CHAPTER 6

Food habits and organochlorine pesticide residues in the body tissues of Little Cormorant: a case study

1. Introduction

Pesticides whether applied directly to the aquatic habitat or used in agricultural fields and other habitats may have an impact on non-target organism in aquatic and semi-aquatic ecosystems. Because of its low solubility in water, most of the applied portion of the pesticide, runoff from the treated zone, which accumulate in water and sediments of aquatic habitats. The nature and magnitudes of the impact varies, according to the influence of the different factors (Mulla *et al.*, 1979).

A general trend in the population decline of the wetland dependant birds has been observed in the past few years. A study carried out in Texas has shown, the pesticide contamination as a causative factor for a population decline of wetland dependant birds with a special emphasis on fish eating birds (King *et al.*, 1978).

In the study area, the reservoirs are periodically filled with canal water from Mahi Right Bank Canal system which adds further pesticide load in wetlands drawing from distantly located treated zones like North Gujarat & Rajasthan. In addition the canal irrigation facility has encouraged farmers to cultivate multiple crop (monocropping) over a year. As a result, the pesticide utilization has also increased in the area. It was observed that high numbers of aquatic fauna were found to be dead in paddy fields after pesticide treatment (*Pers obs*) (Plate IVa). Looking on to these facts

Plate III. Little Cormorant on roosting on trees locate near wetland.

Plate IV. Caracass of peacock recovered from agricultural land died after consuming pesticide treated seeds.

prevailing in the study area it was thought necessary to study the impact of these pesticides used on aquatic fauna.

The Little Cormorant (*Phalacrocorax niger*) was selected as key species (Plate IVb) for assessing the pesticide contamination in the wetland birds for the following reasons.

- It is one of the top carnivores in aquatic ecosystem
- The size is smaller compared to other cormorants available in the study area and small size animal due to higher metabolism will have higher food intake and thus bioaccumulation of pesticide could be greater.
- Population is enough so that one can have easy assess to get the birds for study
- The most important fact is that Little Cormorant is a residential bird of Indian subcontinent. Thus it was thought necessary to study the pesticide impact on local birds and know the degree of contamination in the ecosystem.

The objective of this study was to determine the biomagnifications of the organochlorine pesticides through the food web and its impact on population of little cormorants. For the same, total nesting population, food habit, level of organochlorine pesticides in body tissues, eggs, and major prey items of the species were studied in detail.

2. Material and methods

The whole study was divided into four major parts 1. Nesting population 2. Reproductive success 3. Food habits and 4. Residue analysis

2.1. Nesting population

Survey was carried out to estimate the nesting population of Little Cormorant in study area during August 1999 and 2000. The district was surveyed by identifying the most potential site for nesting on the basis of

existence of water reservoirs and natural wetlands. The nest site characteristic, like substrate for nesting, proximity to water body, proximity to human habitation and cultivated land were recorded The counting of the active nests was done when the colony was sighted for the first time.

2.2. Reproductive success

For studying the reproductive success of Little Cormorant, the heronry selected was near Mahi reverine area little away from human habitation so as to eliminate the influence of human interference on foraging site and ultimately on breeding success. Most of other colonies were located near man-made wetland, which were used for foraging by breeding Little Cormorants as well as by the local people for the drinking water, irrigation, fish farming, cattle grazing and several other purposes. Hence, the disturbance would be higher for foraging Little Cormorants at such sites, and to avoid that natural habitat was selected for the study. Total 10 nests were monitored from nest building to fledgling stage to evaluate the breeding success. The parameter like numbers of eggs laid, numbers of chicks hatched and numbers of chicks fledged from each nest were recorded.

2.3. Food habits and food items

The study on food habit of Little Cormorant was carried out during the breeding season of the species in the year 1999. The regurgitated food samples of the nestling of Little Cormorant were collected from ten colonies distributed in Kheda district. For obtaining the food sample, disturbance was made below the nest by shaking and clapping from below the nesting colony As a result, frighten chick regurgitated the food stored in the crop. The procedure for collection, preservation, analysis of food sample and the data is described in detail in Chapter 3.

2.4. Pesticide residues analysis

The concentration of organochlorine pesticide residues was determined in the major food items, body tissues and in the eggs. The fish being the major component of the diet of Little Cormorant were analyzed for organochlorine residues The method used for tissue and fish sample preparation, analysis and data presentation are same as described in detail in chapter 4.

