THE USE OF WING COLLECTIONS FOR DETERMINING MERCURY LEVELS IN BOBWHITE QUAIL *(Colinus virginianus)*[1]

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ABSTRACT

Wing collections were used to determine mercury levels in bobwhite quail in Tennessee. Results of the assays indicated that the average mercury level in primary wing feathers was six times greater than the minimum acceptable limit established by the United States Food and Drug Administration. Further tests indicated that mercury levels in quail wing feathers were 24 times greater than those found in quail flesh. By comparison, mercury levels in quail were estimated to be safe for human consumption. The much higher mercury levels found in feathers, the consequent less margin for error in detection, and the ease of collecting and handling indicate that wing collections may be better for monitoring trends in mercury levels in bobwhite quail. Advantages, disadvantages, and cautions are discussed.

INTRODUCTION

This paper explores a new technique for monitoring mercury levels in gamebird populations.

The objectives of this study were to determine mercury levels in bobwhite quail (*Colinus virginianus* Linn.) wings in Tennessee, to determine if "back ground" levels could be established for future sampling, and whether data could be used for comparison with tolerance levels established by the Food and Drug Administration for safe human consumption. The need for a mercury monitoring system was necessary for the welfare of gamebird species and for human health implications.

Mercury is one of the heavy metals that is highly toxic to both man and animals (Brown 1967). Borg, et al (1969) reported that a mercury concentration of 30 ppm was a significant mortality level in adult pheasants. Sub-lethal doses of mercury in game birds have resulted in impairment of vital functions and affected behavior and physiological functions (Fyfe 1971). Tejning (1967) found that chickens on a diet of 18.4 ppm mercury displayed signs of neurological disturbances, including walking and standing. Fimreite (1971) reported significantly reduced egg production and hatchability and increased numbers of shell-less eggs in pheasants fed mercury treated grain.

Effects of mercury in humans are not as well known, but evidence on hand suggests that there is no really comfortable separation of toxicity between ourselves and animal forms. The level at which mercury starts to damage the human body is unknown. However, tolerance limits for food consumption have been established in various parts of the world. The National Institute of Public Health, in Sweden set the "safe" level of mercury content in fish as one part per million. The United States Food and Drug Administration and Canada's Food and Drug Directorate has set the tolerance limit for safe consumption in the United States and Canada at 0.5 parts per million.

On July 7, 1970, the Pickwick Lake portion of the Tennessee River was closed to commercial fisheries, and a catch and release announcement was issued to sport fishermen along with a warning not to eat fish they caught. During the same year, commercial fisheries were closed in seven other states, sports fisheries were closed in another four states, and warnings were issued

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in 17 states to sport fishermen not to eat the fish they caught. (Anonymous 1970). These closures and warnings were the result of discoveries showing that mercury levels in fish were greater than the Food and Drug Administration tolerance limit.

The presence of high levels of mercury in Alberta pheasants and partridge collected in 1969 resulted in closure of the 1970 pheasant season (Fyfe 1971). This aroused considerable speculation among sportsmen and the Game and Fish Commission as to whether mercury residues in game birds in Tennessee were within tolerable limits for human consumption. There was an immediate need for knowledge of mercury levels in game birds in Tennessee. The bobwhite quail wing collection, with a representative sample of the hunters bag of quail from every county in Tennessee, provided a "ready made" sample for mercury analysis.

WING COLLECTION

Quail wings were collected throughout Tennessee during the first two weeks of the quail season over the past 20 years. The purpose of the collection was to provide age data to determine the best biological opening date for the quail season (McConnell, 1972). When this study was initiated, the 1969 and 1970 wing collectings were still on hand. A total of 3,252 and 2,528 wings were collected in 1969 and 1970 respectively.

It was decided to use the distal end of the primary wing feathers for analysis. Age and molting characteristics of bobwhite quail dictated that only adult wings could be used in the study. Adult wings comprised less than 20 percent of the total wings collected.

The remaining 946 adult wings were separated by year and counties. Counties were grouped into the three major geographic regions in Tennessee. The geographic regions in this report are called East, Middle and West; the East representing the Eastern valley and ridges of the Tennessee River; the Middle representing the Central Nashville basin and Western valley of the Tennessee River and its Highland Rim; and the West representing the Gulf Coastal Plain and flood plain of the Mississippi River.

It was decided that a sample should consist of 40 wings. The large sample size was used in hopes of gathering enough flesh from the wings for residue analysis of other pesticides and to obtain a statistically valid estimate of mercury levels at each site to avoid a 3 percent error at the 95 percent level. To get this large a sample size, it was necessary to combine wings from several adjacent counties into pools, called sites. This divided the State into 13 sites, three, in the East, six, in the Middle and four in the West. In 1970, forty wings were collected in only 10 of the 13 sites with 40 wings in 1969. A total of 23 samples consisting of 40 wings each and five live quail trapped during January, 1972, were submitted to the laboratory for analysis.

