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THE DIET OF DIPPERS (*CINCLUS CINCLUS*) IN THE AGGTELEK KARST

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Abstract. The study highlights the changes in the food-composition of dippers (*Cinclus cinclus*) based on the method of pellet and faecal analyses. The collected reguriated pellets and faeces were analysed together with the evaluation of the potential food supply for dippers. By applying the two methods simultaneously, I managed to prove the change in the feeding tactics of dippers as well as the efficiency of the two methods.

Keywords: Aggtelek National Park, Cinclus cinclus, diet of dippers, faecal analysis, pellet analysis

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Introduction

The dipper (*Cinclus cinclus*) is a rare, endangered and a highly protected singing bird in Hungary. Individuals nestling on a regular basis can only be found in the clear and swift-running mountain streams abounding in water in the Bükk and Zemplén mountains and the Aggtelek Karst. Due to the natural endowments of the middle-ranged mountains of Hungary this species could not spread all over, in fact it could reach only marginal areas of Hungary. Therefore, Hungary has never had large populations of dippers.

Since our rivers became polluted their water output has decreased to a great extent due to the catchment and the inaccurate practices of forestry management. Thus the invertebrate wildlife has become extremely poor and has changed in many aspects furthermore, the nestling sites of our birds have become treated with concrete leading to a decreased number of birds. In the 1950s the estimated number of dipper pairs reached as far as 50, in 1983 only 23 pairs were recorded in Hungary (14 pairs in the Bükk mountains alone). By 1989 and then by 1992 this number fell to 9 and 3 pairs. In the mid 1990s there was only one pair nestling on the Aggtelek Karst (Horváth 1993, Horváth and Szép 1998, Horváth, Boldogh and Varga 1999)

So far 3 studies on the diet of dippers have been published in Hungary. The first one studied the stomach content of 482 individuals (Vollnhofer 1906) out of which only three had come from the present area of Hungary. The second research involved the analysis of only 39 reguriated pellets (Rékási 1985), therefore it provided rather poor data on this subject. Although the third paper focused exclusively on the winter diet of this species (Horváth and Andrikovics 1991) it involved the analysis of an extraordinary number of dipper pellets reaching as far as 1362.

Reguriated pellet sampling (Jost 1975a) and analysis (Jost 1975b, 1975c, Spitznagel 1985, 1988) are known to be quite wide-spread abroad with an extensive literature. Another method of the analysis, the faecal analysis has also been applied several times (Ormerod, Tyler and Lewis 1985, Ormerod, Boilstone and Tyler 1985, Ormerod 1985a, 1985b, Ormerod and Tyler 1986, Smith and Ormerod 1986, Ormerod, Efteland and Gabrielsen 1987). There has only been one attempt involving only a low number of samples, that is 15 pellets and 20 faecal pellets to compare the two different methods (Spitznagel 1985). Thus, up to this point there was not one thorough study to compare the two methods.

Almost all of the studies dealing with the diet and food-composition of the dippers focused on the indicative characteristics as well as the protection of this species (Andrikovics and Horváth 1997). Classical examples of this include the investigations that give account of the fact that the number of birds were decreasing and the diet, food-composition and food supplies of the dippers were also changing in parallel with the acidification of our rivers (O'Halloran, Gribbin, Tyler and Ormerod 1990, Ormerod and Tyler 1991, Tyler and Ormerod 1994).

My research was aimed at getting information about the food-content of the dippers nestling on the area of the Aggtelek Karst. I have observed that in spring dippers tend to feed on and show a preference for caddisfly larvae. During the study I was to support these observations with precise data. I wanted to learn whether and how the diet of the dippers changes with the breeding season. Furthermore, I wanted to draw a comparison between the results of the reguriated pellet and the faecal analysis to see whether the two methods could be successfully applied together. The two applied methods could be a great help in assessing and studying dipper populations as well as protecting their habitats, which could eventually lead to bringing the decrease in the numbers of dippers to an end.

The study area

The study area coincided with the distribution of dippers in Hungary (Horváth 1988, Horváth and Szép 1998). We collected samples from the dippers nestling on the area of the Aggtelek Karst, around the river-head of the Jósva stream and lake Tengerszem. The Jósva stream forms several branches with artificial or partially natural streambeds, all heading towards Tengerszem lake. The environment of the current leaving behind the storage lake is completely natural.

