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Rooks (*Corvus frugilegus*) dine on snails in Poland

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Abstract: Evidence of breeding rooks feeding on Roman snails (*Helix pomatia*) and grove snails (*Cepaea nemoralis*) is presented. Shell dimensions of food remains and intact Roman snails collected in the study area were measured in order to estimate the size and shape of the snails collected by rooks in relation to the food available in the vicinity of the rookery. Smaller and rounder snail shells were collected by rooks than were available in the area around the colony, indicating that the rooks collected most of the snails elsewhere, in forests, gardens, or ruderal areas located near the colony. A general preference for prey items was ca. 12 cm^3 or 19 g shell size. Moreover, rooks collected yellow grove snail shells and shells with stripes. In addition, snails with a more contrasting layout of shell stripes were collected more often than plain snails.

Key words: rook diet, snails, *Helix pomatia*, *Cepaea nemoralis*, prey size

1. Introduction

During surveys of a rook (*Corvus frugilegus*) colony in western Poland, it was observed that the birds often took snails to their nests. The rooks collected snail shells in their beaks and then transferred them to the nest to feed nestlings. The collected snails were mainly 2 species: Roman snail, *Helix pomatia*, and grove snail, *Cepaea nemoralis*. Rook diets have been studied before (Roosimaa, 1961; Holyoak, 1968, 1972; Jabłoński, 1979; Gromadzka, 1980), but rooks carrying intact shelled snails to the nest site had never been observed. Birds of prey detect their prey by sight (Allen, 1988). Some species distinguish certain shapes and sizes, e.g., *Turdus* sp. (Ożgo, 2012).

The diet of rooks is characterised by very high variability resulting from their ability to change diet and explore food resources that are highly abundant and/or readily available in their feeding areas (Ganzhorn, 1986; Hordowski, 2009; Orłowski et al., 2009). During the breeding season, adult birds usually look for food at short distances from the colony. Kasprzykowski (2003) determined that the vast majority of birds did not move further than 1 km from the nest. It is commonly estimated that the area used by this species is within a radius of 0.3 to 1.0 km.

A literature survey on the rook in different ecosystems and habitats indicated that the rook is an omnivorous species whose diet depends on current availability of food (Hordowski, 2009; Källander, 2007; Kasprzykowski, 2003; Orłowski et al., 2009). Its feeding strategy can be characterised by a rule: "I eat what I see and what is in abundance". The rook's food consists of over- and underground parts of plants (e.g., rye, wheat, oat, moss, *Taraxacum officinale*, corn, weed seeds), fruits (e.g., cherries, mulberries, common elder fruits, grapes, blackberries, wax cherries, plums, apples, watermelon), seeds, animal foodstuffs (eggs, larvae, and small vertebrates as well as invertebrates), and leftovers of anthropogenic origin. During the autumn hoarding period, rooks collect, transport, and cache walnuts and acorns (*Quercus*) to retrieve them in winter (Källander, 2010). It has also been proven that refuse tips, where discarded food is abundant and predictable, can affect the growth dynamics of the breeding population of rooks (Olea and Baglione, 2008). Anthropogenic food, even waste, may act as a buffer against shortages of natural food and thus help threatened birds to survive. Food types and percentage breakdown of plant and animal foodstuffs change significantly throughout the year. For rookeries, preferred as well as avoided types of crops can be identified (Kasprzykowski, 2007). Breeding success depends positively on the area of preferred crops, i.e. pastures as well as spring cereals and spring meadows.

The food composition of rook diets is well known (Hordowski, 2009; Orłowski et al., 2009). Such research has also been done by other authors (Gromadzka, 1980; Ganzhorn, 1986). A list of papers about food composition

