trolled fall result in mortal trauma? Is there any height from which a falling grebe might be able resume flying if it had lost all forward momentum? Further observations and experiments will be instructive.

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# Observations of Geese Foraging for Clam Shells During Spring on the Yukon-Kuskokwim Delta, Alaska

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ABSTRACT.—We studied the behavior of geese on exposed river ice during spring on the Yukon-Kuskokwim Delta. The predominant behavior while on the ice for both sexes was foraging; however, females foraged more than males. Visual inspection of the ice revealed no potential plant or animal food items. However, numerous small (<20 mm) clam shells (*Macoma balthica*) and pieces of shell were noted. It appeared that geese were foraging on empty clam shells. This potential source of calcium was available to breeding geese just prior to egg formation and geese likely stored this calcium in the form of medullary bone for use during egg formation. *Received 9 Sept. 1997, accepted 8 March 1998.*

Arctic nesting geese produce eggs from endogenous reserves (e.g., protein, lipid, and minerals) stored prior to the initiation of egg laying (Ankney and MacInnes 1978). Mineral reserves, particularly calcium, are deposited in the form of labile medullary bone (Simkiss 1967). Females build calcium depots prior to breeding and utilize this reserve when calcium demands for egg shell production exceed dietary intake (Krapu and Reinecke 1992). However, calcium is not always readily available for pre-breeding consumption and this limitation in medullary bone production may be an important factor influencing clutch size in some waterfowl species (Alisauskas and Ankney 1994).

The Yukon-Kuskokwim Delta supports large numbers of breeding Emperor Geese (*Chen canagica*), Cackling Canada Geese (*Branta canadensis minima*), Black Brant (*Branta bernicla nigricans*), and Greater White-fronted Geese (*Anser albifrons*) (Mickelson 1975). All 4 species arrive between late April and early May and begin nesting 1–3

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wks later (Mickelson 1975, Raveling 1978). Raveling and coworkers (1978) concluded that female Cackling Canada Geese stored calcium after their arrival on the breeding grounds. Prior to nesting, geese forage primarily on plant material (e.g., Budeau et al. 1991). Because the calcium content of most waterfowl plant foods is relatively low (Krapu and Reinecke 1992), breeding geese must obtain calcium from some source other than normal forage. Other potential sources of calcium for breeding geese on the Yukon-Kuskokwim Delta are unknown.

For each of the last 10 years, we have observed geese apparently foraging on snow-free river ice in spring. The use of this habitat, and certainly this behavior while on the ice, seemed unusual. Our goal in this study was to investigate and describe this seemingly anomalous behavior of geese using river ice in spring. We interpret these behaviors in relation to other studies regarding calcium intake and storage.

## METHODS

We conducted systematic behavioral observations of geese using a 500 m section of river ice in May 1997. Pairs of geese were observed with a variable power telescope. The first pair observed to fly onto the ice within view was selected for observation. Behaviors were recorded for both the female and male every 15 sec. Behavior classes used were foraging (including searching), alert, roost, walk, preen, swim, and aggression. Sex was determined by body shape as females tend to have more distended abdomens in spring (Gauthier and Tardif 1991, Johnson and Sibly 1993). Each observation continued until the pair departed the river ice. The proportion of time each member of a pair spent foraging while on the ice was calculated. Each member of a pair represented a single datum, and means and standard errors for each sex were calculated accordingly. Percent time foraging was compared among the sexes using a *Z*-test (Pollock et al. 1989).

We conducted general visual inspections of river ice on numerous occasions looking for potential food items. Intensive visual inspections of the river ice in specific locations used by foraging geese were conducted on three occasions and variably sized samples of melt-water, sediment, and ice were collected. Ice samples were thawed and all samples were visually inspected for potential food items.

