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The importance of aquatic insects for landscape integration in the catchment area of the River Gizela (Masurian Lake District, northeastern Poland)

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A b s t r a c t - It appears that for integration of the entire landscape the most important are the species of unstable habitats. The potentially greatest integrating role in the landscape of the catchment area of the River Gizela is played by species occurring in small, still water bodies (mostly Coleoptera and Heteroptera).

K e y w o r d s: aquatic insects, ecological landscape.

1. Introduction

Within the scope of the ecological landscape one may distinguish many components, regarding them as ecosystems, habitats, etc. Between these components there exists a link which is manifested in the migrations and displacement of organisms. It would be interesting to know from which habitats (ecological systems) the migrating individuals come, and which groups of species play the greatest integrating role precisely through these migrations.

The problem of the migration of aquatic insects between lowland flows and valley water bodies has not yet been adequately studied. In the present paper the assumption has been made that migration may take place only between habitats in which the given species occurs. Such an assumption, however, defines only the potential possibilities of migration, while the actual migrations are most probably smaller. There may exist populations of a particular species occurring in different habitats but not remaining in contact through migrating individuals.

The aim of the present study was to investigate which groups of aquatic insects are likely to play an integrating role in the ecological landscape of the catchment area of the River Gizela.

2. Study area

The River Gizela and its catchment are situated on the Ornecka Plain, in the western part of the Masurian Lake District. Gizela rises in the eastern slopes of the Dylewska Góra at an altitude of about 245 m. It enters the River Drwęca downstream of the village Gierłoż at an altitude of 95 m. The entire length of the River is 19.5 km, and its catchment area covers 72 km^2. The river gradient is 7.7‰ . In its upper section the river flows through a strongly folded, woodless territory. Downstream of the River Zajączki the landscape becomes flat and wooded with a few meadows.

Eleven stations were set up in various types of waters: source, flows, and still- water bodies. When deciding the location of the stations full zonal and habitat differentiations were taken into consideration.

Station 1. The source of the River Gizela. It is an artificially deepened limnocren with an area of about 20 m^2 and maximum depth 0.7 m. Its water level shows great seasonal variations, being lowest in the second half of summer. The bottom is loamy-muddy. In the source there occurred: *Lemna minor* (L.), *Callitriche verna* (L.), *Sparganium* sp. (H u d s.), *Bidens tripartitus* (L.), and *Juncus* sp.

Station 2. Glaznoty, the River Gizela - 1.5 km from the source. The flow is 0.5-1 m wide, with a depth not exceeding 10 cm. The bottom is covered with stones and is loamy-sandy in places. The banks of the river are reinforced (with fascines), overgrown with grass, manna grass (*Glyceria* sp.) and rushes (*Juncus* sp.).

Station 3. The village Zajączki, the River Gizela, 5 km from the source. The station was located upstream of the discharge channel of distillery wastes. The width of the river reaches 1.5 m, while the depth is 0.4-0.5 m. The bottom is sandy-gravel with tufts of *Elodea canadensis*. The banks are reinforced. Among the macrophytes there also occurred: *Veronica beccabunda* (L.), *Scirpus silvaticus* (L.) and *Carex* sp. In autumn 1985 (a year before the field studies were begun) the distillery in Zajączki discharged untreated wastes directly into the water, polluting it along a great length.

Station 4. The village Zajączki. Mid-forest tributary of the River Gizela, 1.5 m wide and 0.4 m deep. It is characterized by a fast flowing current, stony bottom without vegetation, and transparent water.

Station 5. The village Kołodziejki, 12 km from the source of the River Gizela. The flow is 2-2.5 m wide and 0.3-0.4 m deep and has a sandy-stony bottom with tufts of submersed vegetation, and fast flowing current. Near the banks there are numerous silted stagnant waters.

Station 6. Lipowo, an affluent of the River Gizela, 3 km in length, flowing through forest, and having a muddy bottom covered with decaying leaves. The stream is about 1-1.5 m wide, and about 0.3 m deep.

Station 7. Gierłoż, about 18 km from the source of the River Gizela. The width of the river is about 4 m, and the depth 0.4-0.5 m. It has a sandy bottom and banks overgrown with grass.

Station 8. Głaznoty. A small, artificial reservoir with an area of about 200 m^2, situated 5 m from the bank of the River Gizela. It has seasonal changes in water level. The depth is 0.5-0.8 m, the bottom loamy-muddy, and the water turbid and yellowish. Aquatic macrophytes are absent and the banks overgrown with grass - *Carex*, *Callitriche* and *Juncus*.

Station 9. Kołodziejki. A mill-pond, with an area of about 2.5 ha and maximum depth of 2 m. The water is turbid, the bottom sandy and covered with a thick layer of mud and leaves fallen from the alders growing near the bank.

Station 10. Lipowo. A few small water bodies of distinctly astatic character, situated on fen. They occupy a surface area of 60-100 m^2, the depth varying from 0.5 to 0.7 m, with a muddy bottom, and turbid brownish-green water colour.

Station 11. Pomierki, a system of small field water bodies of astatic character. The area does not exceed 50 m^2. They have a muddy-peaty bottom, turbid water, while aquatic macrophytes are absent.

