

Differential bioaccumulation patterns of heavy metals and organochlorine pesticides in the Northern Shoveler and Northern Pintail (Avian: Anatidae) related to blood parameters and body condition

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Appendices

Table A.1 Method detection limit (MDL, ng g⁻¹) values for organochlorine pesticides (OCPs) measured in the liver and muscle tissues of the Northern Pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*) sampled in Marismas Nacionales.

OCP	Liver	Muscle
	MDL X 10 ⁻¹	MDL X10 ⁻¹
Aldrin	0.18	0.08
Dieldrin	0.12	0.30
Endrin	0.13	0.31
Endrin aldehyde	0.08	1.74
α-HCH	0.03	0.32
β-HCH	0.14	0.59
Lindane	0.04	0.84
δ-HCH	0.08	0.09
4,4'-DDD	0.11	0.24
4,4'-DDE	0.09	0.31
4,4'-DDT	0.75	0.95
α-Enosulfan	0.43	2.07
β-Endosulfan	0.15	0.56
Endosulfan sulfate	0.75	0.95
Heptachlor	0.58	0.08
Heptachlor epoxide	0.06	0.17

37 **Table A.2** Descriptive statistics of the concentration of pollutants (ng g⁻¹ dry weight) in the Northern Shoveler (*Spatula clypeata*) and Northern
38 Pintail (*Anas acuta*) sampled in Marismas Nacionales (Sinaloa, Mexico). Abbreviations: hexachlorocyclohexanes (HCHs), drins (dieldrin, aldrin,
39 endrin), dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyldichloroethane (DDD). The
40 values of each pollutant are presented in the following order: geometric mean, minimum-maximum range, and frequency

Northern Pintail (<i>Anas acuta</i>)		
	Female	Male
	(n = 7)	(n = 20)
Hg	134.90 ± 165.90	138.50 ± 91.30
	4.90–483.00	<MDL–315.50
	7	19
Pb	5261.00 ± 4053.30	3192.10 ± 2511.80
	1705.10–11966.90	<MDL–10071.00
	7	17
	Liver	Muscle

	Female	Male	Female	Male
	(n = 7)	(n = 20)	(n = 7)	(n = 20)
HCH α	0.90 ± 0.70	0.30 ± 0.30	21.40 ± 16.20	16.20 ± 11.60
	<MDL-2.30	<MDL-1.20	<MDL-50.80	<MDL-42.30
	6	10	7	18
HCH β	0.60 ± 0.70	-	-	-
	<MDL-2.00	<MDL-1.40	<MDL-15.90	<MDL-24.60
	4	5	2	8
HCH γ	-	-	11.30 ± 7.80	7.10 ± 5.70
	<MDL-0.10	<MDL	<MDL-24.70	<MDL-21.10
	1	0	6	18
HCH δ	-	-	-	-
	<MDL-0.04	<MDL-0.70	<MDL-20.40	<MDL-23.60
	1	4	1	7

Total frequency of HCHs	12	19	16	51
Heptachlor	1.30 ± 1.30	1.60 ± 2.60	-	-
	<MDL-3.10	<MDL-10.50	<MDL-63.00	<MDL-164.70
	4	10	2	7
Heptachlor epoxide	-	-	-	-
	<MDL-0.40	<MDL-1.70	<MDL	<MDL-50.30
	1	8	0	4
Total frequency of Heptachlors	5	18	2	11
Aldrin	-	-	-	-
	<MDL	<MDL _v 2.60	<MDL	<MDL-12.80
	0	4	0	3
Dieldrin	-	-	-	-

	<MDL-0.40	<MDL-0.90	<MDL	<MDL-7.30
	1	7	0	1
Endrin	-	-	-	-
	<MDL-7.90	<MDL-84.20	<MDL	<MDL-20.20
	3	7	0	3
Endrin aldehyde	-	-	-	-
	<MDL-2.30	<MDL-2.40	<MDL	<MDL-18.20
	1	4	0	5
Total frequency	5	22	0	12
of Drins				
Endosulfan α	-	-	-	-
	<MDL	<MDL-61.10	<MDL-416.80	<MDL
	0	5	1	0
Endosulfan β	-	-	-	-
	<MDL	<MDL	<MDL	<MDL-370.50

