No evidence of sex-specific differences in choice or size of fish caught for chicks or self-feeding among Common Guillemots *Uria aalge*

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Abstract

Despite slight but significant differences in size of male and female Common Guillemots *Uria aalge* and previously published sex differences in parental behaviour, foraging ranges and diving behaviour, no evidence of sex-specific differences in choice or size of fish caught for chicks or for self-feeding was found among adults caught in a North Norwegian colony.

Introduction

Numerous studies have addressed and documented sexual differences in various aspects of foraging behaviour and food provisioning that are not only common among sexually size-dimorphic birds but also among seabirds where this dimorphism is all but absent (Table 1 in Lewis *et al*. 2002). For example, among the Alcini (guillemots *Uria* spp., Razorbills *Alca torda* and Little Auk *Alle alle*) the sexes are only slightly dimorphic but parental roles are nevertheless skewed. This is most apparent at the end of the nesting period (during which both parents incubate and take care of the chick) when only the male takes the chick to sea and cares for it for several weeks (Gaston & Jones 1998; Harding *et al*. 2004). However, recent studies have revealed more subtle sex-specific differences among the Alcini with e.g. male Brünnich's Guillemots *Uria lomvia*, Razorbills and Little Auks spending more time in the colony, foraging at different times of the day, diving deeper or having longer dive bouts than females (Jones *et al*. 2002; Paredes *et al*. 2008; Thaxter *et al*. 2009; Wojczulanis-Jakubas *et al*. 2009; Paredes & Insley 2010) and have hypothesised that such differences are related to the partitioning of parental roles during the chick development period. We know of only two studies, however, that have addressed sex-specific differences in prey delivered to chicks: Paredes *et al*. (2008) who studied Brünnich's Guillemots and Razorbills and Thaxter *et al*. (2009) who studied Common Guillemots *U. aalge*, neither of which found significant differences. This paper carries Thaxter *et al*.'s (2009) study one step further by investigating not only sex-specific choice of prey brought to Common Guillemot chicks, but also testing whether adult diet is different during the chick-rearing period. Although otherwise very similar in overall body size, male Common Guillemots have slightly larger bills than females (Gaston & Jones 1998) and with the above-mentioned differences in foraging behaviour, one might predict that adult males and females differ in self-feeding diet. Whereas Gaston & Bradstreeet (1993) found no differences in diet among male and female Brünnich's Guillemots in the Canadian Arctic, this is, as far as we know, the first study to address sex-specific differences in choice or size of fish caught for self-feeding among Common Guillemots.

Methods

The study was carried out during the hatching and main chick-rearing period in a colony of c. 8,000 pairs of Common Guillemots (RTB unpubl. data) on Hornøya (72°22'N 31°10'E), a small island in northeast Norway, between 16 June and 17 July 2008. Adults were caught using a noose pole as they came in with fish for the chick. All birds were ringed, weighed (± 5 g) and measured (wing, culmen and head+bill lengths ± 0.5 mm), and a small blood sample (max 50 µl) was taken from the brachial vein for later DNA-based sex determination (Griffiths *et al*. 1998). A stomach content sample was also obtained using the water off-loading method (Wilson *et al*. 2004) (under licence no. S-2008/33166 of the Norwegian Animal Research Authority). Each adult was flushed a maximum of three times to ensure a complete emptying of the stomach. The bird was finally marked with a felt-tipped pen to avoid unnecessary recapture. On release, some birds flew down to the sea before returning to the nest site after a short time whereas others scrambled down the slope and returned immediately to their chick. The off-loaded food remains were stored in a plastic bag, marked and deep frozen for later analysis. When possible, the fish being carried by the adult was also collected and individually frozen. To avoid repeatedly robbing a chick of its food and to avoid pseudoreplication through possible diet specialization by individual birds (Woo *et al*. 2008), only one diet sample (stomach contents and/or fish being carried) was collected from an adult.

