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Selective feeding on jellyfish organs by Northern Fulmars *Fulmarus glacialis*

Ingvar Byrkjedal*
& Gunnar Langhelle

Department of Natural History, University Museum of Bergen, University of Bergen, P.O. Box 7800 Allégaten 41, N-5020 Bergen, Norway.
*Correspondence: ingvar.byrkjedal@uib.no

Abstract: Several marine animals prey extensively on jellyfish in spite of the low energy contents of this type of prey. Northern Fulmars *Fulmarus glacialis* observed in the Barents Sea feeding on medusae of lion's mane jellies *Cyanea capillata* fed from the underside of the jellyfish, eagerly ingesting gonadal tissue as well as oral arms and tentacles, while the gelatinous tissue of the umbrella apparently was neglected by the birds. Gonads, arms and tentacles have about five times higher energetic contents than the tissue of the bell, approaching that of some species of fish. Aggressive defence of their prey and a continued feeding on jellyfish in the presence of discarded fish offal indicated jellyfish to be more than a second choice food for Northern Fulmars. The observations clearly showed that the Fulmars did not primarily feed on organisms associated with jellyfish. Their abundance and slow swimming make jellyfish an easily available prey. Scyphozoan cnidarians may be more important to pelagic seabirds than generally thought.

Key words: Seabird ecology, feeding behaviour, Scyphozoa

INTRODUCTION

Due to their low energy density, and their low organic contents compared to the amount of water and salt, jellyfish have been considered to be of poor nutritional value (Joseph 1979, Arai 1988, Hsieh et al. 2001). Nevertheless coelenterates are preyed upon by a number of marine animals including several species of sea birds (Arai 1988, 2005). In scyphozoans caloric values as well as lipid and protein contents are much higher in gonads, oral arms and tentacles than in the bell (Joseph 1979, Arai 1988, Doyle et al. 2007), and selective feeding by jellyfish predators on such tissue should be predicted. In most cases feeding on jellyfish has been recorded from analyses of stomach contents or regurgitates. Due to their soft substance jellyfish are rapidly dissolved in the alimentary tract and thus tend to be underrepresented in diet analyses, and the amount of tissue from different jellyfish organs is more or less impossible to assess from such samples (Phillips et al. 1999, Purcell & Arai 2001). As pointed out by Doyle et al. (2007) observations of feeding behaviour would be needed in order to reveal selectivity of tissue, but sufficiently detailed observations seem to be lacking.

Among sea birds, predation on scyphozoan medusae is found notably in surface-feeding Procellariformes, including the Northern Fulmar *Fulmarus glacialis* (Harris 1984). The Fulmar's diet comprises a broad spectrum, from small planktonic crustaceans to fish, squid and offal from fishing vessels (e.g., Hudson & Furness 1989, Mehlum & Gabrielsen 1993, Camphuysen & Garthe 1997, Phillips et al. 1999, Mallory et al. 2010). Long ago, however, Anthony (1895) suspected that jellyfish, when abundant, could make up an important part of the diet of this species. In an extensive sample, Harrison (1984) found jellyfish remains in stomachs of more than 40% of Northern Fulmars examined.

Participation in fisheries research cruises in the Barents Sea have given us opportunities to observe Northern Fulmars eagerly feeding on jellyfish. Our observations revealed that the birds fed selectively on different jellyfish organs. We here report the observations and discuss their implications.

MATERIAL AND METHODS

The observations were made while we participated on fisheries cruises with R/V «Johan Hjort» in August 2000 (IB) and R/V «Helmer Hanssen» in September 2013 (GL). All observations were made in calm seas, either from the bridge 10 m above the sea, or from the main deck 2 m above the sea. The observations were made when the ships were stationary carrying out salinity and temperature measurements or, while trawling at a speed of 3 knots. The birds were watched through 10 x 42 binoculars.

