Herring Gulls *Larus argentatus* in Common Eider *Somateria mollissima* feeding flocks – a discerning kleptoparasite

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Abstract

In Scotland, feeding flocks of Common Eider *Somateria mollissima* are regularly attended by Herring Gulls *Larus argentatus* which attack and steal food from the eiders. This study describes the prey brought to the surface by the eiders, their prey handling behaviour, subsequent attacks by gulls, and the outcome of such attacks. The majority of the prey was Blue Mussel *Mytilus edulis* (80%) but Green Urchin *Psammechinus miliaris*, Shore Crab *Carcinus maenas* and Common Starfish *Asterias rubens* were also taken. Attack frequency was not related to the occurrence of each type of prey in the eiders' diet, except that gulls were only observed attacking eiders for non-mussel prey. Attacks were most frequent (79%), and most successful (*i.e.* losses to gulls were highest), against eiders with starfish (73% of prey lost) and crabs (50% of prey lost). In contrast, losses of urchins (4%) and mussels (0%) were low. Despite starfish accounting for < 4% of Common Eider prey, gulls won sufficient (73%) to make kleptoparasitism a common feature of feeding flocks of eiders in this study area. These results indicate that Herring Gulls are highly selective in their attacks on Common Eider, and in the prey that are targeted.

Key words: Common Eider, Herring Gull, kleptoparasitism, *Larus argentatus*, *Somateria mollissima*.

Kleptoparasitism involves stealing by one individual (the kleptoparasite) food already procured by another individual (the host; Brockmann & Barnard 1979). A number of interspecific associations have been identified (Brockmann & Barnard 1979) as potentially facilitating the development of kleptoparasitism: 1) large host concentrations, 2) large quantities of food, 3) large, high-quality food items, 4) predictable food supply, 5) visible food with the host, 6) food shortage for kleptoparasite, and 7) prey handling time by the host. Where diving waterfowl regularly bring large prey to the surface, and especially where these are handled before ingestion, the prey are temporarily available to a potential kleptoparasite (Amat 1990). Where the kleptoparasite feeds at shallower depths than the host species it gains access to prey that it cannot reach itself. Amat (1990) also identified a number of possible evasion tactics used by hosts to reduce the risk from the kleptoparasite, as follows: 1) synchronisation of feeding activities within the feeding flock to confuse kleptoparasites, 2) handle prey more rapidly, 3) increase their distance from the kleptoparasite, 4) shift to a less vulnerable diet, and 5) keep the prey out of the kleptoparasite's sight.

Brockmann and Barnard (1979) have recorded Common Eider *Somateria mollissima* being kleptoparasitised by several large gull species, notably Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus*, Great Black-backed Gull *Larus marinus* and Glaucous Gull *Larus hyperboreus*. In a study of the kleptoparasitic behaviour of Glaucous Gulls taking food from eiders in southwest Iceland, Ingolfsson (1969) noted that the gulls defended feeding flocks of eiders against other gulls, including Great Black-backed Gulls. This has also been witnessed in Scotland (Prys-Jones 1973). Neither Ingolfsson (pers. comm.) nor Prys-Jones (1973) identified the prey stolen by the gulls but presumed them to be mussels. Kleptoparasitising of eiders by Herring Gulls is well known (Amat 1990; Brockmann & Bernard 1979; Kallander 2006). Kallander (2006) found the association between Herring Gulls and Common Eiders to be one of the most frequent kleptoparasitic relationships that he observed in southern Sweden, but was not specific about the prey that the gulls were stealing from the eiders. In eastern Canada, MacCharles (1997) recorded Herring Gulls kleptoparastising eiders for urchins, but intriguingly not for mussels. Hence, despite its widely reported nature, there is little empirical evidence for the type of prey that the Herring Gulls are actually stealing from the eiders. This study aims to record the prey brought to the surface by Common Eider, their prey handling behaviour, subsequent attacks by gulls, and the outcome of such attacks.