Methods

We collected samples from the above mentioned regions both during the winter period (November-December) in 1991 and during the following breeding season (February-March) in 1992 (Table 1). On the artificially constructed bank where the dippers foraged for food on a regular basis we managed to collect the characteristic faecal and reguriated pellets of the adult dippers. The conspicuous empty shells of the Trichoptera larvae (Jost 1972) that were eaten by the dippers were also collected at this site. We tried to identify the caddisflies consumed by dippers on the basis of these, as well.

The benthic fauna of the riverbed serving as a potential food resource was collected with the aid of a special net, at the feeding sites of the birds. During sampling we made an attempt to collect samples the same way each time by focusing on the fact that both the number and the length of each drawing should be the same.

The reguriated pellets and the faeces were collected simultaneously in the winter of 1991 and in

Table 1. Data obtained from dipper faeces, reguirated pellets, empty caddisfly shells and potential prey items collected near the river-head of the Jósva stream and Tengerszem lake in relation to the breeding period of dippers.

Data	Pellet Gammarus/Trichoptera %	Faecal Gammarus/Trichoptera %	Caddisfly shells	Breeding of Dipper
04.09.1991			none	hatch
16. 04.			10/day	hatch out
20.04.- 01. 05.			203-489	
03. 05.			115	nestling fly away
06-0805.			244-344	
09. 05.			59	
10-13. 05.			10	nestling independent
end of November	89 / 6,5	69 / 5,6		
first part of December	82 / 17	78 / 9,3		
18-20. 02.1992	76 / 18	72 / 12		
12. 03.	67 / 31	60 / 18	none	
18-20. 03.	38 / 60	42 / 35	1-6	
22. 03.			140	
24. 03.	52 / 47		71	
25. 03.			32	
27. 03.	37 / 62		103	
28. 03.			29	
30. 03.			24	hatch out
06. 04.			98	nestling destroyed

1992. The reguriated pellets were preserved in 70 % alcohol, hand-sorted and then they were examined under a stereobinocular microscope at magnifications X40-X100 (Spitznagel 1985, 1988). The dipper faeces were fixed in M/2 sodium hydroxide solution for four hours (Ormerod 1985a). Only after this were the remains of the prey items identified. The benthic fauna (as a possible food supply) of the riverbed was preserved in 70% alcohol and was identified using a microscope. The individuals of *Salamandra salamandra* were not collected since they are protected species. These individuals were pooled and soon after sampling they were released. Only after identification did we dry and weigh the prey items. In the results the dry weights are given and the values are percentage contributions by dry weight.

The empty caddisfly shells were collected and counted in the breeding season of 1991 and 1992. The empty shells collected in 1991 were identified under a microscope whereas those sampled in 1992 were not identified. Nevertheless, the proportion of empty caddisfly shells of 1991 and 1992 were more or less the same (Table 1).

The remains of the prey items were identified to the lowest taxon possible. During the study we identified a total of 5 samples of potential food resources (with 4.985 individuals) including 210 reguriated pellets (90 out of which were collected in winter and 120 in the breeding period), 209 pieces of faeces (80 collected in winter and 129 in the breeding season) and 2900 empty caddisfly shells.

Results

The results of the analyses of the samples (i.e. the potential food resources)

2077 individuals (as potential prey items for dippers) belonging to 6 species and one higher taxon were identified in the winter sample of 1991 (Table 2). *Gammarus fossarum, Sadleriana pannonica* and Coleoptera larvae were the most abundant in the sample. Interestingly enough, only 11 individuals of Trichoptera larvae were found in it.

A total of 2908 individuals (as a potential food resource) belonging to one vertebrate and 10 invertebrate taxa were identified in the three samples collected during the breeding season (Table 2). *Gammarus fossarum* and *Sadleriana pannonica* were present here with the largest numbers. The ratio of *Gammarus fossarum* and *Sadleriana pannonica* in the four samples did not change significantly. However, there was an increase in the proportion of Trichoptera larvae. Although it increased more than tenfold, it still did not reach 10 %.

