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The diet of king eiders wintering in Nuuk, Southwest Greenland, with reference to sympatric wintering common eiders

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Abstract Coastal and offshore waters of Southwest Greenland are internationally important wintering areas for king eiders (*Somateria spectabilis*) breeding in eastern Canadian Arctic and in northwestern Greenland. This paper presents the first assessment of their winter diet. Based on esophageal-proventricular samples from 26 females (13 juveniles and 13 older birds) and 15 males (11 juveniles and four older birds) collected in 2000–2002 (November–May) in coastal waters of Nuuk, we identified 28 prey species. The diet consisted of almost equal proportions (aggregate fresh mass) of polychaetes, echinoderms, crustaceans and molluscs. The dominant prey species were *Pectinaria* spp. (26.8%), *Strongylocentrotus droebachiensis* (18.4%), *Mya eideri* (11.2%) and *Hyas araneus* (9.7%). The polychaetes have previously been identified as important prey for eiders in Greenland, but apparently not outside Greenland. Compared with a diet study of common eiders *Somateria mollissima* from the same wintering area, the king eiders consumed significantly less bivalves and significantly more echinoderms. This difference corresponded with observations that common eiders were feeding in shallow waters, while king eiders were feeding in deeper waters farther from the shore. Benthic surveys are needed to confirm that diet corresponds with prey availability.

Keywords King eider · *Somateria spectabilis* · Southwest Greenland · Common eider · *Somateria mollissima* · Winter · Diet · Feeding

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Introduction

The coastal and offshore waters of Southwest Greenland are internationally important wintering areas for seabirds with a minimum of 3.5 million birds using this region in winter. King eider (*Somateria spectabilis*) and common eider (*S. mollissima*) are among the most abundant species (Boertmann et al. 2004, 2006). King eiders breeding in eastern Canadian Arctic and in north–western Greenland use the central part of West Greenland as moulting and staging area in late summer and autumn and subsequently move farther south to winter in Southwest Greenland (Salomonsen 1968; Frimer 1995; Mosbech and Boertmann 1999; Lyngs 2003). In the wintering areas, king eiders are distributed in coastal areas (sympatric with common eiders) or at offshore shallow-water banks. The coastal segment of the population has been estimated to number ca. 150,000 birds (Merkel et al. 2002), while surveys covering mainly offshore areas estimated ca. 300,000 wintering king eiders (Mosbech and Johnson 1999).

Despite the large number of birds and the extended period of time (September/October–April/May) that king eiders spend in Southwest Greenland, their diet has not been studied. Information from Greenland is available for moulting birds (August–October) in central West Greenland (Frimer 1995, 1997), but during winter, only the diet of common eiders has been studied (Merkel et al. 2007).

The marine areas of Southwest Greenland are subject to human use both in summer and winter: commercial hunting and fishing, mineral and petroleum activities, and recreational activities (Bureau of Minerals and Petroleum 2003; Merkel 2004). To minimise unforeseen environmental impacts of such activity it is important to identify key prey species for these eiders.

Here, we provide the first assessment of the diet of wintering king eiders in Southwest Greenland. We present quantitative information from the Nuuk coastal area and we compare the results with a recent diet study of common eiders from the same wintering area. We discuss the findings in relation to other studies of king eiders.

Methods

In 2000–2002, we collected birds from November to May in the coastal area of Nuuk, Southwest Greenland (Fig. 1). Birds were shot by local hunters ($n = 17$) or caught as by-catch in lumpsucker *Cyclopterus lumpus* gillnets ($n = 24$). All birds were frozen on the day of collection. During subsequent dissections we removed and refroze the esophageal-proventricular (gullet) content. We aged birds by plumage and length of the bursa of Fabricius (Baker 1993; Mather and Esler 1999) and in females, by oviduct condition. We sexed immature birds by syrinx morphology (Beer 1963). Among the 41 collected birds, 26 were females (13 juveniles and 13 older birds) and 15 were males (11 juveniles and 4 older birds). We identified eider prey items to species whenever possible using standard identification literature (Sars 1895; McPherson 1971; Laubitz 1972; Just 1980; Lubinsky 1980; Squires 1990; Foster 1991; Petersen 1999). The fresh mass of each diet taxon was weighed to the nearest 0.1 g and the number of individuals counted. For some species, especially the crustaceans, we did not count individuals since they were often in poor condition and few whole specimens were present. We measured and grouped each bivalve species based on shell length to the nearest 5 mm. When calculating the mean length of the bivalves we assigned each bivalve the mid-point value from the given size group.

