Some groups of benthic invertebrates and the physico-chemical conditions in the streams of the Magurski National Park in the Beskid Niski Mts (Northern Carpathians)

Bronisław Szczęsny

Institute of Nature Conservation, Polish Academy of Sciences
Mickiewicza 33, 31-120 Kraków, e-mail: szczesny@iop.krakow.pl

Abstract
From 2001-2003, hydrochemical studies were carried out at 32 sites in the Wisłoka river drainage basin (330-790 m a.s.l.) in the Magurski National Park, benthos samples were collected and imagines of aquatic insects were caught.
In terms of water chemistry, the aquatic habitats were described as typical for the West Beskid Mts. The water was clear, very low on combined phosphorus and nitrogen, and representative of a predominantly bicarbonate-calcidic type (electrolytic conductivity 61-425 µS/cm). Only in the spring sections of some streams, slightly acidic (pH 4.4-5.8) sulphate-bicarbonate-calcidic water was found.
No fewer than 166 taxa were identified in the following groups: *Trichoptera* (92 taxa), *Ephemeroptera* (29), *Plecoptera* (27), *Coleoptera* (7), *Mollusca* (3), *Amphipoda* (3), *Tricladida* (2), *Hirudinea* (2), and *Odonata* (1 taxon). The list of species, along with their altitudinal and spatial distributions are presented. Using statistical methods, 4 types of stream habitats were distinguished, and the qualitative composition and dominance structure of the fauna living in each type were determined. The stream habitats of the Magurski NP and the Bieszczady Zachodnie Mts were compared in terms of the fauna of *Ephemeroptera* and *Trichoptera* living in these regions. The similarities between the fauna of *Ephemeroptera*, *Plecoptera* and *Trichoptera* living in the Magurski NP were ascertained along with those of other national parks in the Polish Carpathians.

Key words
West Carpathians, Magurski National Park, water chemistry, macroinvertebrates, biodiversity, lotic habitats, *Trichoptera*, *Ephemeroptera*, *Plecoptera*.

Received: 20.01.2005
Accepted: 18.03.2005

The Magurski National Park (MgNP), established in 1995, occupies a fairly unique position among all the Carpathian regions under legal protection. It includes a portion of the Beskid Niski Mts, the easternmost part of the Western Carpathians, bordering the Eastern Carpathians. The area was once densely populated and intensively used by man, whilst now it is only sparsely populated, and undergoing the well-advanced processes involved in returning the area to its natural condition. Its summits are not high (below 850 m altitude), and most of its area is situated at a lower altitude, compared with other Carpathian regions. These two factors contribute to climatic conditions which favour both mountain and upland species, and even lowland species preferring warm conditions.

Well-advanced processes of the succession of grassland type vegetation on the abandoned farmlands and the spread of forested areas, favour the restoration of the natural structure of stream beds as well as the reduction of mineral suspension. These processes also facilitate the restoration of populations of species which have high ecological requirements. This pertains particularly to stream species preferring larger streams at lower elevations. Unfortunately, the knowledge to-date of the aquatic fauna of Beskid Niski Mts has been relatively poor. An attempt to survey the qualitative composition of some groups of aquatic invertebrates, the distribution of species and the evaluation of the aquatic fauna as an element of nature in the MgNP, except for *Oligochaeta* and *Diptera*, was carried out within the framework of the statutory research undertaken by the Institute of Natural Conservation, Polish Academy of Sciences. A certain part of the study was contributed to by Anna Wiśniowska, M.Sc., who identified most of the *Ephemeroptera* and *Plecoptera*.

The study area

The Magurski National Park (MgNP), includes the central part of the Beskid Niski Mts (Kondracki 1978). The Beskid Niski Mountains are low, with softly inclined slopes and afforested tops. The highest summit is Lackowa Mt. (1001 m altitude). The highest summit in the National Park is the Magura Wątkowska Mt. (847 m altitude) situated in its northern part. The area of the MgNP is composed chiefly of flysch rocks, mostly of the Silesian Unit, Dukla Unit and Grybów Unit (for more information on the geology and tectonics of the MgNP see Ślączka 2003).

The area of the MgNP (almost 20 000 hectares) is drained entirely by the Wisłoka River headstream and its tributaries, including the Ropa river, the left-bank tributary of the Wisłoka. The southern limit of the catchment area is a part of the drainage divide between the Baltic and Black Sea drainage basins. The hydrological regime of the Wisłoka River, as in other rivers of the Beskid Niski Mts, is of a mountain type with most of the water supplied from precipitation, ground waters and snow melting. Spates develop mainly in spring and summer. The high flows usually continue throughout the March-July period, while minimum flows prevail during late summer and autumn (Dynowska 1971; Chełmicki et al. 1999).

The area is vast, with a fairly high drainage density, offering diverse ecological conditions. The highest spring (790 m altitude) is situated on the northern slopes of the Magura Wątkowska Mt. whereas the lowest site of the river network in the Park's area is in Myscowa stage on the Wisłoka River (330 m altitude). The streams are rather poorly supplied with water, they have a relatively low gradient, and their banks are mostly shaded by alders. The streams draining the northern slopes of the Magura Wątkowska Mt. have the highest gradients and most rapid currents. The Wisłoka River up to its confluence with the Wilsznia stream is rather narrow and has the appearance of a major stream. However, after leaving the border limits of the Park, this water course flows through a wider bed with some deeper sections.

In Krempna, where the Wisłoka River was dammed in 1972, a reservoir of 112 000 cu. m. capacity has been built and a water table of 3.2 hectares created, primarily for recreational purposes. Because of alluvial sediments accumulation the capacity of the reservoir has now been reduced by half. Till 1947, the upper Wisłoka River catchment area was densely populated and the land use in the area was predominantly for pasturing and cultivation. The forested areas did not exceed 40%. After the depopulation, and as a result of a natural succession and a number of specific measures, the area under meadows and forests has increased significantly, at the expense of arable lands. The line between forests and farmlands was lowered from ca. 600 m to 400 m altitude. Doubling the size of the forested area compared with the 1947 figure, plus the emergence of abundantly overgrown wild meadows, has contributed significantly to the alteration of the hydrological conditions in the catchment. In the Upper Wisłoka drainage basin situated in the Beskidy Mts the annual minimum flows, and average monthly flows increased while maximum annual flows decreased (Lach and Wyżga 2001).

Because the MgNP is situated in the eastern part of the West Carpathians, certain features of 'climatic continentalism' occur in the area. They are expressed, *inter alias*, by lowering the ranges of the altitudinal climatic zones, compared with the westernmost part of the Western Carpathians, a shorter vegetation season, and a lower amount of precipitation (averages between 850-1000 mm annually). The isotherm for the annual average air temperature of 6°C runs within the 460-620 m a.s.l. range, depending on land relief, and at 570 m altitude on average. This line separates the moderately warm altitudinal zone from the moderately cool zone. The MgNP is situated almost entirely in the moderately cool altitudinal zone (Hess 1965; Obrębska-Starklowa 2003).

Chemistry

The studies on chemistry are aimed at a general determination of the types and chemical composition of waters in springs and streams as habitats of aquatic fauna. The measurements and sample collection in the field were conducted in parallel to the collection of benthic samples, in most cases on the same sites.

Study method

The water was sampled at 32 sites (and benthos samples – only at 30 sites) located along the Wisłoka River and its 9 direct and indirect tributaries (including 5 springs) within the 330-790 m altitude. In total, 55 samples were collected: at 12 sites the samples were collected between 2-4 times, at the remaining sites – only once (Fig. 1, Table 1).

At each site the following measurements were made in water: the pH value, temperature, electrolytic conductivity (with WTW LF 95 conductometer) and colour of water were determined (with Colour field colorimeter by Merck). The remaining measurements were taken in the laboratory, i.e.: chemical oxygen demand (COD) by the permanganate ($KMnO_4$) method (Hermanowicz 1976), and the sulphate (VI), nitrate (V), nitrate (IV),

Table 1. The collection dates of the hydrochemical samples (o) and benthos samples (+) in the streams of the Magurski National Park, and the collection dates for imagines of insects using light traps (#); pd – right tributary, ld. źr. – springs of left tributary.

No	Streams	Altitude	16-17.V.2001	14-15.VI.2001	13-15.VII.2001	30.IX.2001	10.XI.2001	22-24.V.2002	26.VI.2002	1-2.VIII.2002
1	Barani pd	670		o +						
2	Barani pd	576		o +						
3	Barani	650	o							
4	Barani	600	o +							
5	Barani	550	+		o +					
6	Barani	500	+		o +					
7	Barani	450	o +		+					
8	Barani	400	+ #	o #	o +	+	o	o + #		
9	Kłopotnica	790	o		o			o		
10	Kłopotnica	730						o +		
11	Kłopotnica	650	o +	+				+		
12	Kłopotnica	550			o +			+		
13	Kłopotnica	450	+							
14	Kłopotnica	400	o +					o		
15	Krempna	637			o +					
16	Krempna	570			o +		o	o +		
17	Krempn.ld	500			o +					
18	Krempna	500			o +					
19	Krempna	450		o +			o	o +		
20	Krempna	400		o +	#		o	o +		
21	Krokowy	480						+		
22	Krokowy	450					o	o +		
23	Ryjok	480	o +							
24	Ryjok	450	+		+		o	+	+	+ #
25	Ryjok	425	o + #		+		o +	o #		#
26	Ryjok ld. źr.	428						o		
27	Świerzówka	450					o			
28	Swierzówka	400						o +		
29	Wilsznia	400				+		o +		
30	Wilsznia	360						o +		
31	Wisłoka	425	o +		o +		o			
32	Wisłoka	410		o +	o + #			o + #	#	o +
33	Wisłoka	350		o +				o +		
34	Wisłoka	320		o +	o + #			o +		

chloride, fluoride and phosphate ion concentrations were determined with a DIONEX IC DX – 320 chromatograph with an AS15 4-mm Analytical Column + AG15 4-mm Guard Column whereas the calcium, magnesium, sodium and potassium ion concentrations – by AAS using Varian BQ20.

