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Egg shell dumps and crow Corvus cornix predation on simulated birds' nests

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The use of egg shell dumps by hooded crows is described and its energetic value is discussed. The distribution of depredated simulated nests and the distances that marked eggs were transported to shell dumps were used to study the crows' foraging pattern. It is concluded that it is favourable if the whole egg content can be transported to the nestlings simultaneously. However, the empty shells should not be left close to the crows' nest where they could attract predators. From the site where the adult crow open the eggs it should be able to see its nest and potential predators.
Only a fraction of all eggs taken by crows are transported to shell dumps. If this fraction is determined the number of shells found can be used to estimate the total egg predation in the area. In this study 17% of the depredated eggs were recovered on shell dumps.
The territorial crows seem to use exclusive feeding territories that are less intensively used far from their nests.

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Описывается использование серыми воронами куч яичной скорлупы и их энергетическое значение. Характер расположения гнезд, симулирующих разрушенные и определение расстояний, на которые меченые яйца транспортировались птицами к кучам скорлупы, использованы для изучения характера питания ворон. Установлено, что благоприятным фактором является одновременное перенесение содержимого всего яйца к птенцам. Однако, пустая скорлупа не оставляется в близи гнезда, т.к. она может привлечь хищников. С места, где взрослые вороны отрывают яйца, они могут видеть свое гнездо и потенциальных врагов. Лишь часть яиц, добытых воронами, переносится к кучам скорлупы. Если эту часть определить, то количество найденной скорлупы можно использовать для определения потребления яиц на всей территории. В данном исследовании 17% разбитых яиц было открыто на кучах скорлупы. Территориальные вороны обычно используют дополнительные участки для питания, последние слабее используются вдали от гнезд.

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1. Introduction

Pheasant nests are preyed upon by both mammals and birds (Chessness et al. 1968. Dwernychuk and Boag 1972). Carrion crows *Corvus corone* L. and hooded crows *C. cornix* L. are known to prey upon eggs (Holyoak 1968, Tenovuo 1963). Experiments have shown that crows quickly find and take a large proportion of eggs in the field, even if these are carefully camouflaged (Tinbergen et al. 1962, 1967, Göransson et al. 1975, Picozzi 1975).

The habit of crows to transfer prey eggs to certain places – here termed *shell dumps* – has been described by Myrberget (1971) but no quantitative studies have been reported. Tinbergen et al. (1967) showed that carrion crows hide most of the eggs found and later retrieve and consume them.

Pheasant eggs are heavily preyed upon by hooded crows in the laying period (unpubl.). The shell remnants at the shell dumps can be used for quantifying the egg predation. Simulated pheasant nests with eggs were distributed in crow territories and the number of eggs taken by crows and later recovered at eggs dumps was determined. A number of egg dumps were examined with respect to the natural occurrence of shells and surrounding habitat. The purposes were to describe the shell dumps, discuss their value to the crows and determine the proportion of depredated eggs recovered on shell dumps. Such information could be used to estimate the total pheasant egg losses. This estimation is however not within the scope of this paper.

2. Study area and methods

The study was conducted in the Revinge area in southernmost Sweden (55°42′N, 13°26′E). The landscape is relatively level and characterized by grasslands mixed with small woods, ponds, and marshes. Most soils are sandy. The dominant grass is cock's foot *Dactylis glomerata* L. Around the marshes are meadows on peat soil with tall vegetation, suitable as breeding habitat for pheasants. A eutrophic lake adjoins the study area. The main field work was done in 1974 but further observations were made in 1971–1976. Egg shells were collected from shell dumps over an area of 20 km^2. In the spring of 1974 there were 35 crow nests in this area. The search was intense in the vicinity of the crow nests. An aggregation of at least four eggs was considered a shell dump. The breeding population of the different prey species within this area was approximately known and this information was used to calculate relative prey egg availability.

The main study area covered 0.60 km^2. It supported five pairs of breeding crows and about 40 hens and 25 cocks of breeding pheasants.

