SELECTION AND DROPPING OF WHELKS BY NORTHWESTERN CROWS

by

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(With 7 Figures)
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INTRODUCTION

Predators are frequently confronted with prey which require extensive handling. This may involve killing, removal of inedible parts and reduction into bite-size pieces. A variety of behavioural patterns are used (CURIO, 1976). Hard-shelled food items can be particularly difficult because of the relatively large force required for opening. Several species of birds drop such prey from a height in order to break them open.

Herring gulls (*Larus argentatus*), European gulls (*L. canus*), and glaucous-winged gulls (*L. glaucescens*) have been reported to drop shelled molluscs (OLDHAM, 1930; TINBERGEN, 1953; BARASH, DONOVAN & MYRICK, 1975). Similarly, lammergeiers (*Gypaetus barbatus*) may drop bones (NORTH, 1948; FLEMING, 1955; BROWN & AMADON, 1968). Dropping of molluscs or other shelled prey has also been reported from rooks (*Corvus frugilegus*), common crows (*C. brachyrhynchus*), Northwestern crows (*C. caurinus*), carrion and hooded crows (*C. corone*) and white-necked ravens (*C. albicollis*) (OLDHAM, 1930; PRIESTLEY, 1947; TINBERGEN, 1953; MEINERTZHAGEN, 1959; GOODWIN, 1976). Although song thrushes (*Turdus philomelos*) do not drop snails (*Cepaea spp.*) their habit of hammering snails onto stones and other hard substrates for opening (MORRIS, 1954) is in many ways similar to dropping behaviour. With the exception of BARASH's study of glaucous-winged gulls, most of the literature on dropping behaviour is anecdotal.

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I studied dropping of shelled molluscs in Northwestern crows on Mandarte Island, British Columbia, Canada in the summer of 1977. This little island has a small breeding population of crows (see TOMPA, 1964), which commonly forage in the intertidal zone. They frequently feed on whelks (*Thais lamellosa*) (Fig. 1). These are taken during low tide near the water line. Crows carry whelks singly in their bills and drop them on the beach. This characteristically involves a horizontal flight followed by an almost vertical ascent and then the drop. The vertical ascent and drop are usually repeated until the shell breaks.

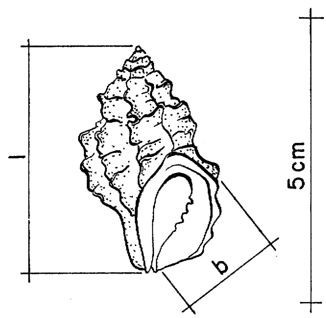

Fig. 1. Large whelk showing measure across base and opening (b) used to predict length (l) and weight of whelks dropped by crows.

The aim of this study was to describe and quantify dropping behaviour. I also investigated selection of whelks and dropping sites. In a second paper (ZACH, 1978) I have examined whether crows forage optimally while dropping whelks.

METHODS

Crows were observed from June to September during the daytime and at low tide when whelks were available to them. I studied five pairs intensively; most of these birds were color-banded. Each pair foraged on an exclusive section of the rocky beach, which was on the average 15 m wide at low tide and bound by about 4 m high cliffs. I measured height of flight to the nearest 25 cm by comparison to a 12 m high marked pole erected on the beach. Only flights within about 3 m of the pole were measured. Crows were observed from the cliffs, so that I could estimate height of flight while looking horizontally at the pole.

I sampled available whelks in the intertidal zone along a series of transects. These were laid out at low tide at random locations across the intertidal zone. All whelks within 10 cm of the transects were weighed and measured.

I collected a sample of 90 freshly broken shells to determine the size of whelks selected by crows. These shells were collected while walking slowly along the beach. Many of the shells had broken off spires, but 76 had an intact base. A measurement (b) was taken across the base of these shells (Fig. 1). I gathered a sample of 57 live whelks of approximately the same size as those broken by crows. From these, regression equations (Bartlett's three group method for model II regression) were computed to predict length ($l = .41 + 20.4\,b$, $r = .85$) and weight ($w = .82 + 1.35\,b^3$, $r = .87$) of whelks selected by crows.

Three discrete size groups of whelks differing in lenth (Small, Medium, and Large, Table 1) were defined to investigate selection of whelks and dropping sites. Some of these whelks were marked with paint so that I could recognize them after breaking.