RESULTS

Ten cases of Fulmar feeding on lion's mane jelly *Cyanea capillata* were observed in detail during the two cruises (Table 1). During the 2013 cruise Fulmars were seen feeding on medusae of *C. capillata* on five or six additional occasions without specific notes being taken. The jellyfish that were fed on had a bell diameter of approximately 15–25 cm.

In all ten cases the Fulmars were feeding from the underside of the jellyfish which was lying upside down at the water surface (Figure 1). The birds eagerly pulled up and devoured large beakfuls of tissue from the gonads, oral arms, and tentacles, whereas tissue from the bell was not seen to be eaten. In case No. 2 and No. 10 the birds were observed at the start of their meal, and in both cases actively rotated the jellyfish by grasping the top of its bell and pulling sideways in order to turn

Table 1. Northern Fulmars observed feeding on *Cyanea capillata* in the Barents Sea

Case No.	Date	Coordinates	Observational circumstances
1	01.08.2000	73°52'N–29°18'E	Ship stationary, bird at 5–6 m distance
2	01.08.2000	73°52'N–29°18'E	Ship stationary, bird at 8–10 m distance
3	01.08.2000	73°52'N–30°00'E	Trawling, bird passed at 30 m distance
4	02.08.2000	73°37'N–32°51'E	Ship stationary, bird at 20 m distance
5	02.08.2000	73°37'N–32°51'E	Ship stationary, bird 3 m from hull
6	02.08.2000	73°37'N–32°47'E	Trawling, bird passed 2 m from hull
7	02.08.2000	73°42'N–31°38'E	Trawling, bird passed at 20 m distance
8	21.08.2013	c 79°N–9°E	Ship stationary, bird 5–7 m from hull
9	21.08.2013	c 79°N–9°E	Ship stationary, bird 5–7 m from hull
10	21.08.2013	c 79°N–9°E	Ship stationary, bird 5–7 m from hull

the medusa upside down (Figure 2). In case No. 4 and 5 the finishing of the meal could be observed: After 2–3 minutes of hectic feeding the bird let the jellyfish sink down and disappear in the sea with the bell more or less intact, apparently with a substantial part of the gonads and arms tissue removed.

Each of the observed cases involved a single Fulmar feeding on a jellyfish. Attempts by other Fulmars to steal from the birds that fed on jellyfish were seen in four of the cases (Nos. 1, 2, 7 and 10), and in the three cases for which notes were taken, the intruders were aggressively and efficiently fended off by pushing and biting, in two of the cases after their having managed to snatch 2–3 beakfuls.

In case No. 3 fish offal from the ship's laboratory was discarded in a stream into the sea through a hatch on the starboard side of the ship, well in sight to the Fulmar. This instantly attracted the other Fulmars from the vicinity of the ship to assemble into a feeding frenzy, while the bird feeding on the jellyfish continued to do so.

DISCUSSION

All cases reported here concern Fulmars feeding on lion's mane jelly *Cyanea capillata*. This is one of the two commonly occurring scyphozoan jellyfish species in the Barents Sea, the other one being the moon jelly *Aurelia aurita* (Eriksen et al. 2012). *C. capillata* is a northern boreal species with a wide pelagic distribution, while the cosmopolitan *A. aurita* has a more coastal affinity. *C. capillata*, although usually not more than 30–50 cm across, may attain an umbrella diameter of more than a metre and have a well-developed assemblage of nematocyst-bearing tentacles that may reach a length of many metres (Russell 1970).

Our observations show that Northern Fulmars feeding on scyphozoan medusae select the most nutritional and energetically rich tissue. It has been suggested that Northern Fulmars feed on jellyfish primarily to prey on crustaceans and young fish living in association with jellyfish (Harrison 1984, Camphuysen & van Franeker 1996, Purcell & Arai 2001), but the way the Fulmars in the present cases were seen wolfing down jellyfish tissue (cf. Figure 1) gave the clear impression that they primarily were after the jellyfish itself, although associated organisms may have followed in the process. Gonadal tissue tentacles and oral arms of *C. capillata* have a calorific content about five times that of the umbrella (Joseph 1979, Arai 1988, Doyle et al 2007).

