Hydrobiologia **353:** 193–198, 1997.

The life cycles of three species of Ephemeroptera in two streams in Poland

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Received 4 April 1996; in revised form 24 June 1997; accepted 8 Junly 1997

Key words: mayflies, life cycles, environmental conditions

Abstract

Nymphs of *Rhithrogena iridina, Baetis alpinus* and *Baetis melanonyx* were collected in the Wołosatka and Terebowiec streams; Bieszczady National Park, southeastern Poland. The streams have different environmental conditions. The life cycles of *Rhithrogena iridina* in the Wołosatka and the Terebowiec streams were of the univoltine winter type. In the Wołosatka (Station 1) this species had a univoltine life cycle with one cohort. In the Terebowiec (Station 2), *R. iridina* had a univoltine life cycle with two cohorts – winter and summer. The development of *Baetis alpinus* took various courses depending on environmental conditions. At the lower station (Wołosatka), where water temperature reached higher values and the stream bed is less shady, the species had a winter-summer cycle with two generations a year. At the higher station, (Terebowiec) it likely had a winter cycle with one or two generations. *Baetis melanonyx* had summer cycles with one generation at both stations.

Introduction

The Bieszczady Mountains (Southeastern Poland) are of unique natural and landscape value. They are the westernmost part of the East Carpathian Mountains (Michalik 1993, Pawłowski, Sterzyńska 1993, Głowaciński 1994). Since 1993 the Bieszczady National Park has been part of the International Biosphere Reserve 'Eastern Carpathians'.

Data on the life cycles of mayflies from Poland can be found in works of Sowa (1965), Jop (1981), Kłonowska et al. (1987). Few life cycles of mayflies in the Polish part of the Carpathian Mountains were investigated by Sowa (1975).

Life cycles of many species of mayflies were studied by Elliot (1967), Brittain (1982), Thorup et al. (1987), and Hefti & Tomka (1990). A comprehensive analysis was made by Clifford (1982), who pointed out a great variability of life cycles between species.

During a four-year period (1985–1988), material on the community structure of Ephemeroptera was collected in the Bieszczady Mountains streams (Kukuła, 1991). The present work describes findings concerning the life cycles of *Rhithrogena iridina*, *Baetis alpinus*, and *Baetis melanonyx* in two streams, differing in environmental conditions.

Methods

Samples were taken from 2 stations, one located on the Wołosatka stream (22°45′E, 49°03′N) and the other on the Terebowiec stream (22°43′E, 49°06′N), both running through the Bieszczady National Park (Southeastern Poland) (Figure 1).

A bottom scraper with a 330 μm mesh bolting cloth net was used for sampling. Samples were drawn from an area of about 5 dm^2 and fixed in 4% formalin. Ten quantitative samples and a single qualitative one were taken from each station. Each individual was measured. Total length, from the anterior margin of the head to the posterior margin of the tenth abdominal tergite, was recorded to the nearest 0.25 mm, and classified in 1 mm size groups. Adults and subimagines were caught with an entomological net. The emergence period of particular species was established on the basis of the presence of the imago and subimago, and nymphs ready to emerge. The samples from Station 1 (the Wołosatka stream) were collected from June 1985 till June 1986.

