

## The Occurrence of Cestodes in the Individual Orders of Birds and the Influence of Food on the Composition of the Fauna of Bird Cestodes

B. RYŠAVÝ

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

**Abstract.** The paper deals with the relation between the occurrence of cestodes in birds and the composition of the nutrition of these definitive hosts. The animal component in the birds' food influences greatly the occurrence of some cestode species. An important factor is the type of biotope on which the bird hosts live. Even birds of one order living on different biotopes, have a different composition of their cestodofauna, because their nutrition varies with the biotope, they feed on different intermediate hosts and thus become infected with the invasive stages of different cestode species. On the other hand the composition of the fauna of cestodes of birds of different orders, feeding on the same food, is very likely to be identical.

The formation of the helminthofauna and especially of the fauna of cestodes of birds, has been affected by several basic factors such as the phylogenetic parasite-host relations manifesting the parasitization of certain groups of birds by certain groups of cestodes. All these relations were studied and analysed by FUHRMANN and recapitulated in the so-called rule of FUHRMANN and SKRYABIN (RYZHIKOV 1964). The entire complex of other factors exerting influence on the formation of the cestodofauna of birds, especially the mode of living involving the composition of the food (DOGEL 1948), should not be omitted.

When grouping the orders, respectively families of birds from our material of cestodes of Czechoslovakia for obtaining a picture of the percentage of invasions by cestodes (Tab. 1) this has been found highest in birds living on the water and in swamps. The external environment of these birds not only provides them with food but it includes also places with the highest concentration of the intermediate hosts of the cestodes on considerably small areas such as ponds with their littoral zone, swamps, wet meadows, blind river arms a.o. Such heavy concentrations of intermediate hosts of the cestodes are not to be found with terrestrial birds since they are always distributed over much wider areas and the birds themselves cover greater distances in their daily flights. This accounts for the considerably lower percentage of invasion by cestodes. An analysis of the cestode invasion of birds, based on the

Order	Predominant mode of living	Predominant type of food	Percentage of cestode load
<i>Anseriformes</i>	water	mixed	92.3
<i>Pelecaniformes</i>	water	animals	91.7
<i>Colymbiformes</i>	water	animals	90.2
<i>Ralliformes</i>	water or swamp	mixed	71.7
<i>Charadriiformes</i>	swamp	animals	61
<i>Ciconiiformes</i>	swamp	animals	58
<i>Lariformes</i>	water partly terrestrial	animals	52.3
<i>Piciformes</i>	terrestrial	animals	43.3
<i>Passeriformes</i>	terrestrial	mixed	32
<i>Galliformes</i>	terrestrial	mixed, predominantly plants	31
<i>Falconiformes</i>	terrestrial	animals	7
<i>Strigiformes</i>	terrestrial	animals	5
<i>Columbiformes</i>	terrestrial	plants	1.07

type of food, revealed that the groups living on animal — or mixed food are most heavily invaded. Of the birds living on mixed food, the highest percentage of cestode invasions was found in groups where the animal component of the food consisted mostly of the intermediate or even of the reservoir hosts of the cestodes irrespectible whether these were invertebrates or vertebrates.

On the grounds of our material comprising over 4,000 helminthologically examined birds (the majority of them were caught on the south Bohemian fish ponds) — (RYŠAVÝ 1961, 1962) we succeeded to solve, besides systematically faunistical problems, also some ecological questions, especially the problem of the life cycles of cestodes and the effect of food on the occurrence and the distribution of cestodes in some orders of birds.

The area in south Bohemia, where swamp- and water birds live for most of their life and where they also devour most of their food, can be divided into three principal zones:

1. The zone of damp meadows along the banks
2. The littoral zone
3. The zone of open waters

This division is practically the same as the one introduced by HEJNÝ (1960) for water- and swamp plants. HEJNÝ's limose phase may answer to our zone of the damp meadows, his littoral phase to our littoral zone and his hydrophase to our zone of the open waters. Although HEJNÝ's division is concerned with the vegetation, it may also serve for some helminthological studies.

The zone of the damp meadows along the banks is mostly inhabited by birds of the order *Charadriiformes* and by some representatives of the order *Ralliformes* (*Rallus aquaticus*, *Crex crex* and *Porzana porzana*).

