BLOOD CHEMISTRY AND BODY MASS CHANGES DURING FASTING IN JUVENILE STELLER SEA LIONS (Eumetopias jubatus)

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Introduction

Fasting in bears, penguins and phocid seals is accompanied by predictable changes in plasma metabolite concentrations related to alterations in the body reserves that are catabolized and illustrate a species' ability to limit protein degradation during long-term fasting (see review in Castellini and Rea 1992, Nordoy et al. 1993, Rea 1995). Steller sea lions *(Eumetopias jubatus)* also undergo periods of fasting in their natural environment; adult females fast while nursing pups on the rookery, males defend breeding territories and young pups fast on the rookeries while their mothers are at sea foraging. Five juvenile Steller sea lions were fasted 'in captivity (with free access to fresh water) for 9 to 14 days to test the hypothesis that juvenile Steller sea lions also exhibit changes in key plasma metabolites indicative of biochemical adaptation to fasting. The secondary objective of this study was to determine if blood metabolite concentrations could be used as biochemical indicators of nutritional status in free-ranging juvenile Steller sea lions.

Methods

The five Steller sea lions included in this study were held at the Vancouver Aquarium, Vancouver, British Columbia, Canada since captured as pups in 1993. These animals (3 males and 2 females) ranged in age from 3 to 4 years at the time of study. Due to the individual attention necessary in handling animals of this size these studies were undertaken individually from June 1998 to October 1997. Animals were held on a complete fast but were maintained on a normal training schedule using ice cubes as replacements for food as rewards for completing tasks. Each study was terminated when the animal had completed a fast of 14 days, or sustained a 15 to 20% body mass loss whichever occurred first. Similar fasting periods and mass losses are reported for wild otariids (Higgins et al. 1988, Baker et al. 1994).

Blood samples and body mass measurements were collected from each sea lion at the onset of the study following an overnight fast. These data provide a control sample for each individual prior to prolonged fasting. Body mass was documented daily and blood samples were collected every 3 to 4 days. Plasma concentrations of blood-urea nitrogen (BUN) and B-hydroxybutyrate (B-HBA) were measured by spectrophotometric assay techniques.

Results

Total mass loss ranged from 20.4 to 35.1 kg which equated to a mean daily percent mass loss of 1.0 to 2.0% for the five animals studied. Mass was lost at a relatively steady rate throughout the fasting period in each animal. Two animals fasted during the breeding months (one male in June 1996 and one female in June 1997) exhibited a mean daily mass loss of 1.6 ± 0.1 kg d^{-1} which was significantly lower than the mean rate of 2.8 ± 0.1 kg d^{-1} seen in the 3 remaining sea lions fasted outside of the normal breeding season (Figure 1).

Blood urea nitrogen concentrations decreased significantly from 7.5 ± 0.4 mM to 4.9 ± 0.6 mM after 2 to 3 days of fasting ($p < 0.001$) and remained at this level throughout the first 7 days of fasting (Figure 2). Significant increases in BUN were evident in three sea lions after 7 days ($p < 0.01$), while two sea lions showed continued low BUN values throughout the study. Plasma concentrations of B-HBA remained below 0.18 mM for the duration of these studies with the exception of one juvenile female who exhibited an increase to 0.34 mM after 12 days of fasting (Figure 3).

Discussion

Daily rates of mass loss in fasting Steller sea lions were more closely related to seasonal timing of the fast than to the initial body size of the animal. Similar findings were reported for black bears when fasted experimentally outside of their normal denning periods (Nelson et al. 1975).

Within the first 3 days of fasting all animals studied showed evidence of protein sparing, a primary biochemical adaptation to fasting. During the period body fat stores are increasingly mobilized, decreasing the need to catabolize lean body tissue for energy during fasting. However, when forced to fast outside of the natural breeding season of this species, three juvenile Steller sea lions showed increases in the utilization of protein stores after only 7 days, reflected in increases in BUN concentrations. When two juveniles were fasted during the natural breeding season, there was continued evidence of protein sparing typical of long-term fasting in phocids.

Unexpectedly, these fasting juvenile Steller sea lions did not show the progressive increase in B-HBA concentrations seen in fasting phocid seal pups. With the exception of the smallest female after 12 days of fasting, B-HBA levels ranged from 0.03 to 0.17 mM. This is similar to concentrations seen in fasting adult bears (Ahlquist et al. 1984) and fasting adult female elephant seals (Williams 1995). This suggests there may be an age related difference in how body reserves are utilized during fasting or how these resulting metabolites are circulated during fasting.