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was published by Jabłoński (1979). In Poland, this topic has been investigated by Gromadzka (1980) and Orłowski et al. (2009). In the latter, molluscs are not mentioned. In other papers where any mollusc is listed in the diet of rooks, it is never a dominant food. Some authors claim that gastropods are only supplementary food, and that their frequency in the food does not exceed 5% (Gromadzka, 1980; Roosimaa, 1961; Holyoak, 1972). Only in a few papers related to research done in Great Britain (Holyoak, 1968; Holyoak, 1972) do the authors indicate molluscs as a complementary food. Based on the literature survey (Lockie, 1956; Holyoak, 1968, 1972; Gromadzka, 1980), the percentage of molluscs in stomach contents is below 5% in Poland during the spring period from April to June, but as much as 10% in Great Britain from March to October. Research on food consumption and digestion by the rooks, which also included food preferences (Luniak, 1977), showed that both terrestrial and freshwater molluscs were not attractive foodstuffs. Nevertheless, the collected data showing even a low percentage of snails in the stomach contents of rooks can be considered interesting. In this paper, we present our contribution to these results, because we have observed rooks feeding on snails during the breeding season. Snails appeared to be a desirable food for transferring to the nests by some specimens. The preferences in selection of shell sizes can be characterised by the empty shells left by rooks.

The amount of snails in rook diets reported in the literature has never been substantial (Roosimaa, 1961; Holyoak, 1972; Gromadzka, 1980), or it was observed to be completely absent from the diet (Ganzhorn, 1986; Orłowski et al., 2009). The largest contribution of snails to rook diet, 25%, was reported for colonies in the UK (Lockie, 1956; Holyoak, 1968). Holyoak (1972) assessed stomach contents and recorded a maximum contribution of snails in the diet of 9%. He suggested that the fragments of snail shells found in stomachs could be collected by the birds as grit.

Apart from rooks, there is evidence that both Laridae and other Corvidae eat snails too. Some species (e.g., snail kite, *Rostrhamus sociabilis*) even bring snails to their nests. Gastropoda is included in the red-backed shrike's (*Lanius collurio*) diet, but together with Myriapoda, Araneae, and Oligochaera, it constitutes only 0.5% of all prey items collected by this species in Poland (Goławski, 2006). Moreover, the number of species that include terrestrial gastropods in their diet is low compared with other groups of prey (Barker, 2004). For example, in Australia only 2.5% of bird species are recorded as feeding on terrestrial gastropods (Blakers et al., 1984). Birds feed on terrestrial gastropods as a source of nutrients to provide energy and the chemical compounds required for a wide range of metabolic processes (Udoh et al., 1995), as well as calcium during the breeding season (Graveland and van der Wall, 1996), and also water (Heller, 1981; Shachak et al., 1981). Birds may forage on multiple types of hard-shelled prey in areas of different soil composition (Switzer and Cristol, 1999).

Small gastropods are eaten whole or crushed in the bird's bill (Baldwin and Casey, 1983). For bigger snails, some bird species use their beaks to lever off pieces of the shell or apply a sharp blow to crack the shell (Mountainspring et al., 1990). This can be achieved by hammering or pecking with the beak, or by holding the snail in the beak and hitting it against a hard object (Heller, 1981; Meads et al., 1984). Some birds (e.g., Laridae and Corvidae) drop or throw snails onto hard objects (Zach, 1979; Cristol and Switzer, 1999; Allen, 2004).

Contradictory opinions have been expressed by scientists on whether the birds' selectivity towards the colour and striping of the shells is a stimulant or inhibitor of predation, as in the case of shape and size. We present the first study in rooks that evaluates this behaviour quantitatively and qualitatively. We hypothesised that rooks will show selective behaviour and only carry snails of a certain size and/or shape to their nests.

2. Materials and methods

The study area was located in the catchment of the Sama River in western Poland (52°25′–52°42′N, 16°22′–16°42′E). The colony occupied 52 pine (*Pinus sylvestris*) trees, and consisted of 164 nests in 2009 and 209 nests in 2010. In 2010, shells were collected under 36 trees in which 121 nests were located. These 36 trees had 2 clusters of nests, 1 of 85 nests in 26 trees and 1 of 36 nests in 10 trees. Samples of shells (451 specimens: 88% in cluster #1 and 12% in cluster #2, respectively) were collected under trees in both clusters after the breeding season. Despite searching, no shells were found in a third cluster of 88 nests in 16 trees. In both 2010 and 2011 in the area of the rookery, along with the shells of dead molluscs, live *Helix pomatia* individuals were also collected to measure their shell sizes.

The colony is surrounded by a forest that occupies 11.81% of the nearby area. However, the majority of that area, i.e. 76.81%, is arable land. In this forest, there are habitats of fresh coniferous, fresh mixed coniferous, and mixed coniferous forests. Moreover, moist mixed coniferous forest, moist forest, and alder swamp forest can be found in depression sites. Home gardens and home orchards, ditches including drainage ditches, roadside afforestations, and ruderal areas are important locations that attract Mollusca, sustain the population, and ensure high abundance.

