Bull. Environ. Contam. Toxicol. (1992) 48:739–746

Environmental Contamination and Toxicology

Residue Levels of Organochlorines and Mercury in Cattle Egret, *Bubulcus ibis*, Eggs from the Faiyum Oasis, Egypt

Wim C. Mullié,[1,2] A. Massi,[3] S. Focardi,[3] and A. Renzoni[3]

[1]Department of Toxicology, Wageningen Agricultural University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands; [2]Foundation for Ornithological Research in Egypt, Belfort 7, 4336 JK Middelburg, The Netherlands, and [3]Dipartimento di Biologia Ambientale, Università di Siena, Via delle Cerchia 3, 53100 Siena, Italy

In Egypt, the Cattle Egret Bubulcus ibis is a common resident bird of the Nile Valley, and locally of the southern part of the Nile Delta, and the Suez Canal area (Goodman & Meininger 1989). In the 1970s it disappeared as a breeding bird from the greater part of the Nile Delta, as did several other bird species, notably birds of prey (Mullié & Meininger 1985). Only in recent years some of the species that had declined are markedly recovering, such as the Black-shouldered Kite Elanus caeruleus (Meininger 1991) and the Cattle Egret (Pineau 1991; G.A.M. Atta pers. comm.).

There is circumstancial evidence that these birds declined -at least partially- as a result of pesticide use in the main cotton growing areas (Ghabbour 1974, 1976; Mullié 1989), but this has never been substantiated by supporting residue analyses. The recent recovery of some bird populations, commencing in the 1980s, coincides with a general shift from the use of organochlorines (except for endrin and HCH which are still in use) towards synthetic pyrethroids, organophosphates and carbamates in Egyptian agriculture: 30 million kg of formulated product annually, of which 70% are applied to cotton (El-Sebae & Soliman 1982).

The number of breeding pairs of Cattle Egrets in a well-known colony at Giza (30°.01'N 31°.13'E) steadily declined from 2500 in 1977 to 1100 in 1984 (Goodman & Meininger 1989). Therefore, it was decided to collect some eggs for residue analysis.

Cattle Egrets are not piscivores, such as most other egrets, but mainly insectivores. They feed in agricultural areas and likely are good indicators for

Send reprint requests to Wim C. Mullié at the above address (1).

pesticide use in these habitats. Based on gizzard contents analysis, Kirkpatrick (1925) concluded that Cattle Egrets in Egypt only occasionally take (semi) aquatic prey, such as toads, and further predominantly Orthoptera and Diptera on arable land.

Various studies have been published with respect to pesticides or heavy metals in the Egyptian environment (e.g. Saad et al. 1982, Aly & Badawy 1984, Badawy & El-Dib 1984, El-Dib & Badawy 1985a and b, Nabawi et al. 1987, Saleh et al. 1988) but, surprisingly, birds have been almost completely ignored. The data presented here are the first residue analyses of bird eggs from an agricultural area in Egypt, and as such they can be considered as baseline data for future research.

MATERIALS AND METHODS

A Cattle Egret colony of some 1445 occupied nests south of El Faiyum, Egypt (29^{o}.19'N 30^{o}.48'E), along the road from Sinnuris, was visited on 31 May 1986. From seven different nests with complete clutches, out of 70 in an Acacia spp. tree, a single egg was collected, numbered, and subsequently stored in a refrigerator at 4 ^{o}C. In July the eggs were shipped to the Department of Toxicology, Wageningen Agricultural University, The Netherlands. Here they were weighed, measured with calipers and yolk and albumen (not separated) were freeze-dried and subsequently transported to the laboratory at Siena, Italy. After drying, eggshells were weighed and shell thickness was measured with a digital electronic micrometer with a resolution of 0.001 mm and an accuracy of $\pm$ 0.002 mm.

Analysis of Hg was performed by Atomic Absorption Spectrophotometry. Pretreatment of the freeze-dried samples was made by a wet-pressure decomposition system as proposed by Stoeppler & Backhaus (1978). The mineralized solution was analysed by a Perkin-Elmer 2280 Spectrophotometer. Mercury was atomized by the cold-vapour technique. Interference due to non-specific absorbance was eliminated by a deuterium background compensator.