3. Material and methods

Investigations on the studied areas were carried out from May till November 1986, at monthly intervals. The samples were collected using a hydrobiological sampler with a triangular frame. Altogether more than 80 samples were taken. They were sorted on a white cuvette, on the spot or in the laboratory. The adopted estimation of the relative population density was based on semiquantitative samples.

The faunal similarities between the stations were calculated on the basis of the formula of B i e s i a d k a (1977a), separately for each order of the insects:

$$P_{xy} = \frac{\sum_{i=1}^{s} \frac{a_i}{b_i}}{n} \cdot 100\,\%$$

where:

Pxy - similarity between stations x and y,
s - number of common species,
n - total number of species,
a_i - smaller density of the i-th species,
b_i - greater density of the i-th species.

The calculation results have been put ordered according to the C z e k a n o w s k i diagram.

The character of the habitat and the degree of eutrophy of the species were established on the basis of studies by G a l e w s k i and T r a n d a (1978) W r ó b l e w s k i (1980), and unpublished data (C z a c h o r o w s k i, L e w a n d o w s k i).

4. Results

4.1. General characteristics of the entomofauna (Table I)

The occurrence of mayflies (Ephemeroptera) was noted in 62 samples. A total of 2560 larvae were caught, representing 9 species. The most numerous species was *Cleon dipterum*, less numerous being: *Baetis rhodani* and *B. bioculatus*. The other 6 species constituted only 2.5% of the whole collected material. The highest frequency in the samples was that of *Baetis rhodani, B. bioculatus* and, *Cleon dipterum*. The greatest numbers of species were found in stagnant waters, while the greatest numbers of individuals were caught in the current.

In 11 samples 150 larvae of dragonflies (Odonata), belonging to 11 species were found to occur. The greatest dominance and frequency were shown by *Coenogrion hastulatum*, and smaller by *Lestes sponsa* and *Sympetrum flavoelum*. Most larvae were caught at Stations 1 and 10. Only one larva, *Aeschna juncea*, was found in the flows.

Table I. Aquatic insects collected in investigated waters. N – number of specimens; D – dominance (%); f – frequency (%)

Taxa	N	D	f
Ephemeroptera (2560 specimens = 100 %)			
Baetis bioculatus (L.)	313	12.3	45
– *rhodani* (Pict.)	591	23.3	54
– *vernus* (Curt.)	43	1.7	18
Cloeon dipterum (L.)	1591	61.8	54
Ephemera ignita (Poda)	5	0.2	18
Paraleptophlebia submarginata (Step.)	6	0.25	37
Caenis macrura (Steph.)	1	0.04	9
Habrophlebia lanta Eat.	2	0.08	9
Centroptilum luteolum (Mull.)	8	0.3	18
Trichoptera (141 specimens = 100 %)			
Rhyacophila fasciata Hag.	7	4.9	9
– *nubila* Zett.	12	8.5	9
– *obliterata (?)* McL.	1	0.7	9
Hydropsyche siltalai Dohler	2	1.4	18
Plectrocnemia conspersa Curt.	10	7.1	9
Oligostomis reticulata L.	6	4.2	18
Limnephilus auricula Curt.	3	2.1	9
– *bipunctatus* Curt.	6	4.2	27
– *extricatus (?)* McL.	1	0.7	9
– *flavicornis* Fabr.	1	0.7	9
– *griseus* L.	17	12.1	9
– sp. (juv.)	2	1.4	18
Anabolia sp.	4	2.8	18
Potamophylax latipennis Curt.	5	3.5	9
Potamophylax nigricornis Pict.	1	0.7	9
Helesus sp. I.	1	0.7	9
Helesus sp. II.	15	10.6	18
Chaetopteryx villosa Fabr.	17	12.1	18
Chaetopterygopsis maclachani Stein	12	8.5	18
Chaetopterygini spp. juv.	14	9.9	27
Lasiocephala bassalis Kol.	3	2.1	9
Notidobia ciliaris L.	1	0.7	9
Odonata (150 specimens = 100%)			
Lestes dryas Kirby	10	6.7	18
– *sponsa* Hans.	21	14.0	18
Platycnemis pennipes Pall.	1	0.7	9
Pyrrhosoma nymphula Sul.	2	1.4	9
Erythroma najas Hans.	15	9.8	18
Coenagrion hastulatum Charp.	67	44.7	45
– sp.	1	0.7	9
Enallagma cyathigerum Charp.	1	0.7	9
Ischnura elegans Lind.	4	2.7	9
Aeschna juncea L.	1	0.7	9
Sympetrum flaveolum L.	23	15.2	18
– *sanquincum* Müll.	4	2.7	9

cont. Table I.

