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Original Research

^{90}Sr, ^{241}Am and Plutonium in Skeletons of Barn Owl (*Tyto alba* Scop.) from Southeast Poland

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Abstract

Numerous studies concerned with accumulation of several various groups of chemical compounds have been performed on Barn Owls (*Tyto alba* Scop.). But up to now we have no data about concentrations of radionuclides in their tissues. However, in Europe a large part of the breeding range of this species might have received fallout from Chernobyl. Nine skeletons of Barn Owls collected in 1999-2002 in southeastern Poland were analyzed for ^{90}Sr, ^{241}Am and plutonium. The results revealed $^{239+240}$Pu (< 0.004 Bq/kg -0.051± 0.007 Bq/kg ash weight), ^{241}Am (< 0.02 Bq/kg – < 0.06 Bq/kg ash weight) and ^{90}Sr (9.7 ± 0.9 Bq/kg – 46.8 ± 3.6 Bq/kg ash weight) concentrations to be similar to those observed in the prey species; therefore, the conclusion is that no accumulative effect has been seen.

Keywords: Barn Owl, *Tyto alba*, radionuclides, Chernobyl fallout

Introduction

The Common Barn Owl (*Tyto alba)* can be regarded as a good model to study contaminant accumulation processes due to its position in trophic chains, its sedentary character and its especially wide cosmopolite range[1-3]. That very reason determined its suitability for contaminant accumulation studies and made it one of the most thoroughly examined nocturnal raptors. Numerous studies concerned with accumulation of various groups of chemical compounds have been performed on this species so far. Yet, only the concentration of polycyclic aromatic hydrocarbons ([4, 5] and the amount of arsenic residue [6] were measured in Barn Owls. Considerable time was spent on studies dedicated to determine doses and interaction mechanisms of pesticides [7-10], and heavy metals [11] in Barn Owl individuals and populations. Nevertheless, knowledge about radionuclide accumulation in birds, especially raptors (including Barn Owls), remains rather scarce [3, 12-15].

Presently, 22 years have passed since the time of the greatest atomic emergency, the Chernobyl catastrophe, which took place in late April 1986. The Chernobyl accident fallout covered a large part of the European range of the Barn Owl (*cf.* [1] *vs.* [16]).

Relatively high (compared to those in bones of other mammals) activities of $^{239+240}$Pu and ^{241}Am and not so enhanced activity of ^{90}Sr [12.17] were found in skulls of rodent *Rodentia* and insectivorous mammals *Insectivora* that are known to be habitual prey of Barn Owls in many areas of Europe [1.2]. Accumulation of those bone-seekers in predators such as owls seemed very likely and was the reason for undertaking the present study.

In Central Europe, no studies on accumulated radionuclide contamination in owls *Strigiformes* have been

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performed, and other studies on raptors are scarce [18, 19]. Our studies also benefited from long-term studies on the population ecology of Barn Owls in southeastern Poland [20, 21] that facilitated collecting the skeletons of dead individuals. This paper presents ^{90}Sr, $^{239.240}$Pu and ^{241}Am activities from sites in southeastern Poland and estimates the potential usage of Barn Owls as an indicator of radionuclide contamination by bone-seeking radionuclides.

Experimental Procedures

Nine skeletons of Barn Owl collected between 1999 and 2002 in southeastern Poland (approximately 23°40' E, 50°50' N) were the subjects of our study. Samples were weighed, dried at 105°C overnight and ashed at 600°C for six hours. A single, combined sample was formed from skeletons of owls found in the same village. Such grouping was necessary in order to obtain samples large enough to enable reliable Pu and Am analyses. Grouping resulted in six samples. Data on the samples are presented in Table 1.

