ARIES CATCHMENT UPPER AND MIDDLE COURSE SMALL STREAMS SEASONAL RUNOFF REGIME CHARACTERISTICS

V.SOROCOVSCHI[1], G. PANDI[2], R. BĂTINAŞ[3]. CS. HORVATH[4]

ABSTRACT. – Aries catchment upper and middle course small streams seasonal runoff regime characteristics. The study is based on the processing and interpreting data from 16 gauging stations, of which 10 control catchments smaller than 150 km^2 and so reflects more faithfully the local characteristics of the runoff. To highlight the runoff regime features during the year we selected three periods (1950-1967, 1950-2009 and 1970-2009). The geographical features of the central eastern part of the Apuseni Mountains, especially the climatic and geomorphic characteristics, are faithfully reflected in the rivers runoff regime. So, on all rivers the dominant is the spring runoff and the lowest percentage of the total annual average water volume is measured in the winter. Distribution and frequency of the richest (March, April and May) and the poorest (January, February, August and September) average runoff months vary according to the catchments altitude. The multiannual seasonal and monthly variation of the runoff was highlighted by the coefficients of variation. The study reveals that the rhythmic structure of the runoff regime reflects the local supply, the geological conditions and the reliefs morphological and morphometric characteristics.

Keywords: Arieş River, seasonal runoff regime, coefficients of variation,

1. INTRODUCTION

Arieş is the largest right tributary of the Mureş River, an important hydrographical axis of the Apuseni Mountains central eastern part, crossing it from west to east and intersecting several depressions in the upper (Arieşeni, Gârda, Albac and Avram Iancu) and middle (Câmpeni, Bistra, Lupşa, Sălciua) catchment. Together with its tributaries, from the bordering mountainous areas, forms a catchment with a strong left asymmetry covering an area of 3.005 km^2.

The studied region is distinguished from other areas of the Apuseni Mountains by its geographic location, but also by the morpho-structural and bio-pedo-climatic complexity. The landscapes diversity correlates well with the geological formation. At the eastern edge of the catchment, corresponding to the

[1] Babeş-Bolyai University, Faculty of Geography, 400006 Cluj-Napoca, Romania e-mail:svictor@geografie.ubbcluj.ro
[2] Babeş-Bolyai University, Faculty of Geography, 400006 Cluj-Napoca, Romania e-mail:pandi@geografie.ubbcluj.ro
[3] Babeş-Bolyai University, Faculty of Geography, 400006 Cluj-Napoca, Romania e-mail:rbatinas@geografie.ubbcluj.ro
[4] Babeş-Bolyai University, Faculty of Geography, 400006 Cluj-Napoca, Romania e-mail:hcsaba@gmail.com

Bihor Mountains, the altitude remains generally between 1500 and 1800 m, decreasing from north to south (below 1500 m on Mount Găina). In the Muntele Mare massif the landscape altitude is also high (1500-1800), decreasing generally from west to east. The mountain area, on the right of the Arieş River formed by the Metaliferi and Trascău Mountains, present much lower altitudes, which rarely exceed 1400 m.

The spatial position regarding the high Bihor Mountains and the landscape altitude defines the air circulation types and the distribution of the main climatic elements, which manifests itself in the characteristics of the landscape and the runoff regime, with obvious contrasts between the western and eastern slopes, which are in a "rain shadow".

The rich hydrographic network favored the landscape fragmentation. The presence of large intermountain depressions and river corridors, also the valleys and low saddles, reduce the massiveness of this mountain area and creates a remarkable diversity of climatic characteristics and runoff regime types. Thus, the annual amounts of precipitation are maintained between 1000 and 1400 mm on the higher altitudes (above 1300 m) of the Bihor and Muntele Mare Mountains (Bătinaş, 2010). To the east, the rainfall reduces to 850-600 mm together with the altitude decrease, the lower areas temperature inversions and the foehn processes.