A total of 253 shells of the Roman snail and 198 shells of the grove snail were examined. Due to Polish conservation laws related to the breeding season, snail specimens were not searched for in nests. Moreover, the nests were rather small and the birds did not leave many food leftovers, including shells. Additionally, 63 Roman snails collected in the study area in 2010 and 2011 were measured. Their width (W) and height (H) were measured, and the shell shape factor, defined as the ratio of height to width (H/W), was calculated. The traces left by birds on the shells were also described (e.g., holes or other damage). For the shells of the grove snail, also colour and colour patterns were also recorded.

To compare the 2 sets according to the grouping variable, the classic t-test could not be applied to assess whether the means of the 2 groups were statistically different from each other, because the variance of both independent samples was not equal (F test, $P < 0.05$). That is why we used a Cochran and Cox test (Stanisz, 2006). We also applied ANOVA, canonical analysis, and factor analysis to distinguish further dependences among variables.

The shell volume can be measured in different ways. This can be calculated by measuring the amount of water needed to fill a shell (Ligaszewski, 2005). One can also estimate this measure on the basis of look-up tables elaborated by Ligaszewski (2005) that express the shell volume in a function of its 3 dimensions.

3. Results

The Roman snails collected by rooks in 2010 were generally smaller than the snails living in the area close to the rookery in 2010 and 2011 (Figure). The latter can be even ranked to adult ones. Furthermore, the range of heights and widths of the shells from snails collected by the rooks was greater than those of individuals living in that area. The standard deviation of collected shells was 0.32 cm for height and 0.27 cm for width, while the respective figures for snails in the area were 0.19 cm and 0.17 cm. As the range of heights in particular was larger, it appears that snails gathered by rooks were biased towards round shapes. The collected snail shells had a shape factor close to 1. In contrast, the typical shape of adult snail shells in the monitored area was more oval, with an average shape factor of 1.1. Moreover, we concluded that a significant difference existed between shape factors of snails collected by the rooks and the general sample (Cochran and Cox test, $P < 0.001$).

Scratches, holes (usually in the last whorl), or damaged shell entrances were found in 10% of shells. Five shells showed traces of a calcareous epiphragm, which testifies that they were obtained at the beginning of the breeding season, when the snails were not yet reproductively active.

Of the grove snails collected by rooks, over 74% of individuals were yellow-shelled specimens with a variable number of stripes or without stripes. Among those with contrasting colours—yellow, brown, or pink shells with a variable number of brown stripes (from 1 to 5)—more than 70% of the specimens were yellow morphs. In the total sample of the grove snails collected during the field research in the rookery, the number of specimens with uniformly coloured shells (i.e. without stripes) was only 28% of all collected individuals.

Among 5 measures (specimen age, shell height and width, number of stripes, and shell colour), the age as well as shell height and width appeared to be the most significant factors that influenced the birds' decision on which shells they preferred to select and carry to the nest. Using ANOVA, we deduced that these 3 variables are statistically significant, and so we can reject the null hypothesis of no

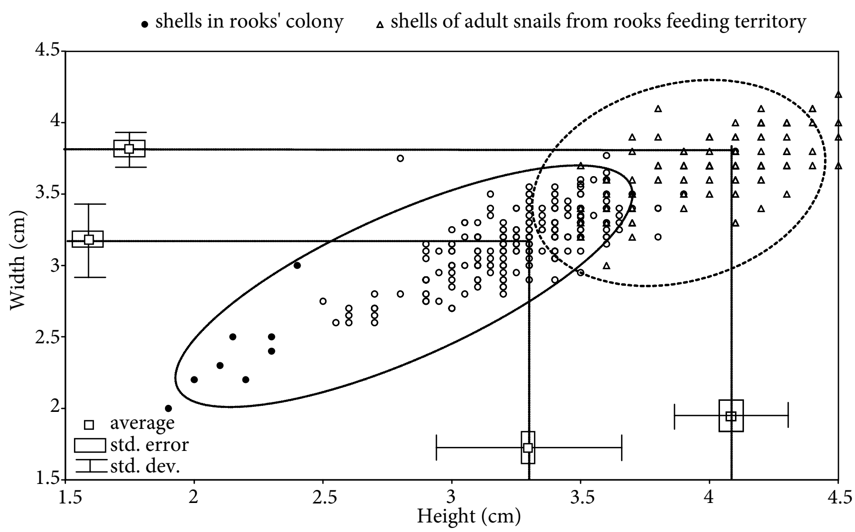

Figure. Shell height and width of *Helix pomatia* snails collected by rooks, and of individual snails living in the study area.

