SPATIAL AND TEMPORAL ANALYSIS OF AQUATIC INVERTEBRATE FAUNA FROM THE OZANA RIVER

Victor SURUGIU and Andreea Elena CRISTEA
"Al. I. Cuza" University Iaşi, Faculty of Biology, Bd. Carol I 20A, 700505 Iaşi, Romania,
vsurugiu@uaic.ro

Abstract. Spatial and temporal distribution of benthic macroinvertebrates from the Ozana River was studied seasonally at 4 stations between autumn 2003 and summer 2004. As a result of the examination of 877 individuals collected 34 taxa were identified. The most diverse group were Ephemeroptera (8 taxa), Diptera (7 taxa), Gastropoda (5 taxa), and Plecoptera (4 taxa), whereas in terms of number of individuals dominant were Ephemeroptera (534 individuals), Trichoptera (121 individuals), and Diptera (93 individuals). The most abundant species was *Ecdyonurus dispar* (211 individuals), followed by *Paraleptophlebia submarginata* (125 individuals), and *Hydropsyche pellucidula* (120 individuals). Species assemblages of the macrobenthos and variations in ecological indices at stations with respect to seasons were determined and discussed.

Keywords: benthic macroinvertebrates, abundance, seasonal analysis, species assemblages, Ozana River.

Rezumat. Analiza spaţio-temporală a faunei de nevertebrate acvatice din râul Ozana. Studiul vizează analiza distribuţiei spaţiale şi temporale a macronevertebratelor bentonice din râul Ozana. Probele au fost colectate în 4 staţii în perioada toamna 2003 - vara 2004. În urma examinării celor 877 indivizi colectaţi au fost identificaţi 34 taxoni. În ceea ce priveşte numărul de taxoni dominante au fost efemeropterele (8 taxoni), dipterele (7 taxoni), gasteropodele (5 taxoni) şi plecopterele (4 taxoni), în timp ce ca număr de indivizi predominau efemeropterele (513 indivizi), trihopterele (121 indivizi) şi dipterele (93 indivizi). Specia cea mai numeroasă a fost *Ecdyonurus dispar* (cu 211 indivizi), urmată de *Paraleptophlebia submarginata* (125 indivizi) şi *Hydropsyche pellucidula* (120 indivizi). Au fost stabilite şi analizate grupările de specii şi variaţiile indicilor ecologici din fiecare staţie în cele patru sezoane ale anului.

Cuvinte cheie: macronevertebrate bentonice, abundenţă, analiza sezonieră, grupări de specii, râul Ozana.

Introduction

The Ozana River is one of the main tributaries of the Moldova River (Fig. 1). It springs from the Stânişoarei Mountains, near the Bivol peak (1530 m) and measures 54 km in length (Gâştescu, 1990). The catchment area of the river covers 425 km^2. The mean annual flow is 2.2 m^3/s, with the minima and maxima ranging from 0.03 to 14.5 m^3/s (Baciu, 1994). The mean slope of the Ozana River is 6.67‰ and the mean velocity of water is 2.2 m/s.

The mineralisation is comprised between 100 and 470 mg/l (Baciu, 1994). The permanent hardness ranges from 0.25 to 4.7 mg/l and the total hardness ranges from 11.9 to 16.66 mg/l. The dissolved oxygen varies between 6.57 and 10.88 mg/l, indicating well oxygenated waters.

The only data concerning the biota which populates waters of the Ozana River can be depicted from the "grey paper" of Baciu (1994).

The purpose of this paper is to provide some preliminary data concerning the diversiy and spatial and temporal distribution of macrozoobenthic assemblages of the Ozana River. The necessity of this study is strengthened by the fact that benthic fauna of this river is yet poorly or insufficiently studied. This study is intended to serve as a starting point for subsequent studies which will pursue in time the evolution of benthic communities and will evidence the potential man-made influences.