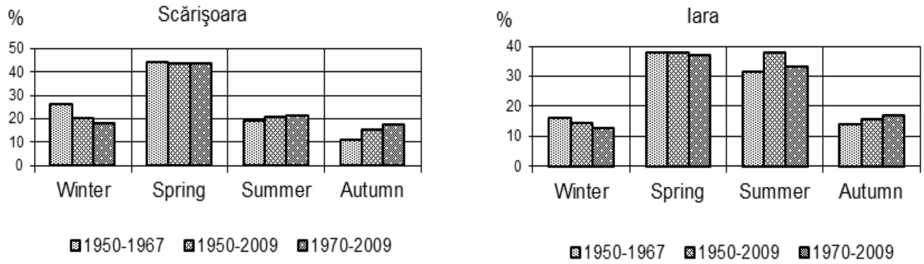

Fig.1. ***Seasonal runoff rates in the chosen study periods***

For the study we processed and interpreted data from 16 representative gauging stations of the region (Table 1), of which ten monitors runoff in river basins which are under 150 km^2. We chose three periods: one long (1950-2009) and two short (1950-1967 and 1970-2009). Analyzing the seasonal runoff percentage from the average annual volume on the three periods we observe that during the 1950-2009 period the winter runoff decreased, while the autumn runoff increased (Fig. 1). The spring runoff percentage values remained the highest through all the periods. In the summer runoff appear significant territorial differences, in the upper basin of Arieş the summer runoff values increased slightly in the 1950-2009 period while the Iara basin vary .

2. SEASONAL RUNOFF REGIME

The seasonal variation of runoff is determined by the basic characteristics of the climatic elements and is one of the dominant features of the studied rivers.

On most rivers the dominant runoff is during spring and the lowest quantity of the average annual water volume is measured in autumn and winter (Table 1).

2.1. Spatial and temporal variation of the seasonal runoff

The gauging stations data analysis and the correlation between the values of the season runoff and the correspondent basin main elevation showed that the seasonal distribution of Aries River runoff is closely dependent on climatic conditions and the other physical and geographical factors influence has only a local character.

Table 1. ***Seasonal runoff percentage values (1970 – 2009)***

Hydrometric station	Q (m^3/s)	Annual runoff percentage			
		Winter	Spring	Summer	Autumn
Scărişoara	5.728	17.9	43.6	21.2	17.3
Albac	7.928	18.4	43.7	21.4	16.5
Câmpeni	13.201	19.4	44.1	20.6	15.8
Baia de Arieş	19.961	20.2	42.6	21.6	15.6
Buru	24.100	19.4	43.0	22.2	15.5
Albac	1.728	17.8	42.7	23.7	15.8
Vadu Moţilor	0.845	22.8	45.4	15.7	16.0
Ponorel	3.37	19.5	44.2	19.8	16.4
Abrud	1.405	21.9	42.3	22.4	13.5
Câmpeni	3.04	22.4	42.7	21.1	13.9
Bistra	1.89	14.3	37.5	29.4	18.8
Poşaga	1.236	11	38.9	32.3	17.9
Ocoliş	0.532	15.5	34.9	33.2	16.3
Budureasa	1.036	11	38.9	32.3	17.9
Valea Ierii	1.156	11.9	34.8	34.2	19.1
Iara	1.628	12.6	36.9	33.3	17.1

In the ***winter*** (XII - II), the territorial distribution of the runoff is influenced largely by the amounts of precipitation (in smaller part liquid) and the thermal regime. The negative temperatures preserve the snow, froze the rivers and retain large amounts of the water circle. At the same time the western and south-western climate influences, manifested by periods with positive temperatures and liquid precipitations, are significantly reduced than on the western slopes of the Apuseni Mountains. So the seasonal runoff regional differences are determined by the catchments altitude and their exposure to the air masses advection from the west and southwest. Thus, the lowest winter runoff (10-15% of the annual average) is recorded on the streams that drain the Muntele Mare area (Valea Mare, Poşaga, Ocoliş and Iara).