For the analysis of chlorinated hydrocarbons, an aliquot of 0.2-0.5 g of the freeze-dried homogeneous material was extracted for 12 hours in a Soxhlet apparatus with n-hexane. The extract was subjected to sulphuric acid clean-up (Murphy 1972), followed by Florisil chromatography. The purified sample was then transferred to a glass column filled with silica-gel to separate DDT and HCH isomers from PCBs (Snyder & Reinert 1971). The eluates were analysed with a Perkin-Elmer F-22 and a Sigma 3 Gas chromatograph equipped with a Ni^{63} Electron Capture Detectors. Glass columns (200 cm x 0.3 cm internal diameter) packed with 4% SE-30 and 6%

SP-2401 on Supelcoport (100-120 mesh) or with 5% OV-101 on chromosorb W HP (80-100 mesh) were used. The carrier gas was argon-methane (95/5); the flow was 60 and 40 (as scavenger) ml min^{-1}; the injector, oven and detector temperature were 210, 200, and 280 ^{o}C respectively. Pure reference standard solutions were used for instrumental calibration, recovery, evaluation, quantification and confirmation.

RESULTS AND DISCUSSION

Results from the residue analyses are summarized in Table 1. Levels of DDE were highest (average of 10.9 mg kg^{-1} dw), while levels of other contaminants were on the average below 1 mg kg^{-1} dw. Except for DDE, measured levels of mercury and organochlorines are not expected to impair reproduction. Not surprisingly, mercury and PCB levels are lower than those usually found in eggs from egret species that are piscivorous.

Table 1. Results from mercury and organochlorine residue analyses in Cattle Egret eggs from El Faiyum, Egypt. Values are expressed as mg kg^{-1} dry weight.

Compound	N	range	mean(± SD)
Hg	7	0.281- 0.842	0.481(0.267)
HCB	7	0.021- 0.036	0.029(0.006)
γ-HCH	7	0.003- 0.236	0.129(0.093)
p,p'DDE	7	3.606-19.893	10.895(6.680)
ΣPCB	7	0.177- 1.587	0.609(0.477)

According to Ohlendorf et al. (1978) there are considerable differences between species in susceptibility to mercury pollutants. However, the average value of less than 0.5 mg Hg kg^{-1} dw in eggs is not likely to cause any problems (e.g. Lambertini & Leonzio 1986). The mercury levels in a single Cattle Egret taken in Wadi el Raiyan (approx. 29°.05'N 30°.20'E) in summer 1984 or spring 1985 were 33.1 mg kg^{-1} dw (kidney) and 20.4 mg kg^{-1} dw (liver). The levels in a single -piscivorous- Little Egret *Egretta garzetta* from the same area were even 85.2 mg kg^{-1} dw (kidney) and 73.4 mg kg^{-1} dw (liver) (Saleh et al. 1988). Although these levels appear to be slightly raised, particularly when compared with levels of 70.5 mg kg^{-1} dw (kidney) and 132.9 mg kg^{-1} dw (liver) in a Little Egret recently shot in a Hg-polluted estuary in NE Italy (A. Renzoni, unpublished), inferences cannot be drawn from the analyses of single birds. The agricultural area of the Faiyum drains to Wadi el Raiyan, and Cattle Egrets occurring in this region are of the same sub-population.

The HCB, γ-HCH (lindane) and PCB levels that we found in the eggs are not higher, or even considerably lower, than levels reported in eggs from (insectivore) non-passerine species inhabiting wetlands bordering agricultural areas elsewhere in the Mediterranean and Black Sea area (Alberto & Nadal 1981, Alberto & Pena 1981, Baluja & Hernandez 1978, Fossi et al. 1984).

