MAGYAR AGRÁR- ÉS ÉLETTUDOMÁNYI EGYETEM

Columella

Volume 9, Number 2, 2022

Columella
Journal of Agricultural and Environmental Sciences

Sexual differences in morphology and winter diet of the Eurasian magpie (*Pica pica*) in Hungary

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Abstract: Eurasian magpie (*Pica pica*) is a widely distributed, common species of the Corvidae family. Since magpies have lived close to humans for centuries, we have much information about the species. However, there are few data about morphological and dietary differences between sexes, primarily due to their monomorphic, omnivorous, and opportunistic characteristics. The aim of the study was to analyse the sexual differences in the morphological characteristics, simultaneously provide the body measurements for both sexes with a high level of accuracy and determine the diet composition through stomach content analysis during the winter. The samples were provided by the local gamekeepers from a hunting in February of 2020, in Hungary. The linear measurements of body parts (eight variables considered) have been done for all individuals ($n = 30$), and the values were compared between the sexes. The stomach contents were categorized among five main food components, and comparisons of stomach contents and their weights were also performed between males and females. The results concluded that there were no significant differences between the sexes in the studied morphological variables. The dietary analysis revealed that during the winter magpies fed on a range of different food types, with seeds, invertebrates, and vertebrates being the most frequently consumed food. We revealed slight differences between sexes in the consumption of the two latter categories. Our investigations supported earlier findings on the high morphological and dietary similarities of the two sexes also in case of a Hungarian magpie population. These results can serve as a potential basis for further research on magpies in Europe.
Keywords: body measurements, monomorphic birds, food composition, stomach analysis, Corvidae

Received 29 June 2022, Revised 20 October 2022, Accepted 21 October 2022

Introduction

The Eurasian magpie (*Pica pica*) is a resident breeding bird throughout Europe, much of Asia, and northwest Africa (Johnson, 1993). Females and males are difficult to distinguish in the field. Among the Corvidae sexes are monomorphic, making accurate sexing a formidable task (Kavanagh, 1988). However, male Eurasian magpie tends to be larger than female (O'Connor, 1985). Application of morphometric analyses becomes more complicated especially when the body size and feather colour vary among different geographical regions (Kahn et al., 1998; Sheppard et al., 2004).

Field studies of wild avian species often require the determination of their sex. The difficulty of sexing avian species stems from the absence of external sex organs in birds (Cerit & Avanus, 2007). Accurate prediction of sex has been successfully performed by analysing external measurements (Green, 1982; Kavanagh, 1988; Wood, 1987). However, in case of magpies there is a considerable overlap between females and males in almost all morphological measurements for adults and juveniles. Due to this reason, sex determination in the field is difficult in the absence of behavioural cues (Tatner, 1992).

To classify certain physical parameters, such as body size, it is difficult to quantify in a single measure. Perhaps the best estimate of overall body size is total mass, but reliable information on mass is often difficult to obtain (Rising & Somers, 1989); so, combinations of several measurements are often required. Beside sexing, body measurements of the species have their important aspect. Among many other parameters, body size is a fundamental characteristic in birds and as such also an important distinctive criterion for species, populations, and sexes. Body measurements of birds provide information on the relative ratios of their body parts at different taxonomic levels and the data provide access to ecomorphological research questions (Leisler & Winkler, 1991). The measure of overall body size in birds is required to test hypotheses predicting patterns of geographic variation (James, 1970). Furthermore, the body mass maintained by a wintering bird can be viewed as a trade-off between the risk of starvation and the risk of predation. A bird should be as fat (or heavy) as possible to minimize its starvation during food scarcity periods, however, a bird should be as lean as possible to minimize its probability of being killed (Lima, 1986).

Dietary habits, as basic elements in constructing the niche of the species, are also essential for revealing the ecology of birds (Woodroffe et al., 2005). The feeding habits of the Eurasian magpie give rise to controversial interpretations between researchers, conservationists, and hunters (Díaz-Ruiz et al., 2015). In Europe, magpies are generally considered as harmful bird species by nature conservation or game management points of view due to their predation on eggs and chicks of songbirds and gamebirds (Birkhead, 1991). The diet of magpie has been the object of several studies focusing on different issues, *e.g.*, seasonal differences, food selection, diet of nestlings or differences between rural and urban magpies (Kryštofková et al., 2011; Ponz et al., 1999; Soler & Soler, 1991). As reported by studies, magpies are generalist consumers that feed on a broad spectrum of food types, including both vegetal and animal resources (Díaz-Ruiz et al., 2015).

