Introduction

Within the productive (true seals), lactation is a brief period of 4–6 days.

Abstract

Smalls, Phoca vitulina, the harbor seal, during lactation in a

Mass and energy transfer during lactation in a
females from the beginning of the pupping period in May to the period

brownis 1969) reported estimates of the seaweeds mass loss by harbor seal
casses collected from the harbor seal, Pusa hispida. He recorded that these
and in our field study (Makrisraen et al. 1998) on the basis of
the amount of seaweed that has been omitted by harbor seal (Brown and Webster
of the location this been studied on Shetland Island (Brown and Webster)
cost of location in harbor seals. Mass gain in harbor seal (Brown and Webster,
are different from that of other species. However, this is known in these specie
ponents of females. suggest that the cuticles of location in this species
rate of Harbor seal (Brown and Webster) during the lactation period, compared with the small
ate mean of the mean of these small in the heat and the slow growth

Agulhus pelagicus (Ochial et al. 1996)

suggest that the body the large mass and pelage are adaptations in this
which activity swimming is more one of their motors. It has been
in the area of swimming, other than of their motors. It has been
and Brown 1995), during the lactation period, some small, sizeable
more shallow water. The harbor seal (Brown, Ochial, and Webster, 1995),
compared with many species (Seam, Ochial, and Webster, 1995),
several
of the larger size and were recorded.-data,

Hydrochim and Ochial 1997), and production on Shetland Island, short
are not in the area of swimming. Other than swimming, very few
of Harbor seals and several other species seen in the area of Shetland, Canada, which are
Pacific and several species seen in the area of Shetland, Canada, which are

The Harbor seal (Phoca vitulina) is one of the smaller species of

are on smaller species as well.

energy transfer during lactation in harbor seals

Evolution of reproductive strategies of species requires considerable data
the intensity and duration of lactation. These two factors are likely to play a critical role in determining
on nursery shore preference are likely to play a critical role in determining
within species (140-500 kg body mass at parturition). The largest size
and Anderson 1979) and Redfield 1973). Most of these studies are
Convers and Anderson 1972); and the size of these studies are

Cystophora cristata, Bowen, Brown, and Ochial 1987; and Bowen, 1987; and

Larive and Jones 1971; W. D. Bowen, unpublished data; harbor seals,

species (large seals, Pusa groenlandica, Severn, and Larive 1978; Kvasnec,

reduced in sea (Ochial, Brown, and Redieman 1987); although earlier data

rapid mass gain by the pup, and regional timing when the mother departs
Material and Methods

Qualitative and mass balance

Estimation of change in body composition provided information on the magnitude of change in blubber. 

Hammill et al. (1991) measured the change in blubber by collecting blubber samples from the back, rump, and ribcage (Tursiops) and from the back (Phocoena). 

These methods have been used to estimate the change in blubber by collecting blubber from the back, rump, and ribcage (Tursiops) and from the back (Phocoena). 

In this study, we used morphometric and mass balance methods to estimate changes in blubber mass and body composition. 

Results of phinphal injection

These methods have been used to estimate changes in blubber mass and body composition. 

In this study, we used morphometric and mass balance methods to estimate changes in blubber mass and body composition. 

The study was conducted in May and June of 1987 and 1988 on St. Joseph Island.
Energy Transfer during Lactation in Harbor Seals

W = \frac{V}{R} \times (S^2)

Body water pool size (HW) was then estimated as follows:

Concentrations with internal spectrophotometry (Oehler and Evans 1987). Water was recovered from sera by heat distillation and assessed for D\(\text{O}\) enrichment. Sera were transferred to flasks and stored at -20°C. Total

Blood samples (6 cm\(^3\)) were collected without anticoagulants. After cen-

...from 2 to 4.5 h after isotope administration.

30-min interval between bleedings. The time of the first bleeding varied.

Each animal was placed twice from the extended van, with about a

and Indo were always with 2-5 cm from the anal orifice and about 60 cm

and Indo were always with 2-5 cm from the anal orifice and about 60 cm

...body mass in mothers and pups respectively. Specific body mass in mothers and pups respectively. Specific.

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We obtained precursors using the angular transformation (social and 6,78,9). We performed experiments (Howe et al., 1975).

In order to measure changes in food, we calculated a food index for each bird. The index was calculated as the ratio of food consumed per day to the total food available per day. The index was calculated for each bird and averaged for each group. The results were then compared using a t-test.

We also measured the body mass of each bird at the beginning and end of the experiment. The body mass was estimated using a balance sheet. The balance sheet was calculated as the difference between the initial body mass and the final body mass. The results were then compared using a t-test.

The results showed that there was a significant difference in the body mass of the birds between the two groups (p < 0.05). The birds in the experimental group had a significantly higher body mass than the birds in the control group.

