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Changes in Energy Stores during Neonatal Development in the Harp Seal, Phoca groenlandica

by

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INTRODUCTION

The prodigious growth of the harp seal, Phoca groenlandica, during the nursing period has been documented by Stewart and Lavigne (1980) with respect to morphometric changes. These authors speculated on the amount of energy stored but did not actually measure it.

Measurement of weight alone, rather than caloric content, can be deceiving due to relative amounts fat, protein and water present. Bailey et al. (1980) monitored changes in levels of carbohydrate and lipid in the liver and blubber of neonate harp seals. They noted that liver carbohydrate and lipid remained essentially unchanged during the lactation period, but that blubber triacylglycerol content increased dramatically during the first few days of development. The current study expands on the work of Bailey et al. (1980) and pursues the growth of energy reserves on a quantitative basis.

MATERIALS AND METHODS

Whole animals from the newborn through to the beater age categories (terminology from Stewart and Lavigne, 1980), were obtained during the 1979 and 1980 pupping seasons in the Gulf of St. Lawrence. In addition one foetus was obtained on 16/02/80 from Les Escoumins, Quebec. All

carcasses were frozen and transported back to Guelph, Ontario for analysis.

Animals were first sculped in sealing tradition. Blubber was subsequently separated from the skin, and both sampled individually. The remaining carcass was eviscerated and then ground in a large animal grinder (model 801B, Autio Co., Astoria, Oregon.). Subsamples of ground carcass, and the blubber and skin samples were freeze-dried. Viscera was initially freeze-dried and then ground and sub-sampled. All freeze-dried carcass and viscera were subsequently reground and mixed individually in a Thomas-Wiley laboratory mill (model 4, Thomas-Wiley Co., Philadelphia, Pennsylvania).

An analysis of proximate composition was performed on three major body components sampled (skin was not analyzed). Water content was calculated as the difference between wet weight and freeze-dried weight. Neutral and polar lipids were extracted over a 4 hour period on a Goldfisch apparatus (Lab Con Co., Kansas City, Missouri) using either petroleum ether or chloroform-methanol (2:1, v:v) respectively as the solvent. Samples were subsequently oven-dried at 72 C for either 12 hours (petroleum ether) or 48 hours (chloroform-methanol), and percentage lipid was estimated as the difference between the pre- and post-extraction sample 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 density was measured directly for some samples using an adiabatic bomb calorimeter (model 1241, Parr Instrument Co., Moline, Illinois). Caloric content was also estimated indirectly for all samples from the proximate compositions, using a caloric density of 9.4 $kcal \cdot g^{-1}$ for lipid and 5.65 $kcal \cdot g^{-1}$ for protein (Lavigne et al., Appendix 1, this report).

RESULTS AND DISCUSSION

The assumption that 'protein' is the sole remaining

constituent when one has accounted for lipid, ash and water is not entirely valid, however due to the low levels of carbohydrate usually found in most tissues it is a reasonable estimate. In order to test this assumption the relationship between the indirect and direct estimates was examined. The indirect estimates were highly correlated with the independent direct estimates ($r = 0.998$, $p = 0.000000000$, $n = 37$).

Newborn animals, in addition to the foetus, had virtually no blubber stores (Table 1). Subcutaneous tissue had a high water content and a low caloric density at this time. During nursing, blubber stores increased both quantitatively and qualitatively, with the caloric density increasing from approximately 3.0 $kcal.g^{-1}$ at birth to approximately 8.9 $kcal.g^{-1}$ at age 18 days. Similarly the percentage neutral lipid in blubber increased from approximately 21% at birth to 93.5% at age 18 days (Fig. 1), paralleling changes in milk composition (Lavigne et al., Appendix 1, this report).

The caloric density of the carcass doubled from its value of 1.1 $kcal.g^{-1}$ at birth to 2.2 $kcal.g^{-1}$ at age 18 days. This increase mirrored the rise in the percentage neutral lipids present (Fig. 1). Neutral lipid content of the carcass increased from 2.3% at birth to 12.5% at age 18 days, and similarly the neutral lipid content of the viscera increased from 3.7% to 7.5% over the same time period (Fig. 1).

Two stillborn animals sampled showed great variability in both their size (Table 1) and their caloric density (Table 2). These animals were generally very low in energy stores and were much smaller than normal full term pups. This could indicate an insufficient energy exchange between the maternal and foetal systems in utero.