Methods

Gare Loch (56°01'N 04°47'W) and Loch Long (56°01'N 04°52'W) are two adjoining sheltered sea lochs 40 km northwest of Glasgow, within the Firth of Clyde, west Scotland. These sea lochs have a contiguous coarse sediment (cobble and boulder) coastline. The littoral and infralittoral (upper sublittoral) zones are dominated by Blue Mussel *Mytilus edulis* beds, together with Sugar Kelp *Laminaria saccharina* grazed by Green Urchin *Psammechinus miliaris* in the infralittoral zone. The coast road around Gare Loch has frequent viewing points; the southeast shore of Loch Long also has a coastal road with similar viewing opportunities.

Observations were made on 34 days over 22 months between July 2000 and March 2003, from a parked vehicle at a range of 50–300 m from flocks of feeding eiders, using 10 × 40 binoculars and a 30 × 80 telescope. Feeding flocks were first counted to determine flock size and the numbers of Herring Gulls present within 10 m of the flock were also counted. The flock was then systematically scanned from left to right, during which time all prey brought to the surface for handling was identified using the techniques described below. Any attacks by gulls and the outcome of the encounter were recorded. The scan continued until feeding in the flock had ceased and birds began to drift offshore. Although this technique may be subject to pseudoreplication due to the potential for repeat sampling of individual birds within a feeding flock in a single feeding bout, each surfacing represents a separate event. Attendant gulls would not have been able to predict which prey item would be brought to the surface by an individual eider, and so prey availability to the gulls was effectively random. Attacks by Herring Gulls could result in three potential outcomes: prey won by the gull, prey won by the eider and prey lost to both. Eiders not subject to attack were considered to have successfully handled and ingested the prey. Attack rates were expressed as a percentage of each of the prey species being made available to gulls by the feeding eider bringing them to the surface for handling. Loss rates to gulls were calculated for each type of prey as the proportion of Herring Gulls attacks that resulted in the eiders losing their food to the gulls. Overall loss rates included the prey won by gulls and those lost by both gull and eider. The retention rate includes the prey not subject to attack and those won by eiders.

Eiders handle different prey in different ways. Feeding techniques and associated behavioural traits have been noted in some detail and are summarised as follows. When feeding on Blue Mussel, surfacing eiders often bring up mussels in clumps, the mussels being attached to each other by strong byssal threads. Birds shake the mussels vigorously, breaking the byssal threads to separate individuals. As the bird grasps a preferred mussel, others separated in this way are not subsequently retrieved from the water. With larger mussels, this is frequently followed by a distinct head back motion to swallow the mussel whole. On bringing Common Starfish to the surface, eiders repeatedly and rapidly open and closed the bill to manoeuvre all starfish limbs into their mouth. Birds sometimes hold the starfish on the surface of water to help capture all the limbs before swallowing whole. Handling of Green Urchin is characterised by the eiders rolling urchins around their bills, on their broader axis, to flatten or break off spines (MacCharles 1997). The birds also regularly dip their bill (and urchin) into the water to help the rolling action before swallowing the urchin whole. On taking Shore Crab *Carcinus maenas*, the eiders shake the crabs vigorously to disarticulate and de-limb them (Picozzi 1958), often necessitating retrieval of the body lost back into the water. In contrast to mussels, the crab body was always retrieved from the water and the process repeated until all limbs had been removed, when the body was swallowed whole. These prey handling techniques are distinctive and readily observable, through a telescope, in flocks feeding at distances of up to ~ 300 m.

Prey handling times were determined from additional observations (outside of flock scans) for a small number of cases where the birds were feeding on mussels (n = 62), urchins (n = 87), and very occasionally starfish (n = 4). The small sample size for Common Starfish was due to their low frequency and high kleptoparasitic loss rate. Handling time was not recorded for eiders feeding on crabs because there were very few such cases seen during the survey.

Linear regression analysis determined there was a significant association between Common Eider flock size and the number of Herring Gulls in attendance, and chi-square tests were used to test the null hypothesis that there were no differences in Herring Gull attack rate, loss rate or retention rate across prey species. A z-test (Fowler & Cohen 1988) compared the mean handling times recorded for eiders feeding on different species. Herring Gull prey selectivity was assessed using the Linear Index of Prey Selection (Strauss 1979). The index is: Li = dl – hl, where dl is the proportional density of prey item i in the diet (Herring Gull attacks) and hl the proportional density available (*i.e.* numbers brought to the surface by eiders). It ranges from –1 to +1, with positive values indicating selection and negative values indicating either avoidance by the predator or reduced prey accessibility. The expected value for random feeding is zero.

