NON-LETHAL SAMPLES PREDICT SOFT TISSUE MERCURY CONCENTRATIONS FOR TWO WADING BIRD SPECIES

Heather A. Brant[a], A. Lawrence Bryan, Jr.[a], Eric L. Peters[b], Charles H. Jagoe[a], Noelle T. Garvin[a], Warren L. Stephens, Jr.[a] and I. Lehr Brisbin, Jr.[a]

[a]*University of Georgia's Savannah River Ecology Laboratory, Aiken SC.* [b]*Department of Biological Sciences, Chicago State University, Chicago, Il*

ABSTRACT

Mercury has been recognized as a serious threat to piscivorous birds, including endangered species such as the wood stork (*Mycteria americana*). Because of their protected status, assessments of mercury accumulation in wading birds would be facilitated by use of an easily-collected, non-invasive tissue sample (e.g., feathers). In order to be effective, this form of bio-monitoring must be evaluated for its sensitivity to temporal and spatial changes in exposure and resulting accumulation. While studies comparing mercury concentrations in keratinized structures with those of soft tissues have been conducted on seabirds and waterfowl, the strength of these associations in wading birds has as yet received little attention. As part of on-going studies, we obtained 49 carcasses of juvenile and nestling wood storks and compared total mercury concentrations in the claws and breast/primary feathers to those of breast and leg muscles, liver, heart, kidney, and brain. We also compared total mercury concentrations in tissues and feathers from captive snowy egret (*Egretta thula*) nestlings fed diets containing 50 or 120 µg mercury kg-1 for 60 days. In both species, mercury concentrations were well correlated between soft tissues and keratinized structures. Tissue concentrations in captive juvenile snowy egrets were similar to those of the free-ranging juvenile wood storks, suggesting that the dietary doses in this experiment were environmentally realistic. Our results show that non-lethal tissue samples can be used to monitor total mercury accumulation in these wading birds.

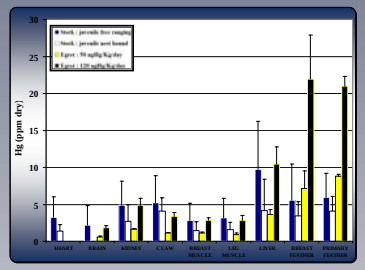
BACKGROUND

- Wood storks (*Mycteria americana*) are at the top of the food web of shallow fresh- and saltwater wetlands and as such, are a sentinel species of the health of these ecosystems.
- Historically, these large piscivorous wading birds were the victims of land use changes in the U.S., as wetlands were drained to support human activities. This loss of foraging habitat has resulted in the classification of *M. americana* as a federally listed endangered species.
- Concurrently, mercury is a global pollutant of growing significance that may impact recovery of the endangered wood stork.
- Mercury is documented in the prey of wood storks and in nestling and adult tissues.
- Concentrations of Hg in down/feathers (typically from the breast area) have been used as non-lethal indicators of Hg concentrations in storks and other avifauna. However, the ability of this tissue to estimate concentrations in organs and other tissues has not been examined for storks. We examined Hg concentrations in feathers of wood stork carcasses relative to other tissues to assess their ability to predict concentrations in these organs and tissues. We also utilized Hg accumulation data from a study of captive snowy egrets fed known Hg concentrations in support of this study

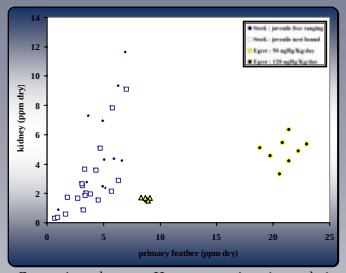
METHODS

- Archived carcasses of juvenile storks collected over a ten-year period from the Southeastern US and oflaboratory reared egrets were dissected for liver, kidney, brain, claw, feather (primary and breast) and breast, leg and cardiac muscle.
- Storks were categorized as either nest bound (n = 27) or free ranging (n = 20); indicating fledging from the nest and more variety of foraging locations. These determinations were made based on data collected from collection sites and from feather plumage.
- As part of a former study, data from the lab-reared egrets were used for comparison purposes. Briefly, Pipping eggs and newly-hatched young were collected from a colony on Pinkney Castle Island in Charleston Harbor, South Carolina. After hatching, small young were housed in artificial nests; they were later (~15 days old) shifted to 1-m^3 cages with an artificial nest, heating pad and a perch. The egrets were fed a diet of 70% ground bass fillets and 30% Nebraska Brand Bird of Prey diet. Bass originated from two sources:(1) L-Lake, Savannah River Site, South Carolina = elevated Hg diet: 0.4–0.5 ppm Hg (120 µg Hg/kg/day), and (2) Thurmond Reservoir, South Carolina = background Hg diet: 0.1–0.2 ppm Hg (50 µg Hg/kg/day), resulting in two levels of mercury exposure. This produced a more environmentally realistic dose. Egrets also received oral Vionate vitamin/mineral supplement, and later intramuscular injections of calcium. The Vionate supplement failed to provide adequate calcium, and several birds were euthanized after being diagnosed with metabolic bone disease. These mortalities were unrelated to dosing, but only 5 lower-dose and 8 higher-dose egret nestlings remained throughout the entire 60-day study. All observations reported here are from these 13 birds.
- Egrets were categorized according to median dose (µgHg/kg/day).
- Tissues were analyzed for total mercury by either acid digestion, BrCl oxidation and cold vapor atomic fluorescence spectrophotometer (CVAFS, Brooks-Rand Ltd.), or thermal decomposition, amalgamation, and atomic absorption (CVAA, Milestone Inc.).
- Analysis of the resulting data was performed using PROC GLM using SAS version 9.0 (SAS Institute, Cary, NC).