The collection of water samples for laboratory analyses was usually carried out in the last day in the field.

Results

The lowest water temperature (2.7-5.4°C) in the MgNP during the study period was recorded in mid-November 2001, in the middle and lower sections of streams. It was a period of slight frosts at night and minor snow precipitation. In slightly warmer periods, the lowest temperatures (not exceeding 5.6°C) were recorded in and around spring sections of streams. The highest temperatures, although not exceeding 19°C, were recorded in the Wisłoka River and in the confluence sections of its tributaries. The average of the measurements taken in streams below 400 m altitude was 16°C, in the 400-499 m range of altitude – 13.3°C, in the 500-600 m range – 11.4°C and in the 601-700 m range – 8.7°C. The thermal conditions in the MgNP's streams in their lower courses thus correspond with those of lowland rivers in the vegetation season.

In the periods with low and medium water levels, the waters of streams were clear and clean; with the colour of water <10 Pt (concentration of chloroplatinate solution [mg/l Pt]). In the lower sections of the streams, the water was often slightly opalescent and turbid which resulted in an increase up to as high as 45 Pt. In the spring sections of some streams, particularly of the Barani stream, the water was of evidently brown colour, indicating the presence of humus compounds. In waters with elevated colour values, the COD was also higher, although only slightly (up to 0.3-0.5 mg/l O_2.

The stream water pH was usually close to neutral or slightly alkaline (pH value ranged between 7 and 8.0), and only in the spring and adjacent stretch of the Barani stream the water showed pH value within 4.4-5.8 range. The electrolytic conductance fluctuated over a wide range of 61-425 µS/cm and changed considerably depending on both the altitude and hydrological situation. In average hydrological conditions, the lowest values appeared in the river springs, and the highest ones – in the lower section of the river course. At the period of low water levels, the conductance increased considerably, e.g. in the spring of the Krempna stream (637 m altitude) from 61 µS/cm on 13 July 2001 to 315 µS/cm on 23 May 2002, at temperatures of 9.2 and 9.6°C, respectively. In the same stream, at 570 m altitude the respective values reached 140 and 425 µS/cm. The chemical analysis indicated that the increase in electrolytic conductance resulted from the increase in bicarbonate concentration.

The increases in the electrolytic conductance with the stream course were evident. For example, the average measured for sites in the 500-599 m altitude was about 216 µS/cm, and below 500 m altitude – 286 µS/cm.

The studied waters represent predominantly the bicarbonate-calcidic type with significant magnesium ion content. The equivalent concentration of calcium always exceeded 20% of all mineral components, and the proportion of magnesium was 10-20% in most of the samples. It was only in the waters of the Świerzówka stream where there was more magnesium than calcium. Only the spring-waters of the Barani and Krempna streams as well as of the uppermost tributaries of the Barani stream represented the sulphate-calcidic type or bicarbonate-sulphate-calcidic type with significant magnesium ion content.

The concentration of nitrate (V) ion was generally low and below 4 mg NO_3/l, whereas the maximum concentration (in spring of the Kłopotnica stream) did not exceed 7 mg. As a rule, the concentrations of this ion were higher in the spring and upper sections of the streams than in the lower sections. On the contrary, all other components showed the increased concentrations following the course of the stream (Table 2).

The correlation coefficient of the nitrate ion concentration in relation to the elevation calculated using multiple regression was positive, high and statistically significant (ß = 0.572, R^2 = 0.327, $p < 0.000003$). This indicator when calculated for correlations between the elevation and concentrations of other mineral components was negative and also statistically significant (ß ranging from 0.27 to 0.52), except for chloride ion.

Summary of chemistry

The review of data shows that the waters of the Magurski National Park differ only slightly in their chemical composition from waters of other parts of the Beskidy Zachodnie Mts on the flysch substrate (Bombówna 1960, 1965, 1969; Szczęsny et al. 2001). They are mostly bicarbonate-calcidic waters with variable proportions of sulphate and magnesium ions. Also, the concentrations of electrolytes in these waters, expressed as the electrolytic conductivity value, were close to the average, as they fell primarily into the 200-300 µS/cm range, during the period of medium water levels. The concentrations of electrolytes in the springs and adjacent stretches of streams in the summit zones of mountains were low (60-150 µS/cm).

Table 2. Average concentrations (mg/dm^3) of major elements in the waters of the Magurski National Park. Abbrev.: max. – maximum, min. – minimum, VC% – coefficient of variation.

Altitude		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	NO_3^{-}	SO_4^{2-}
600-790	average	16.77	3.97	2.52	0.85	1.49	63.70	3.37	19.57
	max.	54.13	11.00	8.01	1.10	3.24	199.1	6.92	27.81
	min.	6.34	1.54	0.60	0.60	0.83	4.80	1.26	15.1
	VC%	85.81	77.00	89.70	20.80	57.34	84.00	43.67	21.45
500-599	average	26.89	7.00	2.86	1.08	0.94	96.50	2.35	20.49
	max.	86.90	12.40	5.00	1.93	1.48	281.9	3.25	34.75
	min.	11.86	3.66	1.20	0.70	0.08	40.70	0.96	16.74
	VC%	77.42	34.60	47.86	32.30	35.28	69.20	35.05	24.52
400-499	average	49.58	11.00	7.71	1.62	1.52	192.90	2.01	23.38
	max.	75.50	19.80	12.38	2.73	5.08	304.10	4.47	37.48
	min.	17.20	5.57	2.96	0.90	0.78	97.80	0.82	14.86
	VC%	30.19	29.80	29.91	26.40	49.29	27.50	46.33	21.47
330-399	average	53.37	9.63	7.67	1.92	1.35	199.70	1.44	23.02
	max.	65.90	11.80	8.61	2.32	1.86	237.00	1.89	26.46
	min.	27.38	8.02	5.86	1.60	0.87	128.5	1.19	16.45
	VC%	25.31	14.90	12.83	16.50	24.74	19.10	15.60	14.57

At the same time, in the waters of these stretches, the equivalent sulphate (VI) and nitrate (V) content was higher.

The nitrate ion content was generally low, and its concentration decreased downstream, which indicates the fact that the aquatic environment in the Park is still remarkably clean.

In the summit zones of the MgNP there are also some sections of streams with low pH (4.4-5.6), acidified by humus compounds, as indicated by the slightly brownish colour of the water. However, the involvement of sulphur and nitrogen compounds in the process could not be excluded, because in these sections the relative proportions of the sulphate and nitrate ions also increased. It is likely that the disappearance of the brownish colour along the course of streams occurs through the precipitation of humus compounds at the bottom, involving bicarbonates. The characteristic black colour of stones at the bottom in the upper of streams sections in beech woods indicates such precipitation.

During the study period, considerable fluctuations in the concentrations of electrolytes appeared in stream waters, resulting from the hydrological conditions.

Benthic invertebrates

Data available to date

The data from the body of literature available to-date indicate that the benthic invertebrates have not yet been studied as an ecological component of the current waters in the Beskid Niski Mts

However, the fauna of *Trichoptera* was studied in the main rivers of this mountain range: the Biała Tarnowska River and the Wisłoka River along with the Ropa River (Szczęsny 1986). In the period 1974-77, more than 5000 specimens of caddis flies at different aquatic stages, were collected in 7 sites situated along the upper river course of the Wisłoka, within the 300-585 m altitude range, and in 10 sites along the Ropa-Ropka stream courses within the 300-735 m altitude range.

In total, 56 taxa were identified, including the genus *Sericostoma* spp., covering the earlier indistinguishable larvae of *S. personatum*, *S. schneideri* and *Oecismus monedula*. Additionally, the *Hydropsyche pellucidula* taxon included two species: the nominal one and *H. incognita* not yet known at the time of the study. For the

Table 3. Benthic invertebrates (except *Trichoptera*) collected from the streams of the Magurski National Park. Symbols: ! – species under legal protection in Poland; * – species placed on the "Red list", with the following status: VU (vulnerable), NT (near threatened), LC (least concern), DD (data deficient); $ – Carpathian endemic species; $s – extensive Carpathian endemic species, N – number of collected specimens; trib. – tributary.

