Determination of Sensitivity of Birds and Mammals to Environmental Contaminants

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Abstract

EPA guidance for ecological risk assessment lists sensitivity of species to contaminants as one of several criteria to be considered when selecting assessment endpoints. Although sensitivity or insensitivity of some taxa to contaminants is known (e.g., mink and starlings), data concerning sensitivity of many avian and mammalian taxa to environmental contaminants are lacking. To address taxonomic sensitivity, residuals from allometric scaling regression models for over 200 chemicals representing alkaloids, carbamates, chlorinated and non-chlorinated hydrocarbons, cyclodienes, anilines, pyridines, inorganics, and organophosphates were analyzed. Positive residuals indicate that measured toxicity for the test species is underestimated relative to other species in the model and the species is **insensitive**. Conversely, negative residuals indicate that measured toxicity is overestimated relative to other species in the model and the species is **sensitive**. The frequency with which residuals were positive or negative was tabulated and tested using one-tailed binomials tests, with the null hypothesis being *"if a species is neither sensitive nor insensitive, the likelihood of over- or underestimation is 0.5"*. Analyses were performed across and within chemical classes by taxonomic groups (e.g., order, family, genera, species) as data permitted. Sensitive avian and mammalian orders included Anseriformes, Columbiformes, Passeriformes, Carnivora, and Primates. Insensitive orders included Galliformes, Psittaciformes, Artiodactyla, and Lagomorpha. Sensitive bird taxa included ducks (family Anatidae), common pigeons (family Columbidae), and blackbirds (family Icteridae). Although patterns of sensitivity were generally constant across chemical classes for mammalian taxa, sensitivity of some avian taxa varied across chemical classes. Additional taxa appeared to be either sensitive or insensitive, but limited sample sizes for some taxonomic groupings and chemicals precluded statistical significance.

Introduction

Biological diversity and the absence of comparative data preclude evaluation of potential risks from environmental contaminants to all species that may potentially occur at a contaminated site. To be protective of most species at a site, ecological risk assessments generally focus on what are believed to be the most sensitive species. This is consistent with EPA guidance for ecological risk assessment, which lists sensitivity of species to contaminants as one of several criteria to be considered when selecting assessment endpoints (EPA 1997, EPA 1998). Although sensitivity or insensitivity of some taxa to contaminants is known (e.g., mink and starlings), data concerning sensitivity of many avian and mammalian taxa to environmental contaminants are lacking. As a consequence, uncertainty concerning the relative protectiveness provided by representative receptors is unknown.

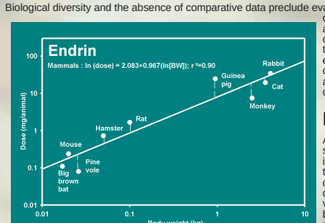


Figure 1. Allometric scaling regression and residuals for endrin in mammals.

Methods

As part of an ongoing study investigating interspecies scaling of toxicity data, we have developed an extensive database of acute toxicity values (144 chemicals for birds and 222 for mammals). Allometric models for extrapolation of toxicity values from one species to another were developed by regressing natural-log transformed acutely lethal doses (LD_{50} in mg chemical/animal) on natural-log transformed body weight (in kg; Sample and Arenal 1999). Separate regression models were developed for each chemical.

To address taxonomic sensitivity, residuals (e.g., difference between the measured value and the value estimated by the regression model) from the allometric scaling regression models were analyzed. Positive residuals indicate that measured toxicity for the test species is underestimated relative to other species in the model and the species is insensitive. Conversely, negative residuals indicate that measured toxicity is overestimated relative to other species in the model and the species is sensitive. Examples of allometric models and residuals are presented for the cyclodiene, endrin (Figures 1 and 2), the organophosphate, ethyl parathion (Figure 3), and the inorganic, arsenic trioxide (Figure 4).

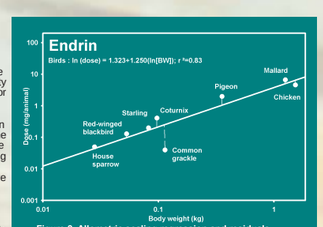


Figure 2. Allometric scaling regression and residuals for endrin in birds.

