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Productivity and PCDDs / PCDFs in Eggs from Two Great Blue Heron Rookeries Near a Pulp and Paper Mill on the Roanoke River, North Carolina.

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Productivity and PCDDs / PCDFs in Eggs from Two Great Blue Heron Rookeries Near a Pulp and Paper Mill on the Roanoke River, North Carolina. **D.K. Beeman,** NCSU, Raleigh, NC; Augspurger, T.A., USFWS, Raleigh, NC; Fleming, W.J., USFWS, Raleigh, NC. We assessed productivity and egg PCDD / PCDF concentrations at two great blue heron (Ardea herodias) rookeries at Roanoke River National Wildlife Refuge in eastern NC. Rookeries were approximately 20 km upstream of a large bleached kraft paper mill; average 2,3,7,8-TCDD equivalents (TEQ) in whole fish near the mill are approximately 80 pg/g with maximum TEQs of 180 pg/g. Clutch size was normal, averaging 3.76 (range 2 to 5) eggs per nest (n = 17). Hatching success was 82.9 percent and productivity averaged 2.07 young per active nest. No gross embryonic abnormalities were noted. Eggshell thickness (0.403 mm) and Ratcliffe Index (1.98) were normal. The 2,3,7,8-substituted PCDDs and PCDFs were analyzed in eggs from 2 nests via high resolution capillary GC/MS. Eggs from 8 additional nests were analyzed for 2,3,7,8-TCDD and 2,3,7,8-TCDF only. The 2,3,7,8-TCDD congener was detected in one sample at 11 pg/g and was below detection (<3 to <10 pg/g) in the rest. The 2,3,7,8-TCDF congener was not detected (<1 to <10 pg/g depending on extent of matrix interferences). Other congeners detected were 1,2,3,7,8,9-HxCDF (12 to 17 pg/g) and OCDD (11 pg/g). Concentrations of 2,3,7,8-substituted PCDDs / PCDFs reported here are below those currently thought to impair avian productivity. Future research efforts should focus on productivity of piscivorous species known to nest and feed downstream of the mill where fish PCDD / PCDF concentrations are highest.

STUDY AREA

The Roanoke River originates in Virginia and flows southeast into the Albemarle Sound in northeastern North Carolina. The lower portion of the river flood plain contains the largest intact bottomland forest ecosystem in the Mid Atlantic.

Two colonies of herons are located in areas that are (or will be) part of the Roanoke River National Wildlife Refuge. Both colonies are located upstream from a large bleached Kraft pulp paper mill at Plymouth , but within the feeding ranges of great blue herons (Figure 1). Although dioxins levels have been steadily declining in recent years the average 2,3,7,8-TCDD equivalents in fish near the mill have been as high as 80 pg/g with maximum TEQs of 180 pg/g.