Material and Methods

The material for the present study was collected on September 24th 2003, January 17th, May 19th, and July 27th 2004. The sampling stations along the Ozana River have been chosed according to the geographical and hydrological characteristics as follows (Fig. 1):

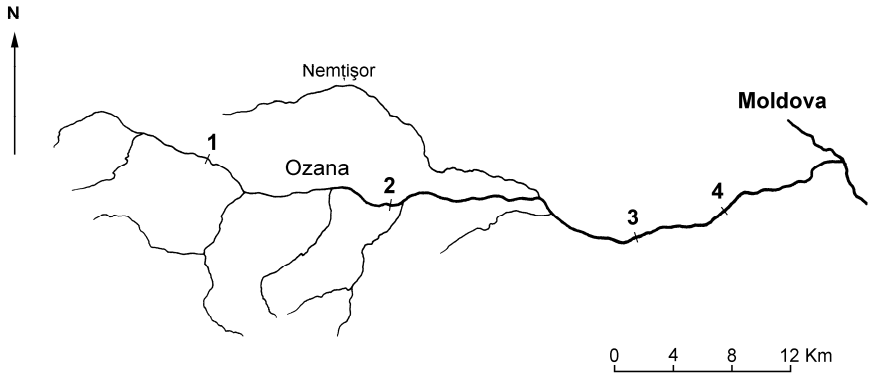

Figure 1. The Ozana River catchment area with the indication of sampling stations: (1) Pipirig, (2) Secu, (3) Blebea, (4) Dumbrava.

- Station 1 (Pipirig) was situated near the Pipirig village (2 km away from the DN 15B road). The riverbed is 1-3 m wide and 7-10 cm deep, according to the season; the substrate consists of boulders and cobbles covered with scarce periphyton and rich vegetal detritus;

- Station 2 (Secu) was located at the entrance of the water course in Târgu Neamţ town, upstream of the confluence with the Secu stream (approximately 1 km away from the DN 15B road). The width of riverbed is 1-3 m; the substrate is formed by stones scarcely covered with microscopic algae and by vegetal detrital material deposited in the spaces between rocks;

- Station 3 (Blebea) was fixed downstream of Târgu Neamţ town; 1 km towards upstream of this station is situated the outfall pipe of the waste-water treatment plant. The riverbed width is about 2 m; the substratum is represented by pebbles mixed with coarse sand;

- Station 4 (Dumbrava) was fixed upstream of the bridge in the vicinity of the Dumbrava locality (1.5 km away from the DN 15B route). Substratum consists of gravel densely covered with periphyton and of coarse sand deposited between particles;

Several physical and chemical parameters, such as water transparency and colour, sediment type, air and water temperature, *p*H, dissolved oxygen and water hardness, were recorded at each sampling site during the collection of biological samples. The temperature, *p*H and dissolved oxygen were measured with a portable CONSORT Model C535 Water Quality Meter. The total water hardness was determined by titration with a standard solution of EDTA in the presense of Erio-T Indicator. The medium riverbed width, the sampling depth and the water velocity were also measured.

In each site benthic samples were taken by a 25×20 cm kick net with 0.5 mm mesh size. Samples were washed *in situ* through the net and material retained was put into plastic bags, labelled and preserved with 4% formaldehyde. In the laboratory all organisms were sorted under stereomicroscope by major taxonomic groups, identified as

possible to the species level and counted. For the identication the keys provided by Cărăuşu *et al*. (1955), Chiriac & Udrescu (1965) and Godeanu (2002) have been used.

For community structure analysis the abundance (*A*), the total number of individuals (*N*), the total number of species (*S*), and the frequency index (*F*) were calculated. Diversity of communities was computed on the basis of abundance data matrix through Shannon-Wiener diversity index (*H'*) with logarithm base 2 (Shannon & Weaver, 1949) and the evenness index (*J'*)(Pielou, 1966).

Results and Discussion

The riverbed width and water depth of Ozana River is variable according to the season. Generally, the water depth increases on going downstream, being greater in places with sills and were the riverbed is narrow. However, in station 4 the depth was very small (Table 1). Due to the exceptionally dry weather in the summer 2003 the river stopped its course during the autumn at the bridge of Dumbrava (station 4). Water velocity ranged between 1.18 m/s in upper reaches of the river in January and 0.53 m/s in lower reaches in July. The largest variation of water temperature occurred in station 4, ranging from 0°C in winter and 21°C in summer, while în station 1 the temperature oscillated between 0°C in winter and 19°C in summer. The transparency was total most of the year, exept the short periods after rains. The hydrogen ion concentration (*p*H) indicated slightly alkaline values, varying according to the station and the season between 7.3 and 8.3. The lowest values for dissolved oxygen were recorded in station 3, where the Ozana River receives waste-water from the treatment plant of Târgu Neanţ town, whereas the maximum values were recorded in station 1, which is characterised by low temperatures and high velocity of water. The total water hardness gradually increased from the upper reaches of the water course to the lower reaches (Table 1).