The average altitude of the mentioned river catchments are higher (between 1100 and 1900 m), which determines the high frequency of negative temperatures, and also reduces the supply possibilities of the rivers from snow melting. Intermediate values between 16 and 20% of the average annual volume are meet on streams in the upper catchment of the Aries River (except the Neagra stream).

The highest winter runoff (20-25% of the annual average) is recorded on the right tributaries of the Arieş River, which drains a mountain area with lower altitudes and with a more favorable exposure to the western air masses advection.

Following the winter runoff multiannual variation we observe that the highest values were registered in different years: in 1976/1977 on the Arieşul

Mare; 1978/1979 on Arieşul Mare and Abrud, 1982 Ocoliş and Poşaga. In those winters there were weather conditions that favored liquid precipitation and supply from melting snow. Similar situations occurred in the winter of 1995/1996 on

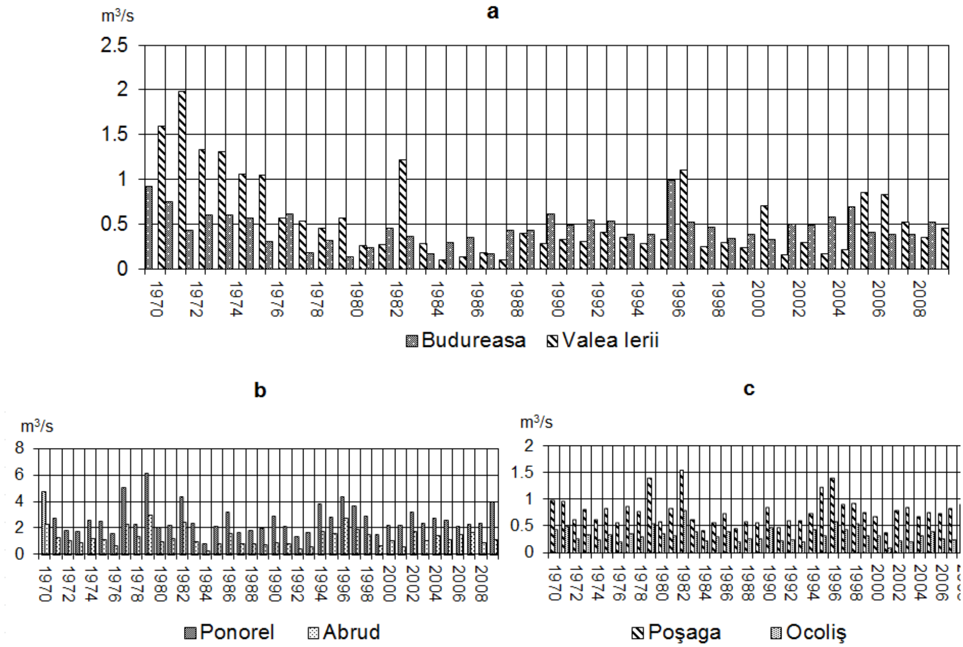

Fig.2. ***Multiannual winter runoff variation at different gauging stations***

Valea Mare and in the Iara River upper catchment, also in 1969/1870 and 1970/1971 in the middle and lower catchment (Fig. 2).

.The smallest runoff values were recorded in the winter of 1983/1984, characterized by a persistent anticyclonic regime with low temperatures and precipitations, which frost most of the water in rivers and retain it in solid form.

Spring (III - V) represents on all the rivers the season with the richest runoff, this is due to the snow melt, the relatively high amounts of precipitation, the low evapotranspiration values and the low infiltration in the saturated or partially frozen soil. Together with the airs positive temperature starts gradually the snow melting phenomenon which is reflected in the spring high waters. Depending on the rate of melting, the duration and intensity of precipitations, spring floods may occur, caused by melting snow, precipitations or overlaying's of the two phenomena.

In this season the average volume of runoff is high, accounting for 34.8% (Iara at Valea Ierii) and 45.4% (Neagra at Vadu Moţilor) of the annual average volume. Spring runoff has a slight and relatively uniform increase vertically. The values are higher in the Aries upper basin (43-45%) and the Metaliferi and Trascău Mountains (42-43%). Nuances are dictated by differences in altitude and catchment exposure in the two regions.