Results

A total of 152 scans of eider feeding flocks were made at 19 separate locations around the two lochs (Table 1). On 29 occasions there were no gulls in attendance. The mean number of Common Eider in the study area was 1,711 birds (s.e. ± 198, range = 674–3,565, n = 22 monthly counts), with the birds occurring in flocks of varying sizes (mean = 16.99, s.e. ± 1.38, range = 2–114). There was a positive relationship between the number of attendant Herring Gulls and the number of birds in the feeding flocks of eiders observed during the study (linear regression: y = 0.056× + 0.707, R^2_{121}= 0.713, P < 0.01, Fig. 1).

A total of 5,346 prey items were identified in the 152 scans of feeding flocks in the study area: 4,262 (79.7%) mussels, 875 (16.4%) urchins, 199 (3.7%) starfish and 10 (0.2%) crab (Fig. 2). Prey handling times were determined separately for 153 items of three prey species (Fig. 3). There was no difference in handling times recorded for mussels (mean = 13.29 s, s.e. ± 1.40, range = 2–56) and urchin (mean = 16.42 s, s.e. ± 1.54, range = 2–75) ($z_{61,86}$ = 1.50, n.s.). Although eiders were timed handling and ingesting starfish on only four occasions, the handling time for this type of prey (mean = 29.0 s, s.e. ± 4.45, range = 16–36) was significantly greater than for both mussels and urchins (mussel versus Starfish, $z_{61,4}$ = 3.36, $P \leq 0.001$; urchin versus starfish $z_{86,4}$ = 2.66, $P \leq 0.001$).

During the 152 observations of feeding flocks, 123 (81%) flocks had attendant Herring Gull, while 29 (19%) did not. Gull attacks were observed during 85 (56%) of the flock observations and a total of 213 individual gull attacks were recorded. The proportion of prey attacked by Herring Gulls was not consistent across prey species (χ^2_3 = 3015, $P < 0.001$). Although mussels were the most frequent prey (79.7%), there were no attacks by gulls on eiders handling mussels seen throughout the study. Gull attacks were most frequent when the eiders were feeding on starfish (3.7% of prey, 79.4% of attacks) and urchins (16.4% of prey, 5.6% of attacks; Fig. 4). The Linear

Table 1. Data on prey taken by Common Eiders and kleptoparasitic attacks by Herring Gulls recorded during observations made at Gare Loch and Loch Long, Firth of Clyde, Scotland from July 2000–February 2003.

Observation point	No. flock scans	No. observation days	No. individual feeding events	No. mussels recorded	No. other prey recorded	No. klepto-parasitic attacks
Kidston Point	1	1	40	37	3	2
Royal Northern Yacht Club	13	10	659	538	121	26
Blairvadach	14	6	319	228	91	14
Shandon Old Church	5	3	141	85	56	7
Shandon/Faslane S	15	9	697	618	79	27
Garelochhead Bay	7	4	131	131	0	0
Dalandhui Point	5	2	25	20	5	1
Rahane	2	1	115	110	5	1
Little Rahane	10	9	833	800	33	17
Crossowen Pt Clynder	26	13	730	557	173	18
Clynder Post Office	3	2	155	135	20	6
Stroul Bay	13	9	426	399	27	16
Camsail Bay	1	1	35	25	10	6
Kilcreggan East	8	4	115	34	81	18
Kilcreggan West	2	1	25	0	25	3
Cove Bay	7	4	124	24	100	15
Knockderry Point	2	1	52	0	52	2
Ardpeaton	3	2	106	101	5	0
Coulport Bay	15	9	618	420	198	34
Total	**152**	**34**	**5,346**	**4,262**	**1,084**	**213**

Index of Prey Selection indicates that the Herring Gulls selected starfish (0.70) and avoided mussels (–0.80), whereas feeding on urchins (0.07) and crabs (0.03) was close to random (Table 2). Gulls were successful in 69% of all attacks. Most successful were attacks for starfish (73%, 115 won, 43 lost), followed by crabs (67%, 4 won, 2 lost) and

