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Quantitative investigations on *Odonata*, *Heteroptera* and *Coleoptera* in a drainage channel near the village of Turew (Poznań region)*

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Abstract — The dominance structure and changes in the density and biomass of *Odonata*, *Heteroptera*, and *Coleoptera* in the vegetative season (May to September 1979) are described for two sectors of a channel (through meadows and woods) flowing across agricultural land. It was found that in the meadow sector the fauna of these insects was qualitatively and quantitatively richer than in the wooded one.

Key words: drainage channel, *Odonata*, *Heteroptera*, *Coleoptera*, dominance structure, density, biomass.

1. Introduction

Within the framework of complex investigations carried out by the Department of Agrobiology and Forestry of the Polish Academy of Sciences in Poznań, a quantitative study of the fauna in a drainage channel near the village of Turew, typical of the agricultural lands of the Poznań region, was also conducted. The complex investigation aims at a synthetic evaluation of the energy flow and cycling of matter in various ecosystems of the agricultural landscape (Ryszkowski 1980). The present author's task was to determine the species composition and dominance structure of *Odonata* larvae, *Heteroptera* larvae and imagines, and *Coleoptera* imagines, with special emphasis on the evaluation

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of their density and biomass in two characteristic sectors of this channel, i.e. a meadow sector and a densely wooded one. Additionally, mean values for the whole area of those two sectors were also calculated.

2. Characteristics of the field of investigation

The channel flows out of Lake Zbęchy, crosses agricultural land in which it joins a network of drainage channels, and falls into one of the Obra Canals near the town of Kościan. It is about 20 km long. The investigated sector is 1063 m long and 4.5 m wide and is located near the village of Turew, about 7—8 km from Lake Zbęchy and about 46 km south of Poznań. In the year of investigation the water level in the channel exceeded 1 m in early spring and in summer fell in some places to 10 cm. No municipal sewage or industrial wastes flow in to the channel.

According to results from 1978, the pH of the water in the channel was 7.96—8.76 and the quantity of dissolved chemical compounds 449.2 —551.1 mg.dm^{-3}, while organic compounds amounted to 83.5—128.1 mg. dm^{-3}. These values, except for the pH, were slightly higher than in the lake from which the channel flows (Życzyńska-Bałoniak 1980).

The greater part of the investigated sector of the channel (813 m) borders arable land and meadows (meadow sector), and the remainder (250 m) adjoins a densely wooded area (wooded sector). The banks of the meadow sector are in places overgrown with *Alnus glutinosa* (L.) Gaertn., accompanied by *Frangula alnus* Mill., *Sambucus nigra* L., and *Humulus lupulus* L. In sunny places (total length 378 m) *Sparganium simplex* Huds. and *Elodea canadensis* Rich. occurred abundantly, while *Butomus umbellatus* L., *Nuphar luteum* (L) Sm., *Sagittaria sagittifolia* L., and *Phragmites communis* Trin. appeared sporadically. The average degree of cover of the bottom with these macrophytes in the vegetative season was 20.7%. The bottom in this sector was mostly muddy, being sandy only in its middle course.

In the tree-lined parts of the meadow sector and in the wooded area (total length of 685 m) the bottom was very muddy, riched in organic matter of allochtonic origin (fallen leaves of trees). The vegetation was very scanty, represented by *Nuphar luteum* and *Sparganium simplex*, and near the banks by *Berula erecta* (Huds.) Coville and grasses. The average degree of cover of the bottom with these macrophytes in the vegetative season was 3.4%.

3. Method and material

The investigation was carried out from May till Septermber 1979, at monthly intervals. Because of the very small number of representatives of the investigated groups, especially of *Odonata* and *Coleoptera*, and

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the great timidity of *Gerridae*, the conventional methods of collecting quantitative samples were aimless. Moreover, it would not have been possible to reach those species living mainly along the banks, on the perpendicular sides of the channel, or among roots of trees laid barely the water. Hence a net scoop was used to obtain representative samples from marked areas.