Tracers, namely ^{85}Sr, ^{242}Pu and ^{243}Am, were added to the ashed samples, which were then treated according to the radiochemical procedure used for determination of plutonium, americium and ^{90}Sr in animal bones [12, 17]. The procedure begins with hot digestion in hydrochloric and nitric acids. Water and oxalic acid were added to the solutions, and the pH was balanced at 6 using ammonia to co-precipitate Sr, Pu and Am with Ca oxalate. Subsequent to destroying oxalates at 600°C, Pu was separated from 8 M HNO_3 on a Dowex-1 anion exchange column, Sr was separated from 8 M HNO_3 on EiChrom Sr-Resin, and Am was purified from rare earth elements by employing Dowex-1 and methanol-acids solutions. To prepare alpha spectrometric sources (Pu, Am), NdF_3 co-precipitation method was applied [22]. A Silena Alpha Quattro spectrometer with Canberra PIPS detectors was used to perform the measurements. Activities of ^{239}Pu and ^{240}Pu are given together ($^{239+240}$Pu) since both radionuclides emit alpha particles of nearly the same energy, 5.15 MeV. Activity of ^{90}Sr was determined with a liquid scintillation spectrometer, Wallac 1414-003 Guardian, while ^{85}Sr recovery was determined by means of gamma spectrometry with an HPGe detector. Recoveries (mean ± standard deviation) were equal to 68±12%, 19±5% and 29±9% for plutonium, strontium and americium tracers, respectively. Obtained recoveries for Am and Sr were lower than usual in our laboratory. The reason for this was not found.

Results and Discussion

The results for ^{90}Sr, $^{239+240}$Pu, ^{238}Pu, and ^{241}Am activity concentrations in ash of Barn Owl skeletons are presented in Table 2. The ^{90}Sr activity concentrations ranged from 9.7±0.9 Bq/kg (a.w. – ash weight) to 46.8±3.6 Bq/kg (a.w.). Such values are comparable with the ones obtained for ^{90}Sr content in skulls of small mammals in southeastern Poland [12], bones of Red Fox (*Vulpes vulpes* L.) [23] and with ^{90}Sr content in diurnal raptors of large size [24]. Our results are also comparable with the results studies on concentrations of radiostrontium in bones of Song Trushes (*Turdus philomelos* C.L.Bhrem) nesting in Fennoscadia and Central Europe and hunt when wintering in SE Spain. There, activities in bones oscillated in range 32.0 ±2.0 – 38 ±2.0 Bq/kg dry w., with lack of any intergenerational and intersexual differences [16]. On the other hand, during detailed studies on skeletons of individuals of Glacous-winged Gull (*Larus glaucescens* Nauman) (n=8), Tufted Puffin (*Fratercula cirrhata* Pallas) (n=3) and Pigeon Guillemot (*Cepphus columba* Pallas)(n=3) from Aleutian Islands (where nuclear explosions were performed during the Cold War) all the levels of ^{90}Sr there were below minimum detectable activity levels [25].

Table 1. Basic data on Barn Owl (*Tyto alba*) samples taken for analyses.

Code	Sampling site	Longitude	Latitude	Year of finding a dead individual	Skeleton dry mass [g]	Ash mass [g]	Remarks
1.	Wierzbica	23° 20 E	51°16'N	2003	12.8	8.1	grouped+2
2.	Wierzbica	-	-	2003	12.1	7.8	grouped+1
3.	Zolkiewka	22° 50'E	50°54'N	1999	18.0	8.7	not grouped
4.	Radziecin	22° 42'E	50°41'N	2002	15.1	7.1	grouped+5
5.	Radziecin	-	-	2002	17.5	8.7	grouped+4
6.	Mycow	24° 00'E	50°27'N	2001	15.7	6.0	not grouped
7.	Polichna	22° 20'E	50° 50'N	2002	20.0	9.4	grouped+8
8.	Polichna	-	-	2001	21.7	11.6	grouped+7
9.	Horyszow Ruski	23° 37'E	50° 45'N	2000	12.6	6.9	not grouped

Table 2. ^{90}Sr, plutonium and americium activity concentrations in Barn Owl (*Tyto alba)* samples from southeastern Poland

Code	Activity [Bq/kg a.w.]			
	^{90}Sr	$^{239+.240}Pu$	^{238}Pu	^{241}Am
1+2	17.5 ± 1.9	< 0.008	< 0.009	< 0.02
3	46.8 ± 3.6	< 0.009	< 0.01	< 0.04
4+5	23.4 ± 2.6	0.009 ± 0.002	< 0.11	< 0.02
6	17.9 ± 2.0	0.028 ± 0.005	< 0.01	< 0.06
7+8	45.2 ± 4.9	< 0.004	< 0.006	< 0.02
9	9.7 ± 0.9	0.051 ± 0.007	< 0.02	< 0.05

Activity concentrations are lower than those found for ^{90}Sr in bones of large wild herbivorous mammals from southeast Poland [26]. It was concluded therefore that no enhanced accumulation of ^{90}Sr was observed in owl bones.