In this context, the main objectives of the study were to obtain data and knowledge about: (i) the morphological characteristics and potential sexual differences in case of the Eurasian magpie in Hungary; (ii) the diet composition of males and females during the winter period.

Materials and Methods

Study area and field sampling

Carcass samples of magpies were collected by the gamekeepers of Csíkvölgyi Wass Albert Hunting Association in Mogyoród, Hungary. Hunting was organized for one day as a group hunting, in Csömör, Pest County, Hungary, during the winter period, in February 2020. The covered area composed of habitats such as a meadow-dominated landscape with some interspersed patches of natural vegetation with shrubs and edges of agriculture fields. Altogether 30 magpie individuals were shot and collected for further analyses. Samples were stored in the freezer until laboratory investigations.

Morphological data collection

First, in this study, the body measurements of the carcasses have been conducted. The manual for bird measurements written by Oschadleus (2012) was followed. Total body weight was measured on an electronic scale, measuring in gram with an accuracy of two decimals. For body measurements we used transparent plastic rulers and tape measures. To precisely measure the length of the wings, a ruler with a zero-stop was applied using the measurement lines in centimetres (accuracy: 0.1 cm). Wingspan measurements were taken with the bird lying on its back on top

 DOI: https://doi.org/10.18380/SZIE.COLUM.2022.9.2.113

Table 1: Description of the different diet components during the stomach analysis of magpie

Diet component	Indicators
Vertebrates	Egg shells, bone parts, feathers, and hairs
Invertebrates	Arthropoda (insects, caterpillars, larvae), Arachnids (spiders), Gastropods and Molluscs (snails, shell fragments, shell apices)
Plants (Seeds)	Cereal, sunflower, barley, wheat seeds and cracked corn
Grit	Grit and stones of 1-2 mm length
Miscellaneous	Grey liquid; brown, dry particles; difficult to quantify

of a ruler, with its wings outstretched. The half wingspan was measured from the centre of the back to the tip of the wing. For total body length the measurements have been done from the tip of the bill to the tip of the tail. Tail length was measured from between the two innermost traces where their bases emerge from the skin to the tip of the longest tail feather in the naturally folded tail, from the dorsal side. Round circle body measurements were taken with a tape measure, starting from the belly of the bird toward the back, touching the rump part of the body. The bill length was measured from the tip of the bill to the angle at the front of the skull. Sexes were determined visually by opening the carcass body cavity and examining the inner reproductive organs.

Stomach content analysis

Investigations of the diet of the magpie have been carried out based on Tatner (1992)'s work. Each sample was prepared, and the stomach contents were set into an appropriately labeled petri dish, separately to all carcasses. The content of each stomach was dried out and weighed (accuracy: 0.01 grams) and investigated by macroscopic analysis under a stereomicroscope and a magnifying glass. The small amount of content in the stomachs prevented the use of nesting sieves. Food items were grouped into the following categories: vertebrates, invertebrates, plants (seeds), grit, and miscellaneous. Description of the different diet components are given in Table 1.

Data analysis

Based on body measurements we compared the average values between sexes for each body parts. From the data obtained from the diet composition analysis, we calculated and compared between sexes (i) the average dry weight of the total stomach contents, (ii) the frequency of each food item (number of samples containing the given food components, %). Statistical comparisons were performed by unpaired t-tests. We processed and analysed data using Microsoft Excel and GraphPad Prism.

Results

Morphological characteristics of magpie

Based on the investigation of the sexual organs we could identify 15 carcasses as female and 15 as male. The results of the linear measurements (Table 2) showed no significant differences between females and males regarding their total body weight (unpaired t-test: $t = -0.014$, $p = 0.98$), both sexes having an average value around 176 g. Neither the body length ($t = 0.95$, $p = 0.34$) showed a significant difference between sexes (43 vs. 42 cm for females and males, respectively). Similarly, we could not reveal any statistical difference in case of the beak length ($t = 0.59$, $p = 0.55$), wing length ($t = 0.70$, $p = 0.48$), wingspan length ($t = 1.15$, $p = 0.25$),

Table 2: The body measurements for female and male magpies: Values for total body weight, body length, beak length, wing length, wingspan length, half wingspan length, round body circle, tail length are compared. $N = 15$ for both sexes. Measurement units are given in centimetre (cm) for the length variables and in gram (g) for the body weight.