In the meadow sector, where the density of the insects was greater, the sampling area covered only half the width of the channel whereas in the wooded sector, where the fauna was poorer and *Gerris najas* very timid indeed, the samples were taken from areas 2—3 times larger than those in the meadow sector (Table I) and always from the whole width.

Table I. Number of samples and area of investigated sectors of the channel surface in m^2

Sector of the channel	Number of samples	Size of the area		
		for one sample		total
		range	mean value	
Meadow, unshaded 378 m	5	7 - 18	11	55
Densely wooded 685 m	5	9 - 45	27	135
Both sectors 1063 m	10	7 - 45	19	190

The triangular frame of the sampler ensured its good contact with the bottom and the water surface (the catching of *Gerridae*, *Veliidae*, and *Gyrinidae*). Samples taken with a scoop having a 0.4 mm mesh net were rinsed on a 0.3 mm one and were segregated *in vivo* in water-filled dishes. This was always done on the spot.

The mean density in each sector of the channel (378 and 685 m) calculated for particular investigation dates, was used to calculate the arithmetical weighted mean density for the vegetative season along the whole length of the channel (1063 m). During the investigation numerous measurements were made on additional material in order to establish the mean biomass of particular species of *Odonata* and *Heteroptera*. At the same time their larval stages and the sex of imagines were determined. These were used for calculating the mean biomass based on the obtained values of density. Only *Coleoptera* originating from the quantitative samples were weighted directly within their family taxa.

4. Results

4.1. Dominance structure

Of 807 specimens collected, 43 were *Odonata* larvae, 629 *Heteroptera* larvae and imagines, and 135 *Coleoptera* imagines.

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Odonata. With reference both to number and biomass *Calopteryx splendens* was markedly dominant. In the densely wooded and shaded sector of the channel it was the only representative of *Odonata* (Table II).

Table II. Dominance structure (in %) of distinguished taxa of Odonata (larvae), Heteroptera (larvae and imagines), and Coleoptera (imagines) with reference to their number (N - individuals·m^{-2}) and biomass (B - mg·m^{-2}) in the investigated sectors of the drainage channel near the village of Turew in the 1979 vegetative season

Taxon \ Sector of the channel	Meadow, unshaded		Densely wooded		Entire	
	N	B	N	B	N	B
Odonata						
Calopteryx splendens (Harr.)	93.6	93.2	100.0	100.0	94.4	95.5
Platycnemis pennipes (Pall.)	2.2	3.8	-	-	1.7	2.5
Ischnura elegans (Vander L.)	4.2	3.0	-	-	3.9	2.0
Heteroptera						
Hydrocorisae	51.3	89.6	18.4	45.8	34.4	73.0
Nepa cinerea L.	24.8	44.0	13.3	26.3	18.9	37.2
Notonecta glauca L.	12.7	41.2	3.3	18.3	7.8	32.5
Corixa sahlbergi (Fieb.)	6.1	2.3	1.5	1.0	3.9	1.8
Sigara striata (L.)	2.7	0.7	0.3	0.2	1.5	0.5
Corixa linnaei (Fieb.)	2.7	0.9	-	-	1.2	0.5
Sigara falleni (Fieb.)	0.9	0.2	-	-	0.5	0.2
- praeusta (Fieb.)	0.5	0.2	-	-	0.2	0.1
- distincta (Fieb.)	0.5	0.2	-	-	0.2	0.1
- semistriata (Fieb.)	0.4	0.1	-	-	0.2	0.1
Amphibicorisae	48.7	10.2	81.6	54.2	65.6	27.0
Gerris lacustris (L.)	46.4	9.5	29.3	13.2	37.5	10.9
- najas (De Geer)	0.3	0.2	45.9	39.0	23.7	15.0
Velia saulii Tam.	-	-	6.1	1.8	3.2	0.7
Gerris thoracicus Schumm.	1.1	0.3	0.3	0.2	0.7	0.3
- rufoscutellatus Latr.	0.9	0.2	-	-	0.5	0.1
Coleoptera						
Dytiscidae	43.1	87.7	39.2	95.2	41.3	91.8
Ilybius fuliginosus (Fabr.)	18.9	.	23.0	.	21.1	.
Laccophilus hyalinatus (Deg.)	9.2	.	2.4	.	5.7	.
Colymbetes fuscus (L.)	3.4	.	0.8	.	2.1	.
Acilius canaliculatus (Nic.)	1.0	.	2.4	.	1.7	.
- sulcatus (L.)	-	-	2.9	.	1.5	.
Platambus maculatus (L.)	-	-	2.9	.	1.5	.
Graphoderus zonatus (Hoppe)	-	-	2.4	.	1.3	.
Rhantus notatus (Fabr.)	2.4	.	-	-	1.2	.
Ilybius fenestratus (Fabr.)	1.8	.	-	-	0.9	.
Hyphydrus ovatus (L.)	1.8	.	-	-	0.9	.
Copelatus ruficollis (Schall.)	1.0	.	-	-	0.4	.
Hydroporini n. det.	3.6	.	2.4	.	3.0	.
Haliplidae	17.1	1.0	6.7	0.3	10.9	0.5
Gyrinidae	15.4	7.1	9.5	3.0	13.0	4.9
Gyrinus natator (L.)	11.6	.	6.8	.	9.6	.
Orectochilus villosus (Müll.)	-	-	2.7	.	1.5	.
Gyrinus marinus Gyll.	2.3	.	-	-	1.1	.
- aeratus Steph.	1.5	.	-	-	0.8	.
Hydrophilidae	24.4	4.2	44.6	1.5	34.8	2.8