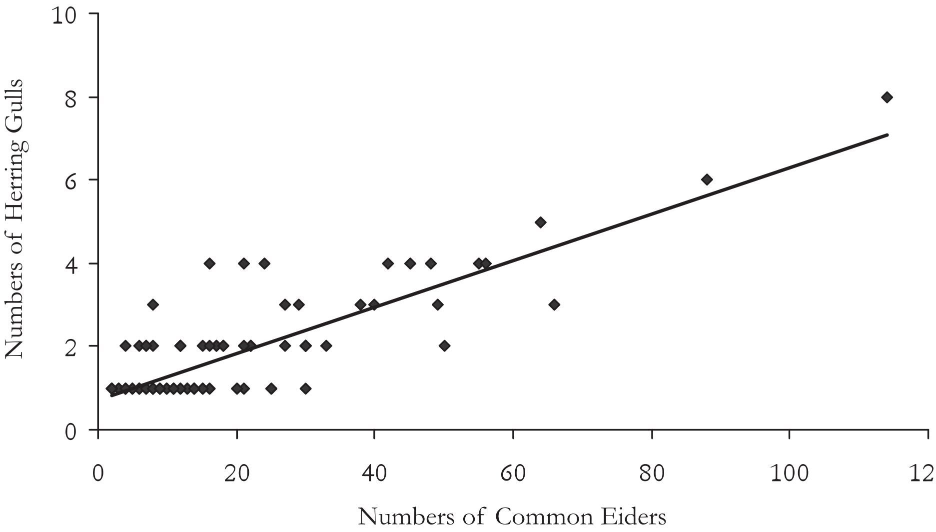

Figure 1. Numbers of Herring Gulls present, in relation to Common Eider flock sizes (*n* = 123 flocks). See text for statistics.

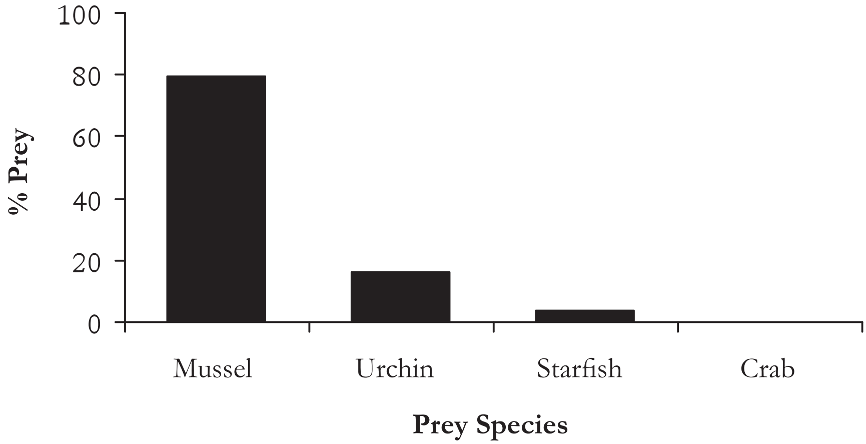

Figure 2. Percentage of different types of prey brought to the surface by Common Eider (*n* = 5,346 feeding events).

urchins (57%, 28 won, 21 lost) (Fig. 5). Starfish were significantly more likely to be won by Herring Gulls from Eiders than urchins (χ^2_1 = 3.98, $P < 0.05$). Eiders feeding on mussels were not attacked and therefore retained all of their prey. Those Eiders feeding on urchins, despite gull attacks, retained 96% of them (Table 2, Fig. 5). Eiders feeding either on mussels or on urchins kept virtually all of their prey, and