differences between means with $P < 0.006 < \alpha$ for these measures, and accept the alternative hypothesis that the means in the snail population are different from each other ($\alpha = 0.05$ was an assumed threshold of error level).

Using canonical correlation for assessing the relationship between the 2 sets of variables, the ones that are measured (species, age, size, volume, number of stripes and shell colour, shell state) and the others that are controlled (shell selection preference), it occurred that for the variate that is statistically significant ($P << \alpha$), the absolute value of the canonical weight is the largest for the shell volume.

The aforementioned variables can be grouped into several factors extracted with the factor analysis. The scree test determined 3 factors listed in the Table. They comprise 1 to 3 variables with factor loadings larger than 0.7. Factor 1 accounts for 29% of the variance, Factor 2 for 17%, and Factor 3 for 16%.

The average weight of the Roman snail collected by rooks was approximately 18.7 g. Another quantity that can characterise rook preferences is the volume of a shell. Using the look-up tables for Roman snail shells collected by the rooks, the average volume was 13.1 cm^3.

4. Discussion

As mentioned in Section 1, the rook feeds on many kinds of food including plants, fruits, seeds, animal foodstuffs, and even anthropogenic rubbish. Earthworms and insect larvae constitute the main part of the diet. The rook also eats small mammals, walnuts, acorns, small birds, their eggs and nestlings, and carrion. These birds are definitely omnivorous and so they forage in habitats near the rookery looking for snails, too. However, the molluscs typically constitute a very small percentage of the rooks' diet. It seems that gastropods are a rather supplementary nourishment. The challenge for rooks in picking a snail up with the beak is the shell size, as well as the shell hardness in getting to the flesh. The latter problem is solved by dropping specimens on nearby roads with a durable surface, for example. The percentage breakdown of foraged foodstuffs changes during the year. The rook collects and caches food in the autumn to have provisions in the winter season. Preferred and avoided types of crops affects some parameters of broods, e.g., the mean number of fledglings (Kasprzykowski, 2007). Breeding success can result from food richness in foraging areas. Rooks used to avoid humans and typically restricted their foraging to open areas (Lenda et al., 2011). However, in recent years, rooks have changed their behaviour. They do not avoid humans, and even occur in residential areas (Moreira and Russo, 2007; Hordowski, 2009).

In the studied rookery in western Poland, rooks collected rounder and smaller snails than the snails living in the vicinity of the colony. This is probably dictated by the easier access to the snail's body in the shell, and/or by the ease of catching and carrying the prey in the beak. They also more frequently collected snails with yellow shells, striped patterns, and a contrasting layout of shell stripes than plain-shelled snails. The shell size of snails found in the colonies was ca. 12 cm^3. One explanation for the observation that the small snails selected by the rooks were mostly missing from the sample of adult snails from the area is that rooks only eat young snails, which were not included in our sample. Alternatively, the rooks may have collected snails in another area. In either case, the nonoverlapping size distributions could indicate that rooks may have depleted the small snails living close to the colony.

Although rooks have an innate facility for learning and cooperation (Seed et al., 2008), not all individuals in the observed colony had learned to eat snails, as we did not encounter shell remains under 1 of the 3 nest clusters. The number of empty shells indicates that in this case snails were only a supplement to the diet, because the amount of snail meat is too little to balance the birds' daily energy requirements. The importance of snails in the diet may be slightly larger than estimated by collecting shell remains in the colonies, as rooks sometimes dropped snails on nearby asphalt roads, a practice also used by rooks for cracking walnuts. Twenty-three species of birds, representing 3 different orders, have been reported to break a wide range of hard-shelled prey by dropping (Cristol and Switzer, 1999).

Table. Variables included in factors derived from principal components analysis based on the factor analysis.