Heteroptera. The dominance structure of these insects is somewhat complicated, being dependent on the environmental conditions. Moreover, the quantitative dominance did not always correspond with that of biomass (Table II). In the meadow sector water bugs *(Hydrocorisae)* dominated only slightly over water-surface ones *(Amphibicorisae)*, whereas their high dominance in biomass was mainly due to large sized insects *(Nepa cinerea, Notonecta glauca)*. In the wooded sector the share of *Hydrocorisae* in the total number of *Heteroptera* was very small. The markedly dominating group here were *Amphibicorisae* (mainly *Gerris lacustris, G. najas*), which in biomass, however, dominated only slightly

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over *Hydrocorisae*. In general, along the whole length of the investigated sector of the channel *Amphibicorisae* were dominant as to number, and *Hydrocorisae* in biomass.

Coleoptera. Quantitatively *Dytiscidae* dominated both in the meadow sector and along the whole length of the channel mainly because of the large share of *Ilybius fuliginosus* among them (Table II). The percentage share of *Haliplidae* and *Gyrinidae* was much greater in the meadow sector than in the wooded one. *Hydrophilidae*, however, feeding on dead plants, dominated in wooded sector, rich in organic matter of allochtonic origin, though their share in the total biomass of *Coleoptera* was small. As Table II shows, *Dytiscidae* were in all aspects the dominating group with regard to biomass.

4.2. Density and biomass

Odonata. In the vegetation-rich meadow sector, the average density of larvae was 20 times, and the average biomass almost four times greater than in the wooded sector (Table III). Of all the studied insect groups, *Odonata* larvae had the smallest density and biomass. In spite of a large

Table III. Mean density (N - individuals·m^{-2}) and biomass (B - mg·m^{-2}) of insects of groups examined in the investigated sectors of the channel