After thawing, a preliminary identification to lowest possible taxon of undigested remains (mainly otoliths, fish scales and pro-otic bullae (characteristic for Herring *Clupea harengus*) and fish eggs (characteristic for Capelin *Mallotus villosus*)) in the stomach samples was noted using Härkonen (1986), Watt *et al*. (1997) and our own reference collection. The samples were then further digested in a saturated solution of biological washing powder (Biotex ©) in an oven at 50° C for at least 24 hours after which additional otoliths were identified. Otoliths of Cod *Gadus morhua*, Saithe *Pollachius virens* and Haddock *Melanogrammus aeglefinus* (the three most likely gadids to be caught off Hornøya) were extremely difficult to distinguish when small, and were therefore initially classified as gadids (Gadidae). The lengths and widths of all otoliths were measured using a calibrated eye-piece graticule in a binocular microscope and used to determine total fish lengths (FL) using equations in Barrett & Furness (1990) for Capelin and Jobling & Breiby (1986) for sandeel *Ammodytes* spp. that are both based on fish caught in the southern Barents Sea. Because Jobling & Breiby's (1986) equation is based on standard fish length, the results were converted to total fish length using a factor of 1.01 (based on own measurements (RTB pers. obs.)). Exploratory studies based on our own measurements of otoliths and fish caught in the region revealed that the relationship between otolith size and fish length were nearly identical for the youngest year class (0-group) of the three gadid species, and that any larger gadids were most probably 1-group Haddock (Bugge *et al*. 2010). Thus in this study, comparisons were made using the equation for Haddock (where fish length FL in cm = $2.36 + 4.7 \times OW - 0.37 \times OW^2 + 0.1 \times OW^3$, where OW = otolith width in mm, Bugge *et al*. 2010).

Diet composition was expressed as frequency of occurrence based on counts of taxa in each sample. It was impossible to improve this quantification due to large differences in the degree of digestion of the samples and the uncertainty as to how many meals each regurgitation represented. Means are given ± 1 standard error. Differences in diet between sexes were tested using Chi-square (χ^2) goodness of fit of all the samples, and differences in body measurements and prey lengths using Student's *t* test. Where several fish were present in a sample from a single bird, the mean lengths of fish per bird were used as units when calculating mean lengths of fish eaten by each sex. We used the general linear model in SYSTAT version 12 to estimate effects of sex and parents (independent variables) on prey size (dependent variable). Separate analyses were performed for 0-group (< 80 mm) and for 1-group (> 130 mm) gadids.

Results

Ninety-two of the 102 adults caught were sexed, 39 males and 53 females. From these, 75 fish and 59 stomach samples were collected. There was no significant difference in wing lengths between the sexes, but males were significantly heavier and had significantly larger bills (length and depth at gonys) and longer heads than females, albeit the differences between sexes were still slight, being 5% or less in all cases (Table 1).

Of the 75 fish caught for the chicks, 62 were Capelin, nine sandeel, two gadid and two Herring. There was no sex-specific difference in the frequencies of diet taxa among fish ($\chi^2 = 0.5$, df = 2, P = 0.8, having combined Herring and gadid as one category, Table 2).

Of the 59 stomach samples, 26 were from males and 33 from females. The most frequent prey observed were gadids, being present in 52 (21 male, 31 female) stomachs, followed by Capelin, Herring and sandeels in 15, 10 and 7 stomachs, respectively (Table 3). The remains of a squid (Teuthida) were also found in one stomach. There was no significant difference between the sexes in the frequencies of these taxa (Table 3, $\chi^2 = 1.4$, df = 2, P = 0.5 having combined Herring, sandeel and squid as one category). Nor were there sex-dependent differences in the sizes of Capelin or sandeels caught either for the chicks or for self-feeding (Table 4). For gadids eaten by the adults (Table 5), there was no significant effect of sex on 0-group prey size (ANOVA, $F_{1,233} = 0.0002$, P = 0.99) or for 1-group ($F_{1,44} = 0.275$, P = 0.60). There was a significant parent effect for 1-group prey size ($F_{22,44} = 3.108$, P = 0.001) but not for 0-group (ANOVA, $F_{33,223} = 1.118$, P = 0.31).

Discussion

In this study, male Common Guillemots were slightly but significantly heavier and had larger bills and heads than females. These differences may give males a greater capability to catch larger fish and to dive to greater depths than females (Halsey *et al*. 2006). There was, however, no evidence of any sex-specific difference in the composition of the diet or in the sizes of Capelin or sandeels fed to the chicks on Hornøya. This lack of sex differences in chick provisioning is consistent with the studies of Thaxter *et al*. (2009) who found no differences between the sexes in choice (Sprat *Sprattus sprattus* and sandeel) or size of fish delivered to Common Guillemot chicks. Paredes *et al*. (2008) also found a very limited difference among Brünnich's Guillemots in the provisioning of chicks with both sexes feeding their chicks mainly (> 80 %) and equal amounts of Daubed Shanny *Leptoclinus maculatus* but with males providing significantly more of a minor food item, Capelin, than females. Nor did they find any differences among Razorbills with both parents feeding equal amounts of sandeel, Capelin and Daubed Shanny.

