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THE DIET OF THE RAVEN *CORVUS CORAX* IN SOUTH-WEST SLOVENIA

Davorin TOME

National Institute of Biology, SI-1000 Ljubljana, Večna pot 111, Slovenia

E-mail: Davorin.Tome@nib.si

Miha KROFEL

Department of Biology, University of Ljubljana, SI-1000 Ljubljana, Večna pot 111, Slovenia

Tomaž MIHELIC

DOPPS-Bird-Life Slovenia, SI-1000 Ljubljana, Tržaška 2, Slovenia

ABSTRACT

The diet of the raven was investigated in 2008 in south-west Slovenia. 158 food items, belonging to 26 different food groups, were retrieved from 60 whole and some broken pellets collected during the spring and autumn. Vertebrate remains were found in 57 pellets and plant debris in 53 pellets. Sheep remains were found in 32 pellets, and were significantly more common in pellets from sheep pastures than from areas with no pastures. Deer, invertebrate and bird remains were scarce.

Key words: the raven, *Corvus corax*, diet, south-west Slovenia

DIETA DEL CORVO IMPERIALE *CORVUS CORAX* IN SLOVENIA SUD-OCCIDENTALE

SINTESI

Gli autori hanno studiato la dieta del Corvo imperiale nel 2008 nella Slovenia sud-occidentale. 158 pezzi di cibo, appartenenti a 26 differenti gruppi alimentari, sono stati recuperati da 60 borre intere ed alcune danneggiate, raccolte durante la primavera e l'autunno. Resti di vertebrati sono stati ritrovati in 57 borre, mentre resti vegetali in 53 borre. Resti di pecora sono stati riscontrati in 32 borre, risultando significativamente più comuni nelle borre raccolte sui pascoli ovisini che in quelle raccolte nelle aree lontane dai pascoli. Resti di cervidi, invertebrati e uccelli sono risultati scarsi.

Parole chiave: Corvo imperiale, *Corvus corax*, dieta, Slovenia sud-occidentale

INTRODUCTION

The raven population (*Corvus corax*) consists of birds with two types of social behaviour: breeding birds, which appear to be territorial and live in pairs, and non-breeding, non-territorial birds, which live year-round in flocks (Ratcliffe, 1997). The raven population in Slovenia is estimated at 2000 to 3000 breeding individuals (1000 to 1500 breeding pairs; Geister, 1995) and at least 1500 to 3000 non-breeding individuals (Tome *et al.*, 2009). Although no quantitative data exists, there are some clues that the population has increased in recent decades (Tome *et al.*, 2009). This increase is consistent with observations all over Europe (BirdLife international, 2004; EBCC 2008) and is thought to be the result of the ban on shooting in some countries and increase of sheep farming practice in others (Tome *et al.*, 2009). The population size of ravens is known to correlate with the extent of sheep farming (Newton *et al.*, 1982).

The raven is first of all a scavenger and, as such, a vulture substitute in northern Europe (Ratcliffe, 1997). It feeds on dead animals from the size of a mouse to a whale. It can also be a predator, catching live prey. The extent to which it attacks live animals depends on the amount of available carrion. Rabbits are usually considered to be the biggest animals that ravens can successfully prey on, but then only if they are cornered or if their defence is disabled in some other way.

A common belief among farmers is that ravens kill sheep for food, especially lambs. The question of lamb killing (also calf killing) has been addressed by scientists several times (Ratcliffe, 1997; Langgemach *et al.*, 1995; Wallschläger *et al.*, 2004; Glandt, 2008), but only rarely hard evidence for successful predation was established. Even then, as found later, the animal under attack had ill developed internal organs or was affected by a potentially deadly disease. On the other hand, a lot of proof of ravens feeding on sheep carcasses has been established. Nevertheless ravens still have a bad reputation as large scale sheep killers.

The main aim of this work is to present the diet of the raven in south-west Slovenia, as derived from pellet analysis. Although raven diet studies are not rare, especially from England and Ireland (Marquiss *et al.*, 1978; Ewins *et al.*, 1986; Marquiss & Booth, 1986; Berrow, 1992), this is the first study of this kind from this part of Europe. It should be noted that the results cannot be taken as an arbiter of raven's guilt or innocence as a sheep killer, as they provide no information about predation and potential killing behaviour. Sheep remains in the raven's diet in this study are solely a sign of the bird feeding habits.

