

Photographic survey of the prey-choice of European Bee-eaters (*Merops apiaster* Linnaeus, 1758) in Hungary at three colonies

TIBOR ISTVÁN FUISZ¹, ZOLTÁN VAS¹, KATALIN TÚRI² & ÁDÁM KÖRÖSI³



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Abstract Prey choice of European Bee-eaters was monitored via taking pictures of parent birds carrying prey items to their perches in front of the nests between 2011 and 2013 at three colonies in Hungary: at Pócsmegyer, Nagykarácsony and Albertirsa. All the colonies were studied in the breeding season, and prey items were identified from the digital images taken of adults carrying food for their chicks. During the three years 25 days were spent with collecting photographic data, and from the thousands of pictures taken 805 were suitable for analysis. On 775 photographs the prey item was identified at least to order level. Combining data from all the colonies hymenopterans were by far the most often consumed insects (50%), followed by dragonflies (17%), while beetles, orthopterans, lepidopterans and dipterans each contributed approximately 7-9% of the consumed prey. Prey composition showed marked differences between the individual colonies, although the ratio of hymenopterans was everywhere high. Bee-eaters at Pócsmegyer, probably due to the abundance of aquatic habitats nearby on the Danube shore, consumed almost as much dragonflies as hymenopterans, and ate very few orthopterans. While at the Albertirsa colony, surrounded by agricultural fields and meadows in a more arid environment, hymenopterans dominated the prey, and orthopterans were almost as often consumed as dragonflies. Lepidopterans constituted approximately 8% of Bee-eaters' diet in all colonies. From an insect ecological viewpoint, our study provides valuable data on the species pool that might be at risk of predation by Bee-eaters, and enables us to roughly estimate the predation pressure on some taxa, and in certain cases even on species by these birds.

Keywords: prey composition, photographic record, habitat dependence

Összefoglalás A gyurgyalagok táplálékösszetételét a fészek előtt álló beülő fákhöz szállított táplálék fotózásával elemeztük 2011–2013 között három magyarországi gyurgyalag telepen: Albertirsa, Pócsmegyer és Nagykarácsony határában. Valamennyi kolóniánál a költési időszakban, elsősorban fiókanevelési időszakban végeztük a vizsgálatokat, és a hordott rovarokat a digitális képek alapján határoztuk meg. A három év alatt 25 alkalommal végeztünk adatgyűjtést, és a több ezer készített felvételtől 805 bizonyult elemzésre alkalmasnak. 775 képen a hozott táplálék azonosítása legalább rend szintig lehetséges volt. A három kolónia összesített eredményei alapján a hátyáasszárnyúak (50%) és szitakötők (17%) voltak a leggyakrabban fogyasztott rovarok, míg a bogarak, egyenesszárnyúak, lepkék és kétszárnyúak egyenként nagyjából a táplálék 7-9%-át tették ki. Ugyan az egyes kolóniákon mindenütt a hátyáasszárnyúak voltak a leggyakrabban fogyasztott rovarok, határozott különbségeket észleltünk a többi fogyasztott rovar részarányában. A pócsmegyeri kolónia táplálékában, feltehetőleg a közeli Duna ártérén található vízi élőhelyeknek köszönhetően, csaknem ugyanolyan arányban képviseltettek a szitakötők, mint a hátyáasszárnyúak, míg az egyenesszárnyúakat meglepően alacsony arányban fogyasztották. A szárazabb környezetben található, mezőgazdasági művelésbe vont területekkel és rétekkel körülvett albertirsai telep esetében a hátyáasszárnyúak alkották a táplálék felét, a szitakötők, egyenesszárnyúak és kétszárnyúak hasonló arányban szerepeltek a táplálékban. A lepkék megközelítőleg 8%-át tették ki a gyurgyalagok táplálékának mindhárom kolóniában. A tanulmány rovarökológiai szempontból értékes adatokat nyújt arra nézve, hogy mely rovarfajok szerepelnek a gyurgyalagok táplálékában, továbbá durva becsléseket tehetünk az egyes taxonokat, illetve szerencsés esetben egyes fajokat sújtó predációs nyomásra.