Activity concentrations of $^{239+240}Pu$ in examined bones ranged from below 0.004 Bq/kg (a.w.) to 0.051±0.007 Bq/kg (a.w.).Unfortunately, due to interference problems with traces of ^{228}Th, the alpha peaks of ^{241}Am and ^{238}Pu activities always fell below the level of detectable activities. In Table 2 only the upper limits for their activities are presented. Such limits happen to be relatively high, which results from the interference mentioned with thorium.

$^{239+240}Pu$ activities reported here for skeletons of owl, though higher than the ones found for wild herbivorous mammals from southeastern Poland [27], were comparable to values found recently for small mammals [12, 17], foxes or eagles [23, 24]. They are at least an order of magnitude larger than found recently for bones of all 10 examined species of sea birds: Cormorant (*Phalacrocorax carbo* L.), Tufted Duck (*Aythya fuligula* L.), Red-throated Diver (*Gavia stellata* Pont), Long- tailed Duck (*Clangula hyemalis* L.), Velvet Scoter (*Mellanita fusca* L.), Eider (*Somateria mollissima* L.), Coot (*Fulica atra* L.), Razobill *Alca torda* L.), Guillemot (*Uria aalgae* Pont), Black Guillemot (*Cepphus grylle* L.) found dead in the Bay of Gdańsk [28].

For comparison, recent studies on plutonium in birds of Aleutian Islands reported activity concentrations above minimum detectable activity (reported to be relatively high, equal to 0.42 Bq/kg $^{239+240}Pu$) only for one of 3 examined skeletons of Pigeon Guillemot. In the case of ^{238}Pu it was found there above detection limits (also high, 0.31 Bq/kg) in one of three skeletons of Tufted Puffin and in two of eight skeletons of Glacous-winged Gull [25].

In presently analyzed Barn Owls bone samples, there was no correlation between $^{239+240}Pu$ and ^{90}Sr ($r = 0.69$, $n = 6$, $p = 0.13$).

As might be expected, our results for ^{90}Sr content differed significantly from those obtained while researching birds from the Chernobyl Nuclear Power Plant (Ch NPP) exclusion zone. In bones of birds nesting on shores of the Pripyat river Shoveler (*Anas clypeata* L.), radiostrontium content of 18.0 (Bq/kg wet weight) was reported. In eggshells of Black-headed Gulls (*Larus ridbundus* L.) and Grey Herons (*Ardea cinerea* L.) foraging on the ChNPP cooling-pond, the observed contents were far higher and were equal to 2200.0 (Bq/kg wet weight) and 37000.0 (Bq/kg wet weight), respectively [29]. The last, high activities correspond with activities found in bones of Starlings (*Strunus vulgaris* L.) from the Kyshtym radioactive trace area when ^{90}Sr were ranged within: 740-1850 kB/kg [30].

Likewise, our results for plutonium and ^{241}Am content were also very small in comparison to the level of 11.0 (Bq/kg wet weight) detected in eggshells of Gargney (*Anas querquedula* L.) associated with the Ch NPP cooling-pond. Even when we keep in mind that the weight of ashed bones contributes to approximately 60-70% of the total weight of wet bones, the difference still spans a few orders of magnitude [29].

Conclusions

The results presented here revealed $^{239+240}Pu$, ^{241}Am and ^{90}Sr concentrations in Barn Owl skeletons similar to the ones observed previously [12] for owls' prey bones. As far as can be determined, no enhanced accumulation of these radionuclides in the food chain can be concluded.

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