MATERIALS AND METHODS

Study area

We collected pellets from two areas in south-west Slovenia. The first was located in the Karst region near the settlements of Sežana, Divača and Kozina (squares on Fig. 1). Pellets were collected from and under the cliffs in rocky depressions, where raven nests were located. These localities were surrounded by forests or overgrown meadows and there were no pastures within at least a kilometre.

The second area comprised sheep pastures at Volovja reber and Gure above Ilirska Bistrica (triangles on Fig. 1). We collected pellets under the trees and rocky outcrops within or close to pastures, where raven flocks were often spotted. We were not aware of any raven nests in this area. We estimate that pellets from both areas were not older than two months on the day of collection.

Materials and methods

The content of the pellets was analyzed in the laboratory. Pellets were soaked in water for ca. 15 minutes and then washed with tap water on a 0.5 mm mesh sieve. Material remaining on the sieve was dried and inspected macroscopically and, if needed, also under 100–400x magnification. The volume proportion of each food item found in a pellet was estimated visually. From each pellet we collected approx. 20 guard hairs and 5 feathers (when present), put them in 96% ethanol for approx. 30 minutes to clean, and let them dry. Macroscopic (general form, size, colour, rigidity, shape of the apex) and microscopic (structure and pattern of cuticular scales, shape of the cross-section, shape and size of the medullary space) characteristics of hairs were noted. The microstructure of the cuticle was inspected using cuticular imprints on celluloid plates. Species determination was performed according to Day (1966), Teerink (1991), Meyer *et al.* (2002) and with the comparative material stored at the Department of Biology at the University of Ljubljana. Teeth and bone remains of small mammals were identified according to Kryštufek (1985, 1999) and with the comparative osteological material. Remains of bats were analysed by a specialist. Plant material was separated into green or wooden material, fruits and seeds. When possible we determined the plants more precisely.

Due to intensive digestion in the stomach, some food remains from pellets were in a very poor condition, and impossible to determine to a species level. For that reason the term food item in this text refers to the part of the material from one pellet belonging to a particular species, genus, family or class, whichever level of determination was the lowest possible.