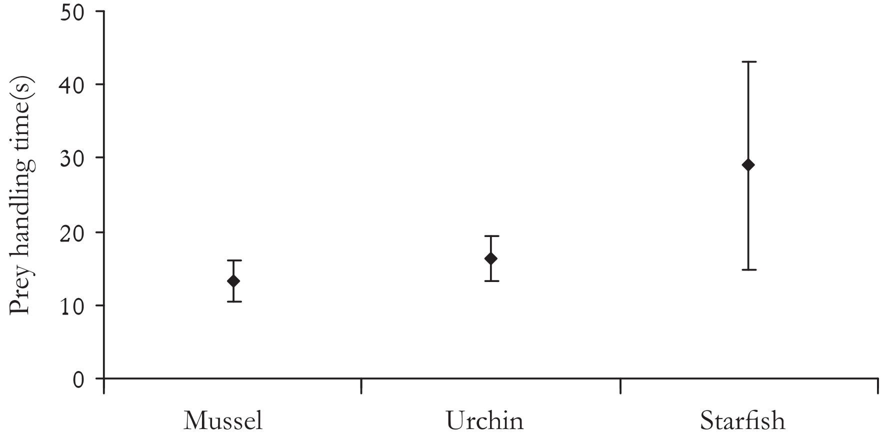

Figure 3. Mean prey handling time (± 95% confidence intervals) for Common Eiders observed in west Scotland (*n* = 62 for mussels, *n* = 87 for urchins and *n* = 4 for starfish).

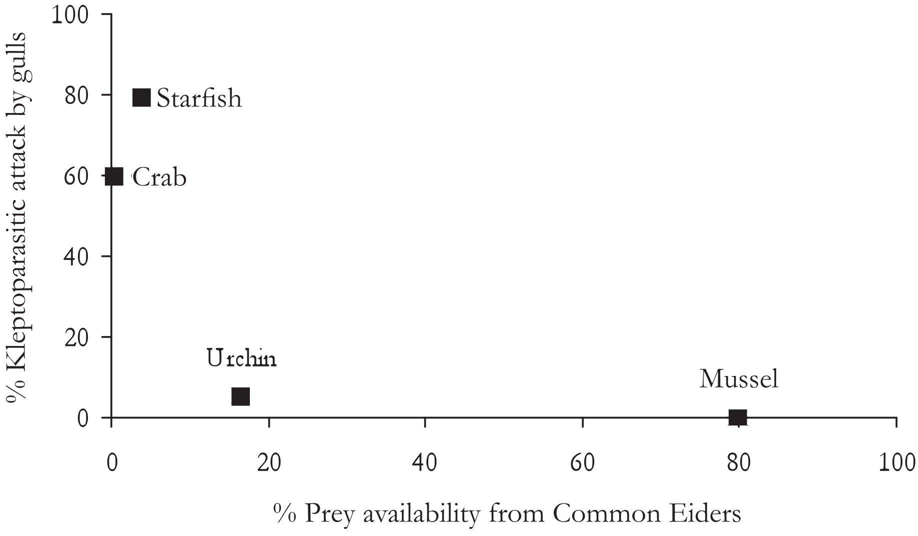

Figure 4. Percentage of kleptoparasitic attacks by Herring Gulls in relation to the type of prey brought to the surface by Common Eiders.

the difference in prey conservation efficiency was not significant (χ^2_1 = 0.07, n.s.). Crab feeders retained 50%. The proportion of prey retained by Eider compared to that lost due to kleptoparasitism was not consistent across prey species (χ^2_3 = 2496, $P < 0.001$). Those feeding on starfish retained only 36% of prey brought to the surface. For starfish, this difference between prey retained by eiders

Table 2. Frequency and outcome of kleptoparasitic attacks by Herring Gulls on Common Eiders feeding on different types of prey item.

	Starfish	**Urchin**	**Crab**	**Mussel**
Prey brought to surface by Common Eider	199	875	10	4,262
Kleptoparasitic attack by Herring Gull	158	49	6	0
Kleptoparasitic attack rate %	79.4	5.6	60.0	0
Linear Index of Prey Selection	0.70	0.07	0.03	–0.80
Outcome of attacks recorded (*n*)	158	49	6	0
% won by Herring Gull (*n*)	72.8 (115)	57.1 (28)	66.7 (4)	0
% won by Common Eider (*n*)	19.6 (31)	32.7 (16)	16.7 (1)	0
% lost to both (*n*)	7.6 (12)	10.2 (5)	16.7 (1)	0
% Common Eider prey retention rate (*n*)	36.2 (72)	96.2 (842)	50.0 (5)	100.0 (4,262)

and that lost due to kleptoparasitism, compared with eiders feeding on mussels and urchins, was significant (mussels versus starfish, χ^2_1 = 2778, P < 0.001; urchin versus starfish, χ^2_1 = 459, P < 0.001).