During the early part of the breeding season (August 2000) the freshly laid eggs (n =10) were collected for residue analysis and shell thickness measurements. The limited number of accessible cormorant nest precluded a systematic collection of eggs. First laid egg of the clutch was taken from each nest. The method for egg sample preparation, residue analysis and data presentation are described in detail in chapter 5. All samples were analyzed for DDE, DDD, DDT, total DDT, HCH and lindane

2.5. Eggshell thickness

The eggshells of eggs collected for organochlorine residue analysis were used to determine eggshell thickness The whole egg was cut around the girth and the egg content was collected for organochlorine residue analysis. The shells after emptying the content were washed gently with water and allowed to dry Shell thickness was measured at three points around the girth/ egg equator using a micrometer (0.01 mm accuracy). The average of the three was used to represent the thickness of the shell Eggs diametric were measured and the mean length, breadth, volume and eggshell index were calculated

3. Results and discussion

3.1. Nesting population

The study area was surveyed for the nesting population of Little Cormorant during August 1999 and 2000 Total 86 heronries were reported from the study area during year 1999 and out of these Little Cormorants were found nesting in 18 heronries The total numbers of nests recorded in these 18 heronries were 580, nesting population was 1160 birds While during 2000, out of total 70 heronries visited, 10 were having the nests of Little Cormorants Total 362 nests were recorded from these 10 heronry and 724 nesting birds (Table 6.1). The percentage of heronries occupied by nesting Little Cormorant was 21 % in 1999 and 14.28 % in 2000.

3.2. Reproductive success

The mean clutch size of Little Cormorant observed in one sample colony was 2 9 (n = 26 nest) Observed and individual clutch ranged from 1 -5 eggs. The difference in the clutch size was not significant amongst the nests observed The average brood size was 2.3. The overall breeding success of Little Cormorant observed was 65.52 %, however, the brood size showed a little variation amongst the nest

3.3. Food habits and food items

The average weight of food sample was 6.84 g and food items recorded from food samples are shown in Table 6.2. A total of 1500 food items were recorded, which belongs to six classes of animals. The fish frequency and occurrence was 80 % and by weight it formed 66 % of the diet. Second major component of diet was crustacean and insects; both showed 10 80 % by frequency. Of the insect the coleopterans formed major part by frequency and biomass compared to hemiptera.

Table 6.1: Nesting population and reproductive success (n = 26 nests) of Little Cormorant

Year	Colonies	No. Nests	No. Eggs	Av. Per nest		
				Clutch size	Hatched	Fledged
1999	18	580	-	-	-	-
2000	10	362	-	-	-	-
Monitored	1	26	76	2.9	2.3	1.9

(Only one colony was monitored in year 2000 to know the reproductive status)

Table 6.2: Dietary analysis of Little Cormorant food in the heronries of Kheda district (n= 152)

Sr. No.	Food items Order wise)	% O	No. item (*fi*)	% *fi*	Gi (g)	%G	RII
1	Coleoptera	13.81	122	8.13	25.18	2.42	0.52
2	Hemiptera	34 21	38	2.8	9.76	0.91	0.70
3	Unidentified insect matter	-	-		0 04	0	
4	**Total Insect matter**	-	-		34.98	3.36	
5	Crustacea	53.95	162	10.80	68.22	6.36	1.97
6	Annelida	23.03	55	3.66	16.54	1.39	0.54
7	Amphibia	19.08	84	5.66	214.29	20.60	8.43
8	Reptilia	15.79	6	0.40	14.89	1.90	0 37
9	Pisces	79.52	1033	68.87	691.07	66.44	87.43
10	**Total non - insect matter**				1005.01		
11	**Grand Total**		1500		1039.99		100

Note: %O Percent Occurrence, *fi* Frequency, %*fi*, Percent frequency, Gi Weight, %Gi Percent weight, RII Relative Index of Importance

In the cormorant diet, of the 1500 items collected 820 were whole undigested fishes, which were weighed and measured (Table 6.3). The mean weight of the individual identified fish species varied from 0.34 to 18.2 g. Length of food item varied from 25 to 125 mm and about 80 % of them were within 100 mm or less.

The fish being the major dietary component of the nestling diet by frequency; biomass and occurrence than the rest five classes of animals represented in the diet. The occurrence and frequency of crustacean and insect was the second in the diet However, by biomass the amphibians were ranked second. The relative Index of importance of each diet component as a diet of Little Cormorant showed the fish having a greater importance followed by amphibians (Figure 6.1) While the remaining classes like insecta, annelida, crustacea and reptilia were of less importance in the nestling diet of Little Cormorant.

