ACTA HYDROBIOL.	19	3	191—213	KRAKÓW 1977

BARBARA KAWECKA

Pokarm dominujących larw fauny dennej rzeki Raby (Polska południowa)*

The food of dominant species of bottom fauna larvae in the River Raba (Southern Poland)

Wpłynęło 8 czerwca 1976 r.

A b s t r a c t — The food of 47 species of larvae of *Ephemeroptera*, *Trichoptera*, and *Chironomidae* inhabiting the River Raba (a Carpathian tributary of the River Vistula) was investigated in the annual cycle. Phytophagous animals constituted 40.4% of those investigated (chiefly *Ephemeroptera* and *Trichoptera*), 19.1 fed on detritus (chiefly *Chironomidae*), unidentified organic matter prevailed in the food of 19.1% (chiefly *Chironomidae*), mineral matter in 10.6% (chiefly *Ephemeroptera*), mixed food in 6.4% (chiefly *Trichoptera*), and animal tissue in 4.3% (chiefly *Trichoptera* and *Chironomidae*). In the majority of larvae the food did not change throughout the year. A dependence was noted between the habitat of the organisms and the content of their alimentary canals. The phytophagous organisms preferred diatoms, among them the cells of the genus *Gomphonema*. The organisms did not select the food actively, simply consuming that which was most readily accessible in the environment.

In the years 1966—1972 in the Laboratory of Water Biology of the Polish Academy of Sciences complex investigations on the River Raba were carried out, including hydrology, geology and soils, chemism of the water, primary production, algae, bottom fauna, and fish.

The bottom fauna is an important link in the transformation of the organic matter produced on the spot and flowing in from the catchment area, since on the one hand it processes the food resources of the river and on the other constitutes the basic nutrition of fish. The aim of the present elaboration was to find out what was the food of the most frequently encountered bottom fauna larvae and whether

* Wykonano w ramach problemu resortowego PAN-21.

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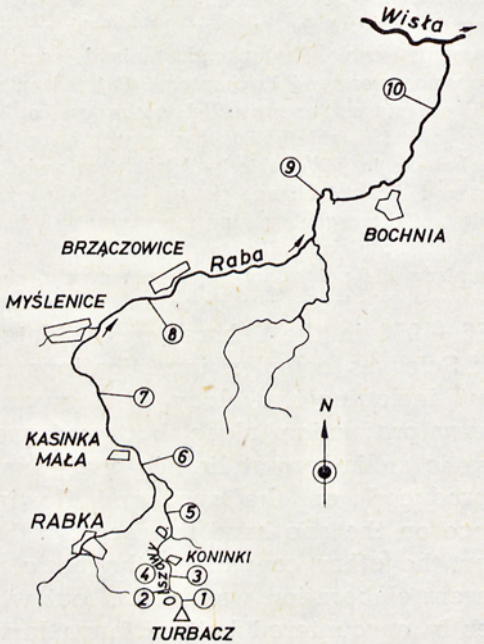
any selection occurred with them with regard to the choice of food. Part of the material concerning the food of *Chironomidae* has already been published (K a w e c k a, K o w n a c k i 1974).

Description of the investigated water system

The River Raba (129 km in length) is a right side tributary of the River Vistula. Its springs are found in the Gorce Mts and in the area of the Sieniawa Gate (Western Carpathians). The highest point in the Raba catchment basin is Mt Turbacz (1310 m) and the lowest one the mouth of the river (180 m). In the upper course the rocky substratum is built of sandstones and shales, in the middle course of flysch formations, and in the lower one of loams (P a s t e r n a k 1969).

The river is of carbonate-lime type with regard to its chemistry (B o m b ó w n a 1969). In the investigation the spring sector of the Raba, from Sieniawa to Mszana Dolna, was omitted because of the locality of Rabka which discharges municipal sewage. The investigated water flow includes the Olszowy Stream (Olszowy Potok) which begins from



Ryc. 1. Rozmieszczenie stanowisk
Fig. 1. Distribution of stations

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the springs under Mt Turbacz, the streams Koninka, Porębianka, Mszanka, and the River Raba down to its outflow into the River Vistula (fig. 1). The investigation was carried out at several selected stations in the upper and middle water course.

The upper course of the river

1) The spring of the Olszowy Stream with its mouth (station 1). It lies on an afforested slope of Mt Turbacz, 1220 m above sea level; the riverbed is up to 0.5 m in breadth, the depth to 0.1 m. The bottom is stony and slimy. The spring is strongly overgrown with moss; *Homoeothrix janthina* is noted (chiefly in the stream mouth), diatoms are frequent with dominant species of the genus *Achnanthes, Gomphonema intricatum* var. *pumilum, Cocconeis placentula* var. *euglypta, Diatoma hiemale* with the variety *mesodon.*

The fauna is poor, *Trichoptera* being the dominants, and among them *Drusus biguttatus* (syn. *D. muelleri* McLach, Szczęsny 1976), *Melampophylax nepos, Apatania carpatica,* and *Allogamus uncatus* (Szczęsny 1975).

2). The Olszowy Stream (station 3), at an altitude of about 780 m. The riverbed is 1.5—3 m in breadth, the depth 0.1—0.5 m; the banks are covered with mixed forest with a dominance of beech. In the autumn-winter period great amounts of detritus from rotting leaves are found on the bottom of the stream. The bottom is stony, sand and slime occurring in stagnant waters. In summer the stones are overgrown by *Homoeothrix janthina, Ulothrix zonata, Phormidium favosum,* and *Chamaesiphon polonicus,* and in winter *Hydrurus foetidus* dominates. Diatoms are numerous with the dominant genus *Achnanthes, Gomphonema intricatum* var. *pumilum, Diatoma hiemale* with the variety *mesodon,* and *Ceratoneis arcus.*

Of the *Ephemeroptera* group *Baetis alpinus, Rhithrogena iridina, R. loyolaea, Ameletus inopinatus,* and also stonefly *Brachyptera seticornis* dominate here (Sowa 1975). The dominant *Trichoptera* are represented by *Rhyacophila tristis, Drusus discolor,* and *Philopotamus ludificatus* (Szczęsny 1975). From *Chironomidae* the most numerous are *Tanytarsini — Microspectra atrofasciata, Heleniella ornaticolis, Eukiefferiella bavarica* gr., and *Thienemannimyia geijskesi* (Kawecka, Kownacki 1974).

The middle river course

The River Raba (stations 6—9 at an altitude of about 370—210 m). The riverbed is 15—40 m in breadth, the depth from 0.1—1.5 m. The banks

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are overgrown with bushes. The bottom is stony, with sand and slime at the banks.

In this sector the river has a similar character with regard to the flora and fauna. The stones are covered by great clumps of *Cladophora glomerata* and *Ulothrix zonata* is fairly frequent as well as *Phormidium favosum*, in winter *Hydrurus foetidus* and *Homoeothrix janthina* being noted. Diatoms are very numerous here, the species of the genus *Achnanthes* still dominating and also *Cymbella ventricosa*, species of the genus *Gomphonema*, *Diatoma elongatum* var. *tenue*, *D. vulgare* with varieties, and *Rhoicosphenia curvata*. Station 9 has a slightly different character since the silting increases, the growth of algae being less abundant.

The bottom fauna is rich. Of the *Ephemeroptera* the genus *Baetis* dominates, chiefly *B. vardarensis*, and also *B. lutheri*, *B. rhodani*, *B. muticus*, *B. fuscatus*, *Rhithrogena semicolorata*, *Habroleptoides modesta*, *Ecdyonurus dispar*, *E. lateralis*, and *Caenis pseudorivulorum* (Sowa 1975). From *Trichoptera* *Hydropsyche pellucidula* dominates, occurring together with *H. bulbifera*, *Hydroptila forcipata*, and *Psychomyia pusilla* (Szczęsny 1975). Of *Chironomidae* the dominants are *Cricotopus* sp., *Conchapelopia pallidula*, *Potthastia gaedii*, *Polypedilum pedestre* gr., and *Eukiefferiella* sp. I (Kawecka, Kownacki 1974).