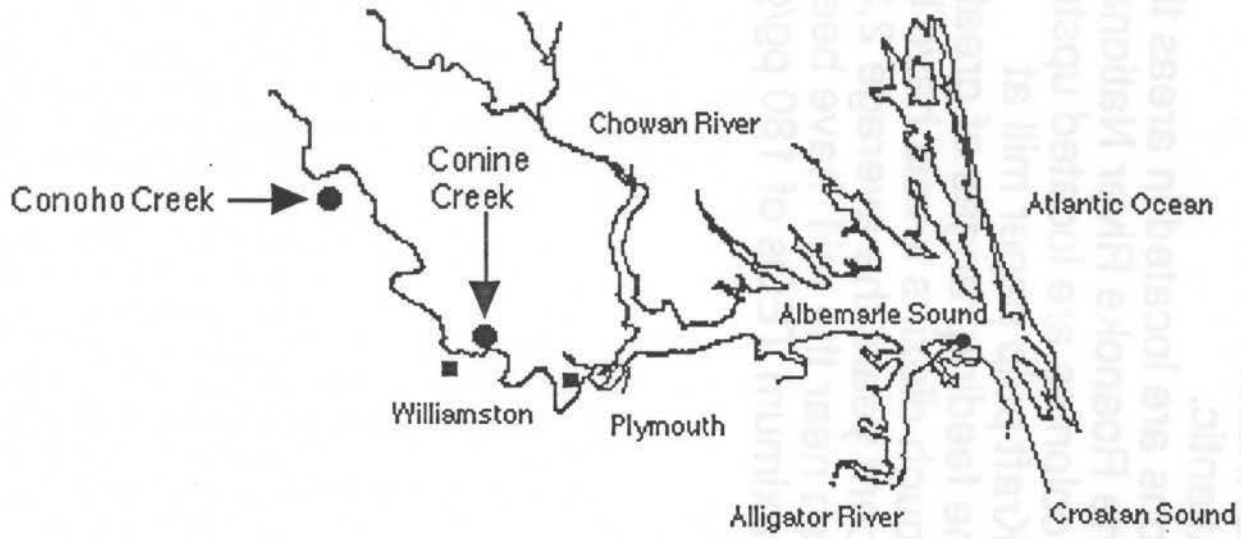


FIGURE 1. LOCATION OF THE CONINE CREEK AND CONOHO CREEK COLONIES OF GREAT BLUE HERONS

INTRODUCTION

Dioxins (PCDDs) are a class of persistent, lipophilic compounds that exhibit high toxicity to vertebrates. They can induce congenital malformations and reproductive failure in birds. Gilbertson and Fox (1977) reported that dead herring gull embryos had symptoms consistent with chick edema disease, a dioxin related condition. Retrospective analysis of these gulls showed 2,3,7,8 TCDD concentrations in the range of those causing chick edema disease within experimental animals (Gilbertson, 1983). High levels of PCDDs in 1987 may have contributed to total reproductive failure in a great blue heron colony located near a pulp paper mill in British Columbia (Elliott et al.,1989).

Fish eating birds are top level carnivores and as such may accumulate lipophilic contaminants to concentrations that decrease reproductive success. Great blue herons, anhingas, ospreys and other aquatic piscivorous birds inhabit the Roanoke River floodplain in North Carolina, an area contaminated with dioxins, a byproduct of pulp paper industries. We have addressed the degree of dioxin exposure and its effects on fish eating birds by assessing the productivity of two colonies of great blue herons and relating it to dioxin levels found in eggs from these colonies.

METHODS

Our basic sampling scheme is described in Figure 2.

Egg Collections

Nests sampled were selected based on accessibility. Professional climbers accompanied us to the colony sites and climbed selected trees to gain access to the heron nests. Each nest was marked for individual identification. One egg was removed from 7 to 10 nests per colony.

Estimating Hatching Dates

Eggs were weighed and measured for length and breadth. The specific gravity of the egg was used to determine hatching dates according to the method of Custer et al. (1992).

Preparation of Egg for Analysis

The eggs were opened at the equator by scoring the egg with a scalpel. Embryos were examined and classified as early, mid or late developmental stage and were examined for gross morphological abnormalities (crossed bills, etc.). Egg contents were placed into chemically cleaned jars , then frozen until analyzed.

Eggshell measurements

Eggshells were allowed to air dry for thirty days and eggshell thickness was determined by three micrometer measurements around the equator of the

egg. Each eggshell was weighed and the Ratcliffe Index calculated (Ratcliffe, 1976).

Hatching Success

A second visit to each colony was timed to assure that the majority of the nests had nestlings one to two weeks old. The number of young, unhatched and missing eggs were noted.

Fledging Success

The number of nests per colony, species composition and the proportion of active nests were estimated by aerial survey. A second flight was conducted to determine the number of fledglings.

Analytical Chemistry

Two eggs representing both colonies were analyzed for the seventeen 2,3,7,8-substituted PCDDs and PCDFs; an additional 8 eggs were analyzed for only 2,3,7,8-TCDD and 2,3,7,8-TCDF. All analyses were performed by Pacific Analytical, Incorporated of Carlsbad, California via high resolution capillary column gas chromatography / mass spectrometry (HRGC/HRMS) according to EPA Standard Method 1613. This method includes addition of stable ^{13}C-labeled analogs of 15 of the PCDDs and PCDFs to each sample prior to homogenization, Soxhlet extraction, and clean-up.

The limit of detection was 3.0 to 10.0 pg/g (wet weight) for 2,3,7,8-TCDD and TCDF depending on the extent of matrix interferences. Lower limits of

detection for analytes in the extended 2,3,7,8-substituted PCDD / PCDF scan ranged from 1.0 to 13.0 pg/g. For non-2,3,7,8-substituted isomers, total concentrations of all isomers within a level of chlorination (i.e., total TCDD less the 2,3,7,8-substituted isomers) are reported.