Measurement	Sex	Mean	SD.	Min.	Max.	*P* value
Total weight	Female	176.22	20.34	147.5	211.4	0.988
	Male	176.92	18.76	138.5	211.2	
Body length	Female	43	2.47	39	49	0.349
	Male	42.06	2.52	37	48	
Beak length	Female	3.63	0.29	3	4	0.558
	Male	3.56	0.31	3	4	
Wing length	Female	18.73	3.13	17	20	0.483
	Male	18.53	0.63	18	20	
Wingspan length	Female	53.66	3.13	49	60	0.258
	Male	52.2	3.80	44	60	
Half wingspan length	Female	24.2	1.85	21	28	0.543
	Male	23.8	1.69	21	27	
Round body circle	Female	20.53	0.85	19	22	1.000
	Male	20.53	0.63	19	21	
Tail length	Female	24.53	2.26	20	30	0.825
	Male	24.1	2.26	19	28	

half wingspan length ($t = 0.62$, $p = 0.54$) round circle body ($t = 0$, $p = 1.0$) or for the tail length ($t = 0.22$, $p = 0.82$).

Diet composition of magpies

We found that the dry mass of stomach contents of females can weigh 1.2 g in average, while that of males is only 1 g, although this difference was not statistically significant due to the variability of data (t-test: $t = 1.06$, $p = 0.29$). The analyses of the stomach contents of the 30 individuals showed that seeds (found in 46.67% of all samples) and invertebrates (30%) were the predominant winter food sources of the magpies, following the categories of vertebrates (20%). Miscellaneous items appeared in 13.33% of the samples, while the grit was revealed in 6.67% of them (Figure 1) (Appendix 1).

The results on Figure 1 reveal the category of seeds, represented as the most frequented food component for both sexes, almost with the same frequencies (40 and 46.67% for males and females, respectively). The second category, invertebrates (Arthropoda, Arachnids, Gastropods and Molluscs) was represented twice higher (40%) for the females, compared to the males (20%). Contrarily, in case of the category of vertebrates, the higher frequency value was clearly noticeable for the males (26.67%) than for females (13.33%). The category of grit (grit and stones: 6.67% for both sexes) and miscellaneous contents (grey liquid, brown, dry particles: 13.33% for both sexes) showed identical frequencies between sexes.

Discussion

The results of the study yielded interesting knowledge about morphological differences and winter diet of magpies in Hungary. According to our results we could not find any

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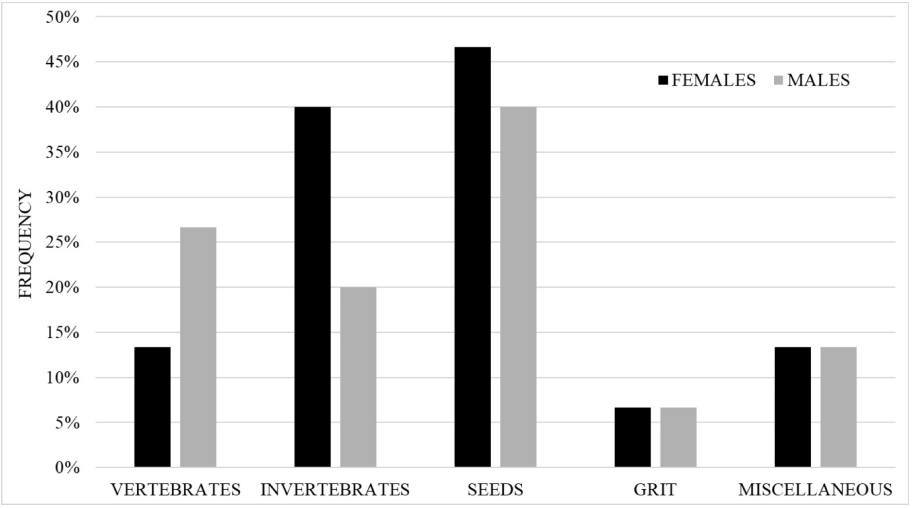

Figure 1: The comparisons of stomach content categories between the sexes (frequency of occurrence of diet components). $N = 15$ for both, females and males.

clear sign of sexual differences of the measured morphological characteristics in case of the species. It means we are not able to recommend any simple body measure for sex identification. Our results are supported by earlier findings that states for magpies as monomorphic, making accurate sexing a formidable task (O'Connor, 1985).