LABORATORY PROCEDURE

The samples were analyzed by the Environmental Science and Engineering Corporation of Nashville, Tennessee, owned by Arthur R. Schulert, Ph. D. A total of 122 assays were made in all. The cost per assay was $13.00. Mercury values were reported to the nearest .03 parts per million for feathers and to the nearest .003 parts per million for body parts. The analytical precision of the assays were reported to be approximately three percent.

The wing samples were analyzed in the following manner. The distal two and one half centimeters of the outer three primary feathers were clipped from each wing in the pool. The feather clippings were thoroughly mixed and chared. The chared residue was divided into four equal portions. A mercury assay was made

for each of the four portions. A total of 92 assays were made of the 23 samples.

Five quail were trapped and delivered to the laboratory. The birds were sacrificed in the laboratory and a sample was collected from the right and left primary wing feathers, the breast muscle, leg muscle, liver, and brain of each of the quail. Thirty mercury assays were made, one for each part collected from each quail.

FINDINGS

Residue analysis:

Results of the assays indicated that wing feathers from the average site contained 3.04 parts per million of mercury. This value was six times greater than the amount termed "safe" by the U. S. Food and Drug Administration. Further study, however, discussed later in this report, revealed that direct comparison of mercury levels in wing feathers could not be made with the FDA figure. This section of the report is devoted only to analysis of the assay findings.

The standard proportional error of all assays was .2829 and the standard deviation of the weighted mean of 3.04 was ± .86. Standard deviation in individual samples varied from a low of three percent to a high of 67 percent with four above 40 percent and the median standard deviation was 32 percent. Since the average analytical precision range was three percent, the variation was attributed to natural biological variation. Using the cumulative data recorded in this study, the number of wings required to avoid an error of three percent at the 95 percent level (De Vos and Mosby, 1969) was 32. A total of 40 wings were placed in each site sample in this study. It was assumed that the sample from each site was a reasonable estimate of mercury levels in adult quail in the hunters bag which should have been representative of the adult quail population in each of the collection sites.

Assay results in parts per million of mercury for individual sites ranged from 1.70 ± .38 to 5.37 ± 1.82. The data for each year from individual sites were grouped into geographic regions. A Chi-square analysis of variance indicated that there was no significant variation among sites within geographic regions during either year of the study (Table 1). It was concluded that mercury levels did not vary significantly within the geographic regions.

Statistical "t" tests were used to determine if there was a significant difference between samples collected in 1969 and 1970. The null hypothesis that there was no significant difference between levels recorded from 1969 and 1970 was accepted at the 95 percent level in all three regions (data with the asterisk in Table II). More "t" tests were run to determine if there was a difference in mercury levels recorded among geographic regions. The null hypothesis that there was no difference in mercury levels among geographic regions was accepted for all combinations of tests between regions at the 95 percent level (data without the asterisks in Table II). It was concluded that mercury levels in adult quail wing feathers were similar throughout Tennessee during 1969 and 1970.

Background levels:

One of the objectives of this study was to determine if "back-ground levels" could be established for future sampling. Background levels are any valid set of pesticide residue data to which subsequent data can be compared. Prior to this study, there were no mercury background levels for bobwhite quail. The statistical validity of the wing collection data herein was presented earlier and establishes "background levels" for adult quail wings in Tennessee during early November. Findings in this report, however, warn that considerable caution should be exercised when using the data for comparing with future samples.

TABLE I
RESULTS OF QUAIL WING ANALYSIS FOR MERCURY AND SITE VARIATION WITHIN REGION FOR 1969 AND 1970

Region	Year 1969 ppm mercury x	1969 Chi Square x^2	1969 x^2 Value .05 level	Year 1970 ppm mercury	1970 Chi Square x^2	1970 x^2 Value .05 level
East	2.36	0.60	5.99	2.96	1.76	3.84
Middle	2.84	0.50	11.07	3.39	2.21	11.07
West	3.02	0.10	7.81	3.31	0.14	3.84

TABLE II
RESULTS OF "t" TESTS COMPARING MERCURY CONCENTRATION IN QUAIL WINGS FROM 3 GEOGRAPHIC REGIONS IN TENNESSEE

REGION	REGION EAST	MIDDLE	WEST
EAST	t=0.52/.05=2.78*	t=0.93/.05=2.12	t=1.08/.05=2.23
MIDDLE	t=0.93/.05=2.12	t=0.96/.05=2.20*	t=0.00/.05=2.11
WEST	t=1.08/.05=2.23	t=0.00/.05=2.11	t=0.72/.05=2.57

*Comparison between 1969 and 1970 data within region.

It was found that mercury is stored in the primary wing feathers of quail. A natural excretory process is accomplished when the feathers are shed. This point will be expanded later on in this paper. Since mercury is continually stored in the primary wing feathers, the amount present at any given time would depend on the amount of mercury consumed and the age of the feather. This combination of factors would ordinarily eliminate the use of wing feathers for monitoring mercury levels except for the fact that quail molt their primary wing feathers in an order of sequence at specific times of the year. (Petrides and Nestler, 1943).

