12. Study of ichthyofauna from Roşu-Puiu lake-complex

NĂVODARU Ion[1], NĂSTASE Aurel[2], CERNISENCU Irina[3]

[1] *Danube Delta National Institute for Research and Development (DDNI), 165 Babadag Str., 820112 Tulcea, Romania; e-mail: navodaru@indd.tim.ro*
[2] *Danube Delta National Institute for Research and Development (DDNI), 165 Babadag Str., 820112 Tulcea, Romania; e-mail: aureln@indd.tim.ro*
[3] *Danube Delta National Institute for Research and Development (DDNI), 165 Babadag Str., 820112 Tulcea, Romania; e-mail: irina@indd.tim.ro*

ABSTRACT. The study of ichthyofauna from Roşu-Puiu lake-complex was undertaken in May 2005, using two complementary methods of sampling: electric fishing for shoreline and gillnet fishing for deep water zone. The paper presents the actual situation of the fish communities from the Roşu-Puiu lake-complex, part of "marine delta" from Danube delta. In this lake-complex there were catched 29 species of fish (5 exotic species and 24 native species. The most abundant fish species are *Alburnus alburnus* (bleak), *Abramis bjoerkna* (silver bream), *Clupeonella cultriventris* (Black Sea sprat), *Carassius gibelio* (Prussian carp) and *Rutilus rutilus* (roach) with slight differences for those two complementary methods of sampling. The biodiversity index and equitability indices were calculated per lake and methods.The lake-complex has a stable ecosystem, with shoreline (1.155 Shanon-Wiener index and 0.437 equitability indices) less stables than open water (1.878 Shanon-Wiener index and 0.576 equitability indices).

Key words: species richness, fish communities, ecologic indices, biodiversity, equitability index

INTRODUCTION

The Roşu-Puiu lake-complex is a part of "marine delta" and is located between Caraorman dunes and the Black Sea, respectively between Sulina branch and Sf. Gheorghe branch, having a total surface of 42,300 ha (out of which 6,660 ha aquatic surface). The lake-complex includes some large lakes, like Roşu lake (1,445 ha), Lumina lake (1,367 ha), Puiu lake (865 ha), Puiulet lake (505 ha), Iacub lake (439 ha) and Roşuleț lake (365 ha) [3], which are interconnected by river branches and man-made canals. The diversity and structure of the fish community varied among lakes and can be considered as a good indicator of ecological state of lakes. The diversity of fish fauna is consequence of changes in hydrology and water quality with effects on fish community distribution [9, 11].

The aim of the present work is to describe the present status of ichthyofauna using species richness, abundance and biomass and the biodiversity indices of the area and to compare the present status of the lakes in context of major human interventions. Biodiversity reflects the heterogenity degree of fish community and level of ecological stability of the ecosystem [10, 13, 14]. It shows the relantionship between the number of the species and number of individuals in the community. High biodiversity and equitability values usually indicate a stable and less damaged ecosystem [2, 14].

In the Roşu-Puiu lake-complex, the ecosystems are dominated by: 1) flooded reed, 2) lakes with a large surface area and/or active change of water, 3) lakes with reduced exchange of water and partially covered with floating vegetations, 4) floating reed beds (plaur) near the lakes with reduced exchange of water [4].

The soil is dominated by organic soil, in the most part of the complex, but also are sandy soil and argillaceous soil, or mixture between last two of this [6].

MATERIALS AND METHODS

The Roşu-Puiu lake-complex was sampled in May 2005, target areas being the following four lakes: Roşu, Puiu, Iacub and Roşuleț (**Fig. 1**).

Fig. 1. Sampling area of Roşu-Puiu lake-complex

We used two complementary methods of sampling: electric fishing (DEKA 7000 W electrofisher, 10 minutes per site, 3 sites per lake) and gillnet fishing (4 gillnets with varied mesh 20, 30, 40, 50 mm + 1 gillnet with 12 panels, 2,5 m each panel, with multiples meshes: 6, 6, 8, 10, 12, 16, 20, 24, 30, 35, 45, 55; totalizing 450 m gillnets per night and lake).

The catch per unit effort (CPUE) is: 1-hour electric fishing per lake at electric fishing and 100 m gillnets per lake at gillnet fishing.

Electric fishing was carried out during day-time, in border zone with little deep water and with a lot of vegetation; gillnet fishing was carried out during night-time (12 hour), in the middle of lake, with deep open waters and little vegetation.