In *C. capillata* developed gonads are highly folded and hang freely down beneath the umbrella, comprising a substantial structure in fully mature individuals (Russell 1970) and should be easily accessible to the birds, provided they are not negatively affected by the nematocysts of the surrounding organs. The numerous marginal tentacles richly supplied with nematocysts would be difficult to avoid for a bird feeding from the underside of a turned *C. capillata*, but the observations did not indicate that the Fulmars attempted to avoid eating tentacles. In *C. capillata* also the oral arms are equipped with nematocysts (Russell 1970), and large chunks of these arms were eaten by the Fulmars. The fact that the Fulmars ate from the underside of the jellies, and not just pierced the top of the jellyfish's nematocyst-free umbrella to get at the gonads, showed that they deliberately and without problems consumed nematocyst-bearing tissue.

While Northern Fulmars will swallow nearly anything floating on the surface (van Franeker 1985), jellyfish is apparently perceived by the birds to be valuable food, as judged from (a) the fact that individual Fulmars fought other Fulmars to keep the jellyfish they were feeding on to themselves, and (b) jellyfish were eagerly eaten in spite of the quantities of fish and crustaceans regularly discarded from the ship (with due exemption from the ban on discards). On the cruise in 2000, trawl hauls were undertaken with only 3 h intervals, and catches of 200–300 kg of small-sized fish such as blue whiting *Micromesistius poutassou*,

Figure 1. A Northern Fulmar feeding from the underside of a *Cyanea capillata* while approached by two conspecific competitors. Photo GL.

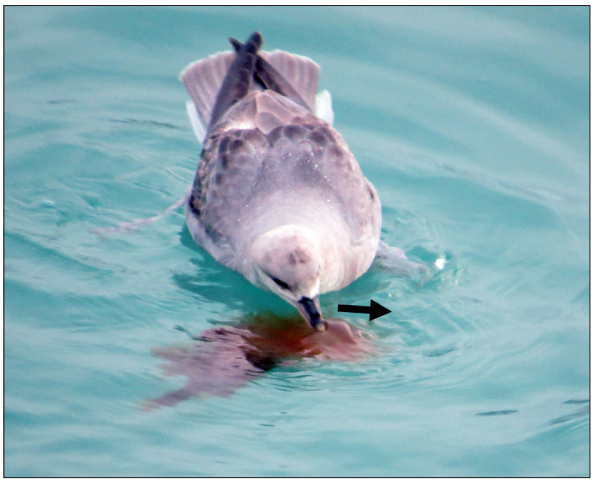

Figure 2. A Northern Fulmar that has seized the upper side of the umbrella of a *Cyanea capillata*, rotating the jellyfish in the arrow's direction in order to turn it upside down before feeding on it. Photo GL.

young haddock *Melanogrammus aeglefinus*, Norway whiting *Trisopterus esmarkii* and capelin *Mallotus villosus* as well as samples of shrimp *Pandalus borealis* regularly discarded must have provided the Fulmars with an ample food supply. Fulmars eagerly consumed the discards, which frequently might have kept the birds close to satiation. The caloric contents of gonads and oral arms (6.7–7 kJ/g dry mass) of *C. capillata* approach those of sandeels *Ammodytes marinus* and sprat *Sprattus sprattus* (6.8–7.6 kJ/g dry mass; Doyle et al. 2007), fish species important in the Northern Fulmar's diet elsewhere (e.g. Phillips et al 1999).

Our observations that Fulmars feed selectively on the most energy-rich organs of the jellyfish support the suggestion by Catry et al. (2004) that scyphozoan mesdusae might be a more important food source for pelagic birds than generally supposed. Their size and abundance make medusae easy to spot, and with their slow movements they may be readily exploited as prey (Hamner & Schneider 1986, Camphuysen & van Franeker 1996). A much higher rate of digestion of gelatinous animals compared to fish and crustacean prey (Arai 2005) may also contribute to make jellyfish an attractive food source for seabirds.

