purple	0.73	-	0.12
Purple	0.70	-	0.30
Purple	0.70	-	0.30
Purple	0.73	-	0.30
Purple	0.67	-	0.30
Purple	0.72	-	0.30
Purple	0.64	2.37	0.15
Purple	0.61	2.37	0.15
Purple	0.69	-	0.15
Purple	0.75	-	0.15
Purple	0.71	-	0.15
Common	0.84	-	0.16
Common	0.88	-	0.16
Common	0.89	-	0.16

a/ Not detected at 0.025 ppm.

TABLE 9. Continued

Species	Average Shell Thickness	ppm	
		Dieldrin	DDE + DDT
Common	0.94	-	-
Purple	0.72	1.57	0.18
Purple	0.68	1.63	-
Purple	0.78	1.63	-
Purple	0.77	1.63	-
Purple	0.71	3.61	0.32

[a] Not detected at 0.025 ppm.

VITA

James Fredrick Fowler was born on July 11, 1943 at Lecompte, Louisiana. He attended public schools in Forest Hill and Lecompte, Louisiana and was graduated from Lecompte High School in May, 1961.

In September of the same year he entered Louisiana State University in the curriculum of Forestry. He graduated with a Bachelor of Science degree in August, 1965. He then enrolled in graduate school at L.S.U. and received the M. S. degree with a major in Game Management in 1967. In September, 1967 he entered the Department of Entomology at L.S.U. and is presently a candidate for the degree of Doctor of Philosophy in Entomology.

EXAMINATION AND THESIS REPORT

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Major Field: Entomology

Title of Thesis: Effect of Dieldrin on Egg Hatchability and Chick Survival in Common and Purple Gallinules

Approved:

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