No	Taxa	N	Altitude	Remarks
	TRICLADIDA			
1	*Dugesia gonocephala* (Dug.)	258	<630	
2	*Crenobia alpina* (Dana)	104	550-720	Kłopotnica
	MOLLUSCA			
1	!*NT *Bythinella austriaca* (Frauenfeld, 1859)	6	570-720	
2	*Lymnea peregra* (O.F.Müller, 1774)	1	350	
3	*Ancylus fluviatilis* (O.F.Müller, 1774)	46	400-550	
	HIRUDINEA			
1	*Erpobdella monostriata* (Lindenf., Pietr. 1890)	1	480	Ryjok
2	*NT *Trocheta bykowskii* Gedroyc, 1913	5	600	Barani
	AMPHIPODA			
1	*Gammarus balcanicus* Schäferna, 1923	590	425-720	
2	*Gammarus fossarum* Koch, 1836	102	450-570	Krempna
3	*Niphargus* sp.	28	570-637	Krempna
	EPHEMEROPTERA			
1	*Alainites muticus* (Linnaeus, 1758)	447	<650	
2	*Baetis alpinus* (Pictet, 1843)	246	410-650	
3	$*LC *Baetis beskidensis* Sowa, 1972	119	<360	
4	*Baetis fuscatus* (Linnaeus, 1761)	14	<450	
5	*Baetis lutheri* Müller – Liebenau, 1967	254	<450	
6	*Baetis melanonyx* (Pictet, 1843)	4	450-550	
7	*Baetis rhodani* (Pictet, 1843)	3114	<650	
8	*Baetis scambus* Eaton, 1870	43	<480	
9	*Procloeon bifidum* (Bengtsson, 1912)	11	350	Wisłoka
10	*Epeorus sylvicola* (E. Pictet, 1865)	54	400-550	
11	$ *Rhithrogena iridina* (Kolenati, 1859)	88	450-650	
12	*Rhithrogena semicolorata* (Curtis, 1834)	132	400-550	
13	$ *Ecdyonurus carpathicus* Sowa, 1973	28	500-650	
14	*Ecdyonurus dispar* (Curtis, 1834)	30	410-450	
15	*VU *Ecdyonurus insignis* (Eaton, 1870)	17	<360	
16	$ *Ecdyonurus subalpinus* Klapálek, 1907	22	630	Barani trib.
17	*Ecdyonurus submontanus* Landa, 1969	254	<570	
18	*Ecdyonurus torrentis* Kimmins, 1942	153	400-550	
19	*Ecdyonurus venosus* (Fabricius, 1775)	9	<480	
20	*Electrogena lateralis* (Curtis, 1834)	121	350-500	
21	*VU *Oligoneuriella rhenana* (Imhoff, 1852)	106	<425	
22	*Habroleptoides confusa* Sartori et Jacob, 1986	259	400-650	
23	*Habrophlebia lauta* Eaton, 1884	103	350-550	
24	*Serratella ignita* (Poda, 1761)	769	570	

Table 3 cont.

25	*Ephemerella mucronata* (Bengtsson, 1909)	11	400-650	Kłopotnica
26	*Torleya major* (Klapálek, 1909)	88	<500	
27	*Caenis luctuosa* (Burmeister, 1839)	6	350	Wisłoka
28	*Caenis rivulorum* Eaton, 1884	32	<450	
29	*Ephemera danica* O.F.Müller, 1764	2	400-450	
	ODONATA			
1	*Gomphus* sp.	1	630	Barani trib.
	PLECOPTERA			
1	*Amphinemura borealis* (Morton, 1894)	118	425-480	
2	*Amphinemura sulcicollis* (Stephens 1836)	6	400-450	
3	*LC *Isoperla buresi* Raušer,1962	4	500-650	
4	$s *Isoperla sudetica* (Kolenati, 1859)	1	650	Kłopotnica
5	*Capnia* sp. juv.	1	425	Ryjok
6	*Leuctra albida* Kempny, 1899	42	<500	
7	*Leuctra aurita* Navas, 1919	31	450-650	
8	*Leuctra autumnalis* Aubert, 1848	21	400-650	
9	*Leuctra braueri* Kempny, 1898	33	550-650	springs
10	*Leuctra digitata* Kempny, 1899	84	400-550	
11	*Leuctra fusca* (Linnaeus, 1758)	1	550	Barani
12	*Leuctra hippopus* Kempny, 1899	54	400-425	
13	*Leuctra inermis* Kempny, 1899	18	425-650	
14	*Leuctra nigra* (Olivier, 1811)	22	500-650	
15	*Nemurella picteti* Klapálek, 1895	59	600	Barani
16	*Nemoura cambrica* (Stephens, 1836)	5	637	Krempna
17	*LC *Perla burmeisteriana* Claassen, 1936	34	<480	
18	*Perla marginata* (Panzer, 1799)	76	<500	
19	*DD *Perla pallida* Guérin, 1838	12	450-630	
20	*Perlodes* sp.	5	550	Kłoptnica
21	*Protonemura auberti* Illies, 1954	43	450-650	
22	*Protonemura intricata* (Ris, 1902)	16	400-650	
23	*Protonemura lateralis* (Pictet, 1836)	8	450-630	Barani
24	*Protonemura montana* Kimmins, 1941	27	450-550	
25	*Protonemura praecox* (Mort.on, 1894)	2	425	Ryjok
26	$ *Chloroperla kisi* Zwick, 1967	10	425-450	
27	*Siphonoperla torrentium* (Pictet, 1841)	2	600	Barani
	COLEOPTERA			
1	*Dytiscidae*	1	500	
2	*Orectochilus villosus* (O.F.Müller, 1776)	8	<425	
3	*Hydraena* spp.	121	<637	
4	*Helodidae* n.det. larvae	42	<630	
5	*Elmis* spp.	422	<720	
6	*Esolus* spp.	153	<650	
7	*Limnius* spp.	192	<650	

Table 4. Number of caddis-fly (*Trichoptera*) species found in the Magurski National Park. Symbols: x – taxon reported in the upper Wisłoka (Szczęsny, 1984); * – taxon reported as *H. pellucidula* (Curt.); # – caught also in light traps; #! – caught only in light traps; other symbols as in Table 3.

No	Taxa	Imagines				Aquatic stages	Altitude
		N ♂♂	N ♀♀	Date		N	
1	*Rhyacophila fasciata* Hagen, 1859 x	24	51	#	16.V-1.VIII	40	400-650
2	*Rhyacophila mocsaryi* Klapálek, 1898 x	14	5	#	16.V-14.VI	85	400-650
3	*Rhyacophila nubila* (Zetterstedt, 1840) x	16	149	#	22.V-1.VIII	605	<480
4	*Rhyacophila obliterata* McLachlan, 1865 x					25	400-500
5	*Rhyacophila philopotamoides* McLachlan, 1879 x	10	1		16-22.V	8	450-720
6	*Rhyacophila polonica* McLachlan, 1879 x					39	450-650
7	*Rhyacophila tristis* Pictet, 1834 x	14	4		22-23.V	55	400-650
8	*Glossosoma conformis* Nebois, 1963 x	2	20	#	14.VI	538	400-650
9	*Glossosoma intermedium* (Klapálek, 1892)					31	450-500
10	*NT *Agapetus delicatulus* McLachlan, 1884					7	400
11	*NT *Agapetus laniger* (Picttet, 1834) x		1	#!	13.VII		
12	*NT *Agapetus ochripes* Curtis, 1834					2	450
13	*LC *Synagapetus armatus* (McLachlan, 1879)x					8	570-720
14	*LC *Synagapetus iridipennis* McLachlan, 1879					26	450-650
15	*Ithytrichia lamellaris* Eaton, 1873					1	320
16	*LC *Allotrichia pallicornis* (Eaton, 1873)		1	#!	14.VII		
17	*Hydroptila forcipata* Eaton, 1873 x	37	3649	#	22.V-1.VIII	20	<450
18	*Hydroptila lotensis* Mosely, 1930	3	19	#	13.VII-1.VIII	15	<350
19	*Hydroptila occulta* (Eaton, 1873) x	39	741	#	13.VII-1.VIII	60	<410
20	*Hydroptila tineoides* Dalman, 1819	9	187	#!	22.V-1.VIII		
21	*Orthotrichia tragetti* Mosely, 1930		1	#!	14.VII		
22	*Wormaldia occipitalis* (Pictet, 1834) x					101	570-637
23	*NT *Wormaldia pulla* (McLachlan, 1878)	2	4	#!	14.VII		
24	*Philopotamus ludificatus* McLachlan, 1878 x	20	6		17-23.V	25	450-650
25	*Philopotamus montanus* (Donovan, 1813) x	11	5		17.V-22	93	400-630
26	*LC *Philopotamus variegatus* (Scopoli, 1763)	139	56	#	22.V-1.VIII	1	500
27	*Cyrnus trimaculatus* (Curtis, 1834) x	3	1	#	22.V-13.VII		
28	*Polycentropus flavomaculatus* (Pictet, 1834) x	38	72	#	22.V-1.VIII	90	<480
29	*Polycentropus irroratus* (Curtis, 1835)	1	1	#!	13.VII-1.VIII		
30	*NT *Polycentropus schmidi* Novak, Botosan. 1965	32	53		13.VII-1.VIII	3	410
31	*LC *Plectrocnemia brevis* McLachlan, 1871					3	570
32	*Plectrocnemia conspersa* (Curtis, 1834) x	2		#	14.VI-1.VIII	28	400-650
33	*Psychomyia pusilla* (Fabricius, 1781) x	5	109	#	22.V-1.VIII	10	<480
34	*Tinodes rostocki* McLachlan, 1878x					5	550-650
35	*Lype reducta* (Hagen, 1868)	1	4	#	22.V-14.VII		
36	*Cheumatopsyche lepida* (Pictet, 1834) x	12	24	#	13.VII-1.VIII	56	<425

Table 4 cont.