Although DDT import in Egypt is reported to have been abandoned in 1971 (El-Sebae & Soliman 1982) this insecticide is still widely used, both in the Nile Valley (Aly & Badawy 1984), and in the Nile Delta (Badawy & El-Dib 1984). DDE levels in the eggs from the Faiyum are higher than those found in most samples of Cattle Egret eggs from the USA and Israel (Ohlendorf et al. 1979, Heinz et al. 1985, Perry et al. 1990) and in two Glossy Ibis Plegadis falcinellus eggs from the heavily polluted Delta of the Danube in Romania (Fossi et al. 1984). Like the Cattle Egret, the Glossy Ibis predominantly takes invertebrate prey (Cramp & Simmons 1977). Only Cattle Egret eggs from two localities, out of 15 in the USA, had comparable DDE levels (x=7.0 mg kg^{-1} ww, N=1; x=4.3 mg kg^{-1} ww, N=6) (Ohlendorf 1979), as did levels reported

from the Ebro Delta in Spain (Ruiz et al. 1982), which were sufficiently high to cause egg breakage, and to impair reproduction (Table 2). Ruiz et al. (1982) found a statistically significant negative relationship between DDE level and eggshell thickness, supporting his data on egg breakage. Such a relationship could neither be demonstrated in our limited sample of seven eggs, nor in the sample of 95 eggs from 15 different localities throughout the eastern United States (Ohlendorf et al. 1979).

No information is available on breeding success of the Cattle Egrets in the Faiyum, but in 1990 the colony had increased to 2581 breeding pairs (Meininger 1991). An even more spectacular increase was noticed in the colony of Giza; from 1604 pairs in 1987 to 7269 pairs in 1990 (Pineau 1991). However, it should be noticed that not information on the colony as a whole, but on the breeding success of individual breeding pairs should be assessed in relation to possible effects of environmental contaminants. Fossi et al. (1984) found extremely high DDE levels (mean 57.2 mg kg^{-1} dw) in Cormorant Phalacrocorax carbo eggs from the Delta of the Danube in Romania. Despite these high levels, corresponding with 20-40% eggshell thinning (Koeman et al. 1973), and likely to impair reproduction, the colony apparently was stable. In a study of reproductive effects of environmental contaminants in the food of the Cormorant in The Netherlands, it was demonstrated that an expanding colony, in an area heavily contaminated with organochlorines, had an extremely low reproductive output (Boudewijn et al.

Table 2. Comparison of DDE levels in Cattle Egret eggs in different geographic regions, in relation to reproductive success or egg breakage.

Country	Year	N	mg kg^{-1} wet weight[1]	mg kg^{-1} lipid weight ([2])	mg kg^{-1} dry weight ([2])	reproductive impairment/ egg breakage	Source
USA	72/73	27[3]	1.2-7.0	-	-	?	Ohlendorf _et al._ 1979
	72/73	68[4]	0.10-0.93	-	-	?	Ohlendorf _et al._ 1979
	1978	2	0.31 (0.24-0.38)	-	-	-	Heinz _et al._ 1985
Spain	1979	10	1.93 (0.63-3.60)	21.52 (7.02-39.91)	-	+	Ruiz _et al._ 1982
Israel	75/78	36	0.62[5] (0.31-1.30)	-	-	-	Perry _et al._ 1990
Egypt	1986	7	3.22 (1.07-5.89)	-	10.89 (3.61-19.89)	?	This study

1 Figures in parentheses refer to range of levels observed; otherwise geometric means are given.
2 To facilitate comparison, all data have been converted to mg kg^{-1} wet weight according to Table 2 in Peakall & Gilman (1979): divided by 11.10 for data on a lipid weight basis, and divided by 3.38 for data on dry weight basis.
3 Collected on 4 different localities.
4 Collected on 11 different localities.
5 Average based on 11 clutches from which the 36 eggs were taken.

1989). DDE residues in Cormorant eggs from this area were on the average 5.28 mg kg^{-1} ww (de Voogt & van Schaick 1990), corresponding with c. 10% eggshell thinning (Koeman et al. 1973). Immigration of (young) birds from a surplus population elsewhere is the key factor responsible for the apparent discrepancy between local population development and reproductive success, and it easily blanks out reproductive impairment if the fate of individual nests are not monitored.