Taxa	N	D	f
Plecoptera (79 specimens = 100%)			
Amphinemura standfussi Ris	7	8.4	9
Nemura cinerea Retz.	18	23.4	36
– *dubitans* Morton	1	1.2	9
– *flexuosa* Aubert	16	20.6	18
– *marginata* Pict.	2	2.4	18
– *sciurus* Aubert	11	13.4	36
– sp.	5	6.0	27
Protonemura intricata Ris	18	23.4	18
Isoperla oxylepis Desp.	1	1.2	0
Heteroptera (545 specimens = 100%)			
Corixa linnaei (Fieb.)	18	3.3	45
– *moesta* (Fieb.)	1	0.2	9
– *sahlbergi* (Fieb.)	174	31.9	73
Sigara concinna (Fieb.)	1	0.2	9
– *distincta* (Fieb.)	5	0.9	27
– *falleni* (Fieb.)	30	5.5	36
– *lateralis* (Leach)	4	0.7	9
– *limitata* (Fieb.)	3	0.6	9
– *nigrolineata* (Fieb.)	1	0.2	9
– *praeusta* (Fieb.)	37	6.8	64
– *semistriata* (Fieb.)	2	0.4	9
– *striata* (L.)	4	0.7	18
Notonecta glauca (L.)	64	11.7	73
Plea minutissima (Leach)	6	1.1	18
Ilyocoris cinicoides (L.)	1	0.2	9
Nepa cinerea (L.)	15	2.7	45
Velia sauli (Tam.)	1	0.2	9
– *caprai* (Tam.)	58	18.1	82
Gerris lacustris (L.)	55	10.0	73
– *lateralis* (Scum.)	3	0.6	18
– *odontogaster* (Zett.)	3	0.6	27
– *rufoscutellatus* (Latr.)	2	0.4	18
– *thoracicus* (Schum.)	17	3.1	27
Coleoptera (663 specimens = 100%)			
Halipius fluviatilis (Aube.)	84	12.67	73
– *lineatocollis* (Marsh.)	8	1.21	55
Noterus clavicornis (Deg.)	1	0.15	9
Hydroporus angustatus (Sturm.)	1	0.15	9
– *discretus* (Fatr.)	1	0.15	9
– *incognitus* (Sharp.)	1	0.15	9
– *neglectus* (Sch.)	1	0.15	9
– *palustris* (L.)	14	2.11	45
– *planus* (F.)	5	0.75	27
– *rufifrons* (Duft.)	1	0.15	9
– *stiola* (Gyll.)	1	0.15	9
– *tristis* (Payk.)	1	0.15	9

cont. Table I.

Taxa	N	D	f
Porhydrus lineatus (F.)	3	0.45	18
Coelambus impressopunctatus (Sch.)	4	0.60	9
Hygrotus decoratus (Gyll.)	2	0.30	18
– *inaequalis* (F.)	35	5.28	36
Potamonectes giseotriats (Deg.)	1	0.15	9
Scarodytes halensis (F.)	6	0.90	27
Hyphydrus ovatus (L.)	2	0.30	9
Laccophilus hyalinus (Deg.)	4	0.60	18
– *minutus* (L.)	5	0.75	27
Platambus maculatus (L.)	19	2.88	27
Agabus bipustulatus (L.)	7	1.05	18
– *fuscipennis* (Payk.)	2	0.30	9
– *paludosus* (F.)	3	0.45	18
– *uliginosus* (L.)	4	0.60	18
– *sturmii* (Gyll.)	4	0.60	18
– *undulatus* (Schr.)	8	1.21	18
Ilybius ater (Deg.)	6	0.90	36
– *fuliginosus* (F.)	39	5.88	18
– *similis* (Thom.)	1	0.15	9
Rhantus exsoletus (Fors.)	1	0.15	9
– *pulverosus* (Steph.)	2	0.30	18
Colymbetes fuscus (L.)	1	0.15	9
– *striatus* (L.)	1	0.15	9
Hydaticus seminiger (Deg.)	1	0.15	9
– *stagnalis* (F.)	1	0.15	9
Dytiscus marginalis (L.)	1	0.15	9
Acilius canaliculatus (Nicol.)	2	0.30	18
– *sulcatus* (L.)	1	0.15	9
Gyrinus marinus (Gyll.)	2	0.30	9
– *mergus* (Ahr.)	2	0.30	18
Hydraena riparia (Kug.)	3	0.45	27
– *excisa* (Kies.)	3	0.45	9
– *gracilis* (Germ.)	30	4.52	36
Limnebius truncululatus (Thom.)	4	0.60	36
Hydrochus elongatus (Schall.)	1	0.15	9
Helophorus aquaticus (Kelch)	3	0.45	9
– *grandis* (Kelch)	7	1.05	27
– *flavipes* (F.)	48	7.24	27
– *griseus* (Kelch)	3	0.45	18
– *minutus* (Sharp)	5	0.75	18
Spercheus emarginatus (Schall)	7	1.05	18
Cercyon ustulatus (Preyss.)	1	0.15	9
Hydrobius fuscipes (L.)	12	1.81	18
Anacena limbata (F.)	149	22.57	82
Laccobius minutus (L.)	9	1.36	36
– *albipes* (Kuwert)	3	0.45	27
Helochares lividus (Fors.)	5	0.75	18
– *griseus* (Ten.)	7	1.05	27
Enochrus quadripunctatus (Herb.)	10	1.51	36
– *minutus* (Arn.)	5	0.75	18
Hydrophilus caraboides (L.)	1	0.15	9
Elmis maugetti (Latr.)	55	8.30	36
Oulimnius tuberculatus (Mull.)	1	0.15	9

Stoneflies (Plecoptera) were found in 14 samples. Altogether 79 larvae, belonging to 8 species, were collected. *Nemura cinerea* and *Protonemura intricata* were species with the highest population density. Most stoneflies were caught at Station 7. One larva of the genus *Nemura* was found in the source; in the still waters Plecoptera did not occur.