TABLE 1

Length (cm) and weight (g) ($\bar{x} \pm SE$) of types of whelks used in experiments

	N	Length	Weight
Small	30	1.6 — 2.2	.82 ± .05
Medium	30	2.7 — 3.3	3.87 ± .18
Large	30	3.8 — 4.4	8.08 ± .17
Natural	30	4.00 ± .03	8.43 ± .19
Light	30	4.01 ± .03	6.43 ± .13
Heavy	30	4.00 ± .02	9.94 ± .23

Weight of small, medium and large whelks are from representative samples of 30. Weights of natural, light and heavy whelks are all significantly different from each other at the .005 level (one-way analysis of variance followed by sum of square simultaneous test procedure).

A sample of 90 large whelks was collected to evaluate the role of weight in prey selection. I randomly divided these into three groups of 30. The animals were then removed from the shells of two of the groups. Shells of one of these groups were stuffed with cotton (Light Whelks) and those of the other with sand (Heavy Whelks). In both cases, I glued opercula back into place. Thus, light and heavy whelks matched the appearance of those of the first group (Natural Whelks). However, natural whelks were significantly heavier than light whelks and significantly lighter than heavy whelks (Table 1). The distributions of the weights of light and heavy whelks were nonoverlapping.

Unless otherwise noted, experimental whelks were laid out in a single group on a flat rock in the intertidal zone when the tide came in. They were arranged randomly over an area of about .25 m^2.

All means are quoted together with standard errors. Statistical tests were taken from Sokal & Rohlf (1969). Probabilities of .05 or less are termed significant.

RESULTS

Selection of Whelks.

Apparently, crows took only large whelks for dropping (Fig. 2). Selected whelks were significantly longer and heavier than available whelks (Table 2). However, these results have to be accepted with caution. Whelks are not necessarily equally available to crows because small ones may be less conspicuous than large ones. Similarly, small, broken shells are more difficult to spot than larger ones. Further, waves may differentially flush away broken shells. Because of these problems, I investigated selection of whelks experimentally.

I supplied each of three pairs of crows with 25 large, 25 medium and 25 small whelks (Table 1). I recorded numbers taken at hourly intervals. Since birds responded uniformly, results were pooled. Crows took whelks nonrandomly (Table 3). They selected large whelks and did not switch to medium

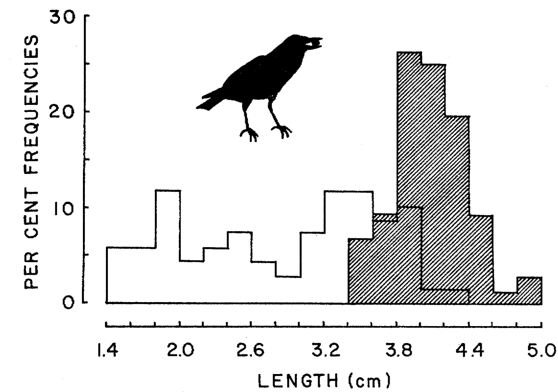

Fig. 2. Length frequency histograms of whelks available in the intertidal zone (open histogram) and whelks selected by crows (shaded histogram).

and small ones even after all or most of the large ones had been taken. These results confirm that crows prefer large whelks while medium and small ones are ignored.

It is possible that medium and small whelks are less palatable than large ones. To investigate this I removed animals from shells and presented one

TABLE 2

Length (cm) and weight (g) ($\bar{x} \pm SE$) of available, selected and rejected whelks

	N	Length	Weight
Available	69	2.86 ± .10	3.58 ± .32
Selected	76	4.08 ± .04	8.80 ± .26
Rejected	48	3.62 ± .05	6.50 ± .28

Whelks differ significantly in length ($P<.005$, Kruskal-Wallis test). Selected whelks are significantly longer than rejected ones ($P<.005$, Wilcoxon's two-sample test, two-tailed test) and rejected whelks are significantly longer than available ones ($P<.005$). Weights of whelks are all significantly different from each other at the .005 level (one-day analysis of variance followed by sum of square simultaneous test procedure). Length and weight of selected whelks were estimated by regression as outlined in text.

pair of crows with 25 of each size class. Crows took these randomly (Table 4). Thus, medium and small whelks are just as palatable as large ones.