Discussion

This study found that Herring Gulls are frequently present in feeding flocks of Common Eiders, where they kleptoparasitise the eiders' prey in a non-random manner. Specifically, the Herring Gulls were highly selective for starfish but not for mussels. Mussels form a major component of the Common Eider's diet across most of its geographic range, and have been considered to be the target of kleptoparasitism by Herring Gulls elsewhere, including in other parts of Scotland (Ingolfsson 1969; Prys-Jones 1973; Kallander 2006). Yet although kleptoparasitism by Herring Gulls was evident in the present study, the gulls were not observed taking mussels from the eiders, despite it being the most common prey. The Herring Gulls' success rates observed in this study on starfish (73%), crabs (67%) and urchins (57%) were much greater that the 38.5% (n = 325) recorded by Kallander (2006).

The ecological conditions proposed by Brockmann & Barnard (1979) as potentially facilitating the development of kleptoparasitism may help to explain the differing results. Eiders generally feed in flocks which are variable in size, and flock size is likely to be influenced by the size and quality of food patches (Guillemette & Himmelman 1996). The present study found that the numbers of associating gulls increased significantly with the size of the

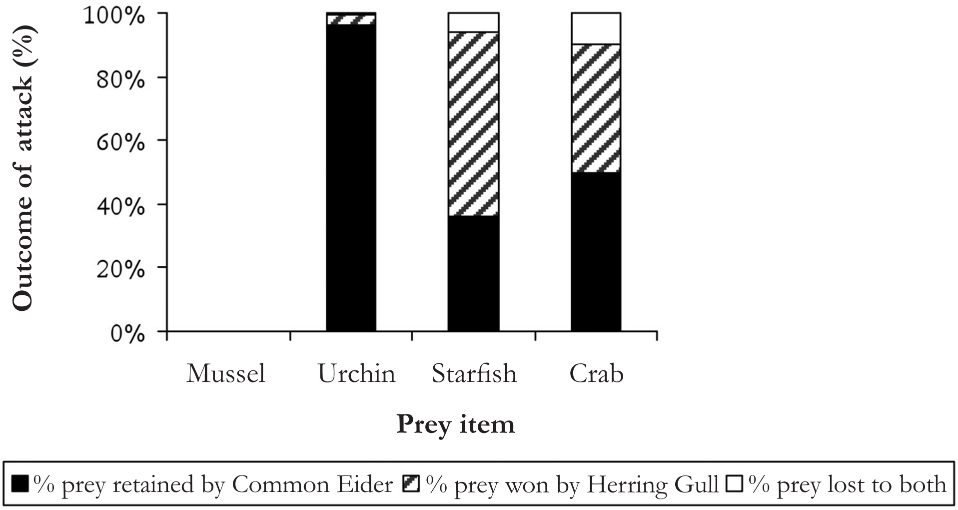

Figure 5. Outcome of kleptoparasitism by Herring Gulls on Common Eiders.

eider flocks. Eiders feed principally over mussel beds where there can be a plentiful supply of food, but they also exploit higher quality food items such as starfish and crabs, which are visible and attractive to Herring Gulls. These more profitable food items also require prolonged handling times by the eiders, extending their availability to kleptoparasitic gulls. All of these food items are accessible to gulls only at the lowest part of the tide cycle, and so are largely unavailable in the absence of kleptoparasitic behaviour.