	Factor 1	Factor 2	Factor 3
	Height	Colour	Species
	Width	Number of stripes	
	Volume		
Eigenvalue	2.94	1.72	1.68
Percent of the total variance	29.43%	17.19%	16.84%

Based on the canonical analysis, one can deduce that shell dimensions determine birds' preferences in shell selection. Using factor analysis, we can conclude that Factor 2 is related directly to *Cepaea nemoralis*, and Factor 3 allows distinguishing the 2 species analysed in this paper.

We found that rooks collected snails of about 19 g. The average weight of the snail specimen is similar to one reported in the literature (Dziabaszewski, 1975). Recalculating the volume to a radius (if a shape factor equal to 1 is assumed), the size of a typical shell was only 1.4 cm. Thus, it seems that for collecting and transferring food the smallest dimension of the prey, and not its volume, is the most important measure.

Forest habitats around the rookeries are conducive for selecting snails as forage for rooks. Additionally, a complex network of the watercourses along the Sama River (including lakes and streams) creates favourable conditions that lead to increasing abundance of the snail population. The greater the abundance in the ecosystem, the easier it is to find snail specimens of the size preferred by the rooks.

The observed behaviour, i.e. collecting snail shells in their beak and then transferring them to the nest to feed nestlings, has a potential impact on the dispersion of snails to new habitats. Cristol (2001), Czarnecka and Kitowski (2010), and Lenda et al. (2011) highlighted the importance of rooks in spreading plant seeds; taking the above observations into account, we can suggest a possibility that snails are also moved to new areas where they can survive if favourable environmental conditions are met. Thus, it can lead to changes in the abundance of snails or even to diminishing the local snail population.

Because the number of *Cepaea nemoralis* specimens with uniformly coloured shells was less than 30% of all found individuals, it seems that a colour preference may exist in rooks, but in order to determine which colour arrangements are preferred, larger samples on colouration of grove snails within the rooks' feeding areas are required. From our small sample, it seems that snails with more contrasting shell stripes were collected more often than plain snails; yellow morphs with stripes constituted almost 94%. It makes it easier for birds to look out for the snails, reducing energy consumption in flying and time spent on food collection.

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References

Allen JA (1988). Frequency-dependent selection by predators. Philosophical Transactions of the Royal Society of London, Series B 319: 485–503.

Allen JA (2004). Avian and mammalian predators of terrestrial gastropods. In: Barker GM, editor. Natural Enemies of Terrestrial Molluscs. Wallingford, UK: CABI Publishing, pp.1–36.

Baldwin PH, Casey TLC (1983). A preliminary list of foods of the Po'o-uli. Elepaio 43: 53–56.

Barker GM (2004). Natural Enemies of Terrestrial Molluscs. Wallingford: CABI Publishing.

Blakers M, Davies SJJF, Reilly PN (1984). The Atlas of Australian Birds. Carlton, Victoria: Royal Australian Ornithologists Union, Melbourne University Press.

Cristol DA, Switzer PV (1999). Avian prey-dropping behavior. II. American crows and walnuts. Behav Ecol 10: 220–226.

Cristol DA (2001). American crows cache less preferred walnuts. Animal Behaviour 62: 331–336.

Czarnecka J, Kitowski I (2010). Seed dispersal by the rook *Corvus frugilegus* L. in agricultural landscape—mechanisms and ecological importance. Polish Journal of Ecology 58: 511–523.

Dziabaszewski B (1975). About Roman snail (*Helix pomatia* L.) and its reproduction. Polskie Towarzystwo Przyjaciół Nauk 39: 1–48 (article in Polish with an abstract in English).

Ganzhorn JU (1986). Quantitative aspects of the feeding biology of rook (*Corvus f. frugilegus* L.) nestlings. Ökol Vögel 8: 57–66 (article in German with an abstract in English).

Goławski A (2006). Comparison of methods for diet analysis and prey preference: a case study on the red-backed shrike *Lanius collurio*. Ornis Fennica 83: 108–116.

Graveland J, van der Wal R (1996). Decline in snail abundance due to soil acidification causes eggshell defects in forest passerines. Oecologia 105: 351–360.

Gromadzka J (1980). Food composition and food consumption of the rook *Corvus frugilegus* in agrocoenoses in Poland. Acta Ornithol 27: 227–256.

Heller J (1981). Visual versus climatic selection of shell banding in the land snail *Theba pisana* in Israel. J Zool 194: 85–101.