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REFERENCES

Anthony, A.W. 1895. The Fulmars of southern California. Auk 12: 100–109.

Arai, M.N. 1988. Interaction of fish and pelagic coelenterates. Canadian Journal of Zoology 66: 1913–1927.

Arai, M.N. 2005. Predation on pelagic coelenterates: a review. Journal of the Marine Biological Association of the United Kingdom 85: 523–536.

Camphuysen, C.J. & Franeker, J.A. van. 1996. Jellyfish and fishery waste as food sources of Northen Fulmars *Fulmarus glacialis* feeding around St Kilda. Sula 10: 143–150.

Camphuysen , C.J. & Garthe, S. 1997. An evaluation of the distribution and scavenging habits of Northern Fulmars (*Fulmarus glacialis*) in the North Sea. ICES Journal of Marine Science 54: 654–683.

Catry, P., Phillips, R.A., Phalan, B., Silk, J.R.D. & Croxall, J.P. 2004. Foraging strategies of Grey-headed Albatrosses *Thalassarche chrysostoma*: interaction of movements, activity and feeding events. Marine Ecology Progress Series 280: 261–273.

Doyle, T.K., Houghton, J.D.R., McDevitt, R. Davenport, J. & Hays, G.C. 2007. The energy density of jellyfish: Estimates from bomb-calorimetry and proximate-composition. Journal of Experimental Marine Biology and Ecology 343: 239–252.

Eriksen, E. Prozorkevich, D., Trofimov, A . & Howell, D. 2012. Biomass of scyphozoan jellyfish, and its spatial association with 0-group fish in the Barents Sea. PLoS ONE 7 (3): e33050.

Franeker, J.A. van 1985. Plastic ingestion in the North Atlantic Fulmar. Marine Pollution Bulletin 16: 367–369.

Hamner, W.M. & Schneider, D. 1986. Regularly spaced rows of medusae in the Bering Sea: role of Langmuir circulation. Limnology and Oceanography 31: 171–177.

Harrison, N.M. 1984. Predation on jellyfish and their associates by seabirds. Limnology and Oceanography 29: 1335–1337.

Hsieh, Y-H.P., Leong, F-M. & Rudloe, J. 2001. Jellyfish as food. Hydrobiologia 451: 11–17.

Hudson, A.V. & Furness, R.W. 1989. The behaviour of seabirds foraging at fishing boats around Shetland. Ibis 131: 225–237.

Joseph, J.D. 1979. Lipid composition of marine and estuarine invertebrates: Porifera and Cnidaria. Progress in Lipid Research 18: 1–30.

Mallory, M.L., Karnovsky, N.J., Gaston, A.J., Hobson, K.A., Provencher, J.F., Forbes, M.R., Hunt, G.L. Jr., Byers, T. &

Dick, T.A. 2010. Temporal and spatial patterns in the diet of northern fulmar *Fulmarus glacialis* in the Canadian High Arctic. Aquatic Biology 10: 181–191.

Mehlum, F. & Gabrielsen, G.W. 1993. The diet of High-Arctic seabirds in coastal and ice-covered, pelagic areas near the Svalbard archipelago. Polar Research 12: 1–20. doi.org/10.3402/polar.v12i1.6698

Phillips, R.A., Petersen, M.K., Lilliendahl, K. Solmundsson, J., Hamer, K.C., Camphuysen, C.J. & Zonfrillo, B. 1999. Diet of the Northern Fulmar *Fulmarus glacialis*: reliance on commercial fisheries? Marine Biology 135: 159–170.

Purcell, J.E. & Arai, M.N. 2001. Interactions of pelagic cnidarians and ctenophores with fish: a review. Hydrobiologia 451: 27–44.

Russell, F.S. 1970. The medusae of the British Isles. Vol. 2. Pelagic scyphozoa, with a supplement to Vol. 1. Cambridge University Press, Cambridge.

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