Table 1. Mean values of physical and chemical parameters measured in the Ozana River during the study.

Sampling station	Riverbed width (m)	Water depth (cm)	Water velocity (m/s)	Air temp. (°C)	Water temp. (°C)	*p*H	Dissolved oxygen (mg/l)	Total water hardness (°dGH)
1	2	9	1.04	6.2	6.9	7.4	10.2	11.9
2	3	16	0.99	11.1	8.8	7.5	9.7	12.3
3	3	30	0.76	11.0	10.0	7.6	7.9	13.4
4	5	8	0.72	11.5	9.8	7.3	8.6	13.7

The examination of 877 individuals collected during this study permitted us to identify 34 taxa of which 20 to the species level. The dominant groups in terms of number of taxonomical units were Ephemeroptera (8 taxa), Diptera (7 taxa), Gastropoda (5 taxa), and Plecoptera (4 taxa). The dominant groups in terms of number of individuals were Ephemeroptera (534 individuals or 60.89% of the total number of individuals), Trichoptera (121 individuals or 13.80%), and Diptera (93 individuals or 10.60%). Baciu (1994) reported for the Ozana River 26 macrozoobenthic taxa, of which 13 taxa are shared in common with the present study. He indicates that numerically dominant were the following groups: Diptera (34.02%), Ephemeroptera (22.22%), Trichoptera (19.57%), and Plecoptera (17.69%).

The most abundant species at all 4 stations during the study was *Ecdyonurus dispar* (24.1% of the total number of specimens), followed by *Paraleptophlebia submarginata* (14.3%), and *Hydropsyche pellucidula* (13.7%). Baciu (1994) indicates that in his study the most abundant species were *Chironomus* sp. (17% of the total number of

individuals), *Hydropsyche pellucidula* (14%), and *Ecdyonurus* sp. (11%). Thus his data are in good agreement with the data obtained in the present study.

The most frequent benthic invertebrates during the study were the chironomids, which occurred in 68.75% of the samples taken. These are closely followed by *Ecdyonurus dispar* (62.5%) and *Paraleptophlebia submarginata* (50%). Common species ($25 \leq F < 50$) were *Hydropsyche pellucidula* (43.75%), *Ephemerella ignita* (37.5%), *Oligoneuriella rhenana* (31.25%), *Atherix ibis* (31.25%), *Baetis* sp. (31.25%), *Erpobdella octoculata* (25%), *Gordius* sp. (25%), and *Isoperla* sp. (25%). The remaining taxa were classified as rare ($F < 25\%$). *Hydropsyche pellucidula* and *Ecdyonurus* sp. had been also found as common in the study carried out by Baciu (1994). However, *Paraleptophlebia* sp. was indicated by him as rare.

Table 2. Abundance of benthic macroinvertebrates sampled in September 2003.

Taxon	Station			
	1	2	3	4
Gordius sp.	12	–	–	–
Erpobdella octoculata (Linnaeus, 1758)	1	–	–	–
Ecdyonurus dispar (Curtis, 1834)	60	–	2	–
Paraleptophlebia submarginata (Stephens, 1835)	50	13	1	–
Bäetis sp.	1	–	–	–
Isoperla sp.	–	1	–	–
Taeniopteryx nebulosa (Linnaeus, 1758)	8	–	–	–
Perlodes microcephala (Pictet, 1833)	–	1	–	–
Perla marginata (Panzer, 1799)	–	1	–	–
Hydropsyche pellucidula (Curtis, 1834)	48	35	–	–
Rhyacophila fasciata Hagen, 1859	1	–	–	–
Limnius sp.	5	–	–	–
Hydrophilidae indet.	–	–	–	1
Atherix ibis (Fabricius, 1798)	15	1	–	–
Tabanidae indet.	–	1	–	–
Tipulidae indet.	5	1	–	–
Chironomidae indet.	9	1	4	–
Psychodidae indet.	1	–	–	–
Total abundance	216	55	7	1

Table 3. Number of species (*S*), number of individuals (*N*), Shannon diversity index (*H'*) and Evenness index (*J'*) calculated for benthic macroinvertebrate fauna sampled in September 2003.

