RESEARCHES WITH RESPECT TO THE FREQUENCY DISTRIBUTION OF THE BEHAVIORAL EVENTS ASSOCIATED TO THE COMPONENT PARTS OF A TRANSVERSE HYDROTECHNICAL WORK

I.C. PETRIȚAN[1] **I. CLINCIU**[1]

Abstract: *The paper includes the manner of classification of the behavioural events associated to the component parts of a transverse hydrotechnical work, as well as the statistic study upon the distribution of these events. What could be enhanced is the existence of a cluster of 7 behavioral events, associated to the 20 component parts of a transverse work, as well as the flexible character of three theoretical distributions (normal, Charlier type A and Beta) used in fitting the experimental distribution.*

Key words: *transverse hydrotechnical work, frequency of the behavioral events, fitting of the distribution.*

1. Introduction

The promotion of a multifunctional, sustainable and competitive forest management, in the context of preventing the environment deterioration through anatropous activities, implies the monitoring of the organized drained basins in the forest zone of the country, the maintenance of the works carried out within these basins, the restoration of the works damaged by the torrential floods and the reassurance of the systems they belong to [6].

Unfortunately - even nowadays - a deficit of preoccupation in this respect has been persisting, and this situation occurs not only because of the lack of interest of the forest units towards this issue, or because of the lack of allotment of the necessary financial resources, but also because of the lack of a coherent system of scientific knowledge, that should substantiate the mentioned actions, insofar as the damages/disfunctionalities noted at the works on the arranged network of the drained hydrographical basins have, as the floods which bring them about, a powerful probabilistic character [2].

Therefore we consider that only a substantially organized scientific research deeply anchored in the concepts and in the methods of the mathematical statistics may lead to the genuine knowledge upon the damages/disfunctionalities noted during the exploitation period of the torrent organization works, only this way the future interventions on emergencies may be set as priorities, and only this way there may be opened the path towards the conceptual re-thinking, towards the completion and the perfection of the current technical standards and norms [3].

[1] Dept. of Forest Management, *Transilvania* University of Braşov.

2. Material and Research Method

The present work attempts such an approach starting from the experimental data accumulated during the period 2002-2004, on the occasion of accomplishing the research project *"Didactical-experimental valences, the behavior in exploitation and the effects of the works of arranging the torrential hydrographical network within the superior basin of Tărlung (upstream the accumulation Săcele)"* (grant CNCSIS-type A; director: prof. dr. eng. Ioan Clinciu).

For every one of the 100 transverse works existing on the arranged torrential network in the superior basin of Tărlung, there were recordings made on a typeset slip of the damages and the disfunctionalities that appeared during the functioning period of the works, since their execution up to the unfolding of the terrain phase of the research (year 2003) [4].

Within the category „damages" the following behavioral events were included: rifts, breakage, driving, deformations, degradations, weathering, decaster, infiltrations, undermining of the work body, undermining of the apron, suffusion.

Within the category of disfunctionalities, there were included: obstruction of the spillway, obstruction of the energy dissipation teeth, clogging of the apron/alluvial deposit canal ± debris ± vegetation, uncontrolled installation of the forest vegetation upstream/downstream the works or even in the execution and functioning area of the works, the unfulfilment of the atteration, the washing of the atteration, the exceeding of the atteration slope, consequently the burial of certain parts of the works, the deepening of the bed downstream the work, the frontal strike of the bank by the water current, erosion (± land slip ± bank slide) of the bank in the areas of incaster. In this category some deficiencies caused by the execution or by the design were also included, such as the accomplishment only in part of several parts of the works (especially incaster, wings), unfulfilment of some earth fills (in the area body-wall guard-spur terminal-bank) or the lack of observance of the solutions in the project as regarding the nature or the quality of certain materials or of certain constructive dimensions (for instance in the case of the metallic grid from the unique barrage type rake on the Tărlung Valley).

There is to be noted that the mentioned behavioral events, in the ground phase of the researches, were in all cases associated to the component parts of the works. In the framework of this association, there were considered as distinct behavioral events, both those detected within the same component part, but which differ through their nature (rifts, breakage etc.), and those which are of the same nature but which were detected at different component parts (weathering at the body of the barrage, weathering at the guard wall etc.).

With the data referring to these events, centralized upon torrential valleys, the frequency distribution of the transverse hydrotechnical works on the torrential network from the superior basin of Tărlung could be made, the study variable being the number of behavioral events recorded during the functioning of the works.