Kulcsszavak: táplálék összetétel, fotográfiai adatgyűjtés, élőhelyi meghatározottság

¹Department of Zoology, Hungarian Natural History Museum, Budapest, Baross utca 13., 1088 Hungary, e-mail: tibor.i.fuisz@gmail.com

²Jászkun Természetvédelmi Egyesület, Szolnok, Pf. 188., 5001 Hungary

³Ecology Research Group, MTA-ELTE-MTM, Budapest, Pázmány Péter sétány 1/C, 1117 Hungary

Introduction

As their name suggests Bee-eaters are well-known predators of hymenopterans, furthermore they are expertly hunting flying insects on the wing gregariously (Snow & Perrins 1998). Most often they locate prey in the air, but also hunt around their nesting holes in a sit-and-wait manner, observing their surroundings from a perch and chasing the prey in the air, or snatching it from the surface of the vegetation. Even the best fliers among insects, such as dragonflies, are chased and captured with amazing efficiency (Fintha 1968). Although any flying insect is targeted, the speciality of Bee-eaters is the handling of stinging prey like bees and wasps (Snow & Perrins 1998). They kill their prey by knocking them against tree branches, and hence birds arriving to the colony with prey are often detected easiest by the knocking noise as they exterminate the captured arthropods. Bee-eaters can remove the sting of wasps and bees by squeezing the abdomen of the insect with their beak and rubbing it against branches. Hence Bee-eaters can exploit a food source neglected or avoided by other insectivorous birds.

In our study we tried to observe the sort of food Bee-eaters carry for their young at three colonies in three breeding seasons, and whether they live up to their reputation by consuming a higher ratio of hymenopterans. Also, as we observed three colonies we tried to establish whether habitat characteristics around the colonies influence the prey composition of Bee-eaters.

Study Areas and Methods

We started to study Bee-eaters in 2011 in order to survey their ectoparasite load and study the dispersion strategies of different feather louse taxa (see Karáth *et al.* 2013). We tried to ring and sample adult birds before females were forming eggs, and the second peak of ringing activities followed when the chicks hatched, and still flew around in the breeding colonies. Hence, we do not have a good temporal representation of prey choice for the whole nesting period. Parallel with the ectoparasite sampling and ringing, the prey items carried to the nesting holes were photographed.

We studied three Bee-eater colonies: in 2011 at Pócsmegyer in the Szentendrei Island (on four occasions in July), and in Nagykarácsony (once 17th July 2011) in the Mezőföld area of the central part of Hungary. In 2012 the Pócsmegyer colony was sampled again (on five occasions in June and July), and we started to work at the Albertirsa colony (see Urbán *et al.* 2013) located at the boundary of the Gödöllő Hills and the Great Hungarian Plain. We photographed birds bringing prey on 8 days in July and August 2012. In 2013 we worked only at the Albertirsa colony (5 days from June to August). *Table 1.* summarises the dates when the colonies were visited and how many prey items were identified from the taken pictures.

The Pócsmegyer colony is located in an abandoned sand pit, and approximately 30 pairs of Bee-eaters breed in the 40 metres long, 2-4 meter high wall. The colony is surrounded by meadows, sparse locust

Year	Locality	Date	Number of prey items identified
2011	Nagykarácsony	2011.07.19.	66
	Nagykarácsony total		66
	Pócsmegyer	2011.07.05.	24
		2011.07.10.	3
		2011.07.17.	34
		2011.07.27.	23
	Pócsmegyer total		84
2011 total			150
2012	Albertirsa	2012.07.01.	23
		2012.07.04.	28
		2012.07.05.	1
		2012.07.12.	91
		2012.07.14.	24
		2012.07.18.	186
		2012.08.02.	64
		2012.08.05.	35
	Albertirsa total		452
	Pócsmegyer	2012.06.22.	5
		2012.06.24.	24
		2012.06.27.	1
		2012.06.28.	9
		2012.07.14.	45
	Pócsmegyer total		84
2012 total			536
2013	Albertirsa	2013.06.02.	5
		2013.06.19.	11
		2013.07.13.	41
		2013.07.31.	17
		2013.08.07.	45
	Albertirsa total		119
Grand total			805

Table 1. Dates and sites of Bee-eater prey surveys, and number of observed prey-items