	0	0	0	3
Endosulfan	-	-	-	-
sulfate				
	<MDL-12.70	<MDL-153.00	<MDL-46.60	<MDL-18.80
	3	3	1	6
Total frequency	3	8	2	9
of Endosulfans				
DDE	-	-	-	-
	<MDL-9.90	<MDL-7.10	<MDL-85.10	<MDL-51.20
	1	9	1	1
DDD	-	-	-	-
	<MDL	<MDL-38539.10	<MDL	<MDL-51.10
	0	4	0	2
DDT	-	-	-	-
	<MDL-6.60	<MDL-14.60	<MDL-185.60	<MDL-114.60

	2	6	1	6
Total frequency	3	19	2	9
of DDTs				
Northern Shoveler (<i>Spatula clypeata</i>)				
	Female		Male	
	(n = 17)		(n = 9)	
Hg	565.8 ± 544.70		737.70 ± 598.60	
	67.30–2200.70		144.70–1798.80	
	17		9	
Pb	3061.00 ± 1957.10		3252.10 ± 2290.90	
	1357.40–7100.10		1603.50–9063.00	
	17		9	
	Liver		Muscle	
	Female	Male	Female	Male

	(n = 17)	(n = 9)	(n = 17)	(n = 9)
HCH α	4.80 $\pm$ 11.70	-	-	6.00 $\pm$ 17.60
	<MDL-35.20	<MDL-0.30	<MDL-4.70	<MDL-50.50
	4	1	4	5
HCH β	-	-	-	-
	<MDL-11.40	<MDL	<MDL-4.20	<MDL-3.10
	1	0	4	3
HCH γ	5.10 $\pm$ 11.30	-	-	5.00 $\pm$ 14.80
	<MDL-31.90	<MDL-52.70	<MDL-1.80	<MDL-42.50
	6	1	3	5
HCH δ	-	-	-	-
	<MDL	<MDL	<MDL-2.70	<MDL
	0	0	3	0
Total frequency of HCHs	11	2	14	13

Heptachlor	74.00 ± 51.00	13.30 ± 40.60	-	-
	<MDL-237.90	<MDL-116.10	<MDL-21.70	<MDL-9.10
	8	5	6	1
Heptachlor epoxide	-	-	-	-
	<MDL-0.10	<MDL-69.10	<MDL-4.00	<MDL-0.10
	1	2	2	1
Total frequency of Heptachlors	9	7	8	2
Aldrin	-	-	-	-
	<MDL-1.40	<MDL-0.50	<MDL-1.80	<MDL-0.60
	2	2	2	1
Dieldrin	-	-	-	-
	<MDL-0.50	<MDL-85.60	<MDL	<MDL
	1	1	0	0
Endrin	36.60 ± 49.80	-	-	-

	<MDL-151.70	<MDL-339.70	<MDL	<MDL
	9	3	0	0
Endrin aldehyde	-	-	-	-
	<MDL-28.90	<MDL-0.40	<MDL	<MDL
	6	1	0	0
Total frequency of	18	7	2	1
Drins				
Endosulfan α	-	-	-	-
	<MDL-144.90	<MDL-13.90	<MDL-62.70	<MDL-52.70
	3	2	1	2
Endosulfan β	-	-	-	-
	<MDL	<MDL	<MDL	<MDL
	0	0	0	0
Endosulfan sulfate	-	-	-	-
	<MDL	<MDL	<MDL	<MDL

	0	0	0	0
Total frequency of	3	2	1	2
Endosulfans				
DDE	-	-	-	-
	<MDL-51.60	<MDL	<MDL-443.40	<MDL-7.10
	2	0	7	4
DDD	-	-	-	-
	<MDL	<MDL-0.20	<MDL	<MDL
	0	1	0	0
DDT	-	-	-	-
	<MDL-77.80	<MDL-57.30	<MDL	<MDL
	2	2	0	0
Total frequency of	4	3	7	4
DDTs				

41 ^a Mean values correspond to pollutants with > 50% of the corresponding data above the method detection limit (MDL).