Processing of samples included:

- species identification (taxonomy) [1, 5, 12].
- determination of fish abundance (A) and biomass for each species per site, lake and gear.
- characterization of fish association [2], by calculating several ecological indices: constance (frequency of occurrence), dominance and ecological significance (W).

Importance of all the species within these communities were determinated based on the W value [8]: leading species (W5>20); characteristic (eudominant-indicator) species (W5=10-20); complementary (accompanying, constantly dominating) species (W4=5-10); associated species (subdominating) (W3=1-5); auxiliary species (W2=0.1-1); accidental species (W1<0.1).

- The biodivesity (Hs) was calculated according to the Shannon-Weiner formula [2, 10, 13, 14]

$$Hs = -\sum_{i=1}^{S} pi \times \ln(pi);$$

$$pi = Nr/N$$

where: S = number of collected species; pi = abundance; Nr = number of individuals belonging to a certain species; N = total number of individuals in a sample.

- The equitability [2, 13] (means the quantum of unequal distribution of different effective species proportion as an ideal community, where every species have the same number of individuals. The value of equitability index is included between 0 and 1 range.

$$E = Hs / Hmax$$

where: E=equitability; Hmax = ln (S); Hmax=maximal diversity

RESULTS AND DISCUSSIONS

Species richness, abundance and biomass

Fish sampling from the Roşu-Puiu lake-complex area was performed in 18 sampling sites (6 sites sampled with electrofishing and 12 sites sampled with gillnet fishing) of four lakes. There were captured 29 fish species: 26 fish species in case of gillnet fishing (out of which 19 species are of commercial importance) and 14 in case of electric fishing (out of which 9 species are of commercial importance) (**Table 1)**.

Table 1.

Fish species richness by fishing methods from the Roşu-Puiu lake-complex

No	Scientific name	Vernacular name	Electric	Gillnet	Native	Exotic	commercial
1	Abramis brama *L. 1758*	Bream	*	*	*		*
2	*Abramis bjoerkna* L. 1758	Silver bream	*	*	*		*
3	*Acipenser stellatus* Pallas 1771	Starry sturgeon		*	*		*
4	Alburnus alburnus L. 1758	Bleak	*	*	*		*
5	*Alosa caspia* Antipa 1906	Caspian shad		*	*		*
6	*Aspius aspius* L. 1758	Asp	*	*	*		*
7	*Atherina boyeri* Risso 1810	Big-scale sand smelt		*	*		*
8	*Carassius gibelio* Bloch 1782	Prussian carp	*	*		*	*
9	*Clupeonella cultriventris* Nordmann 1840	Black Sea sprat		*	*		*
10	*Cobitis taenia* L. 1758	Spined loach		*	*		
11	*Cyprinus carpio* L. 1758	Carp		*		?	*
12	*Esox lucius* L.1758	Pike	*	*	*		*
13	*Gymnocephalus cernuus* L. 1758	Ruffe		*	*		
14	*Hypophthelmichthis molitrix* Valenciennes 1844	Silver carp		*		*	*
15	*Leucaspius delineatus* Heckel 1843	Belica	*		*		
16	*Leuciscus borysthenicus* Kessler 1859	Black Sea chub	*		*		
17	*Lepomis gibbosus* L. 1758	Pumpkinseed		*		*	
18	*Neogobius fluviatilis* Pallas 1814	Monkey goby		*	*		
19	*Perca fluviatilis* L. 1758	Perch		*	*		*
20	*Proterorhinus marmoratus* Pallas 1811	Tube-nosed goby	*	*	*		
21	*Pseudorasbora parva* Temminck & Schlegel 1846	Stone moroko		*		*	
22	*Rhodeus amarus* Bloch 1782	Bitterling	*	*	*		
23	*Rutilus rutilus* L. 1758	Roach	*	*	*		*
24	*Sander lucioperca* L. 1758	Zander		*	*		*
25	*Scardinius erythrophthalmus* L. 1758	Rudd	*	*	*		*
26	*Silurus glanis* L. 1758	Wels		*	*		*
27	*Tinca tinca* L.1758	Tench	*	*	*		*
28	*Umbra krameri* Walbaum 1792	Mudminnow	*		*		
29	*Vimba vimba* L. 1758	Vimba		*	*		*
	TOTAL	29	14	26	24	5	19

In case of both sampling-methods the most abundance species are: *A. alburnus* and *R. rutilus*: But in case of electric fishing there is another abundant species: *R. amarus* (**Fig. 2**). In case of gillnet fishing, other abundant species are: *A. bjoerkna, C. cultriventris* and *C. gibelio* (**Fig. 2**).