Station	*S*	*N*	*H'*	*J'*
1	13	216	2.745	0.742
2	9	55	1.643	0.518
3	3	7	1.379	0.870
4	1	1	0	–

In September the most abundant species was *Hydropsyche pellucidula* (representing 29.7% of the total number of individuals), closely followed by *Paraleptophlebia submarginata* (22.9%), and *Ecdyonurus dispar* (22.2%) (Table 2). Both the total number of species and the total number of individuals gradually decreased from

headwaters (216 specimens in station 1) towards lower reaches of the river (one single individual in station 4). The Shannon diversity index decreased from 2.745 in station 1 to 0 in station 3 (Table 3). However the equitability was greater in station 3 because of low dominance. In station 4 this index was impossible to calculate because of the presence of only one individual.

Table 4. Abundance of benthic macroinvertebrates sampled in January 2004.

Taxon	Station			
	1	2	3	4
Gordius sp.	25	–	–	2
Erpobdella octoculata (Linnaeus, 1758)	3	–	2	–
Stagnicola palustris (O.F. Müller, 1774)	–	–	3	–
Lymnaea stagnalis (Linnaeus, 1758)	–	–	–	2
Hippeutis complanatus (Linnaeus, 1758)	–	–	–	1
Physa fontinalis (Linnaeus, 1758)	–	–	1	–
Bithynella sp.	–	–	–	1
Gammarus balcanicus Schäferna, 1923	–	–	–	12
Ecdyonurus dispar (Curtis, 1834)	15	12	–	–
Paraleptophlebia submarginata (Stephens, 1835)	11	5	1	–
Oligoneuriella rhenana Imhoff, 1852	3	6	–	–
Ephemerella ignita (Poda, 1761)	2	–	–	–
Isoperla sp.	2	1	–	–
Hydropsyche pellucidula (Curtis, 1834)	16	13	–	–
Limnius sp.	3	–	–	–
Haliplidae indet.	–	–	–	2
Atherix ibis (Fabricius, 1798)	11	–	–	–
Tipulidae indet.	2	1	–	–
Chironomidae indet.	3	–	–	1
Total abundance	96	38	7	21

Table 5. Number of species (*S*), number of individuals (*N*), Shannon diversity index (*H'*) and Evenness index (*J'*) calculated for benthic macroinvertebrate fauna sampled in January 2004.

Station	*S*	*N*	*H'*	*J'*
1	12	96	3.045	0.849
2	6	38	2.136	0.826
3	4	7	1.842	0.921
4	7	21	2.058	0.733

In January the dominant species were *Hydropsyche pellucidula* (17.9%), *Ecdyonurus dispar* (16.7%), and *Gordius* sp. (16.7%). The number of species and the number of individuals presented the same trend as in September with the exception that the lowest values were recorded in station 3 (Table 4). This is due to its location downstream of the sewage outfall pipe of Târgu Neamţ waste-water treatment plant. The only species reported in polluted water were the leech *Erpobdella octoculata* and pulmonate gastropods *Stagnicola palustris* and *Physa fontinalis*. Accordingly varied the Shannon diversity index which presented its maximum value in station 1 (3.045) and

minimum in station 3 (1.842). The equitability presented maximal values in station 3 because of lack of dominant species (Table 5).

In May the dominant species was *Ecdyonurus dispar* (46.7%), *Paraleptophlebia submarginata* (28.3%), and *Ephemerella* sp. (7.2%). The highest number of species (9), as well as the highest number of individuals (123) was noted in station 2 (Table 6). The lowest number of species (2) occurred in station 3, situated 200 m downstream of the waste-water outfall pipe of Târgu Neamț. The self-purification process leads to the increase of species diversity and abundance in station 4, where these parameters were comparable with that of the unpolluted station 1. The Shannon diversity index decreased from 2.189 in station 1 to 1.0 in station 3 (Table 7). In station 4 this index increased to 2.006. The evenness index varied from 1 in station 3 (where were present only 2 species each represented by one single individual) to 0.542 in station 2 (where mayflies strongly dominated).

Table 6. Abundance of benthic macroinvertebrates sampled in May 2004.

