The anti-predator function of defecation on their own eggs by female Eiders

P. McDOUGALL and H. MILNE

Introduction

When alarmed, incubating Common Eider females *Somateria m. mollissima* invariably defecate over their eggs as they leave their nests. Such behaviour has been interpreted as having an anti-predator function by some authors (e.g. Beetz 1916; Gross 1938; Bannerman 1958; Swennen 1968), but this is rejected by others (e.g. Montague 1925; Quedens 1961). Experimental evidence by Hammond & Forward (1956) using faeces of Blue-winged Teal *Anas discors* and Shoveler *A. clypeata* suggested that such faeces had no effect on the subsequent predation of the eggs by mammals. However, further experimental work by Swennen (1968) showed that food which had been fouled by Eider faeces was rejected by rats *Rattus norvegicus* and was only acceptable to ferrets *Putorius furo* when no other food was available. Swennen also found that soiling with faeces from non-breeding Eiders did not have any deterrent effect, and that both ferrets and rats would eat food which had been so contaminated. This supports the idea that faeces from incubating birds are sufficiently different from those of non-incubating birds to produce an anti-predator effect when predatory mammals are involved.

Eiders breeding on the Sands of Forvie National Nature Reserve, Aberdeenshire, suffer annual egg losses of about 35% of which at least 21% can be attributed directly to predation by Crows *Corvus corone* and Herring Gulls *Larus argentatus* (Milne 1974). Egg losses on islands where gulls and crows co-exist with breeding Eiders can be as high as 80% if incubating birds are frequently disturbed (Milne & Reed 1974).

During incubation, Eider females sit for about 26 days without taking food, and leave only intermittently during that time to drink. When not disturbed the female covers her eggs with down from the nest cup before leaving for the water. In these instances no faeces are deposited and the nests remain relatively well concealed. However, when disturbed from her nest she normally flies out spraying a foul-smelling liquid faeces over the eggs; in this study, 50 out of 54 birds did so. The eggs are then fairly conspicuous to bird predators flying over head.

Beetz (1916) suggested that 'the green and oily excrement, totally different from the ordinary excrement of Eider and of a frightful odour' will deter the hungriest dog, and Gross (1938) considered that the 'spray of filth accompanied by the quacking and the whirr of wings will confuse and discourage some of the Eider's enemies'. The unusual nature of the excrement produced by Eider females during incubation is most certainly due to the absence of food remains in the alimentary tract as previously suggested by Kear (1963), and the combined effect of intensive bacterial activity within a 'broth' of catabolites. This paper examines by field experiments the question whether faeces produced by female Eiders during incubation may have an inhibiting effect upon such avian predators.

Methods

Domestic hens' eggs, used in all the experiments, were dyed to resemble the colour of Eider eggs (light green/khaki) by placing them for one minute in each of water, Dylon 21, Dylon 34 and Dylon 20 (odourless dyes) all at 70°C.

Twenty-four eggs were used in each experiment and these were placed three metres apart, in two rows, on the intertidal zone of the Ythan estuary where they were visible to passing crows and gulls. Any eggs or associated smells remaining after each experiment were removed by the incoming tides. All observations were made from a vehicle parked nearby so that there was no disturbance to birds by the observers.

Series I—only clean (not fouled with faeces) eggs were used and observations were made to determine which species of bird took eggs from the experimental set-up, and to describe the various approaches made by the birds to the eggs. Five separate tests, each involving 24 eggs, were made in the series.

Series II—for each experiment 24 eggs were set out on the mud and, by means of a syringe, 0·5 ml of Eider faeces (from incubating birds) was sprayed on each of 12 eggs chosen at random. The order and the manner in which the eggs were subsequently predated was noted. The experiments were

repeated fifteen times, using a total of 360 eggs.

Series III—similar in design to the Series II using only a solution of Dylon 34 instead of faeces, and giving the eggs an appearance similar to the experimental eggs in the Series II experiments, but without any associated smells. The experiments were repeated fifteen times as in Series II.

