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Energy Utilization of harp seals, *Phoca groenlandica*, during the post-weaning period

by

G.A.J. Worthy and D.M. Lavigne
Department of Zoology, College of Biological Science,
University of Guelph, Guelph, Ontario, Canada N1G 2W1

ABSTRACT

As part of an ongoing study of the post-weaning period of the harp seal (*Phoca groenlandica*), nine recently weaned harp seal pups were fasted, in captivity, for a period of 10 weeks. Carcasses were obtained on a bi-weekly basis and analyzed for neutral and polar lipids, ash and water content. Protein content was determined by subtraction and caloric contents were calculated. Results indicate that during the initial 2 weeks of the fast the core, or lean body mass, accounted for 47.2% of the animal's total needs. Of this, 16.0% of total came from core protein and 31.2% came from core lipids. Dependence on the core and in particular protein diminished through the balance of the fast, until after 10 weeks, the blubber layer supplied 92.1% of the total energy utilized.

INTRODUCTION

Phocid seals are characterized by having a period of rapid neonatal growth during a relatively short lactation period (Reiter *et al.*, 1978; Stewart and Lavigne, 1980). A large percentage of this weight gain, 75% in the harp seal, *Phoca groenlandica*, is associated with the deposition of blubber.

Stewart and Lavigne (1980) showed that weaned harp seal pups experience significant weight losses during the post-weaning period. Contrary to popular belief, the initial weight loss appeared to occur primarily from the lean body mass or core, and subsequently, after several weeks of fasting, from the blubber layer.

It is now evident (Worthy, this report) that during neonatal development, extensive, albeit diffuse, lipid stores are deposited throughout the carcass and viscera. The purpose of the present study was to document more precisely the energy sources of the harp seal available during the post-weaning fast.

MATERIALS AND METHODS

As part of a comprehensive study of the post-weaning period of the harp seal (Worthy *et al.*, in press), nine recently weaned pups were collected from the Gulf of St. Laurence and returned to Guelph, Ontario. These animals were maintained in salt water tanks and were not fed for the duration of the ten week experiment.

Weight losses were monitored on a weekly basis for all animals. On a bi-weekly basis, two animals were sacrificed for use in proximate composition analysis. Sacrificed animals were sculped according to sealing tradition, and the blubber separated from the skin. The remaining carcass was then eviscerated. Weights were then obtained for these four body components.

Viscera were freeze-dried, ground and sub-sampled. Eviscerated carcasses were initially ground and homogenized in a large animal grinder (Autio, model 301B, Indianapolis) and subsequently sub-sampled and freeze-dried. Prior to further analysis the sub-samples of viscera and carcass were re-ground in a Thomas-Wiley laboratory mill (Arthur H. Thomas Co. PA). Blubber samples were freeze-dried but not ground.

Water content was calculated as the difference between the wet weight and freeze-dried weight. Neutral and polar lipids were extracted over a 4 hour period on a Goldfisch apparatus (Lab Con Co., Mo.) using as the solvent, petroleum ether or chloroform-methanol (2:1, v:v) respectively. Samples were subsequently oven dried at 72 C for either 12 hours (petroleum ether) or 48 hours (chloroform-methanol), and percentage lipid was determined as the difference between the pre- and post-extraction weights. Ash content was determined by burning samples in a muffle furnace for 24 hours at 550 C. Protein content was determined by subtraction.

Caloric content was measured directly for some samples using an adiabatic bomb calorimeter (Parr Instrument Co., IL). Caloric content was also estimated indirectly for all samples from the proximate compositions, assuming a caloric content of 9.40 kcal-g^{-1} for lipid and 5.65 kcal-g^{-1} for protein (Lavigne _et al._, this report).

RESULTS

The analysis of proximate composition indicated declining carcass, visceral and blubber neutral lipid stores throughout the fast (Fig. 1). Protein content as a percentage of the total, increased gradually over the 10 week fast in all three body components analyzed (Fig. 1). Water content increased as neutral lipid decreased (Fig. 1). Carcass and visceral polar lipid remained quite constant at 2.5%, whereas blubber polar lipid decreased from 1.3% to 0.4% (Fig. 1). Visceral and blubber ash content remained constant at 1.0% and 0.3% respectively, but gradually increased in the carcass from 2.4% to 5.5% as muscle stores declined. Statistical analyses of these results were not performed due to the small sample sizes involved.

A linear regression of indirect versus direct caloric content yielded an equation of equality with a multiple R^2 of 99.43%.