37	*DD *Hydropsyche botosaneanui* Marinkovic, 1966	5	173	#	16.V-26.VI	333	<500
38	*Hydropsyche bulbifera* McLachlan, 1878 x	24	426	#	22.V-1.VIII	65	<450
39	*Hydropsyche fulvipes* (Curtis, 1834) x					44	450-650
40	*Hydropsyche incognita* Pitsch, 1993**	27	419	#	22.V-1.VIII	447	<450
41	*Hydropsyche instabilis* (Curtis, 1834) x	33	419	#	22.V-1.VIII	1451	<550
42	*Hydropsyche pellucidula* (Curtis, 1834)	5	32	#	26.VI-1.VIII	94	<480
43	*Hydropsyche saxonica* McLachlan, 1884 x	1	5	#	22.V-1.VIII	79	<570
44	*Hydropsyche* sp.					4	<450
45	*Brachycentrus* sp.		2	#!	22.V		
46	*Micrasema* sp.		2	#!	22.V		
47	*Goera pilosa* (Fabricius, 1775) x	4	1	#!	22.V-1.VIII		
48	*Lithax niger* Hagen, 1859 x					9	550-650
49	*DD *Lithax obscurus* Hagen, 1859 x						
50	*Silo pallipes* (Fabricius, 1781) x					42	360-480
51	*Silo piceus* (Brauer, 1857) x	3	90	#	26.VI-1.VIII	14	450-630
52	*Lepidostoma hirtum* (Fabricius, 1781) x		8	#	14.VII-1.VIII	8	<425
53	*Crunoetia irrorata* (Curtis, 1834) x					2	450-570
54	$ *Apatania carpathica* Schmid, 1954 x						
55	*Ecclisopteryx dalecarlica* Kolenati, 1848		9	#	22.V	1	450
56	*Ecclisopteryx madida* (McLachlan, 1867) x						
57	$ *Drusus brunneus* Klapálek, 1890 x	2	1		23.V	1	650
58	$s *Drusus carpathicus* Dziędzielewicz, 1911x						
59	*Glyphotaelis pellucidus* (Retzius, 1783)	2		#!	1.VIII		
60	*Limnephilus extricatus* McLachlan, 1865		3	#!	1.VIII		
61	*Limnephilus fuscicornis* (Rambur, 1842)	1		#!	14.VII		
62	*Limnephilus griseus* (Linnaeus, 1758)		1		16.V		
63	*Annitella obscurata* (McLachlan, 1876) x					1	500
64	*Psilopteryx psorosa* (Kolenati, 1860) x					37	500-650
65	*Chaetopteryx fusca* Brauer 1857 x					82	400-550
66	$ *Chaetopteryx polonica* Dziędzielewicz, 1889 x					2	600-637
67	$ *Chaetopteryx subradiata* Klapálek, 1907 x					14	550-720
68	*Micropterna lateralis* (Stephens, 1837)	1		#!	14.VI		
69	*Micropterna testacea* (Gmelin, 1788)		3	#!	14.VI		
70	*Stenophylax permistus* McLachlan, 1895 x						
71	$*LC *Potamophylax carpathicus* (Dziędz., 1912)x	1	1		23.V	2	570
72	*Potamophylax cingulatus depilis* Szczęsny, 1994x					146	400-650
73	*Potamophylax latipennis* (Curtis, 1834)x	16	22	#	1.VIII	342	360-550
74	*Potamophylax luctuosus* (Piller, 1783)x	6	5	#	16-22.V	30	400-450
75	*Potamophylax nigricornis* (Pictet, 1834)x					13	576-720
76	*Potamophylax rotundipennis* (Brauer, 1857) x						
77	*Halesus digitatus* (Schrank, 1781) x					30	360-500
78	*Halesus tesselatus* (Rambur, 1842)					8	400-500

Table 4 cont.

79	*Allogamus auricollis* (Pictet, 1834)		1	#	1.VIII	357	400-500
80	*Allogamus uncatus* (Brauer, 1857)					8	550-650
81	*LC *Oecismus monedula* (Hagen, 1859)	2		#	14.VII	6	450-650
82	*Sericostoma personatum* (Spence, 1826)	14	10	#		83	<450
83	*Sericostoma schneideri* Kolenati, 1848				22.V	6	550-637
84	*Notidobia ciliaris* (Linnaeus, 1761) x						
85	*Odontocerum albicorne* (Scopoli, 1763) x	49	6	#	14.VI-1.VIII	165	400-650
86	*DD *Bereodes minutus* (L. 1761)	1	1		22.V		
87	*LC *Beraea maurus* (Curtis, 1834)					3	570
88	*DD *Beraea pullata* (Curtis, 1834)		1		23.V		
89	*LC *Beraeamyia hrabei* Mayer, 1936 x					2	400-500
90	*LC *Ernodes vicinus* (McLachlan, 1879) x						
91	*LC *Adicella filicornis* (Pictet, 1834)					1	720
92	*Mystacides longicornis* (Linnaeus, 1758)	3		#!	14.VII		
93	*Athripsodes albifrons* (Linnaeus, 1758) x					5	<425
94	*Athripsodes bilineatus* (Linnaeus, 1758)		1	#!	14.VII		
95	*Athripsodes commutatus* (Rostock, 1873)	49	21	#	14.VII-1.VIII	4	<450
96	*Ceraclea dissimlis* (Stephens, 1836)	1		#!	14.VII		
97	*Oecetis lacustris* (Pictet, 1834)	1		#!	13.VII		

Wisłoka River alone, the number of taxa totalled 41 (+ 3) items. At present, not all the sites covered by the study are within the borders of the MgNP.

Methods

The study covered 10 streams, either direct or indirect tributaries of the Wisłoka River (including 4 springs) and the Wisłoka River itself, within the borders of the MgNP (Fig. 1). On selected streams, 30 sites were chosen, situated in the 328-730 m altitudinal range, at intervals not greater than 50 m, i.e.: 400 m, 450 m altitude etc. The distribution of sites in the altitude intervals was as follows: >600 m altitude – 5 sites, 500-599 m – 7 sites, 400-499 m – 15 sites, and 300-399 m – 3 sites. In these sites, 56 benthic samples (macro-samples) were taken on various dates (Table 1). Each macro-sample consisted of a certain number of samples taken from various habitats of smaller areas, but totalling not less than 1 sq. m, using a standard bottom sampler (22.5 x 22.5 cm square metal frame, with 320µm mesh bolting cloth stretched over it), or a smaller one (12.5 x 12.5 cm). The material collected was preserved with formalin.

Insects at the imago stage were collected using entomological hand-nets and portable light traps (12 V). The collection with nets was carried out near the streams, springs and at boggy sites. Light traps were operated at 6 sites (Fig.1). The collected materials, preserved in ethanol remain in the author's collection.

Results

In 56 benthic samples, a total of 18 736 specimens of aquatic invertebrates were found (excluding *Oligochaeta* and *Diptera*). Among these, 15 268 were identified to the level of species (and *Coleoptera* – to the level of genus). Only 3468 specimens (ca. 18.5%) in early developmental stages were identified merely to the genus or family level: these included chiefly the caddis-flies of the genus *Hydropsyche*, mayflies of the *Baetis* and *Ecdyonurus* genera and stoneflies of the genus *Leuctra*. More than 8000 imagines were collected; these were mainly *Trichoptera*.

In the material obtained from the benthic samples, insects predominated, and above all mayflies *Ephemeroptera* (7941 specimens) and caddis-flies *Trichoptera* (7352). The stoneflies *Plecoptera* constituted a relatively small group (1367). In this material, 140 taxa were identified (Tables 3-4). The highest numbers of species were found in the group of caddis-flies (66) and mayflies (29). When the imagines collected are taken into account, the total number of species in this group reached as many as 90 species.

Table 5. The most common species of invertebrates in the streams of the Magurski National Park (in brackets: the position of the taxon on the list of species with the highest numbers of individuals represented by sums of the averages for the collection sites)

No	Species	Number of	
		localities	individuals
1	*Baetis rhodani*	26	1317 (1)
2	*Alainites muticus*	23	226 (7)
3	*Habroleptoides confusa*	22	140 (11)
4	*Ecdyonurus submontanus*	19	128 (12)
5	*Dugesia gonocephala*	19	128 (13)
6	*Hydropsyche instabilis*	19	600 (2)
7	*Serratella ignita*	19	314 (4)
8	*Potamophylax latipennis*	19	153 (9)
9	*Odontocerum albicorne*	18	79 (17)
10	*Epeorus sylvicola*	15	27 (45)
11	*Perla marginata*	15	34 (40
12	*Rhyacophila nubila*	15	268 (6)
13	*Torleya major*	14	38 (37)
14	*Gammarus balcanicus*	14	318 (3)

Common and frequently occurring species in the streams of the MgNP

Among the 14 taxa found most often in the running waters of the MgNP, as many as half belong to the order *Ephemeroptera*, including the most common species, *Baetis rhodani*. None of the species occurred in all 30 sites of this study. *B. rhodani* is also top of the list of the ten most common species with the greatest numbers of specimens collected (Table 5). Therefore, there is a fairly evident correlation between the frequency of occurrence of species and their quantitative representation in the collected samples.

