Dioxins and Dioxin-like PCBs in Birds from Australia

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Introduction

Australia is home to over 700 bird species, of which almost half are endemic.[1,2] To date, very little information has been available on exposure of birds in Australia to dioxin-like chemicals. In 2001, the Australian Government Department of Environment and Heritage (DEH) initiated the National Dioxins Program (NDP) with the aim of gathering data on the levels of dioxin-like chemicals present in the environment at a national level. One aspect of this study was to ascertain the levels of dioxin-like chemicals in Australian fauna including birds.[3]

Hydrophobic persistent organic pollutants including dioxin-like chemicals and dioxin-like PCBs are known to bioconcentrate from the abiotic environment. Furthermore, biomagnification (i.e. an increase in the chemical concentration with increasing trophic level, normalised to lipid weight) has been demonstrated to occur for some of these compounds.[4,5] The extent of a compound's biomagnification is related to the resorption of the chemical from the digestion tract into the body, as well as its elimination rate that is influenced by metabolism and excretion via respiratory organs.

Various bird species, in particular raptors, can accumulate elevated concentrations of persistent organic pollutants (POPs) due to their higher position in the food chain and hence a high potential for biomagnification. Therefore, predatory birds have among the highest recorded concentrations of POPs in biota. Due to the high potential for birds to be exposed and to accumulate contaminants present in the environment, the current study has analysed levels of dioxin-like compounds in birds as an indication of the presence of these chemicals in the Australian environment.

Materials and Methods

Collection of birds for this study relied predominantly on opportunistic findings of birds killed on roads. Samples were collected by staff from State National Parks, wildlife carers, zoo and museum staff or other colleagues active in fauna research and/or rehabilitation. In total, eighteen birds representing ten different species were collected from three States and one Territory of Australia. While it is recognised that lipids in recently killed birds may have degraded and resulted in mobilisation of the associated contaminants, this study aimed to provide an indication of the levels of dioxin-like chemical accumulating in Australian birds without sacrificing individuals of populations already under pressure.

Table 1: Samples collected including common and scientific name, with an identification number where applicable, location details (State/territory of collection and main land use in the area) and primary food source, which provides information about trophic level. For all birds N=1

Common name	Species	State	Land use	Main food source	Trophic level
Collared Sparrowhawk-1	*Accipiter cirrhocephalus*	WA	Urban	Birds	High
Collared Sparrowhawk-2	*Accipiter cirrhocephalus*	WA	Urban	Birds	High
Hobby Falcon	*Falco longipennis*	WA	Urban	Mammals	High

Brown Goshawk-1	*Accipiter fasciatus*	QLD	Agricultural	Mammals	High
Wedge-tailed Eagle	*Aquila audax*	QLD	Agricultural	Mammals	High
Galah	*Cacatua roseicapilla*	NT	Urban	Plant material	Low
Pheasant Coucal	*Centropus phasianinus*	NT	Urban	Reptiles	Medium
Brown Falcon	*Falco berigora*	NT	Urban	Mammals	High
Collared Sparrowhawk-3	*Accipiter cirrhocephalus*	SA	Agricultural	Birds	High
Collared Sparrowhawk-4	*Accipiter cirrhocephalus*	SA	Urban	Birds	High
Brown Goshawk-2	*Accipiter fasciatus*	SA	Agricultural	Mammals	High
Black Shouldered Kite-1	*Elanus axillaris*	SA	Remote	Mammals, insects	High
Black Shouldered Kite-2	*Elanus axillaris*	SA	Urban	Mammals, insects	High
Black Shouldered Kite-3	*Elanus axillaris*	SA	Agricultural	Mammals, insects	High
Kestrel-1 (male)	*Falco cenchriodes*	SA	Urban	Mammals, insects	High
Kestrel-2 (female)	*Falco cenchriodes*	SA	Urban	Mammals, insects	High
Peregrine Falcon-1	*Falco peregrinus*	SA	Agricultural	Mammals, birds	High
Peregrine Falcon-2	*Falco peregrinus*	SA	Urban	Mammals, birds	High

Samples were analysed by the National Measurement Institute in Sydney. In brief, birds were dry-plucked and then the whole bird (except the Wedge-tailed Eagle where breast muscle and liver were taken separately) was digested overnight with concentrated hydrochloric acid. Extraction of the lipid was then performed three times using dichloromethane:hexane (25:75). Approximately 1-5g of the extracted lipid was spiked with a known quantity of $^{13}C_{12}$ surrogates and analysed by isotope dilution HRMS for the seventeen 2,3,7,8-substituted PCDD/PCDFs and twelve dioxin-like PCB congeners for which WHO TEF factors have been assigned.[6] The detailed analytical methods have been previously described[7] and are based upon USEPA Methods 1613 and 1668, for PCDD/Fs and PCBs respectively.

An interlaboratory comparison was conducted by sending an aliquot of unextracted lipid from one sample to the Ontario Ministry for the Environment, Canada for analysis. The mean normalised difference for all the congeners that were detected in both laboratories (n=23) was < 15%, which can be considered extremely good.