A method blank was extracted with the samples and was found to be free of contamination above a 1.0 pg/g detection limit. Recoveries of labeled compounds were within acceptable method ranges for accuracy. Concentrations reported below have been corrected for recoveries of labeled analogs. .

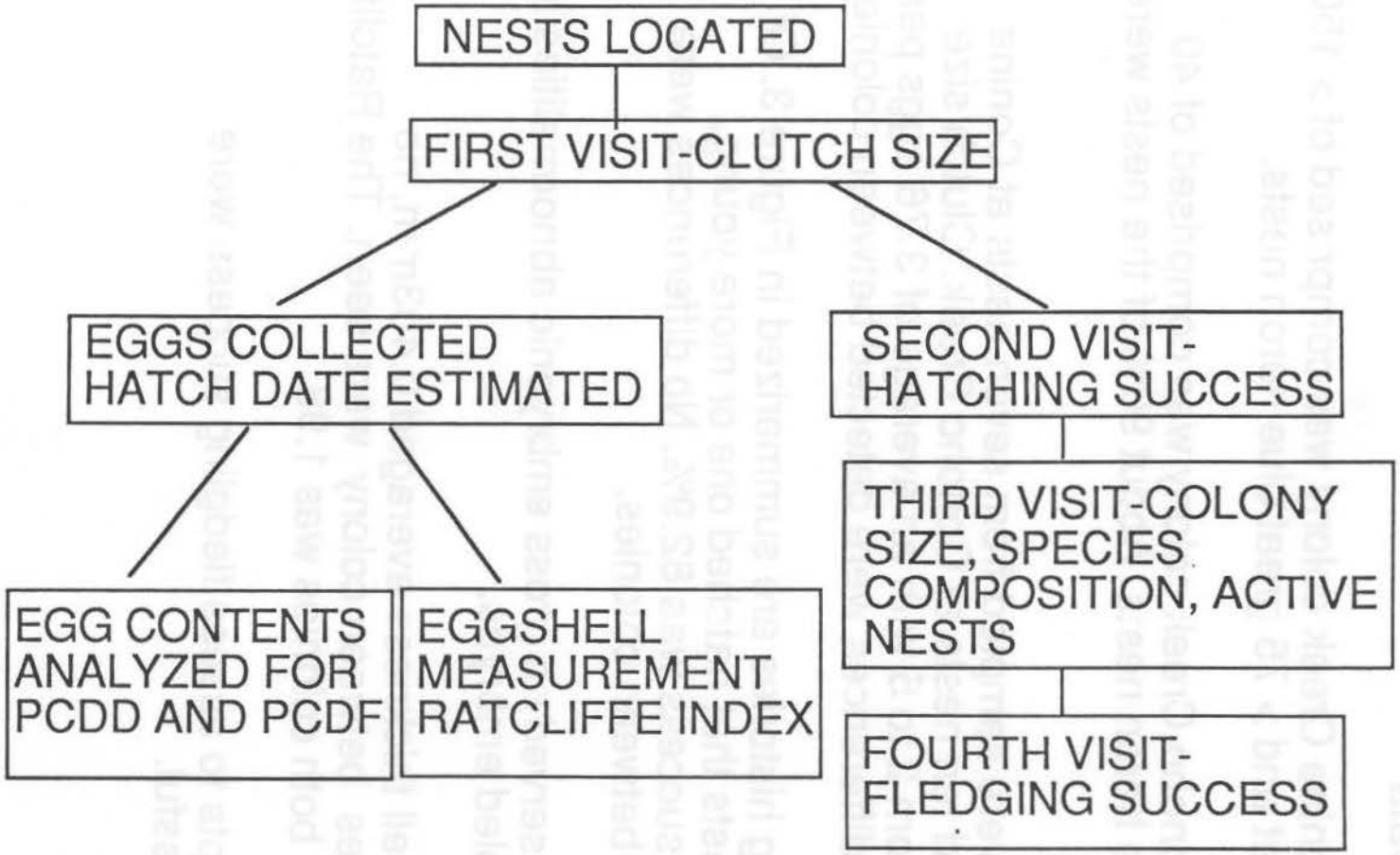


FIGURE 2. EXPERIMENTAL SAMPLING SCHEME FOR GREAT BLUE HERON STUDY, 1991

RESULTS

Nesting Data

1. The Conine Creek colony was comprised of > 150 great egret and > 75 great blue heron nests.

2. The Conoho Creek colony was comprised of 40 great blue heron nests. About 90% of the nests were active.

3. Eggs were sampled from seven nests at Conine Creek and ten nests at Conoho Creek. Clutch size ranged from 2 to 5 with an average of 3.76 eggs per nest. No differences were detected between colonies.