Sector of the channel / Taxon	Meadow, unshaded 378 m		Densely wooded 685 m		Entire 1063 m	
	N	B	N	B	N	B
Odonata	0.59	14.1	0.03	3.8	0.23	7.5
Heteroptera	5.60	263.4	3.31	90.2	4.12	151.8
Hydrocorisae	2.87	236.6	0.61	41.3	1.41	110.8
Amphibicorisae	2.73	26.8	2.70	48.9	2.71	41.0
Coleoptera	1.23	49.7	0.74	33.3	0.92	39.1
Dytiscidae	0.53	43.6	0.29	31.7	0.38	35.9
Haliplidae	0.21	0.5	0.05	0.1	0.10	0.2
Gyrinidae	0.19	3.5	0.07	1.0	0.12	1.9
Hydrophilidae	0.30	2.1	0.33	0.5	0.32	1.1
T o t a l	7.42	327.2	4.08	127.3	5.27	198.4

sampling area and the larval development of the dominating *Calopteryx splendens*, there were times in the investigation period when they were not encountered. Nevertheless, the results obtained give a clear picture of the course of changes in density and biomass, which are in accordance with the biology of development of *C. splendens* (fig. 1A). In the meadow sector the greatest biomass occurred in May and September. A rapid decrease in larval density in June (flight of imagines) was followed by

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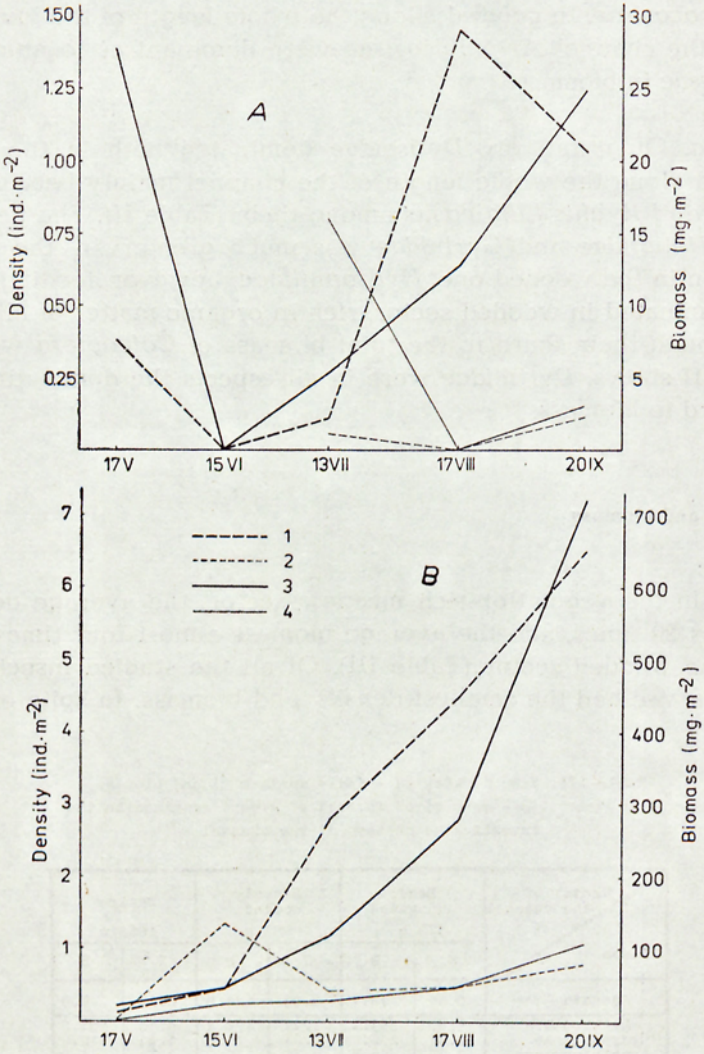

Fig. 1. Course of changes in number (1, 2) and biomass (3, 4); A — *Odonata*, B — *Hydrocorisae (Heteroptera)* in the meadow (1, 3) and wooded (2, 4) sectors of the drainage channel in 1979

a large increase in August (a new generation of larvae). The visible decrease in larval density in September can be interpreted as resulting mortality and even cannibalism. The results obtained for the wooded sector show, above all, two months delay in larval development.