For feeding the food to the nestling, parents were generally found collecting food from the reservoirs near the nesting sites. Most of the fish recovered from the diet was common to the reservoirs nearby and all were fresh water fishes. The reported dietary composition of a related species like Olivaceous Cormorant was also similar to that observed in Little Cormorant (Morison *et al.*, 1977; Telfer *et al* , 1982).

3.4. Pesticide residual analysis

3.4.1. Body tissue

Concentration of the organochlorine pesticides like DDT and their metabolites, HCH and Lindane were analyzed and the findings are presented in Table 6.4 Organochlorine pesticides were detected in all the tested samples except in the two samples of brain tissue and nine samples of deposited fats where the *p,p'* DDT was not detected. Mean concentration of total DDT in brain and deposited fat was 0 048 ppm and

Table 6.3: Fish identified from the diet of Little Cormorant nestlings

Fish Species	Number	% O	Total Weight (g)	Mean Length (mm)
Labeo rohita	526	64 15	946.8	125
Chana striatus	113	13 78	109 61	25
Chana chanos	78	9 51	113.8	64
Mulia sp.	54	6 59	94.5	31
Hetropneustres fossilis	31	3.78	25.42	27
Catla catla	18	2 19	37.8	25

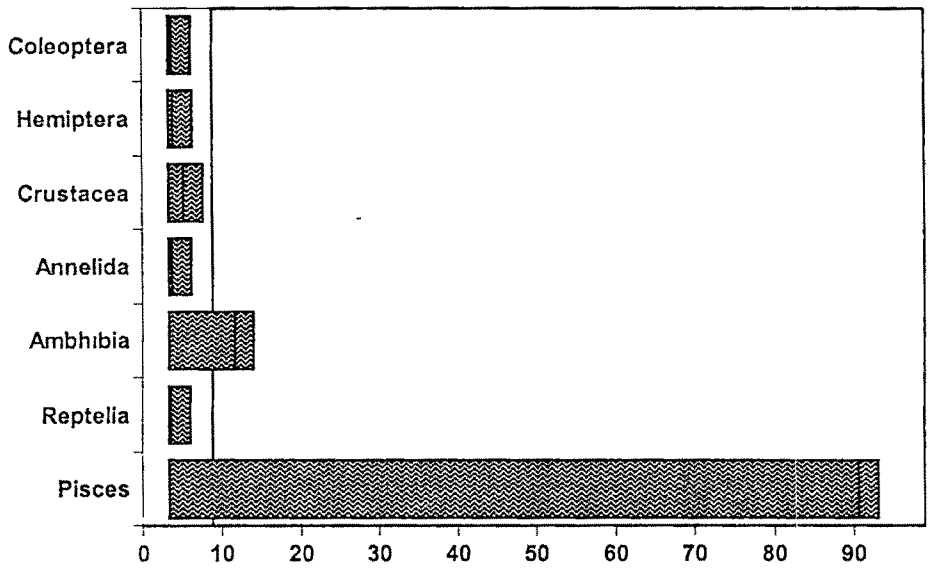

Figure 6.1· Relative Index of Importance as a prey for Little Cormorant

Table 6 4· Range and Geometric means of organochlorine residues in the brain and deposited fats of Little Cormorant

Sr No	Residues of	Brain tissue		Deposited Fats	
		Mean	Range	Mean	Range
1	*p,p'* -DDE	0 022	0 009-0 038	0 030	0.011-0 043
2	*p,p'* -TDE	0.010	0.003-0 020	0.018	0 013-0 027
3	*p,p'* -DDT	0 061	0.00-0 076	0 006	0 00-0 006
4	Total DDT	0.048	0 019 – 0 079	39 73	12 41-68 43
5	Total HCH	0 240	0.231 – 0.248	9.17	3.84 – 12 41
6	Lindane	0.046	0.021 – 0 072	4 87	1.171 – 8 093

39.73 ppm respectively. Mean residues of *p,p'* DDE in brain tissue was 0 022 ppm and its range between 0.009 –0.038 ppm. The *p,p'* DDT in the brain tissue was 0.061 ppm. It was lower than the critical level but it is important to note that the evidence of the current application of DDT in the study area has increased as suggested by residues in the brain tissues when analyzed. The mean concentration of DDT in deposited fat was 39.73 ppm ranging from 12.41 to 68.43 ppm. The concentration of *p,p'* DDT was found only in one sample of deposited fat (0.06). The mean concentration of total HCH and lindane in the brain tissue was 0.240 ppm and 0.046 ppm, while in deposited fat it was 9.17 and 4.87 ppm respectively. The overall concentration of organochlorine pesticide residues in the deposited fat was higher compared to as it was recorded in the brain tissue.