A total of 545 individuals belonging to 23 species were collected. The most numerous was *Corixa sahlbergi*, a species characteristic of dystrophic waters in the woods. Less numerous species were *Velia caprai* (a stenothermal rheophil, often the only representative of aquatic bugs in forest flows), *Notonecta glauca* (a eurytopic species preferring small eutrophic water bodies); to the classes of lower density of population belonged *Geris lacustris* (a eurytopic species, preferring eutrophic waters), *Sigara praeusta* and *S. falleni* (preferring lakes and ponds with sandy bottoms). The highest frequency was exhibited by *Corixa sahlbergi* and *Velia caprai*. The richest fauna of aquatic bugs in terms of quality was found at Stations 2 and 3. As regards quantity, Station 10 was the most abundant.

Caddisflies (Trichoptera) were found in 28 samples. A total of 141 larvae belonging to 21 taxa were caught. In the river there occurred 19 species but in still waters only 5. The most numerous were *Limnephilus grisens* (species occurring in periodical waters) and *Chaetopteryx villosa* (a rheophile). The greatest numbers of species occurred at Stations 5, 3, and 1.

In 80 samples 663 imagines of aquatic beetles (Coleoptera) belonging to 66 species were caught. The greatest dominance was exhibited by *Anacena limbata* (a eutrophile found in small water bodies) and *Haliplus fluviatilis* (a rheophile). The highest frequency was shown by *Haliplus fluviatilis, Anacena limbata*, and *Elmis maugetii*. The species showing the highest frequency and domination were found in various environments. The richest fauna of Coleoptera occurred in the still waters at Stations 10 and 1.

4.2. Analysis of similarities

Faunal similarities between all the stations were examined for each order of insects separately. The results of calculation are presented in Czekanowski's diagrams (figs 1, 2). In the similarities calculated for the dragonflies the block comprising the stations with still waters is relatively poorly distinguished. On the other hand, in the case of stoneflies, the block comprising the river stations and the source is much more distinct. In the case of mayflies and caddisflies two blocks of stations can be distinguished:

stations with still waters including the source, and stations with running waters. In the diagram showing the similarities calculated for the mayflies, these two blocks are connected through the similarities between Stations 2, 7, and 8. Similarities between stations, calculated on the basis of the occurrence of the beetles, formed a continuum and no blocked groups of stations can be distinguished. In the case of aquatic bugs the same similarities were formed, but the gradation of the changes was less distinct (fig. 2).

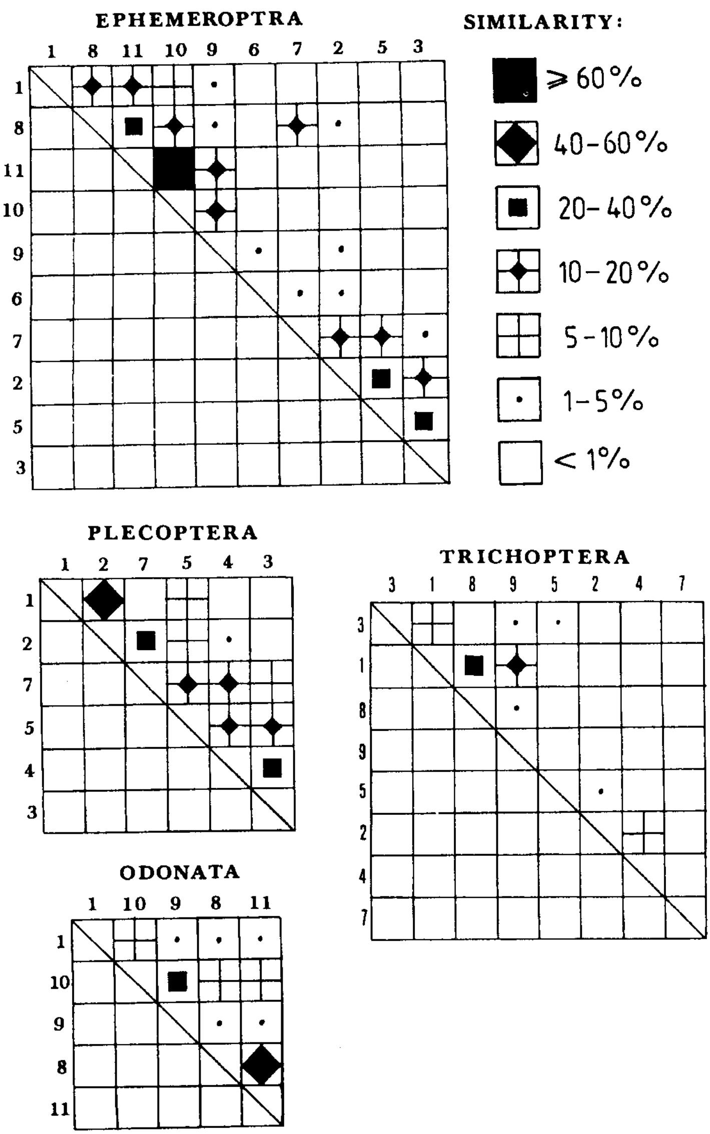

Fig. 1. Diagrams of faunal similarities between stations calculated for mayflies, stoneflies, dragonflies and caddisflies