While foraging near the water, crows picked up whelks with the bill. Some whelks were just pushed aside. If one was immovable it was immediately left. In less than 1% of the cases crows managed to grab the foot of the animal and eat it. Crows usually rejected several whelks ($2.12 \pm .37$, $N = 33$) before accepting one for dropping. Rejects were picked up and immediately laid down again, sometimes repeatedly. Crows probably assessed size of whelks first by sight and then by weight. Rejects were usually laid down by crows with the aperture facing up rather than down, as was the case in undisturbed whelks. Thus, they could be identified readily. I collected a sample of rejected whelks while walking slowly along the intertidal zone. Rejects were significantly shorter and lighter than selected whelks (Table 2). However, they were significantly longer and heavier than available whelks (Table 2).

I presented 30 natural, 30 light and 30 heavy whelks (Table 1) to five pairs of crows to investigate the role of weight in prey selection. Crows became

TABLE 3

Numbers of small, medium and large whelks laid out and cumulative numbers of whelks taken over the subsequent five hours

Type of whelk	Small	Medium	Large
Laid out	75	75	75
Taken after 1h	0	2	28
2h	0	3	56
3h	0	4	65
4h	0	4	68
5h	0	6	71

Results from three pairs of crows were homogeneous (replicated goodness of fit test) and therefore combined. Right from the start whelks were taken nonrandomly ($P < .005$, single classification goodness of fit test).

TABLE 4

Numbers of small, medium and large animals laid out and cumulative numbers taken over the subsequent three hours

Type of whelk	Small	Medium	Large
Laid out	25	25	25
Taken after 1h	8	11	5
2h	20	24	25
3h	25	25	25

Animals were removed from shells before being presented to one pair of crows. Right from the start animals were taken randomly (single classification goodness of fit test).

very reluctant to take additional whelks after having gone unrewarded a few times. However, all crows responded uniformly and selected more natural and heavy whelks (Table 5). Crows also took significantly more heavy than light whelks (Table 5). These results show that crows use weight in assessing size of whelks, preferring heavy ones.

TABLE 5

Numbers of natural, light and heavy whelks laid out and taken

	Laid out	Taken
Natural	30	13
Light	30	4
Heavy	30	15

Whelks were taken nonrandomly ($P < .05$, single classification goodness of fit test). More heavy than light whelks were taken ($P < .025$). Whelks were exposed to a total of five pairs of crows. All took more natural and heavy whelks than light ones and more heavy than light ones.

Dropping behaviour.

Once a crow took a whelk it flew towards the cliffs fringing the beach and dropped it. Most whelks required repeated dropping before they broke (Fig. 3). One was dropped 20 times. Less than 1% were left unbroken.

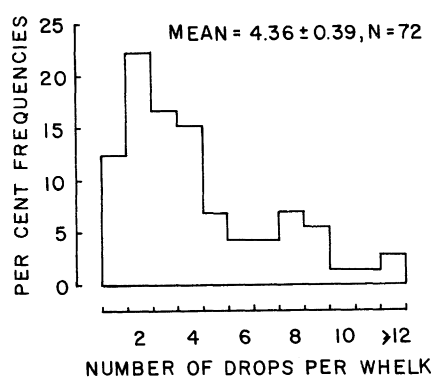

Fig. 3. Frequency histogram of number of drops per whelk.

Most flights prior to dropping were almost vertical. Approximately 8% involved a circle. In about 3%, crows flew first onto a nearby cliff and sat there momentarily before flying higher and dropping the whelk. Following dropping, crows dove after the welk to immediately pick it up. However, sometimes they spent in excess of 60 s locating a whelk.

Height of flight varied considerably (Fig. 4). Since the probability of breaking increase with increasing height (ZACH, 1978), it is interesting to examine changes in height over successive drops of the same whelk. Crows had a slight tendency to increase height over the first few drops (Fig. 5).

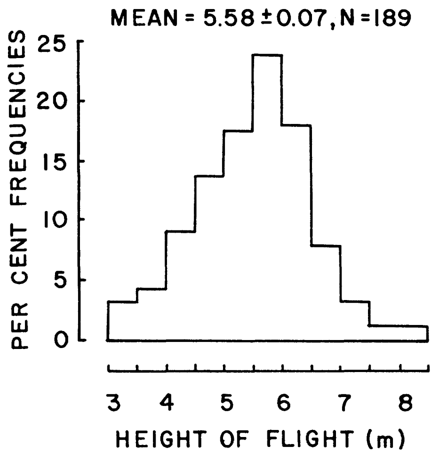

Fig. 4. Frequency histogram of height of flights.