B. rhodani, which prefers the lotic habitats on stone substrates, is the most common species in the Carpathian streams and rivers (Sowa 1975; Kłonowska-Olejnik 2000). It occurs in great numbers within a considerable range of elevations, reaching the spring zone: up to 1100 m a.s.l. on the Babia Góra Mt. (Sowa 1975; Szczęsny and Wiśniowska 2003), and up to 1150 m a.s.l. in the Bieszczady Mts (Kłonowska-Olejnik 2000). It does not occur, however, in the springs themselves. The species is accompanied by two other species with similar ecological requirements and altitudinal ranges: *Alainites muticus* and *Epeorus sylvicola*. These two species are more numerous in the sections of streams at lower elevations, where the remaining mayfly species from the list of the most common in the MgNP can also be found.

A planarian, *Dugesia gonocephala*, is a common species which inhabits Carpathian streams outside the spring zone, whereas the caddis flies: *Hydropsyche instabilis*, *Potamophylax latipennis* and *Rhyacophila nubila* and a stonefly, *Perla marginata*, prefer the middle and lower courses of streams. Only *Gammarus balcanicus*, a freshwater amphipod occurs along the entire length of the Beskidy streams, including the springs, but exclusively in sites without currents. The most common species in the streams of the MgNP are also the most common in all the streams of the Beskid Mts.

Table 6. The vertical distribution of invertebrates in the streams of the Magurski National Park. A – number of individuals (average for sample), B – number of taxa.

Altitude	**>700**		**699-600**		**599-500**		**499-400**		**399-328**	
Number of localities	**1**		**5**		**6**		**15**		**3**	
	A	B	A	B	A	B	A	B	A	B
Tricladida	6.00	1	5.25	2	15.30	2	4.20	1	0.11	1
Mollusca	5.00	1			2.25	2	0.66	1	0.17	1
Hirudinea			1.25	1			0.07	1		
Amphipoda	1.00	1	17.00	2	50.40	3	1.00	2		
Ephemeroptera			24.90	8	132.00	15	148.00	23	193.00	17
Odonata			0.25	1						
Plecoptera	8.00	2	52.50	14	28.30	13	22.00	18	20.20	3
Coleoptera	5.00	1	17.60	5	9.92	5	16.90	6	24.20	5
Trichoptera	15.00	6	27.80	25	61.50	42	153.00	48	190.00	23
Total	**40**	**12**	**147**	**58**	**299**	**82**	**345**	**100**	**427**	**50**

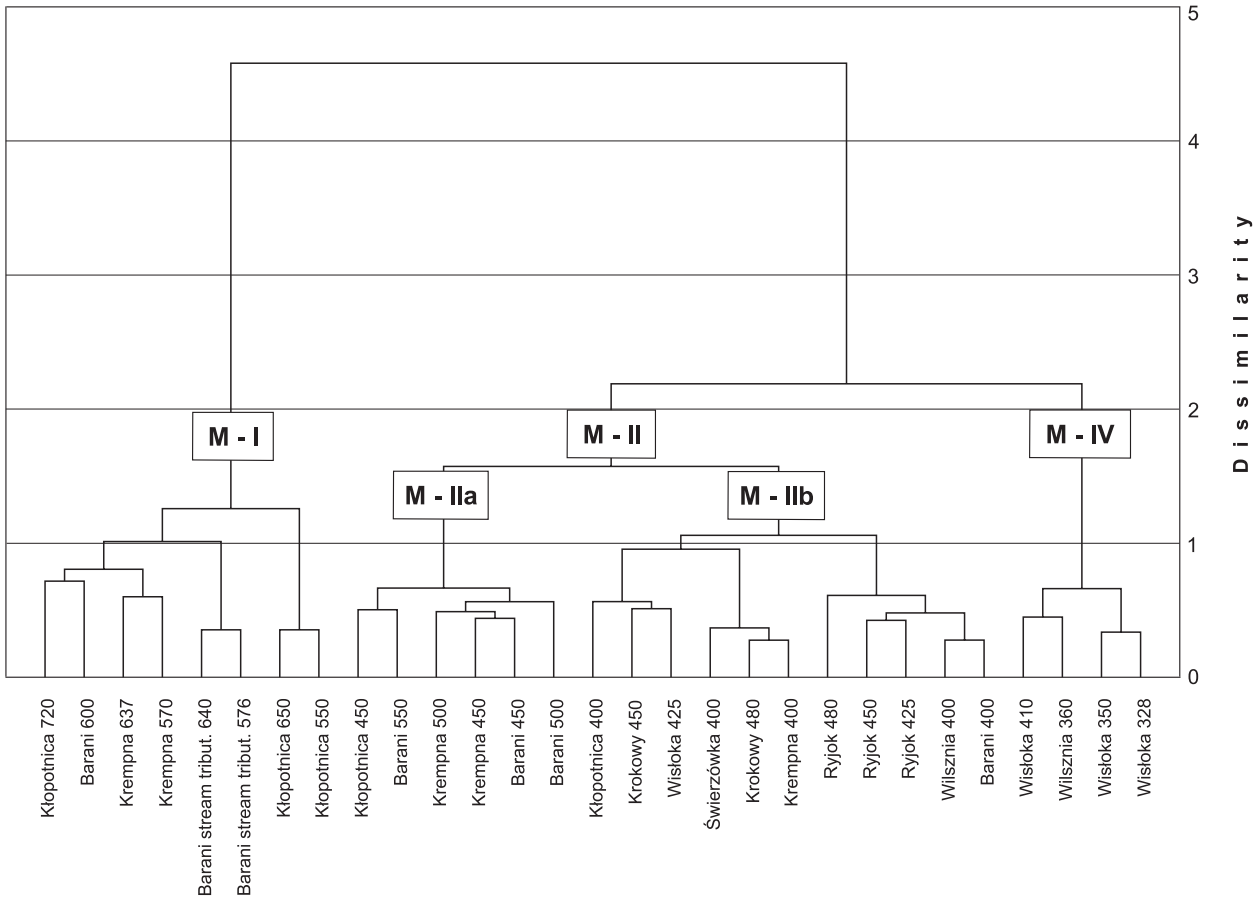

Fig. 2. Groups of localities based on species composition of invertebrates.

Spatial distribution of species in streams

Altitudinal diversity

The features of the river network in the area of the MgNP, which is situated entirely within a small range of altitudes (328-790 m a.s.l.), determined the distribution of the research sites. The greatest number of sites was situated at altitudinal range between 400-499 m, only 1 site is situated above 700 m, and only 3 – below 400 m altitude. The density of benthic fauna studied increased conversely to the gradient of streams and elevation of sites, whereas the greatest species diversity was found in the 400-499 m a.s.l. range (Table 6). Therefore, the density reflected rather the size of stream-bed, whereas the number of species was correlated with the number of sites, i.e. it reflected the degree of habitat differentiation. The aforementioned range contains streams of various sizes with the largest one being the Wisłoka. The drop in the number of species in the sites at lower altitudes can be explained as a result of similar ecological conditions in the lower courses of the Wilsznia and Wisłoka; within this range, the smaller streams were not taken into consideration.

However, particular groups of taxa have shown their specific ecological modalities and their distribution in the streams did not correspond neatly with the regularities found generally in the fauna with respect to species distribution. For example, the numbers of stone flies *Plecoptera* declined somewhat with the decrease in elevation while the *Amphipoda* definitely preferred the upper courses of streams.

Spatial diversity – types of habitats

Out of some 140 species identified, as many as 38 species were found in only one of the studied streams, and 70 species were found in at least 3 streams. Only some of the taxa limited to one stream, were found as single specimens. The spatial diversity in the distribution of species was therefore evident and indicative of major differences in ecological conditions prevailing in particular streams. The greatest numbers of "own" species occurred in the Barani (11) and Kłopotnica stream (9), followed by the Wisłoka (7), Krempna (6), and Ryjok streams (4). Particularly significant are the differences in the species composition

Table 7. The taxa characteristic to the sections of streams represented by stations in the **M-I** group (Fig. 2). Symbols: A – taxa found only in the sites of the group; B – taxa with the highest representation in the sites of the group; N – average number of individuals per sample.