Due to small sample sizes ($n = 41$), statistical hypothesis testing between subgroups of king eiders was inappropriate (Johnson 1999; Nelder 1999). Therefore we pooled samples over time, sex and age. We compared our results for king eiders with data from Merkel et al. (2007, Table 3) for common eider gullet samples collected within the same area and study period. On the phylum/class level, we tested for differences in diet proportions (aggregate fresh mass) between king eiders and common eiders (each proportion representing the mean of a set of proportions), using a two-sample *t*-test after arcsine transformation (Zar 1999). Values are reported as means ± SE.

Results

The 41 king eiders contained 28 diet species and 527 food items in their gullet (esophagus and/or proventriculus), excluding species, such as the crustaceans, which were difficult to enumerate (Table 1). Four species made up 66.1% aggregate percent fresh mass of the diet: the polychaete *Pectinaria* spp. (26.8%), the echinoderm *Strongylocentrotus droebachiensis* (18.4%), the bivalve *Mya eideri* (11.2%) and the crustacean *Hyas araneus* (9.7%). These species occurred in 46, 37, 39 and 20%, respectively, of the bird's gullets. Based on fresh mass, the predominant diet

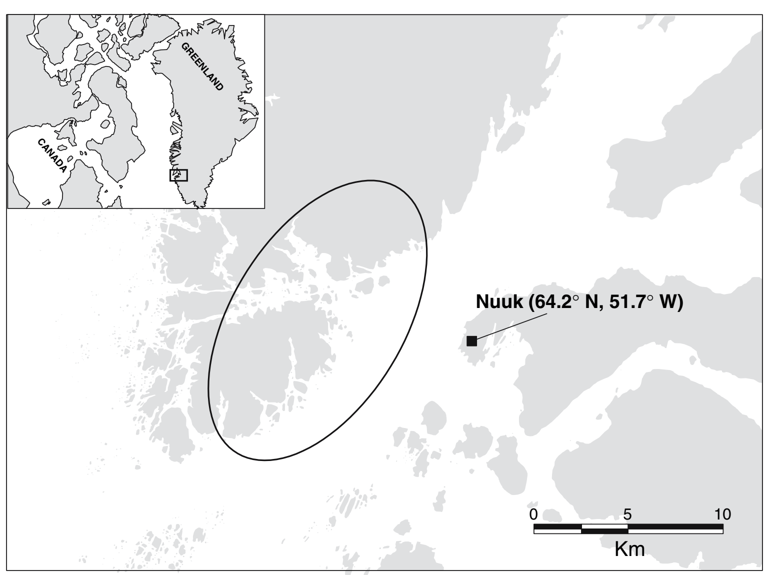

Fig. 1 King eiders were collected in the Nuuk study area between November and May, 2000–2002

Table 1 Esophageal-proventricular content [fresh mass (g)] of 41 king eiders collected during winter and spring (November–May) in Nuuk, Southwest Greenland, 2000–2002