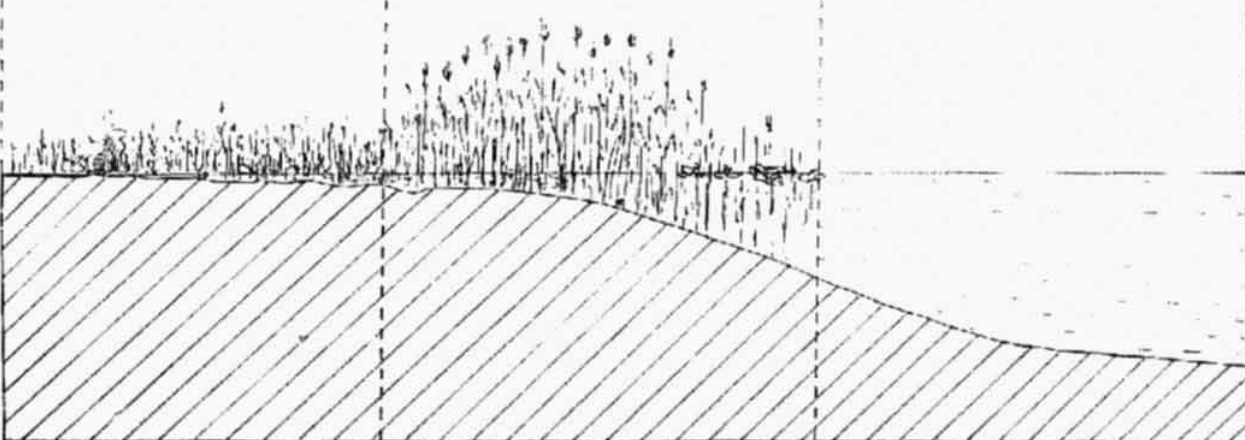
Zone of moist meadows along banks (limose phase)		Littoral zone (littoral phase)		Open water zone (hydrophase)
<b>Charadriiformes</b>	<b>Ralliformes</b>	<b>Anseriformes</b>	<b>Ralliformes</b>	<b>Colymbiformes</b>
<i>Vanellus vanellus</i> <i>Tringa totanus</i> <i>Capella gallinago</i> <i>Limnocryptes minimus</i> <i>Charadrius dubius</i>	<i>Crex crex</i> <i>Porzana porzana</i> <i>Rallus aquaticus</i>	<i>Anas platyrhynchos</i> <i>A. platyrhynchos dom.</i> <i>Anas strepera</i> <i>Aythya fuligula</i> <i>Nyroca ferina</i> <i>Anas crecca</i>	<i>Fulica atra</i> <i>Gallinula chloropus</i>	<i>Podiceps cristatus</i> <i>Podiceps nigricollis</i>
Animal food: Insecta (Orthoptera, Coleoptera, Diptera), Mollusca (Succineidae), Oligochaeta		Mixed food: The animal component consisting of Mollusca, Copepoda, Ostracoda, Insecta (larvae), Oligochaeta		Animal food: fishes, water insect, principally larvae
				
Predominant cestode families		Predominant cestode families		Predominant cestode families
<b>Dilepididae</b>	<b>Hymenolepididae</b>	<b>Hymenolepididae</b>	<b>Hymenolepididae</b>	<b>Hymenolepididae</b>   <b>Amabiliidae</b>
Intermediate hosts: Succineidae (Mollusca), Insecta, Oligochaeta	(genus <i>Aploparaksis</i> ) Intermediate hosts: Oligochaeta	Intermediate hosts: Copepoda, Ostracoda, Reservoir hosts: Water Mollusca	Intermediate hosts: (?)	Intermediate hosts: Insecta (larvae), Copepoda (?)
			<b>Ligulidae</b>	Intermediate hosts: fishes

Fig. 1.

In the littoral zone, the majority of *Anseriformes* spend most of their life but some *Ralliformes* may also be found there (*Fulica atra* and *Gallinula chloropus*).

The zone of the open waters is mostly inhabited by the representatives of the order *Colymbiformes* (Fig. 1).

Table 1 shows that in our material the heaviest invasions occurred in birds of the order *Anseriformes* (93 %). Although the birds of this order live on mixed food, the principal component are water organisms which, in the majority of cases, are either intermediate or reservoir hosts of the cestodes. In these *Anseriformes* we found 30 species of cestodes, 29 of them belonging to the family *Hymenolepididae* and the rest, the species *Anomotaenia ciliata* Fuhrmann, 1913, to the family *Dilepididae*.