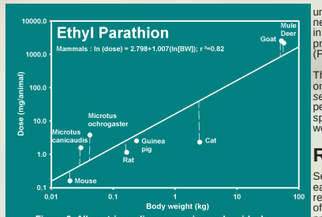


Figure 3. Allometric scaling regression and residuals for ethyl parathion in mammals.

For all chemicals pooled, sensitive avian and mammalian orders included Anseriformes, Columbiformes, Passeriformes, Carnivora, and Primates; insensitive orders included Galliformes, Psittaciformes, Artiodactyla, and Lagomorpha.

Sensitivity of avian taxa was not constant across all chemical classes. For example, galliforms (quail, chickens, and pheasants) were found to be insensitive to alkaloids, carbamates and organophosphates, while being sensitive to chlorinated hydrocarbons; columbiforms (pigeons and doves) were insensitive to chlorinated hydrocarbons and pyridines, while being sensitive to organophosphates (Table 1).

In contrast to birds, patterns of sensitivity among mammalian taxa across chemical classes were fairly constant. House mice, primates (represented by humans), and carnivores were consistently sensitive, while Artiodactyla (even-toed hooved mammals), rabbits, and hamsters were consistently insensitive.

Although additional taxa appear to be either sensitive or insensitive, limited sample sizes for some taxonomic groupings and chemicals preclude statistical significance.

Discussion

Overall, our sensitivity results were in agreement with the available published literature. Some mechanisms presented in the literature that explain differences in sensitivities among species include differences in (1) anatomy, (2) metabolic kinetics of the contaminant, (3) site of action, (4) enzyme catalytic function, (5) non-enzymatic chemical activity (e.g., antioxidants, mutagens), and (6) membrane regulation. The following are some examples related to these mechanisms.

1. Anatomy - Anatomical structures can minimize or dilute exposure.

   Sterner et al. (1998) reported that the alkaloid strychnine was much less toxic to bobwhite quail than to mallard ducks. The authors listed physical differences in crop structure between quail and duck as a possible mechanism for the differences in susceptibility. Quail have a unilateral sac for temporary food storage and a thick epithelium sac which may slow strychnine deposition into the gizzard.

2. Metabolic kinetics of the contaminant - Some species have an ability to efficiently convert or rapidly metabolize a chemical that affects its toxicity.

   Cats were determined to be the most sensitive to nitrogen-containing hydrocarbon dimethylnitrosamine (DMN), compared to guinea pigs, rats, monkeys, lizards, and birds, in order of decreasing susceptibility. This difference was attributed to the cat's high rate of DMN metabolism compared to the slower rates of DMN metabolism in the other test species (Maduagwu and Bassir 1980).

   The pyridine, 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) is most toxic to humans and other primates. Rats are resistant and mice show intermediate resistance. Riachi et al. (1988) found that the rat's resistance was due in part to its ability to efficiently convert MPTP to its inert metabolite MPP^+, while mice were less efficient and humans least efficient at making this conversion. In contrast, hamster resistance to 1,3-dinitrobenzene exposure was likely due to the hamster's inability to form this hydrocarbon's toxic metabolites (Obasaju et al. 1991).

3. Site of action - Species may differ in the site of toxic action.

   American kestrels were found to be highly sensitive to carbofuran, despite lower levels of brain cholinesterase (ChE) inhibition in dead kestrels compared to dead eastern screech-owls. Vyas et al. (1998) suggested that ChE activity/inhibition at critical neuromuscular junctions was an important factor in explaining kestrel sensitivity to carbamates. In comparison to kestrels, the screech-owls showed little indication of ChE inhibition at neuromuscular junctions.

4. Enzyme catalytic function - Functional differences in enzymes across species often result from species-specific differences in the receptor enzyme, such as charge interactions on the enzyme or structure-activity hindrances (e.g., steric), which can inhibit binding.