The simulated nests were distributed randomly over this area. Each nest contained three eggs. It was put on a bed of sand (0.2 m ∅) in order to, if possible, secure tracks of predators. In 1974 a pilot experiment had shown that there was no difference in predation rate on 120 eggs put on sand and 240 without a sand bed (χ^2 = 0.18, P = 0.70–0.60). The nests were partly covered with grass and herbs in a natural fashion. In a first experiment 90 nests containing domestic hen's eggs were used. They were distributed on 12 May 1974. In a second experiment, starting on 12 June 1974, we used 71 nests containing bantam hens' eggs. Both experiments were run for one week. The eggs were painted to look like pheasants' eggs and were individually marked at both ends. Also the eggs in a few natural pheasant's nests that were found were individually marked. Some of the marked eggs were recovered at shell dumps. The probability of predation for eggs of pheasant (equal in size to bantam hens' eggs) and domestic hens' eggs respectively, was tested in an experiment with 40 and 41 nests respectively, conducted on 17–24 June 1975 in the same experimental area. No difference was detected (χ^2 = 1.18, P = 0.20). 63 nests were located with reference to natural landmarks and 98 to labelled sticks that were placed 20 m from the nest. The predation on the nests with a stick was not higher than on unmarked nests (χ^2 = 27, P = 0.70–0.50).

The results from May and June 1974 are in most cases pooled in the calculations below.

Predators were identified by tracks and remnants in the nests (Göransson and Loman 1976, Rearden 1951). When no shell remnants were left, the predation was ascribed to crows, as in many of these cases the shells were found close to crow nests or marks from crow feet or beaks were found on the sand beds. In a few cases other corvids or mammals, especially the red fox *Vulpes vulpes* L. (Rearden 1951), may have preyed upon these nests. However, no tracks of red foxes were recorded on the sand beds.

In 1976 experimental nests were distributed with eggs containing radio transmitters. These provided us with data on the fate of the robbed eggs.

4. Results

4.1. Occurrence of shell dumps

Out of the 35 crow nests in the area we found one or more shell dumps in the vicinity of 16 nests all of which produced fledglings. Two pairs that lost their nestlings ceased using established shell dumps after this. As a rule the crows seemed to use the shell dumps only if they had nestlings.

4.2. Structure and localisation of shell dumps

The mean distance between a shell dump and the closest crow nest was 77 m and all dumps were found within 200 m from a nest. Shell dumps were most common in very low vegetation (<0.05 m), and in wooded areas close to water (with dense stands of *Salix* spp.). These

Tab. 1. Distribution of crows' shell dumps (defined in text) on different types of vegetation.

	Number of shell dumps	Mean number of eggs per dump
Open areas, short or no vegetation	8	20
Open areas, with field layer vegetation	3	25
Wooded areas, under bushes and close to water	8	22
Wooded areas without bush layer	3	12

also contained the highest number of egg shells (Tab. 1), although these two habitats did not dominate in the vicinity of crow nests.

4.3. Prey egg species

The largest shell dump contained 82 eggs but usually there were less than 30 shells (Tab. 2). The species distribution of shells found on dumps in 1971–1974 was: Pheasant 75%, black headed gull *Larus ridibundus* L. 19%, mallard *Anas platyrhynchos* L. 3% and coot *Fulica atra* L. 3% (N = 638). Water rail *Rallus aquaticus* L. and curlew *Numenius arquata* L. also occurred but with less than 1%. The proportion of shells of pheasant, mallard, and coot found at the shell dumps in 1974 agreed with our estimation of egg availability of these species (Tab. 3).

4.4. Prey egg transports

Of the 161 simulated nests in 1974 109 were preyed upon within 7 d, probably exclusively by crows. From these at least one egg from each nest was recovered at shell dumps in 37 cases (34% of the preyed nests). We recovered in all 57 eggs out of 327 preyed upon. There was individual variation between the five crow pairs. Of the total number of eggs preyed in their estimated territories (Fig. 1), 10, 9, 15, 18 and 21% were found at egg dumps.

