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Growing Fast and Dying Young: Effects of Forage Quality on Growth and Survival of Arctic Geese

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Background

Keystone herbivores such as geese in Arctic ecosystems are highly sensitive to reduced quantity and quality of available forage. At many stop-over and brood-rearing areas, intensive grazing by geese has resulted in dramatic habitat changes that may affect gosling growth and survival and hence influence goose populations (Jefferies *et al*. 2004, Fig. 1).

Fig. 1. Exclosure at La Perouse Bay (James Bay, Canada) showing effects of goose grazing.

Objective

Determine the effects of diet quality on growth and survival of Canada and Snow geese.

Study Design

- We collected 100 Canada and 100 Snow goose eggs (1 egg per nest) from Akimiski Island, James Bay, Hudson Bay, Canada (Fig.2).

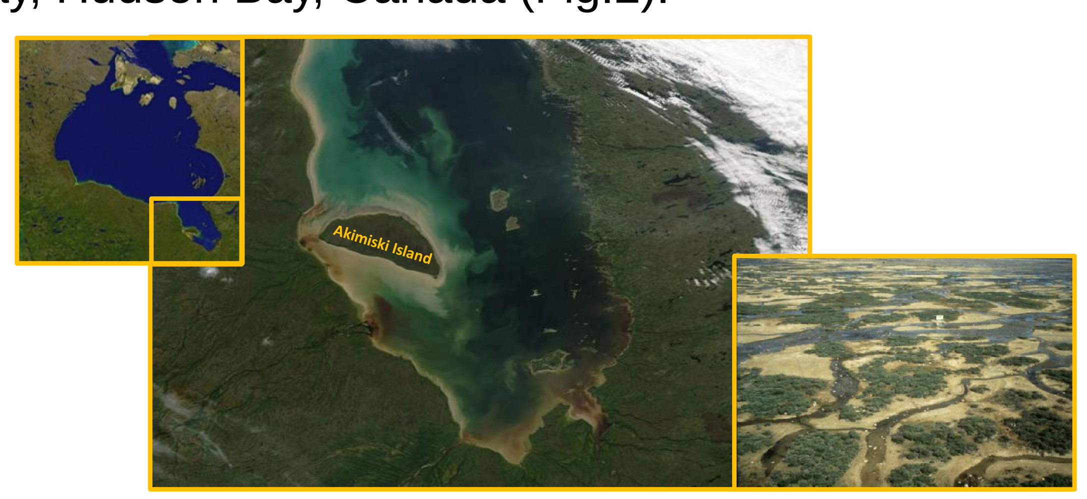


Fig. 2. Location of Akimiski Island, Canada.

- Goslings were raised on isocaloric (~18 kJ g^{-1}) grass-based diets with certain amounts of protein and neutral detergent fiber (Fig. 3).

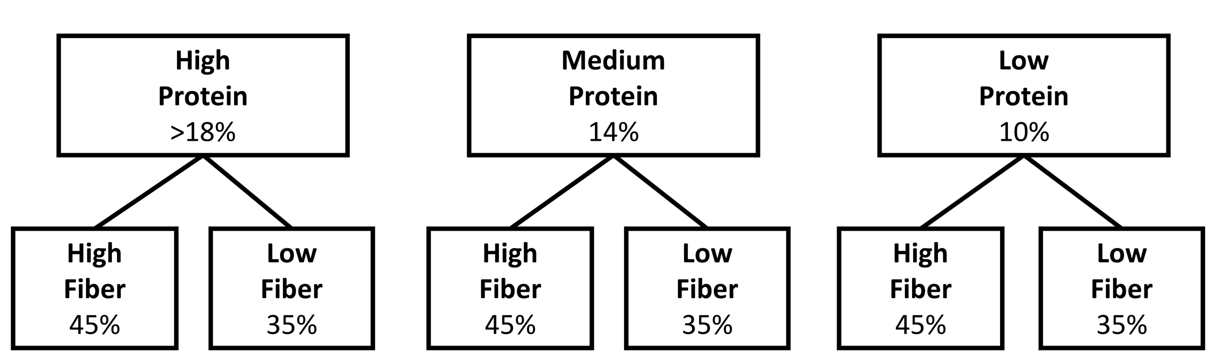


Fig. 3. Grass-based experimental diets fed to captive goslings (n = 4 to 12 per diet group).

- We measured body mass and structural size (head, culmen, tarsus, and 9th primary length) of goslings every ca. 3 days from hatch until up to 120 days old.
- Effects of diet quality on survival and growth rates were tested using PROC LIFETEST, PHREG, and GLMM (SAS Institute).

Results

Effects of Diet Quality on Survival

- Survival probabilities were relatively low for Snow goslings, especially during early growth (< 15 days), compared to Canada goslings (Fig. 4).
- Hazard ratios were 2x and 4x higher for Canada and Snow goslings, respectively, fed the low-quality diet relative to those fed higher-quality diets.
- Kaplan-Meier log-rank survival estimates between diets were similar for Canada goslings (χ^2 = 2.7, *df* = 5, *P* = 0.74), but were significantly different for Snow goslings (χ^2 = 28.3, *df* = 5, *P* = <0.0001).