Method

The material was collected in 1969/1970 at intervals of 1 or 2 months. In order to characterize the envrionment, at each station an evaluation was made of what percentage of a determined area of the stream bottom (e.g. 25 m²) was covered by algae forming macroscopic conglomerations such as *Cladophora glomerata*, *Ulothrix zonata*, *Homoeothrix janthina*, and *Hydrurus foetridus*, and also by mosses and by mud. Then about 10 algological samples were collected and preserved in a 4% solution of formalin. Small fragments of algal communities were also collected together with animals, to analysing the food of organisms in their microhabitat. A part of the algological material from each sample was macerated in sulphuric acid with an addition of potassium dichromate, and solid preparations were made from the obtained pure frustules of diatoms. The algological characteristic was based on the author's own investigations.

The animal material was collected and identified by: Dr. R. Sowa (*Ephemeroptera*), Dr. B. Szczęsny (*Trichoptera*), and Dr. A. Kownacki (*Chironomidae*).

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The alimentary canals of at least 10 specimens of each species were prepared under stereoscope and then, in a drop of distilled water, directly surveyed under the microscope. The fragments of animals in the content of the canals were indentified by dr. A. Kownacki.

The quantitative relations were presented as a percentage. The percentage content of food constituents was determined in relation to the whole content of the isolated canals. The percentage share of diatom species in the environment and in the food was determined indirectly: first the number of cells of each species was counted in 10 fields of vision of the microscope and then their number was expressed as percentage.

In order to investigate selectivity in the choice of diatoms in the food of animals, the index of food selection of diatoms (K) was calculated as expressing the ratio of the percentage share of this species in the food (O_f) to its percentage share in the environment (O_e), thus $K = \frac{O_f}{O_e}$. It was assumed that an index value of more than 1 suggested a preference for the given diatom species by the animal. The index of food selection of diatoms was calculated for the groups of mayflies, caddis-flies, and *Chironomidae*, composed of organisms in which the diatoms constituted at least 40% of the total food.

If the obtained index of food selection was over 1, the Gosset-Student test was used to find out whether the selection of the given diatom species was statistically significant. Since the numerical values of diatoms were expressed in percentage and the population distribution differed from the normal one, the arcsinus transformation was applied according to Snedecor (1957). The Gosset-Student test was used both for the percentage values and for the transformed ones. The obtained results were identical.

Results

The food of animals and the degree of digestion of algae and animals in the content of alimentary canals.

The following categories were noted in the food of larvae:

1. Cells and fragments of algal talli;
2. Fragments of higher plants;
3. Unidentified organic matter probably constituting digested plant material;
4. Fragments of animals;

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5. Detritus (fragments of decomposing plants and animals);
6. Mineral matter.

In the animals' food 82 taxons of algae were encountered, among them 65 diatoms, 11 green algae, 4 blue-green algae, 1 from yellow-brown algae, and 1 red alga. The majority of diatoms were identified as to species, the remaining organisms usually as to genus.

The animals encountered in the alimentary canals were identified and assigned to nine higher taxonomic units (*Oligochaeta, Nematoda, Rotatoria, Tardigrada, Hydracarina, Ephemeroptera, Plecoptera, Trichoptera,* and *Diptera*), among these one to the family of *Naidae*, three to the subfamily *Chironomidae*, and one to the genus *Baetis*.

The algae were digested in varying degree. The measure of digestion was the loss of cell content inside the cell membrane, which was never digested. The inner content of blue-green algae *Phormidium favosum* and *Homoeothrix janthina* was poorly digested, while *Merismopedia glauca* and *Chamaesiphon incrustans* were not digested at all. Yellow-brown alga *Hydrurus foetidus* was only poorly digested. Small specimens of diatoms (12.5—30 μm in length and 2.5—20 μm in breadth) usually had a partially or wholly digested chloroplast. Large diatoms (40—60 μm in length and 7.5—20 μm in breadth) appeared with inner content preserved. Silicic frustules were not destroyed. Gelatinous tendrites were not digested. The inner content of filamentous green algae *Ulothrix zonata, Spirogyra* sp., *Oedogonium* sp., and *Cladophora glomerata* were frequently well digested. The cells of desmids and *Scenedesmus* sp. were poorly digested. Among red algae *Chantransia* sp. was quite undigested.

No significant differences were observed between the degree of digestion of algae and the consumer species. Only in the content of the alimentary canals of *Rhithrogena ferruginea* were the well digested cells of desmids noted while with *Hydroptila forcipata* the majority of diatom cells had the chloplast well preserved.

Usually the animals appeared in fragments, more rarely whole specimens of *Chironomidae* being noted. Hard parts, such as head capsules, fragments of mouth parts, chitinous shells, and claws, were well preserved.

Feeding habits of bottom fauna larvae inhabiting the upper course of the River Raba

1. The spring of the Olszowy Stream (station 1) (fig. 2)

Four species of caddis-flies, which dominated there, consumed vegetal food. The food of *Allogamus uncatus* was composed of plant mass in which fragments of plants, probably of mosses, constituted a large percentage. In the food of *Melampophylax nepos, Apatania carpatica,* and

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Drusus biguttatus algae dominated, the composition of food being particularly varied in the case of *Melapophylax nepos*.

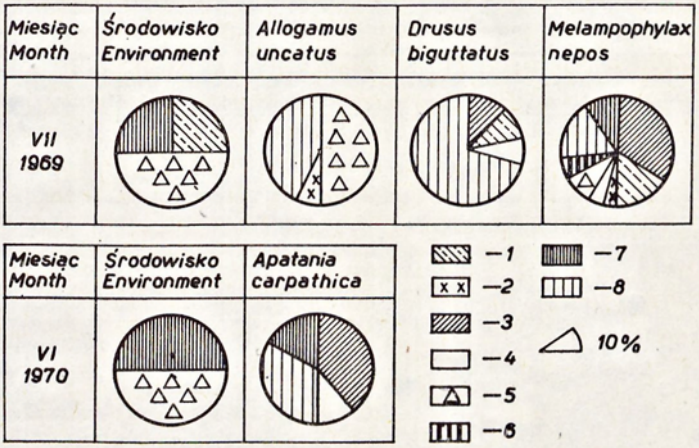
2. The Olszowy Stream (station 3) (fig. 3)

Ephemeroptera

Rhithrogena iridina, *Baetis alpinus*, and *Brachyptera seticornis* fed chiefly on diatoms. Species of the genus *Achnanthes* often occurred in communities composed of several scores of cells. The alimentary canals of *Amelatus inopinatus* and *Rhithrogena loyolaea* were filled with a mass of dark detritus. Diatoms being an admixture; among them the cells of the genus *Achnanthes*, *Gomphonema intricatum* var. *pumilum*, were most numerous, while with *Rhithrogena loyolaea* the cells of *Cocconeis placentula* var. *euglypta* prevailed.

Trichoptera

The food of *Drusus discolor* was composite, a high percentage being composed of fragments of animals. The head capsule and some abdominal segments of *Chironomidae* of the *Orthocladiinae* group, a well digested specimen of *Corynoneura* gr. *minuta*, a body fragment of an arthropod,



Ryc. 2. Pokarm larw chruścików zamieszkujących górny bieg Olszowego Potoku (stanowisko 1): 1 — *Homoeothrix janthina*; 2 — *Phormidium favosum*; 3 — okrzemki; 4 — *Chantransia* sp.; 5 — mech w środowisku, fragmenty tkanek roślinnych w treści przewodów pokarmowych; 6 — detritus; 7 — materia mineralna; 8 — nie zidentyfikowana materia organiczna

Fig. 2. Food of caddis-fly larvae inhabiting the upper course of the Olszowy Stream (station 1): 1 — *Homoeothrix janthina*; 2 — *Phormidium favosum*; 3 — diatoms; 4 — *Chantransia* sp.; 5 — moss in environment; fragments of plant tissue in alimentary canals; 6 — detritus; 7 — mineral matter; 8 — undetermined organic matter