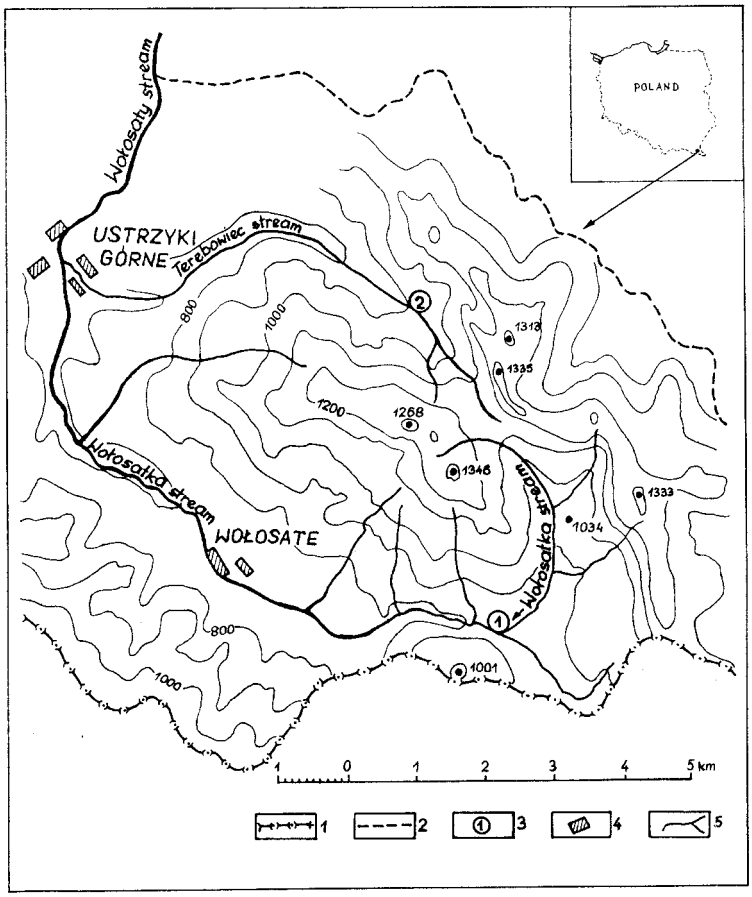

Figure 1. Map of the study area. 1 – state border; 2 – border of the Bieszczady National Park; 3 – stations; 4 – buildings; 5 – streams.

The samples from Station 2 (the Terebowiec stream) were collected from January till November 1986.

Baetis alpinus and *Rhithrogena iridina*, most numerous at both stations, were chosen for investigation. At Station 1, *B. alpinus* constituted 56.6%, *R. iridina* 26.0% of all mayflies caught, while at Station 2, 50.5% were *B. alpinus* and 33.9% were *R. iridina*. *Baetis melanonyx* constituted only 2.7% at Station 1 and 0.8% at Station 2 (Kukuła, 1991).

Results

Environmental conditions

The substratum of both stations was composed of rock and gravel, but the Wołosatka stream had a lower gradient, less shading of the stream bed (Table 1), higher water temperature in summer and greater fluctuations of temperature across the year (Table 2). The hydrographic and hydrological data in Table 1 are mean values for the study period. Table 2 includes mean water temperatures of a given month calculated on the basis of 6–8 measurements taken in 1985–1989. In winter months, samples were taken only sporadically.

Life cycle of Rhithrogena iridina

At stations 1 and 2, *R. iridina* occurred simultaneously with *Rhithrogena carpatoalpina* and *Rhithrogena puytoraci* (Kukuła, 1991). As small nymphs of these three species are similar (Kłonowska et al., 1987), some nymphs of size classes 1, 2 and 3 on the diagram of *R. iridina* (Figure 2), may have belonged to these other species. However, there was few *R. carpatoalpina* and *R. puytoraci* at both stations: 0.7% (Station 1,

Table 1. Hydrographic and hydrological data on stations of the Wołosatka stream (Station 1) and Terebowiec stream (Station 2).

Station number	Altitude (m)	Distance from source (km)	Gradient (‰)	Width (m)	Depth (m)	Current velocity ($m\ s^{-1}$)	Shading of the stream bed (%)
1	825	4.1	21	2.5–6.0	0.3–0.8	1.5	30–60
2	900	1.7	85	1.5–4.0	0.1–0.3	1.5	90–100

Table 2. Mean water temperatures and maximum and minimum water temperatures (°C) on stations of the Wołosatka stream (Station 1) and Terebowiec stream (Station 2).