Bailey et al. (1980) indicated that between the newborn and thin-white age categories there was a 2.5 fold increase in the triacylglycerol content of a unit amount of blubber. This mirrors the changes noted in the present

study. They also noted, that the liver triacylglycerol stores remained somewhat constant throughout the first month of neonatal development. The results of the present study indicate that large amounts of lipid are deposited in both the carcass and viscera during neonatal development. This energy is very significant to survival during the post-weaning fast (see Worthy and Lavigne, this report).

Total caloric content of all body components examined increased (Table 2), with the exception of the greycoat starvlings. The newborn pups analyzed in this study had an average weight of 7.3 ± 1.2 kg. (± S.D.). This weight is considerably smaller than the average weight reported by Stewart and Lavigne (1980) of 10.8 ± 0.65 kg. (± 95% C.I.) for animals sampled from 1976 through 1979. Mean weight of all newborns sampled in 1980 was not significantly different from previous years (Stewart and Lavigne, this report) and therefore for the purposes of this study, it is assumed that the changes in composition of these analyzed pups are representitive of neonatal harp seals in general.

Lavigne and Stewart (1979) speculated that an 11 kg. newborn pup would represent 24 000 kcal. They used an average caloric density of 2.16 $kcal.g^{-1}$ obtained for ringed seals, Phoca hispida (Stirling and McEwan, 1975), which were less than 1 month old. The average caloric density of newborns in this study was 1.73 ± 0.047 $kcal.g^{-1}$. This value is not significantly different from Stirling and McEwan's (1975) value (α = 0.05, Student's t-test), but was used to re-calculate the net production energy realized by a female harp seal at whelping (lavigne and Stewart, 1979).

An 11 kg newborn harp seal would represent approximatley 19 000 kcal and the placenta an additional 1400 kcal (Lavigne and Stewart, 1979), totaling a net energy production of 20 400 kcal. Assuming that net energy represents 68 - 75% of gross energy (Lavigne and Stewart, 1979), the female harp seal would require an intake of 27-30 000 kcal or approximately 20% less energy than was originally calculated to account for the production of the pup and placenta.

Over the period of lactation there is an increase in the total caloric content of the pup of approximately 180 000 kcal. All of this energy must be mobilized from the female's energy stores, as the female fasts throughout the suckling period.

Three starving greycoats sampled in 1980 had virtually no blubber layer present and showed very low caloric density of both carcass and viscera. Assuming a metabolic rate of 76 $kcal.kg^{-1}.day^{-1}$ (Worthy, unpubl. data), an extrapolation can be made backwards to the time of abandonement by the female (Fig. 2). It would appear that these animals were deserted at birth and possibly were never suckled. It may be theorized that such desertion may be mediated by low energy stores in post-partum females (see Stewart and Lavigne, this report).

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Table 1: Total weights and the weights of the viscera, eviscerated carcass, blubber and skin for all age groups sampled.

Age Group	Total Weight	Skin Weight	Blubber Weight	Carcass Weight	Viscera Weight
Foetus F1	4.6	1.7	0.5	2.4	0.8
Stillborn					
SB1	3.9	0.8	0.3	2.0	0.9
SB2	6.0	1.2	0.3	3.5	1.1
Newborn NB2	6.8	1.0	0.4	4.0	1.4
NB3	6.1	1.2	0.4	3.5	1.1
NB4	8.9	1.5	0.5	5.0	1.8
Yellowcoat					
Y1	9.3	1.7	1.1	4.7	1.7
Y2	9.2	1.8	1.2	5.0	1.4
Thin White					
TW2	14.6	2.3	5.0	5.0	2.3
Fat White					
FW1	27.3	3.2	10.6	10.0	3.3
Greycoat G1	35.0	2.8	15.6	13.7	2.8
G2	36.0	2.5	17.6	13.4	2.5
Greycoat Starvling					
GS1	8.4	1.7	0.0	5.2	1.4
GS2	6.3	1.4	0.0	3.4	1.0
GS3	5.2	2.1	0.4	1.6	1.1
Beater B1	30.0	2.3	14.1	11.6	2.0
B2	41.0	2.7	18.3	17.1	2.9

Table 2: Caloric content for the four body components sampled, as well as the total caloric content for all animals sampled. Terminology from Stewart and Lavigne (1980).