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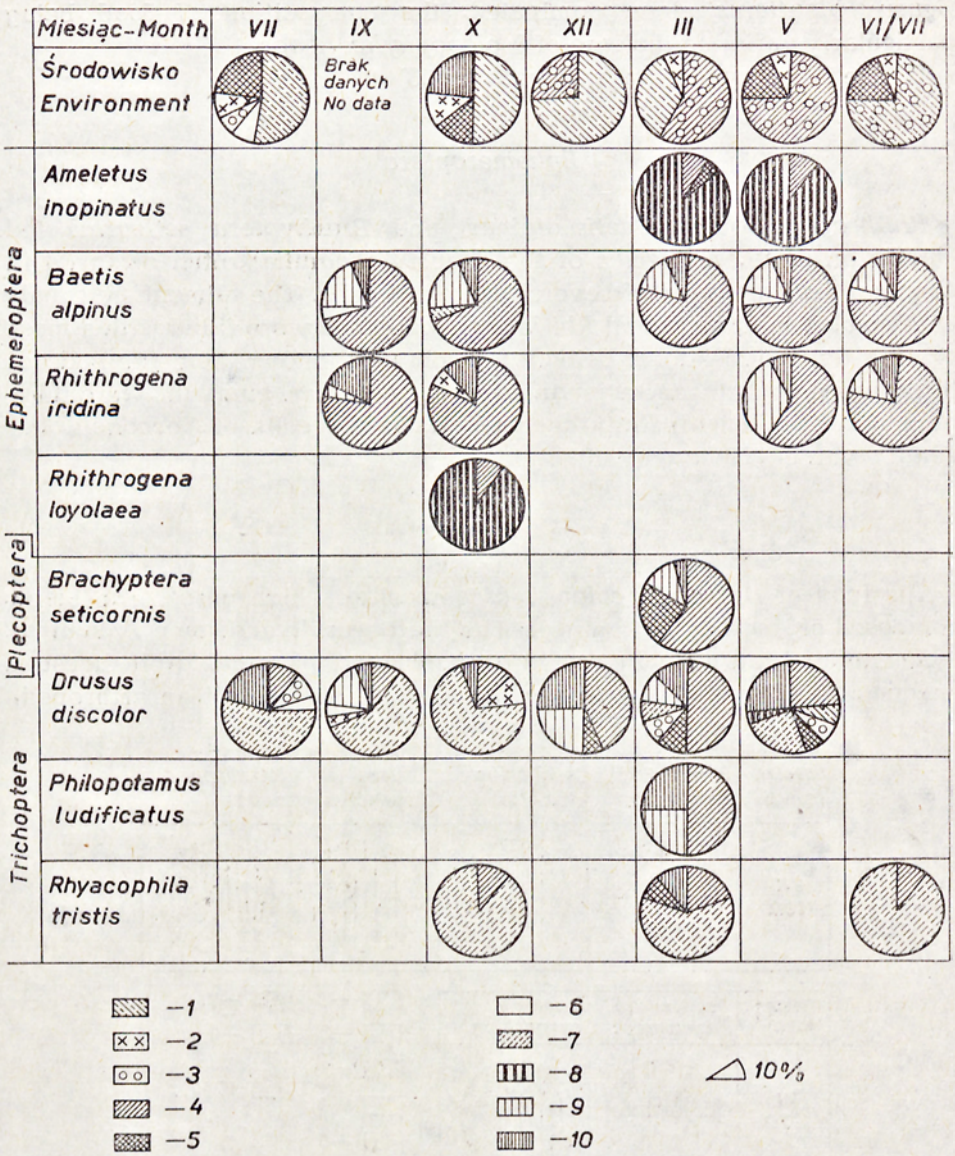

Ryc. 3. Pokarm larw jętek, widelnicy oraz chruścików zamieszkujących Potok Olszowy (stanowisko 3): 1 — *Homoeothrix janthina* (w środowisku wraz z okrzemkami); 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — okrzemki; 5 — *Ulothrix zonata*; 6 — *Chantransia* sp.; 7 — fragmenty zwierząt; 8 — detritus; 9 — nie zidentyfikowana materia organiczna; 10 — materia mineralna

Fig. 3. Food of mayfly, stonefly, and caddis-fly larvae inhabiting the Olszowy Stream (station 3): 1 — *Homoeothrix janthina* (in environment with diatoms); 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — diatoms; 5 — *Ulothrix zonata*; 6 — *Chantransia* sp.; 7 — fragments of animals; 8 — detritus; 9 — undetermined organic matter; 10 — mineral matter

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a mayfly or a stonefly, cerci, a leg, skin, and stylus of species of the genus *Baetis*, a whole specimen and a leg of *Hydracarina*, a fragment of the eye of an adult insect, a mandible, a thigh, and skin covered with diatom cells of an unidentified insect were found here. Besides, the following algae appeared: *Hydrurus foetidus*, *Chantransia* sp. overgrown by *Chamaesiphon incrustans*, *Ulothrix zonata*, *Phormidium favosum*, filaments of *Homoeothrix janthina* aggregated in clusters, and diatoms, *Gomphonema intricatum* var. *pumilum* being the most numerous, and also species of the genus *Achnanthes*, and *Diatoma hiemale* with the variety *mesodon*. In the alimentary canals of *Rhyacophila tristis* larvae chiefly fragments of animals were encountered, among which fragments of mandibles, legs and claws of insects, chitinous shells, probably of caddis flies, hairy chitinous shells of an unidentified insect, and flesh and fat tissues. Diatoms constituted and admixture of the food, *Gomphonema intricatum* var. *pumilum* in clusters of several scores of specimens being most numerous, *Cymbella affinis* and species of the genus *Achnanthes* were also fairly numerous. The alimentary canals of *Philopotamus ludificatus* were filled with a dark slimy mass in which numerous diatoms were submerged.

Chironomidae

The dominant species fed mainly on detritus, as previously reported (Kawecka, Kownacki 1974 — fig. 3). In the alimentary canals of *Heleniella ornaticolis* fragments of wood, plant fibre, fragments of animals (head, claws of a fore and hind legs, bristles, and *Chironomidae* skin), fragments of *Phormidium*, cells of diatoms, and spores of a fungus. The alimentary canals of *Micropsectra atrofasciata* contained a number of organic and mineral remnants and a few diatoms. With *Eukieferiella bavarica* gr. fragments of blue-green algae, red algae, red-brown organic structures, bristles of animals, and fragments of plant tissues were noted in the food. In the content of the alimentary canals of *Thienemanimyia geiskesi* unidentified organic matter prevailed in which a quantity of fragments of animals from the *Orthocladiinae* group were found, among others *Eukiefferiella* (mandible, lower lip, fragments of a leg, claws of a fore or hind leg), a tardigrade, fragments of a young mayfly, probably a rotifer, and *Hydracarina*. *Rheotanytarsus* sp. also consumed detritus. It is an interesting subdominant since its biology is wholly unknown (fig. 6).

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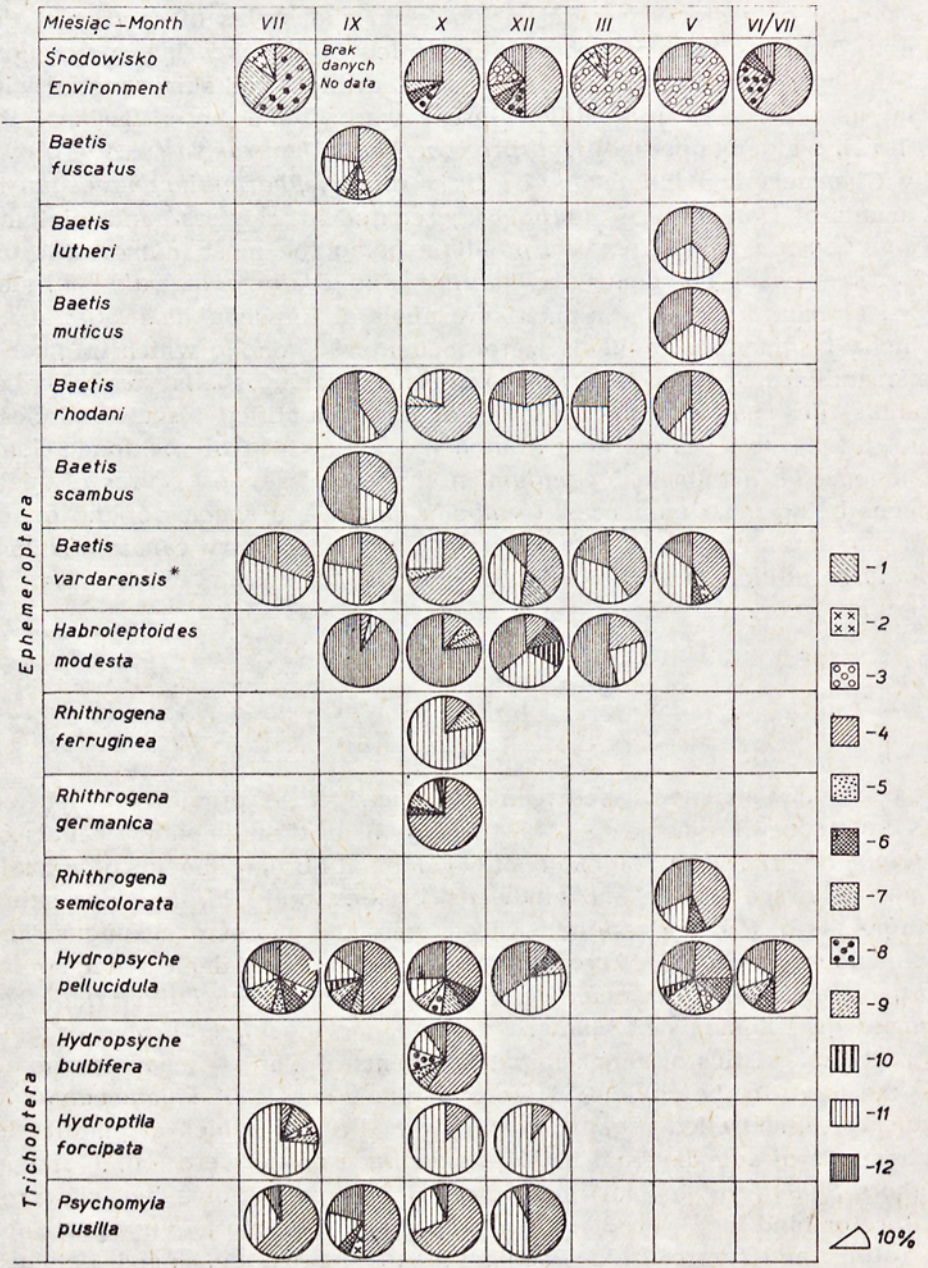