Holyoak DT (1968). A comparative study of the food of some British Corvidae. Bird Study 15: 147–154.

Holyoak DT (1972). Food of the rook in Britain. Bird Study 19: 59–68.

Hordowski J (2009). Gawron na Podkarpaciu. Monografia gatunku i znaczenie gospodarcze. Arboretum i Zakład Fizjografii w Bolestraszycach (in Polish).

Jabłoński B (1979). Food of the rook, *Corvus frugilegus* L., in different parts of its territory. Prz Zoologiczny 23: 67–80 (article in Polish with an abstract in English).

Källander H (2007). Food hoarding and use of stored food by rooks *Corvus frugilegus*. Bird Study 54: 192–198.

Kasprzykowski Z (2003). Habitat preferences of foraging rooks *Corvus frugilegus* during the breeding period in the agricultural landscape of eastern Poland. Acta Ornithol 38: 27–31.

Kasprzykowski Z (2007). Reproduction of the rook, *Corvus frugilegus* in relation to the colony size and foraging habitats. Folia Zool 56: 186–193.

Lenda M, Skórka P, Knops JM, Moroń D, Tworek S, Woyciechowski M (2011). Plant establishment and invasions: an increase in a seed disperser combined with land abandonment causes an invasion of the non-native walnut in Europe. Proc Roy Soc B: 1–8.

Ligaszewski M (2005). Changing indicators of usable value of edible snails from *Helix* genus in diverse breeding and environmental conditions. Instytut Zootechniki, Cracow (article in Polish with an abstract in English).

Lockie JD (1956). The food and feeding behaviour of the jackdaw, rook, and carrion crow. J Anim Ecol 25: 421–428.

Luniak M (1977). Consumption and digestion of food in the rook, *Corvus frugilegus* L., in the condition of an aviary. Acta Ornithol 16: 213–234 (article in Polish with an abstract in English).

Meads M.J, Walker KJ, Elliott GP (1984). Status, conservation, and management of the land snails of the genus *Powelliphanta* (Mollusca: Pulmonata). New Zeal J Zool 11: 277–306.

Moreira F, Russo D (2007). Modelling the impact of agricultural abandonment and wildfires on vertebrate diversity in Mediterranean Europe. Land Ecol 22: 1461–1476.

Mountainspring S, Casey TLC, Kepler CB, Scott JM (1990). Ecology, behavior, and conservation of the Po'o-uli (*Melamprosops phaeosoma*). Wilson Bulletin 102: 109–122.

Olea PP, Baglione V (2008). Population trends of rooks *Corvus frugilegus* in Spain and the importance of refuse tips. Ibis 150: 98–109.

Orłowski G, Kasprzykowski Z, Zawada Z, Kopij G (2009). Stomach content and grit ingestion by rook *Corvus frugilegus* nestlings. Ornis Fennica 86: 117–122.

Ożgo M (2012). Shell Polymorphism in the land-snail *Cepaea nemoralis* (L.) along a west–east transect in continental Europe. Folia Malacologica 20: 181–253.

Roosimaa U (1961). About feeding of rooks in Estonia. Obščestvo Ispytatelej Prirody Pri Akademii Nauk Estonskoj SSR 54: 196–215 (in Russian).

Seed AM, Clayton NS, Emery NJ (2008). Cooperative problem solving in rooks (*Corvus frugilegus*). P R Soc B 275: 1421–1429.

Shachak M, Safriel UN, Hunum R (1981). An exceptional event of predation on desert snails by migratory thrushes in the Negev Desert, Israel. Ecology 62: 1441–1449.

Stanisz A (2006). Przystępny kurs statystyki z zastosowaniem STATISTICA na przykładach z medycyny. Tom 1. Statystyki podstawowe, StatSoft Polska, Cracow, 2006 (in Polish).

Switzer PV, Cristol DA (1999). Avian prey-dropping behavior. I. The effects of prey characteristics and prey loss. Behav Ecol 10: 213–219.

Udoh AP, Akpanyung EO, Igiran IE (1995). Nutrients and anti-nutrients in small snails (*Limicolaria aurora*). Food Chem 53: 239–241.

Zach R (1979). Shell dropping: decision-making and optimal foraging in northwestern crows. Behaviour 68: 106–117.