4.5. Use of other sites than shell dumps

Shells were sometimes found in the immediate vicinity (at most 5 m away) of the depredated nests. In 1974 these constituted 6% of the total number of nests preyed in May (N = 216) and 2% in June (N = 111). In 1973 the corresponding figures were 11% (N = 612) and 2% (N = 213) respectively. This seasonal difference is significant (data from the two years pooled (χ^2 = 20.5, $P < 0.001$).

Single shells were also found at other places, in a few cases together with evidence that they had been hidden in grass litter close to the site of consumption. In 1976 22 radio-tagged eggs, all from different simulated nests, were preyed upon by crows. Six of these were recovered intact and well hidden in grass litter. One of these was left by us in the hiding place but had disappeared some days later. None of the hidden eggs was situated at an shell dump. Crows were seen to carry chickens' eggs in their bills without breaking them.

4.6. Distribution of predation and transportation tendency within the territory

Simulated nests closer to crow nests than 225 m were more often preyed upon than those further away (Tab. 4, $\chi^2 = 5.57$, d.f. = 1, $P < 0.02$). The distance from the simulated nests to the closest crow nest did not significantly affect the probability of a preyed egg being recovered at a shell dump (Tab. 5, $\chi^2 = 5.75$, d.f. = 3, P = 0.20–0.10). Simulated nests close to a previously or later preyed nest were not more often preyed upon than nests further away (median test; the median distance

Tab. 2. Distribution of shell dumps on different size classes. There were no dumps in the range 51–70 eggs.

No. of eggs per dump	4–10	11–20	21–30	31–40	41–50	71–80	81–90
No. of dumps	11	4	2	1	2	1	1

Tab. 3. Number of larger eggs available to the crows in study area and the number of egg shells found on shell dumps in 1974. The number of prey bird eggs are estimated (re-nesting ignored) from rough figures on the breeding bird population sizes in the actual area. The areas closest to the lake are excluded as we lacked data on egg availability there.

	Pheasant *P. colchicus*	Mallard *A. platyrhynchos*	Coot *Fulica atra*
Estimated number of eggs available	2000 (91%)	140 (6%)	60 (3%)
Number of egg shells found	343 (94%)	15 (4%)	7 (2%)
Proportion of estimated number of eggs of each species found at shell dumps	17%	11%	12%

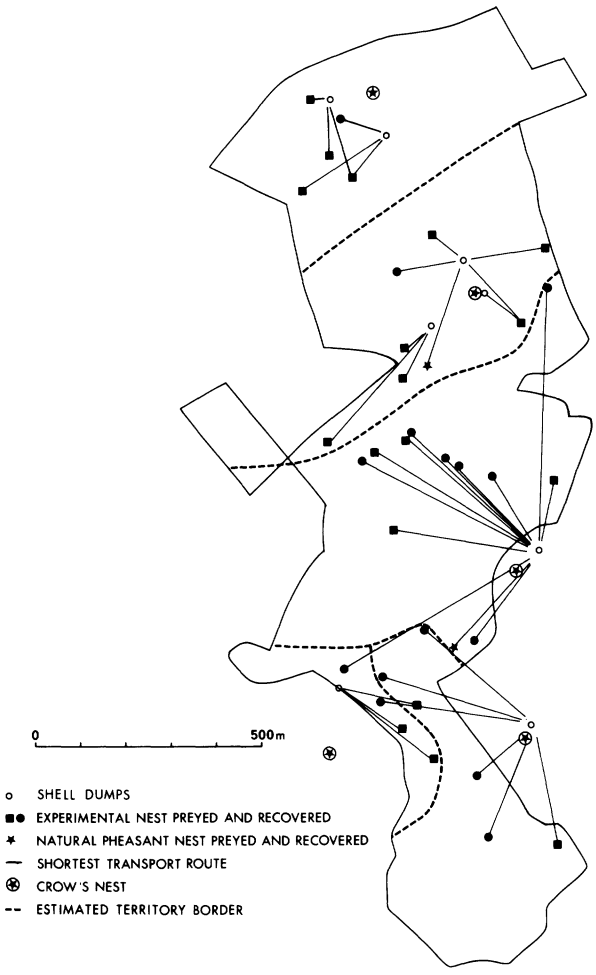

Fig. 1. Eggs transported by crows from experimental nests to shell dumps in 1974. In two cases the transported eggs belonged to natural pheasant nests. The estimated crow territory borders are also included.