Ryc. 4. Pokarm larw jętek oraz chruścików zamieszkujących środkowy bieg rzeki Raby (stanowisko 6). * — w miesiącach X—III formy młodociane (dane mogą odnosić się także do *Baetis lutheri*): 1 — *Homoeothrix janthina*; 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — okrzemki; 5 — *Chlorophyta*; 6 — *Ulothrix zonata*; 7 — desmidie; 8 — *Cladophora glomerata*; 9 — fragmenty zwierząt; 10 — detritus; 11 — nie zidentyfikowana materia organiczna; 12 — materia mineralna

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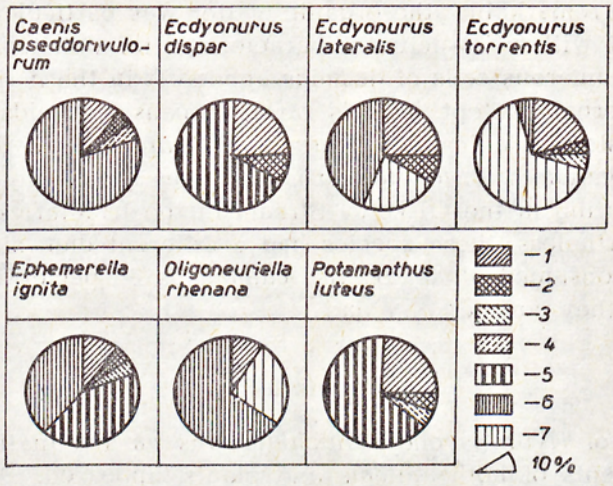

Ryc. 5. Pokarm larw jętek zamieszkujących środkowy bieg rzeki Raby (stanowisko 8): 1 — okrzemki; 2 — *Ulothrix zonata*; 3 — desmidie; 4 — fragmenty zwierząt; 5 — detritus; 6 — materia mineralna; 7 — nie zidentyfikowana materia organiczna

Fig. 5. Food of larvae of mayflies inhabiting the middle course of the River Raba (station 8): 1 — diatoms, 2 — *Ulothrix zonata*; 3 — desmids, 4 — fragments of animals; 5 — detritus; 6 — mineral matter; 7 — undetermined organic matter

Feeding habits of the bottom fauna larvae inhabiting the middle course of the River Raba

Ephemeroptera (figs 4, 5)

The majority of species fed on the algae: *Baetis fuscatus, B. lutheri, B. scambus, B. rhodani, B. vardarensis, Ecdyonurus torentis, Rhithrogena germanica,* and *R. semicolorata.* Diatoms constituted a great percentage of their food, which was also composed of fragments of blue-green algae, green algae, and cells of desmids, among them chiefly *Cosmarium* and *Staurastrum.* In the food of a few species mineral matter prevailed: this was fine-grained and loamy with *Ecdyonurus lateralis* and *Oligoneuriella rhenana,* and composed of sand crystals in the case of *Hybroleptoides modesta* and *Caenis pseudorivulorum.* Much detritus was found in the alimentary canals of *Potamanthus luteus, Ecdyonurus dispar,* and *Ephemerella ignita.* The content of the alimentary canals of *Rhithrogena fer-*

Fig. 4. Food of mayfly and caddis-fly larvae inhabiting the middle course of the River Raba (station 6). * — in the months X—III juvenilestage, (data can refer also to *Baetis lutheri*): 1 — *Homoeothrix janthina*; 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — diatoms; 5 — *Chlorophyta*; 6 — *Ulothrix zonata*; 7 — desmids; 8 — *Cladophora glomerata*; 9 — fragments of animals; 10 — detritus; 11 — undetermined organic matter; 12 — mineral matter

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ruginea was remarkable: the organic matter was particularly fine-grained, dark but without structures characteristic for detritus, while at the same time numerous cells of desmids appeared, in the majority of cases with no internal content. This is rarely because desmids are usually poorly digested by animals. *Rhithrogena ferruginea* and *Baetis fuscatus* were not dominants. *R. ferruginea* is a species closely related to *R. iridina*, dominating in the Olszowy Stream in the tributaries of the River Raba. Nevertheless, these species had a different diet, since *R. iridina* decisively consumed algae. *Baetis scambus* is a species identical with *B. fuscatus;* they both fed on algae.

Trichoptera (fig. 4)

The food of *Hydropsyche pellucidula* was varied. In the alimentary canal fragments of both animals and plants appeared. Among plants diatoms prevailed, the cells of *Achnanthes*, *Cymbella*, and *Gomphonema* being most numerous. Large forms, e.g. *Amphora ovalis*, *Diatoma vulgare*, or *Gomphonema olivaceum* preserved their internal content. From green algae fragments of *Ulothrix zonata*, *Cladophora glomerata* overgrown with cells of *Cocconeis pediculus*, probably *Gongrosira* sp., *Spirogyra* sp., *Oedogonium* sp., *Draparnaldia* sp., *Cosmarium* sp., *Staurastrum punctulatum*, *Closterium Leibleinii*, fragments of blue-green algae, such as *Homoeothrix janthina*, *Phormidium* sp., *Hydrurus foetidus*, and spores of a fungus were encountered. Fragments of animals of the groups *Orthocladiinae*, *Cricotopus*, and *Eukiefferiella* (body, head capsules, skin, mandibles, claws of fore or hind legs, and eyes), fragments of mouth parts of a mayfly or a stonefly, a nematode, and eggs of crustaceans (*Bosmina*) were also noted there. Also *Hydrophyche bulbifera* had a varied food. Diatoms prevailed, the cells of *Cymbella* concentrated in mucous covers, cells of *Rhoicosphenia curvata*, and *Cocconeis placentula* being poorly digested. Filaments of *Cladophora glomerata* overgrown with epiphytes, *Ulothrix zonata*, probably the filaments of *Oedogonium* sp., cells of *Staurastrum* sp., and *Cosmarium* sp. were also noted. In the food of *Hydroptila forcipata* the unidentified organic matter prevailed, probably composed of fatty substance. As an admixture, diatoms with a well-preserved chloroplast, fragments of a blue-green alga, probably *Homoeothrix janthina*, *Phormidium* sp., and also fragments of mouth parts of an insect appeared. In the food of *Psychomyia pusilla* diatoms decisively dominated.