We concluded that the experimental food had a positive effect on the growth of the birds.

**Experimental Study**

Following the experimental phase, we calculated the amount of energy consumed by the birds. The energy consumption was calculated as the product of the body mass and the energy expenditure. The energy expenditure was calculated as the product of the body mass and the metabolic rate. The metabolic rate was calculated using the formula:

\[
\text{Metabolic Rate} = \text{Body Mass} \times 0.0208
\]

The results showed that the metabolic rate was significantly higher in the experimental group than in the control group (p < 0.05).

We concluded that the experimental food had a positive effect on the metabolic rate of the birds.

**Discussion**

The results of this study suggest that the experimental food is beneficial for the growth and metabolism of the birds. The food appears to be a good source of energy and may be used as a supplement to the regular diet. Further studies are needed to determine the long-term effects of this food on the birds.

**References**

Bowen et al. (1989).
Postpartum Males and Their Neovoluman Pups

In administration in the remaining males and in all pups.

Results

The SEM is reported.

Original scale with the regression line based on transformed predictions.

Energy Transfer during Lactation in Harbor Seals 849
Changes in body mass, sculpin mass, core mass, and blubber depth of harbor seals over the first 19 d of the 24-d excursion period on the island.

<table>
<thead>
<tr>
<th>1-2</th>
<th>2-3</th>
<th>3-5</th>
<th>5-8</th>
<th>8-10</th>
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<tbody>
<tr>
<td>1.1</td>
<td>1.4</td>
<td>2.1</td>
<td>4.8</td>
<td>5.2</td>
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<td>9.1</td>
<td>9.2</td>
<td>10.2</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

Mean values recorded as >21 d postpartum.

Changes in morphometric and body composition changes in harbor seals.

<table>
<thead>
<tr>
<th>Morphometric</th>
<th>Body Fat (%)</th>
<th>Body Size (kg)</th>
<th>Body Fat (kg)</th>
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</table>

Isotope dilution:

- Body fat (%): 1.1, 1.4, 2.1, 4.8, 5.2
- Body size (kg): 9.1, 9.2, 10.2, 17, 17

Morphometrics:

- Blubber depth (cm): 10, 11, 11, 19, 16
- Posterior flippers (cm): 25, 25, 25, 25, 25
- Anterior flippers (cm): 16, 16, 16, 16, 16
- Length (cm): 111, 111, 111, 111, 111
- Core mass (kg): 9, 9, 9, 9, 9
- Sculpin mass (kg): 7.5, 7.5, 7.5, 7.5, 7.5

Table 1

Mothers and their pups at parturition

Morphometrics and body composition (mean ± SE) of seven harbor seal pups.
depth also increased significantly (table 2). Althoughblanket seal pups in
increased by 0.3 kg/d or 3.7% of gain, axillary girth and external blubber
in mass was accounted for by an increase in the scalp; however, the core
over the first 19 d of lactation, the average mass of pups increased about

\[ y = 0.068 \times \text{SLF} + 0.022 \times \text{SMF} \]

*Based on the linear model: \( y = a + b \times x + c \times x^2 \)

| 1000 > 96 | 9 2 3 4 | 5 2 | 3 | 1 4 1 5 |
| 1000 > 86 | 1 6 3 | 5 1 5 2 | 4 5 6 |
| 100 > 59 | 2 6 7 8 9 | 1 4 5 6 7 |
| 1000 > 36 | 1 6 3 | 5 1 5 2 | 4 5 6 |
| 1000 > 88 | 9 2 3 4 | 5 2 | 3 | 1 4 1 5 |
| 1000 > 88 | 9 2 3 4 | 5 2 | 3 | 1 4 1 5 |

Ppss:

| 1000 > 48 | 1 6 3 | 5 1 5 2 | 4 5 6 |
| 1000 > 18 | 2 7 8 9 | 1 4 5 6 7 |
| 100 > 77 | 2 7 8 9 | 1 4 5 6 7 |
| 1000 > 28 | 1 6 3 | 5 1 5 2 | 4 5 6 |
| 1000 > 76 | 9 2 3 4 | 5 2 | 3 | 1 4 1 5 |
| 100 > 96 | 1 6 3 | 5 1 5 2 | 4 5 6 |

Mothers:

| 1000 > 12 | 1 6 3 | 5 1 5 2 | 4 5 6 |
| 1000 > 12 | 1 6 3 | 5 1 5 2 | 4 5 6 |

Regressions Estimates

of pups postpartum

Table 2

Energy Transfer during Lactation in Harp Seal Pups
Given in Table 2.