A	**N**	**B**	**N**
Wormaldia occipitalis	5.20	*Gammarus balcanicus.*	20.00
Nemurella picteti	4.60	*Habroleptoides confusa*	5.70
Crenobia alpina	3.60	*Dugesia gonocephala*	5.20
Ecdyonurus subalpinus	1.70	*Baetis alpinus*	4.60
Niphargus spp.	1.40	*Gammarus fossarum*	3.90
Potamophylax nigricornis	1.00	*Hydropsyche fulvipes*	2.70
Chaetopteryx subradiata	1.00	*Protonemura auberti*	2.10
Synagapetus armatus	0.50	*Leuctra braueri*	2.00
Lithax niger	0.50	*Rhithrogena iridina*	1.90
Bythinella austriaca.	0.40	*Psilopteryx psorosa*	1.30
Nemoura cambrica	0.40	*Plectrocnemia conspersa*	1.30
Trocheta bykowskii.	0.40	*Leuctra nigra*	1.30
Sericostoma personatum	0.30	*Rhyacophila polonica*	1.10
Chaetopteryx polonica .	0.20	*Ecdyonurus carpathicus*	1.00
Siphonoperla torrentium	0.20	*Synagapetus iridipennis*	0.90
Tinodes rostocki	0.20	*Rhyacophila tristis*	0.70
Plectrocnemia brevis	0.10	*Leuctra aurita*	0.60
Beraea maurus	0.10	*Silo pallipes*	0.50
Potamophylax carpathicus	0.10	*Philopotamus ludificatus*	0.50
Adicella filicornis	0.10	*Leuctra autumnalis*	0.50
Gomphus sp.	0.10	*Protonemura lateralis*	0.50
Drusus brunneus	0.03	*Perla pallida*	0.40
Isoperla sudetica	0.03	*Protonemura montana*	0.40
		Leuctra inermis	0.40
		Rhyacophila philopotamoides	0.30
		Oecismus monedula	0.30
		Allogamus uncatus	0.20
		Baetis melanonyx	0.10
		Crunoetia irrorata	0.04

in the spring sections spring zone of streams, e.g. the Alpine planarian *Planaria alpina* and the Carpathian endemics: a caddis fly *Drusus brunneus* and a stonefly *Isoperla sudetica* were found only in the upper course of the Kłopotnica stream. A leech *Trochaeta bykowski* was found only in the upper course of the Barani stream.

Grouping the sites of similar species composition (using the Ward method and the 1^{-r} Pearson method of the "Statistica" software package) allowed the separation of three main groups, when the cut is made at the level of 2 (Fig. 2).

The **M-I** group of sites, including springs and adjacent stretches of streams at the highest elevations had the most distinctly specific fauna. At least 23 taxa were found exclusively in sites of this group, including crenobionts and crenophiles, which are characteristic for spring communities. In addition, 29 more species should also be considered as preferring this type of stream habitat, because the highest numbers of specimens (as an average per sample) of the taxa were collected in this group of sites (Table 7). In general, this aquatic habitat type had the

Table 8. The taxa characteristic to the sections of streams represented by stations in the **M-IIa** group (Fig. 2). Symbols as in Table 7.

A	N	B	N
Glossosoma intermedia	0.90	*Baetis rhodani*	25.8
Agapetus ochripes	0.06	*Glossosoma conformis*	9.50
Leuctra fusca	0.03	*Potamophylax cingulatus depilis*	3.20
Philopotamus variegatus	0.03	*Odontocerum albicorne*	3.00
Annitella obscurata	0.03	*Ecdyonurus submontanus*	2.70
		Habrophlebia lauta	2.00
		Chaetopteryx fusca	1.60
		Rhyacophila mocsaryi	1.30
		Leuctra digitata	1.20
		Ancylus fluviatilis	1.00
		Philopotamus montanus	0.90
		Rhyacophila obliterata	0.70
		Rhyacophila fasciata	0.60
		Isoperla buresi	0.10
		Beraeamyia hrabei	0.03

highest number of taxa in MgNP. Particularly interesting is the occurrence in this habitat of a numerous population of *Gammarus fossarum*. This amphipod in the Polish Carpathians, outside the Wisłoka catchment, was only recorded in the Pieniny Mts (Jażdżewski 1975).

The **M-II** group of sites includes two subgroups differing in rather minor characteristics: **M-IIa** – the sites of the middle course (in 500-550 m a.s.l. range) and **M-IIb** – the sites of the lower course (400-480 m a.s.l.) of streams.

The stream habitat represented by the **M-IIa** group of sites was populated by a fairly small group of taxa; only 5 "own" taxa and 15 preferring ones, i.e. those with the highest numbers of specimens (as an average per sample) found therein (Table 8). The "own" species occurred as a few specimens, and even the most numerous among them, *Glossosoma intermedia*, did not reached the level of 1 individual (as an average per sample). But the most numerous species among those which preferred the habitat, such as mayflies *Baetis rhodani* and *Ecdyonurus submontanus*, and caddis-flies *Glossosoma conformis*, *Potamophylax c. depilis*, *Odontocerum albicorne*, and several other species of the genus *Rhyacophila*, should be regarded as the characteristic species of this stream habitat in the MgNP.

The group of species preferring the stream habitat represented by the **M-IIb** group of sites was much larger. There were 7 "own" species and 23 preferring species (Table 9). Again, in this group, the "own" species occurred in fewer numbers; therefore, it was rather the species of the second category that should be regarded as the characteristic species, in particular the caddis-flies of the genus *Hydropsyche*.

The sites of the **M-III** group, including the Wisłoka below the mouth of the Ryjok stream, and the stretch of the Wilsznia stream near its confluence are distinctly different from the above mentioned groups (Fig. 2). The group had 9 "own" species and 20 species preferring this habitat over other habitats. Both groups included some species which occurred in high numbers of specimens (Table 10). The mayflies of the genus *Baetis*, and *Serratella ignita*, *Oligoneuriella rhenana* species, and the caddis-flies of the family *Hydropsychidae*, of the genus *Hydroptila* as well as the *Rhyacophila nubila* and *Sericostoma schneideri* species, can be regarded as characteristic for this type of habitat.

Discussion

Stream habitats of the MgNP (the West Beskid Mts) and the Bieszczady Zachodnie (the East Beskid Mts)

When comparing the data obtained e.g. with respect to *Ephemeroptera* and *Trichoptera*, with the results of studies of a similar profile carried out in the Bieszczady Mts, only

Table 9. The taxa characteristic to the sections of streams represented by stations in the **M-IIb** group (Fig. 2). Symbols as in Table 7.

A	N	B	N
Leuctra hippopus	0.67	*Hydropsyche instabilis*	12.50
Agapetus delicatulus	0.26	*Alainites muticus*	5.23
Chloroperla kisi	0.26	*Potamophylax latipennis*	4.59
Erpobdella monostriata	0.04	*Allogamus auricollis*	3.65
Protonemura praecox	0.02	*Hydropsyche botosaneanui*	3.34
Ephemera danica	0.02	*Rhithrogena semicolorata*	2.26
Ecclisopteryx dalecarlica	0.01	*Ecdyonurus torrentis*	1.95
		Hydropsyche saxonica	1.95
		Amphinemura borealis	1.87
		Torleya major	1.33
		Electrogena lateralis	1.12
		Polycentropus flavomaculatus	1.05
		Silo piceus	1.02
		Perla marginata	0.84
		Epeorus sylvicola	0.70
		Halesus digitatus	0.45
		Potamophylax luctuosus	0.39
		Protonemura intricata	0.26
		Halesus tesselatus	0.23
		Ecdyonurus venosus	0.19
		Ephemerella mucronata	0.15
		Amphinemura sulcicollis	0.08
		Athripsodes commutatus	0.03

a short distance away (Kłonowska-Olejnik 2000; Szczęsny 2000a; Kukuła and Szczęsny 2000), it can be deduced that the number of species recorded in the streams of the MgNP is generally lower. Except for the East Carpathian endemic species, whose distribution does not reach further west beyond the Bieszczady Mts, the number of species occurring in the MgNP was on average lower by ca. 28%. The maximum numbers of species of *Ephemeroptera* and *Trichoptera* (23 and 48 respectively), were found in the streams of the MgNP within the 400-499 m a.s.l. range of altitudes (Tables 3-4). In the streams of the Bieszczady Mts, the maximum numbers of species (42 and 53) were found in the 600-699 m a.s.l. range (Kłonowska-Olejnik 2000; Szczęsny 2000a).

In the spring habitats of the MgNP, 28% species (i.e. 5), found elsewhere, did not occur, including: *Apatania carpathica*, *Ecclisopteryx madida* and *Drusus discolor*; which are otherwise fairly common in the Bieszczady Mts The first two of these species were found in the tributaries of the Upper Wisłoka River, but outside the Park' borders. In the upper stream course habitat, some 10% (i.e. 2 species) were not found, in the lower course habitat – 30% (18), and in the middle course habitat as many as 43% (9) of the overall number of species did not appeared there. Among those species which were not found in samples collected in the streams of the MgNP, were those which occur in massive numbers in the middle and/or lower courses of the Bieszczady streams: *Brachycentrus montanus* and *Micrasema setiferum* and the species that are abundant there include: *Caenis beskidensis*, *C. macrura*, *Rhithrogena carpatoalpina*, *R. puytoraci*, *Ceraclea annulicornis*, and *Ecdyonurus starmachi*. Another species occurring in massive numbers in the lower course of streams in the Bieszczady Mts, *Agapetus ochripes*, was found in the streams of the Magurski National Park merely as single individuals.