Chironomidae

These fed on algae and animal matter, mineral matter constituting a large percentage (K a w e c k a, K o w n a c k i 1974 — fig. 4). The food

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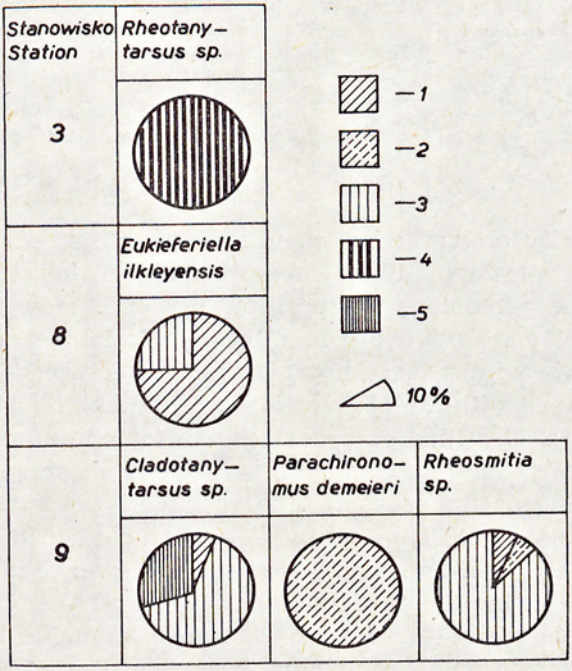
content of *Cricotopus* sp. was chiefly composed of diatoms, among them frequently *Gomphonema* on gelatinous tendrites. *Cosmarium subcrenatum*, *Scenedesmus* sp., *Ulothrix zonata*, *Phormidium favosum*, and *Homoeothrix janthina* were occasionally noted. In the food of *Potthastia gaedii* organic matter prevailed. A quantity of diatoms were found, *Diatoma vulgare* and *Rhoicosphenia curvata* frequently occurring in clusters. Of green algae fragments of *Oedogonium* sp., *Stigeoclonium* sp., and cells of *Cosmarium* sp. occurred, of blue-green algae filaments or only envelopes of *Homoeothrix janthina*, fragments of *Phormidium* sp., and *Merismopedia glauca*. The mineral matter consisted of sand. Sand prevailed in the content of the alimentary canals of *Polypedilum pedestre* gr.



Ryc. 6. Pokarm larw *Chironomidae* (subdominanty) zamieszkujących Olszowy Potok i rzekę Rabę: 1 — okrzemki; 2 — fragmenty zwierząt; 3 — nie zidentyfikowana materia organiczna; 4 — detritus; 5 — materia mineralna

Fig. 6. Food of *Chironomidae* larvae (sub-dominants) inhabiting the Olszowy Stream and the River Raba: 1 — diatoms; 2 — fragments of animals; 3 — undetermined organic matter; 4 — detritus; 5 — mineral matter

Diatoms, fragments of a green alga, probably *Chaetophora* sp., and cells of *Scenedesmus* sp. constituted and admixture. The diet of *Conchapelopia pallidula* was varied. Here fragments of green algae, such as *Ulothrix zonata*, *Oedogonium* sp., *Stigeoclonium* sp., cells of *Scenedesmus* sp., *Cosmarium* sp., *Staurastrum* sp., and diatoms were encountered,

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among them *Cymbella ventricosa*, gathered in clusters of several scores of cells in mucous covers, being most frequent.

A great part consisted of animal tissue, in which *Chironomidae* (*Orthocladiinae* and *Chironimini*) were noted: whole partly digested specimens, head capsules, fragments of mouth parts, and claws of fore and hind legs. The food of *Eukiefferiella* sp. was chiefly composed of algae, *Homoeothrix janthina* being the dominant.

Several species of the sub-dominant group (fig. 6) should also be mentioned, since their biology is as yet only poorly known. *Parachironomus demeieri* was found to be a predator and in its alimentary canals *Oligochaeta* of the *Naididae* group were encountered. The content of the alimentary canals of *Rheosmittia* sp. was probably composed of fat. Diatoms, often with a well-preserved internal content, dominated in *Eukiefferiella ilkleyensis*.

The food of larvae throughout the year; diatom communities in the food of bottom fauna larvae

In the majority of larvae no changes were observed in the type of food consumed throughout the year, only certain variations being observed in the percentage composition of food. However, in *Drusus discolor* animal matter prevailed in the canals in the summer-autumn months, while in winter these organisms consumed plant material. This was in accordance with the observations of Mecom (1972), who found that *Trichoptera*, classified as predators, consumed animal food only in summer till early autumn. Changes in the food of some bottom fauna larvae depending on the season of the year were observed by Champan and Demory (1963), and by Armitage (1968) in *Chironomidae*. Haage (1970) did not find any specific difference in food selection by *Trichoptera* during the particular seasons of the year. Also Kosloucher and Minshall (1973) found food to be stable throughout the year with species of the genera *Hydropsyche* and *Baetis*.

In the food of herbivorous species diatoms always prevailed in spite of the distinct changes among the dominant alga species in the environment. For example the food of three species of mayfly of the genus *Baetis* which succeeded one another along the river course (*Baetis alpinus* in the upper course, *B. lutheri* and *B. vardarensis* in the middle and lower course) was examined in two seasons of the year, in May and July. In spite of the fact that in May *Hydrurus foetidus* and in July *Homoeothrix janthina* and *Cladophora glomerata* dominated in the environment, in the majority of cases these three mayfly species consumed diatoms (figs 7 A,B). Special attention was paid to the changes in the qualitative composition of diatoms in the food of those animals in which diatoms constituted

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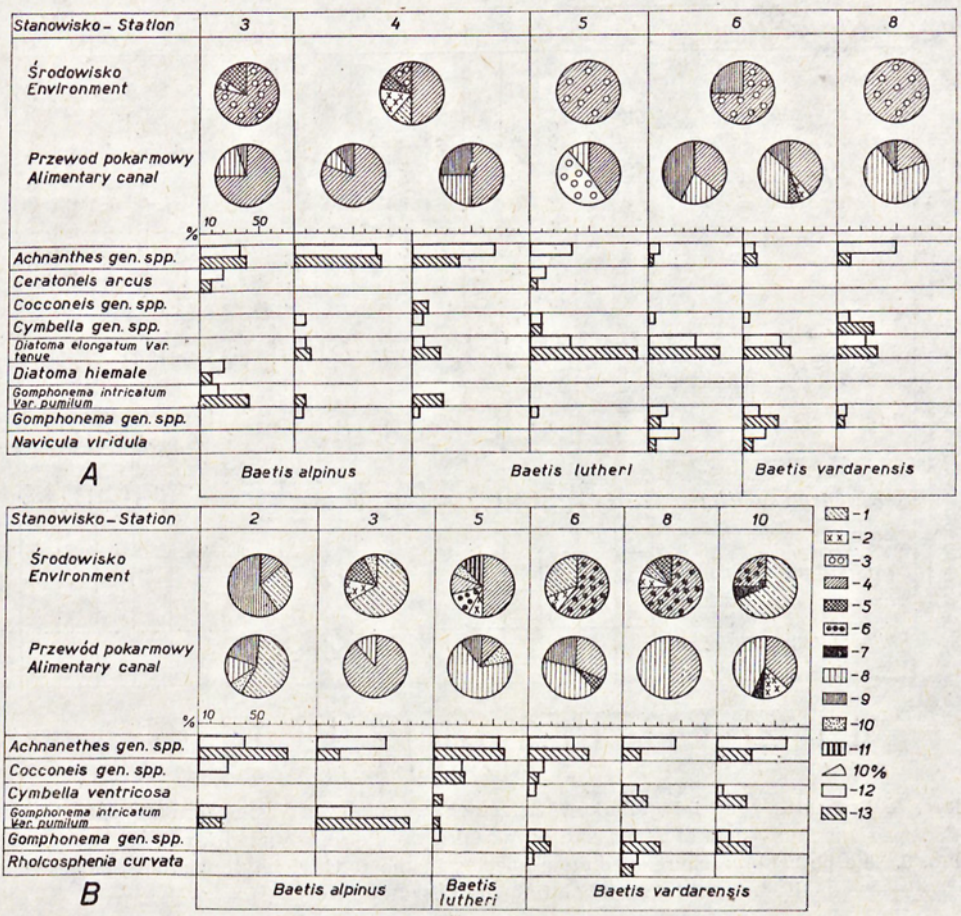

Ryc. 7. Pokarm trzech gatunków reobiontycznych jętek z rodzaju *Baetis* w rzece Rabie w maju (A), oraz w lipcu (B): 1 — *Homoeothrix janthina*, 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — okrzemki; 5 — *Ulothrix zonata*; 6 — *Cladophora glomerata*; 7 — desmidie; 8 — nie zidentyfikowana materia organiczna; 9 — materia mineralna; 10 — *Chlorophyta*; 11 — detritus; 12 — środowisko; 13 — przewód pokarmowy

Fig. 7. Food of rheobiontic species of mayfly of the genus *Baetis* in the River Raba in May (A) and in July (B); 1 — *Homoeothrix janthina*; 2 — *Phormidium favosum*; 3 — *Hydrurus foetidus*; 4 — diatoms; 5 — *Ulothrix zonata*; 6 — *Cladophora glomerata*; 7 — desmids; 8 — undetermined organic matter; 9 — mineral matter; 10 — *Chlorophyta*; 11 — detritus; 12 — environment; 13 — alimentary canal

at least 40% of the alimentary canal content. In such cases the qualitative composition of diatom species in the food and the changes in the composition of species represented the relations in the environment. In the animals inhabiting the upper river course the food changed only slightly, similarly as the development of diatoms in the environment (fig. 8).