Monomorphism is assumed to be the ancestral state, where there is no obvious signature of selection differentiating the sexes. However sexual monomorphism, can also be a derived condition, evolving from sexual dimorphism (Staub, 2020). Results obtained by Owens and Hartley (1998) suggested that size dimorphism is associated with intrasexual competition described by the mating system, meanwhile plumage colour dimorphism is linked to the frequency of extrabond paternity. Santos et al. (2007) demonstrated that the European Magpie has sexually dichromatic plumage characteristics that are invisible to the human eye.

But even if body measures are not eligible to distinguish sexes, they can serve for other purposes. A measure of overall size is required to test hypotheses predicting patterns of geographic variation (Handford, 1983; Murphy, 1985). In addition, species must be ranked by body size to test models that predict size ratios among coexisting species in ecological communities (Brown & Maurer, 1986; Miles & Ricklefs, 1984). In physiology, standard measures of metabolic activity are frequently expressed as a function of body size, and it is often useful to examine the relationship of structures or organs relative to overall body size (Packard & Boardman, 1988; Paladino, 2015).

Regarding the diet, our finding clearly indicates the seeds as the predominant food sources (40%) for both sexes during the winter period for the magpies in Hungary. In the study by (S., 1928) the vegetable material was a major constituent of the adult magpie diet during the winter and spring in America, but there is a difference in the type of plant material involved. In Manchester, seeds (mainly grain) and root material were the most abundant forms of vegetable matter (Holyoak, 1968). Besides, winter resources are generally good for farmland corvids; invertebrates and stubble grain are available and other food sources appear sporadically, for example when fields are plowed, pastures are mucked, or stock food put out (Feare et al., 1974; Waite, 1985). Moreover, during snow cover harrowed fields are avoided,

more birds frequent ploughed fields during snow cover and frost compared to thaw and no snow cover, thus, during winter event avoided habitats were utilized to a high degree by magpie (Møller, 1983).

Beside plant materials, animal food was also important for magpies. Previous studies conducted in different parts of the world like Korea, Spain, France also indicated that magpies presented a generalist diet which included a wide range of food types (Bravo et al., 2020; Díaz-Ruiz et al., 2015; Song et al., 2012). The relatively frequent occurrence of vertebrates (eggshell, hair, fur, and mammal remnants) with 20% in their diet, suggests that magpies can opportunistically consume small mammals, songbirds, or carcasses. The stable presence of invertebrates (30%) in the late winter diet of magpies suggest that these birds are able to find the active or hiding insects even when this prey type is less available. Magpies can select food items independently of their availability, as reported for some invertebrate groups (Kryštofková et al., 2011; Martínez et al., 1992), At the same time, we revealed that invertebrates were consumed with higher frequency by females and vertebrates were more eaten by males. This dietary shift can be due to the different needs of the two sexes leading to different prey searching strategies, but this question needs further investigations. It is interesting to note that the frequency occurrence of the grit (stones of 1–2 mm) was 6.67%. This finding can be supported by the fact that many extant animals such as different birds, seals, turtles, or crocodiles possess stones in their stomach (Wings, 2007). For birds, it is generally assumed that these stones contribute to the mechanical crushing of food (Ziswiler & Farner, 1972).

The comparisons of the total weight of the stomach content between sexes show that for females the stomach weight was a little bit heavier than that of males in average. Although it was not a statistically significant difference, it can have some biological meaning. Nilsson et al. (2020) showed that female birds benefit more from extra food in the winter. If females receive additional food, they do not need to reduce their body temperature as much as they would have otherwise, and the chances of surviving cold nights increase.

Conclusions

With the respect to the present study, essential morphological data of magpie were obtained. Overall, based on the linear body measurements and comparisons between sexes, we confirm that no phenotypic feature based on which males and females of this species can be distinguished in the field by hunters or birders. However, trapping of magpie can be performed very effectively, which can promote to gain deeper insight into the population structure and potential sexual differences of this bird species. Furthermore, the outcome of this study showed that the main winter diet components of magpies in Hungary were the plant seeds supplemented with the consumption of invertebrates and vertebrates, but these two latter with a bit different importance for males and females. However, these studies did not consider every period of the year. Thus, we propose a year-round investigation of both magpie diet and food supplies to gain a better knowledge of the species feeding preferences and utilization. More studies on the magpie (especially on its effects on other species (e.g., nest-predation experiments) can help elucidate its role in the population dynamics of threatened bird and invertebrate species.

Acknowledgements

We are very grateful to hunters and game managers who provided us with samples, B.

 DOI: https://doi.org/10.18380/SZIE.COLUM.2022.9.2.113

Bócsi and Csíkvölgyi Wass Albert Hunting Association in Mogyoród. We thank people who assisted us during the sample transport and storage.

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