Taxon	Station			
	1	2	3	4
Gordius sp.	–	–	–	5
Ecdyonurus dispar (Curtis, 1834)	7	62	–	2
Paraleptophlebia submarginata (Stephens, 1835)	–	43	–	–
Oligoneuriella rhenana Imhoff, 1852	1	–	–	–
Ephemerella ignita (Poda, 1761)	1	1	–	–
Ephemerella sp.	–	11	–	–
Baetis sp.	1	–	–	–
Torleya sp.	–	2	–	–
Isoperla sp.	–	1	–	–
Taeniopteryx nebulosa (Linnaeus, 1758)	1	–	–	–
Hydropsyche pellucidula (Curtis, 1834)	1	–	–	–
Atherix ibis (Fabricius, 1798)	1	–	–	–
Tabanidae indet.	–	1	–	–
Tipulidae indet.	–	1	1	5
Chironomidae indet.	–	1	1	1
Thurauia aquatica Rübsaamen, 1899	–	–	–	1
Total abundance	13	123	2	14

Table 7. Number of species (*S*), number of individuals (*N*), Shannon diversity index (*H'*) and equitability index (*J'*) calculated for benthic macroinvertebrate fauna sampled in May 2004.

Station	*S*	*N*	*H'*	*J'*
1	7	13	2.189	0.780
2	9	123	1.719	0.542
3	2	2	1.000	1.000
4	5	14	2.006	0.864

In July the most abundant species was *Ephemerella ignita* (25.2%), followed by *Oligoneuriella rhenana* (20.0%), and *Ecdyonurus dispar* (15.0%). Both the total number of species and the total number of individuals presented their maximum values in station 2 (Table 8). The lowest number of species as well as the total number of individuals was observed in station 3. It is worth mentioning that this station was dominated by the

amphipod *Gammarus balcanicus*. The Shannon diversity index decreased from 2.208 in station 1 to 1.131 in station 3 (Table 9). In station 4 this index raised to 1.718 due to the self-purification of waters. The highest evenness occurred in station 4 (0.740) and the lowest in station 1 (0.697).

Table 8. Abundance of benthic macroinvertebrates sampled in July 2004.

Taxon	Station			
	1	2	3	4
Erpobdella octoculata (Linnaeus, 1758)	–	–	7	–
Asellus aquaticus (Linnaeus, 1758)	–	–	–	1
Gammmarus balcanicus Schäferna, 1923	–	–	20	–
Ecdyonurus dispar (Curtis, 1834)	8	41	–	2
Paraleptophlebia submarginata (Stephens, 1835)	–	1	–	–
Oligoneuriella rhenana Imhoff, 1852	6	65	–	–
Ephemerella ignita (Poda, 1761)	31	22	–	27
Baetis sp.	2	4	–	10
Ephemera danica Müller, 1764	2	–	–	–
Gomphus flavipes (Charpentier, 1825)	–	–	2	–
Taeniopteryx nebulosa (Linnaeus, 1758)	–	2	–	–
Hydropsyche pellucidula (Curtis, 1834)	1	6	–	–
Atherix ibis (Fabricius, 1798)	–	1	–	–
Empididae indet.	3	1	–	–
Tipulidae indet.	1	–	–	–
Chironomidae indet.	3	4	–	11
Total abundance	57	147	29	51

Table 9. Number of species (*S*), number of individuals (*N*), Shannon diversity index (*H'*) and Evenness index (*J'*) calculated for benthic macroinvertebrate fauna sampled in July 2004.

Site	*S*	*N*	*H'*	*J'*
1	9	57	2.208	0.697
2	10	147	2.147	0.646
3	3	29	1.131	0.713
4	5	51	1.718	0.740

The temporal analysis shows that the highest total number of individuals occurred in July and the lowest in May (Fig. 2). Almost in the same way varied the number of the chironomid larvae, with a peak of abundance in July-September and a decrease in number in January-May. The number of myflies *Ecdyonurus dispar* and *Paraleptophlebia submarginata* was lowest in January. It icreased in May and declined in July, followed by a second increase to a lesser extent in September (Fig. 2). Conversely, the abundance of the caddisfly *Hydropsyche pellucidula* continuously decreased from September to May. The January is the only month when were identified the lunged snails, most of them in polluted stations 3 and 4. The larvae of the dragonfly *Gomphus flavipes* occurred in samples only in July in station 3.

Conclusions

During this study were identified 34 taxa. The most abundant group were Ephemeroptera and Trichoptera. The dominant species was *Ecdyonurus dispar*, which accounted for 16.5% of the total number of individuals, followed by *Paraleptophlebia submarginata* (14.3%), and *Hydropsyche pellucidula* (13.7%). These three species were also the most frequent in the Ozana River.