In the middle river course *Diatoma elongatum* var. *tenue* appeared in the food additionally, in time with its development in the river (fig. 9).

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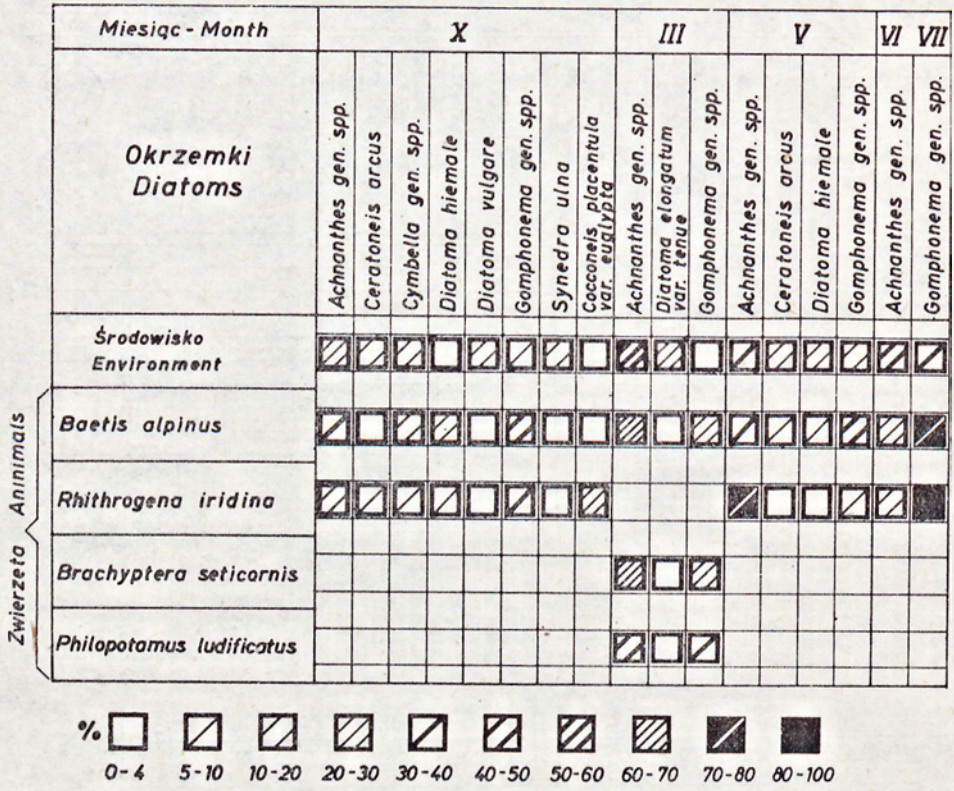

Ryc. 8. Procentowy udział gatunków okrzemek w pokarmie roślinożernych gatunków fauny dennej zamieszkujących Olszowy Potok (stanowisko 3)

Fig. 8. The percentage share of diatom species in the food of phytophagous species of the bottom fauna inhabiting the Olszowy Stream (station 3)

Similarly, the qualitative composition of diatoms in the content of the alimentary canals of the above-mentioned species of mayflies changed in time and space according to the development of these organisms in the environment.

Food selection of the bottom fauna

The food of the investigated species of larvae of the bottom fauna may be divided into several categories. Plant food: with the prevalence of algae or with the prevalence of tissue plants; animal food; mixed food (containing fragments of plants and animals), detritus; or plant and mixed food with the prevalence of detritus, plant or mixed food with the prevalence of unidentified organic matter, or with a prevalence of min-

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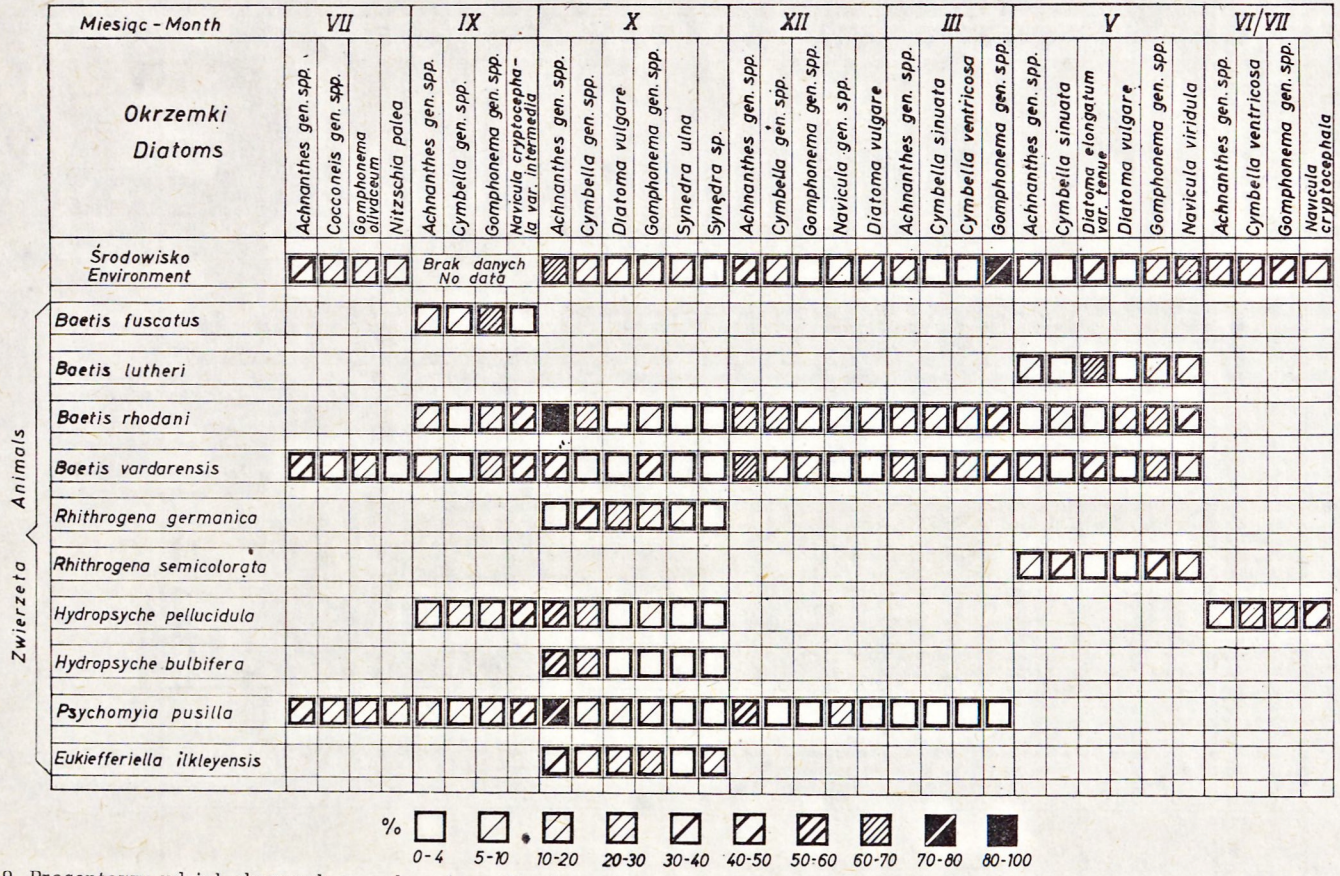