Regarding the fish biomass, the dominant species are slightly different in case of the two sampling-methods. In case of electrofishing: dominant species are *R. rutilus, A. alburnus, E. lucius* and *C. gibelio*. In case of gillnet fishing, dominant species are: *A. bjoerkna, C. gibelio, R. rutilus* (**Fig. 3**). The most productive lake was Iacub and the less productive one was Roşu lake.

Ecological significance and biodiversity index

Ecological significance:
- leading species are bleak (in case of both sampling-methods); beyond this, silver bream was also dominant in case of gillnet fishing;
- eudominant-indicator is roach in case of both sampling-methods;
- complementary species are bitterling (in case of electric fishing), Black Sea sprat and Prussian carp (in case of gillnet fishing);
- the rest of species are associated and auxiliary in case of electric fishing; in case of gillnet fishing more than 30% of all species are associated and auxiliary species, and almost 50% are accidental species (**Table 2**).

Table 2

Ecological significance index (W) of fish species from Roşu-Puiu lake-complex

Class of W: %	Electric fishing	Gillnets fishing
W1:<0,1		*Atherina boyeri* *Silurus glanis* *Vimba vimba* *Acipenser stellatus* *Hypophthalmichthis molitrix* *Neogobius fluviatilis* *Proterorhinus marmoratus* *Pseudorasbora parva* *Rhodeus amarus* *Tinca tinca* *Cyprinus carpio* *Lepomis gibbosus*
W2: 0,1-1	*Leuciscus borysthenicus* *Scardinius erytrophthalmus* *Abramis bjoerkna* *Abramis brama* *Aspius aspius* *Carassius gibelio* *Tinca tinca* *Umbra krameri*	*Cobitis taenia* *Abramis brama* *Sander lucioperca* *Aspius aspius* *Esox lucius*
W3: 1-5	*Proterorhinus marmoratus* *Esox lucius* *Leucaspius delineatus*	*Gymnocephalus cernuus* *Scardinius erythrophthalmus* *Alosa nordmanni* *Perca fluviatilis*
W4: 5-10	*Rhodeus amarus*	*Clupeonella cultriventris* *Carassius gibelio* *Rutilus rutilus*
W5: 10-20	*Rutilus rutilus*	
W6: >20	*Alburnus alburnus*	*Alburnus alburnus* *Abramis bjoerkna*

The diversity index has smaller value and the disorder degree has higher value in case of electric fishing (in comparison with the values obtained in case of gillnet fishing) (**Table 3**). These results are not similar to the ones obtained in case of other lake-complexes [7, 8].

The equitability index has higher value in case of electric fishing (0.437) and smaller value in case of gillnet fishing (0.576). In the border zones of the lakes the ecosystem is less stable than in open water in case of this lake-complex, this feature being opposite to the ones observed in case of other lake-complexes [7, 8].

In Roşu-Puiu lake-complex the diversity of fish community from border zone with shallow water and dense vegetation (sampled on days when electric fishing was performed in the respective areas) have smaller heterogenity in comparison with the deep-water zones (**Table 3**). The high biodiversity value indicates a stable and less damaged ecosystem in the deep-water zones, a situation which is opposite to the ones observed in case of the Somova-Parcheş lake-complex and Gorgova-Uzlina lake-complex [7, 8].

Table 3.

Values of biodiversity indices of Roşu-Puiu lake-complex

indices/Roşu-Puiu complex	electric	gilnet
H'	1.155	1.878
Hmax	2.639	3.258
E	0.437	0.576

All lakes which are connected with the river through canals have the smallest values of biodiversity and equitability indices, in comparison with the values of the same indices calculated in case of small lakes and lakes located at remote distance from the central lakes (**Table 4**).

Table 4

Diversity and equitability index of various lakes of Roşu-Puiu lake-complex

No.	Lake	Electric fishing			Gill neting		
		H'-e	Hmax-e	E-e	H'-g	Hmax-g	E-g
1	Puiu	1,816	2,397	0,757	1,461	2,639	0,553
2	Iacub	0,901	2,397	0,375	1,44	2,639	0,545
3	Roşuleţ				2,001	2,89	0,692
4	Rosu				1,645	3,044	0,54

Results of the electric fishing show that Puiu lake have the biggest values of the indices, suggesting that Puui lake has a more stable ichthyofauna than Iacub lake (which has the smallest values probably because of bigger negative impact of the human activities) (**Fig. 4**).