Heteroptera. These insects had the highest values of density and biomass (Table III). In the meadow sector of the channel the average biomass of *Hydrocorisae* was 9 times greater than that of *Amphibicorisae*,

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although they were similar in density. In the wooded sector, however, where the density was several times lower, the biomass was also much lower. In the meadow sector the lowest values of density and biomass were found in May and June. Their dynamic increase from July to September (fig. 1B) was caused by the development of *Nepa cinerea* larvae as well as the migration of *Notonecta glauca* and representatives of *Corixidae*. In the wooded sector *Hydrocorisae* increased in density and biomass during the vegetative season very slowly, being temporarily fairly high only in June (the appearance of *N. cinerea* larvae).

In the course of changes in density and biomass of *Amphibicorisae* two distinct peaks could be seen, which in the meadow sector occurred in June and August (fig. 2A). These changes reflect above all the dyna-

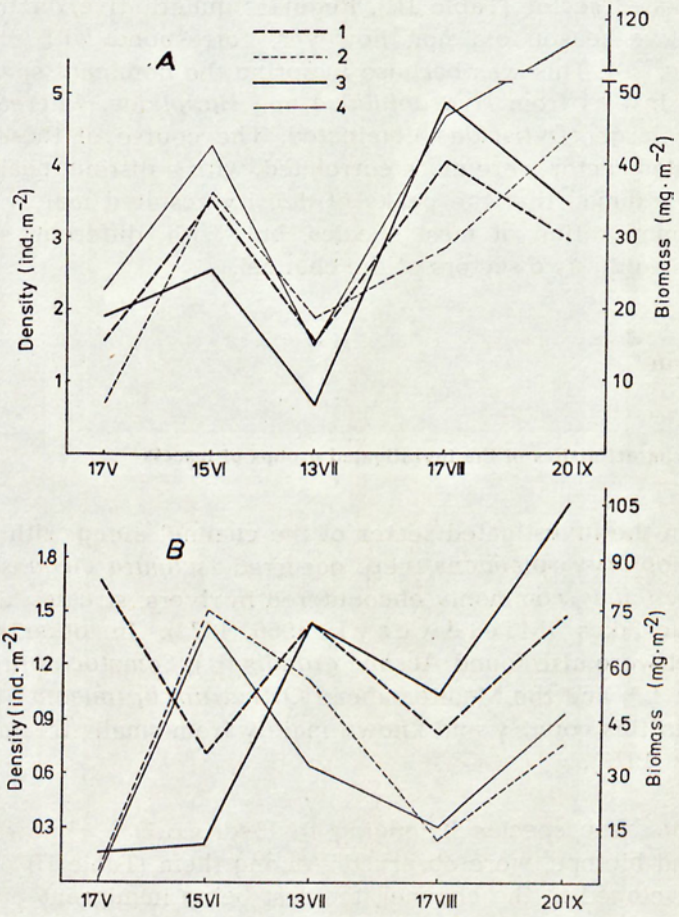

Fig. 2. Course of changes in number (1, 2) and biomass (3, 4); A — *Amphibicorisae (Heteroptera)*, B — *Coleoptera* in the meadow (1, 3) and wooded (2, 4) sectors of the drainage channel in 1979

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mics of development of *Gerris lacustris*, a remarkably dominant species which has two generations a year. In the wooded sector the changes followed a similar course but the second peak occurred as late as September and for biomass it was much higher. This was due to the relatively large individual biomass of the dominant *Gerris najas*, which has one generation a year and metamorphose in September, as well as an influx of *G. lacustris* finding more food towards the end of summer on water surfaces surrounded by trees and shrubs.

Coleoptera. In spite of a very low density of these insects, their average biomass in the whole examined sector of the channel was relatively high because of the large biomass of *Dytiscidae*. In the meadow sector the mean values of density and biomass were distinctly greater than in wooded sector (Table III). Regular quantitative fluctuations in the vegetative season did not, however, correspond with changes in biomass (fig. 2B). This was because in spring the dominant species were very small insects from *Hydrophilidae* and *Haliplidae*, whereas in September the larger *Dytiscidae* dominated. The course of these changes in the wooded sector were more correlated, with a distinct peak in June. It may be assumed that the peaks of density resulted mainly from the intensive immigration of most species, but with different selectivity with regard to the two sectors of the channel.