Results

The birds which participated in the field experiments were mainly Crows which hunted the area in non-territorial flocks, Herring Gulls, Rooks *C. frugilegus*, and Great Black-backed Gulls *L. marinus*. Since the Rooks only took a small number of eggs in the Series I and III experiments, and the Great Black-backed Gulls visited the experimental site but did not eat any of the eggs, these will not be discussed further.

The various approaches used, and the reactions of the main predators (crows and gulls) in the Series I experiments are summarized in Table 1. There was a clear distinction between the approaches made by crows and gulls to the eggs on the shore; crows always landed up to 30 metres from the eggs and walked in very cautiously, whereas the gulls walked in or flew directly to the eggs in about equal numbers of occasions. Crows showed similar caution when dealing with eggs by usually (79% of 43 cases) examining the egg for at least 3 seconds before making any move to touch it, compared to only 8% (of 51 observations) of gulls showing the same behaviour. After examining the nearest egg 50% (21 of 43 observations) of crows nudged it carefully with the side of the bill in contrast to only 2% (1 out of 53 observations) of gulls. These differences are all statistically highly significant (Table 1).

In the Series II experiments, where half of the eggs were fouled with Eider faeces, gulls showed no preference or aversion to either clean or fouled eggs, whilst crows showed either a clear preference for clean eggs or a distinct aversion to fouled eggs (Table 2).

In the Series III experiments, in which half of the eggs were discoloured with a dye similar to the colour of Eider faeces, crows took 22 clean eggs and 13 discoloured eggs (Table 3). Although there appeared to be some preference for clean eggs, the difference is not statistically significant.

Table 1. The numbers of approaches and methods used by crows and gulls in response to the egg experiments in Series I.

Method of approach of predator to eggs	Crows	Gulls	x^2	p
Walk-in	43	28	23·292	<0·001
Fly-in	0	23		
Total number of eggs taken	43	51		
Stand by egg for 3 seconds, or more, before dealing with it	34	4	46·232	<0·001
Deal with egg immediately	9	47		
Deal with egg *in situ*	21	29	0·3240	NS
Carry egg away	22	22		
Nudge egg with side of bill	21	1	27·026	<0·001
Did not nudge egg with bill	22	52		

Table 2. Selection of eggs by crows and gulls in Series II experiment.

	Total eggs	Taken by Crows	Taken by Gulls	Not eaten
No. of clean eggs	180	22	26	132
No. of fouled eggs	180	4	19	157

$x^2 = 4·263$; $p < 0·05$.

Table 3. The numbers of clean and discoloured eggs taken by crows in the Series III experiments.

	Total eggs	Taken by Crows	Not taken by Crows
Clean eggs	180	22	158
Discoloured eggs	180	13	167

$x^2 = 2{\cdot}026$; $p > 0{\cdot}1$.

Choice experiments using captive birds

Naive captive jackdaws and crows were given a choice of eating a clean egg or an egg fouled with 0·5 ml of eider nest faeces.

Crows A, B and C were caged in a large outdoor aviary along with three other crows and were fed a ration of a mixture of 'Katkins' and turkey starter pellets during the period of the experiment (6 days). Jackdaws D and E shared a cage and were fed their normal rations during the experiment, whilst Jackdaws F, G and H had cages to themselves and were not fed during the experimental period apart from the test eggs presented to them.

On the first day the crows took both kinds of egg, and fed on the fouled eggs first. Subsequently, the clean eggs were eaten first, and only one fouled egg was ever taken.

In the case of the captive Jackdaws, the preference was not so clear cut. Birds D and E again took the fouled eggs first on the first test but ignored the test eggs completely after the third test. Birds F, G and H ate 13 clean and 9 fouled eggs, and did not show any preference when taking the first egg.

Eider faecal material

The mean pH of nest faeces from 14 incubating birds was found to be $7{\cdot}8 \pm 0{\cdot}21$ and was more alkaline than that of the faecal contents of non-nesting birds (pH about 7).