Table 1. Mean mass (g) and measurements (mm, ± SE) of 39 male and 53 female adult Common Guillemots *Uria aalge* caught at Hornøya, North Norway, 2008

	Mass	**Wing**	**Culmen**	**Gonys**	**Head+bill**
Male	1105.4 ± 13.8	214.9 ± 0.9	49.4 ± 0.3	14.5 ± 0.1	118.3 ± 0.4
Female	1063.2 ± 10.1	217.0 ± 0.7	47.3 ± 0.3	13.8 ± 0.2	115.4 ± 0.5
Student t	2.46	-1.85	4.75	2.50	4.40
df	73	74	89	66	88
P	0.016	0.068	< 0.001	0.015	< 0.001

Table 2. Numbers of fish collected from male and female Common Guillemots *Uria aalge* at Hornøya, North Norway, 2008.

Sex	**Capelin**	**Sandeel**	**Gadid**	**Herring**
Male	28	3	0	2
Female	34	6	2	0
Total	62	9	2	2

Table 3. Frequency of occurrence of prey types in diet of male and female adult Common Guillemots *Uria aalge* at Hornøya, North Norway, 2008; n = sample size.

	Male (n = 26)	**Female (n = 33)**
Prey type	**No. samples containing prey type**	**No. samples containing prey type**
Gadid	21	31
Capelin	8	7
Herring	5	5
Sandeel	1	6
Squid	0	1

Table 4. Size of Capelin *Mallotus villosus* and sandeels *Ammodytes* spp. caught by male and female adult Common Guillemots *Uria aalge* to feed to chicks and for self-feeding at Hornøya, North Norway, 2008. N = sample size.

		Capelin				**Sandeel**			
		Mean mm	**SE**	**Range mm**	**n**	**Mean mm**	**SE**	**Range mm**	**n**
Chick	Male	137.3	2.8	105–167	28	123.0	6.5	116–136	3
	Female	143.8	2.3	99–168	34	125.5	4.1	113–135	6
		t = -1.83, df = 53, P = 0.07				t = -0.33, df = 3, P = 0.77			
Adult	Male	108.4	8.5	89–130	5	112.7	20.0	72–137	3
	Female	113.8	4.0	101–131	7	110.2	6.0	88–127	6
		t = -0.58, df = 5, P = 0.59				t = -0.42, df = 2, P = 0.68			

Table 5. Size of 0-group (< 80 mm) and 1-group (> 130 mm) gadids (here exemplified with Haddock *Melanogrammus aeglefinus*) eaten by male and female adult Common Guillemots *Uria aalge* at Hornøya, North Norway, 2008; n = sample size.

	0-group gadid				**1-group gadid**			
	Mean mm	**SE**	**Range mm**	**n**	**Mean mm**	**SE**	**Range mm**	**n**
Male	56.2	1.1	48–62	13	166.1	5.6	134–186	10
Female	58.5	0.6	52–62	22	164.2	2.4	147–174	14
	ANOVA, $F_{1,233}$ = 0.0002, P = 0.99				ANOVA, $F_{1,44}$ = 0.275, P = 0.60			

This study is the first to show that there was similarly no sex-specific difference in the composition of adult diet among Common Guillemots. This was somewhat unexpected considering the many reported sex differences in foraging ranges, trip durations, and diving behaviour within the Alcini (Jones *et al*. 2002; Harding *et al*. 2004; Paredes *et al*. 2008; Paredes & Insley 2009; Wojczulanis-Jakubas *et al*. 2009; Thaxter *et al*. 2009) but does corroborate Gaston & Bradstreet's (1993) study of Brünnich's Guillemots in Canada. Intuitively, one could expect these foraging differences to translate into different prey items being caught e.g. at different distances from the colony or at different depths. On the other hand, Capelin and the youngest age-classes of Herring and gadids (the commonest prey eaten by adults) are all readily available off Hornøya (Barrett 2002, 2007; TP unpubl. data), thus eliminating any constraints imposed by the slight sexual dimorphism. As a result, any sex differences in body size or foraging, e.g. males diving deeper than females, may not be played out in the diet.

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Figure 1. Common Guillemot *Uria aalge* with Brünnich's Guillemot *U. lomvia*, Razorbill *Alca torda* and Black-legged Kittiwake *Rissa tridactyla* in flight around Hornøya Island, Norway, 18 March 2010. © *Hugh Harrop*.

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