The histogram of the experimental distribution of the number of behavioral events associated to the component parts of a transverse hydrotechnical work is the one presented in Figure 1.

From the analysis of this histogram, there can be noted that:

- 5 of the 100 works were affected by no behavioural event, whereas other 5 works were affected by a single behavioural event;
- for other 4 works, two behavioural events were noted;

...

- for a single work, 16 and respectively 17 behavioural events could be detected.

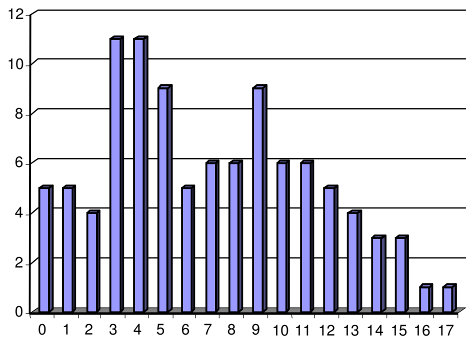


Fig. 1. *Histogram of the experimental distribution of the number of behavioral events recorded during the works of organization of the torrential hydrographical network from the superior basin of Tărlung*

3. Results and Discussions

The data resulting from the researches show that, at the works of arrangement of the torrential hydrographical network on the Tărlung Valley, during their exploitation, a high variability could be recorded with regard to the apparition and the manifestation of the behavioral events. There could be noted differences, both from one experimental valley to the other, and from one transverse work to another, within the same torrential valley.

In order to detect the laws that rule upon the phenomenon, the frequency distribution that had been found was searched both in the variant of non-grouping the frequencies on classes, and in the 4 variants of grouping the frequencies on class intervals.

In the case of all study variants, the values of the main statistic indicators were calculated and analyzed and fittings of the frequencies of the behavioral events identified according to three of the most known theoretical distributions (normal, Charlier type A and Beta) were carried out (see details in [1]).

3.1. The Main Statistic Indicators of the Distribution of the Number of Recorded Behavioral Events

For all 5 study variants, the following statistic indicators of the experimental distribution were determined and analyzed: the arithmetical average, the standard deviation, the variation coefficient, the non-homogeneity coefficient, the asymmetry index, the excess index.

The obtained results are centralized in Table 1.

On the basis of these data, the following may be noted:

- during the exploitation period of the 100 works under research, on average, a cluster of 7 behavioral events associated to the 20 component parts of a transverse work were recorded;
- the standard deviation is of 4 behavioral

Table 1

The values of the main statistic indicators of the distribution under research

Nr. crt.	Statistic indicator		Study variant				
			I	II	III	IV	V
			Non-grouped frequencies	Frequencies grouped on classes			
				***h* = 2**	***h* = 3**	***h* = 4**	***h* = 5**
1	Arithmetical average		6.94	7.40	7.03	6.52	6.90
2	Standard deviation		4.289	4.292	4.273	4.320	4.490
3	Variation coefficient		61.8	57.9	60.8	66.3	65.1
4	Homogeneity coefficient		0.21	0.11	0.19	0.29	0.27
5	Asymmetry index	A	0.299	0.307	0.350	0.307	0.453
		A / s_A	1.24	1.28	1.49	1.28	1.88
6	Excess index	E	–0.87	–0.91	–0.89	–0.85	–0.81
		E / s_E	1.83	1.89	1.84	1.77	1.69
Note: *h* signifies the value of the class interval							