Ryc. 9. Procentowy udział okrzemek w pokarmie roślinożernych gatunków fauny dennej zamieszkujących środkowy bieg rzeki Raby (stanowisko 6)

Fig. 9. The percentage share of diatoms in the food of phytophagous species of the bottom fauna inhabiting the middle course of the River Raba (station 6)

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Tabela I. Pokarm larw fauny dennej na tle siedliska ich życia

Table I. Food of larvae of bottom fauna against the background of their habitat

Gatunek Species	Stanowisko Station	Siedlisko życia Habitat	Rodzaj pokarmu (w nawiasie umieszczono składnik dominujący) Kind of food (the dominant component is given in brackets)
Ephemeroptera			
Potamanthus luteus (L.)	6	muł, żwir, bez prądu mud, gravel, no current	roślinny (detritus) vegetal
Rhithrogena ferruginea Navás	6	kamienie, słaby prąd stones, weak current	roślinny (materia organiczna niezidentyfikowana) vegetal (undetermined organic matter)
- germanica Eth.	8	kamienie, średni prąd stones, medium current	roślinny (glony) vegetal (algae)
- iridina (Kol.)	3	kamienie, średni prąd stones, medium current	roślinny (glony) vegetal (algae)
- loyolaea Navás	3	kamienie, słaby prąd stones, weak current	roślinny (detritus) vegetal
- semicolorata (Curt.)	6	kamienie, silny prąd stones, strong current	roślinny (glony) vegetal (algae)
Ecdyonurus dispar (Curt.)	8	kamienie, słaby prąd lub bez prądu stones, weak or no current	roślinny (detritus) vegetal
- lateralis (Curt.)	8	kamienie, unika prądu stones, keep out of current	roślinny (materia mineralna) vegetal (mineral matter)
- torrentis Kimm.	6	kamienie, słaby prąd stones, weak current	roślinny (materia organiczna niezidentyfikowana) vegetal (undetermined organic matter)
Habroleptoides modesta Hag.	6	muł, żwir, liście, słaby prąd mud, gravel, leaves, weak current	roślinny (materia mineralna) vegetal (mineral matter)
Amelatus inopinatus Etn.	3	muł, unika prądu mud, keeps out of current	roślinny (detritus) vegetal
Baetis alpinus (Pict.)	3	kamienie, prąd stones, current	roślinny (glony) vegetal (algae)
- fuscatus (L.)	6	różne siedliska, średni prąd various habitats, medium current	roślinny (glony) vegetal (algae)
- muticus (L.)	6	różne siedliska, średni prąd various habitats, medium current	roślinny (glony) vegetal (algae)
- lutheri M.C.	6	kamienie, silny prąd stones, strong current	roślinny (glony) vegetal (algae)
- rhodani Pict.	6	kamienie, żwir, średni prąd stones, gravel, medium current	roślinny (glony) vegetal (algae)
- scambus Etn.	6	różne siedliska, średni prąd various habitats, medium current	roślinny (materia mineralna) vegetal (mineral matter)
- vardarensis Ikon.	6	kamienie, silny prąd stones, strong current	roślinny (glony) vegetal (algae)
Oligoneuriella rhenana Imh.	8	kamienie prąd stones current	roślinny (materia mineralna) vegetal (mineral matter)
Ephemerella ignita Poda	6	kamienie, słaby prąd stones, weak current	roślinny (detritus) vegetal
Caenis pseudorivulorum Keff	8	muł, słaby prąd mud, weak current	mieszany (materia mineralna) mixed (mineral matter)
Plecoptera			
Brachyptera seticornis (Klap.)	3	kamienie, silny prąd stones, strong current	roślinny (glony) vegetal (algae)
Trichoptera			
Rhyacophila tristis Pict.	3	kamienie, prąd stones, current	mieszany (fragmenty zwierząt) mixed (fragments of animals)

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Gatunek Species	Stanowisko Station	Siedlisko życia Habitat	Rodzaj pokarmu (w nawiasie umieszczono składnik dominujący) Kind of food (the dominant component is given in brackets)
Hydroptila forcipata Eat.	6	glony epifityczne epiphytic algae	mieszany (materia organiczna niezidentyfikowana) mixed (unidentified organic matter)
Philopotamus ludificatus McLach	3	kamienie, muł prąd stones, mud, current	roślinny (glony) vegetal (algae)
Hydropsyche bulbifera McLach	6	kamienie, silny prąd stones, strong current	roślinny (glony) vegetal (algae)
- pellucidula Curt.	6	kamienie, silny prąd stones, strong current	mieszany (glony) mixed (algae)
Psychomyia pusilla Fabr.	6	roślinny epifityczne epiphytic algae	roślinny (glony) vegetal (algae)
Apatania carpatica Achmid	1	kamienie, słaby prąd stones, weak current	roślinny (glony) vegetal (algae)
Drusus biguttatus Pict.	1	kamienie, prąd stones, current	roślinny (materia organiczna niezidentyfikowana vegetal (unidentified organic matter)
- discolor Ramb.	3	kamienie, silny prąd stones, strong current	mieszany mixed
Melampophylax nepos McLach	1	kamienie w oprysku hygropetric	roślinny (glony) vegetal (algae)
Allogamus uncatus Brau.	1	muł, żwir, detritus, słaby prąd mud, gravel, detritus, weak current	roślinny (fragmenty tkanek roślinnych) vegetal (fragments of plant tissue)
Chironomidae			
Thienemanimyia geiskesi (G.)	3	muł, słaby prąd mud, weak current	mieszany (materia organiczna niezidentyfikowana) mixed (unidentified organic matter)
Conchapelopia pallidula (Mg.)	6	kamienie zamulone silted stones	mieszany (materia organiczna niezidentyfikowana) mixed (unidentified organic matter)
Potthastia gaedii (Mg.)	6	kamienie zamulone silted stones	mieszany (glony) vegetal (algae)
Eukiefferiella bavarica gr.	3	szeroki zakres-wide range preferuje mech-prefers moss	detritus
- ilkleyensis Edwards	8	preferuje mech prefers moss	roślinny (glony) vegetal (algae)
Eukiefferiella sp. I	6	nie znana not known	roślinny (materia organiczna niezidentyfikowana) vegetal (unidentyfied organic matter
Cricotopus spp.	6	szeroki zakres wide range	roślinny (glony) vegetal (algae)
Heleniella ornaticolis (Edw.)	3	zastoisko, słaby prąd stagnant water, weak current	detritus
Rheosmitia sp.	9	nie znane not known	mieszany (materia organiczna niezidentyfikowana) mixed (unidentified organic matter)
Parachironomus demejerei Krus.	8	żwir gravel	fragmenty zwierząt fragments of animals
Polypedilum pedestre gr.	6	słaby prąd, zastoisko weak current, stagnant water	roślinny (materia mineralna) vegetal (mineral matter)
Micropsectra atrofasciata K.	3	słaby prąd, zastoisko weak current, stagnant water	detritus
Cladotanytarsus sp.	9	słaby prąd, zastoisko weak current, stagnant water	roślinny (materia organiczna niezidentyfikowana) vegetal (unidentified organic matter)
Rheotanytarsus sp.	3	kamienie, słaby prąd stones, weak current	detritus

Uwaga-Note: Prąd szybki Strong current 0,7,-1,5 m/sec. Prąd średni Medium current 0,3 -0,4 m/sec. Prąd słaby Weak current 0,05-0,20 m/sec.

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Tabela II. Wskaźniki wybiórczości pokarmowej okrzemek u dominujących grup fauny dennej rzeki Raby oraz Olszowego Potoku

Table II. Indices of food selection of diatom in dominant groups of bottom fauna in the River Raba and the Olszowy Stream

Grupa zwierząt Group of animals	Stanowisko Stations	Achnanthes gen. spp.	Cymbella gen. spp.	Diatoma gen. spp.	Diatoma elongatum var. tenue	Gomphonema gen. spp.	Navicula gen spp
Ephemeroptera	3	1.4	0.2	0.5		2.9	
	6	0.7	2.3	0.9	0.9	1.1	0.5
Trichoptera	6	1.2	0.7	0.3		0.7	0.8
Chironomidae	8	0.3	1.3	1.6	0.6	2.2	1.5

eral matter. The kind of food was distinctly correlated with the habitat of the organisms as well as with the way of feeding (Table I). Organisms living in the current usually consumed algae growing on stones, while those which lived in stagnant water fed on detritus collected there together with organic matter. Mixed food was noted in organisms building nets (e.g. *Hydropsyche*) and consuming all that was brought into these nets by the current. Mixed food also appeared in the predatory forms, the plant food probably coming from the alimentary canals of the animals consumed. Meierjürgen (1935) reported connections between the food and the habitat of animals, suggesting that *Ephemeroptera* fed according to their ecological occurrence. Champan and Demory (1963) also claim that environment and way of living explain the feeding habit.