Examinations of faecal bacteria from nesting (unknown stage of incubating) and non-nesting birds revealed a striking difference in the presence of anaerobic bacteria in incubating birds and the total absence of such bacteria from non-incubating birds. In contrast, coliform bacteria were absent in the incubating birds but were present in all of the non-incubating birds (Table 4).

Discussion

The experiments described in this paper, although artificial by being set up on the open beach, were regarded as being quite valid since both crows and gulls fed regularly in that area. The usual method employed by crows to find Eider nests on Forvie is to walk through the area searching and prodding at all likely sites (Milne 1963). In the experiments, all of the crows walked into the area where the eggs were deposited, and very often examined the eggs carefully before taking one. Herring Gulls, on the other hand, normally find nests by soaring over the nesting area observing the activities of both Eiders and crows. In these experiments they invariably flew over and landed among the eggs.

The most obvious difference between the two species was the crows' continuous nudging of the eggs with the side of the bill, before attempting to break or lift them. There was little difference between crows and gulls in their preference for carrying eggs away or dealing with them *in situ*, but there was a greater tendency for gulls to lift and drop eggs just as if dealing with hard-shelled molluscs.

In a series of experiments carried out by Tinbergen, Impekoven & Frank (1967), a pair of crows carried off eggs and buried them. In our experiments, non-territorial flocks birds were involved and no such behaviour was seen. Tinbergen *et al.* (1962) found Herring Gulls to be much more timid than crows; this did not appear to be the case in the present study where the gulls' approach was always more direct, and a feeding gull would raise its wings in threat if approached by another bird, whereas a crow would move away and leave the egg to the newcomer.

The crows showed a clear preference for clean eggs in the experiments, both in the numbers eaten and in the order in which they were eaten. The behaviour of the crows while taking eggs suggests that sight and smell are important in determining whether to eat an egg or not. In most cases a crow would stand some 25 cm from an egg for several seconds before stepping forward to deal with it, or turning away and leaving it. If the egg had been fouled by faeces the crow, without ap-

Table 4. Bacterial component of faeces of (a) incubating and (b) non-incubating Eiders. Bacterial counts expressed as numbers per g weight of faecal material.

(a) *Incubating females*

Stage of incubation	Female No.	Numbers and types of bacteria present		
		Coliform	Anaerobic	'Other'
'Early'	1	None	None	None
	2	None	10^5/g	None
	3	None	10^6/g	10^6/g
	4	None	10^6/g	10^6/g
	5	None	10^6/g	10^6/g
	6	None	10^3/g	None
	7	None	None	None
	8	None	None	None
'Mid'	9	None	10^6/g	None
	10	None	10^3/g	None
	11	None	10^3/g	None
'Late'	12	None	10^6/g	None
	13	None	None	None
	14	None	10^3/g	None
	15	None	10^6/g	10^6/g

(b) *Non-incubating birds*	Coliform	Anaerobic	Other
Adult Female	10^3/g	None	Bacillus type spp.
Adult Male	10^6/g	None	Streptococcus spp.
1st year Male	10^3/g	None	Various soil bacteria

proaching nearer than 25 cm, always 'flutter-jumped' except when the egg was taken. In the first experiment, however, when only clean eggs were used, the flutter-jump reaction was only observed twice although 43 eggs were taken by crows. The implication is that the flutter-jump is a behavioural response to the smell of the fouled eggs.

In the third experiment, eggs were given the appearance of having been fouled (by dyes), but smell was absent, and crows took 22 clean eggs and 13 'fouled' eggs ($\chi^2 = 2{\cdot}6$, not statistically significant). This indicates that smell may be more important than sight in determining whether an egg will be eaten by crows or not. No flutter-jumps were seen during this experiment, supporting the conclusion that such behaviour is associated with the sense of smell.

The behaviour of these predators in relation to the experimental eggs suggested that crows, by their inquisitiveness, are more likely to find eggs in nests than are gulls and supports field-observations at Forvie, where crows locate nests more frequently than gulls. These preliminary experiments also indicate that fouling of the eggs by the female eider may deter crows through their sense of smell from taking eggs from the nest, but is less likely to deter gulls. The feeding trials with captive birds are not so conclusive, but it did appear as though nest faeces was distasteful to corvids, and that inexperienced birds soon learned that fouled eggs are unpalatable. Jackdaws, which are not normally predators on Eider eggs, showed a weaker response to fouled eggs than did the crows, and this level of avoidance of fouled eggs was related to the availability of alternative food during the experiments.