Canada Goose | Snow Goose

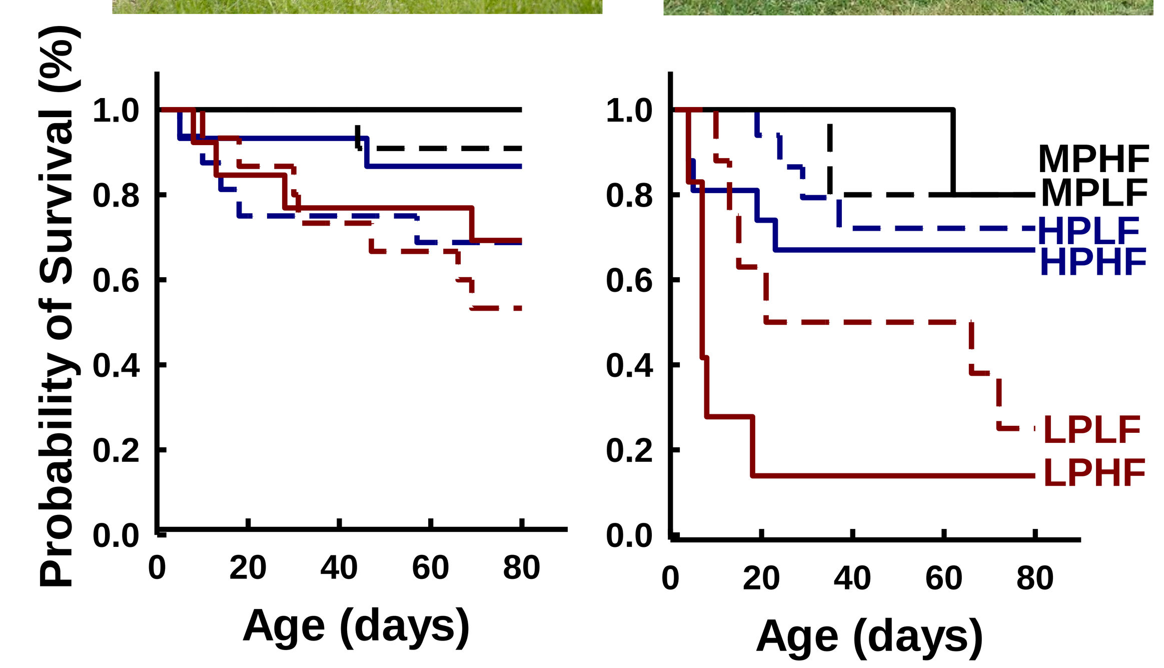
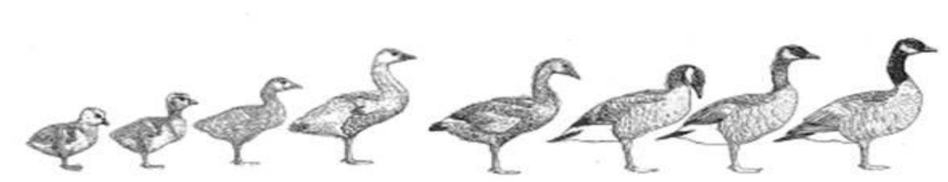


Fig. 4. Survival probability for captive-reared Canada and Snow goose goslings fed diets with certain amounts of protein and fiber (see Fig. 3).

Effects of Diet Quality on Growth



- Canada and Snow goslings fed low protein diets were lighter (Canada~40%; Snow ~65%) and had reduced growth rates for tarsus (Fig. 5), as well as skull, culmen, and 9th primary compared to goslings fed higher protein diets.
- The effects of dietary protein and fiber were more extreme for Snow goslings compared to Canada goslings, especially on the low protein diets (Fig. 5).
- In general, Snow goslings had higher protein requirements than Canada goslings.
- Interspecific differences in compensatory growth between species were best explained by diet quality (both protein and fiber content) and digestive physiology.