Tab. 6. The predation on simulated nests in an estimated, 100 m broad, territory border zone compared with the predation on nests in the surrounding areas.

	Border zone	Surrounding areas
Number of nests	51	110
Proportion depredated	29%	35%

distance was 50 m in May and 65 m in June) $\chi^2 = 0.54$, P = 0.50–0.40). The predation in a 100 m broad territory border zone was compared to the predation in the surrounding areas (Tab. 6), and the two rates were found not to differ significantly ($\chi^2 = 1.61$, d.f. = 1, P = 0.30–0.20).

5. Discussion

5.1. Shell dumps

Why do the crows concentrate egg shells to special sites? If the preyed eggs are used to feed the nestlings it would be inefficient to fly from the preyed nest with parts of the egg content in the throat. On the other hand, if the eggs are brought to the nest, opened there, and the shells left under the nest, this could attract predators. That may be why the eggs are brought to about 50–100 m from the crow nest. This agrees with the tendency for robbed eggs from simulated nests closer than 125 m from a crow nest, not to be transported to a shell dump (Tab. 5). Within this zone, the places that meet the following requirements are chosen. The site should offer protection from predators as well as from competing crows. It is also advantageous if the site offers a good overall view so that potential predators of the crows' own nests can be discovered, as well as of the

Tab. 4. Predation on simulated nests at different distances from the closest crow's nest. Data from May and June 1974.

Distance between the simulated nest and the closest crow nest (m)	0–125	126–225	226–325	326–525
Number of simulated nests	29	55	50	27
Total proportion preyed upon within seven days	66%	82%	58%	59%

Tab. 5. The probability that egg(s) from a preyed nest will be retrieved at a shell dump. Data from May and June 1974.

Distance between the simulated nest and the closest crow's nest (m)	0–125	126–225	226–325	326–525
Number of nests that were preyed on within seven days	19	45	29	16
Proportion of these nests from which at least one egg was retrieved at a shell dump	16%	42%	24%	50%

adult crows themselves. The typical shell dump is suitable in one of these partly opposing aspects (Tab. 1). Some pairs have both kinds of shell dumps.

Adult crows may also eat the eggs themselves. This can be done in the robbed nest or in another place that permits a view of the crows' own nest and of possible predators. It is suggested that this aspect is important because fewer egg shells were found in the robbed nests in June when vegetation is high and sight is poor, than earlier. Finally, the eggs can, as we observed with radio-tagged eggs and as Tinbergen et al. (1967) observed directly, be hidden in the vegetation by crows. This is done at various places other than the shell dumps. These latter are not suitable as hiding places since the vegetation is short and any concentration of intact eggs would run a high risk of being stolen by other egg eating animals. Intact eggs stay fresh for a long time and are thus suitable for storing. Those eggs that were neither found at the shell dumps nor in the preyed nests were thus probably eaten by the adult crows in the vicinity of the preyed nest or were hidden and consumed later, probably at the hiding place.

The shell dumps can be used to make rough estimates of the number of eggs taken by crows within a crow territory. If renestings are excluded a majority of the available eggs of pheasants, mallards and coots were probably taken by crows as 17, 11 and 12% were found at the shell dumps (Tab. 3) compared to 10–20% in the experiments. The effect of this predation on the pheasant population is not evaluated here.

5.2. Search strategy and predation pattern

Avian predators, such as the crow, may exhibit several nest search patterns, viz.: the nests are actively searched for either (1) while walking through, or (2) flying over suitable nesting vegetation (habitat-restricted search), or (3) perching in a tree, spotting egg laying or incubating birds as they arrive to or leave their nests. The nests may also be accidently found either while (4) flying to or from a foraging area, (5) watching territory from a tree or (6) foraging on ground for other prey items. Pattern (3) did not apply in this study as there were no birds on the simulated nests. If (4) was important a higher proportion of nests should be found close to the crows' own nests than elsewhere. This was, however, not the case (Tab. 4). No further conclusions are possible on the basis of our data.