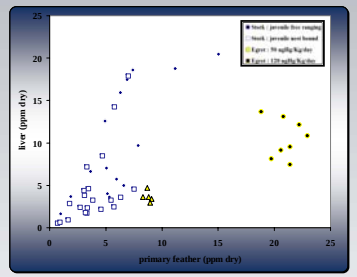
RESULTS



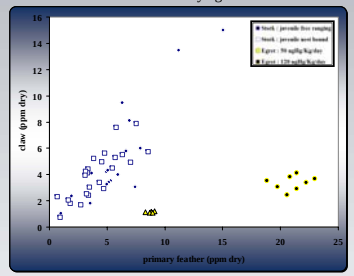
Mean and SE tissue Hg concentrations (ppm, dry) of wood storks and snowy egrets.



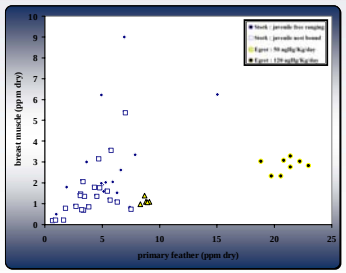
Comparisons between Hg concentrations (ppm, dry) in primary feathers and kidneys of juvenile wood storks and snowy egrets.



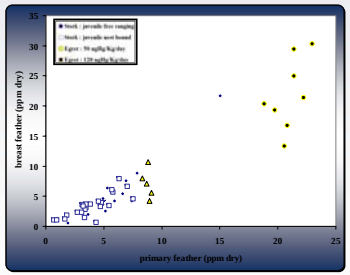
Comparison between Hg concentrations (ppm dry) in primary feathers and liver for juvenile wood storks and snowy egrets.



Comparison between Hg concentrations (ppm dry) in primary feathers and claw for juvenile wood storks and snowy egrets.



Comparison between Hg concentrations (ppm dry) in primary feathers and breast muscle for juvenile wood storks and snowy egrets.



Comparison between Hg concentrations (ppm dry) in primary feathers and breast feather for juvenile wood storks and snowy egrets.

Table 1. Pearson correlations (r) between log-transformed Hg concentrations (mg kg^{-1}) in the tissues of all wood storks (n = sample size; P = correlation significance). Hg concentrations in keratinized tissues were significantly correlated with the soft tissues examined.

		r (n)								
		Muscle						Feather		
		Breast	Leg	Cardiac	Liver	Kidney	Brain	Primary	Breast	Claw
	Breast Muscle		.924 (38)	.939 (40)	.863 (37)	.915 (32)	.975 (5)	.735 (38)	.549 (39)	.658 (39)
	Leg Muscle	<.0001		.896 (40)	.708 (37)	.930 (30)	.929 (5)	.635 (39)	.439 (37)	.636 (41)
	Cardiac Muscle	<.0001	<.0001		.902 (38)	.933 (32)	.969 (5)	.763 (41)	.598 (39)	.707 (43)
	Liver	<.0001	<.0001	<.0001		.976 (30)	.280 (5)	.804 (37)	.635 (36)	.684 (38)
P	Kidney	<.0001	<.0001	<.0001	<.0001		.937 (3)	.837 (31)	.564 (32)	.730 (32)
	Brain	.0020	.0194	.0032	.6843	>.9999		.317 (5)	.565 (5)	.848 (5)
	Primary Feather	<.0001	<.0001	<.0001	<.0001	<.0001	.6426		.804 (39)	.833 (42)
	Breast Feather	.0002	.0061	<.0001	<.0001	.0006	.3650	<.0001		.725 (39)
	Claw	<.0001	<.0001	<.0001	<.0001	<.0001	.0776	<.0001	<.0001	

CONCLUSIONS

Our results show that non-lethal tissue samples can be used to monitor total mercury accumulation in these wading birds.

Wood storks:

- Of the two most slow-growing keratinized tissues (primary feathers and claw), primary feathers were the best predictor of soft tissue Hg concentrations (correlations between brain and keratinized tissues were not statistically significant due to low sample sizes).
- Inclusion of breast feather or claw Hg concentrations in statistical analyses did not significantly improve predictions of Hg level in liver, kidney, breast muscle or leg muscle obtained from primary feathers alone.

Snowy egrets:

- The levels of Hg in tissues of egrets dosed at 50 ugHg/Kg/day resembled those of the wood storks, but at 120 ugHg/Kg/day, Hg was much higher. However, Hg in feathers (BUT NOT CLAWS) was much higher in egrets, and the concentration ratios of these tissues relative to liver was much higher. Possible explanations include differences in feather formation between the two species, different metabolic rates, etc.

ACKNOWLEDGMENTS

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The University of Georgia
Savannah River Ecology Laboratory