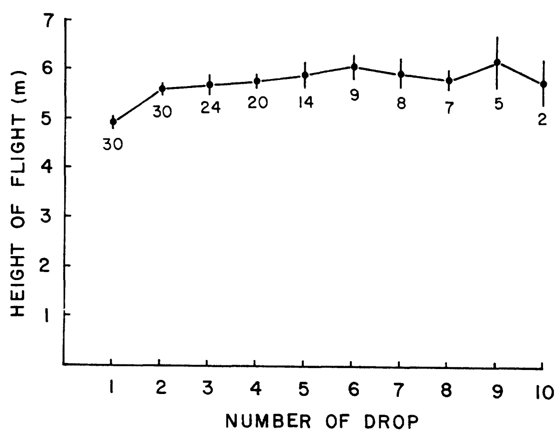

Fig. 5. Change in height of flights over successive drops of the same whelk. Vertical bars are standard errors and numbers sample sizes.

I assessed this statistically by classifying heights of successive couplets of flights dichotomously with respect to each other. Thus, Low High indicates an increase in height and High Low a decrease. There were significantly more couplets indicating an increase (70) than a decrease (43) ($P<.025$, single classification goodness of fit test).

Height of flight did not necessarily correspond to height of drop. Usually, crows lost some height (.35 ± .04 cm, N = 62) before releasing whelks (Fig. 6B). Crows started the downward flight before the release. The loss of height reduced the average drop to 5.23 m. About 15% of the whelks were released at the highest point of flight (Fig. 6A). Some crows released whelks consistently at the highest point of flight while others consistently delayed the release.

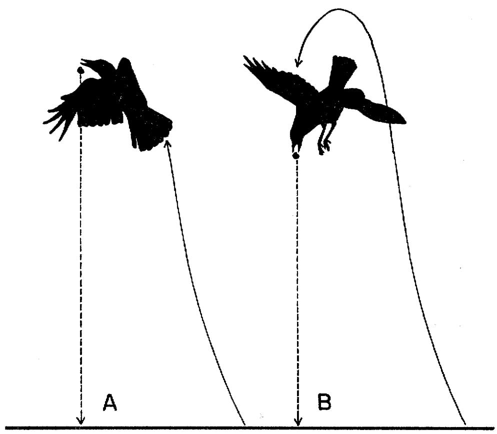

Fig. 6. Flights during dropping. Some crows release whelk at highest point of flight and are unable to see whelk fall (A). Most crows lose some height before dropping but are able to see whelk fall (B). Solid line indicates flight of crow up to point of release and broken line free fall of whelk. Birds drawn from photographs.

Usually, crows carried and dropped only one whelk at a time. However, in about 3% of the cases, they processed two whelks simultaneously. Picking up two whelks near the water or after an unsuccessful drop seems to be rather cumbersome and time-consuming. Usually, one whelk was held fully across the bill while the other was held on top of it with the upper mandible partly inserted in its aperture. All double-carries involved the same crow.

Damage to shells.

Crows carefully inspected whelks after each drop. Accessible, edible parts were immediately consumed or stored in the crop. Unless the entire animal could be extracted, whelks were usually dropped again. While extracting the animal, crows held whelks down with one or both feet.

Shells left by crows can be grouped into three classes: Spire Off, One Whorl Open and Two or More Whorls Open (Fig. 7). Of the 90 freshly broken shells collected on the beach, approximately 76% had the spire broken off, 14% a single whorl open and 10% two or more whorls open. I suspect that many shells with one or more whorls open were dropped again until the spire broke off (see ZACH, 1979). From such shells crows can usually extract the entire animal readily.

To see whether crows always got the entire animal, I marked a total of 75 large whelks. These were presented to three pairs of crows. I recovered 36 spires and 35 bases. Two bases (6%) and seven spires (19%) still contained some prey. In the case of spires, this amounted to very little biomass. Results show that crows usually obtain most or all of the animal from dropped whelks.