In case of open waters, remote lakes like Roşuleţ lake have high values of indices, meanwhile others lakes have smaller values (Iacub lake, Puiu lake or Roşu lake) (**Fig. 4**).

CONCLUSIONS

Generally, Roşu-Puiu lake-complex has a stable ecosystem, suggested by the studies on its ichthyofauna, with medium values of equitability indices.

Roşuleţ lake has the biggest values of biodiversity and equitability indices and Iacub lake has the smallest values of these indices (with small differences between the results obtained with the two methods of sampling. The lakes peculiar biodiversity may be explained by the changings in hydrology and water quality and their effects on fish community distribution [9, 11].

The diversity of fish community from border zones of the lakes from Roşu-Puiu lake-complex have smaller values (1.155 Shanon-Wiener index and 0.437 equitability index) than the open waters (1.878 Shanon-Wiener index and 0.576 equitability indice), because of equitable number of individuals from each species.

According to the results of both sampling-methods, the most abundant, leading-eudominanting species is the bleak, dominating species are roach and silver bream, complementary (constantly dominating) species are biterling, Prussian carp and Black Sea sprat, but accidental species are more than 66% of the total number of species.

Regarding to fish biomass, the dominant species are: *Abramis bjoerkna, Carassius gibelio, Rutilus rutilus, Alburnus alburnus* and *Esox lucius*.

REZUMAT

Complexul lacustru Roşu-Puiu face parte din delta maritimă, ocupând o suprafaţă de 42300 ha din care 6660 ha ocupat de ape deschise permanente, se evidenţiază prin prezenţa a 29 specii de peşti (24 specii native şi 5 exotice) dintre care cele mai abundente specii, caracteristice complexului pentru cele două metode de pescuit cu unele diferenţe sunt obleţii (*Alburnus alburnus*) şi batca (*Abramis bjoerkna*), urmate de boarţă (*Rhodeus amarus*), gingirică (*Clupeonella cultriventris*), babuşcă (*Rutilus rutilus*) şi caras (*Carassius gibelio*). Ca biomasa domină batca, carasul, babuşca, obleţii şi ştiuca. Indicii de biodiversitate şi echitabilitate ne arată o ihtiofauna mediu stabilă, cu o entropie scăzută şi heterogenitate crescută (mai ales în zona de apelor deschise şi adânci, mai mult decât în zona de ţărm). În complex, lacul Roşuleţ are cele mai mari valori ale indicilor de biodiversitate a ihtiofaunei evidenţiind o influenţă mai scăzută a omului, pe când în lacul Iacub impactul antropic a provocat efecte destul de grave asupra faunei piscicole.

Acknowledgements. We would like to thank Mr. Popa Leonte piscicultural technician and the fishermen (Anton Gal and Ciotic Andrei) for their help during the field-works.