Nest faeces were more alkaline than faecal contents of non-nesting birds, and presumably reflects the reduction in secretion of hydrochloric acid in the proventriculus resulting from the absence of food in the alimentary tract during incubation. An increase in the uric acid content of urine from the breakdown of body protein, and the possible production of amines due to intense bacterial activity may be additional factors affecting the pH of faeces.

It is generally true that Eiders are found

breeding on offshore islands or only at mainland sites where mammalian predators are absent. In an island habitat, where crows and gulls are normally present, the Eider female's habit of sitting on the nest throughout incubation clearly has survival value for the eggs. Further, the habit of fouling the eggs in the nest would have survival value wherever crows are a major predator.

Acknowledgements

We are most grateful to Dr I. J. Patterson for advice on the design of the experiments and to Professor A. Macdonald, Dept. of Bacteriology, for plating the bacteria and for his assistance in identifying and counting these micro-organisms. Dr M. L. Gormans & S. Baillie made helpful comments on the draft manuscript, and R. F. Yule & W. Murray very kindly assisted with the captive birds.

Summary

Field experiments involving gulls and crows, and choice experiments with captive birds, demonstrated that the strong-smelling faeces sprayed over the eggs by an incubating female Common Eider *Somateria m. mollissima* when she is disturbed from the nest had a deterrent effect on predation by crows, probably through smell, but is less likely to deter gulls.

References

Bannerman, D. A. 1958. *The Birds of the British Isles*. Vol. 7. Edinburgh and London: Oliver & Boyd.

Beetz, J. 1916. Notes on the Eider. *Auk* 33: 286–92.

Gross, A. O. 1938. Eider ducks of Kent Island. *Auks* 55: 387–400.

Hammond, M. C. & Forward, W. R. 1956. Experiments on causes of duck nest predation. *J. Wildl. Mgmt.* 20: 243–7.

Kear, J. 1963. The production of offensive excreta by nesting wildfowl. Wildfowl Trust Ann. Rep. 14: 162–4.

Milne, H. 1963. Seasonal distribution and breeding biology of the Eider *Somateria mollissima mollissima L.*, in the north-east of Scotland. Ph.D. thesis, University of Aberdeen.

Milne, H. 1974. Breeding numbers and reproductive rate of Eiders at the Sands of Forvie National Nature Reserve, Scotland. *Ibis* 116: 135–52.

Milne, H. & Reed A. 1974. Annual production of fledged young from the Eider colonies of the St. Lawrence estuary. *Can. Field Nat.* 88: 163–9.

Montague, F. A. 1925. Notes on the summer habits of the Northern Eider. *Brit. Birds* 19: 138–144.

Quedens, G. 1961. Den Eiderenten auf der spur. *Kosmos* 7: 356–9.

Swennen, C. 1968. Nest protection of Eider ducks and Shovelers by means of faeces. *Ardea* 56: 248–58.

Tinbergen, N., Impekoven, M. & Frank, D. 1967. An experiment in spacing out as a defence against predation. *Behaviour* 28: 305–21.

Tinbergen, N., Brockhuysen, G. J. Feekes, F., Houghton, J. C. W., Kruuk, H. & Szulc, E. 1962. Egg shell removal by the Black-headed Gull, *Larus ridibundus*, L.: a behaviour component of camouflage. *Behaviour* 19: 74–117.

P. McDougall and Dr H. Milne, Culterty Field Station, Newburgh, Ellon, Aberdeenshire, Grampian, AB4 0AA

The African Macco Duck *Oxyura maccoa* bred for the first time in captivity at Slimbridge in 1974 and has bred most years since. The male (above) indulges in courtship display to the female (below). (*Philippa Scott*)