Lowest values between 25 and 40% are recorded on Muntele Mare, where the katabatic circulations effects are felt.

On most rivers in the region the highest spring runoff occurred in 2006, except for those that drain Muntele Mare, where the spring maximum was recorded in different years: 2005 in Ocoliş and Poşaga, 1970 in the Iara basin.

In the mentioned years the long frontal rains with high enough intensity generated large quantities of water, which flowed at a rate of 80-85% due to the substrate high humidity.

The lowest values of the spring runoff occurred also in different years: 1973 in the upper basin of Aries, 1992 at Bistra and Poşaga, 2002 at Abrud and Ocoliş, 1979, 2003 and 1994 in the Iara basin.

Summer (VI - VIII) the precipitation decrease, the temperature rise and the vegetation development leads to increased evapotranspiration. This phenomenon, together with the increased infiltration is reflected in the significant decrease of runoff. At the low summer waters contribute also the reduced groundwater supply. Following heavy convective precipitations and rarely frontal rains, there are summer floods, which sometimes can reach very high amplitudes and produce flooding as in June 1970, June 1974, July 1980, etc..

Table.2. ***Summer and autumn runoff data.***

River .	Hydrometric station	Qv (m^3/s)	C_v	Summer		Qt (m^3/s)	Cv	Autumn	
				Year Max.	Year Min.			Year Max.	Year Min.
Ariesu Mic	Ponorel	2.664	0.54	1974	2003	2.212	0.53	2002	1983
Albac	Albac	1.633	0.41	2006	1993	1.091	0.42	2002	1987
Abrud	Abrud	1.255	0.58	1975	2000	0.759	0.62	1972	2000
Abrud	Câmpeni	2.560	0.59	1975	2000	1.682	0.67	1996	2000
Valea Mare	Bistra	1.711	0.33	1980	1983	1.097	0.36	1998	1983
Ocolis	Ocolis	0.747	0.57	2005	2000	0.347	0.38	1972	2000
Posaga	Posaga	1.485	0.37	2005	2000	0.856	0.32	1972	2000
Iara	Budureasa	1.338	0.43	1973	1993	0.739	0.45	1972	1979
Iara	Valea Ierii	1.580	0.95	2005	1994	0.883	0.98	1972	2000
Iara	Iara	2.170	0.98	2005	1994	1.116	0.81	1972	1983

Summer represents between 15.7% (Vadu Stone) and 34.2% (Budureasa) of the average annual flow. The smallest recorded summer runoff values are in Ariesul Mic Basin, between 15 and 20% of the average yearly volume. Compared to the previous season the runoff decrease is considerable (24-30%) and is explained by the relatively small quantities of precipitation and the fast depletion of snow reserves by the spring high waters. Somewhat higher summer runoff values are recorded at Abrud (between 21 and 15%) and at Valea Mare (between 26 and 30%), and the largest values between 31 and 35%, close to the spring runoff, are recorded in the Iara catchment (Table 2).

The lowest summer values occurred in 2000 and 1993 in the upper basin of Aries, 2000 at Abrud, 1993 and 1994 in the Iara catchment. In those summers there were over 20 days without precipitation, causing many streams with small basin areas to drain.

In ***autumn*** (IX-XI), following the temperature the evaporation decreases, there are autumn precipitations but the underground reserves are exhausted so the infiltration is high. As a result at the beginning of this season the runoff regime registers the low autumn water period. Late autumn floods may occur caused by persistent rains.

Autumn is the season with the lowest contribution to the average annual volume (13.5% - 17.9%), although the amounts of precipitation are almost double than those in winter. In autumn the runoff distributions shows an obvious contrasts caused by the spatial variety of climatic conditions. Thus, the autumn runoff values remain between 13 and 16.5% in the Abrud lower catchment and Aries upper basin, also at 16.5 and 18% on the Muntele Mare streams. On most rivers the highest autumn runoff occurred in 1972 and lowest in 1983 and 2000 (Table 2).

