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The effect of Drought on the Fauna *Ephemeroptera, Plecoptera* and *Trichoptera* of a Mountain Stream

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Streams of the Tatra mountains are characterised by swift current, caused by large falls in level, e. g. for Roztoka Stream 100‰, and low water temperature e. g. yearly average for the Kościeliski Stream was 4,46°C in 1950 (according to I. Gieysztor's unpublished data-see M. Gieysztor 1955). Both these factors are the cause of considerable oxygen content of the water and the continous transport of materials with the flow of water. On the whole, streams of the Tatra mountains are not very vide (to 15 m.), or deep (average to 50 cm.). The shallowness of these streams results in considerable variations in the water level, which become more marked the smaller the stream. The considerable flux in the water level is observed to be not only seasonal but also diurnal. The variations in the water level are accompanied by changes in the bottom configuration and the shape of the shore linie. In extreme cases they lead to the drying up of some parts of the channel and even the whole stream.

In the year 1956/57 during studies on the *Ephemeroptera, Plecoptera* and *Trichoptera* fauna of the streams of the Tatra mountains attention was drawn to the influence of variations in the flow of water, drying up and freezing to the bottom, on the occurence and distribution of stream fauna. The terrain first observed consisted of small rivulets, affluents of the streams Olczyski and Roztoka. In July 1957, in order to corroborate the observations made on these streams, more systematic work was started on the stream Świński, an affluent of the Olczyski, from the 7th of July to 1st August.

The 7th to the 9th July were the last three days of a long period of high temperatures and very sparse rainfall. However, from the 9th to the 29th July was a period of continuous rainfall. On the 29th of July the rain stopped. At the beginning of the period of study a plan of the Świński stream was drawn up of scale 1:5000 (fig. 1). It was established that during

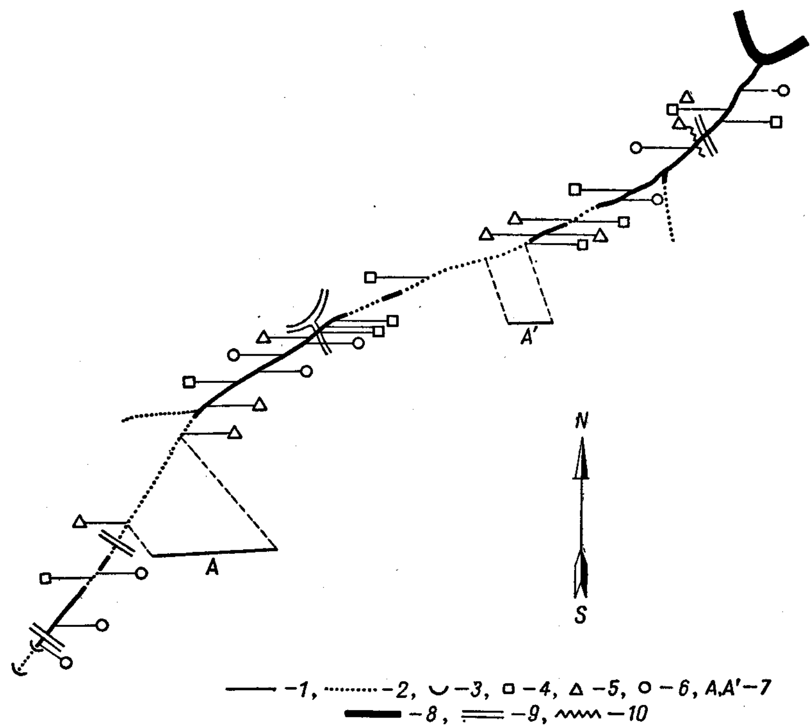


Fig. 1. Plan of the Świński stream according to the water level on the 7th August 1957.