During their development most cestodes of the family *Hymenolepididae*, parasitising *Anseriformes*, have to pass through plankton crustaceans such as *Ostracoda*, *Copepoda*, exceptionally also through *Oligochaeta* (the cestode *Aploparaksis furcigera*; its intermediate host is *Lumbriculus variegatus*) or through *Hirundina*—the intermediate host for *Kowalewskius parvulus* is the leech *Herpobdella atomaria*. The reservoir host, however, may also become a source of invasions with cestodes of the family *Hymenolepididae*, because the invasive phases of these cestodes, the cysticeroids, amass in it. This concerns mostly water snails (*Lymnaea ovata*, *L. peregra*, *L. stagnalis* a.o.). All these organisms are constantly present in the food of the birds of the order *Anseriformes* and devoured by them in great numbers. According to CHARIN and TALYSIN (1953) a single domestic duck, left on the pond for 20 min, ingests 16,000 specimens of *Daphnia magna* at various developmental stages 1,817 specimens of plankton crustaceans (*Ostracoda* and *Copepoda*), 265 specimens of water *Oligochaeta*, 159 specimens of water snails, principally the species *Lymnaea peregra* and *L. ovata*, *Pisidium* sp. a.o., and 20 specimens of leeches. These data were confirmed in repeated experiments by both authors. We obtained practically the same results in our experiments carried out on the artificial fish ponds in southern Bohemia and southern Moravia.

The food composition of the birds of the order *Ralliformes* (*Fulica atra*, *Gallinula chloropus* and mainly of birds inhabiting also the littoral zone) resembles that of the *Anseriformes* although, according to our preliminary investigations, there is a preference for the vegetation component, the animal component of their food is very similar to that of the *Anseriformes*. Both mentioned species are predominantly invaded by cestodes of the family *Hymenolepididae* and some species are found in both orders (*Diorchis inflata*, *D. ransomi*, *Microsomacanthus compressa*, *Dicranotaenia coronula*, *Tschertkowilepis setigera*). On ponds where great numbers of domestic ducks are being kept the percentage of the invasion with cestodes, typical for *Fulica atra* and *Gallinula chloropus*, is very high (Tab. 2).

Very different is the composition of the cestodofauna of the other representatives of the order *Ralliformes* (*Crex crex*, *Rallus aquaticus* and *Porzana porzana*) living in the zone of the meadows along the banks. We observed only two cestode species—*Anomotaenia pyriformis* and *Aploparaksis porzana*—not found previously in *Fulica*

**Table 2.** Composition of the fauna of cestodes in birds of the order *Ralliformes* from southern Bohemian fishponds 162

Cestode species	Water birds		Swamp birds			Intermediate hosts
	<i>Fulica atra</i>	<i>Gallinula chloropus</i>	<i>Crex crex</i>	<i>Rallus aquaticus</i>	<i>Porzana porzana</i>	
<i>Diorchis inflata</i>	+	—	—	—	—	<i>Ostracoda</i>
<i>Diorchis acuminata</i>	+	—	—	—	—	<i>Ostracoda</i>
<i>Diorchis ransomi</i>	+	+	—	—	—	<i>Ostracoda</i>
<i>Dubininolepis multistriata</i>	+	—	—	—	—	?
<i>Microsomacanthus compressu</i>	—	+	—	—	—	<i>Copepoda</i> , reservoir host <i>Mollusca</i>
<i>Dicranotaenia coronula</i>	—	—	—	—	—	<i>Copepoda</i> , reservoir host <i>Mollusca</i>
<i>Tschertkovilepis setigera</i>		—	—	—	—	<i>Copepoda</i> , <i>Ostracoda</i>
<i>Aploparaksis porzana</i>	—	—	—	—		?
<i>Anomotaenia pyriformis</i>	—	—	+	+	+	<i>Lumbriculus variegatus</i> ( <i>Oligochaeta</i> )
<i>Tatria acanthorhyncha</i>	+	—	—	—	—	<i>Agrion puella</i> (larvae?)

*atra* and *Gallinula chloropus* although the biotopes of both bird orders are only at a distance of a few meters from each other. The results of an analysis of the pharynx and stomach of *Crex crex* disclosed that this species feeds exclusively on animals, i.e. principally on various insects (*Orthoptera*, *Coleoptera*, larvae of *Tabanidae* and *Tipulidae*), on swamp *Oligochaeta* and *Mollusca*, mostly representatives of the family *Succineidae*.

The different way of living and the different composition of the food of the birds of one order expressively affects the composition of the fauna of their cestodes even when living in close vicinity.