Table 10. The taxa characteristic to the sections of streams represented by stations in the **M-III** group (Fig. 2). Symbols as in Table 7.

A	N	B	N
Baetis beskidensis	3.42	*Serratella ignita*	15.10
Hydroptila occulta	1.50	*Hydropsyche incognita*	12.60
Ecdyonurus insignis	0.68	*Rhyacophila nubila*	11.30
Hydroptila lotensis .	0.46	*Sericostoma schneideri*	3.54
Procloeon bifidum	0.42	*Oligoneuriella rhenana*	3.35
Caenis luctuosa	0.23	*Baetis lutheri*	2.49
Polycentropus schmidi	0.06	*Cheumatopsyche lepida*	1.58
Ithytrichia lamellaris	0.04	*Hydropsyche bulbifera*	1.44
Lymnea peregra	0.04	*Hydropsyche pellucidula*	1.07
		Caenis rivulorum	0.85
		Hydroptila forcipata	0.68
		Leuctra albida	0.63
		Perla burmeisteriana	0.61
		Baetis scambus	0.55
		Ecdyonurus dispar	0.42
		Baetis fuscatus	0.35
		Psychomyia pusilla	0.26
		Athripsodes albifrons	0.13
		Lepidostoma hirtum	0.12
		Orectochilus villosus	0.09

Also characteristic are changes in the affiliation of species to certain statistically-defined types of habitats in both areas. It was found, that many species "shifted" their locations within the habitats typified in the MgNP, closer to the springs than those in the Bieszczady Mts It may be supposed that it is a reaction of the species to the differences in ecological conditions in the streams of the MgNP, which are situated at a much lower range of altitudes (330-760 m) than in the Bieszczady Mts (330-1225 m).

The ecological features of stream habitats are determined, inter alias, by climatic conditions and the basin relief. The rather low elevations of the mountain massifs in the MgNP (maximum of 847 m altitude), the small differences in their relative heights, plus the rather low precipitation figures result in relatively short stream courses and low water flows. Particularly short are their steeply inclined stretches, i.e. those of upper and middle courses. On the other hand, meandering streams in lower course are quite a frequent phenomenon. Short courses and limited water supply do not favour the formation of certain stream habitats, particularly in the middle courses. These habitats are distinctly stony, with quick currents and stable flow, and moderately low water temperature – which are most favoured by the aquatic developmental stages of mayflies. These environmental conditions should be considered as the reason for the disproportionately low number of mayfly species in the streams of the MgNP (29 species), compared with the streams of the Bieszczady Mts (64 species), particularly the rheobiontic species of the family *Heptageniidae*.

Aquatic fauna of the MgNP viewed against the background of the West Carpathian fauna

Trichoptera, are, apart from *Ephemeroptera*, the most thoroughly studied group of invertebrates in the West Carpathians, from among the three main groups which most densely populated stream bottom in the MgNP. In the MgNP, at least 96 species were found, 90 species in the Gorce Mts (Szczęsny 1998), 93 in the Pieniny Mts (Szczęsny 2000b), 102 in the Babia Góra Mt. massif, and 120 species in the Tatra Mts (Szczęsny 2003). The records from the Bieszczady Zachodnie Mts (West Carpathians) list

122 species of caddis flies (Szczęsny 2000a). The numbers of caddis-fly species in the various mountain ranges are fairly similar, and they correlate better with the size of the range and the diversity of ecological conditions than with the height of their summits. In the Outer Carpathians (West Beskid Mts and the Carpathian forelands), 165 species of caddis flies have been discovered to-date, and in the whole of the West Carpathians – 216 species.

When the check lists of caddis-fly species in the MgNP are compared with those of the Gorce Mts and the Babia Góra massif, one notes, above all, the lack in the MgNP of species associated with high or moderately high mountains, as well as those whose distribution ranges end in the West Carpathians on the line between the Tatra and the Gorce Mts e.g. *Rhyacophila glareosa*, *Acrophylax vernalis*, *Halesus rubricollis*, *Drusus biguttatus*, *D. trifidus*, *Rhyacophila vulgaris*, *Annitella thuringica*, and *Oligoplectrum maculatum*.

On the other hand, in the MgNP there exist the species associated with water courses in forelands or even lowlands, e.g. of the families *Hydroptilidae* (*Hydroptila occulta*, *H. tineoides*), *Leptoceriidae*, and *Hydropsychidae* (*Hydropsyche bulbifera*). A particularly significant example among these is a large population of freshwater amphibian *Gammarus fossarum*, for which the MgNP is only the second station (apart from the Pieniny Mts) in the West Carpathians where this species lives on a site elevation above 500 m a.s.l.

Evidently, less species of mayflies *Ephemeroptera* and stoneflies *Plecoptera* were collected in the MgNP than in other West Carpathian mountain ranges: only 29 (mayflies) and 27 (stoneflies). When compared with the Gorce Mts where 40 species of mayflies have been collected to-date (Szczęsny, 1998), and the Babia Góra massif – with 39 species found (Szczęsny and Wiśniowska 2003a), the number seems to be an underestimate. This difference seems even more pronounced, because the collection of mayflies in the Gorce Mts were made at higher altitudes (>500 m), and in the Babia Góra Mt. >600 m, and it is well-known that the number of mayfly species increases with the decrease in altitude (Sowa 1975; Kawecka and Szczęsny 1984). In the Pieniny range, where the lotic waters are situated at a lower range of altitudes (430-720 m), 48 species have been found to-date (Szczęsny 2000b).

Even more evident is the difference in the number of stonefly species in the MgNP, when compared with the list for the Gorce Mts where 68 species were found (Fiałkowski et. al. 1987; Szczęsny 1998), or that for the Babia Góra Mt. – where 59 species have been found (Szczęsny et al. 2003b).

Similarly as in the case of caddis flies, in these groups certain deficits are noted, above all in the group consisting of recognized mountain species, e.g. among mayflies: *Ameletus inopinatus* and *Rhithrogena loyolaea*, among stoneflies: *Leuctra armata*, *L. handlirschi*, *L. rosinae*, *Diura bicaudata*, and *Protonemura auberti*, but not only these. The lower elevation of the river network in this section of the Beskid Niski Mts and the lack of conditions for the development of these distinctly mountain forms, does not explain fully the fairly limited numbers of mayfly and stonefly species found in the MgNP. It seems that these lists are not exhaustive yet.

Species of particular importance to the MgNP

The taxa considered to be particularly important to the MgNP include: species of limited distribution ranges, i.e. endemic species, endangered species subject to legal protection and/or placed on the national "Red list of threatened species". Also included are the species occurring in the Park in isolated populations (*Gammarus fossarum*).

Among the invertebrates occurring in the MgNP, only one species is covered by legal protection. It is a snail *Bythinella austriaca* which has been placed on the Red list as "nearly threatened" (NT). In the MgNP, 4 endemic species of mayflies, 2 of stoneflies and 6 of caddis flies occur. Two of these: *Baetis beskidensis* and *Potamophylax carpathicus* have been placed on the "Red list" in the Least Concerned (LC) category. Twenty-five other species have been placed on the "Red list" including two mayfly species, *Ecdyonurus insignis* and *Oligoneuriella rhenana* (listed as Vulnerable – VU), a leech *Trochaeta bykowski* and 4 species of caddis flies classified in the Near Threatened category (NT), 2 species of stoneflies and 10 of caddis flies in included in the Least Concern (LC) category, and 1 species of stonefly and 4 species of caddis flies with given the status of Data Deficient (DD). It should be noted, that some of these species live in the MgNP in fairly numerous populations, e.g. mayflies *Baetis beskidensis*, *Oligoneuriella rhenana*, *Rhithrogena iridina*, *Ecdyonurus carpathicus*, and stonefly *Polycentropus schmidi*.

Apart from the above-listed invertebrates, three fish species covered by legal protection inhabit the drainage basin of the Upper Wisłoka: the brook minnow *Eupallasella* (*Phoxinus*) *percnurus*, the rifle minnow *Alburnoides bipunctatus* and the miller's thumb *Cottus poecilopus*. The two minnows occur in quite large populations, thus making the stream habitats of the MgNP a kind of refuge area for these species in the Polish Carpathians, particularly in the case of the rifle minnow (Kukuła 2003).

A loach, *Barbatula barbatula* (L.), which has until very recently been covered by legal protection, also lives in the Park.

REFERENCES

Bombówna M. 1960. Hydrochemische Charakteristik des Flusses Soła und seinr Nebenflüsse. Acta Hydrobiol., 2: 175-200.

Bombówna M. 1965. Hydrochemical characteristcs of the Wielka Puszcza stream. Acta Hydrobiol., 7, Suppl. 1: 1-7

Bombówna M. 1969. Hydrochemical characteristcs of the river Raba and its tributaries. Acta Hydrobiol., 11: 479-504.

Chełmicki W., Skąpski R., Soja R. 1999. Reżim hydrologiczny rzek karpackich w Polsce (The flow regime of Poland's Carpathian rivers). Folia Geogr., series Geographica-Physica 29/30: 67-81 (in Polish with an English summary).