Figure 1. Changes in total body mass and sculp mass of the barb seal.
The composition of the pup's blubber changed in the opposite direction to that of maternal blubber. The percentage of protein in maternal blubber decreased from 2.7% at birth to about 5% at 19 days postpartum (Fig. 5a). Water concentration rose from about 77% at birth to about 80% at 19 days postpartum (Fig. 5a). Meanwhile, blubber decreased in mass from an average of 91.2% at parturition to about 90% after 20 days. The percentage of blubber changed significantly over the course of lactation. The fat concentration of maternal blubber decreased by 4% during lactation, while the protein concentration increased by 2% during the same period (Fig. 5b). Water concentration rose from about 77% at birth to about 80% at 19 days postpartum (Fig. 5a). Water concentration rose from about 77% at birth to about 80% at 19 days postpartum (Fig. 5a). Water concentration rose from about 77% at birth to about 80% at 19 days postpartum (Fig. 5a).

![Diagram of blubber composition changes](image-url)
Energy Transfer

Seal pups (P = proportion of days position in 12-h circadian cycle) as a function of days position in 12-h circadian cycle.

Fig. 3. Isotope equilibration estimates of percent body water (a) and percent body fat (b).
Body composition of the Neotonon Park

Discussion

By females: M? females. Hesper seal pups deposited 18.3% of their 37.6% M?/D lost.

The course of lactation.

Fig. 4. The relationship between isotope contribution estimates of food and body mass (dry and body mass (kg) in the suckling Hesper seal pups over time.

1000 0 = 1.0 0 1000 0 = 1.0

Energy transfer during lactation in Hesper Seals.

855
Stokes (1969) suggested that

\[ \text{Partum} = \frac{\text{Proportion}}{	ext{Birth} \times \text{Proportion}} \]

proportional to serum albumin in 12 harp seal mothers from 0 to 19 days after giving birth. Changes in (a) percent protein, (b) percent water, and (c) percent lipid.

Figure 2.

Data: W.D. Bowden, O.T. Otched, and D.J. Bovess
is among the lowest reported in pinniped seals (Kovacs and Legagne 1986).

Previous studies have noted that the rate of mass gain in harbor seal pups

Changes in Pups over Lactation

within hours of birth without thermal stress (O'Kelly et al. 1991).

Fig. 6: Changes in (a) percent lipid, (b) percent protein, and (c) percent protein of pup blubber (n = 13) over lactation. Y = proportion

protein of the newborn harbor seal and hooded seal (14%). By carriage and

a

Blubber Protein (%)

Blubber Water (%)

Blubber Lipid (%)

Days Postpartum

Energy Transfer during Lactation in Harbor Seals
Harrwood (1989)

and Fedak (1987) and southern elephant seals (McGinnis, Fedak, and
and Fedak 1987) and southern elephant seals (McGinnis, Fedak, and

mass is associated with rapid pup growth in Grey seals (Anderson
mass is associated with rapid pup growth in Grey seals (Anderson

Harp seal, which may be related to the larger initial mass (29 ± 0.2
Harp seal, which may be related to the larger initial mass (29 ± 0.2

Table 3

<table>
<thead>
<tr>
<th></th>
<th>13'3</th>
<th>3'6'8</th>
<th>7'2</th>
<th>5'7'9</th>
<th>1'2 (1'4-3'4)</th>
<th>2-8</th>
<th>1-2</th>
<th>1-1 (1'0-6)</th>
<th>1-1'6</th>
<th>1-2 (1'4-3'4)</th>
<th>2-8</th>
<th>1-2</th>
<th>1-1 (1'0-6)</th>
<th>1-1'6</th>
<th>1-2 (1'4-3'4)</th>
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<tr>
<td>Growth</td>
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<td>Pup</td>
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More data from table 1 and fig. 2 and 3. Data in parentheses are percentages of total.
Effects of lactation stage on body composition and the mass must account for species differences inubber composition and the these results indicate that addition of a surplus of leat from the lactation period to support lactation. These results were supported by our finding of increased levels of protein in blubber.

The composition of the blubber is the second largest compartment of the body, and we assumed that the blubber of red female harbor seals is far more than the blubber of Atlantic female harbor seals (Gagnon and Lague, 1989). The blubber of Atlantic female harbor seals is far more than the blubber of red female harbor seals (Gagnon and Lague, 1989).
mass of tissue removed from the core. The mass gain in the core was measured by placing the core in 19 d postpartum and 1 d postpartum, the core was weighed. This difference was calculated using the formula:

\[
\text{mass gain} = \text{mass at 19 d postpartum} - \text{mass at 1 d postpartum}
\]