1 — sections of the stream with running water; 2 — sections of dry channel; 3 — sources of stream; 4 — quantitative samples from stony milieu; 5 — quantitative samples from stagnant milieu; 6 — quantitative samples from mossy milieu; 7 — sections which after the period of rainfall, dried up again; 8 — stream Olczyski; 9 — road; 10 — station where measurements of flow were taken

a period of drought the stream bed is not devoid of water for its whole length. Sections with flowing water are separated by stretches of dried up channel. In the upper stretches of the stream rheocrenes occur. On the 7th do the 9th of July water from the bed was observed to disappear. Sections with a dry bed considerably increased in size. Thus, for example, one stretch of the dry bed of the rivulet measured 20 m. on the 7th July, 38.5 m. on the 8th July and 40.5 m. on the 9th July. On the days 10th to 19th July however, water was observed to collect in the rivulet. As a result of rainfall, the dry stretches of bed gradually become smaller and on them there arose small isolated pools. Two such pools were observed. The dimensions of the surface area of the water changed as follows: Pool I — day 8th July dimensions of surface area of the water 38×26 cm., 11th July — 40×26 cm., 12th July — 55×30 cm.; Pool II — 8th July 35×25 cm., 11th July 37×26 cm., 12th July 39×29 cm. After the 12th July a third pool was formed (dimensions 20×15 cm.) and from the 17th July in place of the separate pools there was a uniform stream of water 1.5 m in width. From the 17th July to the 29th July the stream flowed its whole length, its width varying from 1—2.5 m. On the 1st August stretches of dry bed started to appear afresh. They appeared in the same places where the stream was dried up previously (fig. 1). Rivulets, therefore, always lose their water in the same places. This is corroborated by observations made in other rivulets in 1956 and 1957.

At the same time observations were also made on the fluctuations in the water level of the Olczyski stream. Measurements and calculations of the flow of water in both streams were performed, taking 15 measurements at selected points which were stable for each stream. Tables I and II give some of the data from these measurements: shape of the cross sections, (bathymetry), surface of cross section, flow (according Biuletyn Geograficzny.1954) maximum depth, surface current velocity and daily rainfall

Table I

Variations in water level of the stream Olczyski depending on rainfall

Date	Rainfall in mm.	Cross-section in $dcm.^2$	Flow in litr/sec.	Maximum depth in cm.	Surface velocity of current m./sec.
8.VII	0.5	126	546.0	27	0.59
9.VII	0.0	134	861.2	30	0.76
11.VII	0.8	105	658.6	27	0.73
12.VII	14.2	114	762.1	30	0.78
17.VII	3.8	211	1848.0	48	1.03
18.VII	0.0	190	1507.0	40	0.93
19.VII	—	157	1147.0	30	0.86
20.VII	2.7	121	818.1	33	0.79
22.VII	12.5	130	822.9	33	0.74
25.VII	1.7	166	1175.8	40	0.83
26.VII	1.8	160	1046.1	35	0.76
27.VII	6.3	151	898.5	35	0.70
28.VII	0.0	160	1379.7	30	1.01
29.VII	—	138	873.5	30	0.74
1.VIII	—	130	1268.0	30	1.14

in mm for Zakopane. The magnitude of the flow of water in the Olczyski and Świński streams varied with the amount of rainfall (tables I and II). After rainfall the flow increases. Fig. 2 illustrates the ratio of the flow on a given day in the period studied to the minimal flow in this period which is taken as 1. From this curve, it can be seen that the flow in the Świński