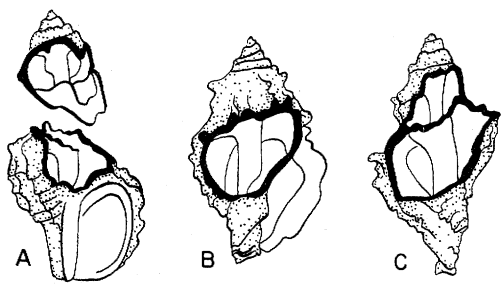

Fig. 7. Types of damage to shells broken by crows. Spire off (A), one whorl open (B) and two or more whorls open (C).

Site selection.

Crows apparently have specific dropping sites since certain areas of the beach are littered with broken shells. However, this could be the result of wave action collecting broken shells at these sites.

I subdivided the shore frequented by a pair of crows into five sections each 15 m long and counted numbers of whelks found and dropped by crows in each of these sections. Whelks were taken and dropped nonrandomly (Table 6A). Crows took most whelks from section 1 where they were more abundant. However, whelks were mainly dropped in section 2. Thus, numbers of whelks dropped across the five sections did not reflect numbers found in those sections (Table 6A). Crows carried some whelks in excess of 40 m, although the mean distance was considerably less (24.04 ± 1.22 m, $N = 37$). It seems that crows may have specific dropping sites. However, the results could have been brought about by differential availability of whelks. Most whelks were broken close to where they were found (Table 6A).

I investigated dropping site selection experimentally by provinding large marked whelks in each of the five sections. These were laid out in conspicuous white containers. Whelks removed were continuously replaced so that

TABLE 6

Numbers of whelks found and dropped in 5 sections of shore each 15 m long frequented by one pair of crows. A. Non-experimental whelks found near water. B. Experimental whelks taken from containers

Section	1	2	3	4	5
A. Non-experimental					
Number taken	24	2	4	3	4
Number dropped	2	20	9	6	0
B. Experimental					
Number taken	2	3	16	16	2
Number dropped	1	35	2	0	1

Both non-experimental and experimental whelks were taken and dropped nonrandomly across the five sections ($P<.005$ in all cases, single classification goodness of fit test). In both non-experimental and experimental whelks numbers of whelks dropped across the five sections did not reflect numbers found ($P<.005$, in both cases).

each container always had more than five. I counted whelks taken and searched the beach carefully for broken marked shells. Crows took and dropped whelks nonrandomly (Table 6B). Again, numbers of whelks dropped across the five sections did not reflect numbers found in those sections (Table 6B). Although birds switched foraging areas by taking whelks mainly from sections 3 and 4, they again dropped most in section 2. These results clearly indicate that this pair of crows had a specific dropping site in section 2.

The dropping site was littered with broken shells. It was in an approximately 10 m wide and 6 m deep recess in the cliffs fringing the beach. The recess had a level rocky floor relatively distant from the water. Most of the surrounding beach was also rocky but much closer and sloping down to the water. I found several similar sites on the island all littered with broken shells. Apparently, most or all pairs of crows have specific dropping sites.

DISCUSSION

Besides whelks, mussels (*Mytilus edulis*) are also readily available to crows on Mandarte Island. Although these are more difficult to tear off the substrate than whelks, they break more readily. However, crows dropped only whelks. In other locations, Northwestern crows commonly drop mussels (Goodwin, 1976). Carrion crows are also known to drop mussels (Oldham, 1930; Goodwin, 1976). Mussels on Mandarte Island may be too small to be profitable. Broken ones encountered on the beach were readily eaten by crows.

Crows selected only large whelks for dropping, ignoring smaller ones (Fig. 2). As shown by ZACH (1979), large whelks are more profitable than smaller ones because they break more readily and also yield more energy. Since crows have to invest a considerable amount of energy in each whelk selected for dropping before obtaining a meal, they must choose whelks carefully. Crows probably choose whelks first by sight and then by weight, lifting and rejecting several before accepting one. Since whelks occur in dense patches, crows could make simultaneous and successive comparisons readily. It is not clear whether visual assessment of prey size is made by comparing shell length, area or volume. Weight and volume would allow more accurate discrimination than the other measures since they are approximately cubic functions of length. Thus, large whelks used in experiments are only about twice as long as small ones but almost ten times as heavy (Table 1). Intuitively, weight would seem to be easier for assessing size than volume. Whelk assessment by crows seems to be similar to seed assessment in pinõn jays (*Gymnorhinus cyanocephalus*) (LIGON & MARTIN, 1974). Jays use visual, tactile and also auditory cues to distinguish good from bad seeds. The ability to distinguish seeds is learned. Unlike song thrushes, crows never selected empty shells for breaking (MORRIS, 1954; GOODARD, 1958).