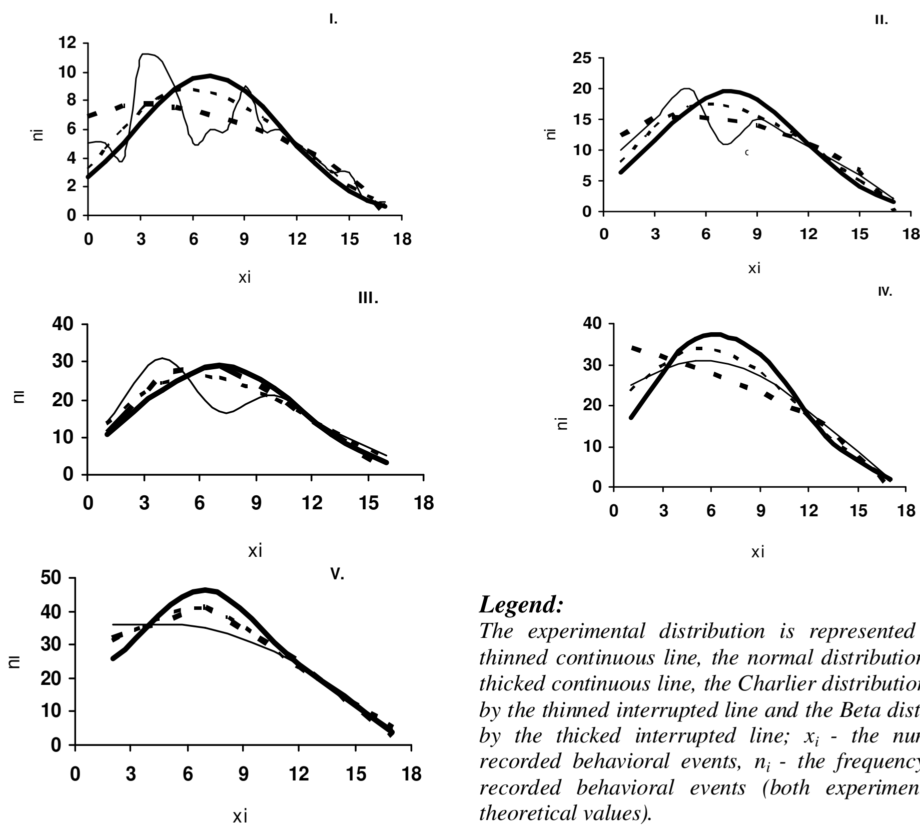
events and the variation coefficient is of about 60%, which proves that, for the case under study, the distribution of the behavioral events is strongly non-homogeneous [5];

- this distribution asserts itself through positive asymmetry (left-handed) and negative excess (platicurtic curve); the values of these two indicators are however not significant from the statistic point of view;

- following the frequency grouping upon classes, the values of none of the statistic indicators suffered essential modifications.

3.2. Fitting of the Frequency Distribution of the Number of Recorded Behavioral Events

Furthermore, the possibility of fitting the frequency distribution of the number of behavioral events recorded after 3 of the most known theoretical distributions: normal distribution, Charlier distribution type A, and beta distribution was investigated. Starting from the file of experimental frequencies and using the software *Statistica 7.1* [7], the



Legend:
The experimental distribution is represented by the thinned continuous line, the normal distribution by the thicked continuous line, the Charlier distribution type A by the thinned interrupted line and the Beta distribution by the thicked interrupted line; x_i - the number of recorded behavioral events, n_i - the frequency of the recorded behavioral events (both experimental and theoretical values).

Fig. 2. *Searched experimental distribution and its fitting according to three theoretical distributions, both in the variant of non-grouping of the frequencies on classes (I), and in the four variants of grouping the frequencies on classes (II…V)*

frequencies for all 5 variants of data grouping on classes and for all 3 mentioned distributions were determined (Figure 2).

For each case in particular, it was subsequently resorted to the application of the fitting test χ^2, a test on the basis of which it could be decided to what extent there is a concordance between the file of

Values of the test χ^2, for the distributions and variants under study Table 2

Variant	Experimental value of the test χ^2 for the distribution			Degrees of liberty for the distribution		Theoretical value of the test χ^2 for the distribution	
	Normal	Charlier-type A	Beta	Normal and Charlier-type A	Beta	Normal and Charlier-type A	Beta
I	12.95	9.91	8.65	16	15	26.29	24.9
II	9.22	3.49	3.38	7	6	14.06	12.59
III	10.13	5.45	11.01	4	3	9.48	7.8
IV	6.30	0.78	3.21	3	2	7.81	5.99
V	6.72	1.72	2.75	2	1	5.99	3.84

experimental frequencies, on the one hand, and the file of theoretical frequencies, on the other hand.

In settling the degrees of liberty, the number of classes was taken into consideration as well as the number of parameters of the theoretical distribution (a single one in the case of the normal distribution and of the Charlier distribution type A and two in the case of the Beta distribution). Therefore, the value χ^2 was separately specified for the normal and Charlier distribution type A and separately for the Beta distribution.

On the basis of the data in Table 2, the following conclusions could be formulated:

Variant I: the experimental distribution is successfully fitted after all 3 theoretical distributions, the best quality of the fitting being offered by the Beta distribution, followed by the Charlier distribution-type A and by the normal one.

Variant II: the experimental distribution is successfully fitted after all 3 theoretical distributions, the best quality of the fitting being likewise offered by the Beta distribution, followed by the Charlier distribution-type A and by the normal one; the quality of the fitting offered by the first two theoretical distributions being obviously better.