1. táblázat A gyurgyalogok táplálékelemzésének helyszínei, dátumai és a zsákmányolt rovarok mennyisége

tree stands, and is located near the Danube. Some Poplar (*Populus* sp.) and Black Locust (*Robinia pseudoacacia*) trees and Hawthorn (*Crataegus monogyna*) bushes grow near the sand wall, and birds bringing food land on these perches offering an opportunity to photograph the brought prey. The Nagykarácsony colony is an approximately 10-12 meter high and 40 meters long loess wall, and we estimated around a 50 pairs of Bee-eaters breed there. The colony is surrounded with pastures extensively grazed by Cattle (*Bos primigenius taurus*). Above the loess wall a wheat field and a dry meadow is situated with black locust trees, hawthorn and Dog Rose (*Rosa canina*) bushes, and many Bee-eaters perched here before returning to the nests with prey. This site provided an opportunity to place our hide and photograph Bee-eaters with the captured insects. The Albertirsa colony is the largest among the three, with approximately 250-300 Bee-eater pairs. Dry Black Locust trees artificially dig 10-15 metres in front of the wall offer perches for the breeding pairs, and allowed the first author to photograph the prey carried for the young.

Prey items carried to the nesting holes were photographed from a hide erected approximately 10 metres from the perches of bee-eaters. In all of the studied colonies near the nest holes there were perches for the birds, and they often engaged in social activities, courtship feeding, transferring food to their mate to feed the chicks. Two camera bodies were used for taking pictures: a Nikon D7100 and a Nikon D200, and pictures were taken from a Manfrotto tripod with a fluid head to avoid camera shake with a 500 mm / 4P Nikkor manual focus tele-photo lens. For birds that were landing outside the scope of the large lens a hand-held camera with an attached 100-400 mm / 3.5-5.6 Sigma Apo macro zoom lens was applied. Of every bird

carrying food more picture were taken in order to get views from many angles on the prey items. From the same bird and same prey only one image was entered into the prey composition survey.

The digital images were stored according date and location from each session, and then identified to the best possible taxonomic resolution. As sampling effort was not even between years and locations statistical tests were not carried out, only descriptive comparisons are made and we intend to provide a list of consumed prey for reference for other researchers.

Results

The combined results of the three years observation revealed that Bee-eaters consume hymenopterans in large quantities (*Figure 1*), half of the prey delivered to the nests belonged to this order. Within hymenopterans the Apidae family was the most numerous, especially bumblebees (*Bombus* spp.) and Western Honey Bee (*Apis mellifera*) dominated (see Appendix). Dragonflies (Odonata) were also frequently consumed, they constituted almost a fifth of the prey, while dipterans, orthopterans, lepidopterans and coleopterans were consumed in similar quantities around 7-9% each. Among orthopterans *Caliptamus* species were most often hunted.

Table 2. gives the proportions of each insect orders at the locations, combined for the sum of all observations. The percentage of consumed insects is quite similar at Albertirsa and Nagykarácsony, the dominance of hymenopterans is evident, they constitute around half of the all consumed prey. At both locations they are followed by dragonflies, but interestingly at the Nagykarácsony site, where the colony is surrounded

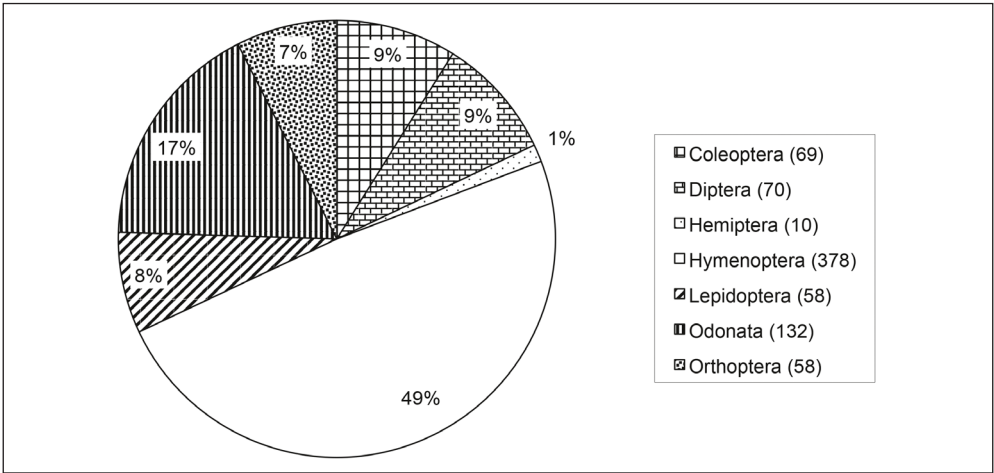


Figure 1. The composition of European Bee-eater prey summed for the three years of the study at the three colonies