MONTEVECCHI (1976) investigated egg size selection in common crows and fish crows (*C. ossifragus*). Birds preferred relatively small eggs because these could be grasped more readily than larger ones. Small eggs were of approximately the same size as whelks selected by crows in the present study (Table 2). However, occasional presentation of whelks exceeding 6 cm in length showed that crows would have preferred larger ones than were commonly available.

Whelks exhibit a marked size gradient in the intertidal zone with large ones occupying lower areas (BERTNESS, 1977). Results of this study indicate that crow predation could be responsible for such gradients. On Mandarte Island large whelks have little chance of surviving in the upper part of the intertidal zone where exposure to crow predation is greatest. Small whelks are immune from predation because they are not selected fror dropping (Fig. 2), nor are they eaten whole.

Crows, gulls and lammergeiers drop hard-shelled food items repeatedly if these do not break readily (OLDHAM, 1930; TINBERGEN, 1953; BROWN & AMADON, 1968; BARASH, DONOVAN & MYRICK, 1975). Some birds are incredibly persistent. TINBERGEN (1953) observed a gull drop a shelled mollusc 37 times in succession into shallow water. In the present study, crows rarely left whelks unbroken although many had to be dropped repeatedly (Fig. 3). This suggests that repeated dropping is more profitable than giving up and attempting to find and break another whelk. Alternatively, crows may not be able to count number of drops.

Breaking of whelks by dropping is basically a stochastic process. The probability of breaking depends on type of substrate, size of whelk and height of drop. Whelks are more likely to break if dropped from greater height (ZACH, 1979). Thus, for standing drops glaucous-winged gulls required 3.91 drops per clam (*Sacidonus giganteus*) and for flying drops 1.72 (BARASH, DONOVAN & MYRICK, 1975). Standing drops involved heights of less than .5 m and flying drops ranged from approximately .5-15.0 m. Northwestern crows do not use standing drops. However, such drops would be completely inadequate for breaking whelks (ZACH, 1978). The lowest drop observed was 3.0 m and the highest 8.3 m. On Vancouver Island Northwestern crows feeding on cockels (*Clinocardium nuttalli*) commonly drop these prey from less than 3.0 m. Since cockels break more readily than whelks, this suggests that crows may adjust height depending on type of prey dropped.

In most flights crows lose some height before releasing whelks (Fig. 6B). This probably allows them to watch whelks fall (compare Figs. 6A and 6B). Upon impact, whelks frequently bounce for a considerable distance. Since the ground is often littered with broken shells, seeing whelks fall and bounce probably increases efficiency of finding and compensates for any loss in height. It is also possible that crows attempt to increase acceleration of whelks. Apparently, lammergeiers also lose height before releasing a bone and then keenly watch its fall (BROWN & AMADON, 1968). However, this does not seem to be the case in gulls which hover briefly before the release (BARASH, DONOVAN & MYRICK, 1975). In Northwestern crows, the drop in height does not involve lateral displacement. Therefore, selection of favourable substrate for breaking would have to occur before flying up.

Crows on Mandarte Island have specific dropping sites on the beach where dropped whelks are unlikely to roll into the water and out of reach. All whelks were dropped onto rock. None were dropped over water or grass beyond the beach. While this suggests selection for hard substrate, this may have been coincidental since the entire beach was rocky. Further, dropping onto grass would have required longer flights than dropping onto rock. However, no whelks were dropped over water although most were found nearby. It seems that crows selected hard substrate for breaking. Thus, combined selection for safe sites and hard substrate resulted in the use of specific dropping sites.

OLDHAM (1930) cited several observers who had seen carrion crows take shelled molluscs from mud flats to a shingle-covered beach. In one instance, when the flats were covered with ice, they dropped molluscs there and no longer went to the more distant site. Hooded crows observed by TINBERGEN (1953) dropped fresh water mussels (*Anodonta spp.*) consistently on a road where they broke readily. It appears that most crows drop shelled prey selectively over hard substrates. If such substrate is scarce, they may use specific dropping sites.