Due to variability in the starting weights of the animals used in this study, the weight loss data of individual animals (Fig. 2) were normalized so that starting weight was equal to zero (Fedak and Anderson, in prep.). All changes in weight were then expressed as a weight loss over each 2 week period. An average rate of weight loss was determined from the slope of the least squares regression line which was forced through the origin (Fig. 3). The slope of this line was $-1.83\ kg \cdot wk^{-1}$, which converts to an average daily weight loss of 0.26 kg.

Wet weights of viscera, eviscerated carcass and blubber for each animal were expressed as a percentage of total weight (Table 1). These percentages were then used to determine the weights of these components in an average pup which initially weighed 32.1 kg. (mean weight of all seals on arrival in Guelph) and lost weight as predicted by the regression line (Table 2).

Proximate composition of this average pup was then calculated using the average proximate composition of animals at each of the 5 bi-weekly samplings. Changes, in absolute amounts, of protein and neutral lipid and the caloric equivalent of these changes over these bi-weekly periods were then estimated (Table 3).

During the initial 2 week period of the fast, carcass and visceral neutral lipids accounted for 31.2% of the animals energy requirements and protein from the core accounted for 16.0% of the total energy. Over the following 6 weeks the importance of core energy reserves, particularly protein, decreased (Table 3). During the last 2 weeks of the 10 week fast, blubber neutral lipids accounted for 92.1% of the animals requirements, with visceral neutral lipids accounting for 2.3% and visceral and blubber proteins the remaining 5.5%.

DISCUSSION

Ortiz *et al.* (1978) and Pernia *et al.* (1980) have shown that the northern elephant seal (*Mirounga angustirostris*) uses blubber during its 10 week land-based fast to meet its energetic and water requirements. The southern elephant seal (*Mirounga leonina*), on the other hand, living in the colder antarctic environment, appears to consume both blubber and core musculature during its fast (Bryden, 1969). Similarly, Worthy *et al.* (in press) and Stewart and Lavigne (1980) have shown, using gross morphometric changes, that the harp seal utilizes core reserves initially and subsequently switches over to mobilizing blubber reserves during its fast in sub-arctic waters.

The present results confirm a reliance on lipid as an energy source for the harp seal throughout the post-weaning fast, as had been suggested from changes in plasma fatty acid composition of fasting animals (Bailey *et al.*, in press). However, the present study indicates that the animal is not relying on the blubber layer as its sole source of energy. The core is initially very important, with core lipids, and also considerable amounts of core protein, supplying almost one half of the animals energetic requirements during the first two weeks of the fast.

The utilization of blubber in some species and the sparing of blubber in other species, such as the harp seal, may be related to thermal exchange with the environment. Maintenance of an effective insulative layer is especially important in the young harp seal, with its large surface area to volume ratio. Utilization of core protein and lipid minimizes the early depletion of the blubber layer, prolonging its effectiveness as an insulator, and extending the maximum duration of the fast.

Field results (Worthy *et al.*, in press) indicate that weaned harp seal pups commence feeding in the Northwest Atlantic after about 6 weeks of fasting. This coincides with the attainment of a core size approximating a newborn (Worthy *et al.*, in press) and the endpoint of the role of protein as an energy source.

During the last 2 weeks of the experimental fast, protein oxidation accounted for only a small fraction of total requirements. Pernia *et al.* (1980) estimated that protein oxidation accounted for only 2.2% of the northern elephant seals requirements throughout its fast. The low levels of utilization achieved in harp seals after 6 to 8 weeks of fasting, may reflect the normal maintenance turnover rate for protein.

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<u>Table 1</u>: Percentage of total weight accounted for by the skin, blubber, viscera and eviscerated carcass.

Week	Skin	Blubber	Viscera	Carcass
0	7.8%	45.5%	8.1%	38.6%
2	9.6%	48.1%	6.0%	36.4%
4	13.0%	46.1%	6.7%	34.2%
6	12.6%	45.9%	6.9%	34.7%
8	16.0%	37.7%	8.7%	37.7%
10	12.4%	33.1%	7.1%	47.4%

Table 2: Weight losses exhibited by an average pup which was losing weight at the rate of 0.26 kg/day. Weights of blubber, viscera and carcass were calculated by multiplying total weight by the percentages in Table 1.

	Weight (kg)			
Week	Total	Blubber	Viscera	Carcass
0	32.1	14.6	2.6	12.4
2	28.5	13.7	1.7	10.4
4	24.6	11.4	1.7	8.5
6	21.2	9.7	1.5	7.3
8	17.5	6.6	1.5	6.6
10	13.8	4.6	1.0	6.6

Table 3: Energy obtained from protein and neutral lipid stores and the percentage of total energy derived from the consumption of these tissues for each 2 week period.