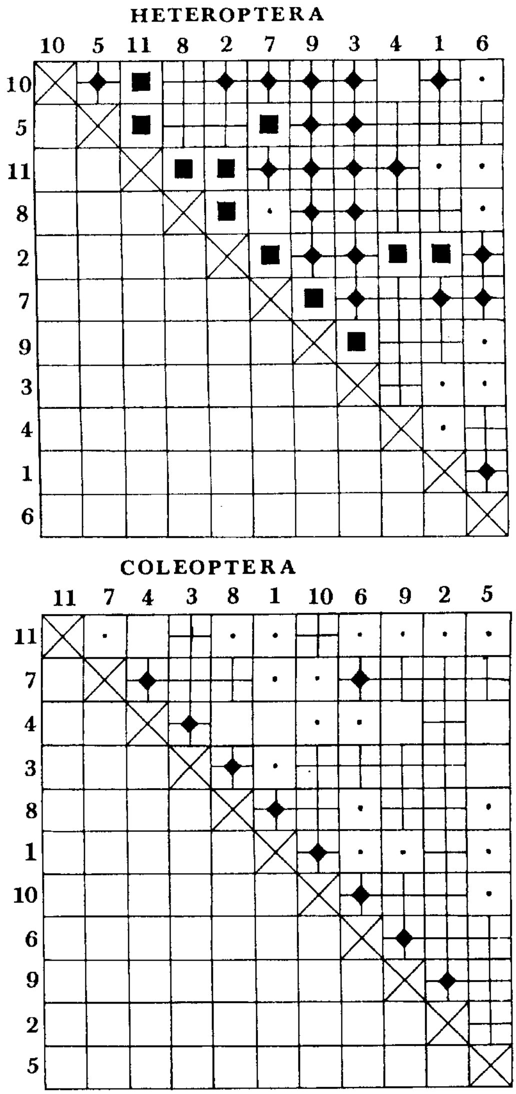

Fig. 2. Diagrams of faunal similarities between stations calculated for aquatic bugs and beetles. Explanations as in fig. 1

A graphic specification was prepared, giving the numbers of species occurring exclusively in the source, flows, and in still waters, as well as the numbers of the common species (figs 3-5). In the case of mayflies exclusive species were recorded only in the flows, while the species occurring both in flows and in still waters were less numerous. In terms of quantity, species occurring only in the flows represented a small percentage, while the common species showed a higher density of population.