		Caloric Content (kcal)				
Age Group	ID#	Total	Carcass	Viscera	Blubber	Skin
Foetus	F1	9 342	2 828	1 029	1 058	4 427
Stillborn	SB1	7 118	2 688	1 302	1 107	2 021
	SB2	9 621	4 724	1 330	496	3 070
Newborn	NB2	11 566	5 534	2 063	1 409	2 559
	NB3	10 292	4 578	1 486	1 285	2 943
	NB4	15 675	7 464	2 543	1 958	3 710
Yellowcoat	Y1	22 116	8 430	2 950	6 270	4 466
	Y2	20 392	8 038	2 525	5 223	4 606
Thin White	TW2	52 598	7 695	3 926	35 091	5 885
Fat White	FW1	123 507	24 176	6 312	84 831	8 188
Greycoat	G1	179 442	34 281	5 637	132 359	7 164
	G2	194 288	33 530	5 033	149 328	6 397
Greycoat Starvling	GS1	13 578	7 137	2 010	0	4 431
	GS2	10 755	5 647	1 448	0	3 660
	GS3	10 529	2 132	1 607	1 509	5 281
Beater	B1	164 107	28 830	4 008	125 384	5 885
	B2	217 952	42 499	5 812	162 733	6 909

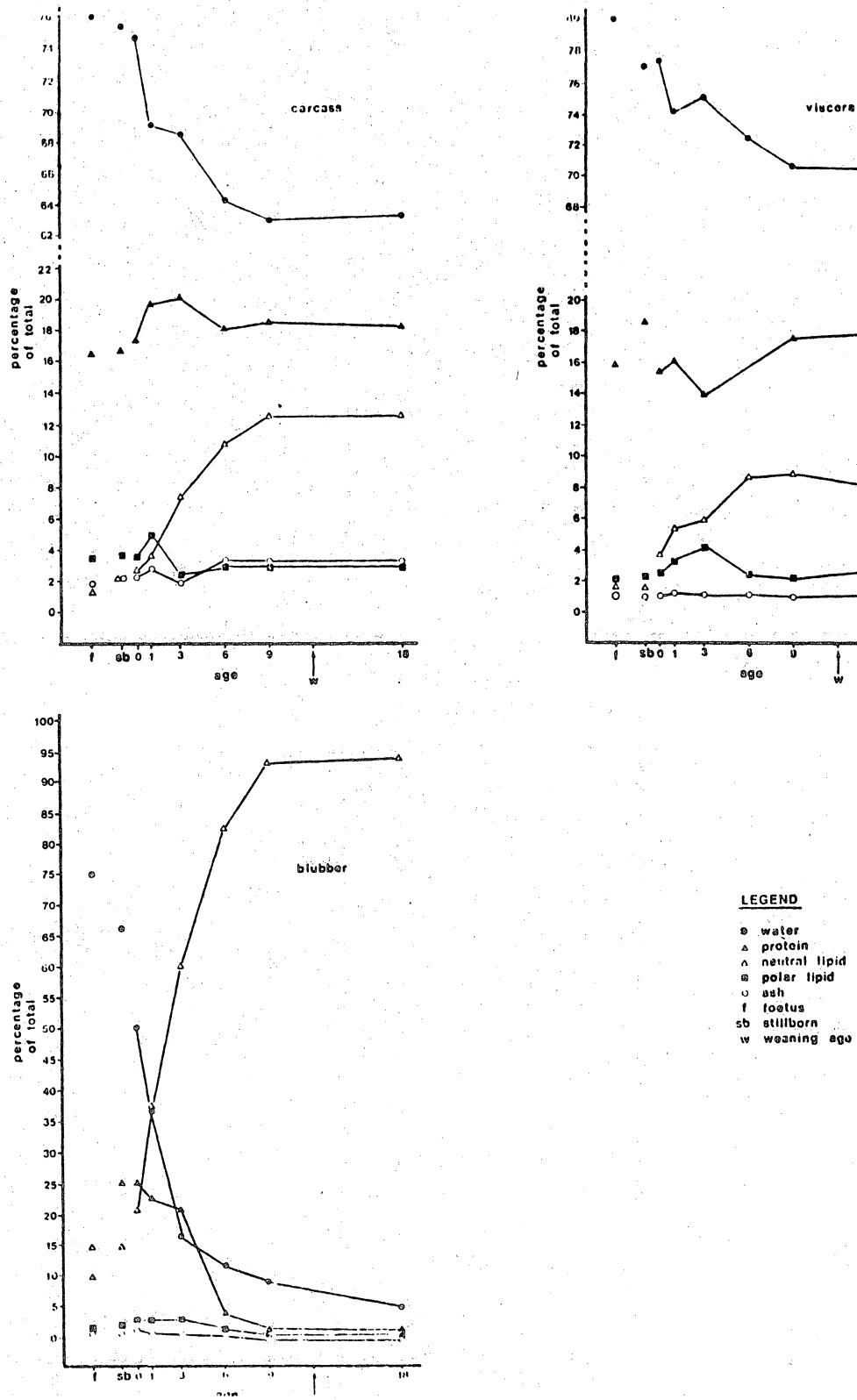

Fig. 1: The changes in composition of the blubber, carcass and viscera during the neonatal period with respect to neutral and polar lipids, protein, ash and water. All components are expressed as a percentage of total weight.