Cattle Egrets in northern Africa are generally residents, but they are by no means sedentary (Cramp & Simmons 1977). In Egypt, it is also a winter visitor and passage migrant in unknown numbers (Goodman & Meininger 1989), as is also shown by the recovery of a bird ringed in June 1989 in northern Israel and recovered in the Nile Delta in the winter of 1989/90 (Meininger & Nikolaus 1991). Although residue levels of DDE found in the Faiyum were high enough to have impaired reproduction, only a combined study linking the fate of individual nests, and preferably the demography of the colonies under study, to residues found will provide meaningful information.

Acknowledgments. Sherif Baha el Din generously shared his appartment with the senior author while he worked in Egypt, and David Merrie, British Petroleum Ltd, Egypt Branch, kindly helped with breath-taking acrobatics to obtain the eggs in the Faiyum. Mervat Morcos, Egyptian Wildlife Service, Giza, was instrumental in providing the necessary permits, and Peter Verwey, Dept of Toxicology, Wageningen Agricultural University, kindly shipped the eggs to Siena. Peter L. Meininger, FORE, commented upon an earlier draft of this paper.

REFERENCES

Alberto LJ , Nadal J (1981) Residuos organoclorados en huevos de diez especies de aves del delta de Ebro. P Dept Zool Barcelona 6: 73-83

Alberto LJ , Pena JC (1981) Niveles de contaminantes organoclorados y metales pesados en huevos de aves de las Marismas del Guadalquivir, 1975. Doñana, Acta Vertebrata 8: 195-206

Aly OA , Badawy MI (1984) Organochlorine residues in fish from the River Nile, Egypt. Bull Environ Contam Toxicol 33: 246-252

Badawy MI , El-Dib MA (1984) Residues of organochlorine pesticides in fish from the Egyptian Delta lakes. Environ Int 10: 3-8

Baluja G , Hernandez LM (1978) Organochlorine pesticide and PCB residues in wild bird eggs from the south-west of Spain. Bull Environ Contam Toxicol 19: 655-664

Boudewijn TJ , Dirksen S , Mes RG , Slager LK (1989) De Aalscholver indicatorsoort van de Nederlandse wateren.

Limosa 62: 96-97
Cramp S , Simmons KEL (eds.) (1977) The birds of the Western Palearctic, vol 1. Oxford University Press, Oxford
De Voogt P , van Schaick MJM (1990) DDE en verwante bestrijdingsmiddelen in eieren en braakmonsters van Nederlandse Aalscholvers. Free University, Institute for Environmental Studies, Amsterdam
El-Dib MA , Badawy MI (1985a) Organo-chlorine insecticides and PCBs in River Nile water, Egypt. Bull Environ Contam Toxicol 34: 126-133
El-Dib MA , Badawy MI (1985b) Organochlorine insecticides and PCBs in water, sediment, and fish from the Mediterranean Sea. Bull Environ Contam Toxicol 34: 216-227
El Nabawi A , Heinzow B , Kruse H (1987) Residue levels of organochlorine chemicals and polychlorinated biphenyls in fish from the Alexandria region, Egypt. Arch Environ Contam Toxicol 16: 689-696
El-Sebae AH , Soliman SA (1982) Mutagenic and carcinogenic chemicals in the Egyptian agricultural environment. pp. 119-126 in: Fleck RA , Hollaender A (eds) Genetic toxicology. Plenum Publishing Corp
Fossi C , Focardi S , Leonzio C , Renzoni A (1984) Trace-metals and chlorinated hydrocarbons in birds' eggs from the delta of the Danube. Environ Conserv 11: 345-350
Ghabbour SI (1974) Insecticides and cotton in Egypt. Biol Conserv 6: 62-63
Ghabbour SI (1976) The ecology and pest status of sparrows Passer in Egypt. Int Studies on Sparrows 9: 17-29
Goodman SM , Meininger PL (eds) (1989) The birds of Egypt. Oxford University Press, Oxford
Heinz GH , Erdman TC , Haseltine SD , Stafford C (1985) Contaminant levels in colonial waterbirds from Green Bay and Lake Michigan, 1975-80. Environ Monit Assess. 5: 223-236
Kirkpatrick TW (1925) The Buff-backed Egret as a factor in Egyptian agriculture. Bull Min Agric Egypt 56: 1-28
Koeman JH , van velzen-Blad HCW , de Vries R , Vos JG (1973) Effects of PCB and DDE in Cormorants and evaluation of PCB residues from an experimental study. J Reprod Fert , Suppl 19: 353-364
Lambertini M , Leonzio C (1986) Pollutant levels and their effects on Mediterranean seabirds. pp.359-378 in: MEDMARAVIS , Monbailliu X (eds) Mediterranean marine avifauna. NATO ASI Series G12
Meininger PL (1991) Systematic list of birds observed in Egypt (December 1989-July 1990). In: Meininger PL , Atta GAM (eds) Ornithological studies in Egyptian Wetlands 1989/90. Zeist: WIWO report [in press]
Meininger PL (1991) Range extension of Black-shouldered Kite Elanus caeruleus in northern Egypt. Sandgrouse: in press
Meininger PL , Nikolaus G (1991) Ringing recoveries resulting from the Egyptian wetland project 1989/1990. In: Meininger PL , Atta GAM (eds) Ornithological studies