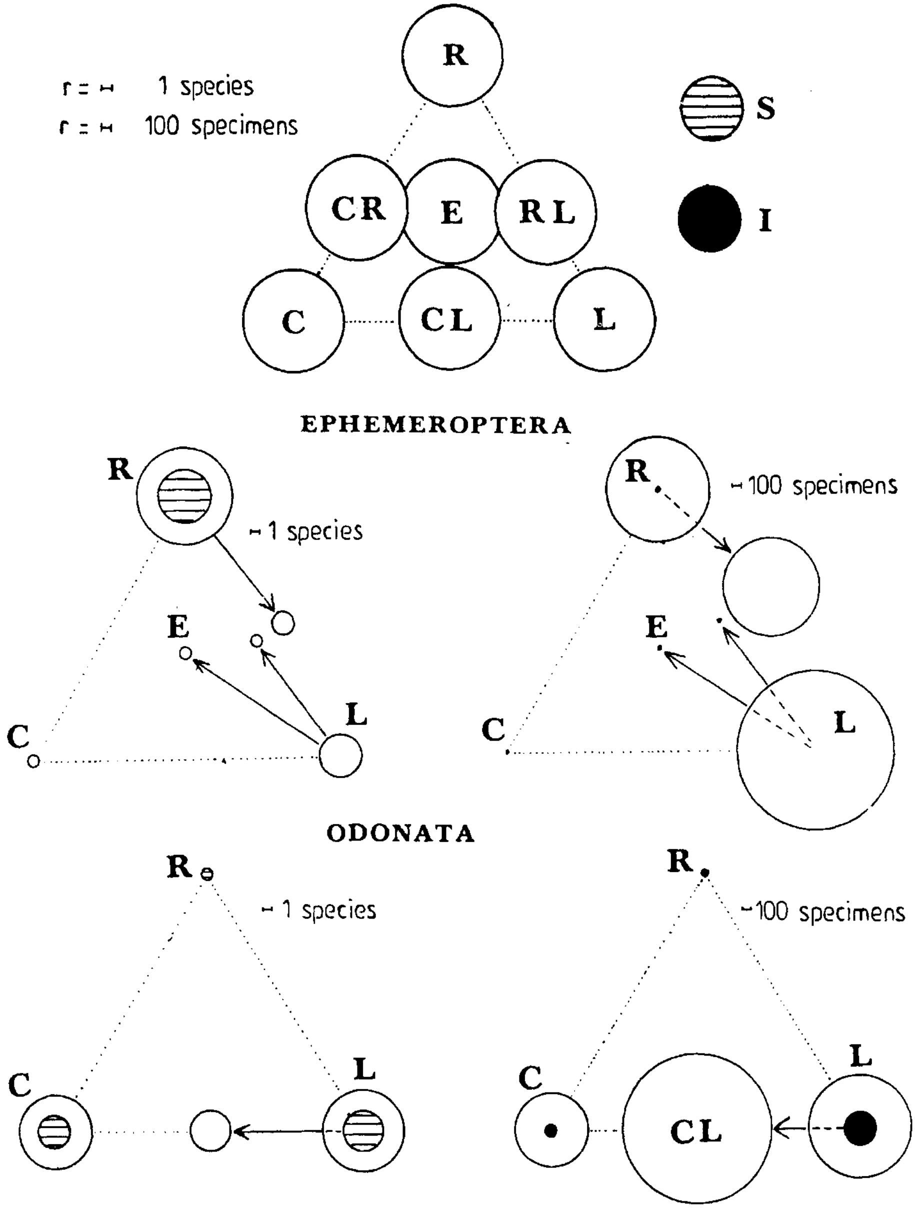

Fig. 3. Graphic representation of the number of individuals and species of Ephemeroptera and Odonata occurring in various types of water. S - species exclusive to the particular type of water; I - number of individuals of the exclusive species; C - species occurring exclusively in the source; R - species exclusive to the flows; L - species exclusive to still waters; CR - species occurring in both source and flows; CL - species occurring in both source and still waters; E - species occurring in all types of water