Song thrushes also have specific sites for opening snails (MORRIS, 1954). This must be due to limited availability of suitable hard substrate. However, even in winter when snails can be broken on the frozen ground, thrushes break shells near sites used during the summer (GOODARD, 1958). NORTH (1948) described a site of bare rock littered with broken bones apparently dropped by lammergeiers, but others have doubted that these bones were gathered by lammergeiers (see MEINERTZHAGEN, 1959 and FERGUSON-LEES, 1960). Herring and European gulls apparently release shelled molluscs indiscriminately over a variety of substrates including water (OLDHAM, 1930; TINBERGEN, 1953; MEINERTZHAGEN, 1959). However, glaucous-winged gulls dropped clams more often on hard than soft substrates (BARASH, DONOVAN & MYRICK, 1975).

In gulls dropping behaviour does not seem to be very flexible and it is perhaps largely innate (see TINBERGEN, 1953). In crows flexibility suggests that learning may play an important role. Thus, a comparative study of the development of dropping behaviour in gulls and crows could be very fruitful.

SUMMARY

Prey selection, dropping behaviour and dropping site selection was investigated in Northwestern crows (*Corvus caurinus*) feeding on whelks (*Thais lamellosa*).

Crows selected only the largest whelks available in the intertidal zone. Although equally palatable, smaller whelks were ignored. Crows assessed size of whelks first by sight and then by weight. Thus, some were picked up with the bill and laid down again before a final selection was made. Rejects were longer and heavier than available whelks and shorter and lighter than selected ones. Usually, crows carried and dropped only one whelk at a time.

While dropping, crows typically flew almost vertically up, released the whelk and then dove after it. The mean number of drops required to break a whelk was 4.36. Crows dropped whelks until they could obtain most or all of the soft parts. Usually crows did not give up dropping a whelk until it broke. The mean height of drop was 5.23 m. Crows had a tendency to increase height of drop over successive attempts. During most flights, crows lost some height before releasing a whelk. Presumably, this allowed them to watch whelks fall and bounce.

All whelks were dropped onto rock. None were released over water or grass. Crows had specific dropping sites. This was because they selected hard substrate and safe sites for dropping. On dropping sites whelks were unlikely to bounce into water.

Results were compared with those of other studies of dropping behaviour in gulls and hawks. Dropping behaviour in crows seems to be much more adaptable than in gulls.

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ZUSAMMENFASSUNG

Die Beutewahl und das Verhalten von Krähen (*Corvus caurinus*) während des Raubes und Brechens von Muscheln (*Thais lamellosa*) wurde untersucht.

Die Krähen nahmen nur die grössten der vorhandenen Muscheln. Kleinere wurden nur akzeptiert wenn sie ohne Schale waren. Die Krähen schätzten die Grösse der Muscheln zuerst durch Sicht und dann nach Gewicht. Bevor sie eine Muschel akzeptierten wurden andere aufgehoben und wieder zurückgelegt. Letztere Muscheln waren länger und schwerer als das Mittel aller Muscheln, jedoch kürzer und leichter als die akzeptierten. Meistens trugen und brachen die Krähen die Muscheln einzeln.

Vor dem Fallenlassen der Muscheln flogen die Krähen nahezu vertikal auf. Die Muschel wurde jeweils losgelassen und die Krähe folgte im Sturzflug. Zum Brechen der Muscheln benötigten die Krähen im Durchschnitt 4.36 Flüge. Sie liessen die Muscheln so oft fallen, bis sie fast alles oder alles Fleisch herausnehmen konnten. Charakteristisch war, dass sie fast alle akzeptierten Muscheln brachen. Die durchschnittliche Höhe von welcher Muscheln fallen gelassen wurden war 5.23 m. Wenn eine Muschel nicht brach,

flog die Krähe bei folgenden Flügen meist höher auf. Bei fast allen Flügen verloren die Krähen etwas an Höhe bevor die Muscheln losgelassen wurden. Das ermöglichte ihnen höchst wahrscheinlich, die fallenden Muscheln zu sehen.

Die Krähen liessen alle Muscheln auf Felsen, keine auf Wasser oder Gras fallen. Sie suchten sich zum Brechen der Muscheln besondere Plätze über den Felsen, von denen aus diese nicht ins Wasser rollen konnten.

Die Resultate wurden mit denen anderer Untersuchungen über verschiedene Krähenarten, Möwen und Raubvögel verglichen. Das Raubverhalten von Krähen in bezug auf das Brechen von Muscheln ist anpassungsfähiger als das von Möwen.