   Differences in the electronegativity of the binding site on the enzyme was indicated as a factor in the greater sensitivity of birds and mammals to OPs compared to fish. Thus the strong nucleophilic center of rat and chicken acetylcholinesterase (AChE) confers a greater affinity for the OP oxygen analogue than the weak nucleophilic center of trout AChE (Wallace and Kemp 1991). Wallace and Kemp (1991) further indicated that differences in rat and chicken OP sensitivity were determined by differences in steric hindrance at the AChE binding site.

   Huan et al. (1998) compared the toxicity of Pyrrolizidine alkaloid plant toxins in 8 mammals and 2 birds, and concluded that species differences appeared to be dependent on the individual species' hepatic microsomal enzymes catalytic capability. Similarly, differences in the sensitivity of several bird species to OP insecticides were attributed to species-specific catalytic properties (Fossi et al. 1996).

   Inter-species differences in Ah receptor affinities for TCDD and coplaner PCBs may partly account for species differences in susceptibility (Brunström and Halldin 1998).

5. Non-enzymatic chemical activity - These may included species-specific differences in antioxidant and mutagenic activities.

   Many chlorinated and non-chlorinated hydrocarbons and some inorganics cause lipid peroxidation resulting in animal toxicity. The high resistance of pig heart tissue and red blood cells to lipid peroxidation compared to rats, quail, and rabbits was likely a reflection of greater tissue reserves of non-enzymatic antioxidants (e.g., vitamin E) relative to the other species (Godin and Garnett 1992).

   Graves et al. (1995) described the mechanism of susceptibility in mice to methylene chloride. In contrast to resistant rats, hamsters and humans, mice exposed to this chlorinated hydrocarbon suffer many DNA single strand breaks which lead to carcinogenesis.

6. Membrane regulation - Differences in membrane permeability can affect toxicity.

   Gingell and Wallcave (1974) observed the hamster to be particularly resistant to the toxic effects of DDT compared to mice, despite no species differences in absorption, hepatic or bacterial detoxification, or excretion. They concluded that differences were associated with differences in the permeability of the blood/brain barrier which regulated brain DDT concentrations.

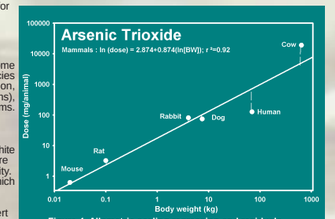
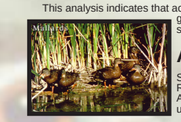


Figure 4. Allometric scaling regression and residuals for arsenic trioxide in mammals.

Conclusions

This analysis indicates that acute toxicity data may be used to evaluate the sensitivity of avian and mammalian taxa to contaminants. The results obtained are generally in agreement with, and supported by, research linking differing mechanisms to expressions of toxicity. Availability of information such as that presented in this poster should facilitate selection of more appropriate assessment endpoints in ecological risk assessments.



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References

Bank, PA, EF Yao, CL Phelps, PA Harper, and MS Denison. Species-specific binding of transformed Ah receptor to a dioxin responsive transcriptional enhancer. Europ J Pharm - Environ Toxicol Pharm Sect 228:85-94.

Brunström, B and K Halldin. 1998. EROD induction by environmental contaminants in avian embryo livers. Comp Biochem Physiol 121C:213-219.

EPA. 1997. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. Interim Final. U.S. Environmental Protection Agency, Emergency Response Team.

EPA. 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002F. Risk Assessment Forum, Washington, D.C.

Fossi, MC, L Lari, and S Casini. 1996. Interspecies variation of "B" esterases in birds: the influence of size and feeding habits. Arch Environ Contam Toxicol 31:525-532.

Gingell, R and L Wallcave. 1974. Species differences in the acute toxicity and tissue distribution of DDT in mice and hamsters. Toxicol App Pharm 28:385-394.

Godin, DV and ME Garnett. 1992. Species-related variations in tissue antioxidant status-II. differences in susceptibility to oxidative challenge. Comp Biochem Physiol 103B:743-748.