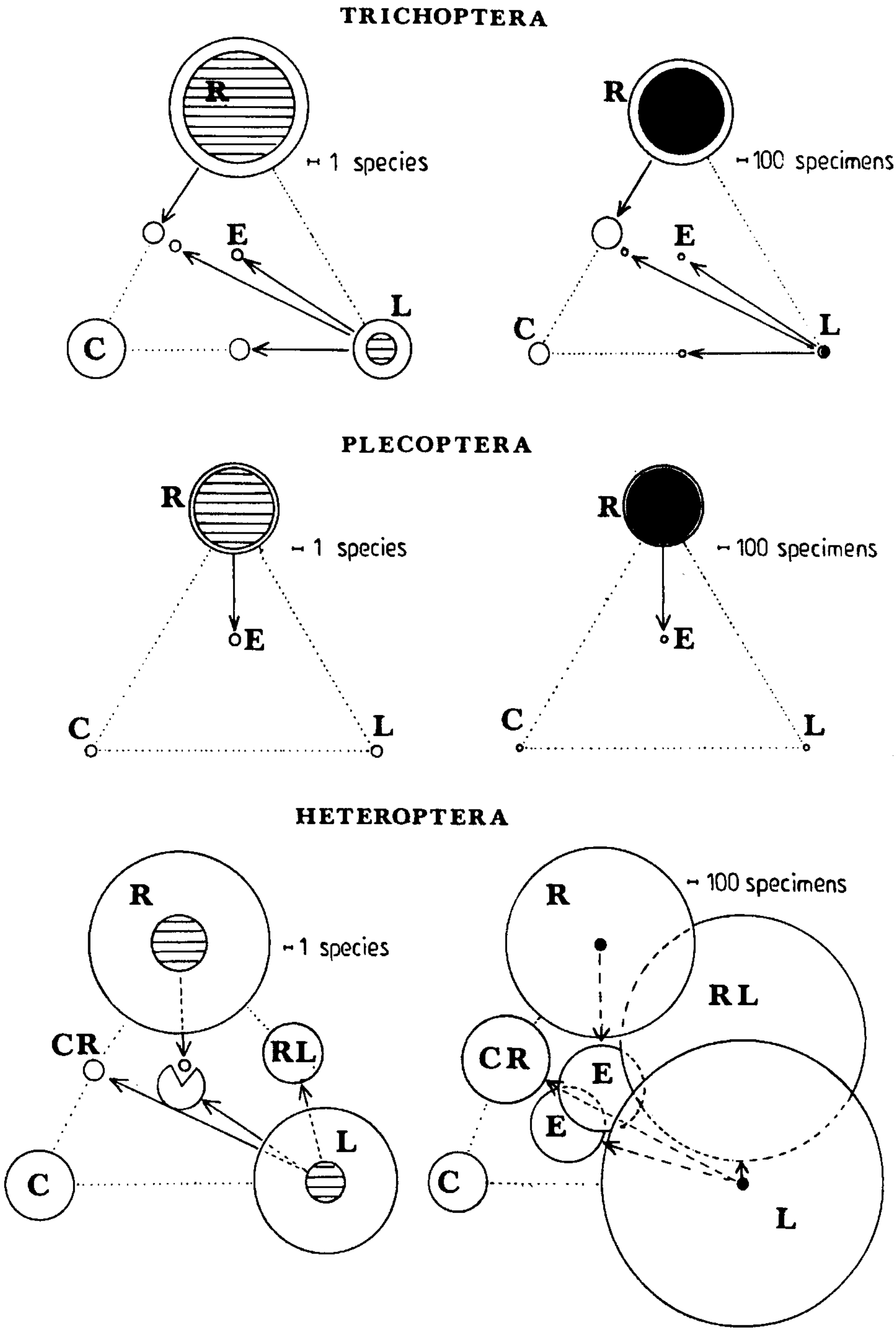

Fig. 4. Graphic representation of the number of individuals and species of Trichoptera, Plecoptera, and Heteroptera occurring in different types of water. Explanations as in fig. 3

COLEOPTERA

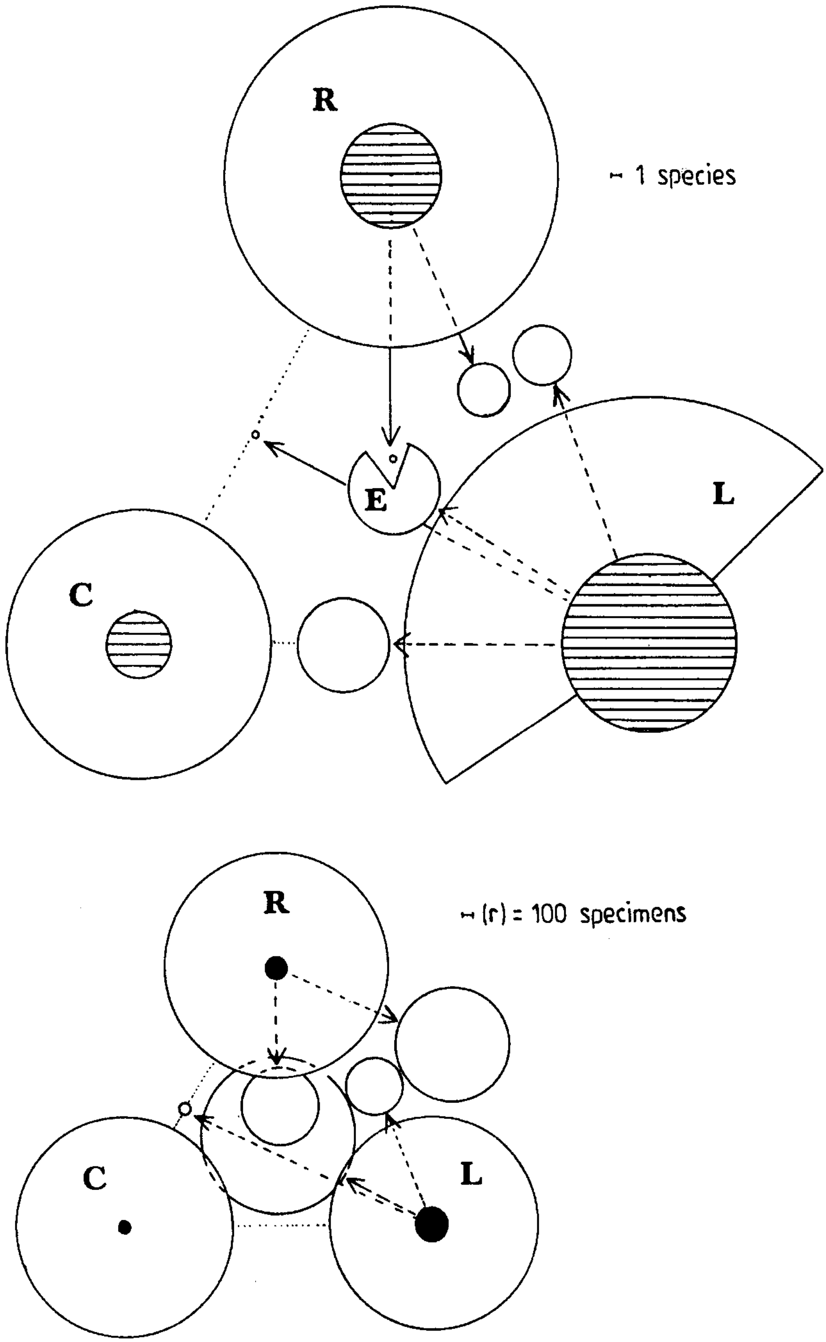

Fig. 5. Graphic representation of the number of individuals and species of Coleoptera occurring in different types of water. Explanations as in fig. 3

In the case of dragonflies, those species occurring exclusively in still waters or in the source, as well as those common for both still waters and source were equally numerous. The number of species found only in flows was much smaller. In terms of quantity, the proportions between synecological elements were similar, though the larvae of species exclusive to the limnocren source and still waters appeared in the greatest numbers (fig. 3).