5. Discussion

5.1. General characteristics of the investigated groups of insects

Odonata. In the investigated sector of the channel along with the rheophilous *Calopteryx splendens* there occurred *Ischnura elegans* and *Platycnemis pennipes*, commonly encountered in rivers, streams, and weakly eutrophic lakes (Mielewczyk 1966, 1972). In other sectors of the channel were also found *Aeshna grandis* (L.), *Somatochlora metallica* (Vander L.), and the Mediterranean *Orthetrum brunneum* (Fonsc.), very rare in this country and known mainly from small streams (Mielewczyk 1979).

Heteroptera. Nine species belonging to Hydrocorisae, known mainly from a pond biotope, were observed. Among them (Table II) only *Nepa cinerea* developed in the channel, the rest being immigrant (no larvae). Among *Corixidae*, the dominant was *Corixa sahlbergi*, a species characteristic of shaded, forest waters (Mielewczyk 1970). In the group of *Amphibicorisae* (5 species) *Gerris thoracicus* was an immigrant, appear-

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ing in the channel only in spring when the emergent vegetation was little developed. This species lives mainly on the surface of small water bodies with no macrophytes (Mielewczyk 1978b). Of the other species *Velia saulii* and *Gerris najas* are rheophilous. In general, the species composition of *Amphibicorisae* in the investigated sector of the channel is characteristic for small rivers and streams.

Coleoptera. Among the representatives of *Dytiscidae* and *Gyrinidae* found in the investigated channel, the following species were characteristic for flowing waters: *Ilybius fuliginosus, Laccophilus hyalinus, Platambus maculatus, Orectochilus villosus,* and *Gyrinus aeratus* (Galewski, Tranda 1978). The remaining species (Table II), living usually in small, stagnant water bodies, were mainly immigrant.

The qualitative composition of the fauna in the meadow sector was richer (84% of species) than in the densely wooded one (56%).

5.2. Density and biomass

Data concerning quantitative estimations of *Odonata, Heteroptera,* and *Coleoptera* occurring in flowing waters in Poland are very few and fragmentary. Especially scanty are those on their biomass.

In two sectors of the drainage channel near the village of Turew it was found that the mean density of *Odonata* in the vegetative season is very low (0.03 and 0.06 individuals.m^{-2}), though it is very close to the mean annual values (to 2 individuals.m^{-2}) obtained by Wielgosz (1979) in the River Łyna (Masurian Lake District). The values 15 and 30 individuals.m^{-2} given by Iwaszkiewicz (1964) for the Stobnica stream (Wielkopolska Lowland), and 5 to 10 individuals.m^{-2} given by Giziński (1961) for the Trzebiocha stream (Pomeranian Lake District) concern only single sampling stations, the means not having been properly calculated. The results obtained by Siemińska (1956) for the River Brynica in Upper Silesia (50 to 150 individuals.m^{-2}) and by Mielewczyk (1978a) for the old bed of the River Dunajec in the Pieniny Mountains (190.5 individuals.m^{-2}) are of similar character and are only examples of maximum densities. For this reason biomass figures of the order 780 and 1743 mg.m^{-2} (Iwaszkiewicz 1964) and 1100 to 3300 mg.m^{-2} (Siemińska 1956) should be treated merely as very high local ones.