Results and Discussion

Dioxin-like chemicals were detectable in all bird samples collected. The concentration of dioxin-like chemicals expressed as WHO TEQ_{AVIAN} (referred to in the rest of the document as TEQ_A) ranged from about 1 pg/g lipid in a sample of a seed eating Galah from the Northern Territory to about 3,900 pg/g lipid in a sample of a Collared Sparrowhawk-4 that was found in an urban area of South Australia. The mean concentration for all birds was 760 pg/g lipid and for raptors was 850 pg/g lipid (i.e. all birds excluding the Pheasant Coucal and the Galah). 2,3,7,8-TCDD was detectable in all bird samples except the Galah from Northern Territory with concentrations up to 510 pg/g lipid in a Collared Sparrowhawk-1 found in an urban area in Western Australia. 1,2,3,7,8-PeCDD and PCB 126 were the two dioxin-like chemicals that contributed the greatest to the TEQ_A for all samples with average contributions of 36 and 28%, respectively (Table 2).

Table 2: Concentrations of the predominant and most toxic PCDD/PCDF and PCB congeners identified in the bird

samples, in order of lowest to highest concentration on a TEQ_A basis. For all birds n=1

Common name	State	Trophic Level	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	2,3,7,8-TCDF	2,3,4,7,8-PeCDF	PCB77	PCB81	PCB126	TEQ_A
Galah	NT	Low	ND	ND	ND	ND	ND	ND	ND	1
Black Shouldered Kite-1	SA	High	0.4	3	ND	3	ND	ND	5	12
Brown Falcon	NT	High	6	20	14	5	2	1	2	52
Goshawk-1	QLD	High	18	54	ND	2	1	1	12	92
Pheasant Coucal	NT	Medium	6	38	ND	23	ND	ND	22	99
Kestrel -1 (male)	SA	High	5	23	7	9	31	5	39	120
Hobby Falcon	WA	High	3	9	5	11	19	8	70	130
Brown Goshawk-2	SA	High	12	32	13	22	8	5	32	130
Wedge-tailed Eagle (breast)	QLD	High	16	110	ND	25	7	4	50	220
Wedge-tailed Eagle (liver)	QLD	High	23	86	ND	18	14	8	110	280
Peregrine Falcon-1	SA	High	26	160	11	68	22	6	75	400
Collared Sparrowhawk-3	SA	High	52	100	65	120	31	18	150	570
Black Shouldered Kite-3	SA	High	15	34	5	94	36	21	490	740
Black Shouldered Kite-2	SA	High	340	260	2	33	4	5	168	830
Collared Sparrowhawk-1	WA	High	58	160	28	120	120	40	510	1,100
Peregrine Falcon-2	SA	High	100	280	97	100	150	85	720	1,600
Collared Sparrowhawk-2	WA	High	510	1,000	39	190	14	9	120	2,000
Kestrel-2 (female)	SA	High	17	57	90	72	430	36	1,400	2,200
Collared Sparrowhawk-4	SA	High	120	570	14	420	250	130	2,200	3,900

ND = not detected; units are TEQ_A/g lipid

An indication of the extent that the concentration of dioxins and dioxin-like compounds vary between different tissues within individual birds was investigated through separate analysis of both liver and breast tissue from one Wedge-tailed Eagle. The PCDD/F and PCB concentrations in both tissue types were similar within the range of TEQ_A values (280 pg TEQ_A/g lipid in liver and 220 pg TEQ_A/g lipid in muscle). A comparison of the congeners present in the different tissues indicated reasonably good agreement between the concentrations in liver and breast muscle when data are expressed on a per gram lipid basis. Some exceptions include the higher chlorinated congeners such as

OCDD, OCDF, 1,2,3,4,6,7,8-HpCDD and 1,2,3,4,7,8,9-HpCDF, which were found in higher concentrations in the liver compared to the muscle.

Although sample sizes are extremely low, it is evident that overall concentrations and PCDD/PCDF and PCB congener profiles varied substantially between each sample. This variation was present between samples from different species as well as among individuals of the same species. For example, the levels of dioxin-like chemicals in the Black Shouldered Kite-1 sample from a remote area in South Australia were 1-2 orders of magnitude lower compared to the two Black Shouldered Kites-2,3 that were found in urban and agricultural areas in SA. Furthermore, the latter two kite samples showed very different compound profiles with one being dominated by PCBs and PCDFs and the other by high levels of PCDDs. These results suggest that the habitat and contamination of food may have important influences on the levels and profiles of dioxins and dioxin-like compounds in these animals. An interesting inter-species difference was observed between the raptors and the Pheasant Coucal. OCDD concentrations in the Pheasant Coucal (a mid-trophic level bird that is often found in dense undergrowth) were noticeably higher (6,700 pg/g lipid) than levels found in any of the raptors (average 510 pg/g lipid and median 92 pg/g lipid).

Overall the concentrations found in the birds analysed from Australia cover a wide range, from relatively unexposed birds such as the Galah from the Northern Territory, to the more highly exposed raptors collected near urban areas. The predatory birds from Australia generally had lower TEQ values than did comparable birds from Japan[8], North America[9], and the Baltic region[10], in which the concentrations exceeded 100,000 pg/g lipid (expressed as TEQ). Similarly, data from a White-bellied Sea Eagle found in Sydney were considerably higher compared to the animals analysed in this study.[11] Nonetheless, it is worth noting that an ecological risk assessment conducted as part of the NDP[12] identified a potential risk to the subpopulations of raptors that showed elevated exposure to dioxin-like chemicals in the current study.

Acknowledgement

The studies on which this paper is based were funded under the National Dioxins Program administered by the Australian Government Department of the Environment and Heritage. The views expressed herein are not necessarily those of the Commonwealth of Australia. ENTOX is co-funded by Queensland Health. Finally, our thanks go to the skilled staff at the National Measurement Institute's Dioxin Analysis Unit for the analysis of the birds.

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