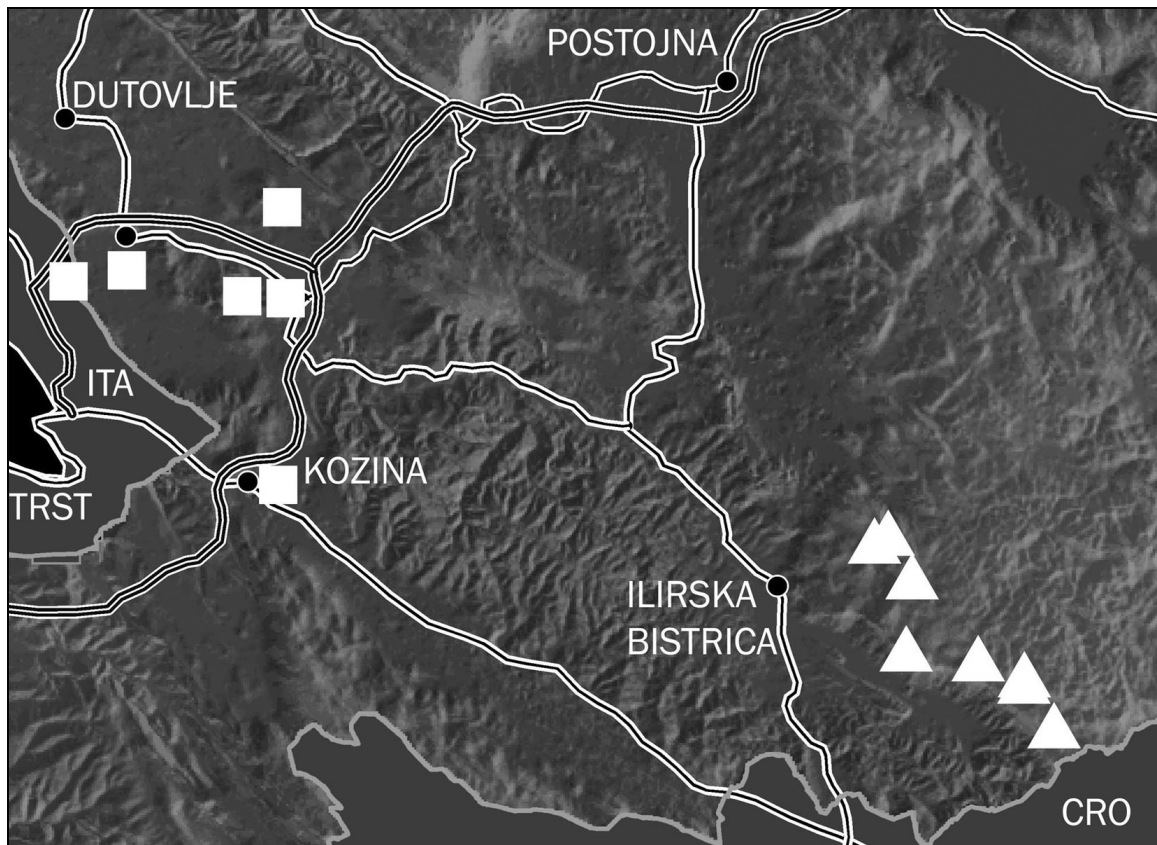


Fig. 1: Study site (squares: localities of pellet collection on Karst region; triangles: localities of pellet collection on pastures).

Sl. 1: Raziskovano področje (kvadrati: lokalitete zbiranja izbljuvkov na Krasu; trikotniki: lokalitete zbiranja izbljuvkov na pašnikih).

We used four methods to present pellet analysis results: 1) frequency of occurrence, calculated as the proportion of pellets in which a food item was found; 2) proportion of occurrence, calculated as the number of pellets where a particular food item was found divided by the number of food items from all pellets; 3) volume proportion, calculated as the sum of the volume proportions of a particular food item in pellets divided by the total number of pellets, and 4) average volume proportion, calculated as the sum of the volume proportion of a particular food item in pellets divided by the number of pellets including this food item only.

All pellets were analyzed by the same person (MK) to minimize variability caused by observer-related errors. We climbed the nests to collect the pellets only after the nestlings were fledged.

RESULTS

Food remains were analyzed in 60 whole raven pellets and some broken pellet material from 13 locations. Spring samples (15 pellets) were collected from 9th to 13th May 2008 in the Karst region only, autumn samples (45 pellets) from 11th September to 15th October 2008 in pastures. 158 food items, belonging to 26 different food groups, were separated from pellets. In single whole pellets we found one to five food items, on average 2.4 food items per pellet (s.d. = 0.85).

Vertebrate remains were found in 57 whole pellets (95%), and plant remains in 53 whole pellets (88%). Sheep remains were found in 32 whole pellets (53%), while remains of other domesticated animals were scarce. Small mammals were also relatively common, followed by deer, birds and invertebrates. Green plant material was the most common plant food item, followed by fruits and seeds (Tab. 1).

Tab. 1: Diet composition of ravens in SW Slovenia (N of all food items is 158).**Tab. 1: Sestava prehrane krokarjev v JZ Sloveniji (N vseh enot hrane je 158).**