Seasonal runoff distribution types were determined by sequencing seasons in decreasing order of their annual flow contribution, not taking into account the spring which annual runoff is predominant in all the rivers of the studied region. Using this criterion we found that in most rivers the dominant type is S.W.A. (Summer-Winter-Autumn). In case of these rivers the highest seasonal runoff after spring occurs in summer and lowest in autumn. Type W.S.A. is only specific to a small area corresponding to the Neagra and Abrud river catchments. There is also a subtype of transition between the two mentioned runoff regime types it is characteristic to Arieşului Mic and Abrud rivers upper basin, here the summer runoff slightly exceeds that of winter, with 0.3 to 0.5%.

2.2. Seasonal runoff trends and oscillations

The runoff's Time variation can be revealed by calculating the data coefficient of variation. By analyzing the seasonal variation coefficient we found that the highest values correspond to the autumn (0.36 to 0.62) and summer (0.37 to 0.98) seasons (Fig. 3). The lower spring and winter values of the coefficient reflect a more uniform character of the runoff distribution (Fig. 3).

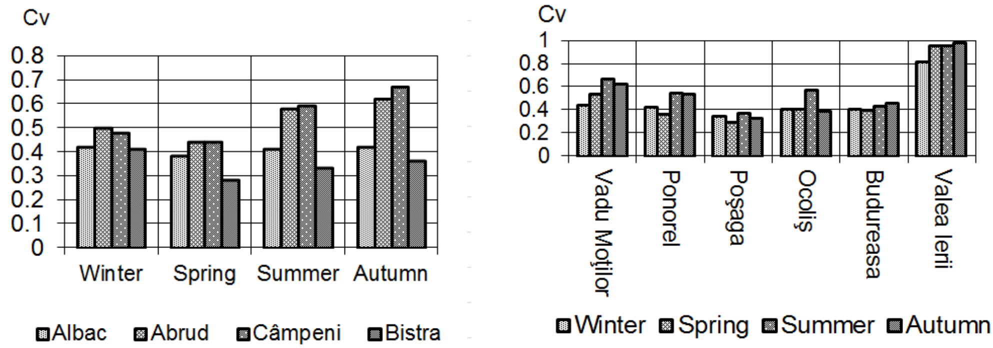

Fig.3. ***Seasonal variation coefficients at the studied gauging stations.***

Instead in the summer and autumn, the coefficients of variation are highest and the regional differences are more pronounced. Thus appear quite obvious contrasts between the rivers of the western, southern and eastern slopes of the Muntele Mare Mountains (Bistra, Ocoliş, Poşaga and Iara) and those in the upper basin of the Aries River (Arieşul Mare and Arieşul Mic). An intermediate situation appears in the rivers that drain the Metaliferi and Trascău Mountains. In the study period, between 1970 and 2009, there were various trend directions in the runoff caused by natural and anthropogenic factors.

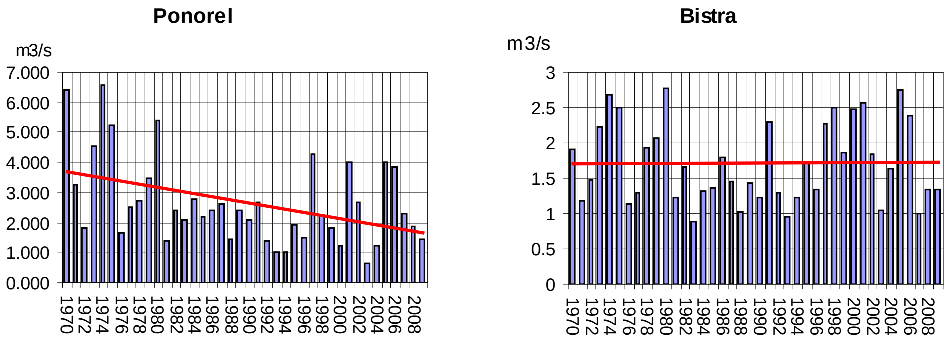

Fig.4. ***Variation and trend of the summer runoff at Ponorel and Bistra gauging stations***

In winter, in the Ariesul Mic, Ocoliş and Abrud catchments there is a slight downward trend and on the Arieşul Mare and Valea Mare a moderate growth trend of the runoff. Stationary evolution was revealed at Poşaga and Iara upper basin.