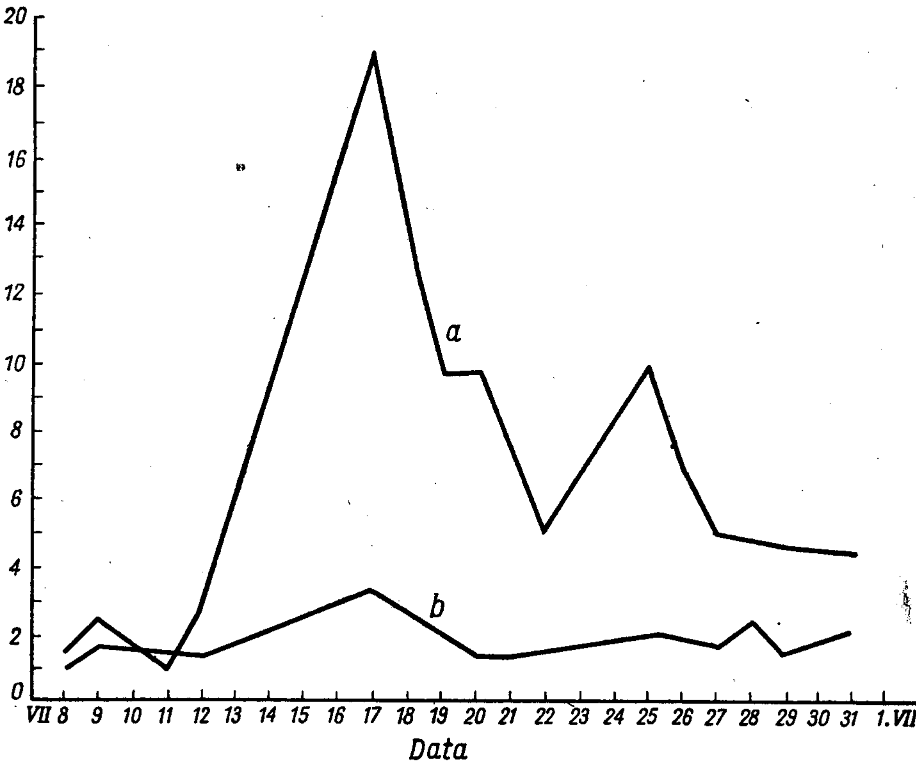
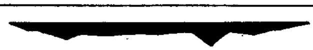
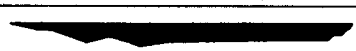
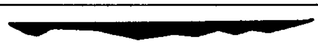
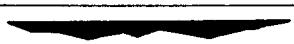
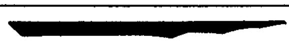


Fig. 2. Ratio of flow on a given day to minimal flow taken as 1 in the period under study
a — Świński stream; *b* — Olczyski stream

stream has a greater amplitude of variation that the Olczyski stream. This corroborates our observations that small streams are less stable than large ones. Comparing the average flow of the Olczyski stream, with the average for the Świński stream it is seen that the average flow of the Olczyski stream was, in July 1957, 138 times greater than in the Świński stream. During high rainfall changes in bottom configuration were observed. These changes are caused by the amplitude of variation of the flow and the type of bottom. Considerable changes in the bottom configuration were seen in small streams e. g. Świński (table II). It was observed that flow of water in streams, both large and small, reacts to rainfall with a delay of one day.

Table II

Variations in water Level of the stream Swiński depending on rainfall						
Date	Rain-fall in mm.	Cross-section of Świński stream skale 1:10	Cross-section in dcm².	Flow in litr/sec.	Maximum depth in cm.	Surface velocity of current m./sec.
8.VII	0,5		0,62	1,57	2,5	0,29
9.VII	0,0		0,70	2,76	2,4	0,46
11.VII	0,8		0,50	1,15	2,0	0,29
12.VII	14,2		0,70	3,17	2,5	0,53
17.VII	3,8		4,25	22,02	7,5	0,61
18.VII	0,0		3,31	14,07	6,5	0,50
19.VII	-		2,52	11,15	50	0,52
20.VII	2,7		2,49	11,26	5,0	0,53
22.VII	12,5		1,79	5,94	5,5	0,39
25.VII	1,7		2,62	11,36	4,5	0,51
26.VII	18		1,70	8,03	3,0	0,55
27.VII	6,3		1,31	5,68	3,0	0,51
28.VII	0,0		1,30	5,68	3,0	0,51
29.VII	-		1,40	5,41	3,0	0,45
1.VIII	-		1,38	5,15	3,0	0,44

Ephemeroptera and Trichoptera larvae were collected quantitatively from the Świński stream and the following percentage composition of species were found.

Ephemeroptera	percentage
1. *Ecdyonurus subalpinus* K. (only imagines)	—
2. *Ecdyonurus venosus* Fabr.	1,7
3. *Rhitrogena semicolorata* Curt.	74,5
4. *Ameletus inopinatus* Eaton	5,1
5. *Baëtis carpathica* Mort.	17,0
6. *Baëtis bioculatus* L.	1,7
7. *Habroleptoides modesta* Hag.*	—

[In the identification of *Ephemeroptera* use was made of the following papers: Handlirsch (1926—30), Kimmins (1950), Lestage (1916, 1919), Macan (1950), Mikulski (1936).]