The present study indicates that the organochlorine residues obtained from the tissue were lower than the critical level of residue to cause serious impact on population (Appendix 1). Several reports indicate DDE level found in the carcasses of Olivaceous Cormorants was below the level of chronic poisoning and reproductive abnormalities (Stickel, 1973; Custer and Heniz, 1980; Blus, 1982). Response of birds to DDE varied greatly with wide inter-specific differences in both tolerance and building up of residues through food chain. Birds experiencing greatest effect from DDT are long-lived and K- selected species that form the top consumers (carnivore) in the food chains that range from relatively simple to complex in an ecosystem

3.4.2. Eggs

All the eggs (n=10) contained DDE but the levels were highly variable from 0.2 to 26.0 ppm wet weight. Only in two eggs, *p,p'* DDT was detected. Both HCH and Lindane was detected in all the eggs. However, in general all the eggs were contaminated with organochlorine (Table 6.5).

Table 6.5: Residual analysis and egg shell thickness of little Cormorant eggs (n = 10)

Sr. No	Residues of / detected in (n)	ppm wet Weight basis
1	*p,p'*–DDE (n = 10)	1.52 (0.2 –26)
2	*p,p'*–TDE (n = 3)	0.1 (0- 0.1)
5	Total DDT (n = 2)	0.1 (0- 0.1)
6	Total HCH (n = 10)	0.11 (0.05 –0.18)
7	Lindane (n= 10)	0.05 (0.03 –0 08)
Egg shell Thickness		
1	Mean egg shell Thickness ± S.E	0 338 ± 0.031
2	Range	0.27 –0.38
3	% Change from the museum value	NS

NS –Non significant

The DDE residue levels obtained in the eggs were generally below the level associated with chronic poisoning or reproductive problems. Similar observations were reported by several ecotoxicologist from different parts of the world (Stickel *et al.,* 1973; Custer and Heniz, 1980; Blus, 1982; Henny *et al.,* 1982a; heniz *et al.,* 1983; King and Kryntsky, 1986; Henny *et al.,* 1989). Contaminant residues in the eggs are an index of exposure of the embryo to the pollutant. Morrison *et al.* (1977) in their studies during 1976-1977 at Sidney Island, Texas reported that the level of DDE less than 1.00 ppm had no effect on Olovaceous Cormorant reproduction. While studies on other cormorant species had suggested that there was little reproductive impairment associated with egg residues that ranged up to 9 ppm. Although Kury (1969) reported that mean of 6.2 ppm DDE in Double Crested Cormorant (*P. auritus*) eggs did not reduce the breeding success. From 1-9 ppm DDE in eggs of Shag (P. *aristotelis*) from Great Britain had no effect on embryo mortality, egg breakage or fledgling success (Potts 1968). May be this level is within the tolerance. In our study also the mean DDE 1.52 ppm compared to other reported levels is very low, which should not be having significant effect on embryo development, growth, mortality and fledgling success etc.

3.4.3. Eggshell thickness

The mean shell thickness of the little cormorant eggs was 0.338 mm (Table 6.5) and was found similar to the thickness 0.34 mm, museum collected information (Morrison et al., 1977). Individual shell thickness varied from 0.27-0.38 mm. Only one egg was with shell thickness less than 0.3 mm, which is 23 % thinner than the normal egg. Otherwise no other incidences of shell thinning were observed. There was a significant negative correlation between DDE and the eggshell thickness Residues were not significantly correlated with shell thickness, probably because of less sample size Shell thinning in many species of birds has been associated primarily with residues of DDE (Blus et

al., 1974; Blus, 1982; Stickel et al,. 1984). DDE is negatively correlated with eggshell thickness (King and Krynitsky, 1986).

3.4.4. From diet

All the four organochlorine pesticides were detected in the Little Cormorants food item fish (Table 6.6). The amount of DDE detected was at low level (0.01 to 0.03 ppm) but present in all the fish samples studied, whereas TDE level obtained was 0.01 ppm only in 4 fish samples out of six identified fishes. The HCH and Lindane range was from 0 03 to 0 10 and 0.01 and 0.03 ppm respectively.