Weeks	Body Component											
	Carcass				Viscera				Blubber			
	Neutral Lipids		Protein		Neutral Lipids		Protein		Neutral Lipids		Protein	
	kcal	%	kcal	%	kcal	%	kcal	%	kcal	%	kcal	%
0 - 2	5214.8	25.0	2498.0	11.9	1286.5	6.2	856.8	4.1	11005.9	52.8	0.0	0.0
2 - 4	1555.1	7.3	1495.3	7.1	234.4	1.1	0.0	0.0	17965.8	84.5	10.6	0.0
4 - 6	2154.1	10.4	929.9	4.5	65.1	0.3	243.5	1.2	17058.6	82.5	236.8	1.1
6 - 8	1687.1	5.7	902.1	3.0	0.0	0.0	0.0	0.0	27157.4	91.3	0.0	0.0
8 - 10	0.0	0.0	0.0	0.0	388.1	2.3	516.3	3.1	15313.4	92.1	402.6	2.4

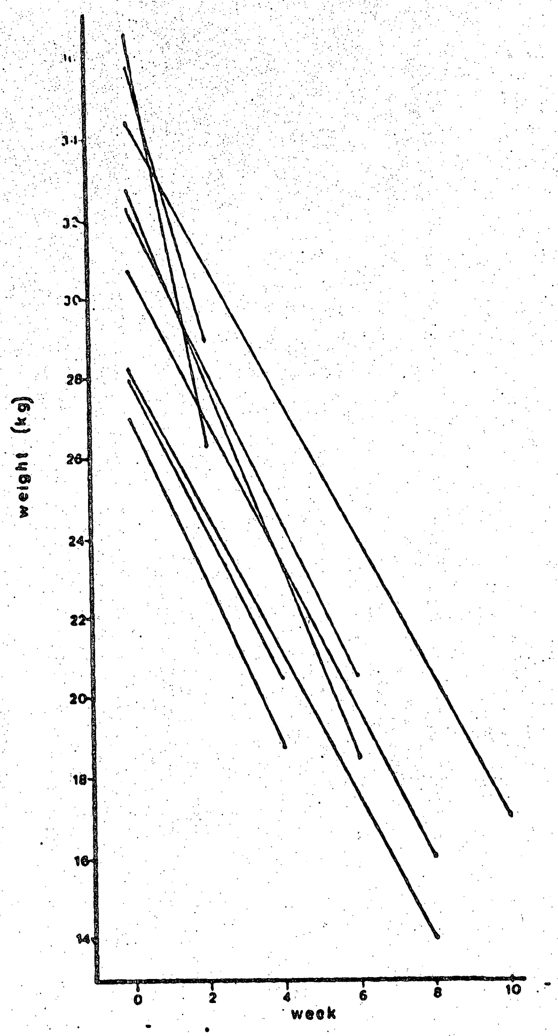

Fig. 1: Weight losses of fasting harp seal beaters throughout the experimental fast.

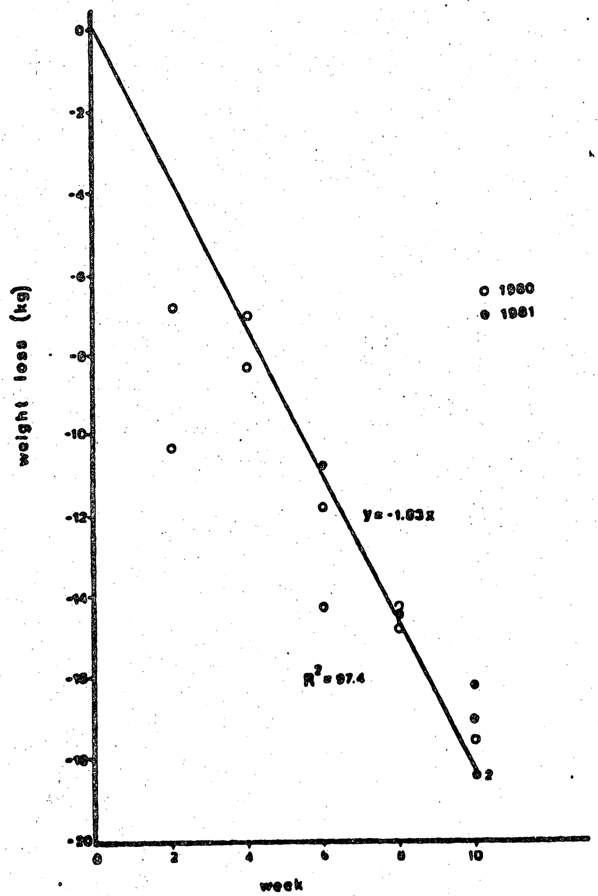

Fig. 2: Weight losses of fasting harp seal beaters, normalized so that starting weight is equal to zero. Average rate of weight loss was determined as the slope of the least squares regression line which was forced through the origin. Average rate of weight loss was 1.83 $kg\text{-}wk^{-1}$ or 0.26 $kg\text{-}day^{-1}$. Also shown are data obtained from a similar study done in 1981.