Juvenile birds molt their primary wing feathers during November and the molt is usually complete by mid-December. Adults begin molting their primary wing feathers in December and have usually completed the molt by mid-January. Mercury levels in new feathers of adults in January should be lower than those of old feathers collected in November. A study was set up to test this hypothesis.

A small collection of new primary wing feathers from 10 wings was made in January of 1972. The average mercury level found in the new primaries was 0.75 ± .32 ppm. The average for old feathers in November was 3.04 ppm. A statistical "t" test was conducted to determine if mercury levels in the new primaries were significantly lower than mercury levels in old November primaries used in this study. The null hypothesis was rejected at the 95 percent level (t=4.85, .05=2.04) and it was concluded that mercury levels in adult quail wing feathers collected in

January were significantly lower than those collected in November. It is recommended that two things be taken into consideration when using these data for background levels. One, to make sure the quail in the sample are adults and two, that the collections represent the same period of the molt cycle, preferably the same month.

Comparison with FDA tolerance limit:

The final objective was to determine if the mercury levels found in the wing feathers could be used for comparison with the FDA tolerance of .5 ppm level for safe human consumption.

The lowest levels of mercury found in the wing samples in this study were three times greater than the FDA tolerance limit. The higher levels found were over 10 times greater. The .5 ppm limit was established for flesh and the data in this study were from primary wing feathers and were not considered valid for comparison with those of flesh. Work by Dindal (1970) and Dindal and Peterle (1968) had shown that chloronated hyrocarbons had occurred in varing concentration in different body parts of ducks. A study was set up to compare mercury levels in quail wing feathers with mercury levels found in other parts of the quail's body. Five quail were captured in Middle Tennessee in January of 1972. They were sent to the laboratory for analysis of mercury levels in wing feathers, breast muscle, leg muscle, liver, and brain.

The results of these assays (Table III) clearly indicated that primary wing feathers contained much higher levels of mercury than any other tissue, averaging 24 times greater than breast muscle. The data strongly suggest that mercury is stored in primary wing feathers that are shed at a later date thereby elliminating mercury from the system.

Mercury levels in breast muscle, leg muscle, liver and brains were well within the FDA's tolerance limits set for "safe" human consumption.

If mercury levels in the November wing collection were 24 times greater than levels in the breast muscle of those birds, mercury breast muscle levels would have been approximately 0.12 ppm. By comparison then, Tennessee bobwhite quail could be expected to be safe for human consumption.

CONCLUSION

Mercury levels were very easily determined from primary wing feathers. In fact, mercury levels in wing feathers were found to be 24 times greater than any other part of the body. This alone allows for a greater margin for sampling and analytical error. The advantages to collecting and handling are obvious. In addition, collections can be made without having to sacrifice birds. Statistically and analytically valid background levels were established for bobwhite primary wing feathers. Interpretation of the background data, however, requires a knowledge of the molting characteristics. It is believed that a procedure for making valid comparisons with FDA tolerance limits for safe human consumption can be developed. The use of primary wing feathers for monitoring mercury levels in bobwhite quail appears to be a valid technique. It offers several advantages over using other body parts but more knowledge is needed on season variations and relationships to levels in other parts of the body. When these variations and relationships are better known, the use of wing collections may be the better method for monitoring mercury levels in bobwhite quail.

TABLE III
MERCURY RESIDUES IN DIFFERENT BODY PARTS OF BOBWHITE QUAIL

Quail #	Parts Mercury Per Million							
	Breast Muscle	Leg Muscle	Liver	Brain	Left Wing Feathers	Right Wing Feathers	Average Feathers	Ratio Feathers/ Breast Muscle
1	.025	.032	.043	.035	0.55	0.39	0.47	19
2	,041	.032	.049	.032	1.14	1.12	1.13	28
3	.033	.020	.033	.031	0.64	0.91	0.78	24
4	.046	.023	.049	.032	0.41	0.63	0.52	11
5	.022	.030	.026	.030	0.45	1.25	0.85	39
Ave.	.033	.027	.040	.032			0.94	28=Ratio of Averages 24=Average of Ratios

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HOME RANGE AND DISPERSAL IN A NORTH CAROLINA GRAY SQUIRREL POPULATION

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ABSTRACT

Home range and dispersal patterns of gray squirrels (*Sciurus carolinensis*) in an unexploited population near Raleigh were determined by recapturing marked or tagged animals in leaf nests, live traps and artificial nest boxes during 1956-65. Adult gray squirrels occupied yearly home ranges averaging 1.8 Younger squirrels were more mobile and had larger home areas, 2.7 acres for subadults and 2.5 acres for juveniles. In all age classes males had larger average home ranges than females. Home ranges of young females and of adults were