Taxon	Total no. of items	Total fresh mass	Aggregate % fresh mass	% Occurrence
Cnidaria				
Hydroida spp.	–	1.3	0.6	4.9
Annelida				
Pectinaria spp.	272	62.0	26.8	46.3
Mollusca				
Gastropoda				
Tectura testudinalis	4	0.2	<0.1	4.9
Margarites groenlandicus	1	0.1	<0.1	2.4
Margarites helicinus	2	0.1	<0.1	2.4
Boreotrophon truncatus	4	0.5	0.3	4.9
Oenopota spp.	1	0.1	<0.1	2.4
Cylichna spp.	1	0.1	0.5	2.4
Total of Gastropoda	13	1.1	0.9	17.1
Bivalvia				
Musculus discors	1	0.2	0.1	2.4
Mytilus edulis	1	0.4	0.4	4.9
Macoma spp.	4	0.2	0.1	7.3
Hiatella byssifera	57	25.8	6.9	29.3
Mya eideri	66	23.0	11.2	39.0
Astarte borealis	1	0.1	0.2	2.4
Total of Bivalvia	130	49.7	18.9	48.8
Total of Mollusca	143	50.8	19.7	56.1
Crustacea				
Balanus spp.	–	1.7	0.8	14.6
Caprella septentrionalis	–	14.3	6.9	19.5
Gammarellus homari	–	0.2	<0.1	2.4
Gammarus locusta	–	1.4	0.4	4.9
Gammarus marinus	–	0.2	<0.1	2.4
Socarnes vahli	–	0.2	0.1	4.9
Unidentifiable amphipods	–	0.4	2.5	7.3
Caridea sp.	–	0.7	0.5	2.4
Hyas araneus	–	15.4	9.7	19.5
Total of Crustacea	–	34.5	21.0	58.5
Echinodermata				
Ophiura sarsi	68	6.1	4.2	17.1
Strongylocentrotus droebachiensis droebachiensis	43	45.1	18.4	36.6
Pentamera calcigera	–	5.5	4.8	7.3
Psolus fabricii	1	0.3	0.1	2.4
Total of Echinodermata	–	57.0	27.5	43.9
Pisces				
Ammodytes spp.	–	2.5	1.9	2.4
Algae	–	0.5	0.4	9.8
Pebbles	–	2.9	1.7	14.6

groups, in decreasing order, were the echinoderms, polychaetes, crustaceans and bivalves (Fig. 2). Many species did not appear to be of much significance to king eider diets; 18 of the 28 species each accounted for <1% of the diet and in total contributed to only 4.2% of the diet (Table 1). On average, the 41 king eiders contained

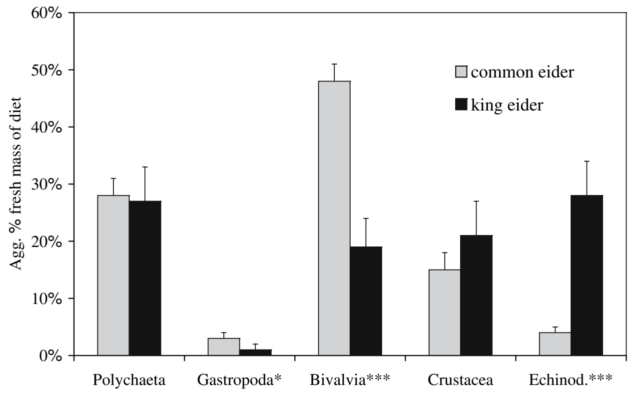

Fig. 2 Winter diet composition (aggregate % fresh mass) of common eiders ($n = 119$) and king eiders ($n = 41$) within the same study area in Nuuk, Southwest Greenland, 2000–2002. The data on common eider diet are from Merkel et al. (2007, Table 3), pooled over sexes and ages. *Asterisks* show the level of significance from 0.05* to 0.001*** (two-sample *t* test)

3.2 ± 0.3 prey species in the gullet, ranging from one to nine species. The bivalves most frequently preyed upon by the king eiders, *Mya eideri* and *Hiatella byssifera* (Table 1), had a mean length of 12.2 ± 0.68 mm ($n = 58$) and 13.1 ± 0.96 mm ($n = 57$), respectively. Among the echinoderms, the green sea urchin *Strongylocentrotus droebachiensis* was also common in the diet and had a mean diameter of 10.6 ± 1.09 mm ($n = 42$).

Compared with common eiders from the same wintering area (Merkel et al. 2007), the fresh mass proportion of echinoderms was significantly higher for king eiders ($t = -5.26$, $df = 158$, $P < 0.001$), while the proportion of bivalves was significantly smaller ($t = 4.46$, $df = 158$, $P < 0.001$). For polychaetes and crustaceans the proportions were of equal size ($t = 0.74$, $df = 158$, $P = 0.46$; $t = -1.48$, $df = 158$, $P = 0.14$; respectively).