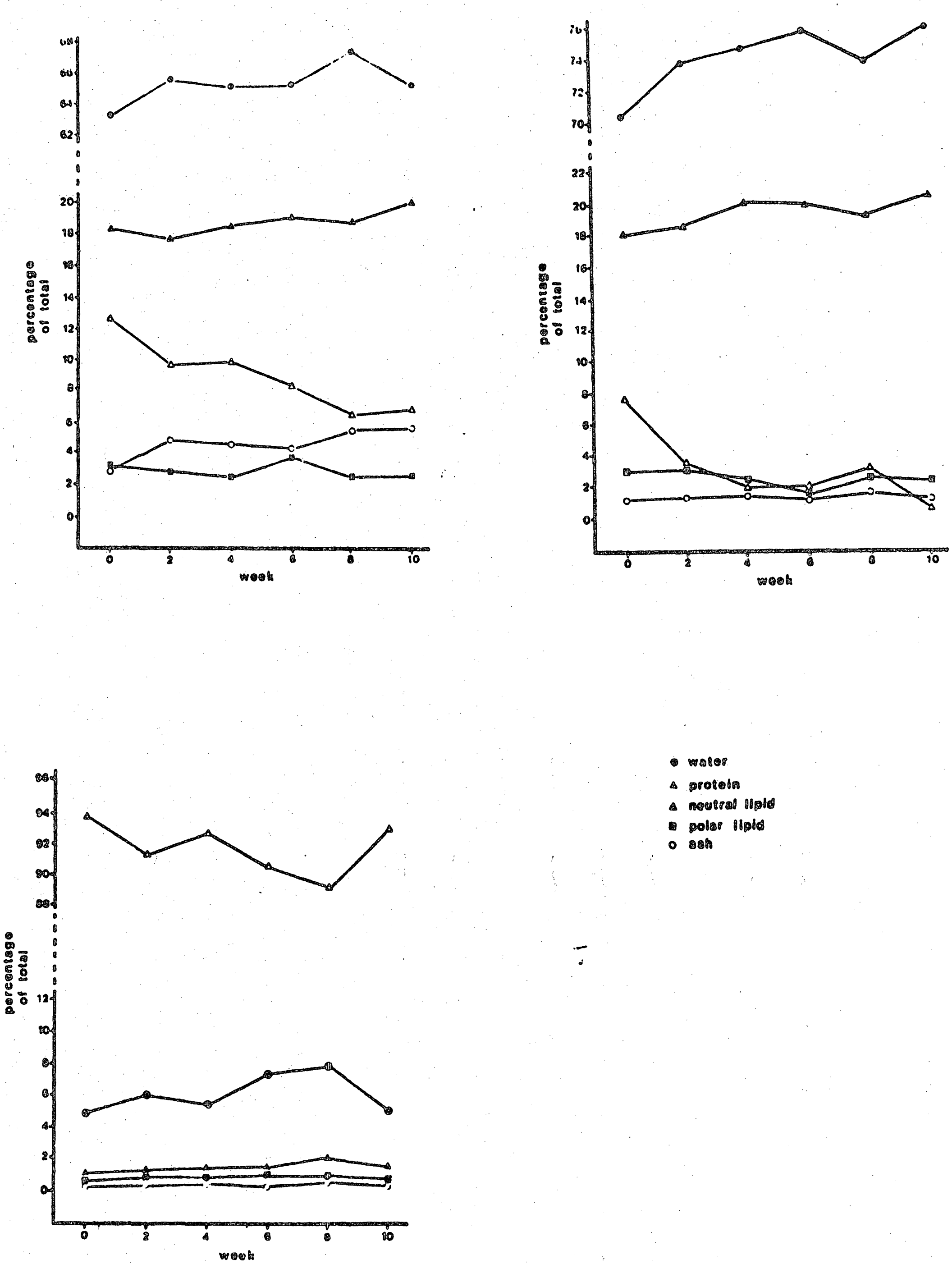

Fig. 3: Changes in water, protein, neutral and polar lipid and ash, expressed as a percentage of the total, for the carcass, viscera and blubber of animals obtained throughout the study fast.