Birds of the order *Colymbiformes* live mostly in the zone of the open waters and feed on animals. The fauna of cestodes of these birds differs from all the other groups of birds. Predominant are cestodes of the genus *Dubininolepis* (*D. furcifera*, *D. capillarioides*, *D. podicipina* and *D. multistriata*) and of the family *Amabiliidae* (representatives of the genus *Tatria* and *Schistotaenia*). Of all these cestodes only

163 *Dubininolepis multistriata* was found in *Anseriformes* (*Nyroca nyroca*) and in *Ralliformes* (*Gallinula chloropus*). One more species found in *Colymbiformes* is *Ligula colymbi* which is closely connected with the feeding on fishes.

With the exception of the species *Ligula colymbi*, nothing is known of the life histories of the cestodes parasitizing birds of the order *Colymbiformes*. LINSTOW (1892) and MRÁZEK (1905, 1926) found that the intermediate hosts of the cestode *Tatria acanthorhyncha* are the larvae of *Agrion puella*; contrary to that JARECKA (1960) indicates that the intermediate host of this cestode is the copepod *Macrocyclops albidus*. The little information available on the life history of these cestodes is too scanty for analysing the relation of food and the composition of the fauna of cestodes parasitizing birds of the order *Colymbiformes*. It may, however, be possible to apply the rule of Fuhrmann because the *Colymbiformes* are phylogenetically distant from all other water birds which is reflected in a very different fauna of their cestodes.

The birds of the order *Charadriiformes* are typical swamp birds, the composition of their food is very similar to that of the *Ralliformes* (insects, swamp *Oligochaeta*, *Mollusca*—mainly of the family *Succineidae*). The dominant cestodes are representatives of the family *Dilepididae* (in our material 6 cestodes belonged to the family *Dilepididae* and only 3 cestodes to *Hymenolepididae*). All cestode species of the family *Hymenolepididae* observed by us belonged to the genus *Aploparaksis* and their life cycle is bound to the *Oligochaeta*. The only cestode of the family *Dilepididae* with a known life history is the species *Anomotaenia citrus*, its intermediate host is the mollusc *Succinea putris*.

In their development the birds of the order *Lariformes* resemble the birds of the order *Charadriiformes*. Some simultaneous observations were made on the fauna of cestodes in *Larus ridibundus* and *Sterna hirundo* in biotopes of southern Bohemia. While *Sterna hirundo* feeds mostly on fish, the food of *Larus ridibundus* is very variegated including water insects and their larvae, occasionally small fishes, reptiles, amphibians, terrestrial insects, small mammals and other animals. In search of food this bird covers great distances and has been observed even to devour wastes in towns and villages close to his nesting colonies. The evidence of the composition of the fauna of the cestodes obtained from our comparative studies in southern Bohemia shows many differences. In *Sterna hirundo* we observed only 2 cestode species—*Ligula intestinalis* and *Paricterotaenia sternina*, while in *Larus ridibundus* we found the species *Aploparaksis fusus*, *A. cirrosa*, *Paricterotaenia porosa*, *P. gongyla*, *Tetrabothrium erostre* and *Ligula intestinalis*, which is very rare in *L. ridibundus* but quite common in *Sterna hirundo* (Tab. 3).

Similar differences in the composition of the fauna of cestodes parasitizing birds of one order could also be observed in *Ciconiiformes*. We investigated the fauna of cestodes of three species, *Ciconia ciconia*, *Ardea cinerea* and *Nycticorax nycticorax*. While *A. cinerea* and *N. nycticorax* are fish-eating birds, the species *Ciconia ciconia* feeds mainly on reptiles, amphibians, bigger terrestrial insects, small mammals and quite exceptionally on fishes. This variety of food is also reflected by the fauna

**Table 3.** Comparison of cestode species parasitizing *Larus ridibundus* and *Sterna hirundo*

Cestode species	<i>Larus ridibundus</i>	<i>Sterna hirundo</i>
	Nutrition	
	insects, small fishes, reptiles, micromammalia, occasionally various fruit	fishes, occasionally water insects
<i>Aploparaksis fusus</i>	+	
<i>Aploparaksis cirrosa</i>	+	
<i>Paricterotaenia porosa</i>	+	
<i>Paricterotaenia gongyla</i>	..	
<i>Paricterotaenia sternina</i>		+
<i>Tetrobathrium crostre</i>	+	
<i>Ligula intestinalis</i>		

of its cestodes. In *C. ciconia* we found only one cestode species, *Anomotaenia discoides*, while in *Ardea cinerea* and *Nycticorax nycticorax* we observed 3 species—*Dilepis unilateralis*, *Gryphorhynchus pusillus* and *G. cheilancristrotus*. All species of cestodes from *A. cinerea* and *N. nycticorax* are bound to fishes by their life cycle (Tab. 4).