REFERENCES

1. BĂNĂRESCU (P.) 1964 – Pisces-Osteichthyes. IN: *Fauna R. P. R.*, vol. XIII, 959 p. Edit. Acad. R.P.R., Bucureşti.
2. BOTNARIUC (N.), VĂDINEANU (A.),1982 – Ecologie. "Anexe metodologice". 419 p. Edit. Did. şi Pedag., Bucureşti.
3. DIACONU (C.), NICHIFOROV (I.), 1963 – Zona de vărsare a Dunării. Monografia hidrologică. Edit. Tehnică, Bucureşti.
4. GÂŞTESCU (P.), OLTEAN (M.), NICHERSU (I.), CONSTANTINESCU (A.), 1999 – Ecosystems of the Romanian Danube Delta Biosphere Reserve. Explanation to a map 1:175000. RIZA werkdocument 99.032.
5. KOTTELAT (M.), 1997. European Freshwater fishes. IN: *Biologia*, Supl. 5, 272 p.
6. MUNTEANU (I.), CURELARIU (Gh.), 1995 – Romanian Danube Delta Biosphere Reserve soil map 1:100 000.
7. NĂSTASE (A.), NĂVODARU (I.), 2004 – Ichthyofauna from complex lakes Somova-Parches from flooded predeltaic meadow of Danube. IN: *Univ. Bacău. Studii şi Cercetări Biologice, serie nouă*, vol. 9, pp. 86 – 88.
8. NĂSTASE (A.), NĂVODARU (I.), 2006 – Study of ichthyodiversity from Gorgova-Uzlina lake-complex. IN: *Scientific annals of the Danube Delta Institute*, vol. 12, pp. 91 – 96. Tulcea.
9. NĂVODARU (I.), BUIJSE (A. D.), STARAŞ (M.), 2002 – Effects of hydrology and water quality on the fish community in Danube Delta lakes. IN: *Internat. Rev. Hydrobiol.*, vol. 87, No. 2 – 3, pp. 329 – 348.
10. ODUM (E. P.), 1975 – Ecology: The link between the natural and the social sciences. Second edition. A Holt International Edition.
11. OOSTERBERG (W.), SATARAS (M.), BOGDAN (L.), CONSTANTINESCU (A.), COOPS (H.), HANGANU (J.), IBELINGS (B. W.), MENTING (G. A. M.), NAVODARU (I.), TÖRÖK (L.), 2000 – Ecological gradients in the Danube Delta lakes. Present state and man-induced changes. IN: *RIZA rapport 2000.015*. pp119-138. ISBN 90.369.5309x.
12. OŢEL (V.), 2001 – Actual status of ichthyofauna in the Danube Delta Biosphere Reserve-Roumanian sector: systematics and conservation. IN: *The 10-th Europ.Congr. of Ichthyology -Praga, Book of Abstracts*, page 61.
13. SÂRBU (I.), BENEDEK (A. M.), 2004 – Ecologie practică. 259 p. Edit. Univ. Lucian Blaga, Sibiu.
14. URECHE (D.), PRICOPE (F.), BATTES (K. W.), 2002 – Prospective monitoring of Putna basin ichthyofauna. IN: *Anal. Şt. I.D.D. 2002*, pp. 205 – 223. Tulcea.

Manuscript received: February 4th, 2007
Manuscript accepted: June 30th, 2007
Printed: October 2007