In fasting phocid seal pups, β-HBA concentration has provided the best indication of the relative duration of fasting, with BUN concentrations confirming a protein sparing metabolism. Unfortunately, since β-HBA concentrations have not exhibited a gradual increase with fasting duration in these 5 animals studied, and elevated BUN concentrations were evident in at the beginning and end of the fasting period in some animals, evaluation of nutritional stats of free-ranging animals from the metabolite profiles of a single blood sample becomes problematic. This study does suggest that B-HBA levels between 0.05 and 0.2 mM are typical for healthy juvenile sea lions undergoing a 2 to 14 day fast, and that B-HBA concentrations above 0.2 mM were only seen after 12 days of fasting in one sea lion. Thus conservatively, B-HBA concentrations above 0.2 mM, particularly when accompanied by BUN concentrations below 6.0 mM would suggest a state of fasting in free-ranging juvenile Steller sea lions. However, it would not be possible to accurately estimate the duration of that fasting period.

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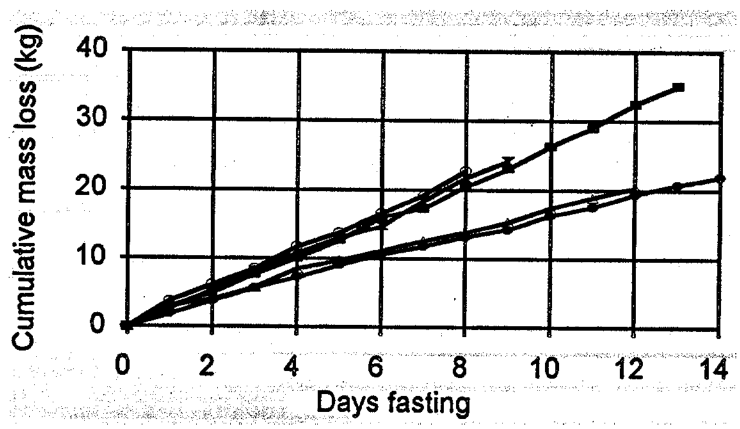

Figure 1. Cumulative mass loss (kg) for 5 juvenile Steller sea lions during complete fasting.

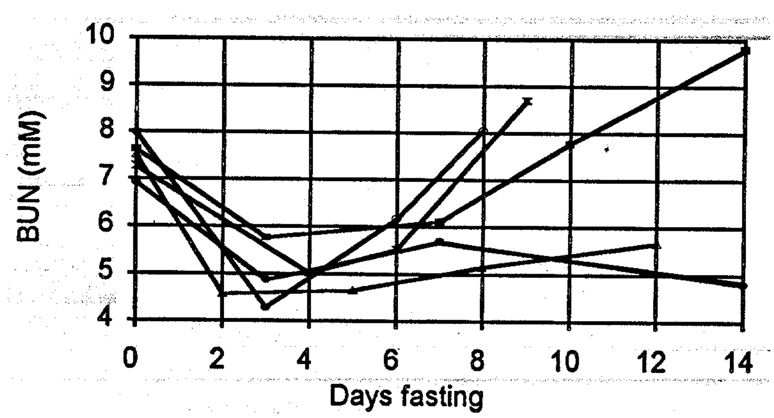

Figure 2. Blood urea nitrogen (BUN) concentrations (mM) for 5 juvenile Steller sea lions during complete fasting.

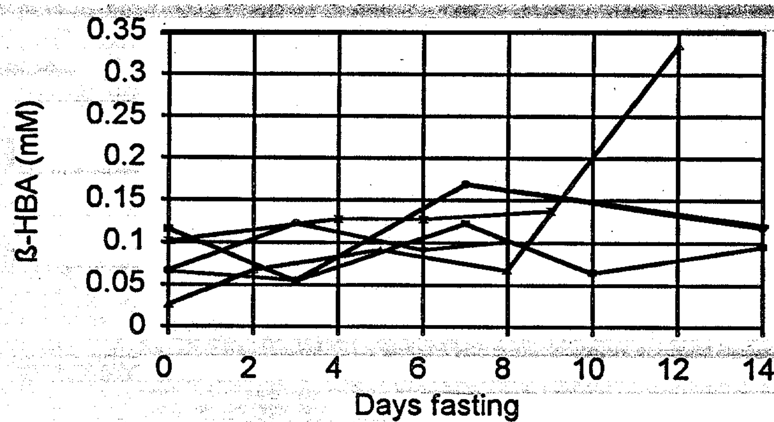

Figure 3. Ketone body (β-HBA) concentrations (mM) for 5 juvenile Steller sea lions during complete fasting.