Possible evasion tactics (Amat 1990) are used by eiders to reduce the risk from the kleptoparasitic Herring Gull. Synchronised feeding, diving and surfacing has been described in eider feeding flocks subject to kleptoparasitic behaviour by Herring Gulls elsewhere (MacCharles 1997). The dominance of lower energy content prey (namely mussels and urchins) in the items that Eider brought to the surface in the presence of gulls may suggest that the host may already adjust their dietary choice when selecting prey on the bottom. Energy content of starfish (23.3 KJ g^{-1} ash-free dry weight, Larsen & Guillemette 2000) and crabs (23.7 KJ g^{-1} AFDW, Klein Breteler 1975) is higher than that of mussels (19.5 KJ g^{-1} AFDW, Elner & Hughes 1978) or urchins (17.4 KJ g^{-1} AFDW, Otero-Villanueva *et al.* 2004). Starfish and crabs, as predators, occupy a higher trophic level in the ecosystem, than either urchins (omnivores) or mussels (filter-feeders). Other things being equal, the energy gained by both Common Eiders and Herring Gulls feeding on starfish and crabs would therefore be expected to be greater than on urchins or mussels. However, extracting the flesh content from the shell/exoskeleton comes at a cost. Bustnes (1998) has shown that eiders select mussel size to minimise shell content. Similarly, there are costs for the Herring Gull in handling and processing the captured prey. The smallest prey can often be swallowed *in situ* but larger prey requires more handling effort. Prey that has to be broken open by dropping on to, or hammered against, a hard surface necessitates the gull to leave the feeding eider flock and fly to the shore.

Starfish kleptoparasitised from eiders are often ingested *in situ* without the gulls having to leave the eider feeding flock. However, gulls with larger starfish are often pursued by other gulls, showing intra-specific kleptoparasitism, and forced to leave the eider feeding flock to retain their prey. Verbeek (1977a, b) found that, when available, starfish are clearly preferred by Herring Gulls over mussels, but they are only normally available to Herring Gulls at the lowest stages of the tidal cycle period, which is short (about 2 h) and infrequent (only during spring tides).

Small crabs kleptoparasitised from eiders can be ingested whole *in situ*, but larger ones have to be taken to the shore to be handled, where they are either repeatedly dropped or turned over and the underside hammered open by the bill.

In eastern Canada, MacCharles (1997) observed that eiders fed preferentially on mussels, and that Green Urchins were also an important source of food, but kleptoparasitic attacks by Herring Gulls were recorded only when the eiders were feeding on urchins. She described gulls rushing at an eider as soon as it surfaced, to try to steal urchins. Urchins are only normally available to gulls at the lowest stages of the tidal cycle. As for the crabs, all except the smallest urchins are taken to the shore by the gulls for handling and ingestion.

Although not evident in the present study, other research has shown that Herring Gulls do take mussels of varying sizes (Hilgerloh *et al.* 1997). Smaller ones will be swallowed whole, and the shell remains subsequently regurgitated as a pellet. Larger mussels are taken to a hard surface where they are repeatedly dropped from a height to break into them.

Of the prey that Herring Gulls kleptoparasitise from eiders, starfish appear to be the easier for the gulls to handle and ingest. Processing starfish can take place while the gull remains within the eider feeding flock, increasing opportunities for further attack attempts during the remainder of the eider flock feeding bout.

Kleptoparasitic prey selection by Herring Gulls is likely to be determined by a balance of prey energy value gained set against prey handling and processing costs. When compared to the other prey made available by the feeding eider, the predominance of starfish selected by Herring Gulls found in this study can be attributed to either, or a combination of, higher energy value and lower processing costs.

Given the very low proportion of crabs in the overall prey spectrum, the kleptoparasitic association between Herring Gulls and Common Eiders appears to depend solely upon the eiders continuing to bring starfish to the surface. The reward to the gulls from pursuing urchins would likely be insufficient to support kleptoparasitism as a viable feeding strategy. There remains a question about the persistence of starfish in eiders' diet, given the high rate of gull attacks and low retention rate by the ducks. There may be more to starfish than their energy value alone implies. There is a need to examine the relative roles of: 1) minimising shell or exoskeleton intake and their processing costs, 2) salt water intake and the cost of salt excretion, 3) the range and amount of various carotenoids in the diet, and 4) the possible parasite loading for each of the Common Eider prey species. These all remain to be assessed in the context of kleptoparasitism of eiders by Herring Gulls. Additionally, there is a need to test for any differences in the feeding behaviour of the Common Eider with and without kleptoparasitising gulls being present.

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