Table 2. The range of potential prey items for dippers near Jósva stream during the winter of 1991 and the spring of 1992 (number and percentage)

<table>
<tr><th rowspan="2"></th><th rowspan="2">Glossiphonia complana (Annelida)</th><th rowspan="2">Gammarus fossarum</th><th rowspan="2">Ephemera vulgata</th><th rowspan="2">Coleoptera larva</th><th>Trichoptera sp.</th><th>Parachiona picicornis</th><th>Sericostoma personatus</th><th>Sericostoma turbatum</th><th>Chaetopteryx sp.</th><th>Limnephilidae</th><th rowspan="2">Sadleriana pannonica</th><th rowspan="2">Succinea putris</th><th rowspan="2">Laciniaria turgida</th><th rowspan="2">Arionidae</th><th rowspan="2">Salamandra salamandra (Amphibia)</th><th rowspan="2">Total number</th></tr>
<tr><th colspan="6">TRICHOPTERA</th></tr>
<tr><td rowspan="2">01.12.199</td><td rowspan="2"></td><td rowspan="2">1390 ind 66,9 %</td><td rowspan="2">20 ind 1,0 %</td><td rowspan="2">32 ind 1,5 %</td><td rowspan="2"></td><td>1 ind</td><td>7 ind</td><td>3 ind</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">624 ind 30 %</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">2.077</td></tr>
<tr><td colspan="3">0,5 %</td></tr>
<tr><td>21.02.1992</td><td>7 ind</td><td>437 ind 61 %</td><td></td><td>1 ind</td><td></td><td></td><td></td><td></td><td>9 ind 1,2 %</td><td></td><td>248 ind 35 %</td><td>9 ind</td><td>1 ind</td><td></td><td></td><td>712</td></tr>
<tr><td rowspan="2">22.03.1992</td><td rowspan="2"></td><td rowspan="2">553 ind 46 %</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td>47 ind</td><td>16 ind</td><td rowspan="2">576 ind 48 %</td><td rowspan="2">9 ind</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">1.201</td></tr>
<tr><td colspan="2">5,2 %</td></tr>
<tr><td>30.03.1992</td><td></td><td>347 ind 52 %</td><td></td><td>1 ind</td><td>56 ind 8,4 %</td><td></td><td></td><td></td><td></td><td></td><td>258 ind 39 %</td><td></td><td></td><td></td><td>1 ind</td><td>663</td></tr>
<tr><td>06.04.1992</td><td></td><td>134 ind 40 %</td><td></td><td></td><td>17 ind 5,1 %</td><td></td><td></td><td></td><td></td><td></td><td>177 ind 53 %</td><td>2 ind</td><td></td><td>2 ind</td><td></td><td>332</td></tr>
</table>

Table 3. The results of reguriated pellet for dippers during the winter of 1991 and the spring of 1992 (number and dry weight)

	Gammarus fossarum	*Anacaena globulus*	*Lymnus volcmari*	TRICHOPTERA: Trichoptera indet.	TRICHOPTERA: *Hydropsyche* sp.	TRICHOPTERA: *Rhyacophila* sp.	Lepidoptera caterpillar	*Sadleriana pannonica*	Part of plants	Stone	Total weight Number of pellet Average weight
10.1991	2,9499 g 89,29 %			0,1100 g 3,33 %	0,0420 g 1,27 %	0,0636 g 1,93 %	0,0620 g 1,87 %	5 ind	0,0120 g 0,36 %	0,0642 g 1,94 %	3,3037 g 30 pcs 0,1101 g
					6,53 %						
12.1991	5,2056 g 82,29 %	0,0119 g 0,18 %			0,4391 g 6,94 %	0,6548 g 10,35 %		3 ind	0,0012 g 0,01 %	0,0132 g 0,2 %	6,3258 g 60 pcs 0,1054 g
					17,29 %						
18-20. 02.1992	6,3846 g 76,73 %	0,0102 g 0,12 %	0,0016 g 0,02 %	0,3666 g 4,41 %	0,6896 g 8,28 %	0,4896 g 5,88 %		7 ind	0,0820 g 0,99 %	0,2962 g 3,56 %	8,3204 g 65 pcs 0,1280 g
					18,58 %						
12.03. 1992	1,6140 g 67,92 %		0,0011 g 0,04 %	0,3706 g 15,59 %	0,1712 g 7,20 %	0,2072 g 8,72 %		42 ind	0,0020 g 0,08 %	0,0104 g 0,44 %	2,3765 g 20 pcs 0,1188 g
					31,52 %						
18-22. 03.1992	1,0190 g 38,14 %		0,0019 g 0,07 %	0,8422 g 31,52 %	0,4211 g 15,76 %	0,3428 g 12,80 %		12 ind	0,0021 g 0,08 %	0,0427 g 1,60 %	2,6718 g 21 pcs 0,1272 g
					60,11 %						
24-25. 03.1992	0,2105 g 52,59 %		0,0011 g 0,27 %	0,0813 g 20,31 %	0,0668 g 16,69 %	0,0406 g 10,14 %		1 ind			0,4003 g 4 pcs 0,1001 g
					47,14 %						
27.03. 1992	0,4314 g 37,70 %		0,0016 g 0,14 %	0,4212 g 36,81 %	0,1032 g 9,02 %	0,1868 g 16,33 %					1,1442 g 10 pcs 0,1144 g
					62,16 %						