1. ábra A gyurgyalagok táplálékösszetétele összesítve a három vizsgált kolóniára és a vizsgálat teljes időtartamára

Colonies / Prey Orders	Coleoptera	Diptera	Hemiptera	Hymenoptera	Lepidoptera	Odonata	Orthoptera	Not identified	Total number
Albertirsa	5%	10%	2%	50%	7%	13%	10%	4%	571
Nagykarácsony	24%	2%	0%	48%	8%	15%	0%	3%	66
Pócsmegyer	15%	6%	0%	35%	8%	29%	2%	5%	168
Total number	69	70	10	378	58	132	58	30	805

Table 2. The proportions of insect orders at the three colonies, summed for all the observation sessions

2. táblázat Az egyes rovarrendek százalékaránya a három kolónián, összegezve az összes mintavételi alkalomra

by a pasture grazed by cattle, we did not observe orthopterans among the captured prey items. At Nagykarácsony high quantity of coleopterans was consumed, but as this colony was observed only for a single day, we can not assess whether they are consumed in high quantities in the whole nesting period. Furthermore, all the possibly identified specimens belonged to the Scarabaeidae family (e.g. *Cetonia* sp.), it might have been a gradation that time.

The comparison of the Albertirsa and Pócsmegyer colonies is more interesting, as both location were sampled for two years and on many occasions. At the Pócsmegyer colony hymenopterans only gave one third of the prey, and dragonflies were consumed in similar quantity, which was unparalleled at the other colonies. But at the Pócsmegyer colony orthopterans were consumed very seldom. At the Albertirsa colony, on the other hand, orthopterans and dipterans

Colonies / Prey Orders	Coleoptera	Diptera	Hemiptera	Hymenoptera	Lepidoptera	Odonata	Orthoptera	Not identified	Total
Pócsmegyer 2011	19%	6%	0%	45%	5%	19%	4%	2%	84
Pócsmegyer 2012	12%	6%	0%	24%	12%	39%	0%	7%	84
Albertirsa 2012	4%	8%	1%	51%	7%	13%	12%	4%	452
Albertirsa 2013	6%	20%	3%	50%	5%	13%	2%	1%	119

Table 3. The comparison of proportions of insect orders at Albertirsa and Pócsmegyer between years
3. táblázat Az egyes rovarrendek százalékarányának összehasonlítása az albertirsai és pócsmegyeri telepeken az évek között

constituted a similar ratio of prey as dragonflies, all around 10%.

The yearly representation of prey composition (Table 3) reveals that at Pócsmegyer the amount of hymenopterans in the prey decreased considerably from 2011 to 2012, while the amount of dragonflies doubled. On the other hand, at Albertirsa the proportions of hymenopterans and dragonflies were stable between 2012 and 2013. Considerable difference was detected in the frequency of consumed dipterans: compared to 2012 in 2013 their ratio doubled, while that of orthopterans decreased very markedly.

We show the 5 most frequently consumed order at the Albertirsa colony in 2012, in the year when we performed the most obser-

vations (Figure 2). It clearly indicates the dominance of hymenopterans through the whole breeding season, and the representation of dragonflies was quite even, and showed a peak on the 18th July. Orthopterans were more often preyed upon from the middle of July, and also peaked on 18th July. Interestingly the representation of lepidopterans increased towards the end of the breeding season.

Discussion

Bee-eaters in our study lived up to their reputation as being predators of bees and wasps. We found that similarly to many studies car-

