Relationship Between PCB Concentration, Body Burden, and Percent Body Fat in Female Polar Bears while Fasting

Polischuk, S.C.[a], Letcher, R.J.[b], Norstrom, R.J.[b,c], Atkinson, S.A.[a], M.A. Ramsay[a].

[a]Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0, Canada.
[b]Carleton University, Centre for Analytical & Environmental Chemistry, Ottawa, Ontario K1S 5B6, Canada.
[c]Environment Canada, Canadian Wildlife Service, Hull, Quebec K1A 0H3.

Introduction

Contaminant studies on free-ranging animals generally report on the concentration of compounds from a tissue sampled once. Additional biological data from study organisms, such as body condition and percent body fat, are usually not known. Organochlorine compounds, such as PCBs, accumulate in lipophilic tissues and the total body burden is presumably affected by the nutritional history of the animal. Polar bears (*Ursus maritimus*) feed at the top trophic level on a marine food chain and are exposed to relatively high levels of contaminants. They also experience large seasonal changes in body composition. Body mass of individual polar bears can more than triple during a relatively short period of hyperphagia and adipose tissue may constitute more than 50% of the total body mass[1] . After extended fasting, adipose tissue depots may be reduced to less than 10% of body mass[2,3]. Consequently, polar bears may provide an ideal model to examine changes in organochlorine concentrations and burdens with changes in total body composition.

Polar bears in the population inhabiting western Hudson Bay, Canada, come ashore when the ice melts in summer and remain on land for 4-5 months until the Bay re-freezes. During their on-land stay they fast and live off their extensive adipose reserves which they have accumulated during the spring. Pregnant females do not return to the ice in autumn but, instead, find a den in which they spend the winter. Gestation, parturition, and the early stages of lactation are carried out entirely while fasting. These females remain in their den for 6-8 months until late spring when they emerge with their cubs.

We determined the relationship between PCB concentrations, body burdens, and percent body fat changes in different reproductive classes of fasting females and their cubs.

Methods

Adipose tissue biopsies were collected from free-ranging polar bears sampled in the vicinity of Churchill, Manitoba, Canada from 1992-1994 at the start and end of a period of fasting. Bears were classified according to their reproductive status (solitary and pregnant, females with cubs-of-the-year in spring, females with cubs-of-the-year in summer / autumn, females with yearlings, and cubs). Samples were analyzed for organochlorine content according to the methods of Zhu et al.[4], Letcher et al.[5] and Polischuk et al.[6]. Polychlorinated biphenyl burden was calculated by: (PCB conc./lipid) X (lipid conc./fat biopsy) X (body fat wt.)

The body composition of each animal was determined by using a two-step model that involves measurement of total body water in vivo by the dilution of deuterated (^2H) water[7,8]. A two-tailed equal variance Student *t*-test was used to compare differences in PCB concentration, body burden, and percent body fat of reproductive classes before and after a period of fasting.

Results and Discussion

Polychlorinated biphenyl data are given as the sum of the 15-16 congeners which can be detected in polar bear tissues[9]. Six congeners, CB99, CB153, CB138/163, CB180, and CB170, account for >95% of the total PCB congeners. Our study is unique because we have obtained direct quantitative, not qualitative measurements of body condition of animals analysed for organochlorine content.

The concentration of PCBs in adipose tissue tends to have an inverse relationship with percent body fat (Fig. 1a), but there seems to be an equilibrium between PCB concentration and weight of fat which is reached around 60 kg of body fat (Fig.1b). Polychlorinated biphenyl body burden of bears did not show a relationship with percent body fat and kilograms of body fat (Fig.1c&d). Females that had a higher percent and weight of body fat did not necessarily have the highest PCB body burden. As adipose mass was lost some bears decreased their PCB body burden while most bears increased the concentration of the contaminant levels in the adipose tissue. Addison[10] has suggested an inverse relationship with blubber thickness and PCB concentrations among seals whereas Kuiken[11] did not find any correlations between PCB levels and body condition in small cetaceans.

The group of female polar bears that were pregnant in summer and had cubs the following spring showed a significant decline in mean percent body fat while their mean PCB concentrations increased (Table 1). This group contains only two individuals sampled at both time periods. Sampled over a considerably shorter interval, the females with cubs showed a similar trend, with PCB concentrations rising and body fat declining (Table 1). There was no significant change in PCB body burdens among the different reproductive classes between the start and end of the fasting period (Table 1). Addison and Stobo[12] hypothesized that, in seals, the organochlorine burden remains relatively constant and is diluted and concentrated by fluctuations in lipid reserves. However, the constancy of PCB body burden of pregnant females which give birth to cubs is not supported by the data for individual bears. Individual bears sampled sequentially show a different trend than do bears grouped by reproductive class where large variation in PCB concentration among individuals biases the data.

Sequential sampling of individual bears indicates that females with neonates in spring decrease their PCB body burden by 50% in 7 months relative to that at the beginning of their pregnancy (Table 2). The body burdens of females with cubs stayed constant over a 2-3 month period with the exception of Bear C who had the lowest body fat reserves before and after fasting, 25% and 13%, respectively. It appears, therefore, that female polar bears decrease their PCB body burden during pregnancy and the early stages of lactation. If these compounds are being transferred directly to the cubs, then cub survival and growth could be compromised. Additional studies to determine the transfer of organochlorines in milk have been initiated. Our next goal is to analyze tissue samples from fasting male polar bears to see whether the kinetics of organochlorine body burdens differ from those of females since males do not undertake pregnancy and lactation.

