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MERCURY RESIDUES IN WOOD DUCKS AND WOOD DUCK FOODS IN EASTERN TENNESSEE

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ABSTRACT: Liver, breast muscle and body fat from 50 juvenile and five adult wood ducks (*Aix sponsa*) collected on the Holston River, Tennessee were analyzed for total mercury content. Black fly larvae (*Simulium vittatum*), sago pondweed (*Potamogeton pectinatus*), tapegrass (*Vallisneria americanus*), water stargrass (*Heteranthera dubia*), *Elodea canadensis*, and river bottom sediments were also analyzed to elucidate the distribution of mercury in the wood duck's environment. Liver tissues of juveniles contained the highest mean concentration of mercury (0.42 ppm). Mercury in breast muscle and body fat of juveniles averaged 0.15 and 0.10 ppm, respectively. Residues in corresponding tissues of adults were lower. Of environmental components tested, sediments had the highest mean concentration (0.76 ppm). Black fly larvae and aquatic plants had mean levels below 0.10 ppm.

INTRODUCTION

In the early 1970's mercury contamination in several Tennessee waterways came to the attention of the Tennessee Valley Authority (news release, 14 July 1970) and the Tennessee Game and Fish Commission (1971). Their immediate investigations into the extent of the mercury problem resulted in closing to fishing Pickwick Reservoir in west Tennessee and the North Fork of the Holston River in east Tennessee and Virginia.

Mercury pollution in the Holston River resulted primarily from wastes discharged by a chlor-alkali plant located along the North Fork in Saltville, Virginia. This plant discharged in waste water about 0.23 kg per day of elemental Hg into the Holston River until it closed in July 1972. Mercury continues to enter the Holston River from this plant in seepage from sedimentation lagoons (Bailey, 1974). Sampling by the Virginia State Water Control Board (1974) indicated that mercury levels in fish and sediments did not decrease as expected immediately following closure. Mercury in sediments is very persistent and may continue to contaminate aquatic organisms for decades (Wallace et al., 1971).

Studies of mercury contamination of waterfowl have concerned seed-eating birds such as mallards (*Anas platyrhynchos*) and pintails (*A. acuta*) which ingest mercury by eating agricultural grains coated with a mercury fungicidal seed dressing (Vermeer, 1971; Vermeer and Armstrong, 1972; Krapu et al., 1973), or species which feed on aquatic invertebrates and fish (Fimreite, 1974; Peterson and Ellarson, 1976). Kleinert and Degurse (1972) reported mercury levels in 20 wood ducks from several locations in Wisconsin, and Pearce et al. (1976) analyzed mercury content in breast muscle of two wood ducks from eastern Canada, but this species has been little studied in this respect.

Our objective was to determine concentrations of mercury in juvenile wood ducks on the Holston River and in various components of their food chain. Flightless juveniles were selected for analysis to assure that mercury residues in their tissues were picked up from our study area.

METHODS AND MATERIALS

The study area was a 51.5-km segment of the Holston River extending south from the confluence of the North and South Forks of the Holston River near Kingsport, Tennessee. The Holston River is characterized by long, bending pools intermittently broken by shallow, rocky segments of shoals. The river bed is composed entirely of Sevier shale, a very thick layer of blue-gray shale, sandy shale and limestone (Rodgers, 1953). Average width of the river channel is 128 m, with a floodplain varying from 0.4 to 1.6 km.

Flow rates of the river changed rapidly due to runoff from heavy rainfall and discharges from Ft. Patrick Henry Dam located 13.2 km above the study area on the South Fork of the Holston River. Minimum flow rate from this dam was 12.7 CMS. Maximum flow during our study was 1,132.8 CMS at a point on our area about 45 km downstream from the dam. Daily water discharges were intermittent, with larger discharges occurring during the daylight hours of the weekdays. Aquatic vegetation was abundant throughout the study area, primarily sago pondweed,

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TABLE 1. Mercury residues (ppm) in tissues of wood ducks from the Holston River, Tennessee.

Tissue	Juveniles (n = 50)			Adults (n = 5)		
	$\bar{x}$	Range	SD	$\bar{x}$	Range	SD
Liver	0.42	0.13–1.10	0.23	0.20	0.12–0.34	0.09
Breast muscle	0.15	0.05–0.40	0.08	0.08	0.06–0.11	0.02
Fat	0.10	0.01–0.40	0.09	0.06	0.01–0.11	0.05

curly leaf pondweed, and water stargrass. Turbulence resulting from high water levels caused uprooting of large mats of sago pondweed, the principal rooted aquatic plant species, and an important food for young wood ducks.