Graves, RJ, C Coutts, and T Green. 1995. Methylene chloride-induced DNA damage: an interspecies comparison. Carcinogenesis 16:1919-1926.

Huan, J, CL Miranda, DR Buhler, and PR Cheeke. 1998. Species differences in the hepatic microsomal enzyme metabolism of the pyrrolizidine alkaloids. Toxicol Let 99:127-137.

Maduagwu, EN and O Bassir. 1980. A comparative assessment of toxic effects of dimethylnitrosamine in six different species. Toxicol App Pharm 53:211-219.

Obasaju, MF, DF Katz and MG Miller. Species differences in susceptibility to 1,3-dinitrobenzene-induced testicular toxicity and methemoglobinemia. Fund App Toxicol 16:257-266.

Riachi, NJ, SI Harik, RN Kalaria, and LM Sayre. 1988. On the mechanisms underlying 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine neurotoxicity. II. Susceptibility among mammalian species correlates with the toxin's metabolic patterns in brain microvessels and liver. J Pharm Exper Therap 244:443-448.

Sample, B.E., and C.A. Arenal. 1999. Allometric models for interspecies extrapolation of wildlife toxicity data. Bull. Environ. Contam. Toxicol. 62: 653-663.

Sterner, RT, CA Pedersen, BR Helsten, and MJ Goodall. 1998. Subchronic dietary toxicity of strychnine: bobwhite quail are less sensitive than mallard ducks. Arch Environ Contam Toxicol 35:498-505.

Vyas, NB, LA Thiele, and SC Garland. 1998. Possible mechanisms for sensitivity to organophosphorus and carbamate insecticides in eastern screech-owls and American kestrels. Comp Biochem Physiol Part C 120:151-157.

Wallace, KB and JR Kemp. 1991. Species specificity in the chemical mechanisms of organophosphorus anticholinesterase activity. Chem Res Toxicol 4:41-49.

Zar, J.H.1984. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ. 718 pp.