The results of the pellet analysis

The 90 reguriated pellets collected on two occasions in the winter period of 1991 have much in common (Table 3). The majority of their dry weigh was provided by *Gammarus fossarum* in both samples (89% and 82 %). The number and proportion of Trichoptera larvae, however, showed a slight increase: from 6,5% over 17%.

During the spring of 1992 we collected samples on six different occasions. In the breeding season 120 reguriated pellets with individuals belonging to 6 invertebrate species as well as plant matters and smaller stones were found. Almost all the samples contained large numbers of *Gammarus fossarum* and various Trichoptera species (Table 3). Taking a closer look at the tables, it becomes obvious that while the proportion (77%) of *Gammarus fossarum* in the 65 pellets of February is similar to the values of the November and December samples of 1991 (89 % and 82 %), it keeps decreasing gradually in the successive pellets until it reaches 37 %. In the meantime the ratio of caddisflies seemed to be increasing in the samples (from 19 % to 62 %).

The results of the faecal analysis

At the end of 1991 we did not collect only reguriated pellets but faeces, as well. In the winter period 80 pieces of dipper faeces were gathered on two occasions. The faecal analysis revealed similar results as the reguriated pellet analysis (Table 4). In the second sample the proportion of Trichoptera larvae also rose from 6 % over 9 % in the faeces. Moreover the increased number of small stones in the November sample is also of high significance.

During the spring of 1992 we collected 129 pieces of faeces simultaneously with pellets. The results of the faecal analysis are close to that of the reguriated pellet analysis. The ratio of caddisflies increased from 12 % to 35 % at the expense of that of the Amphipods. Simultaneously, the portion of *Gammarus* decreased to 42 %.

The results of the identification of the caddisfly shells

98.9 % (i.e. 2868 pieces) of the 2900 empty caddisfly shells, which were collected in 1991, were

Table 4. The results of faecal analysis for dippers during the winter of 1991 and the spring of 1992 (dry weight)

	Gammarus fossarum	*Gammarus* – Trichoptera	Coleoptera indet.	*Lymnus volcmari*	Trichoptera indet.	*Rhyacophila* sp.	*Hydropsyche* sp.	*Sadleriana pannonica*	Secondory product of digestion	Stone	Total weight Number of faecal Average weight
11.1991	0,8831 g 69,81 %	0,1124 g 8,89 %		0,0340 g 2,69 %	0,0327 g 2,58 %	0,0244 g 1,93 %	0,0138 g 1,09 %		0,0668 g 5,28 %	0,0978 g 7,73 %	1,2650 g 20 pcs 0,0632 g
						0,0709 g 5,60 %					
12.1991	2,3082 g 78,47 %	0,2606 g 8,86 %		0,0016 g 0,05 %		0,0978 g 3,32 %	0,1772 g 6,02 %		0,0966 g 3,28 %		2,9420 g 60 pcs 0,0490 g
						0,2750 g 9,35 %					
18.02.1992	2,8681 g 72,20 %	0,4482 g 11,28 %	0,0012 g 0,03 %			0,2107 g 5,30 %	0,2812 g 7,08 %		0,0826 g 2,08 %	0,0800 g 2,02 %	3,9720g 72 pcs 0,0552 g
						0,4919 g 12,39 %					
12.03.1992	0,8012 g 60,47 %	0,1341 g 10,12 %				0,1279 g 9,65 %	0,1218 g 9,19 %	2 ind	0,1213 g 9,16 %	0,0188 g 1,41 %	1,3251 g 20 pcs 0,0663 g
						0,2497 g 18,84 %					
18.03.1992	1,0066 g 42,39 %	0,4042 g 17,02 %			0,3640 g 15,32 %	0,1981 g 8,34 %	0,2842 g 11,96 %		0,0846 g 3,56 %	0,0329 g 1,39 %	2,3746 g 37 pcs 0,0642 g
						0,8463 g 35,64 %					