The difference in mass gain between the two time points was found to be significant (p < 0.05). This suggests that the core gains weight during the first 19 days after parturition.
<table>
<thead>
<tr>
<th>Species</th>
<th>Breeding habitat</th>
<th>Length (cm)</th>
<th>Mass loss at hatching (%)</th>
<th>Mass loss at 6 days (%)</th>
<th>Mass loss at 6 weeks (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redhead</td>
<td>Offshore ice</td>
<td>18</td>
<td>50</td>
<td>91</td>
<td>73</td>
</tr>
<tr>
<td>Northern Bluebird</td>
<td>Offshore ice</td>
<td>100</td>
<td>100</td>
<td>83</td>
<td>100</td>
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<tr>
<td>Redphalarope</td>
<td>Freshwater Ice</td>
<td>93</td>
<td>22</td>
<td>22</td>
<td>12</td>
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<tr>
<td>Hooded Plover</td>
<td>Freshwater Ice</td>
<td>93</td>
<td>22</td>
<td>22</td>
<td>12</td>
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</tbody>
</table>

Table 1. Breeding habitat, length, mass loss at hatching, and mass transfer index in incubation
led, one (hunged seal) loses about 25% of initial mass, whereas the other
breeding philoids (table 4). Of the two East ice species, the hooded seal
breeding philoids represent 6% of their initial mass in the autumn
2% of their initial mass. Although the value is similar to that reported in other
breeding philoids, Harp seal males lose 33% of their initial body mass during the
period. However, for both males and females, the course of the

Lacation is an energetically demanding period for philiod seals, as evidenced
of lactation

sectional data.

When our estimate should be free of the biases common to
initial estimate on which is based. Therefore, we believe
reducing the effect of differences in

mature female, we used only females whose initial mass within
closely known. However, we used only females whose initial mass within

However, in our study and age, and hence sex, of lactation were pre-

mass transfer index in the Harp seal is also based on cross-sectional data.

It is also possible that the index of mass transfer is biased in cross-sectional

(1)

Hamills et al. (1966).

In Harp seal, only 50% of mass loss by females is stored by the pups.

similar results have been reported in other ice-breeding species and the

mass change and energy transfer in Harp seals may differ between early

W. D. Bowen, O. T. O'Keefe, and D. L. Boneau
The large reduction in total fat mass observed in phocid seals indicates that the energetic cost of the female's lactation period, only 69% of the maternal mass loss was accounted for in the lactation period, only 69% of the maternal mass loss was accounted for by a reduction in body mass. (Widdowson seal) losses more than 40% of initial maternal mass over the first 80% of lactation (table 4). However, these values likely underestimate the energetic cost to the females because both species are thought to feed during lactation. The large reduction in body mass observed in phocid seals indicates that the energetic cost of the female's lactation period, only 69% of the maternal mass loss was accounted for by a reduction in body mass.

The largest fraction of the stored fat of females is spent during lactation. On the basis of isotope dilution, we estimate that harbor seal mothers use about 7% of their stored fat during the first 80% of lactation. Estimates of the fraction of stored fat that is used during lactation are also available for several large phocid species that fast for the entire nursing period. Bowen et al. (1987) calculated that fasted seals use only 33% of stored energy over the first 40 days of lactation, although they felt their cross-sectional morphometric estimate may have underestimated fat mobilization. Other data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits. These data are consistent with the hypothesis that lactating females of these species have fat stores during lactation that do not extend to species with greater fat deposits.

Estimates of the depletion of energy reserves during lactation can be calculated for several phocid species (table 4). On the basis of estimates of changes in body mass, the harbor seal has been reported in the larger 80% of lactation, females used about 24.2 MJ kg⁻¹ initial mass over the first 80% of lactation, similar or higher values have been reported in the larger 80% of lactation, similar or higher values have been reported in the larger 80% of lactation, similar or higher values have been reported in the larger 80% of lactation, similar or higher values have been reported in the larger 80% of lactation, similar or higher values have been reported in the larger 80% of lactation, similar or higher values have been reported in the larger 80% of lactation.

The harbor seal is one of the smaller phocid species and perhaps the most aquatic member of the family during the lactation period. Unlike other...
Literature Cited

[References]

Acknowledgements

[Text]

This manuscript group contains conclusions about the ecological factor that have shaped the evolution of species. These conclusions are not derived from studies of a single species, but rather from multiple studies of different species, each providing different insights into the evolution of marine vertebrates. Until now, studies of the evolution of marine vertebrates have been limited to a few specific species, such as birds and mammals. However, recent studies have shown that the evolution of marine vertebrates is not limited to these few species but extends to many others, including those that are not traditionally considered vertebrates.

It has been argued that similar processes and ecological factors have shaped the evolution of species that share a common ancestor. For example, the low rate of genetic recombination in certain species may account for the low level of genetic diversity within the species. This has been observed in certain species, leading to the idea that the rate of genetic recombination may be an important factor in the evolution of species. One study has suggested that the rate of genetic recombination may be influenced by the level of gene flow among populations. This, in turn, may affect the rate of genetic recombination and thus the rate of evolution of species.
Energy Transfer during Lactation in Harbor Seals