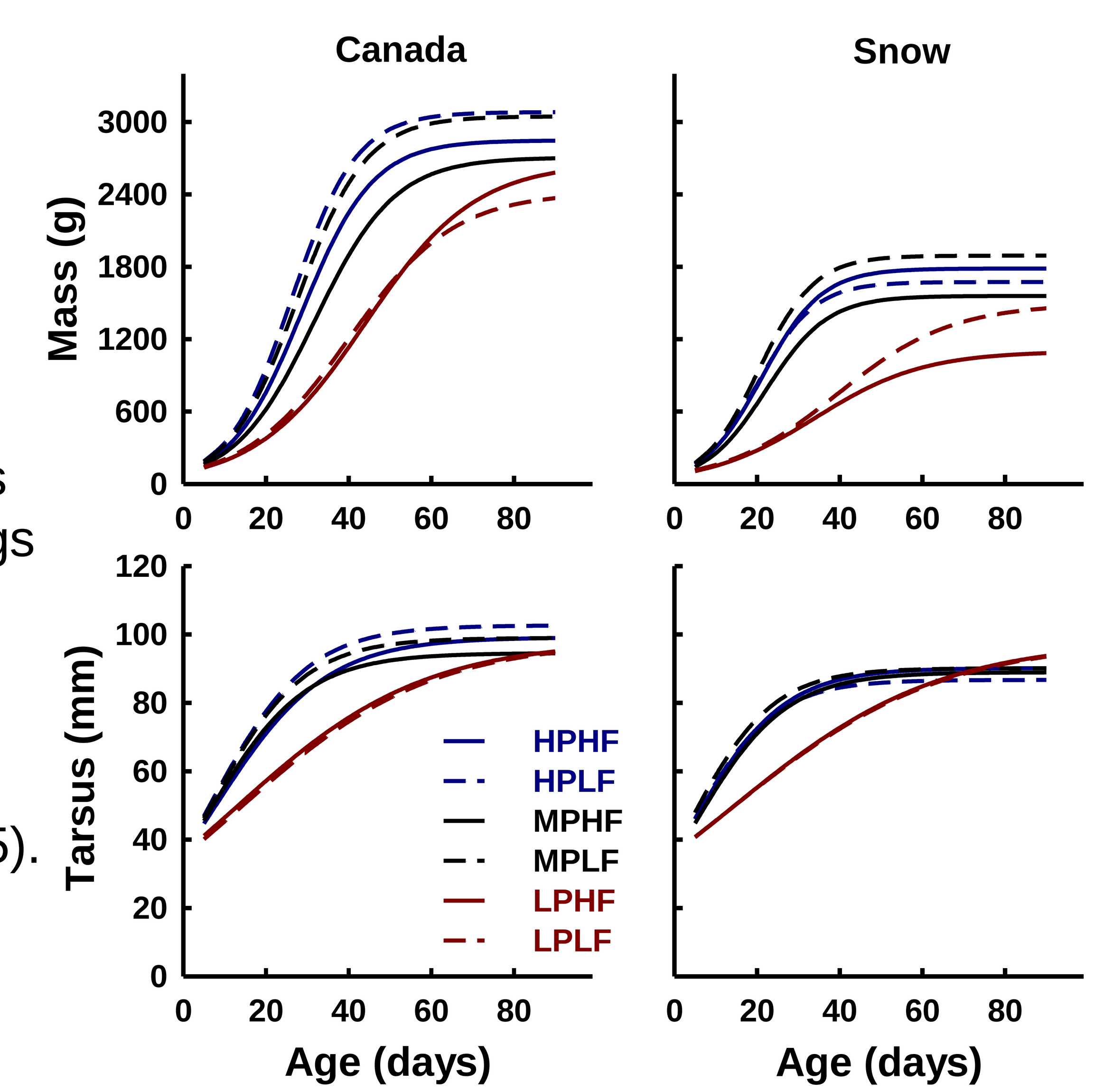


Fig. 5. Body mass (g) and tarsus length (mm) fit to the logistic-growth equation for individual Canada and Snow goose goslings fed diets with certain amounts of protein and fiber (see Fig. 3).

Table 1. Mean age when reaching 90% (T_{90}) of asymptotic body mass (g) and tarsus length (mm) of captive-reared Canada and Snow goose goslings fed grass-based diets with certain amounts of protein and fiber (see Fig. 3).

Diet	Canada		Snow	
	Mass T_{90} (days)	Tarsus T_{90} (days)	Mass T_{90} (days)	Tarsus T_{90} (days)
HPHF	48	38	38	30
HPLF	44	33	35	27
MPHF	53	32	38	29
MPLF	46	31	36	26
LPHF	75	65	63	69
LPLF	68	64	70	70

- Snow and Canada goslings reached asymptotic size ca. 35 days later when fed the low protein diets (Table 1). This delay in growth has dire consequences for arctic-nesting geese and especially for Snow geese that must grow rapidly and depart before the early onset of winter.

Discussion

- Canada and Snow goslings had reduced survival, body mass, and structural size when fed low protein diets; snow geese were more limited in their ability to compensate for reduced forage quality (McWilliams and Leafloor 2005).
- Phenotypic flexibility in gosling growth and their digestive system allows geese to respond successfully to considerable habitat change; however, there appears to be a lower limit to the quality of forage eaten (<10% protein and high fiber) that is to a degree species-specific.
- The reduced growth and survival of these keystone herbivores in response to changes in plant quality suggest that they are good indicators of the health of arctic ecosystems.

References

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McWilliams, S. and J. Leafloor. 2005. Effects of Elevated CO_2 on Keystone Herbivores in Modern Arctic Ecosystems. Pages 369-393 *in* I. T. Baldwin et al., editors. A History of Atmospheric CO2 and Its Effects on Plants, Animals, and Ecosystems. Springer-Verlag.