Table 3. ***Seasonal runoff trends***

River	Hydrometric station	winter	Spring	Summer	Autumn
Ariesu Mic	Ponorel	Ds	St	Da	Is
Albac	Albac	Is	St	Ds	St
Abrud	Abrud	Ds	Is	Ds	St
Abrud	Câmpeni	St	Is	Ds	St
Valea Mare	Bistra	Is	Is	St	Is
Ocolis	Ocolis	Ds	St	St	Du
Posaga	Posaga	St	Is	St	St
Iara	Budureasa	St	Ds	Ds	St
Iara	Valea Ierii	Da	Da	Da	Da
St- stationary					
Increase	*Is - small* *Ia - accentuated*		*Decrease*	*Ds - small* *Da- accentuated*	

Spring trend show's a slight increase on Poşaga, Bistra and Abrud and on the other rivers remained stationary (Table 3). Summertime, the runoff evolution in the analyzed period was stationary on Bistra, Ocoliş and Poşaga (Fig. 4.) and showed a moderate decrease at Albac, Abrud, upper Iara chatchment and an accentuated decrease on the Ariesul Mic.

In the autumn the runoff trend was stationary on the Ariesul Mic, Abrud and on the upper basin of the Iara River and showed a moderate increase on Albac and Bistra (Table 3).

The anthropogenic influence on the runoff evolution is manifested strongly in the seasonal regime of the middle and lower basin of the Iara River where in all seasons there was a sharp decline due to the upper basin's water abstractions.

CONCLUSIONS

The Arieş catchment represents an area with a large variety of genetic runoff factors. As a result, the seasonal runoff regime features manifest very differently in space and so we were able to define several areas with specific characteristics, mainly conditioned by natural factors but also by anthropogenic. Their analysis in conjunction with the particular runoff regime allowed the identification of several areas where the regime manifests itself differently. Thus are different the Arieşul Mare from the Arieşul Mic and Abrud catchments. Also there are quite obvious contrasts between the rivers with catchments that developed on the southern and northern or western and eastern slope of the Muntele Mare Mountain. In the middle and lower catchment of the Iara River the anthropogenic influences are felt due to the water abstraction in the upper basin.

REFERENCES

1. Arghiuş, V. (2008), *Studiul viiturilor de pe cursurile de apă din estul Munţilor Apuseni şi risurile asociate*. Edit. Casa Cărţii de Ştiinţă, Cluj-Napoca.
2. Bătinaş, R. H.(2010), *Studiul calităţii apelor de suprafaţă din bazinul Arieşului*, Edit. Presa Universitară Clujeană, Cluj-Napoca.
3. Diaconu C., Şeban P. (1994), *Sinteze şi regionalizări hidrologice,* Ed.Tehnică, Bucureşti.
4. Iacob, Ersilia, (1965*), Consideraţii asupra bilanţului hidrologic din Munţii Apuseni,* SUBB, f. 2, Cluj_napoca.
5. Sorocovschi, V., Pandi, G. (2012) *Particularities of seasonal and monthly flowing regime on the small rivers of Maramureş Mountains*. In Water resources and wetlands, Conference Procceedings 14-16 september 2012, Tulcea-Romania, Editor Petre Găştescu, Wiliam Lewis Jr, Petre Breţcan, Edit. Transversal, Târgovişte, p.39-47.
6. Ujvari, I. (1972*), Geografia apelor României*. Editura Ştiinţifică, Bucureşti
7. * * *(1971), *Râurile României.*