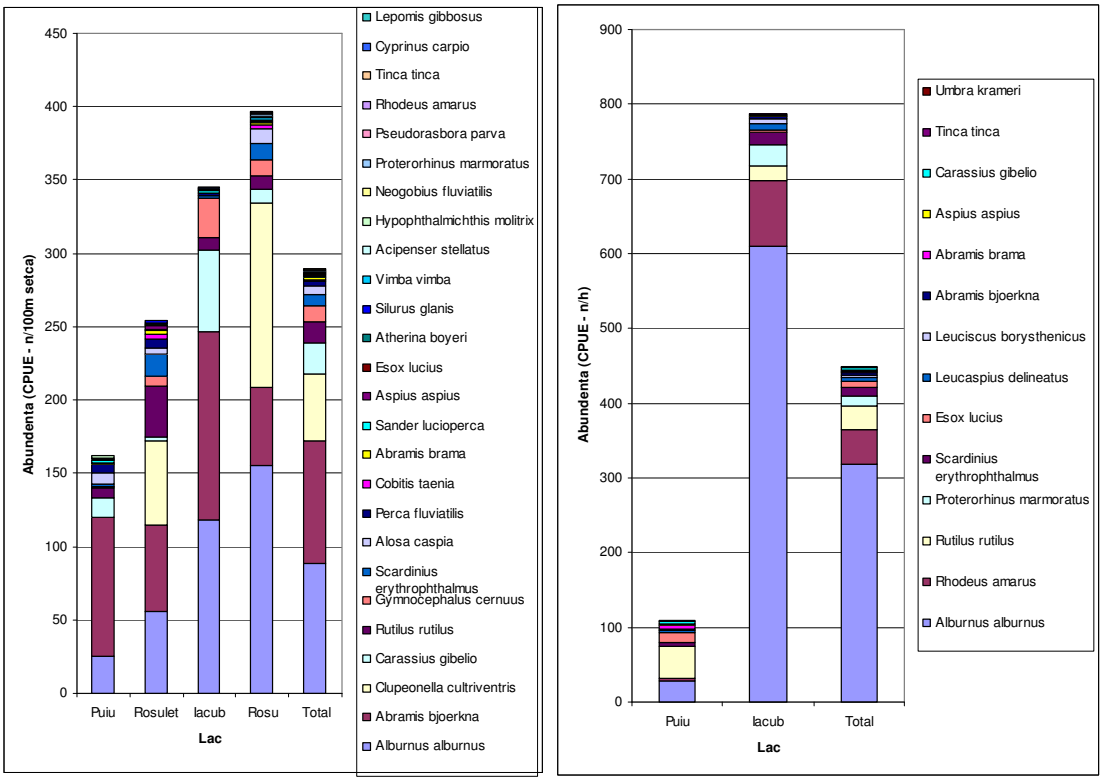

Fig. 2. Relative abundance (CPUE) per lake and sampling method

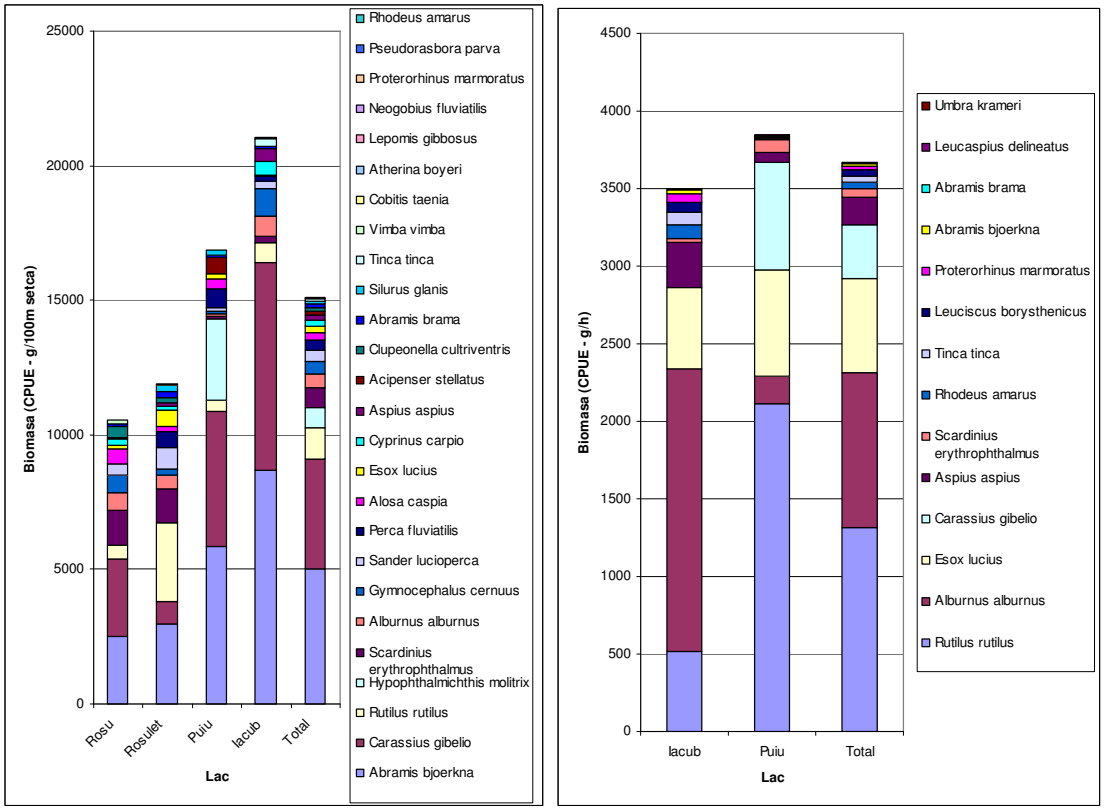

Fig. 3. Relative biomass (CPUE) per lake and sampling method

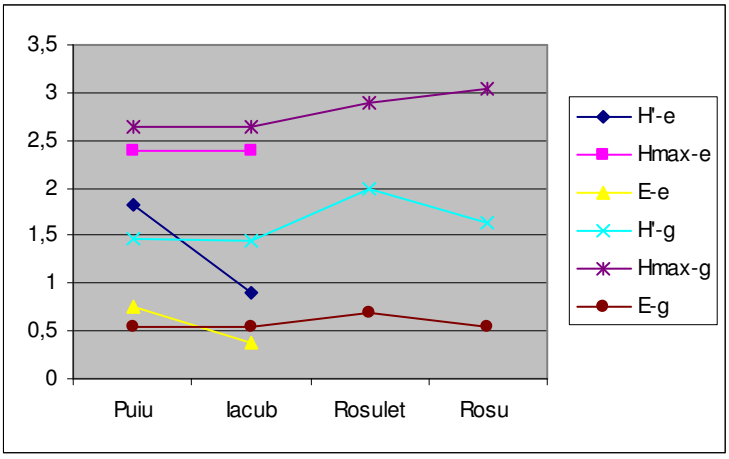

Fig. 4. Difference between lakes concerning at ichthyodiversity indices