Dynowska I. 1971. Typy reżimów rzecznych w Polsce (Types of river regimes in Poland). Zesz. Nauk. UJ. Pr. Geogr. 28: 1-147 (in Polish with an English summary).

Fiałkowski W., Olechowska M. 1987. A preliminary report on the stoneflies (*Plecoptera*) inhabiting main watercourses in the Gorce Mts (Southern Poland). Acta Hydrobiol., 29, 4: 443-451

Fiałkowski W., Sowa R. 2002. *Plecoptera* Widelnice (Stoneflies). In: Z. Głowaciński (Ed.) Czerwona lista zwierząt ginących i zagrożonych (Red List of Threatened Animals in Poland). Institute of Nature Conservation PAS, Kraków, pp. 122-124

Hermanowicz W., Dożańska W., J. Dojlido J., Koziorowski B. 1976. Fizyczno-chemiczne badanie wody i ścieków (Physical and chemical analysis of fresh waters and sewages). Arkady, Warszawa, pp. 1-847.

Hess M., 1965. Piętra klimatyczne w Polskich Karpatach Zachodnich (Vertical climatic zones in the Polish Western Carpathians). Zesz. Nauk. UJ, Prace Geogr. 11: 1-258 (in Polish with an English summary).

Jażdżewski K. 1975. Morfologia, taksonomia i wystepowanie w Polsce kiełży z rodzajów *Gammarus* Fabr. i *Chaetogammarus* Mart. (*Crustacea*, *Amphipoda*) (Morphology, taxonomy and distribution of gammarids of the genera *Gammarus* Fabr. and *Chaetogammarus* Mart. (*Crustacea*, *Amphipoda*) in Poland). Acta Univ. Łódź., pp. 1-187 (in Polish).

Kawecka B., Szczęsny B. 1984. Dunajec. In: B.A. Whitton (ed.). Ecology of European Rivers. Blackwell Scient. Publ., Oxford: 499-525.

Kłonowska M. 1990. Jętki (Mayflies) (*Ephemeroptera*). In: Szczęsny B. 1990. Bezkręgowce dorzecza Kamienicy Gorczańskiej (Invertebrates of the Kamienica Gorczańska drainage net). Institute of Nature Conservation PAS, (manuscript) (in Polish).

Kłonowska-Olejnik M. 2000. Jętki (*Ephemeroptera*) Bieszczadów Zachodnich (Mayflies (*Ephemeroptera*) in the Western Bieszczady Mountains). Monogr. Bieszczadzkie, 7: 145-156, Ustrzyki Dolne (in Polish with an English summary).

Kłonowska-Olejnik M. 2002. *Ephemeroptera* Jętki (Mayflies). In: Z. Głowaciński (ed.) Czerwona lista zwierząt ginących i zagrożonych (Red List of Threatened Animals in Poland). Institute of Nature Conservation PAS, Kraków pp.128-132 (in Polish with an English summary).

Kondracki J. 1978. Karpaty (The Carpathians). Wydawn. Szkol. i Pedag., Warszawa, 273 pp (in Polsh).

Kukuła K. 2003. Ryby (Fish). In: Górecki A., K. Krzemień, S. Skiba, B. Zemanek (eds). Przyroda Magurskiego Parku Narodowego (Nature of the Magurski National Park). MgPN, UJ, Krempna-Kraków, pp.113-117 (in Polish with an English summary).

Lach J., Wyżga B. 2001. Zmiany geometrii i przepływu górnej Wisłoki po zwiększeniu lesistości zlewni (Channel and flow changes of the Upper Wisłoka River, Southern Poland, subsequent to the reafforestation of its catchment). Czasop. Geogr. 72(3-4): 329-355 (in Polish with an English summary).

Obrębska-Starklowa B. 2003. Warunki klimatyczne (Climate). W: Górecki A., K. Krzemień, S. Skiba, B. Zemanek (eds). Przyroda Magurskiego Parku Narodowego (Nature of the Magurski National Park). MgPN, UJ, Krempna-Kraków, pp. 51-62 (in Polish with an English summary).

Olechowska M. 1989. Widelnice (*Plecoptera*) głównych cieków gorczańskich (rkps) (Stoneflies of the main streams in the Gorce Mts) (manuscript). Institute of Nature Conservation PAS, Kraków (in Polish).

Olechowska M. 1990. Widelnice (Stoneflies)(*Plecoptera*) In: Szczęsny B. 1990. Bezkręgowce dorzecza Kamienicy Gorczańskiej (rkps) (Invertebrates of the Kamienica Gorczańska drainage net) (manuscript). Institute of Nature Conservation PAS, Kraków (in Polish).

Piechocki A. 2002. Gastropoda aquatica Ślimaki wodne. In: Z. Głowaciński (ed.) Czerwona lista zwierząt ginących i zagrożonych (Red List of Threatened Animals in Poland). Institute of Nature Conservation PAS, Kraków, pp. 34-37 (in Polish with an English summary).

Riedel W. 1978. Chruściki (*Trichoptera*) Pienin (Die Köcherfliegen (*Trichoptera*) der Pieninen. Fragm. faun., 22: 247-264 (in Polish with a German summary).

Soja R. 2003. Wody (Waters). In: Górecki A., Krzemień K., Skiba S., Zemanek B. (eds). Przyroda Magurskiego Parku Narodowego (Nature of the Magurski National Park). MgPN, UJ, Krempna-Kraków, pp. 43-50 (in Polish with an English summary).

Sowa R. 1975. Ecology and biogeography of mayflies (*Ephemeroptera*) of running waters in the Polish part of the Carpathians. 1. Distribution and quantitative analysis. Acta Hydrobiol., 17: 223-297.

Sowa R., Fiałkowski W. 1988. Diversity, abundance, and zonation of stoneflies (*Plecoptera*) from the water system: Olszowy Potok stream – River Raba (Southern Poland). Acta Hydrobiol., 30, 3/4: 381-391.

Szczęsny B. 1986. Caddis flies (*Trichoptera*) of running waters in the Polish North Carpathians. Acta Zool. Cracov., 29, 21: 501-586.

Szczęsny B. 1987. Ecological characteristics of caddis flies (*Trichoptera*) of streams in the Gorce Mts (Southern Poland). Acta Hydrobiol., 29, 4: 429-442.

Szczęsny B. 1998. Operat ochrony fauny wodnej Gorczańskiego Parku Narodowego (A management plan of the aquatic fauna conservation in the Gorce National Park). Dyrekcja GPN Poręba Wielka (in Polish).

Szczęsny B. 2000a. Trichopterofauna Bieszczadów Zachodnich (Karpaty Wschodnie) {*Trichoptera* of the Western Bieszczady Mts (Eastern Carpathians)}. Monogr. Bieszczadzkie, 7: 189-250, Ustrzyki Dolne (in Polish with an English summary).

Szczęsny B. 2000b. Operat ochrony ekosystemów wodnych Pienińskiego Parku Narodowego (A management plan of the aquatic ecosystems conservation in the Pieniny National Park). Dyrekcja PPN, Krościenko n. Dunajcem (in Polish).

Szczęsny B. 2002. *Trichoptera* Chruściki (Caddis flies). In: Z. Głowaciński (ed.) Czerwona lista zwierząt ginących i zagrożonych (Red List of Threatened Animals in Poland). Institute of Nature Conservation PAS, Kraków, pp. 76-79 (in Polish with an English summary).

Szczęsny B. 2003. Fauna chruścików *Trichoptera* Babiej Góry (Karpaty Zachodnie) {*Trichoptera* of Mt. Babia Góra (Western Carpathians)}. In: Wołoszyn B.W., Wołoszyn D., Celary W. (eds). Monografia fauny Babiej Góry (Fauna of Mt. Babia Góra, Poland). Publikacje Komitetu Ochrony Przyrody PAN, Kraków, pp. 251-278 (in Polish with an English summary).

Szczęsny B., Wiśniowska A. 2003a. Fauna jętek (*Ephemeroptera*) Babiej Góry (*Ephemeroptera* of Mt. Babia Góra). In: B.W. Wołoszyn, D. Wołoszyn, W. Celary (eds). Monografia fauny Babiej Góry (Fauna of Mt. Babia Góra, Poland). Publikacje Komitetu Ochrony Przyrody PAN, Kraków, pp. 123-139 (in Polish with an English summary).

Szczęsny B., Wiśniowska A. 2003b. Fauna widelnic (*Plecoptera*) Babiej Góry (*Plecoptera* of Mt Babia Góra). In: Wołoszyn B.W., Wołoszyn D., Celary W. (eds). Monografia fauny Babiej Góry (Fauna of Mt. Babia Góra, Poland). Publikacje Komitetu Ochrony Przyrody PAN, Kraków, pp. 141-158 (in Polish with an English summary).

Szczęsny B., Zięba D. 2001. Chemical contents of water at the Babia Góra Mountain (Southern Poland). Nature Conservation, 58: 109-118.

Ślączka A. 2003. Budowa geologiczna (Geology). In: Górecki A., Krzemień K., Skiba S., Zemanek B. (eds). Przyroda Magurskiego Parku Narodowego (Nature of the Magurski NationalPark). MgPN, UJ, Krempna-Kraków, pp. 13-20 (in Polish with an English summary).