## RESULTS

We collected data on 26 pairs of geese from 15–17 May 1997 (15 pairs of Cackling Canada Geese, 8 pairs of Black Brant, 2 pairs of Emperor Geese, 1 pair of White-fronted Geese). Average time spent on the river ice for a pair was 16.8 ± 2.7 min. SE (range 1–49 min.). Foraging was the most common behavior and females spent more time foraging while on the ice than males ($Z = 2.25$, $P < 0.01$; Table 1). We found no potential food items (i.e., plants or invertebrates) during visual inspection of specific foraging sites. We did observe numerous small (<20 mm length) clam (*Macoma balthica*) shells and pieces of clam shell on top of the ice. All of the shells we observed were empty and lacked any potential source of protein.

TABLE 1. Percentage of time spent in each behavior by 26 pairs of geese using exposed river ice during spring on the Yukon-Kuskokwim Delta, Alaska.

| | Females | | Males | |
|---|---|---|---|---|
| Behavior | Mean | SE | Mean | SE |
| Forage | 73.5 | 3.7 | 54.5 | 4.4 |
| Alert | 12.5 | 3.3 | 28.1 | 3.6 |
| Walk | 9.0 | 1.6 | 10.5 | 1.9 |
| Roost | 3.4 | 1.7 | 3.2 | 1.7 |
| Preen | 1.0 | 0.5 | 2.8 | 0.9 |
| Swim | 0.6 | 0.5 | 0.0 | 0.0 |
| Aggression | 0.0 | 0.0 | 0.8 | 0.5 |

## DISCUSSION

It appeared that geese likely were consuming clam shells while foraging on river ice during early spring on the Yukon-Kuskokwim Delta. Observations similar to ours have been reported for nesting Northern Pintails (*Anas acuta*) which consumed empty snail shells during egg laying (Krapu and Swanson 1975), and in the extreme case of King Eiders (*Somateria spectabilis*) consuming small bones (Uspenski 1972 *in* Krapu and Reinecke 1992). This behavior suggests that calcium availability during reproduction may be limited for some species.

Calcium content of most waterfowl plant foods is relatively low (Krapu and Reinecke 1992). Consequently, it may be difficult for females of some species to build calcium reserves prior to the initiation of egg laying. In fact, Alisauskas and Ankney (1994) concluded that insufficient mineral reserves might limit egg formation of Ruddy Ducks (*Oxyura jamaicensis*). Although based on small sample sizes, Raveling and coworkers (1978) thought

that female Cackling Canada Geese stored calcium after their arrival on the breeding grounds. Raveling (1979) thought that the observed increase in skeletal mineral content prior to nest initiation was sufficient to account for most of the calcium required for clutch formation. Foraging on clam shells may explain how female Cackling Canada Geese obtain calcium after arrival on breeding grounds.

Medullary bone serves as the storage site of minerals that may be ingested at variable rates during the day but are required at constant rates during egg shell formation (Alisauskas and Ankney 1992). This ability to store calcium may explain the short duration of the foraging bouts we observed. In a short period of time female geese likely are able to ingest large amounts of calcium which is then stored for shell production in the form of medullary bone. It is unclear why male geese would consume clam shells since males do not experience the high calcium demand associated with egg production. It may be that males (and potentially females) are consuming clam shells as a source of grit since there are no sources of grit on or near our study area. Thus, for females the ingestion of clam shells may serve a dual function as grit and enhancement of calcium reserves.

The clam shells we observed were associated with a thin layer of sediment on top of the river ice. It is unknown how this material becomes incorporated into the river ice. Typically, the river ice breaks up about the time that nest initiation commences so these clam shells are available to nesting geese just prior to the peak calcium demand. Additionally, we have observed geese foraging on ice floes moving with the tide after the river ice had broken which suggests the limited availability of alternative sources of comparable forage. We have generally noted clam shells on the river ice, and geese using river ice habitats each spring since 1987. Thus, it is likely that this habitat may provide an important and annually consistent source of calcium and/or grit for breeding geese on the Yukon-Kuskokwim Delta.

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