Station number	Month								
	III	IV	V	VI	VII	VIII	IX	X	XI
1	2.1 (1.0–3.1)	4.5 (2.1–7.3)	8.2 (7.6–10.3)	11.7 (10.0–13.8)	14.1 (12.4–17.6)	15.0 (14.1–19.1)	12.1 (8.7–14.3)	8.2 (4.1–10.2)	4.0 (2.5–5.0)
2	1.5 (1.0–3.0)	4.0 (1.5–5.2)	7.2 (5.6–8.4)	9.3 (8.6–10.1)	10.8 (10.1–14.6)	11.4 (10.0–14.8)	9.3 (7.1–10.1)	7.2 (4.2–8.6)	4.0 (2.0–5.0)

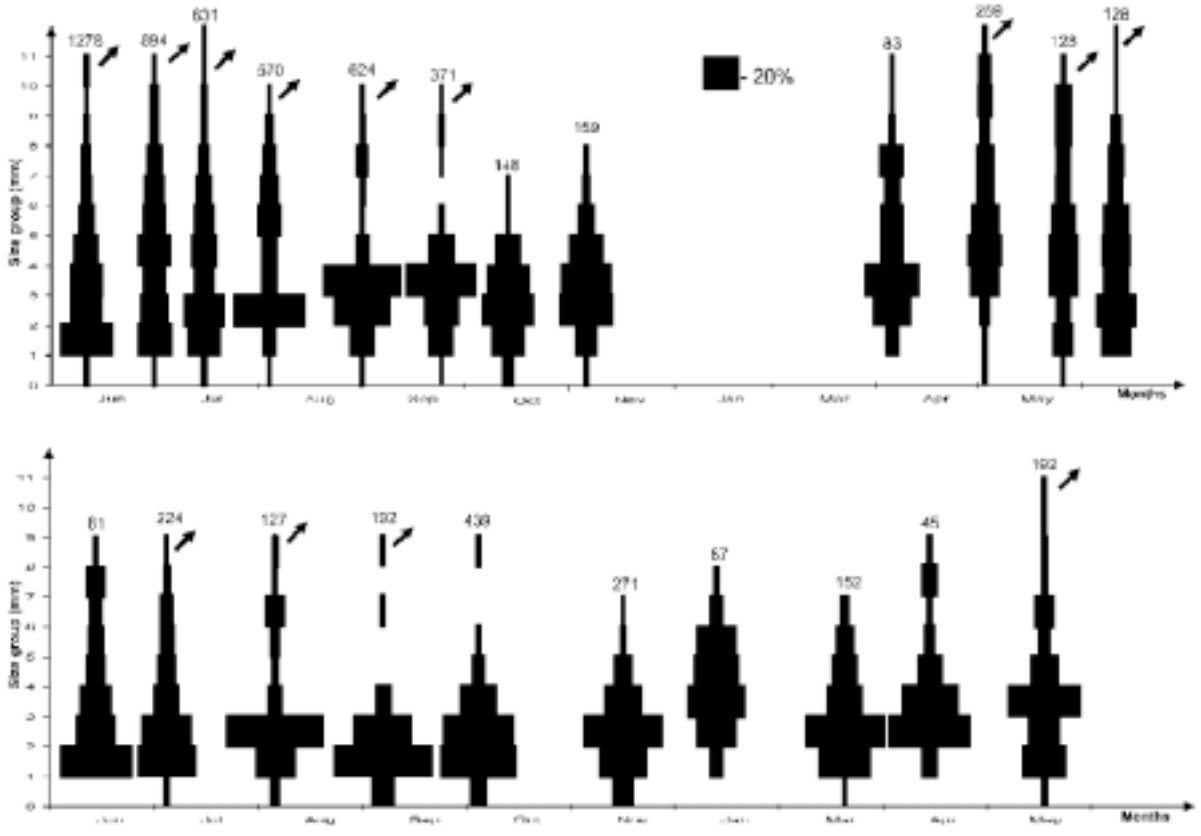

Figure 2. Life cycle of *Rhithrogena iridina* in the Wołosatka stream (above) and in the Terebowiec stream (below). Arrows: emergence period. Numbers above the histograms: absolute number of specimens measured.