in Egyptian Wetlands 1989/90. Zeist: WIWO report [in press]
Mullié WC (1989) Responses of birds to changing environments. pp. 96-110 in Goodman SM , Meininger PL (eds) The birds of Egypt. Oxford: Oxford University Press
Mullié WC , Meininger PL (1985) The decline of bird of prey populations in Egypt. ICBP Techn Publ 5: 61-82
Murphy PG (1972) Sulfuric acid for the cleanup of animal tissues for analysis of acid-stable chlorinated hydrocarbons residues. Jour Ass Off Anal Chem 55: 1360-1362
Ohlendorf HM , Risebrough RW , Vermeer K (1978) Exposure of marine birds to environmental pollutants. US Department of the Interior, Fish and Wildlife Service. Wildlife Research Report 9, Washington DC
Ohlendorf HM , Klaas EE , Kaiser TE (1979) Environmental pollutants and eggshell thickness: Anhingas and wading birds in the eastern United States. US Department of the Interior, Fish and Wildlife Service. Special Scientific Report - Wildlife No. 216, Washington DC
Peakall DB , Gilman AP (1979) Limitations of expressing organochlorine levels in eggs on a lipid-weight basis. Bull Environ Contam Toxicol 23: 287-290
Perry AS , Sidis I , Zemach A (1990) Organochlorine insecticide residues in birds and bird eggs in the coastal plain of Israel. Bull Environ Contam Toxicol 45: 523-530
Pineau O (1991) The Cattle Egret Bubulcus ibis colony of Giza, April 1990. In: Meininger PL , Atta GAM (eds) Ornithological studies in Egyptian Wetlands 1989/90. Zeist: WIWO report [in press]
Ruiz X , Llorente GA , Nadal J (1982) Incidence des composés organochlorés sur la viabilité de l'oeuf du Bubulcus ibis dans le Delta de l'Ebre. Proc. VIth ICSEM/IOC/UNEP Workshop on pollution of the Mediterranean, Cannes: 807-811
Saad MAH , Abu Elamayem MM , El-Sebae AH , Sharaf IF (1982) Occurrence and distribution of chemical pollutants in Lake Mariut, Egypt. Water Air Soil Pollut 17: 245-252
Saleh MA , Saleh MA , Fouda MM , Saleh MA , Abdel Latif MS , Wilson BL (1988) Inorganic pollution of the man-made lakes of Wadi El-Rayan and its impact on aquaculture and wildlife of the surrounding Egyptian desert. Arch Environ Contam Toxicol 17: 391-403
Snyder D , Reinert R (1971) Rapid separation of polychlorinated biphenyls from DDT and its analogues on silica gel. Bull Environ Contam Toxicol 18: 697-705
Stoeppler M , Backhaus F (1978) Pretreatment studies with biological and environmental materials. I: Systems for pressurized multisample decomposition. Fresenius Z Anal Chem 291: 116-120

Received April 15, 1991; accepted December 9, 1991.