successfully identified to subgenus or family. 65 % of the identified caddisflies belongs to the *Anabolia* and *Halesus* subgenus. Furthermore, individuals belonging to the following two taxa: the *Allogamus* subgenus (12 %- 349 pieces) and the Limnephilidae family (11% - 321 pieces) were present in large numbers. In Table 1 it is evident that there is a correlation between the feeding period of the nestling and the mass appearance and disappearance of the empty shells of Trichoptera larvae (larvae eaten by dippers).

Table 1 well demonstrates that despite the early nestling, the mass appearance of the empty shells of the Tricheroptera larvae, which are consumed by dippers, also correlated with the nestling period of these birds in 1992. Unfortunately the diurnal fluctuations in the number of caddisflies could not have been accurately observed because of the heavy tourist industry and the subsequent disturbances.

Discussion

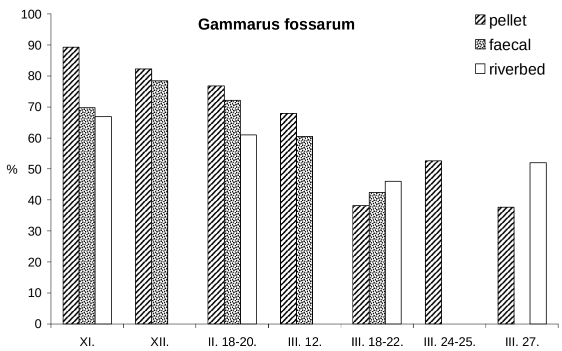
The results of the pellet and the faecal analysis

The results of the faecal analysis can be used at least on the area of the Aggtelek National Park. We could now compare it with the results of the modified (Spitznagel 1985) reguriated pellet analysis (Figs 1. and 2.). The results of the faecal and pellet analyses, which have been carried out simultaneously, seem to be very similar. They show slight differences in only few cases and these minor differences are far from showing any real tendencies. This method thus makes it possible to apply the faecal analysis alone when assessing the diet of dippers and to compare the results of the reguriated pellet and faecal analysis within smaller regions.

Diet of dipper

The reguriated pellet an faecal analyses proved the presence of 9 invertebrate animals (taxa), as well as small stones, plant matters and feathers. The feathers and the various plant tissues (mainly taken from mosses) are likely to have been mixed with the samples while collecting them. The small stones (perhaps stones present in the gizzard of the birds) may also have got mingled with the samples the same way.

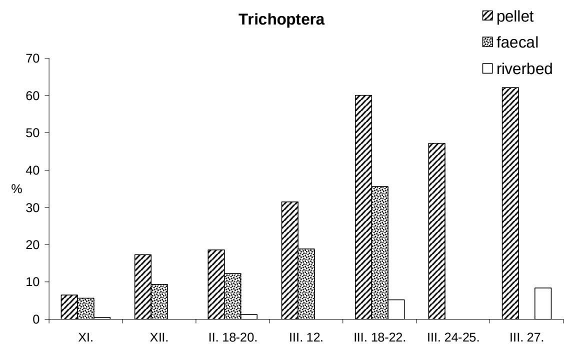
The data of the reguriated pellet analysis supports our earlier observations (Rékási 1985, Horváth and Andrikovics 1991), namely that *Gammarus* is predominant (over 80 %) in the winter diet of dippers in Hungary. Such high values have only been reported from the area of Angara (Pastuchov 1961). Having examined more than 6000 items of food, the author reported a proportion of 93,8 %. Although in Germany the ratio was alleged to be below 40 % (Jost 1975/B, Spitznagel 1985), there were some pellets with a dominance of more than 90 % (Spitznagel 1985). In Wales 5,4 % of the number prey and 3,2 % of the mass pray *Gammarus* made up. Nevertheless, it was not found in the dipper pellets in Spain (Santamarina 1990) and Morocco (Tyler and Ormerod 1991).