| Food item | N of food items | Frequency of occurrence | Proportion of occurrence | Volume proportion | Average volume proportion |
|-------------------------|-----------------|-------------------------|--------------------------|-------------------|---------------------------|
| animals | 78 | 0.919 | 0.494 | 0.548 | 0.436 |
| Vertebrata | 71 | 0.919 | 0.449 | 0.518 | 0.452 |
| Mammalia | 65 | 0.887 | 0.411 | 0.450 | 0.429 |
| Cervidae | 7 | 0.113 | 0.044 | 0.054 | 0.476 |
| Carnivora | 4 | 0.065 | 0.025 | 0.021 | 0.333 |
| undet. large mammals | 4 | 0.065 | 0.025 | 0.016 | 0.255 |
| domesticated ungulates | 36 | 0.581 | 0.228 | 0.228 | 0.393 |
| sheep | 32 | 0.516 | 0.203 | 0.224 | 0.434 |
| goat | 2 | 0.032 | 0.013 | 0.002 | 0.050 |
| pig | 1 | 0.016 | 0.006 | 0.002 | 0.100 |
| horse | 1 | 0.016 | 0.006 | 0.001 | 0.050 |
| small mammals | 14 | 0.210 | 0.089 | 0.130 | 0.575 |
| <i>Myotis myotis</i> | 2 | 0.032 | 0.013 | 0.020 | 0.625 |
| Muridae | 2 | 0.032 | 0.013 | 0.010 | 0.325 |
| Gliridae | 2 | 0.032 | 0.013 | 0.021 | 0.650 |
| <i>Talpa europaea</i> | 1 | 0.016 | 0.006 | 0.015 | 0.900 |
| undet. small mammals | 7 | 0.113 | 0.044 | 0.064 | 0.564 |
| Aves | 6 | 0.097 | 0.038 | 0.068 | 0.703 |
| Passeriformes | 3 | 0.048 | 0.019 | 0.034 | 0.700 |
| Falconiformes | 1 | 0.016 | 0.006 | 0.008 | 0.520 |
| undet. birds | 2 | 0.032 | 0.013 | 0.026 | 0.800 |
| Invertebrata | 7 | 0.113 | 0.044 | 0.030 | 0.269 |
| Coleoptera | 3 | 0.048 | 0.019 | 0.021 | 0.440 |
| Saltatoria | 1 | 0.016 | 0.006 | 0.008 | 0.500 |
| undet. insects | 2 | 0.032 | 0.013 | 0.000 | 0.015 |
| snails | 1 | 0.016 | 0.006 | 0.000 | 0.030 |
| plants | 67 | 0.806 | 0.424 | 0.433 | 0.401 |
| green plant material | 40 | 0.645 | 0.253 | 0.306 | 0.475 |
| fruit | 1 | 0.016 | 0.006 | 0.016 | 1.000 |
| cereals | 1 | 0.016 | 0.006 | 0.016 | 1.000 |
| corn | 2 | 0.032 | 0.013 | 0.014 | 0.425 |
| undet. fruits and seeds | 18 | 0.290 | 0.114 | 0.075 | 0.257 |
| wooden plant material | 5 | 0.081 | 0.032 | 0.006 | 0.078 |
| stones | 10 | 0.161 | 0.063 | 0.009 | 0.057 |
| undetermined | 3 | 0.048 | 0.019 | 0.009 | 0.193 |

Sheep remains were significantly more common in pellets found in the area with sheep pastures than in those in the area with no pastures. Ravens distant to pastures fed more on fruits, seeds, small mammals and large wild mammals. There was also a significant difference in the proportion of bird remains between two areas. Very few were found in pellets from pastures, but rather more in pellets found in areas where sheep were not available as food (Tab. 2).

DISCUSSION

None of the quantitative measures of the raven diet in this study (frequency of occurrence, proportion of oc-

currence, volume proportion) are directly proportional to the real quantities of food ingested. For example, sheep remains from pellets in one locality could have arisen from one or from several animals; ravens could have eaten a whole sheep or only a part of it. The amount of food remains regurgitated in pellets depends on the degree of digestion, which is different for different items. So the results do not provide an exact picture of the diet. They are probably quite accurate in presenting its qualitative composition, but only provide an approximate indication of the importance of particular food items.

Tab. 2: Diets of ravens dwelling near and far from sheep pastures. Numbers are proportions of the occurrence in pellets, the difference is denoted using Chi-square test (* $p < 0.05$; ** $p < 0.01$).