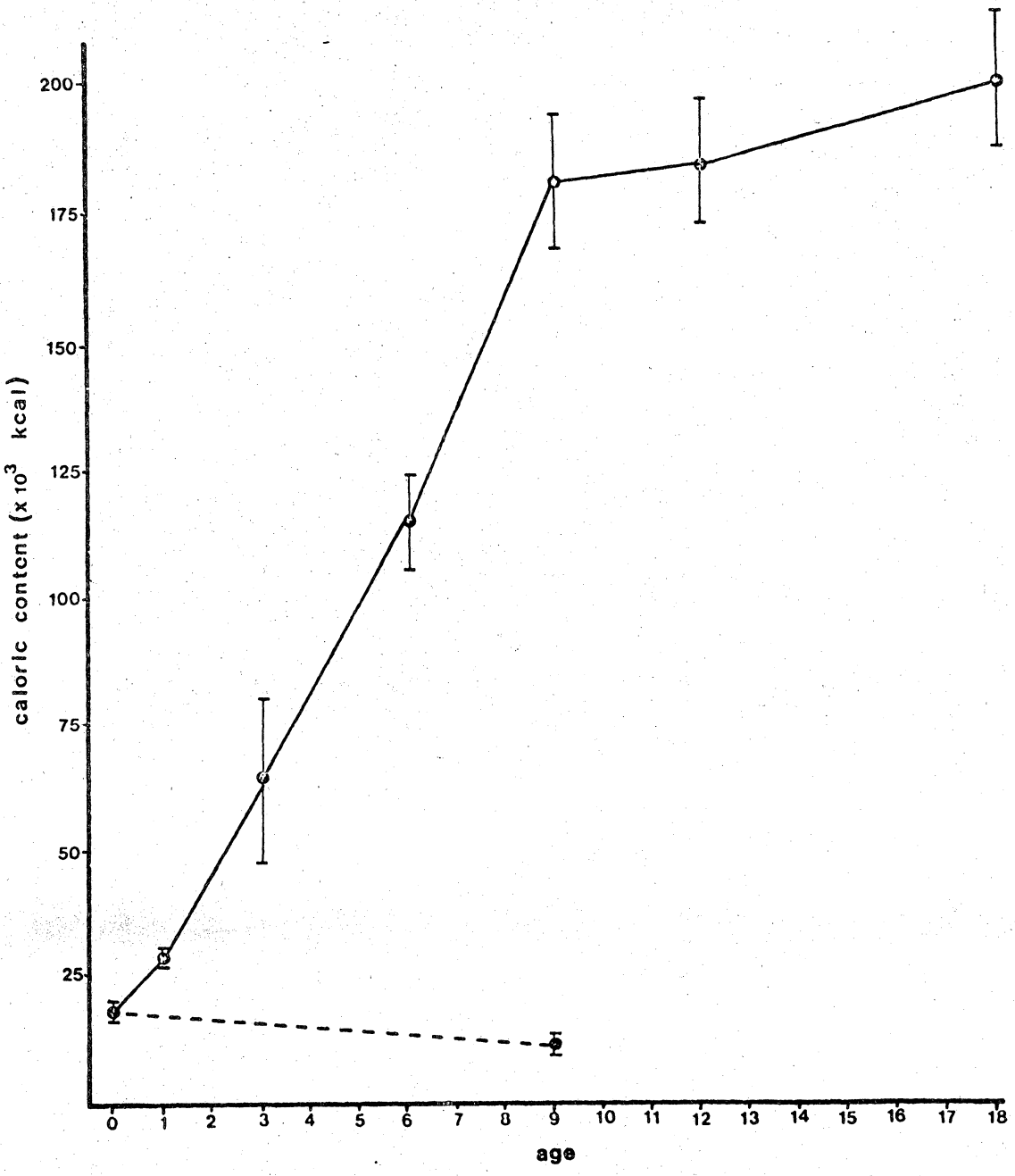

Fig. 2: This 'energy growth curve' shows the increase in total caloric content for neonate harp seals, calculated by using the average caloric density for each age group determined in this study, in combination with the growth data presented by Stewart and Lavigne (1980). Also shown is the calculated rate of decrease of energy stores in abandoned animals which were sampled at approximately 9 days of age. This rate of decrease was calculated assuming a metabolic rate of 76 $kcal \cdot kg^{-1} \cdot day^{-1}$ (Worthy, unpubl. data).