SHORT COMMUNICATIONS

The Development of Shell-cracking Behavior in Herring Gulls

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The habit of many species of gulls of cracking shells and other hard food objects by dropping them from the air is well known. The most thorough observations appear to be those of Oldham (1930). He concluded that Herring Gulls (*Larus argentatus*) and Mew Gulls (*L. canus*) dropped food objects indiscriminately on land, showing no choice between sand and rocks, yet rarely dropped objects in water, from which they were for the most part obtained. However, the observations of Wheeler (1946) on Pacific Gulls (*L. pacificus*) and Goethe (1958) on Herring Gulls indicated that these gulls dropped food objects preferably on hard surfaces. Our own preliminary observations left no doubt that Herring Gulls showed marked preferences for hard surfaces. Paved roads and parking lots were frequently used as dropping grounds and gulls often flew some distance over mud and sand to reach them. Stretches of paved roads were sometimes strewn with broken shells, while few shells were seen on softer surfaces alongside.

Our initial observations suggested that immature Herring Gulls were less efficient than adults in cracking shells. We therefore decided to study the shell-cracking behavior of different age groups.

Field observations were carried out in several localities in southeastern Massachusetts from October 1969 to February 1970. All gulls engaged in shell-cracking behavior were aged and placed in one of the following groups: (1) first-year gulls, (2) second-year gulls, (3) third-year gulls, or (4) adults. Plumage and bill coloration were used in ageing. Immature gulls of the same age are quite variable, however, and it is probable that a few mistakes were made in ageing first and second-year birds. For each gull the following data were then obtained: (1) kind of food dropped, (2) number of times each food object was dropped, (3) type of surface onto which food object was dropped, (4) height from which food was dropped, and (5) result of food-dropping. Other observations were made in a less systematic manner.

In analyzing the data, the Fisher's Exact test or, when sample size allowed, the Chi-square test were applied on 2×2 contingency tables.

Bay scallops (*Pecten irradians*) were the most common food dropped by Herring Gulls. Crabs and starfish were sometimes dropped, but these instances have been omitted in the following analysis.

The best overall measure of efficiency in shell-cracking is probably the proportion of gulls that succeeds in cracking the shell and feeding on its contents. Most gulls were successful in this (Table 1). However, first-year birds succeeded significantly less often than older birds, while there was no significant difference among other age groups. Furthermore, during October and the first half of November the success of first-year gulls was lower (9 out of 16 successful) than later in winter (26 out of 29) ($0.025 > P > 0.01$). Even so, the success of first-year birds during the latter period was less than that of older gulls during that time (157 of 158 successful) ($0.025 > P > 0.01$).

Young birds needed more effort to successfully crack a shell than older birds. The average number of drops needed by successful gulls was as follows: first-year: 2.3; second-year: 2.1; third-year: 1.7; adults: 1.6. The majority of the gulls cracked the shell in the first drop, but a few needed more, up to 8–10 in some cases (this was even true of adults). First-year birds needed more than one drop to crack a shell significantly more often than third-year and adult birds, but no other significant differences are found in this respect (Table 1).

The data in Table 2 indicate the reasons for the low efficiency of first-year birds. The scallops are almost always retrieved from shallow water by diving from the air. All third-year and adult gulls carried the scallops from the water to dry land before dropping them, but a number of drops by first-year and second-year gulls were made over the water, usually close to where the shells were obtained. First-year birds did this significantly more often than second-year birds, which in turn did this more often than older gulls. Furthermore, first-year birds dropped shells significantly more often in water during October and early November (11 of 47 drops) than later in the winter (1 of 58) ($P < 0.001$). Scallops dropped in water were frequently lost after the first drop, although at times the scallops were repeatedly retrieved and, occasionally, eventually dropped on land. Of those gulls that dropped scallops on the ground, the great majority dropped them on rocks or pavements (Table 2). However, first- and second-year gulls did

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TABLE 1. Efficiency of shell-cracking behavior of Herring Gulls of different ages[a]

Age group	(1) Number of gulls showing shell-cracking behavior	(2) Number of gulls successfully cracking shells	(3) Percentage of gulls successful	(4) Number of gulls cracking shells in first drop	(5) Percentage of successful gulls cracking shells in first drop
First-year	45	35	78	15	43
Second-year	57	55	96	33	60
Third-year	47	47	100	29	62
Adult	136	136	100	89	65

[a] Statistical analysis:
Columns (1) and (2) (Fisher's Exact Test)
First-year *vs.* second-year: $0.005 > P > 0.0025$
First-year *vs.* all older gulls: $P < 0.000001$
Second-year *vs.* all older gulls: $0.1 > P > 0.05$
Columns (2) and (4) (Chi-square)
First-year *vs.* second-year: $0.25 > P > 0.1$
First-year *vs.* all older gulls $0.05 > P > 0.025$

so significantly less often than older birds. It should be noted that gulls were sometimes successful in cracking shells when dropping them on grounds softer than rock. Gulls also frequently made a drop or two on soft ground while a car was passing along the road that they had been using. The above results indicate that second-year gulls are somewhat less efficient in cracking shells than older birds, although this difference does not quite reach significant proportions in the data analyzed in Table 1.