1. Fig. The ratio of *Gammarus* on the diet of Dippers.

In Hungary the proportion of *Gammarus* in the dippers' diets sometimes starts dropping even in February, at the beginning of the nestling period. By the time the nestlings have hatched, it does not even reach 50 %. In the meantime, the ratio of Trichoptera larvae is gradually increasing, sometimes it may even exceed 60 %. Similar data was observed and obtained in Germany (Jost 1975b, Spitznagel 1985), in Spain (Santamarina 1990) and Scotland (Vickery 1988). In Wales (Ormerod and Tyler 1986), Ireland (Tyler and Ormerod 1991) and Norway (Ormerod, Efteland and Gabrielsen 1987) the ratio of Trichoptera larvae in the reguriated pellets of dippers reached as far as 30 %.

Still, it is noteworthy that on the area of the Carpathian Basin (not on the present territory of Hungary) a proportion of 10 % of *Gammarus* and about 50 % of *Trichoptera* was recorded in 1906 (Vollnhofer 1906). We should also emphasise the fact that the data was obtained by analysing the stomach-content of shot and dissected individuals from more than 1000 metres above sea level.



2. Fig. The ratio of caddisflies on the diet of Dippers.

Studying the benthic fauna of the stream it became evident that the reason for the previously recorded predominance of *Gammarus* (Rékási 1985, Horváth and Andrikovics 1991) during the winter period lies in the composition of available food resources. In winter mostly *Gammarus* and *Sadleriana pannonica* were abundant in the stream as well as smaller numbers of caddisfly larvae without shells. That is the reason why dippers tended to feed on *Gammarius*.

At the end of winter, however, the ratio of caddisflies (as a potential food resource) rose and exceeded 8 % (Table 2). The increase is even more significant if we exclude *Sadleriana pannonica*, towards which dippers do not show much preference and which they rarely feed on. In this case the proportion of caddisflies (as potential food resources) reaches up to 10 % (30^{th} March: 14 %, 6^{th} April: 11 %). Dippers seem to exploit it since the ratio of Trichoptera larvae was gradually increasing in its food. These are primarily the so called caddisflies without shells (*Hydropsyche*, *Rhyacophila*), which are abundant here (Nógrádi – Uherkovics, 1988). Just before the nestlings hatch, the proportion of caddisflies in the dippers' diet swells even exceeding that of the Trichoptera available in the benthic fauna (Table 1 and 2). This even supports the idea that dippers tend to show preferences for certain foods within the available prey, namely they seem to prefer caddisfly larvae. An evident explanation for this is the difference in the energy content between the two prey types. While *Gammarus* provides the birds with 3900 cal/g energy, Trichoptera larvae mean 6000 cal/g. This might even be supported by the observation that when the nestlings hatch, the number of caddisflies (mainly *Halesus*) start to swell (Table 1).

It is conspicuous how little role *Sadleriana pannonica* plays in the diet of the dippers (Tables 3 and 4), though they are present in great numbers all over the year (Table 2). It is the size of the shell and the great percent of indigestible parts (more than 46 %) that accounts for the dippers' lack of preference for these prey (Horváth and Andrikovics 1991).

On the basis of the above mentioned data (and our observations using binoculars) we could say that like in Wales and Norway (Omerod 1985a, Ormerod, Efteland and Gabrielsen 1987) dippers also feed their nestlings with caddisflies in Hungary. Owing to some failed experiments, however, we did not succeed in proving this directly either by the method of ligature nor by an artificial nestling. My theory can also be supported by the fact that *Gammarus* was not proved from the faeces of the nestlings.

The changes in the feeding strategies of the dippers have already been mentioned by researchers (Ormerod, Efteland and Gabrielsen 1987). Still the details of the process and the transition have not been thoroughly examined. Therefore studies involving such questions may be relevant for further research. They could help us reveal the correlation between water pollution, the transformations and changes in the invertebrate aquatic wildlife and the disappearance of dippers.

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