Although non-pregnant females and cubs feed little over the summer / autumn period and fat reserves are mobilized to meet energy demands, total body burdens of organochlorines did not decline. Because of the much shorter time period between sampling, no conclusions can be drawn about the over-winter rates of PCB clearance in non-pregnant females.

Feeding status, reproductive status, body condition and age can all affect the kinetics of organochlorines stored in body tissues. It seems prudent, therefore, that biological factors should be considered when trying to interpret chemical analyses.

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Table 1. Mean concentration of PCBs (μg/g lipid weight), percent body fat, and PCB body burden (mg) in female polar bears and their cubs before and after a period of fasting. Values in parentheses designate standard error.

Reproductive Class	Date Sampled	n	PCB conc. (μg/g lipid)	PCB body burden (mg)	Body fat (%)
Pregnant	August	7	2.6 (0.6)	379.6 (123.8)	41.9 (2.6)
Females with cubs in spring	March	5	*6.9 (2.9)	309.9 (115.7)	*27.0 (4.4)
Females with cubs	Aug/Sept	6	4.6 (3.5)	291.7 (172.2)	30.4 (4.2)
	Oct/Nov	7	7.6 (6.1)	302.7 (95.1)	24.7 (5.9)
Cubs	Aug/Sept	3	5.5 (1.2)	228.9 (90.5)	29.8 (3.4)
	Oct/Nov	5	8.6 (4.3)	217.9 (111.6)	25.83 (2.1)

Table 2. Sequential body burden (mg) data on individual bears before and after a period of fasting.

Reproductive Class		Date Sampled	Body Burden (mg)
Pregnant/with spring cubs			
	Bear A	August	450
		March	192
	Bear B	August	615
		March	394
Females with cubs-of-the-year			
	Bear C	August	623
		October	421
	Bear D	August	177
		October	269
	Bear E	September	336
		October	354
Females with yearling cubs			
	Bear F	August	203
		October	398
	Bear G	September	229
		October	176
	Bear H	October	182
		November	196
Yearling cubs			
	Bear I	August	219
		October	117

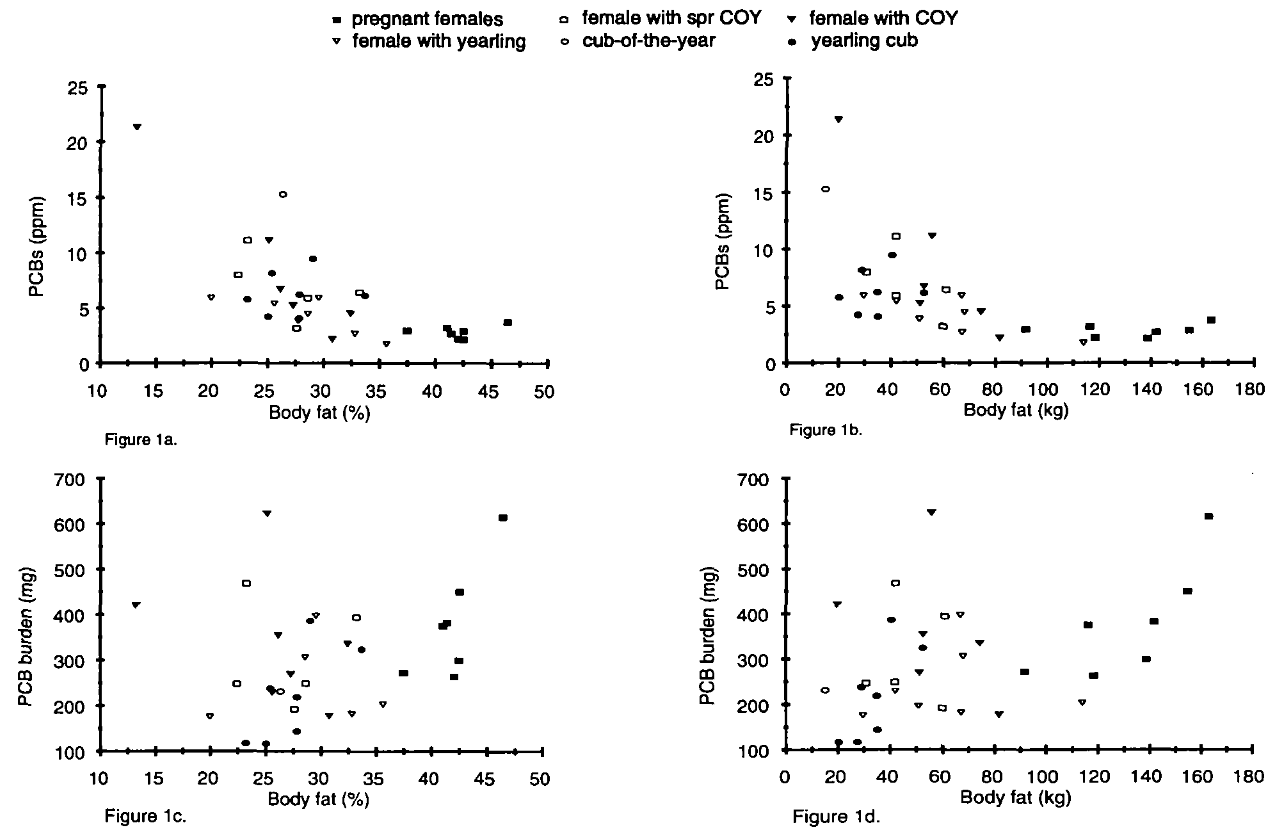

Figure 1 a-d. Comparison of PCB concentration (µg/g lipid weight) and PCB body burden (mg) with percent body fat and kiograms of body fat in pregnant female polar bears, females with cubs, cubs-of-the-year (COY) and yearling cubs (YRLG).