**Table 4.** Comparison of the cestode fauna of *Ciconia ciconia* and the other representatives of the order *Ciconiiformes* in southern Bohemia

Cestode species	<i>Ciconia ciconia</i>	<i>Ardea cinerea</i>	<i>Ardea purpurea</i>	<i>Nycticorax nycticorax</i>	Intermediate host
<i>Anomotaenia discoides</i>	+	+	+		?
<i>Dilepis unilateralis</i>		+		+	fishes
<i>Gryphorhynchus cheilancristrotus</i>		+	+	+	fishes
<i>Gryphorhynchus pusillus</i>		+		+	fishes
<i>Ligula intestinalis</i>		+			I. Copepoda II. fishes

The birds of the order *Passeriformes* are a most diverse group ranging from exclusively insectivorous to exclusively phytovorous species, from birds nesting in trees to birds permanently living close to the water. This great variety in the composition of their food and the different ways of living is also reflected in the composition of the fauna of their cestodes.

In our material from *Passeriformes* we found a total of 31 species of cestodes of which 15 belonged to the family *Dilepididae*, 9 to the family *Hymenolepididae*, 2 to *Davaineidae* and 5 to *Paruterinidae*. The heaviest invasions with cestodes were observed in birds of the family *Hirundinidae*. 54.7 % of these exclusive insectivores were invaded by 7 species, 6 of which belonged to the family *Dilepididae* and 1 to the family *Hymenolepididae*. All 6 species of the family *Dilepididae* are typical parasites of the family *Hirundinidae*. (Tab. 5). Although some of them have

**Table 5.** Composition of the cestode fauna of birds of the family *Hirundinidae* in Czechoslovakia

Cestode species	<i>Hirundo rustica</i>	<i>Delichon urbica</i>	<i>Riparia riparia</i>	Cestode family
<i>Anomotaenia hirundina</i>	·	·		<i>Dilepididae</i>
<i>Anomotaenia dehiscens</i>	·			
<i>Anomotaenia praecox</i>	·			
<i>Anomotaenia orolaciniatu</i>	·			
<i>Anomotaenia rustica</i>	·			
<i>Angulariella beema</i>	·			
<i>Passerilepis passeris</i>				<i>Hymenolepididae</i>

occasionally been found in hosts of other families of the order *Passeriformes* they are most often occurring in *Hirundinidae*. The birds of the family *Hirundinidae* can only catch flying insects; this seems to be a factor determinating the composition of their cestode fauna. The characteristic composition of the fauna of cestodes parasitizing the representatives of the family *Hirundinidae* cannot be judged only from the phylogenetic aspect without considering the specific composition of their food.

The second group most heavily invaded by cestodes are the birds of the family *Turdidae*. In our material we found in birds of this family 17 cestode species, 8 species belonging to the family *Hymenolepididae*, 6 to *Dilepididae* and one to *Davaineidae*. The most frequent species, occurring in 49.3 % of the birds examined,



167 was *Dilepis undula*. The frequent occurrence of this species is connected with its life cycle. Its intermediate hosts are *Oligochaeta*, especially the species *Lumbricus terrestris*, a constant component of the food of *Turdidae*. In some species such as *Turdus merula*, *T. ericetorum philomelos*, *T. musicus*, the invasions with the cestode *D. undula* are as high as 90 %. Other cestode species (Tab. 6) are less frequent in birds of the family *Turdidae*.

The birds of the family *Sturnidae* are closely related to the *Turdidae* by the composition of their food and the way of living. The composition of the fauna of cestodes of the most frequent species, *Sturnus vulgaris*, is also similar to that of the *Turdidae*, the most frequent cestode is the species *Dilepis undula*. The extensity of the invasions with this parasite in starlings comes up to 43.6 %.