Table A.3 Frequency of occurrence of organochlorine pesticides (OCPs) in the Northern Pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*) sampled in Marismas Nacionales. Abbreviations: hexachlorocyclohexanes (HCHs), drins (dieldrin, aldrin, and endrin), and dichlorodiphenyltrichloroethanes (DDTs)

Tissue	Sex	HCHs	Heptachlors	Drins	Endosulfans	DDTs
<i>A. acuta</i>						
Liver (20)	M	13	13	14	14	15
Liver (7)	F	7	5	4	4	4
Muscle (20)	M	19	18	18	11	9
Muscle (7)	F	7	6	6	3	2
<i>S. clypeata</i>						
Liver (9)	M	2	5	5	6	7
Liver (17)	F	8	9	10	9	9
Muscle (9)	M	6	6	6	3	3
Muscle (17)	F	8	9	7	7	6

Table A.4 Results of permutational multivariate analysis of variance (PERMANOVA) pairwise comparisons between species-sex groups for metal and organochlorine pesticide (OCP) concentrations in the Northern Pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*) sampled in Marismas Nacionales

Comparisons	t	P (perm)	Average dissimilarity (%)
<i>A. acuta</i> -Female vs. <i>A. acuta</i> -Male	0.75	0.66	30.29
<i>A. acuta</i> -Female vs. <i>S. clypeata</i> -Female	1.88	0.03*	31.36
<i>A. acuta</i> -Male vs. <i>S. clypeata</i> -Male	1.85	0.01*	32.71
<i>S. clypeata</i> -Female vs. <i>S. clypeata</i> -Male	0.77	0.65	25.68

*Significant differences

Table A.5 Statistical summary of the redundancy analysis (RDA) of the biomarker-pollutant relationship in the Northern Pintail (*Anas acuta*). Abbreviations: hexachlorocyclohexanes (HCHs), drins (dieldrin, aldrin, and endrin), dichlorodiphenyltrichloroethanes (DDTs), heterophil/lymphocyte index (H/L), spleensomatic index (SI), condition index (CI), polychromatic erythrocytes (PCE), micronucleated mature erythrocytes (MNE), micronucleated polychromatic erythrocytes (MNPCE), bud cells in polychromatic erythrocytes (BCE), and bud cells in mature erythrocytes (BC).

<i>Anas acuta</i>	RDA1	RDA2
Eigenvalues	2.13	0.52
Total variance explained: 45.54%	26.64	6.53
Biomarker-pollutant relationship explained (%)	58.50	14.34
Axis-pollutant correlation		
Hg	-0.16	0.17
Pb	-0.49*	-0.43
HCHs-L	-0.41	-0.22
Heptachlors-L	0.01	-0.19
Drins-L	0.83*	-0.16
DDTs-L	0.10	-0.24
HCHs-M	-0.10	0.02
Axis-pollutant correlation		
H/L	0.51*	0.76*
SI	-0.54*	-0.32
CI	0.70*	-0.29
PCE	0.90*	-0.17
MNE	-0.06	0.53*
PCMNE	-0.26	-0.28
BCE	0.13	0.56*
BC	0.78	0.17

*Significant correlation with an axis.

Table A.6 Statistical summary of the redundancy analysis (RDA) of the biomarker-pollutant relationship in the Northern Shoveler (*Spatula clypeata*). Abbreviations: hexachlorocyclohexanes (HCHs), drins (dieldrin, aldrin, and endrin), dichlorodiphenyltrichloroethanes (DDTs), heterophil/lymphocyte index (H/L), spleensomatic index (SI), condition index (CI), polychromatic erythrocytes (PCE), micronucleated mature erythrocytes (MNE), micronucleated polychromatic erythrocytes (MNPCE), bud cells in polychromatic erythrocytes (BCE), and bud cells in mature erythrocytes (BC)

<i>Spatula clypeata</i>	RDA1	RDA2
Eigenvalues	1.10	0.92
Total variance explained: 41.88%	13.75	11.48
Biomarker-pollutant relationship explained (%)	32.82	27.41
Axis-pollutant correlation		
Hg	-0.29	-0.01
Pb	0.18	0.07
HCHs-L	-0.27	-0.25
Heptachlors-L	-0.22	-0.11
Drins-L	-0.22	-0.51*
DDTs-L	0.89*	-0.13
HCHs-M	-0.07	0.44
Axis-pollutant correlation		
H/L	-0.35	-0.35
SI	0.09	-0.30
CI	-0.15	0.10
PCE	0.54*	0.59*
MNE	0.14	0.58*
PCMNE	0.94*	<0.01
BCE	0.11	0.91*
BC	0.02	0.84*

*Significant correlation with an axis.