The fact that the predation did not increase in the vicinity of an already depredated nest indicates that there was no area-restricted search (Croze 1970) associated with the finding of a simulated nest. This is reasonable if the natural pheasant nests are not clustered.

Several patterns of predation from territorial and nonterritorial birds in an area with fairly even prey distribution will be discussed. They are represented graphically in Fig. 2. The case of ideal feeding territories without intrusion from non-territorial birds is illustrated

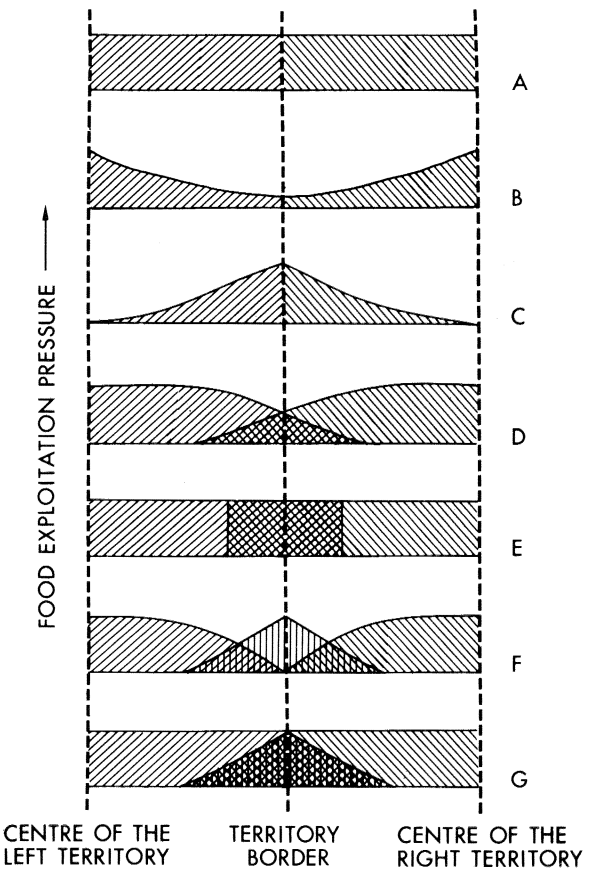

Fig. 2. Models of food exploitation from territorial and nonterritorial crows in two neighbouring crow territories.

in A. Case B can be expected if the density of prey is not decreased by the feeding activities of the crows, as it would be advantageous from the point of view of energy conservation to feed as close to the nest as possible. This strategy could also be upset if there were other reasons (e.g. territory advertising) for the crow to spend some time further away from the nest. Furthermore in case B the nest would have been easier to defend. If territory defense was very important and feeding was incidental to this, case C can be expected. D and E represent imperfect feeding territories. In case D territory intrusions are accompanied by a decreased individual feeding intensity in the border zone. In cases F and G the border zone is utilized by non-territorial crows. In case F there is also a decreased feeding intensity from the territorial birds in the border zone.

In this study most patterns are contradicted against. There was a significantly lower predation on nests further away from the crow nests than nearer (Tab. 4). This contradicts pattern C and G. As the predation in the territorial border zone was not significantly different from elsewhere (Tab. 6) the patterns C, E and G do not seem probable. There was hardly any overlap in feeding ranges (Fig. 1), which contradicts patterns D and E. Non-overlapping feeding territories were also found by Charles (1972). Eggs from simulated nests preyed upon at the border zone were more often transported to shell dumps than those from other nests (39% and 25% respectively), and this contradicts pattern F and G as non-territorial crows probably do not use shell dumps. The only patterns left are A and B, but as shown in Tab. 4, the predation was less further away from the crow nest, and we therefore conclude that pattern B is the most realistic.

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