The composition of the fauna of cestodes in birds of the family *Corvidae* is also similar to that of the two foregoing bird families except that the percentage of the invasions by the cestode *Dilepis undula* is much lower, while the species *Anomotaenia*

Table 7. Cestode fauna of birds of the family *Fringillidae* from Czechoslovakia

Cestode species	<i>Fringilla coelebs</i>	<i>Fringilla montifringilla</i>	<i>Emberiza citrinella</i>	<i>Emberiza schoeniclus</i>	<i>Passer domesticus</i>	<i>Passer montanus</i>
<i>Anomotaenia constricta</i>	-	-	-	-	+	-
<i>Anomotaenia passerum</i>	-	-	-	-	+	-
<i>Anomotaenia rosickyi</i>	-	-	-	-	-	-
<i>Choanotaenia passerina</i>	-	-	-	-	+	-
<i>Choanotaenia musculosa</i>	+	-	-	-	-	-
<i>Variolepis crenata</i>	-	-	-	-	+	-
<i>Variolepis clerici</i>	-	-	-	-	+	+
<i>Passerilepis passeris</i>	-	-	-	-	+	-
<i>Passerilepis brevis</i>	-	-	-	-	+	-
<i>Passerilepis stylosa</i>	-	-	-	-	+	-
<i>Anonchotaenia globata</i>	-	-	+	+	-	-
<i>Anonchotaenia magniuterina</i>	-	-	+	-	+	+
<i>Biuterina passerina</i>	-	-	-	+	-	-
<i>Raillietina sartica</i>	-	-	-	-	+	-

*constricta* and *Variolepis crenata* are more frequent. These data correspond with our knowledge about the feeding habits of the *Corvidae* which feed much less on earthworms than the *Turdidae* and the *Sturnidae*.

A cestodofauna resembling that of the *Hirundinidae* has also been found in birds of the family *Paridae* which live mostly in trees and feed on insects. Of the 8 cestode species recorded 2 belonged to the family *Hymenolepididae*, 4 to *Dilepididae* and 2 to *Paruterinidae*. The species *Anomotaenia dehiscens* and *A. praecox* are typical for the family *Hirundinidae*, the species *Anonchotaenia globata* and *A. magniuterina* are typical for the family *Paridae* and *Sittidae*. The birds of the latter family also live in trees and feed on insects and therefore the fauna of their cestodes is closely related to the fauna observed in the birds of the family *Paridae*. Very interesting is the finding of the cestode *Anomotaenia hirundina* in *Sitta europaea*. This cestode was only found in this special host if also many swallows lived in this locality and if ponds or rivers were nearby. The apparent intermediate hosts of this cestodes seem to be some flying water insects. These cestodes are very rare in birds of the family *Fringillidae* and *Sylviidae*, the average percentage of the invasion is only 1.04. The composition of their cestode fauna resembles the one described from *Turdidae* except the species *Dilepis undula* which does not occur in them (Tab. 7).

## CONCLUSION

The composition of the fauna of cestodes, parasitizing birds of various orders or families, does not only depend on their phylogenetic relations but also on the way of living and the composition of their food. Basing on the rich material of cestodes collected from birds in Czechoslovakia we analysed the influence of the food and the way of living on the composition of the fauna of cestodes in some orders or families of birds. Similar food and a similar way of living may account for the formation of a similar or even identical fauna of cestodes and that even in phylogenetically different groups of hosts. On the other hand a different way of living and different food may be responsible for the formation of a different fauna of cestodes even when these cestode parasitize only one order of birds. The fauna of cestodes parasitic in birds of the order *Anseriformes* resembles that of the *Ralliformes*. Both orders are bound to water conditions. Contrary to that the birds of the order *Ralliformes* living in swamps have a quite different fauna of cestodes although the biotopes of both ecological groups of hosts are in close vicinity. Similar differences have been observed in birds of the orders *Ciconiiformes* and *Lariformes* where a different composition of the food resulted in a different fauna of cestodes parasitic in them. Quite characteristic is the fauna of cestodes in birds of the family *Hirundinidae* (*Passeriformes*) which feed principally on flying insects. As to the speciation and quantity, the richest fauna of cestodes has been observed in birds of the family *Turdidae*. The most variegated composition of their food facilitates

169 the development of a rich fauna of cestodes. The most frequent species encountered in them is the cestode *Dilepis undula*; its larva develops in earthworms which are the most important food component of birds of the subfamily *Turdinae*. A very similar composition of the cestode fauna has been observed in birds of the family *Sturnidae* in consequence of a much alike mode of living and food composition.

In other families of the order *Passeriformes* the fauna of cestodes resembles that of the family *Turdidae* with one exception: the birds of this family are not parasitized by the cestode *Dilepis undula*. It also occurs very seldom in birds of the family *Corvidae*.

Our investigations have proved that the food and its composition constitutes a very important factor in the formation of the fauna of bird cestodes confirming thus the conclusions of DOGEL on this subject.

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