Table 1

CLASS	ORDER	FAMILY	GENUS	SPC		All Chemicals NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Carbamates NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Chlorinated Hydrocarbons NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Cyclodienes NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Anilines NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Pyridines NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)	Organophosphates NUMBER OVER	NUMBER UNDER	p(SENSITIVE)	p(INSENSITIVE)
Aves						486	508	0.25269	0.76715	65	65	0.53492	0.53492	44	47	0.41704	0.66239	23	22	0.617	0.5	58	59	0.5	0.5733	39	32	0.82876	0.23834	157	182	0.09616	0.92109
Mammalia						556	569	0.36027	0.6618	23	25	0.44272	0.66727	115	124	0.30246	0.74109	32	34	0.45108	0.64388	15	18	0.36417	0.75657	11	12	0.5	0.66118	94	72	0.96304	0.05142
Aves		Anseriformes				38	53	0.0709	0.95353	2	10	0.01929	0.99683	7	5	0.80615	0.38721	6	2	0.96484	0.14453	4	0	1	0.0625	0	1	0.5	1	15	23	0.12794	0.92835
Aves		Columbiformes				44	59	0.08372	0.94277	6	9	0.30362	0.84912	9	3	0.98071	0.073	4	2	0.89063	0.34375	1	4	0.1875	0.96875	7	1	0.99609	0.03516	8	26	0.00147	0.99959
Aves		Falconiformes				5	6	0.5	0.72559													3	0	1	0.125	1	0	1	0.5	0	2	0.25	1
Aves		Galliformes				142	101	0.99653	0.00507	24	8	0.99895	0.0035	10	23	0.01754	0.99323	5	10	0.15088	0.94077	14	13	0.64945	0.5	4	5	0.5	0.74609	62	31	0.99959	0.00086
Aves		Gruiformes				4	1	0.96875	0.1875	1	1	0.75	0.75	1	0	1	0.5													2	0	1	0.25
Aves		Passeriformes				242	284	0.03686	0.96965	32	35	0.4036	0.6873	17	16	0.63583	0.5	8	8	0.59819	0.59819	34	41	0.24434	0.82215	23	25	0.44272	0.66727	68	99	0.00999	0.99348
Aves		Psittaciformes				10	2	0.99683	0.01929	0	1	0.5	1									2	0	1	0.25	4	0	1	0.0625	2	1	0.875	0.5
Mammalia		Artiodactyla				31	19	0.96755	0.05946	2	6	0.14453	0.96484	9	3	0.98071	0.073	4	2	0.89063	0.34375					1	0	1	0.5	9	3	0.98071	0.073
Mammalia		Carnivora				67	92	0.02833	0.98056	2	1	0.875	0.5	16	25	0.10551	0.94136	6	6	0.61279	0.61279	0	4	0.0625	1	0	1	0.5	1	8	10	0.40726	0.75966
Mammalia		Chiroptera				3	4	0.5	0.77344					1	3	0.3125	0.9375	0	2	0.25	1									2	0	1	0.25
Mammalia		Lagomorpha				87	68	0.94606	0.074	3	2	0.8125	0.5	22	12	0.97119	0.06072	4	3	0.77344	0.5	4	1	0.96875	0.1875	1	1	0.75	0.75	8	11	0.3238	0.82036
Mammalia		Marsupialia				9	11	0.4119	0.74828																								
Mammalia		Perissodactyla				4	2	0.89063	0.34375					1	0	1	0.5																
Mammalia		Primate				23	42	0.01241	0.99375	2	0	1	0.25	3	16	0.00221	0.99964					0	4	0.0625	1	1	0	1	0.5	2	1	0.875	0.5
Mammalia		Rodentia				332	331	0.53095	0.5	14	16	0.42777	0.70767									18	17	0.63206	0.5	10	13	0.33882	0.79756	9	10	0.5	0.6762	65	47	0.96384	0.05389
Aves		Anseriformes	Anatidae			38	53	0.0709	0.95353	2	10	0.01929	0.99683	7	5	0.80615	0.38721	6	2	0.96484	0.14453	4	0	1	0.0625	0	1	0.5	1	15	23	0.12794	0.92835