Wood ducks were collected by shooting in July–August 1972 and May 1973. Each bird was weighed and labeled according to sex, age, location, date and time of collection. Breast muscle, body fat and liver tissues were removed immediately following shooting, placed in polyethylene vials, and frozen in dry ice containers. Kidney tissue was removed from 17 birds and handled similarly.

Sago pondweed tubers and the leaf and stem portions of water stargrass, tape grass and *Elodea* were selected for analysis. These aquatic plants were shown to be important food items for young wood ducks by Hocutt and Dimmick (1971). Black fly larvae were collected by hand in shallow riffle areas. All food items were placed in 2-dram polyethylene vials and frozen immediately. Bottom sediment was collected by pushing vials into the sediment until full, thus sampling the upper 5.8 cm of sediment. Excess water was drained and the samples frozen immediately. All samples were shipped in dry ice containers to the Research Reactor Facility in Columbia, Missouri for analysis by flameless atomic absorption technique, following the procedure described by Vermeer (1971). Though mercury was likely ingested by the ducklings in its methylated form, the analytical procedures defined concentrations as ppm elemental mercury on a wet-weight basis.

Statistical analyses included computation of means and standard deviations of mercury concentrations in all materials analyzed. Correlation analyses were used to detect differences in mercury concentrations related to distance from the source.

RESULTS AND DISCUSSION

A total of 50 juvenile and five adult wood ducks were analyzed for mercury residues in liver, breast muscle and body fat. All juveniles were pre-flight age, averaging 345.2 g (range 95–524 g). All adults weighed more than 520 g. The limited mobility of the flightless juveniles, and the scarcity of subsidiary feeding areas in the vicinity of the study area were strong indicators that the highly productive, but mercury contaminated Holston River was the source of most of the food of juveniles.

Mercury residues were highest in liver tissue and lowest in body fat for both age groups (Table 1). Breast muscle residues averaged 37% of liver tissue levels in juveniles, comparable to Fimreite's (1974) observations for adult mallards. Residues in adult tissues were lower than residues in comparable tissues of juveniles. By comparison, Fimreite (1974) found much greater mercury residues in adult mallards and lower residues in adult common goldeneyes (*Bucephala clangula*). Kidney tissue from 17 juveniles contained mercury residues (0.41 ppm) similar to liver.

Among juvenile wood ducks mercury residues in liver and breast muscles were positively correlated (r = 0.77). However, mercury levels were not correlated with body weight, indicating that the young birds accumulated a dosage level early in life without significant later increase. This may have been related to dietary patterns which change with increasing age. Hocutt and Dimmick (1971) observed that Class A ducklings on John Sevier Lake, immediately downstream from our study area, fed predominantly on dipteran larvae, while older ducklings fed predominantly on pondweed tubers. Black fly larvae contained greater mercury residues than pondweed tubers (Table 2). Twenty-nine ducklings in our sample fed principally on curly-leaved pondweed, black fly larvae and sago pondweed tubers, but we had no Class A ducklings in our sample. The shift in diet from predominantly animal to plant with increasing age of ducklings observed by Hocutt and Dimmick (1971) may reduce the daily intake of mercury to a level comparable to excretion rates.

Of environmental components examined, bottom sediments were most heavily contaminated with mercury (Table 2). Black fly larvae, which along with adults and pupae were important foods, contained mercury residues less than 10% that of bottom sediments but several times greater than the ducklings' principal plant foods.

TABLE 2. Mercury residues (ppm) in wood duck habitat components on the Holston River, Tennessee.

Habitat component	n	x̄	SD
River bottom sediments	15	0.76	0.442
Black fly larvae (*Simulium vittatum*)	15	0.07	0.036
Sago pondweed tubers (*Potamogeton pectinatus*)	15	0.01	0.005
Elodea canadensis	5	0.05	0.015
Water stargrass (*Heteranthera dubia*)	5	0.02	0.005
Tapegrass (*Vallisneria americanus*)	5	0.02	0.006

Correlation analyses demonstrated no consistent trend in mercury levels in bottom sediments of our study area related to distance from the source in Saltville. However, the upper end of our study area was more than 80 km from the source, so we do not conclude that distance from the pollution source is not significant for the river system as a whole. Neither did we detect a consistent trend in mercury residues in wood duck tissues related to distance from the source.