4. Nesting histories are summarized in Figure 3. Of the 11 nests that hatched one or more young, hatching success was 82.9%. No differences were detected between colonies.

5. We observed no gross embryonic abnormalities in the sampled embryos.

6. Eggshell thickness averaged 0.403mm, no differences between colony were seen. The Ratcliffe Index for both colonies was 1.98.

7. Attempts to assess fledgling success were unsuccessful.

PCDDs and PDCFs

1. The 2,3,7,8-TCDD congener was detected in one sample at 11 pg/g (wet weight) and was below detection (<3 to <10 pg/g) in nine eggs. The 2,3,7,8-TCDF congener was not detected in any samples (<1 to <10 pg/g depending on extent of matrix interferences).

2. In the extended scans performed on two samples, 1,2,3,7,8,9-HxCDF was detected at 12 and 17 pg/g, and OCDD was detected in one sample at 11 pg/g. Calculated 2,3,7,8-TCDD equivalents (TEQ) for the two eggs in which residues were detected are 2 pg/g and 12 pg/g (Table 1).

3. For the non-2,3,7,8-substituted isomers, total TCDD was < 1 pg/g, total PeCDD ranged from 10 to 13 pg/g, HxCDD and HpCDF were < 5 pg/g, total TCDF ranged from 120 to 260 pg/g, total PeCDF ranged from 85 to 230 pg/g, total HxCDF ranged from 85 to 220 pg/g, and total HpCDF was detected at 54 and 150 pg/g.

TABLE 1. PCDDs AND PCDFs IN TWO GREAT BLUE HERON EGGS FROM THE ROANOKE RIVER,THE CORRESPONDING TOXICITY EQUIVALENCY FACTORS (TEFs), AND CALCULATED 2,3,7,8-TCDD EQUIVALENCIES(TEQs). CONCENTRATIONS ARE PG/G WET WEIGHT.

ANALYTE	CONCENTRATION		TEFa	TEQ	
	SAMPLE # 1	SAMPLE # 2		SAMPLE #1	SAMPLE 2
2,3,7,8 TCDD	11	ND	1.000	11	
1,2,3,7,8 PeCDD	ND[b]	ND			
1,2,3,4,7,8 HxCDD	ND	ND			
1,2,3,6,7,8 HxCDD	ND	ND			
1,2,3,7,8,9 HxCDD	ND	ND			
1,2,3,4,6,7,8 HpCDD	ND	ND			
OCDD	ND	11	0.001		0.0
2,3,7,8 TCDF	ND	ND			
1,2,3,7,8 PeCDF	ND	ND			
2,3,4,7,8 PeCDF	ND	ND			
1,2,3,4,7,8 HxCDF	ND	ND			
1,2,3,6,7,8 HxCDF	ND	ND			
1,2,3,7,8,9 HxCDF	12	17	0.100	1.2	1.7
2,3,4,6,7,8 HxCDF	ND	ND			
1,2,3,4,6,7,8 HpCDF	ND	ND			
1,2,3,4,7,8,9 HpCDF	ND	ND			
OCDF	ND	ND			
TOTAL PCDD/PCDF TEQS				12	2

a International TEFs from Kutz et al 1990 .