Wołosatka) and 1.4% (Station 2, Terebowiec) of the total (Kukuła, 1991).

The emergence of *R. iridina* at the Wołosatka (Station 1) lasted from early May till mid September (Figure 2). In July and August, a division in two cohorts became apparent. The first was formed of nymphs of the first three size classes (the majority belonged to *R. iridina*), the second consisted of nymphs of class 5 up to class 12. The nymphs of the first class originated from eggs laid in May and June, while those of the second cohort had hatched in autumn of the previous year. The increase in the number of smaller nymphs in September may have been due to hatching from the summer oviposition, while the gradual reduction of the larger nymphs was caused by their emergence. The size frequency distribution in early spring samples indicates that nymphs grew slowly in winter. At the end of May, there were many nymphs of size classes 2 and 3 which probably belonged to *R. iridina*.

In the Terebowiec, at Station 2, the emergence period of *R. iridina* was shorter (Figure 2). Nymphs ready for emergence as well as subimagos and imagos appeared first in May, then again from August till the beginning of October. The largest number of mature individuals occurred in August. At this station, the division of the population in two cohorts was more distinct than in the Wołosatka. The cohort of nymphs hatched in autumn grew during winter and emerged in late spring. The individuals of this cohort emerged in summer or early autumn. Nymphs of the first cohort attained a larger size than those of the second one.

Life cycle of Baetis alpinus

Larval stages of *B. alpinus* are morphologically similar to those of *B. melanonyx*, and distinction of young nymphs of these species is impossible. Because of this, nymphs up to class 4 inclusive, may belong to either of these two species (Figure 3).

At the Wołosatka station, *B. alpinus* emerged from May till the first half of October. Mature nymphs, ready to emerge in spring and in the first half of July, were more numerous and of larger size than those emerging in August, September and October. In mid July, the population of nymphs fell in two distinct groups. One consisted of nymphs of size classes 1 and 2 originating from eggs laid in early spring. In mid July, nymphs of classes 3 and 4 consisted of young, fast – growing nymphs of *B. melanonyx*. The second group consisted of nymphs of *B. alpinus*, originating from eggs laid in the previous year. In August, *B. alpinus* which hatched from eggs the previous autumn were scarce. Smaller nymphs (first size classes) were mostly *B. alpinus*. Larger ones (classes 3 and 4) probably hatched from eggs laid in early spring, and smaller ones (classes 1 and 2) originated from eggs laid later. Large individuals of *B. alpinus*, from September and October samples, belonged to a second generation hatched from eggs laid by the spring generation. Eggs laid in autumn underwent complete embryologic development before winter (Figure 3).

The development of *B. alpinus* in the Terebowiec stream took a different course. Emergence lasted probably from mid May till August. These nymphs grew slowly during winter. A division in two groups in April and particularly in May resulted from the hatching of the first nymphs of *B. melanonyx* in early spring. From mid June onwards, nymphs of *B. alpinus* from eggs of that same year became abundant in classes 1 - 4. The presence of older nymphs of *B. alpinus* in September and October, as well as a lack of them in November, indicates a possible second generation.

Life cycles of Baetis melanonyx

In the Wołosatka (Station 1), larger nymphs appeared in mid June, and by mid July, were fully grown. Emergence lasted from mid July till mid August. In the Terebowiec stream, the first nymphs hatched in early spring. Nymphs ready to emerge were observed in August only. Eggs laid in July and August underwent a long quiescence, until the following spring (Figure 3).