The average density of water bugs *(Hydrocorisae)* in the vegetative season (1.41 individuals.m^{-2}) in the channel near Turew was many times greater than that of *Odonata* (Table III) but still very low if compared with the 4 to 18 individuals.m^{-2} given by Wielgosz (1979) and 5 to

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20 individuals.m^{-2} by Giziński (1961); their results, however, were calculated as mean values for particular sampling stations and not whole areas of the stream, and concerned only one species (*Aphelocheirus aestivalis* Fabr.). Also the results given by Iwaszkiewicz (1964) were very high (30 individuals.m^{-2} and 6203 mg.m^{-2}), but here again they were calculated for one station and one family only *(Nepidae)*. Local density of water bugs *(Hydrocorisae)* can be very great. In the Pieniny Mts in the old bed of the River Dunajec, measured for several species of *Sigara* Fabr. including larvae, it was as high as 781 individuals .m^{-2}, and for the earlier stages of larval development 3460 individuals .m^{-2} (Mielewczyk 1978b). The maximum density of the larvae of the smallest bug, *Micronecta poweri* (Dougl. et Sc.), was nearly 180 000 individuals.m^{-2}. For water-surface bugs *(Amphibicorisae)* the density of the rheophilous *Velia caprai* Tam. reached here 132 individuals.m^{-2}.

The authors quoted above also gave different density values for *Coleoptera* imagines, these again being very high. Giziński (1961) at some stations found densities from 5 to 130 individuals.m^{-2}, Iwaszkiewicz (1964) usually arrived at 15 to 30 individuals.m^{-2}, and only exceptionally 45 individuals.m^{-2}, while Wielgosz (1979) gave figures of 7 and 17 individuals.m^{-2}. Sowa (1965) in the stream Wielka Puszcza (Western Beskid Mts) found 9 to 15 individuals.m^{-2} on a gravel bottom and 18 to 77 individuals.m^{-2} on a muddy bottom with at the same time a rich species composition. *Coleoptera* biomass, as given by Iwaszkiewicz (1964), lay between 15 to 73 mg.m^{-2}, in spite of large numbers, and therefore approached the values obtained for the drainage channel near the village of Turew (Table III).

The quantitative share of *Odonata, Heteroptera,* and *Coleoptera* in the fauna of flowing waters is usually very small, though the figures quoted suggest a high density of these insects even if the maximum values are discounted. However, they relate to particular stations and do not give a full picture of the situation in whole streams or even in large sectors of them. The mean density and biomass of insects of these groups in the vegetative season obtained in the present investigation are rather low but they are calculated for the whole water area of two characteristic sectors of the channel — meadow and densely wooded — separately and together. They are, at the same time, the first estimations of the kind made for flowing waters in Poland.

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6. Polish summary

Badania ilościowe nad *Odonata*, *Heteroptera* i *Coleoptera* w kanale odwadniającym koło Turwi (region poznański)

W sezonie wegetacyjnym 1979 roku przeprowadzono badania nad składem jakościowym, zagęszczeniem i stanem biomasy larw *Odonata*, larw i imagines *Heteroptera* oraz imagines *Coleoptera* w kanale odwadniającym koło Turwi, uwzględniając dwa jego charakterystyczne odcinki — łąkowy i zwarcie zadrzewiony. Ze względu na małą liczebność tych owadów i dużą ruchliwość niektórych gatunków (np. *Gerridae*) pobierano próby, zależnie od potrzeby, z powierzchni 7—45 m² (Tabela I). W stosunkowo bogatym materiale, reprezentowanym przez 12 rodzin, wyróżniono 32 gatunki (Tabela II); rodzin *Haliplidae* i *Hydrophilidae* bliżej nie oznaczono.

Większość gatunków *Heteroptera* i *Coleoptera* reprezentowała element charakterystyczny dla biotopu stawowego i należała głównie do imigrantów (brak larw). We wszystkich jednak grupach owadów występowały gatunki reofilne lub bardziej właściwe wodom płynącym: z *Odonata* — *Calopteryx splendens*, z *Heteroptera* — *Gerris najas* i *Velia saulii*, z *Coleoptera* — *Ilybius fuliginosus*, *Laccophilus hyalinus*, *Platambus maculatus*, *Orectochilus villosus* i *Gyrinus aeratus*. W poszczególnych grupach pod względem liczebności dominowały: *Calopteryx splendens*, *Nepa cinerea*, *Gerris lacustris*, *G. najas* i *Ilybius fuliginosus*, a pod względem biomasy: *Calopteryx splendens*, *Nepa cinerea*, *Notonecta glauca* i ogólnie *Dytiscidae* (Tabela II).