In phytophagous organisms the dominance of diatoms was noted in the food, in spite of the fact that at the same time mass development of *Cladophora glomerata*, *Ulothrix zonata*, or *Hydrurus foetidus* was observed in the environment. It was also observed that these animals preferred certain species of diatoms. Here belong the diatoms whose index of food selection of diatoms (K) was over one (1), thus cells of the genera *Achnanthes*, *Cymbella*, *Diatoma*, *Gomphonema*, and *Navicula* (Table II). However, the statistical analysis showed that the index of food selection was statistically significant only for the species of the genus *Gomphonema* in relation to *Chironomidae* living in the middle course of the River Raba ($p < 0.01$) and to mayflies living in the Olszowy Stream ($p < 0.05$). In other cases the results showed randomness in the selection of diatom species by the organisms. Thienemann (1954) mentions that with *Chironomidae* diatoms dominate in the food of species of the groups *Orthocladiinae*, *Tanytarsini*, and *Chironomini*, small forms of *Navicula* and *Gomphonema* being particularly numerous. Rehborn (1937)

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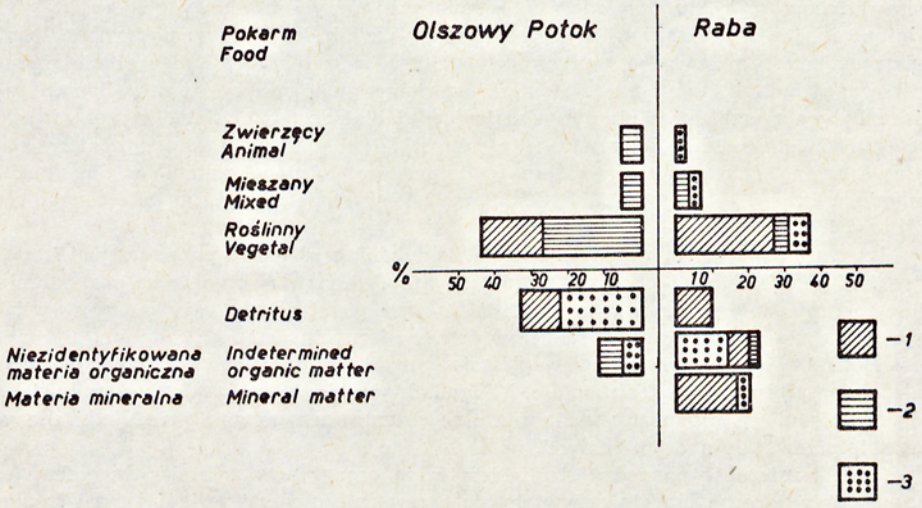
supported the dominance of diatoms in the food of *Chironomidae*, but did not observe any preference for any particular species.

The probable reason why diatoms are preferred by the animals is that these algae form epiphytic communities and, consequently, are the first to be scrabed from the surface by the feeding animals. This was supported by an investigation on the food of larvae of *Cricotopus* sp. taken from microhabitats-clumps of *Cladophora glomerata* covered with epiphytes and without them. In the former case diatoms prevailed in the food and in the latter the organisms consumed the filaments of green alga (K a w e c k a, K o w n a c k i 1974 — fig. 6).

The consumption of species of the genus *Gomphonema* by the animals is probably connected with the structure of these diatoms. The organisms live on tall gelatinous tendrites and, in consequence, in the communities of epiphytes their cells jut out above other algae, becoming an easy prey to animals feeding in the surface layer of the community.

Recapitulation

With the 47 investigated species of bottom fauna larvae the food structure is correlated with the nutrient resources of the environment. In the Olszowy Stream, where organic matter of allochtonic origin (fallen beech leaves) and algae growing there occurred in great amounts



Ryc. 10. Struktura pokarmowa dominujących larw fauny dennej Olszowego Potoku oraz rzeki Raby: 1 — *Ephemeroptera*; 2 — *Trichoptera*; 3 — *Chironomidae*

Fig. 10. The food structure of the dominant larvae of the bottom fauna in the Olszowy Stream and the River Raba: 1 — *Ephemeroptera*; 2 — *Trichoptera*; 3 — *Chironomidae*

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a high percentage of phytophagous as well as detritivorous organisms was noted. In the middle course of the river, where algae prevailed in the environment, herbivorous organisms decisively dominated. Algae were chiefly used as food mayflies and caddis-flies, and detritus chiefly by *Chironomidae* (fig. 10).

With all groups of animals a dependence was found between the feeding habits and the habitat of the organisms. Animals living on poorly granulated substrata, in the current, fed chiefly on algae growing on stones, while those living in stagnant water with sediments consumed mineral matter and detritus.

Phytophagous larvae in the first place consumed algae occurring in the surface layer of the community, i.e. above all the epiphytic diatoms. The organisms did not actively select food but simply consumed that which was most readily accessible in the environment.

The majority of organisms showed food stability throughout the year. Only in *Drusus discolor* was a change from mixed to vegetal food observed in winter.

I wish to thank Dr. A. Kownacki for identifying fragments of animals in the food canals, and Docent J. Włodek for help in the statistical evaluations.

STRESZCZENIE

Rzeka Raba (długość 129 km) jest karpackiem dopływem rzeki Wisły. Zbadano w cyklu rocznym (1969/70) pokarm 47 gatunków larw fauny dennej z grupy *Ephemeroptera, Trichoptera* i *Chironomidae* zamieszkujących górny i środkowy bieg rzeki. Wyróżniono 6 kategorii pokarmu biorąc pod uwagę składnik dominujący: pokarm roślinny, zwierzęcy, mieszany, pokarm z przewagą detritusu, materii mineralnej oraz nie zidentyfikowanej materii organicznej. Stopień strawienia glonów był różny. Najlepiej trawione były okrzemki, oraz nitkowate zielenice, słabiej desmidie, sinice oraz *Hydrurus foetidus*. Zupełnie nie były trawione krasnorosty. Błona komórkowa roślin nigdy nie była naruszona. Pokarm larw w większości wypadków nie ulegał zmianie w ciągu roku. Jedynie u *Drusus discolor* obserwowano przejście w zimie z pokarmu mieszanego na roślinny.

Struktura pokarmowa larw kształtowała się zgodnie z zasobami pokarmowymi środowiska. W górnym biegu — w potoku śródleśnym, gdzie materia organiczna pochodzenia allochtonicznego, którą stanowiły opadłe liście, była podobnie obfita jak glony rozwijające się na miejscu, zarówno procent larw detritusożernych jak i roślinożernych był wysoki. Detritusożerców reprezentowały głównie gatunki *Chironomidae*, formy roślinożerne należały w przewadze do *Trichoptera*. W środkowym biegu rzeki, gdzie w środowisku dominowały glony, organizmy roślinożerne reprezentowane głównie przez jętki zdecydowanie przeważały nad pozostałymi.

Istniała zależność pomiędzy siedliskiem życia organizmów a rodzajem pokarmu. Organizmy żyjące na prądzie odżywiały się przeważnie glonami zasiedlającymi kamienie. Organizmy żyjące w zastoiskach, gdzie gromadziły się osady, odżywiały się przeważnie detritusem wraz z materią mineralną.

Organizmy roślinożerne preferowały okrzemki, a wśród nich szczególnie gatunki z rodzaju *Gomphonema*. Przypuszcza się, że nie jest to selekcja czynna, lecz podykto-

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wana jedynie dostępnością pokarmu. Okrzemki tworzą bowiem zbiorowiska epifityczne, przy czym komórki *Gomphonema* na wysokich galaretowatych stylikach wysuwają się ponad inne organizmy. W masie zaofiarowanego pokarmu glony te tworzą powierzchniową warstwę, która jest w pierwszej kolejności zdrapywana przez żerujące zwierzęta.

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Adres autorki — Author's address

dr Barbara Kawecka

Zakład Biologii Wód, Polska Akademia Nauk, ul. Sławkowska 17, 31-016 Kraków.

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