Variant III: the experimental distribution is successfully fitted only after Charlier.

Variant IV: the experimental distribution is successfully fitted after all 3 theoretical distributions, this time being the Charlier distribution-type A the one which offers the best quality of the fitting, followed by the Beta distribution and by the normal one.

Variant V: the experimental distribution is successfully fitted only after Charlier and Beta, the first ensuring a better quality of the fitting.

This way, Charlier distribution-type A successfully fits the experimental frequencies in all 5 cases, Beta distribution in 4 of 5 cases, and the normal distribution in 3 of 5 cases. We could say that the normality of the frequency distribution is statistically proved. At the same time, there was an enhancement of the fact that through raising the class interval, the frequency distribution of the number of recorded behavioral events goes off normality (excepting variant 4).

Comparing, from the point of view of fitting quality, the distributions Beta and Charlier-type A (recognized through their flexibility), we could note that the former occupies the first place for the variants I and II (which means for the frequencies which are not grouped upon classes or for the variant with the smallest class interval), whereas for higher values of the class interval, the distribution Charlier-type A is situated first.

4. Conclusions

The probabilistic character of the apparition of the damages/disfunctionalities noted at the works on the organized network of the drained hydrographical basins allowed us to use the instruments specific for the statistic-mathematical analysis in constituting and studying the distribution of the recorded behavioral events in view of detecting and characterizing the laws that rule upon the presented phenomenon.

On the basis of the information offered by the values of the statistic indicators used in characterizing the studied distribution, indicators determined both for the non-grouping variant, and for other four variants of grouping the values on frequency classes, the existence, during the exploitation period of the 100 works under research, of a cluster of 7 behavioral events associated to the 20 component parts of a transverse work could be highlighted as well as the strongly non-homogeneous character of the distribution of behavioral events, a character grasped by the high values of the variation coefficients. Despite this strong non-homogeneity, the values of asymmetry and excess indices remained insignificant. Following the frequency grouping on classes, the values of none of the statistic indicators suffered essential modifications.

At the same time, there was an analysis of the behavior of the initial distribution and of the four variants of grouping upon frequency classes during the action of fitting according to three theoretical distributions (normal, Charlier type A and Beta). Regarding this aspect, proof was presented that the distribution Charlier-type A successfully fits the experimental frequencies in all 5 cases, Beta distribution in 4 of 5 cases, and the normal distribution in 3 of 5 cases. Additionally, the fact that through raising the class interval, the frequency distribution of the number of recorded behavioral events goes off normality was highlighted (excepting the variant 4).

Eventually, through carrying out a comparative study of the Beta and Charlier-type A distributions (recognized through their flexibility), from the point of view of the fitting quality, we noted that the first occupies the first place for the variant with frequencies non-grouped on classes, or for the variant with the smallest class interval, while at higher values of the class interval, the first place is held by the Charlier-type A distribution.

References

1. Chiţea, Gh.: *Biostatistică forestieră* (*Forest Biostatistics*). Braşov. *Transilvania* University of Braşov, 2001.
2. Clinciu, I., Lazăr, N.: *Bazele amenajării torenţilor* (*Bases of Torrent Fitting*). Braşov. Lux Libris Publishing House, 1999.
3. Clinciu, I.: *Corectarea torenţilor* (*Torrent Correction*). Braşov. *Transilvania* University of Braşov, 2001.
4. Clinciu, I., Chiţea, Gh., Păcurar, V.D., et al.: *Didactical-Experimental Valences, the Behavior in Exploitation and the Effects of the Works of Arranging the Torrential Hydrographical Network Within the Superior Basin of Tărlung* (*Upstream the Accumulation Săcele*). In*:* Revista de Politica Ştiinţei şi Scientometrie (2005).
5. Giurgiu, V.: *Metode ale statisticii matematice aplicate în silvicultură* (*Methods of Mathematical Statistics Applied in Forestry*). Bucharest. Ceres Publishing House, 1972.
6. Munteanu, S.A., Traci, C., Clinciu, I., Lazăr, N., Untaru, E.: *Amenajarea bazinelor hidrografice torenţiale prin lucrări silvice şi hidrotehnice* (*vol .I*) (*Fitting of the Drained Basins through Forest and Hydrotechnical Works*). Bucharest. Publishing House of the Romanian Academy, 1991.
7. *** StatSoft, Inc. 2005 STATISTICA für Windows (Software-System für Datenanalyse) Version 7.1. http://www.statsoft.com.