Mercury residues in tissue of wood ducks in our sample were lower than levels reported for waterfowl in several other areas believed to be contaminated by mercury (Vermeer and Armstrong, 1972; Krapu et al., 1973; Vermeer et al., 1973; Fimreite, 1974; Baskett 1975), and were on the low end of the range for waterfowl from uncontaminated areas (Baskett, 1975). Juvenile pintails and mallards in Ontario, for example, contained mean mercury residues in liver of 0.72 and 2.19 ppm, respectively, and adult common mergansers (*Mergus merganser*) from two heavily contaminated lakes contained mercury in their livers in excess of 46 ppm (Fimreite, 1974). Fimreite and Karstad (1971) determined that 20 ppm mercury in livers approximated the lethal level of red-tailed hawks (*Buteo jamaiciensis*) fed experimental diets high in methyl mercury. Apparently, however, other birds are less affected as demonstrated by the high levels observed by Fimreite (1974) in several species of wild birds. It is unlikely that wood ducks on the Holston River are threatened by current levels of mercury in their tissue, or in their environment. Similarly, we would not expect wintering waterfowl, seasonally abundant but highly transient, to incorporate significant levels of mercury into their tissues.

From the standpoint of human health, mercury in breast muscle of wood ducks from the Holston River posed no problem for consumers. The greatest mercury level for juveniles was 0.4 ppm, and the mean value (0.15 ppm) was much lower than safe levels defined by the FDA (1.0 ppm).

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BOOK REVIEW . . .

Diseases of Wildlife in Wyoming, E. T. Thorne, N. Kingston, W. R. Jolley, and R. C. Bergstrom, eds. Wyoming Fish and Game Dept., 5400 Bishop Blvd., Cheyenne, Wyoming, USA. 1982. 353 pp. $20.00 US (hardbound) $12.00 US (softbound).

I was never able to obtain a copy of the original edition of Diseases of Wildlife in Wyoming (R. F. Honess and K. B. Winter, 1956, Bull. 9, Wyo. Game and Fish Comm.), but the copy made available to me the last 10 yr shows evidence of heavy use. The reason is clear. Until 1971 when the Davis et al. series on diseases and parasites of wild birds and mammals appeared, Honess and Winter was the only substantive reference book for diseases of wildlife in the Rocky Mountain region. Unlike edition one, the current edition comes on the heels of several similar books including: Manual of Common Parasites, Diseases and Anomalies of Wildlife in Ontario (1979, edited by Fyvie and Addison), a similar manual for Colorado (1981, edited by Adrian), and a volume on Alaskan Wildlife Diseases (1981, edited by Dieterich). Diseases of Wildlife in Wyoming will fare well among the competition.

Edition two contains seven sections: viruses (27 pp., 117 refs.), bacteria (75 pp., 281 refs.), protozoans (47, 143), platyhelminths (32, 81), nematodes (41, 104), ectoparasites (29, 52), and miscellaneous diseases (40, 223). There is a useful appendix on methods for collecting and preserving specimens for diagnostic examination. The glossary (~350 terms) is well done and the book well indexed (26 pp.). The text is annoyingly but accurately referenced by number. This space-saving tactic does have benefits (check the price).

There are 35 color photographs, most of which are useful, and numerous black and white photographs and drawings, some of which are poor in quality. The decision to not only retain many photographs and drawings from the first edition, but to reduce many of them in this revision was an error. Photographs are particularly poor (dark) in the platyhelminths section and even when photographs were not reduced, their quality is sometimes poor (see p. 176) when compared to the original edition.

The writing style of the book is technical but readable. Treatment of each organism or group of organisms is consistent in each section and covers: distribution and hosts affected, life cycle, transmission, pathogenesis, clinical signs, pathology, diagnosis, prognosis, control, and implications (i.e., how hosts are affected). The title is slightly misleading in two respects: *disease* is used in a very broad context often including only the presence of a parasite, and *wildlife* includes, primarily, terrestrial game animals.

Viruses (see under *viruses* and *miscellaneous diseases*) are covered in up-to-date, accurate style. There is a terrific review table on tumors. The *bacteria* section is, perhaps, the best in the book; it contains an excellent summary table of bacteria recovered from Wyoming's wildlife.

Treatment of internal and external parasites is fairly extensive and, generally, good. Summary tables for some of the conditions (for example, characters of oocysts of *Eimeria* spp. or prevalences, intensities, hosts of nematodes) would have helped particularly since one aim of the book is to aid in the diagnosis of conditions. The coverage of certain conditions such as coccidiosis could have been better. In that area, descriptions of oocysts are too brief, there are some factual errors (see, for example, "*Eimeria* of rabbits and hares"), and line drawings of oocysts could have been put to good use. Use of two scientific names for two life stages of the same parasite (here, cestodes of wild ruminants) is confusing.

Twenty-three authors have contributed to this good reference text. The book will find wide use among various wildlife disciplines. It should prove particularly useful to wildlife managers, veterinarians who deal with wildlife, and wildlife students of the Rocky Mountain region. There are some deficiencies, but the overall product makes this a worthwhile purchase.

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