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Comparative Analysis of Heavy Metals in Two Species of Ichthyophagous Bats *Myotis vivesi* and *Noctilio leporinus*

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Bats have highly diverse and specialized feeding habitats (Wilson 1973). Only a few species, of different families, are mainly fish eating, and to a lesser extent may eat crustaceans and some insects (Altenbach 1989; Benedict 1926; Brook 1994; Freeman 1984). We studied two Ichthyophagous species of bats. The main difference between them is that *Myotis vivesi* feeds on ocean species (Walker 1950) and *Noctilio leporinus* feeds more in ponds and quiet streams, and at times, estuaries, bays, and lagoons along the coastline (Hood and Jones 1984). Kidney and liver are the principal target organs for metals in mammals (Medvedev 1995), so the main goal of this work is compare metal levels in both species. These analyses provide baseline data concerning heavy metals in two fishing bats, both from relatively undisturbed and unpolluted environments. Monitoring fishing bats may be useful as an indicator of environmental contamination by heavy metals.

MATERIALS AND METHODS

In this study we used 10 adult *Myotis vivesi* and 10 adult *Noctilio Leporinus*.

The specimens were captured in mist nets; *Myotis vivesi* over the deck of the oceanographic ship "Altair" of the Mexican Navy, off Isla Montserrat in the Sea of Cortez, 14 km offshore and 50 km from Loreto, Baja California Sur and *Noctilio leporinus* captured 4 km north of Bajos de Coyula, on a silk-cotton tree near a coastal lagoon in the Mexican state of Oaxaca. The specimens are now in the mammal collection of the Escuela Nacional de Ciencias Biológicas (ENCB) and Centro de Investigaciones Biológicas del Noroeste (CIBNOR).

Because we captured just a few animals of each species we decided to combine females without any gonadic development and males of each species to make a representative number for the statistical analysis.

For determination of heavy metals, the livers were dried to constant weight in an oven at 70°C and digested in acid-washed test tubes with a mixture of concentrated nitric and perchloric acid and slowly boiled to dryness on a hotplate (Van Loon 1985). Dried samples were analyzed by atomic absorption (BUCK, Scientific model 200). An air-

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acetylene flame was used for copper (Cu), zinc (Zn), iron (Fe), and magnesium (Mn), and a graphite furnace (BUCK, Scientific model GF1) for cadmium (Cd) and lead (Pb). Detection limits for the metals were 0.02, 0.01, 0.03, 0.01, 0,02 and 0.2μg/g dry weight for Cu, Zn, Fe, Mn, Cd and Pb. Precision was checked against the standard reference material of the National Research Council of Canada (DORM-1 for dogfish), and was within the range of certified values. Quality assurance procedure also included the analysis of samples spiked with varying amounts of each element that were analyzed together with unspiked samples. The average recovery values ranged from 87 to 95%. All metal concentrations were expressed as μg/g dry weight.

RESULTS AND DISCUSSION

The result of the analysis of heavy metals in the liver of *Myotis vivesi* and *Noctilio leporinus* shows a significant difference ($P<0.001$) in all metals tested, except for cadmium (Table 1). Levels of manganese, iron, zinc, copper, and lead were higher in *Myotis vivesi* than in *Noctilio leporinus*.

A possible explanation for these results could be the food ingested. Although *N. leporinus* and *P. pipistrellus* are considered as piscivorous, their diets also include other animals, depending on the season. Aerial insects have been reported as the main source of food for *N. leporinus* during the wet season (Brooke 1994). The information available about the feeding habits of *M. vivesi* is scarce. Their diet is mainly based on small crustaceans and fish (Walker 1950). Crustaceans are a good source of some metals. Shrimp hepatopancreas accumulate zinc, manganese, iron, and copper through metallothionein (Vogt and Quinitio 1994). Thoracal extensions of the antennal gland in the shrimp is the main site where there are lead granules, and the exoskeleton is used for cadmium detoxification (Vogt and Quinitio 1994; Méndez et al. 1997). In addition, other factors as reproductive stage, sex, age, and season of the prey used as food and the habitat could be involved (Páez-Osuna and Ruiz-Fernández 1995).

Streit and Nagel (1993) reported, in adults of the insectivorous bat *Pipistrellus pipistrellus*, levels of lead in the liver between 2.95 and 38.5 mg/g dry mass, and copper levels between 15.7 and 32.0 mg/g dry mass. These values are much higher than values we obtained (Table 1). They believed that the local hunting area can strongly affect metal levels in a single species because metal levels in the organism can vary depending what the animals feed and eliminate.

We found cadmium levels were not significantly different for the two species studied. However in both species it was higher than the values found by Streit and Nagel (1993) in *Pipistrellus pipistrellus*, which were between 0.044 and 1.53 μg/g. We can assume the high concentration of the heavy metals in the liver of *Myotis* is because some areas in the Sea of Cortez and in the Baja California Peninsula have high natural concentrations of zinc and cadmium (Martin and Flegal 1975; Méndez et al. 1998), so is possible that the food ingested can also be high in these elements.

Beatles and isopods also constitute part of the diet of *N. leporinus* (Brooke, 1994). These insects accumulate nonessential metals as cadmium (Scharenberg and Ebeling

Table 1. Metals levels (μg/g in dry weight) of *Myotis vivesi* and *Noctilio leporinus*

	Mn	Fe	Zn	Cu	Pb	Cd
Myotis vivesi						
Mean	3.68	1781	133	27.4	1.25	6.5
s	0.30	350	47	4.8	0.30	1.2
Max	7.15	2455	211	35.8	1.94	7.9
Min	2.41	1197	65	21.6	0.91	4.1
Noctilio leporinus						
Mean	1.40	1217	57	13.1	0.57	8.0
s	0.61	84	8	4.1	0.25	3.6
Max	2.95	1341	72	24.8	1.09	14.4
Min	0.58	1026	44	8.1	0.35	1.5

1996). Contaminated isopods also contain zinc and lead, so these animals can be an important source of these metals in these species of bats.

We believe that the ichthyophagous bats, *Myotis vivesi* and *Noctilio leporinus* may be good species for the monitoring of the contamination by heavy metals in different regions, mainly because of their wide-ranging habits and the ease with which they disperse throughout appropriate habitat and also their higher trophic level. It may be necessary to review other species that feed in the Sea of Cortez, mainly those feeding on crustaceans, and make a comparison between populations of the same species on the Sea of Cortez and the Pacific coast of the Baja California Peninsula.

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