Discussion

Several authors suggest a wide range of life cycle types in the Ephemeroptera (Sowa, 1975; Clifford, 1982; Brittain, 1982, 1990). Eliott (1967), Humpesch (1979), and Brittain (1990) claim that water temperature is a major factor determining egg development and nymphal growth. The Wołosatka stream had higher water temperatures across the year than the Terebowiec (Station 2). *R. iridina* was univoltine with one cohort in the Wołosatka stream, and univoltine with two cohorts in the Terebowiec stream (Figure 2). According to Sowa (1975), *R. iridina* is a monocyclic species with heterogeneous growth of nymphs. Clifford (1982) suggests that life cycles of the majority *Heptageniidae* are univoltine. Breitenmoser–Würsten & Sartori (1995) confirmed a univoltine winter cycle in the rivers Saane and Turbach (the Bernese Alps)

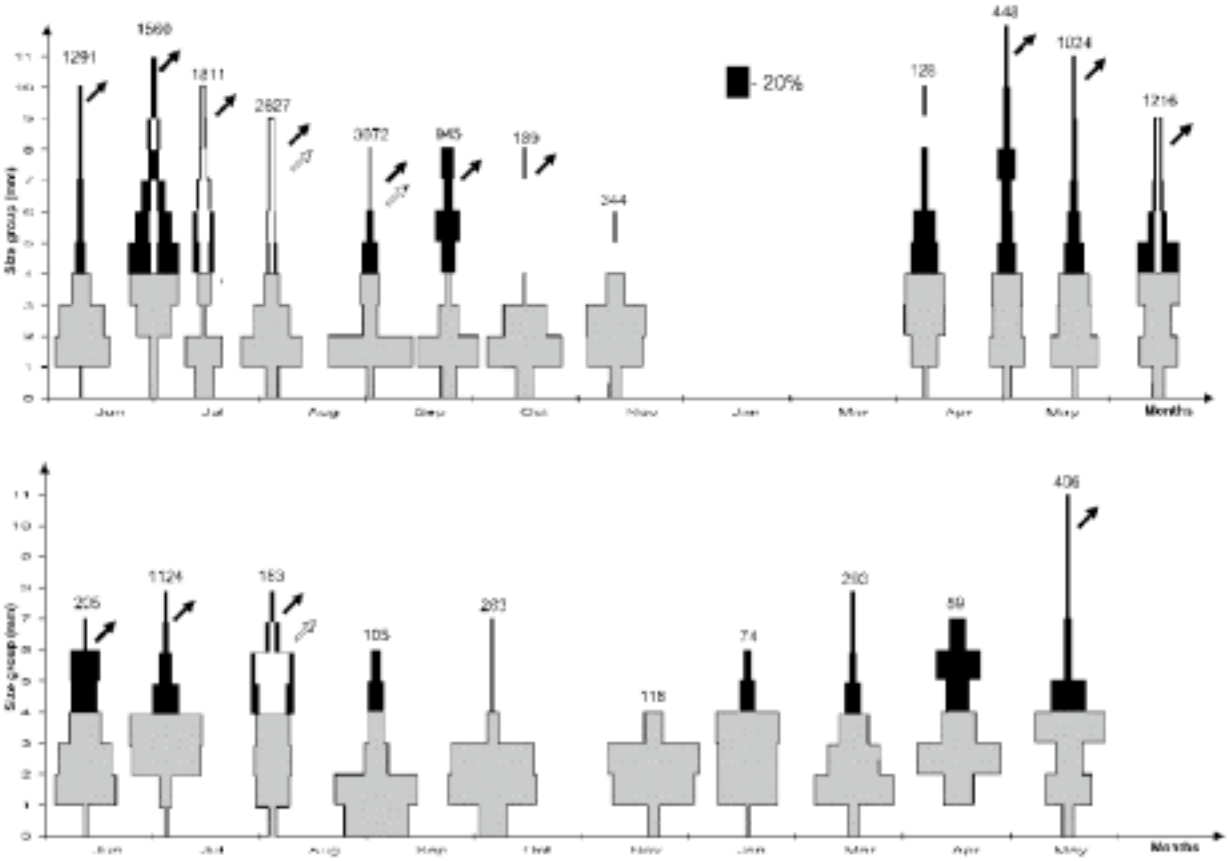

Figure 3. Life cycle of *Baetis alpinus* and *B. melanonyx* in the Wołosatka stream (above) and in the Terebowiec stream (below). Black arrows: emergence period of subimagines *Baetis alpinus*; white arrows: emergence period of *B. melanonyx*. Grey columns – young nymphs belong to either of the two species; white columns – nymphs of *B. melanonyx;* black columns – nymphs of *B. alpinus*. Numbers above the histograms: absolute number of specimens measured.

for *R. iridina*. In the Lissuraga stream (Pyrenees), this species was bivoltine too. The emergence period of *R. iridina* in the Lissuraga stream was longer than in the Wołosatka and the Terebowiec. This related to a higher water temperature in the Lissuraga in winter (Thibault, 1971). The life cycle of *R. iridina* in the Terebowiec was similar to that of *Ecdyonurus subalpinus* in spring in the Wielka Puszcza stream, where a distinct division of the population of *Ecdyonurus subalpinus* into two cohorts, winter and summer (Sowa, 1965), was observed.

The development of *B. alpinus* depended on environmental conditions. At the lower station (Wołosatka, Station 1), where water temperature was higher and the stream bed less shady, it had a winter–summer cycle with two generations a year. At the higher station (Terebowiec, Station 2), it probably had a winter cycle with one or two generations (Figure 3). For *B. alpinus* in Czechoslovakia, Landa (1969) found a single generation at high stations, and two generations at lower sites. Degrange (after Müller-Libenau, 1969) states that *B. alpinus* has two generations: one in spring, and one in autumn. Sowa (1975) found two generations for *B. alpinus* at two stations on the Olszowy stream. At the higher station, the second generation was difficult to distinguish. The data compiled by Clifford (1982) also indicate that the life history of *B. alpinus* is variable. Depending on altitude, this species can have a single generation or one generation before winter and a second one in summer. Following Clifford's classification (1982), at Station 1 (the Wołosatka) *B. alpinus* was a bivoltine winter–summer species, while at Station 2 (the Terebowiec), it was either univoltine or bivoltine with a partly second generation. Also Weichselbaumer (1984), who investigated nymphs from an alpine stream at approximately 1000 m in Austria, con-

firmed a yearly cycle in *B. alpinus*. He found three peaks of emergence but did not find essential differences between the individual sizes of each group. In the Saane and Turbach rivers (the Bernese Alps), *B. alpinus* exhibited a bivoltine cycle with overwintering nymphs that emerged in spring and early summer, and a summer generation that emerged in late summer and early autumn (Breitenmoser–Würsten & Sartori, 1995). The temperature of the Saane was higher in winter but lower in summer compared with the Turbach. In the Turbach, *B. alpinus* had a less extended flight period than in the Saane. In the Terebowiec stream, the flight period was also less extended than in the Wołosatka (Figure 3). Humpesch (1979) described a univoltine cycle of *B. alpinus* from an altitude of 1355 m., and a bivoltine cycle with a winter generation from an altitude of 615 m. In a torrential pyrenean stream (altitude 2190 m), Lavandier (1988) described a semivoltine life cycle for *B. alpinus*.

B. melanonyx had summer cycles with one generation at both our stations. The life cycle of this species has been rarely investigated. According to Müller-Liebenau (1969), it has a summer cycle with one generation. This was confirmed by Sowa (1975), who found a single yearly generation in the Olszowy stream.

Acknowledgments

The author thanks his mentor, the late Prof. Ryszard Sowa from the Department of Hydrobiology of the Jagiellonian University in Kraków as well as the workers of the Bieszczady National Park, and particularly Tomasz Winnicki M.Sc., who helped him with sampling.

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