The species richness was highest in station 2 (Secu) and lowest in station 3 (Blebea). The number of individuals generally decreased on going downstream from station 1 (Pipirig) to station 3 (Blebea).

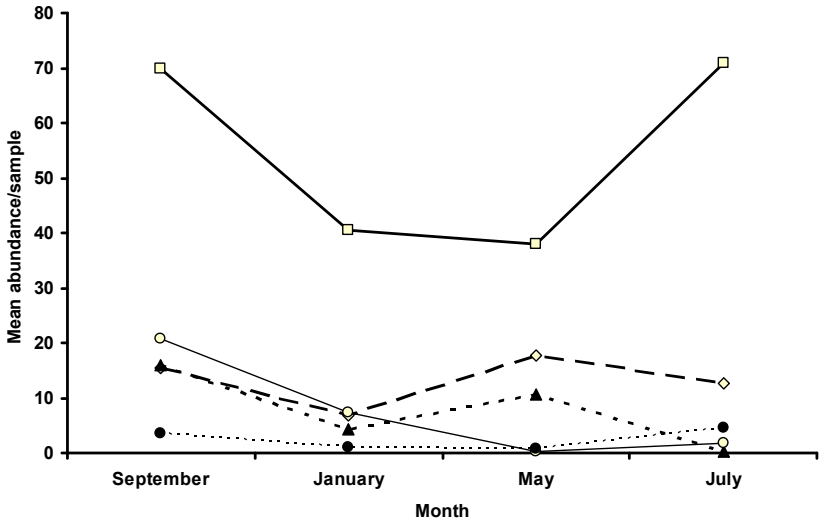

Figure 2. The seasonal variation in mean abundance for the total macrofauna (solid line with open squares), *Ecdyonurus dispar* (dashed line with open rhombi), *Paraleptophlebia submarginata* (dotted line with solid triangles), *Hydropsyche pellucidula* (thin line with open circles), midgefly larvae (dotted line with solid circles).

The Shannon diversity index presented the maximum values in station 1 (Pipirig) and the minimum values in station 3 (Blebea). The highest values equitability occurred in polluted station 3 situated downstream of treatment plant of Târgu Neamt because of presence of few tolerant species each represented by few individuals. The lowest values for equitability occurred in station 2 situated upstream of Târgu Neamţ, associated with strong dominance of ephemeropterans.

Thus, the most polluted site was the station 3 (Blebea), situated immediately downstream of the treatment plant of the Târgu Neamţ town. Here persist only the most tolerant organisms such as leeches, pulmonate gastropods, amphipods and chironomid larvae. The most unimpacted site was station 2 (Secu), which is characterised by a high dominance by sensitive species such as mayfly and caddisfly larvae. Stonefly larvae were relatively poorely represented in unpolluted sites and missed completely in polluted sites.

References

Baciu, M., 1994. *Contribuţii la caracterizarea hidrobiologică a râului Ozana pe sectorul Vânători-Timişeşti*. Lucrare de gradul I, Facultatea de Biologie, Universitatea "Alexandru Ioan Cuza" Iaşi (România).

Bray, J.R., Curtis, J.T., 1957. An ordination of the upland forest communities of Southern Wisconsin. *Ecol. Monogr*., **27**: 325-349.

Cărăuşu, S., Dobtreanu, E., Manolache, C., 1955. *Amphipoda, Fauna R.P.R.* Editura Academiei R.P.R., **IV (4)**: 1-410.

Chiriac, E., Udrescu, M., 1965. *Ghidul naturalistului în lumea apelor dulci*. Editura Ştiinţifică, Bucureşti.

Gâştescu, P., 1990. *Fluviile Terrei*. Editura Sport-Turism, Bucureşti.

Godeanu, S.P., 2002. *Diversitatea lumii vii. Determinatorul ilustrat al florei şi faunei României.* ***II*** *– Apele continentale.* Editura Bucura Mond, Bucureşti.

Pielou, E.C., 1966. The measurement of diversity in different types of biological colllections. *J. Theoret. Biol*., **13**: 131-144

Shannon, C.E., Weaver, W., 1963. *The Mathematical Theory of Communication*. University of Illinois Press. Urbana.