b ND=not detected at estiamted detection limits ranging from 3 to 10 pg/g

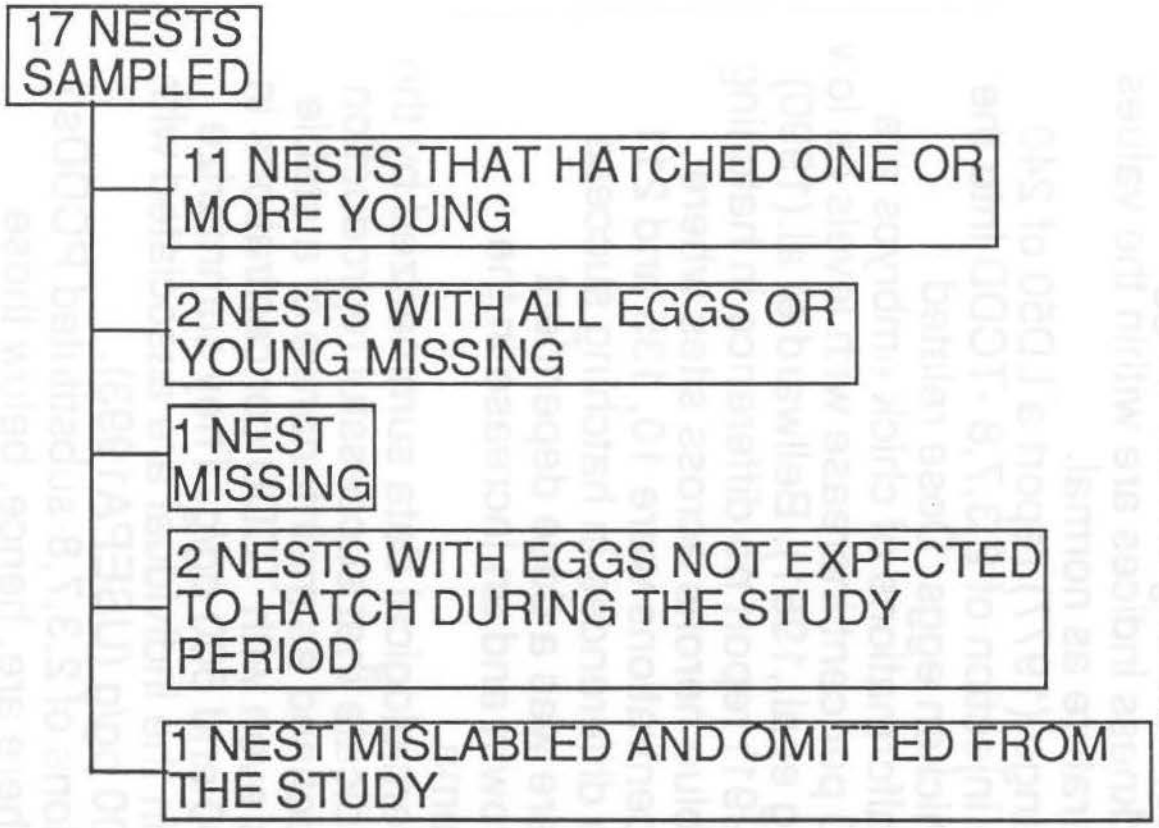


FIGURE 3. NESTING HISTORIES OF GREAT BLUE HERONS FROM TWO COLONIES ON THE ROANOKE RIVER, 1991

DISCUSSION

Osborn and Custer (1978) reported the Conine Creek colony consisted of about 100 great egrets and 175 great blue herons in 1976; our estimates were 150 and 75 in 1991. The size of the Conoho Creek colony was about half that reported in 1976. However average clutch size, hatching success, eggshell thickness and thickness indices are within the values reported in the literature as normal.

Allred and Strange (1977) report a LD50 of 240 pg/g following the injection of 2,3,7,8 -TCDD into the air cell of fertile chicken eggs. Dose related cardiovascular malformations of chick embryos are reported with a 20 per cent increase with levels as low as 6 pg/g (Cheung et al.,1981). Bellward et al.(1990) and Hart et al. (1991) report no difference in hatching success of great blue herons across sites where mean TCDD concentrations were 10, 135 and 211 pg/g. Although no differences in hatching success were detected there was a dose dependent suppression of growth and an increase in the occurrence of edema.

Available epidemiological data summarized by the USEPA (1993) indicate that successful reproduction in wild colonies, defined as maintenance of a stable population, exists even with TCDD concentrations in eggs between 200 and 500 pg/g. They summarize that toxic effects in the individual are associated with levels at about 100 pg/g (USEPA1993).

Concentrations of 2,3,7,8-substituted PCDDs / PCDFs reported here are, hence, below those currently thought to impair avian productivity.

CONCLUSIONS

1. The numbers of nests in Conine Creek and Conoho Creek have decreased since the last intensive surveys.

2. Average clutch size, hatching success, eggshell thickness, and thickness indices are consistent with good productivity.

3. Residues were detected in 20 per cent of the eggs sampled but reproductive effects were not seen. Levels are not within the range known to effect reproduction in other avian species.

4. Other fish eating birds should be sampled.

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