Przebieg liczebności i stanów biomasy badanych grup owadów w sezonie wegetacyjnym był bardzo różny, zależny od biologii rozwoju poszczególnych gatunków lub nasilenia ich imigracji, a także od warunków ekologicznych (ryc. 1—2).

W łąkowym odcinku kanału fauna była jakościowo bogatsza (84%) niż w odcinku zwarcie zadrzewionym (56%). Również średnie wartości zagęszczenia i stanu biomasy badanych grup owadów były wyraźnie wyższe w odcinku łąkowym niż w zwarcie zadrzewionym (Tabela III). Jedynie zagęszczenie pluskwiaków nawodnych (*Amphibicorisae*), odżywiających się owadami opadłymi na powierzchnię wody, oraz saprofagicznych chrząszczy *Hydrophilidae* w obu odcinkach kanału było prawie jednakowe. Ogólnie największe wartości zagęszczenia i stanu biomasy osiągały *Heteroptera*.

7. References

Galewski K., E. Tranda, 1978. Chrząszcze *(Coleoptera)*. Rodziny: pływakowate *(Dytiscidae)*, flisakowate *(Haliplidae)*, mokrzelicowate *(Hygrobiidae)*, krętakowate *(Gyrinidae)*. Fauna Słodkowodna Polski, 10.

Giziński A., 1961. The bottom fauna of Trzebiocha stream. Roczn. Nauk Roln., D, 93, 339—363.

Iwaszkiewicz M., 1964. The course of natural regeneration of ichthyofauna in the section of a stream after an experimental outcatch of fish by electro-fishing. Prace Kom. Nauk Roln., Kom. Nauk Leśn., PTPN, 4, 3, 1—40.

Mielewczyk S., 1966. Larvae of dragonflies *(Odonata)* in the Great Poland National Park. Prace Monogr. Przyr. Wielkop. Parku Nar. PTPN.

Mielewczyk S., 1970. Die Libellen *(Odonata)* und Wasserwanzen *(Heteroptera)* eines Flachmoores bei Gniezno (Woiwodschaft Poznań). Fragm. Faun., 16, 1—10.

Mielewczyk S., 1972. Die Libellen *(Odonata)* der Umgegend von Gniezno. Fragm. Faun., 18, 141—162.

Mielewczyk S., 1978a. Libellen *(Odonata)* der Pieninen. Fragm. Faun., 22, 265—294.

http://rcin.org.pl

Mielewczyk S., 1978b. Die Wasserwanzen (*Heteroptera aquatica* et *semiaquatica*) der Pieninen. Fragm. Faun., 22, 295—336.

Mielewczyk S., 1979. Ein neuer Fundort von *Orthetrum brunneum* (Fonscolombe) und die Verbreitung der Art in Polen *(Anisoptera: Libellulidae)*. Notul. Odonatol., 1, 4, 59—61.

Ryszkowski L., 1980. Introduction to the volume "Research on agricultural landscape". Pol. Ecol. Stud., 6, 105—111.

Siemińska J., 1956. The River Brynica from the point of view of hydrobiology and fishery. Pol. Arch. Hydrobiol., 3 (16), 69—160.

Sowa R., 1965. Ecological characteristics of the bottom fauna of the Wielka Puszcza stream. Acta Hydrobiol., 7, Suppl. 1, 61—92.

Wielgosz S., 1979. The effect of wastes from the town of Olsztyn on invertebrate communities in the bottom of the River Łyna. Acta Hydrobiol., 21, 149—165.

Życzyńska-Bałoniak I., 1980. Dissolved organic matter in water of lake and channel in the agricultural landscape (Wielkopolska region). Pol. Ecol. Stud., 6, 155—166.

http://rcin.org.pl