Aves		Anseriformes	Anatidae	Anas	Mallard duck	31	43	0.10034	0.93491	2	7	0.08984	0.98047	4	4	0.63672	0.63672	4	1	0.96875	0.1875	3	0	1	0.125	0	1	0.5	1	13	19	0.18854	0.89234
Aves		Anseriformes	Anatidae	Branta	Canada goose	3	6	0.25391	0.91016	0	2	0.25	1	1	0	1	0.5	1	0	1	0.5									2	3	0.5	0.8125
Aves		Columbiformes	Columbidae			44	59	0.08372	0.94277	6	9	0.30362	0.84912	9	3	0.98071	0.073	4	2	0.89063	0.34375	1	4	0.1875	0.96875	7	1	0.99609	0.03516	8	26	0.00147	0.99959
Aves		Columbiformes	Columbidae	Columba	Rock dove	29	42	0.07696	0.95204	4	6	0.37695	0.82812	6	1	0.99219	0.0625	3	1	0.9375	0.3125	1	1	0.75	0.75	1	0	1	0.5	8	22	0.08006	0.99739
Aves		Columbiformes	Columbidae	Zenaida		14	14	0.57472	0.57472	2	2	0.6875	0.6875	3	2	0.8125	0.5	1	1	0.75	0.75	0	2	0.25	1	5	0	1	0.03125	0	4	0.0625	1
Aves		Columbiformes	Columbidae	Zenaida	Mourning dove	10	9	0.6762	0.5	1	1	0.75	0.75	3	2	0.8125	0.5	1	1	0.75	0.75	0	1	0.5	1	3	0	1	0.125	0	2	0.25	1
Aves		Falconiformes	Accipitridae			3	3	0.65625	0.65625													2	0	1	0.25					0	1	0.5	1
Aves		Falconiformes	Accipitridae	Aquila	Golden eagle	1	3	0.3125	0.9375																					0	1	0.5	1
Aves		Falconiformes	Falconidae			2	2	0.6875	0.6875													1	0	1	0.5	1	0	1	0.5	0	1	0.5	1
Aves		Falconiformes	Falconidae	Falco	American kestrel	2	2	0.6875	0.6875													1	0	1	0.5	1	0	1	0.5	0	1	0.5	1
Aves		Galliformes	Phasianidae			141	101	0.99587	0.00601	24	8	0.99895	0.0035	10	23	0.01754	0.99323	5	10	0.15088	0.94077	13	13	0.57749	0.57749	4	5	0.5	0.74609	62	31	0.99959	0.00086
Aves		Galliformes	Phasianidae	Alectoris	Chukar	19	4	0.99976	0.0013	1	1	0.75	0.75	0	1	0.5	1	0	1	0.5	1									16	1	0.99999	0.00014
Aves		Galliformes	Phasianidae	Callipepla	California quail	6	1	0.99219	0.0625	2	0	1	0.25	0	1	0.5	1	0	1	0.5	1									2	0	1	0.25
Aves		Galliformes	Phasianidae	Colinus	Bobwhite quail	5	11	0.10506	0.96159	3	0	1	0.125	0	4	0.0625	1	0	2	0.25	1	0	2	0.25	1	4	0	1	0.125	0	3	0.125	1
Aves		Galliformes	Phasianidae	Coturnix	Coturnix quail	64	33	0.99948	0.00108	9	3	0.98071	0.073	5	5	0.62305	0.62305	4	0	1	0.0625	12	10	0.73827	0.41591	3	5	0.36328	0.85547	25	5	0.99997	0.00016
Aves		Galliformes	Phasianidae	Gallus	Domestic chicken	12	6	0.95187	0.11894	2	0	1	0.25	2	5	0.22656	0.9375	0	3	0.125	1									6	1	0.99219	0.0625
Aves		Galliformes	Phasianidae	Phasianus	Ring-necked pheasant	29	38	0.16422	0.88923	5	4	0.74609	0.5	3	5	0.36328	0.85547	1	2	0.5	0.875	1	0	1	0.5	1	0	1	0.5	9	19	0.04358	0.98215
Aves		Galliformes	Phasianidae	Tympanuchus	Sharp-tailed grouse	4	3	0.77344	0.5	2	0	1	0.25	0	1	0.5	1													2	2	0.6875	0.6875
Aves		Gruiformes	Gruidae	Grus	Sandhill crane	4	1	0.96875	0.1875	1	1	0.75	0.75	1	0	1	0.5													2	0	1	0.25
Aves		Passeriformes	Corvidae			8	13	0.19166	0.90538	2	1	0.875	0.5	0	1	0.5	1					2	5	0.22656	0.9375	1	3	0.3125	0.9375	0	2	0.25	1
Aves		Passeriformes	Corvidae	Corvus	Corvus spp.	4	7	0.27441	0.88672	1	1	0.75	0.75	0	1	0.5	1					1	2	0.5	0.875	0	1	0.5	1	0	1	0.5	1
Aves		Passeriformes	Corvidae	Pica	Pica spp.	3	4	0.5	0.77344	0	2	1	0.5									1	1	0.75	0.75	0	2	0.25	1	0	1	0.5	1