Discussion

Considering that no other information about king eider diet is available from the Southwest Greenland wintering area, this study constitutes a valuable first assessment of their diet. In addition, the study area is within the coastal waters of Nuuk, which have been identified as a key wintering area for king eiders and common eiders in Southwest Greenland (Merkel et al. 2002). However, due to small sample size we were unable to evaluate differences between sexes, among age groups or across time in king eiders. These factors have previously been shown to influence the diet of eider species (Pethon 1967; Bustnes et al. 2000; Merkel et al. 2007). Further, we sampled in only a single study area (Fig. 1) and it has been shown that diet composition can vary considerably between wintering sites located only short distances apart, i.e., about 50 km (Brun 1971; Bustnes and Erikstad 1988; Merkel et al. 2007). Thus, additional work is required to explore the variety of the diet of king eiders wintering in Southwest Greenland, including the offshore shallow-water banks.

The four most important prey species in this study were distributed across four different taxa; annelids, molluscs, crustaceans and echinoderms (Table 1) and support earlier findings that this species has a varied diet (see review by Suydam 2000). In the diet of common eiders from the same study area in Nuuk, only annelids and molluscs were dominant prey groups (Merkel et al. 2007). The mean number of prey species per bird was relatively low for the king eiders in this study (3.2 ± 0.3) compared to common eiders from the same area (Merkel et al. 2007: 3.9 species) and compared to other studies of king eiders (Bustnes and Erikstad 1988: 6.9 species; Frimer 1997: 4.5 species), but our data are probably biased by a small sample size and non-random collection methods. Among the molluscs, the proportion of bivalves (aggregate fresh mass) was significantly smaller for king eiders than for common eiders from the same area (Fig. 2) and based on frequency of occurrence (49%, Table 1), also less common than Frimer (1997) found for moulting king eiders in central West Greenland (100%). With respect to the *Pectinaria* polychaetes, it is worth noting that so far, these have been identified as important prey in all diet studies of eiders in Greenland (Frimer 1997; Merkel et al. 2007, this study), but to our knowledge, not elsewhere in the wintering range of king eiders, although data are not extensive for other wintering areas. It is not clear if the same species of Pectinaria was common in the diet of both king eiders and common eiders in our study area; species identification was not possible. Both: *P. granulata* and *P. hyperborea* are reported as common from central west Greenland (Curtis 1977; Schmid and Piepenburg 1993). *P. granulate* was primarily found on relatively shallow sandy bottoms while *P. hyperborea* was mainly confined to greater depths and finer substrates (Curtis 1977).

The high proportion of echinoderms found in our study (28% fresh mass), mainly due to a high frequency of the green sea urchin *Strongylocentrotus droebachiensis*, is in sharp contrast to the diet of common eiders from the same area (Fig. 2). The high proportion was also among the highest of those previous reported for king eiders. The highest values that we found in the literature were 68% from northern Norway (Bustnes and Erikstad 1988) and 13 and 17% from two locations in Alaska (Preble and McAtee 1923 and Cottam 1939, respectively, cited in Suydam 2000). The large proportion of echinoderms found in king eiders in northern Norway also coincided with a high proportion of sea urchins in the diet of the king eiders, and a sympatric winter distribution of common eiders. Bustnes and Erikstad (1988) postulated this difference was due to a segregated distribution of the two-eider species. King eiders were feeding at greater depths and this coincided with a distribution of sea urchins down to 20 m. Common eiders, on the other hand, feed mostly on mussels that did not occur below 5 m.

We hypothesize *P. hyperborea* was most important to king eiders and *P. granulata* was most important to common eiders based on presumed depth of foraging. Although we do not have benthic survey data to support our contention, it is reasonable to explain the differences in diet between king eiders and common eiders due to water depth in areas where eiders were foraging. The segregation of common eiders over shallow waters and king eiders farther offshore was indeed observed in our study area (Merkel et al. 2007). Frimer (1995) and Bustnes and Lønne (1997) report a similar segregation between king eiders and common eiders, with diving depth as the most important factor. In our study area, both eider species feed on a mixture of soft- and hard-bottom prey species, but the major diet differences were found among hard-bottom prey species (for comparison with common eider see Table 1 in Merkel et al. 2007). Direct observations on prey availability are needed to further explore prey and habitat selection in this study area, as well as interactions between king eiders and common eiders.

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