Trichoptera	percentage
1. *Rhyacophila septentrionis* McL.	2,0
2. *Rhyacophila tristis* Pict.	2,0
3. *Rhycophila philopotamiodes* McL.	2,0
4. *Plectrocnemia conspersa* Curt.*	—
5. *Stenophylax rotundipennis* Bran.	2,0
6. *Halesus* sp.	2,0
7. *Chaetopteryx villosa* Fabr.	57,0
8. *Metanoea flavipennis* Pict.	6,0
9. *Drusus discolor* Ramb.	9,0
10. *Apatania* sp.	14,0
11. *Lithax niger* Hag.	2,0
12. *Sericostoma personatum* Spen.	2,0

[In the identification of *Trichoptera* use was made of the paper of Meyer Ulmer (1909)]

As a result of the loss of water in the stream, a considerable increase in the density of the larvae of insects was observed in the pools which were forming. With the further loss of water the fauna of the pools gradually disappeared. The last representatives of the insects larvae surviving in the disappearing pools were caddis flies.

Table III

Influence of drought on fauna of Świński stream. Comparison of the number of specimens of *Plecoptera*, *Ephemeroptera* and *Trichoptera* per unit of surface

Stony environment				Stagnant depths			
Flowing stream		Drying — up stream		Flowing stream		Drying — up stream	
No of sample	No of specimens per m.²	No of sample	No of specimens per m².	No of sample	No of specimens per m².	No of sample	No of specimens per m².
235	114	237	44	245	5	248	10
236	127	238	0	246	2	252	0
240	180	239	0	247	4	253	0
241	89	244	0	249	1	254	0
242	134			250	20		
243	37			251	3		

* Does not occur in the quantitative samples, found in the stream from time to time.

After the whole channel fills up with water in consequence of rainfall the only representatives of the examined insects groups, occuring in the sections which periodically dry up, are caddis flies. However, they also rarely invade these areas. Table III give the numbers of specimens collected in specific milieu of the stream, on stretches with water and stretches which periodically dry up. Those which periodically dry up show a differentiation into only two types of milieu: a-stony bed and shallow water, b-stagnant deep water. A mossy milieu which occurs in sections with continually flowing water was absent. In all samples from sections which were drying up, only one species of caddis fly was found, *Chaetopteryx villosa*. This species was usually collected in large numbers in the bed depressions of small streams and in the stagnant regions of larges streams and thus always in calm water.

A quantitative analysis of the caddis fly fauna showed that the species *Chaetopteryx villosa* representing 57% of the collected specimens, dominates in Świński stream. In the Olczyski stream this same species represents 6% of all the larvae collected. Species representing a large proportion of the fauna of the Olczyski stream like *Metanoea flavipennis* (48%) and *Drusus discolor* (33%), in the Świński stream only represent 6% in the first case and 9% in the latter. Similarly, of the *Ephemeroptera*, the species *Rhitrogena semicolorata* (mean current velocity in which this species is found is 0.43 m/sec.) which shows a weak positive rheotaxis, dominates in the Świński stream (74.5%) whereas in the Olczyski it appears in smaller numbers (27%) giving way to *Baëtis carpathica* (73%) which exhibits a stronger positive rheotaxis. Such a differant frequency of the same species in large (Olczyski stream) and in small (Świński) streams, as it seems, is the result of much larger fluctuations in the water level in the case of small streams than in large ones. These fluctuations promote the creation, in small streams, of large sections with calm water and sections which are drying up.

In small streams, less species are met with than in large streams e. g. in Świński rivulet—12 species, in Olczyski—19. At the same time a smaller density of fauna was found for small streams. Specimens number per 1 m^2. in the small (Świński) and large (Olczyski) streams was as follows:

	Olczyski Stream	Świński Stream
Plecoptera	1192	57
Ephemeroptera	66,5	21
Trichoptera	866,5	312

The characteristics of small streams mentioned above, influence the species composition of the fauna, causing the elimination of some of the species which are living in large streams, and also influence the quantitative relations and the density of fauna in the stream.

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