Tab. 2: Prehrana krogarjev, živečih blizu in daleč stran od ovčjih pašnikov. Številke predstavljajo delež pojavljanja v izbljuvkih, razlika je označena s testom hi-kvadrat (* $p < 0,05$; ** $p < 0,01$).

| Prey category | Sheep pastures far | Sheep pastures near | Chi-square |
|---------------------------------|--------------------|---------------------|------------|
| sheep | 0.065 | 0.259 | ** |
| domesticated animal excl. sheep | 0.109 | 0.027 | * |
| large wildlife | 0.130 | 0.045 | |
| small mammals | 0.152 | 0.063 | |
| birds | 0.109 | 0.009 | ** |
| invertebrates | 0.065 | 0.036 | |
| green plant material | 0.109 | 0.313 | * |
| fruits and seeds | 0.174 | 0.125 | |
| wood, stones, undetermined | 0.087 | 0.125 | |
| N food items | 46 | 112 | |

Sheep carrion appears to be a frequent food item in raven pellets in south-west Slovenia, which is similar to findings of studies made elsewhere (*i.e.*, Newton *et al.*, 1982; Ewins *et al.*, 1986). In our samples from all localities, sheep remains were found in over half of the pellets. But sheep are by no means essential for the survival of ravens. Almost no sheep remains were found in pellets collected from nest sites. This indicates that even at a time of great demand for food, when adults must feed themselves and the young birds, ravens can thrive without domesticated animals as a food source, at least if they have sufficient nutritious plant material, small mammals and birds at hand, which were frequently found in those pellets.

Although in two sampling areas pellets were collected in different seasons (pellets from the Karst region in breeding season pellets above Ilirska Bistrica in post-breeding season), we argue that differences in the diet are not season related. The raven is opportunistic in its diet, exploiting whatever locally is available the most (Ratcliffe, 1997). The difference is probably mostly due to lack of sheep pastures in one and its abundance in the other area.

There is little doubt that pellets from nest sites belong to breeding ravens, adults or young fed by adults. There is also no reason not to believe that pairs with nests close to pastures have more sheep remains in the diet

than those we inspected. Less clear, however, is the social status of ravens whose pellets were found in autumn at Volovja reber and Gure. Since they were observed in groups, not in pairs, it is possible that they belong to the year-round flocks of non-breeding individuals. According to Ratcliffe (1997), breeding birds in the UK remain around the nest site in pairs throughout the year, protecting the territory, so large groups can always be considered as non-breeders. More observations on individually marked birds or even telemetry studies would be necessary to investigate whether, in Slovenia, breeding pairs join non-breeders in flocks after the breeding season. The results would be interesting from the point of view of the raven – sheep interaction. They would add some understanding to the current enigma as to which social group is responsible for ravens being on farmers' black lists: non-breeders or both non-breeders and breeders – quite possibly only the more mobile non-breeders.

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PREHRANA KROKARJA *CORVUS CORAX* V JUGOZHODNI SLOVENIJI

Davorin TOME

Nacionalni inštitut za biologijo, SI-1000 Ljubljana, Večna pot 111

E-mail: Davorin.Tome@nib.si

Miha KROFEL

Oddelek za biologijo, Univerza v Ljubljani, SI-1000 Ljubljana, Večna pot 111

Tomaž MIHELČ

DOPPS-Bird-Life Slovenia, SI-1000 Ljubljana, Tržaška 2

POVZETEK

V letu 2008 smo v jugozahodnem delu Slovenije raziskovali prehrano krokarjev (*Corvus corax*) na osnovi preiskave izbljuvkov. Izbljuvke smo nabirali na dveh lokacijah, na Krasu in na območju Volovje rebri in Gur pri Ilirski Bistrici. Iz 60 celih in nekaj razdrobljenih izbljuvkov smo izolirali 158 enot hrane, ki so pripadale 26 različnim taksonomskim skupinam. V 57 izbljuvkah smo našli ostanke vretenčarjev, v 53 izbljuvkah ostanke rastlinske hrane. Ostanke ovc smo odkrili v 32 izbljuvkah; značilno več v izbljuvkah nabranih v bližini ovčjih pašnikov kakor v izbljuvkah nabranih na lokacijah, ki so bile od pašnikov oddaljene. Ostanke srnjadi, jelenjadi, ptic in nevretenčarjev so bili redki.

Ključne besede: krokar, *Corvus corax*, prehrana, jugozahodna Slovenija

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