

Organochlorine Residues in Eggs of the Endangered American Crocodile (*Crocodylus acutus*)

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Most of the 27 species and subspecies of surviving crocodilians have declining populations and 22 of them are considered to be severely endangered (IUCN 1971). The United States population of the American Crocodile is no exception; it probably numbers between 100 and 300 individuals (OGDEN 1976). Nests of the species have been regularly surveyed by the staff of Everglades National Park. Our sample consists of eggs that remained in nests after the hatching of broods and of one clutch laid in captivity by an unmated female. Analysis of these samples for organochlorine contaminants has permitted a detailed examination of their contaminant loads and has allowed comparisons with a small sample analyzed in 1972 (OGDEN et al. 1973).

MATERIALS AND METHODS

All eggs were measured and weighed and their volume was determined by water displacement. Twenty-three eggs from eight clutches were analyzed for organochlorines at Patuxent Wildlife Research Center. One clutch was represented by a single egg, one by two eggs, five by three eggs, and one by five eggs.

The entire egg was analyzed except for the shell and shell membrane. Analytical methods were modified from CROMARTIE et al. (1975) as follows: A 10 g subsample of egg homogenate was blended with sodium sulfate and extracted 7 h with hexane in a Soxhlet apparatus. An aliquot of hexane extract equivalent to 5 g of the subsample was chromatographed on a Florisil column to remove lipids. A portion of this eluate was column chromatographed on silicic acid into four fractions to separate pesticides from polychlorinated biphenyls (PCBs) and to ensure the separation of dieldrin and endrin into a separate fraction. We analyzed the samples by electron-capture gas-liquid chromatography using a 1.5% OV-17/1.95% QF-1 column. PCBs were quantified on the basis of Aroclor 1260. Recoveries ranged from 83 to 104%. Residues were not adjusted for recovery. The lower limit of detection was 0.01 ppm.

Eggshell thickness was measured with a vernier caliper to the nearest 0.01 mm at three points around the equator of the bisected shell after removal of the thick shell membrane.

A few eggs had desiccated before collection. Their weights

were corrected to more accurately express residue levels by use of the equation $Y = -4 + 1.13X$, derived from fresh eggs, in which Y = egg mass (g) and X = volume (cc).

None of the eggs had embryos.

RESULTS AND DISCUSSION

The eggs contained a variety of organochlorine contaminants (Table 1). DDE, DDT, and PCBs were detected in all eight clutches. DDD, dieldrin, and metabolites of chlordane were each detected in seven clutches. Heptachlor epoxide was present at detectable levels in five clutches and mirex was found in four clutches. Endrin, toxaphene, and HCB were not detected. Mean residues were highest for DDE (1.2 ppm) and PCB (0.54 ppm) and were less than 0.1 ppm for all other contaminants.

There is remarkably close correspondence of the levels and kinds of contaminants present in eggs from the same clutch. In clutch no. IV from which five eggs were analyzed, for example, coefficients of variation for most contaminants fell between 0 and 25%, even though the amounts recorded were often near the detection limit. When tested by analysis of variance, differences among clutches were significant ($P < 0.05$) for DDE, DDT, and DDD and PCBs, but not for dieldrin. It is not surprising that such similarity should exist among eggs in a clutch owing to the reptilian pattern of yolking and depositing an entire clutch simultaneously. It seems therefore that a single egg per clutch would constitute an adequate sample for eggs of reptilian species.

OGDEN et al. (1973) reported analyses of five crocodile eggs collected from Everglades National Park in 1972. The number of clutches represented in that sample was not stated. DDT and DDD residues were higher significantly than in our later samples (Table 2), suggesting that environmental levels of these easily metabolized materials have declined in the interim. Mean levels of DDE were lower in the later samples, but the difference was not significant; these results are in agreement with other studies showing DDE's long persistence in the environment. Dieldrin, another extremely persistent contaminant, showed no significant change in levels over the 5-6 year interval between the samples. PCBs were not detected in the 1972 sample, but they were present in relatively great amounts in the later sample. PCB contamination may have occurred only recently in Florida Bay, or analytical difficulties may explain the differences. OGDEN et al. (1973) reported PCBs in some of the many species analyzed, but in most the levels were considerably lower than those reported here.

Residues of organochlorines in both samples were high compared with residues in most birds, fish, and invertebrates from the same area (OGDEN et al. 1973). However, they were low compared to residues in bald eagle eggs from Everglades National Park (KRANTZ et al. 1970). Also, DDE and dieldrin levels were lower than the 2.5 and 0.54 ppm in brown pelican eggs reported to affect repro-

TABLE 1
Mean residues (ppm, wet weight) of organochlorine pollutants in
eggs of the American crocodile.

Contaminant	Clutch ¹							
	I (3)	II (3)	III (3)	IV (5)	V (1)	VI (2)	VII (3)	VIII (3)
*p,p' DDE	1.0	1.5	0.68	1.5	0.37	2.9	.37	.99
*p,p' DDD	.04	.05	.01	.07	nd	.01	.01	.05
*p,p' DDT	.05	.04	.02	.23	.02	.12	.02	.06
Dieldrin	.02	.01	.01	.02	.02	.03	.02	nd
Heptachlor epoxide	.01	.01	nd	.04	nd	.02	.01	.01
Oxychlordane	.01	.01	nd	.04	.07	.03	nd	.01
<u>cis</u> -chlordane	nd	nd	.01	.01	nd	.01	nd	nd
<u>trans</u> -nonachlor	.02	.01	nd	.04	nd	.02	nd	.02
<u>cis</u> -nonachlor	.02	.01	nd	.03	nd	.02	nd	.03
mirex	.02	.01	nd	nd	nd	.02	.01	nd
*PCBs	.86	.39	.20	.69	.14	1.4	.11	.33

ENDRIN, TOXAPHENE, HCB - not detected.

¹ Numbers in parentheses are number of eggs analyzed.

* Significant differences among clutches, $p < 0.05$.

ductive success in that extremely sensitive avian species (BLUS et al. 1974). Therefore, it seems unlikely that the residues reported in American crocodiles are affecting reproductive success.

Shell thickness averaged $0.49 \pm .05$ mm and measurements were not significantly correlated with residues of DDE.

TABLE 2

Comparison of mean residues of pollutants in crocodile eggs in 1972 and 1977-78.

	1972; N = 5 (OGDEN et al. 1973)	1977-78; N = 23 (present study)	difference ¹
DDE	1.84	1.19	ns
DDD	0.11	0.04	*
DDT	0.33	0.09	*
Dieldrin	0.01	0.02	ns
PCB	nd ²	0.52	*

¹ - * statistically significant, $P < 0.05$; ns not significant.

² - not detected.

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