The stoneflies were distinguished by the largest groups of species exclusive to the flows. The population densities were similar (fig. 2).

The aquatic bugs were characterized by the most numerous groups of species exclusive to the flows and still waters, as well as fairly numerous common species appearing in various types of water. Quantitatively, the exclusive species were represented by very small numbers of individuals. On the other hand, the species living in still waters, those common to both flows and still waters, as well as those occurring in the flows alone were decidedly dominanting. The share of the most eurytopic species was also large.

In the case of caddisflies the most numerous was the group comprising species exclusive to the flows, the other groups of species being represented in small numbers, while there were no species exclusive to the source. Quantitatively, the relations between the synecological groups were similar (fig. 4).

With regard to the beetles, all species groups were encountered, with a great number of exclusive species and those common in various types of water. Most numerous was the group of species exclusive to still waters. Their quantitative relations were similar, though the exclusive species were of less importance, the common species occurring in two or more types of water bodies being more important (fig. 5).

5. Discussion

If we assume that the migration of species can take place only between the habitats of their occurrence, then the eurytopic species will enjoy a potentially greater possibility of migration. However, the ability for a potential migration is not the same as actual migration.

Accepting the above assumption, Coleoptera, and to a somewhat smaller degree Heteroptera, play the greatest role (among the examined groups) in the integration of the aquatic part of the landscape of the catchment area of the River Gizela. This is evidenced by the greatest number of eurytopic species, found in all the distinguished types of water (figs 3-5), as well as by the gradient-like configuration of similarities between the stations (figs 1, 2). A much smaller potential role might be that of Ephemeroptera and Trichoptera, while the smallest one might be played by Plecoptera and Odonata on account of their strong bond with only one type of water and more distinct differentiation of the various types of water bodies (figs 1-4).

The integrating role of Coleoptera and Heteroptera most probably does not result from the specificity of the order, but to the dominance in these groups (in the collected material) of species typical and characteristic of small, still water bodies, characterized by the highest eutrophy. Also among other groups it was precisely those species characteristic of small, still water bodies that showed the highest eutrophy. However, their number in these insect orders was small. Thus the general conclusion may be drawn that the highest potential integrating role was played by the eutrophic species characteristic of small, still water bodies.

Other investigations point to the great migrating character of fauna typical of small, still water bodies (C z a c h o r o w s k i, S z c z e p a ń s k a 1991, B i e s i a d k a 1977b). The investigations on aquatic bugs and beetles in the old mine reservoirs near Konin, conducted by B i e s i a d k a, indicated that these waters were populated mainly by eurytopic species from small, still water bodies. This is evidence of their great dispersion and strong migrating character.

It appears that the integrating role is the result of those two factors as features adapting the insects to astatic habitats. This observation is in agreement with the literature data (B r u t o n 1989, B r z e z i e c k i 1990). It may therefore be expected that in the ecological landscape (conceived on a wider scale than the waters of a drainage area) the stable habitats represent components increasing internal differentiation and separation (isolation) from the environment, while the unstable ones contribute to the integration of the habitats and other ecological systems within the landscape through the migrations and dissemination of dispersive species (C z a c h o r o w s k i in press).

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6. Polish summary

Znaczenie owadów wodnych w integrowaniu krajobrazu w zlewni rzeki Gizeli (Pojezierze Mazurskie, północno-wschodnia Polska)

Badania terenowe prowadzono od maja do listopada 1986 roku na rzece Gizeli wraz z jej dopływami i sąsiadującymi drobnymi zbiornikami wód stojących. Do badań wyznaczono 11 stanowisk (źródło, cieki, wody stojące). Pobrano ponad 80 prób półilościowych. Łącznie zebrano 4131 larw i imagines zaliczonych do 138 gatunków z 6 rzędów owadów wodnych (tabela I).

Wyliczono podobieństwa faunistyczne pomiędzy stanowiskami dla każdego rzędu owadów oddzielnie a wyniki zestawiono w diagramach Czekanowskiego (ryc. 1, 2). W przypadku ważek, wyraźnie wyodrębniły się stanowiska wód stojących, natomiast dla widelnic wyodrębnił się blok stanowisk wód bieżących. Dla jętek i chruścików stanowiska grupowały się w dwóch blokach stanowisk: cieków oraz wód stojących. Podobieństwa między stanowiskami wyliczone na podstawie występowania chrząszczy i pluskwiaków układały się w kontinuum, bez grupowania się w grupy stanowisk. Analizowano także występowanie owadów z poszczególnych rzędów z uwzględnieniem liczebności osobników i liczby gatunków wyłącznych dla jednego typu wód lub występujących w dwu i trzech typach wód (ryc. 3-5).

Wydaje się, że największą rolę integracyjną poprzez potencjalne migracje pomiędzy wyróżnionymi typami wód miały Coleoptera i w nieco mniejszym stopniu Heteroptera, a najmniejszą Plecoptera. Integracyjna rola chrząszczy i pluskwiaków w ramach zlewni rzeki Gizeli wynikała z licznego udziału gatunków charakterystycznych dla drobnych wód stojących, gatunków odznaczających się dużą dyspersyjnością.

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