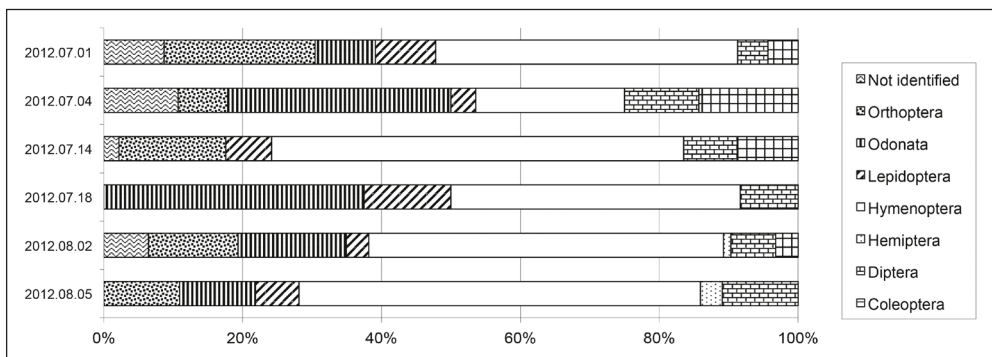


Figure 2. Temporal pattern of prey composition at the Albertirsa colony in 2012

2. ábra Az albertirsai gyurgyalag kolónián hordott táplálék időbeni mintázata 2012-ben

ried out in Hungary (Fintha 1968, Gyovai 1993, Laczik 1996), mainly hymenopterans, and members of the Apidae family, predominantly bumblebees (*Bombus* sp.) and Western Honey Bee (*Apis mellifera*) give the bulk of their prey. Similarly, Fintha (1968) found that based on the analysis of a dozen pellets collected around blooming alfalfa fields and aquatic habitats on the 11th July, 1960 around two third of their prey was hymenopterans. On a later sampling on the 2nd August, 1962 he found 70% of the prey belonged to bumblebees, and he explained it by the fact that the plants on the riverbank were blooming and hence attracted a lot of hymenopterans. He also noted that preying on Honey Bees was seldom observed, and happened only on cool, cloudy days, when flight activity of other insects was very low. Although it might be true, their damage might be more serious as stingless drones are selected as prey especially for feeding nestlings (Matousek 1951, Galeotti & Inglis 2001). Gyovai (1993) also emphasised the dominance of nectar feeding insects, and showed that almost 80% of their prey were hymenopterans. Their opportunistic prey selection was shown by Rékási and Haraszthy (2005), who found analysing pellets from a small colony situated in the great Hungarian Plain at Nagyiván, that one third of their prey was hemipterans, a very seldom hunted prey-type in our study. Laczik (1996) also emphasised that the ratio of Honey Bees in their diet was influenced by the distance of apiaries from the colony. This view is also supported by Costa (1991), who also found that food composition of the feeding birds near and further an apiary mirrors the availability of Honey Bees. Fry's (1983) study also demonstrated that European Bee-eaters prey mostly on those insects that are most available in their surrounding in a given time period. Swift's (1959) study carried out in South France also

showed that hymenopterans are the most important prey, followed by dragonflies, coleopterans, lepidopterans, dipterans and orthopterans. He concluded that the prey composition of Bee-eaters reflects the seasonal changes in the availability of flying insects. Three European studies on large samples of pellets showed that well above 60% representation and sometimes even the absolute dominance of hymenopterans. For example Austria: 83% (Ursprung 1979), Denmark: 59% in June then increasing to 91% in August (Larsen 1949), Spain 69% (Herrera & Ramirez 1974), and only the remaining small fraction was composed of coleopterans, dragonflies, orthopterans and lepidopterans, hemipterans dipterans. Our results showed a very similar composition with a dominance of hymenopterans in all colonies. The outstanding representation of dragonflies in 2012 in the food of Bee-eaters in the Pócsmegyer colony probably reflects the influence of nearby aquatic habitats. Likewise, the high ratio of dipterans in 2013 and orthopterans in 2012 in Albertirsa might reflect a local and temporal abundance of these insects.

Birds are widely acknowledged important predators of several insect taxa, for example adult butterflies, although hardly any field studies could demonstrate the degree of bird predation pressure on them, especially at a species level (Shreeve *et al.* 2009). Our study shows that Bee-eaters can occasionally predate on large-bodied papilionids and nymphalids, as well as day-flying moths (mainly noctuids and sphingids), dragonflies and bumblebees. Regarding our relatively short sampling periods, we suggest that predation by Bee-eaters may imply a significant component of adult mortality in some large-bodied butterflies. We found that Bee-eaters occasionally preyed on butterflies having deflective properties on their wings.