During weekly visit to the colonies, Little Cormorant was found feeding regularly from shallow ponds/ reservoirs adjacent to the agricultural fields. Even the colonies were located within a range of 0 to 100 m from the water bodies. All these reservoirs harbor fresh water fishes (Many of the reservoirs are utilized for fish production also). The cormorant most commonly catches the species of fish, which are top water feeders However, the study period being during the breeding season, so the little cormorants exploit the most readily available prey, even other than fish also, which is identified from the list of animals obtained from regurgitated food samples (Table 6.2). Although, DDE was detected in all the 6 species of fishes most common in the nestling diet, maximum concentration obtained 0 03 ppm was well below the national mean (0.20 ppm) for the fish studied in United States (Schmitt *et al.,* 1985).

The biomagnifications of organochlorine contaminants can be seen through food base of cormorants in Kheda district (Table 6.7). The levels detected in the body tissues were quite higher than found in the food. The only compound that was detected in all the three tissue forms at a $\geq$ 50 % frequency of occurrence was DDE and HCH. The mean concentration of DDE in the tissue and egg was considerably higher than those in fish

Table 6.6: Residue analysis in the identified fish obtained from the diet of Little Cormorant

Sr. No	Fish Species	Residues (ppm Whole wet Weight)					
		p,p' - DDE	*p,p'*- TDE	*p,p'* - DDT	Total DDT	Total HCH	Lindane
1	Labeo rohita	0.03	0.01	ND	0.04	0.09	0 01
2	*Chana striatus*	0.02	ND	ND	0.03	0.10	0.02
3	*Chana chanos*	0.02	ND	ND	0.02	0 06	0.01
4	*Mulia sp.*	0.02	0.01	ND	0.03	0.08	0.03
5	*Hetropneustres fossilis*	0.03	0.01	ND	0.03	0.03	0.02
6	*Catla catla*	0.01	0.01	ND	0.02	0.06	0.02

ND Not Detected

Table 6.7· Comparative account of organochlorine residues in the diet, eggs and body tissue of Little Cormorant

Sr No	Residues	Mean values in ppm wet Weight			
		Diet	Eggs	Brain Tissue	Deposited Fat
1	*p,p'* -DDE	0.021	1 52	0.022	0.030
2	*p,p'* -TDE	0 006	0.1	0.010	0 018
3	*p,p'* -DDT	ND	0.1	0.061	0.006
4	Total DDT	0.028	0.70	0.048	39.73
5	Total HCH	0 07	0.11	0.240	9.17
6	Lindane	0.018	0.05	0.046	4.87

(0.021 ppm). Similar observations were also noted in case of HCH. Total DDT concentration was found highest in deposited fats (39.73 ppm), which is significantly lower in the diet (0.028 ppm).

For biomagnification of organochlorines in Little Cormorant tissues, in addition to fish the other components of the diet also must be responsible. The insects, which also forms important component of Little Cormorant' s food by frequency, could add some of the load of organochlorine to the feeders. Because aquatic insect feeders could show more organochlorine contamination than terrestrial insect feeders. For the reason aquatic insects are known to metabolize DDT to DDE and bioaccumulate DDE to the concentration several times greater than in water (Derr and Zabik, 1972; Lindberg *et al.*, 1985; Beril *et al.*, 1990)

Though the levels of organochlorine obtained are below the critical level. But certain figures obtained cannot be just ignored, for example the level of DDE in the egg is 69 times higher than in brain tissue or 50 times higher than in deposited fat. This magnified level of DDE in the egg needs to be highlighted, and what will be the consequences of such a magnified level of DDE in the growing/developing young one, already having DDE, and is also fed with organochlorine contaminated food. So whatever little percentage decrease of hatching and fledging success is recorded, may be not very significant, but could be partly due to these pesticide effects.

Since the data of exact population of these birds is not available, but one can get the picture of depleting figures from the number heronries reported to be occupied in the year 1999 was 21 %, where as in 2000, only 14 % were reoccupied. These could be due to number of speculative reasons for this small insignificant population decline from 1999-2000. Thus even if it is not very definite but to a greater extent, it can be established through this study that the concentration of chemical raises

from source (Food) to the tissue which after certain level could prove to be detrimental.