Aves		Passeriformes	Emberizidae	Zonotricia	Zonotricia spp.	5	3	0.85547	0.36328	0	2	0.25	1	1	0	1	0.5									2	0	1	0.25	1	0	1	0.5
Aves		Passeriformes	Fringillidae	Carpodacus	House finch	19	18	0.62859	0.5	0	4	0.0625	1	1	0	1	0.5									0	1	0	1	0	7	0.88672	0.27441
Aves		Passeriformes	Icteridae			66	160	0.0001	1	10	20	0.04937	0.97861	6	8	0.39526	0.78802	3	5	0.36328	0.85547	4	24	0.00009	0.99999	6	13	0.08353	0.96822	18	55	0.00001	1
Aves		Passeriformes	Icteridae	Agelaius	Agelaius spp.	31	94	0.0001	1	4	9	0.13342	0.95386	4	4	0.63672	0.63672	3	1	0.9375	0.3125	4	21	0.00046	0.99992	5	6	0.5	0.72559	5	31	0.00001	1
Aves		Passeriformes	Icteridae	Agelaius	Red-winged blackbird	30	90	0.0001	1	4	8	0.19385	0.927	4	4	0.63672	0.63672	3	1	0.9375	0.3125	4	19	0.0013	0.99976	5	5	0.62305	0.62305	5	31	0.00001	1
Aves		Passeriformes	Icteridae	Quiscalus		21	43	0.00407	0.99816	3	7	0.17188	0.94531	1	4	0.1875	0.96875	0	4	0.0625	1	0	2	0.25	1	1	4	0.1875	0.96875	9	18	0.06104	0.97388
Aves		Passeriformes	Icteridae	Xanthocephalus	Yellow headed blackbird	6	13	0.08353	0.96822	0	3	0.125	1	1	0	1	0.5													0	3	0.125	1
Aves		Passeriformes	Ploceidae			7	16	0.0457	0.98266	2	1	0.875	0.5	0	1	0.5	1	3	0	1	0.125	1	2	0.5	0.875	1	0	1	0.5	1	9	0.01074	0.99902
Aves		Passeriformes	Passeridae	Passer	Passer spp.	63	38	0.99533	0.00825	7	3	0.94531	0.17188	5	2	0.9375	0.22656	3	1	0.9375	0.3125	18	3	0.99989	0.00074	3	4	0.5	0.77344	13	18	0.23656	0.85948
Aves		Passeriformes	Passeridae	Passer	House sparrow	62	37	0.99568	0.00772	6	3	0.91016	0.25391	5	2	0.9375	0.22656	3	1	0.9375	0.3125	18	3	0.99989	0.00074	3	3	0.65625	0.65625	13	18	0.23656	0.85948
Aves		Passeriformes	Ploceidae	Quelea	Red-billed quelea	5	14	0.03178	0.99039	1	1	0.75	0.75	0	1	0.5	1					2	0	1	0.25	1	0	1	0.5	1	9	0.01074	0.99902
Aves		Passeriformes	Sturnidae	Sturnus	European starling	68	26	1	0.00001	10	1	0.99951	0.00586	4	4	0.63672	0.63672	2	2	0.6875	0.6875	7	6	0.70947	0.5	6	2	0.96484	0.14453	26	8	0.99959	0.00147
Aves		Psittaciformes	Psittacidae			10	2	0.99683	0.01929	0	1	0.5	1									2	0	1	0.25	4	0	1	0.0625	2	1	0.875	0.5
Mammalia		Artiodactyla	Bovidae			16	12	0.82754	0.28579	2	3	0.5	0.8125	5	2	0.9375	0.22656	2	1	0.875	0.5									3	3	0.65625	0.65625
Mammalia		Artiodactyla	Bovidae	Bos	Cattle	3	6	0.25391	0.91016					1	1	0.75	0.75													0	2	0.25	
Mammalia		Artiodactyla	Bovidae	Capra	Domestic goat	6	4	0.82812	0.37695	2	2	0.6875	0.6875	2	1	0.875	0.5	1	1	0.75	0.75									2	1	0.875	0.5
Mammalia		Artiodactyla	Bovidae	Ovis	Domestic sheep	7	2	0.98047	0.08984	0	1	0.5	1	2	0	1	0.25	1	0	1	0.5									1	0	1	0.5
Mammalia		Artiodactyla	Cervidae	Odocoileus	Mule deer	10	3	0.98877	0.04614	0	3	0.125	1	4	0	1	0.0625	2	0	1	0.25									4	0	1	0.0625
Mammalia		Carnivora	Canidae			45	53	0.23985	0.81832	1	1	0.75	0.75					3	2	0.8125	0.5	0	2	0.25	1	0	1	0.5	1				
Mammalia		Carnivora	Canidae	Canis	Canis spp.	44	51	0.2692	0.79404	1	1	0.75	0.75	10	14	0.27063	0.84627	3	2	0.8125	0.5	0	2	0.25