For example, papilionid species with wing tails (*Papilio machaon*, *Iphiclides podalirius*) and nymphalids having eyespots (*Apatura ilia*, *Inachis io*, *Maniola jurtina*) were equally present on the prey list. Therefore deflective properties of butterfly wings do not seem to effectively prevent Bee-eaters from preying on butterflies (see also Dennis *et*

al. 1986, Brakefield *et al.* 1992, Lyytinen *et al.* 2003, Stevens *et al.* 2008). However, further experimental testing is inevitable. Further studies would be clearly necessary in this issue. We suppose that body size of butterflies, as an important determinant of their profitability as preys, influences whether certain species are preyed by Bee-eaters or not.

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Appendix

Order	Family	Species	N
Coleoptera			36
Coleoptera	Scarabaeidae	<i>Cetonia</i> sp.	13
Coleoptera	Scarabaeidae	<i>Cetonia aurata</i>	5
Coleoptera	Scarabaeidae	<i>Melolontha</i> sp.	15
Diptera			50
Diptera	Asilidae		3
Diptera	Syrphidae	<i>Eristalis tenax</i>	1
Diptera	Tabanidae		13
Diptera	Tabanidae	<i>Tabanus bovinus</i>	3
Hemiptera			7
Hemiptera	Pentatomidae	<i>Palomena viridissima</i>	3
Hymenoptera			5
Hymenoptera	Apoidea		58
Hymenoptera	Apidae	<i>Apis mellifera</i>	34
Hymenoptera	Apidae	<i>Bombus</i> sp.	228
Hymenoptera	Apidae	<i>Xylocopa</i> sp.	25
Hymenoptera	Crabronidae	<i>Cerceris</i> sp.	1
Hymenoptera	Siricidae		1
Hymenoptera	Siricidae	<i>Sirex</i> sp.	1
Hymenoptera	Siricidae	<i>Urocerus gigas</i>	1
Hymenoptera	Vespidae		12
Hymenoptera	Vespidae	<i>Eumenes</i> sp.	1
Hymenoptera	Vespidae	<i>Polistes</i> sp.	3
Hymenoptera	Vespidae	<i>Vespa crabro</i>	8
Lepidoptera			9
Lepidoptera	Noctuidae		7
Lepidoptera	Noctuidae	<i>Agrotis segetum</i>	2
Lepidoptera	Noctuidae	<i>Autographa gamma</i>	1
Lepidoptera	Noctuidae	<i>Cucullia umbratica</i>	1
Lepidoptera	Noctuidae	<i>Helicoverpa armigera</i>	5
Lepidoptera	Noctuidae	<i>Noctua fimbriata</i>	1
Lepidoptera	Nymphalidae	<i>Apatura ilia</i>	4
Lepidoptera	Nymphalidae	<i>Inachis io</i>	1
Lepidoptera	Nymphalidae	<i>Maniola jurtina</i>	1
Lepidoptera	Nymphalidae	<i>Vanessa atalanta</i>	4
Lepidoptera	Nymphalidae	<i>Vanessa cardui</i>	5
Lepidoptera	Papilionidae	<i>Iphiclide podalirius</i>	2
Lepidoptera	Papilionidae	<i>Papilio machaon</i>	2
Lepidoptera	Sphingidae	<i>Hyles galii</i>	5
Lepidoptera	Sphingidae	<i>Hyles galii</i> v. <i>euphorbiae</i>	1
Lepidoptera	Sphingidae	<i>Macroglossum stellatarum</i>	6
Lepidoptera	Sphingidae	<i>Sphinx ligustri</i>	1
Odonata			101
Odonata	Aeshnidae		2
Odonata	Aeshnidae	<i>Aeshna</i> sp.	5
Odonata	Aeshnidae	<i>Aeshna affinis</i>	7
Odonata	Aeshnidae	<i>Aeshna cyanea</i>	2
Odonata	Aeshnidae	<i>Aeshna viridis</i>	6
Odonata	Aeshnidae	<i>Anax imperator</i>	1
Odonata	Gomphidae	<i>Gomphus flavipes</i>	5
Odonata	Libellulidae	<i>Orthetrum cancellatum</i>	2
Odonata	Libellulidae	<i>Sympetrum meridionale</i>	1
Orthoptera			24
Orthoptera, Ensifera			2
Orthoptera	Acrididae	<i>Calliptamus</i> sp.	25
Orthoptera	Acrididae	<i>Calliptamus italicus</i>	4
Orthoptera	Tettigonidae	<i>Tettigonia viridissima</i>	3

The observed prey listed by taxonomic resolution (A gyurgyalagok által fogyasztott táplálék rendszertani besorolása)