The first-year gulls appeared to be somewhat less successful than adults in cracking shells on hard surfaces, although it is difficult to evaluate this fully from the available data. A total of 76 drops by first-year birds were made on hard surfaces, while the number of eaten shells was only 35, or a ratio of 2.2 such drops per success. Older birds (no differences indicated among age groups) made 355 drops on hard surfaces, while the number of eaten shells was 238. The corresponding ratio here is 1.5. (As noted above, drops on hard surfaces were sometimes interspersed with drops on softer ground, and the terminal drop was sometimes on soft ground). This difference may be related to the dropping heights used. Although height estimations were inaccurate, the data indicate that first-year birds dropped shells from a greater range of heights than did older birds, which most frequently dropped the scallops from heights of 5–15 m. Drops from lower heights in particular may not result as frequently in the cracking of the shells, while drops from greater heights may be no more successful but require more effort, and may more easily miss a rock or a road. A further possibility not investigated is that in addition to learning to select hard substrates and appropriate dropping heights, gulls were also learning to select more fragile shells.

Tinbergen (1953) cites evidence suggesting that it is the hardness of the food objects that elicits dropping from the air. However, we have on several occasions seen Herring Gulls drop starfishes from the air,

TABLE 2. Proportion of shell drops made by Herring Gulls of different ages on land and on hard surfaces (rocks, pavements)[a]

Age group	(1) Total number of drops observed	(2) Number of drops made on land	(3) Percentage of drops made on land	(4) Number of drops made on rocks and pavements	(5) Percentage of drops on land made on rocks and pavements
First-year	105	93	89	76	82
Second-year	120	116	97	82	71
Third-year	82	82	100	77	94
Adults	218	218	100	196	90

[a] Statistical analysis:
Columns (1) and (2) (Fisher's Exact Test)
First-year *vs.* second-year: $0.025 > P > 0.01$
First-year *vs.* all older gulls: $P < 0.00001$
Second-year *vs.* all older gulls: $0.01 > P > 0.005$
Columns (2) and (4) (Chi-square)
First-year *vs.* second-year: $0.1 > P > 0.05$
First-year *vs.* all older gulls: $0.75 > P > 0.50$
First-year *vs.* third-year and adult: $0.025 > P > 0.01$
Second-year *vs.* third-year and adult: $P < 0.005$

apparently without any effect on these comparatively soft animals. Harber and Jones (1947) quote a similar observation concerning a Great Black-backed Gull (*L. marinus*) repeatedly dropping a rat from the air.

Our observations started in October, about 2–3 months after the first-year birds had fledged. At this age the gulls were already dropping shells from the air with considerable success. The efficiency of this behavior improved rapidly during the first winter and continued to improve slightly for an additional year (Table 2). After the gulls enter their third winter, i.e. when somewhat more than 2 yr of age, there is no further improvement in efficiency. Efficiency is improved primarily through better choice of substrate and probably also by increasing use of optimum dropping heights.

Lower feeding efficiency of young birds has frequently been postulated in the past (e.g. Lack 1954), but only recently has it been demonstrated directly that feeding efficiency of wild birds with delayed maturity increases for at least 1 or 2 yr after hatching (e.g. Orians 1969, Recher and Recher 1969, Dunn 1972). Verbeek (1977) found that immature Herring Gulls at least 1 yr old were less efficient in obtaining starfish by diving than adults. Increase in feeding skills with age, evidently by trial and error learning, has also been observed in captive birds (Kear 1962, Vince 1964). Trial and error learning is presumably also involved in the improvement in shell-cracking efficiency. Our observations indicate that an early step in this process is a formation of an association between dropping food objects and gaining access to their soft tissues, while this behavior then becomes increasingly directed towards hard surfaces. The behavior of first-year birds at times appeared quite disorganized. We sometimes observed first-year birds drop shells only to retrieve them again in midair (see also Wheeler 1946). In other instances the young gulls dropped scallops and then flew away to pick up another without investigating the result of their action. In one such instance the shell was even successfully cracked. First-year gulls were frequently seen attempting to rob scallops from older birds engaged in shell-cracking (cf. Verbeek 1977). This may aid in associating the behavior pattern with hard surfaces.

The mortality rate of first-year Herring Gulls is considerably higher than that of older birds (Kadlec and Drury 1968). The lower efficiency in feeding shown by young gulls is undoubtedly a significant factor in this context, especially if gull populations are food-limited (Ingolfsson 1976).

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