

9. Status of biodiversity, habitats, sustainable exploitation of natural resources and socio-economic implications in Danube Delta Biosphere Reserve in 2020

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Abstract: This paper will present the results of research conducted in 2020 in Danube Delta Biosphere Reserve regarding the mapping of DDBR habitats in the Romanian classification system, assessment of the sustainable exploitation of plant resources, conservation status of invertebrate species of community interest, assessment of the ecological status of ichthyofauna in the context of recent changes due to the emergence of new limiting factors, fisheries research for the sustainable exploitation and conservation of biodiversity, colonial waterfowl species, bird species of conservation interest with insufficiently known nesting and pilot study of bioacoustics, mammal species of Community interest, socio-economic revitalization of human settlements and the dynamics, support research for the substantiation of ecotourism in order to sustainably capitalize on the landscape resource.

Key words: biodiversity, conservation, flora, fauna, natural resources, socio-economic systems, tourism

INTRODUCTION

Mapping is the field tracking and transposition, by conventional signs and colors, on topographic maps, of the spread and characters of different elements in nature, in our case the transposition of **habitats** in the Romanian classification system following the correspondence of vegetation identified in the field. Vegetation structure data are very important for the quality of the monitored habitat and cannot be widely assessed from the ground. The first level is the field identification of conservatively important habitats, usually with small areas. The second level is the mapping of large-area habitats using different analysis indices (Zlinszky et al., 2015) (eg NDVI, reflectance, vegetation height).

Natural sustainable harvestable **vegetal resources** of Danube Delta Biosphere Reserve territory consist from medicinal herbs, pastures, beekeeping important plants, reeds and edible mushrooms. These species capitalization can provide additional sustainable income to the local population of Danube Delta Biosphere Reserve territory maintaining a proper balance between conservation and economic use. Therefore, knowing estimated harvesting potential of each resource, which our study is providing, is the key to keep the equilibrium of these species' populations.

According to Directive 92/43 / C.E.E. - Annex II, following the observations and conclusions drawn up in the Biogeographical Seminars, in DDBR are reported as present a number of 9 species of **invertebrates**, 8 species of entomofauna (insects) and 1 species of gastropod, of Community Importance whose conservation requires the designation of special conservation areas (SCI), recorded in NATURA 2000 Standard Form of the ROSCI0065 Danube Delta.

Globally, inland **fish resources** are steadily declining as a result of habitat degradation and overfishing (Allan et. al. 2005). This trend, generated mainly by the intensification of multiple water uses (in agriculture, in energy generation, navigation, etc.), cannot be changed as long as states do not pay enough attention to the fisheries sector and will not pay attention to it until they have enough information on fish and fisheries and their values for the present and the future.

During the breeding season of 2020 a survey of the 26 **colonially breeding waterbirds** (*Pelecaniformes*, *Ciconiiformes* and *Charadriiformes*) were carried out in DDBR. The study provides an overview of the numbers, distribution and trends of colonial waterbird species in the DDBR. The aim of this study was to identify the key factors responsible for site selection and population size of colonial waterbirds.

Danube Delta is home of a number of 165 breeding **bird species**, of which some are well understudied, with no breeding certainty mainly due to their nocturnal or cryptic behavior, or a reduce number of observations in the studied area.

Thus, the aim of the study is to evaluate the breeding of the following **bird species of conservation interest** in Danube Delta Biosphere Reserve in 2020:

- *Crex crex*
- *Bubo bubo*
- *Cettia cetti*
- *Tyto alba*

This study presents the 9 **mammal species** of Community interest (strictly protected as listed in Annex 2 of Habitat Directive of European Union, implemented in Romania by Annex 3 of OUG nr. 57/ 2007) inhabiting the Natura 2000 site named ROSCI0065 "Delta Dunării" and ROSCI0066 "Delta Dunării - Zona Marină", as well as their vicinity and areas surrounding the SCI sites.

From an **economic perspective**, in Romania, with the exception of the Bucharest-Ifov region, the economic development of the other regions followed a decreasing west-east direction, the underdeveloped areas being concentrated along the Danube River. This underdevelopment is correlated with unemployment and also with the prevalence of rural activities and the inability to attract foreign direct investment (M.A.E, 2016).

In protected natural areas, such as the Danube Delta Biosphere Reserve, **ecotourism** is the most valuable form of sustainable tourism, specific to rural areas within communities with a tradition in agricultural activities that cover both access to flora and fauna and people's social and cultural habits, from those areas that focus on educating tourists about protecting and conserving biodiversity (Dinu. M., 2005).

MATERIALS AND METHODS

Habitat identification is carried out between May and October 2020 in three regions of the ROSCI0065 Danube Delta (Gorgova – Uzlina, Matita – Merhei and Rosu - Puiu), by recognizing, in the field, the phytocenoses that characterize them, namely by taking into account the edifying species (generally dominant) and indicators ecological and / or cenological, as well as by recognizing the characteristics of the resort, first of all geographical location, altitude, relief and soil. The size of the sample areas is directly proportional to the complexity of the structure of the studied habitat. The choice of the surface of the samples is based on the concept of minimum area which is defined as the minimum area on which the vegetation survey must be carried out to capture most of the species included in the phytocenoses (Braun-Blanquet 1932, Borza et Boşcaiu 1965, Cristea 1993, Cristea et al. 2004). The analysis of the flora was done by field trips during different vegetation periods, as well as based on the botanical material collected, preserved and determined between May and September 2021. Habitats have been established on the basis of identified plant associations, in accordance with the Romanian Habitats Manual (Donita et al. 2005) and the Habitats Interpretation Manual (Gafta & Mountford, 2008), in accordance with the Habitats Directive (92/43 / EEC). consulting the European Union Habitat Interpretation Manual.

Generally, the **harvesting potential** estimation method includes an inventory of the vegetal species and edible mushrooms, harvestable quantity (estimated as biomass per square meter) on each administrative unit of Danube Delta Biosphere Reserve territory. This methodology is particular to each harvestable vegetal resource maintained each year to keep unity and coherence all over the study (**, 2019).

Field investigations concerning **invertebrates** involve taking samples, making observations on the biology, ethology or interrelationships of the investigated superindividual system, data on its natural environment, etc.

Invertebrate investigation techniques:

Capture and collection techniques:

- Collection with limnological net (aquatic species);
- Species collection with entomological net (terrestrial entomofauna species) (Sîrbu & Benedek, 2004; Ionescu & Apetrei, 1988).

Field investigation techniques:

- Collection on a set surface;
- The method of transects (Ionescu & Apetrei, 1988);
- Collection of high-resolution images;
- Identification and indication of distribution points (GPS).

The collection of biological material targeting invertebrate species of conservative interest is carried out in the spirit of respect for professional ethics - only a small number of specimens of each species in each investigated area are sacrificed, rarely or not at all if they belong to protected or endangered species. It is also not deontological to sacrifice species that are known or that can be determined in the field.

The method that can be used to estimate the evolution trends of the size of **fish population** in time and space is that Catch Per Unit Effort (CPUE) in relative abundance and biomass. Effort Catch Index (CPUE) is quantified. Can be used for any fishing gear (electric, gillnets, seine, others). Quantitative results are expressed in density data per station, for which the following analytical and synthetic ecological indices are used, with their classes (**Table1**): dominance, constancy, ecological significance indexes.

Table 1. Dominance, constancy, and ecological significance classes

Dominance (D)		Constancy (C)		Ecological significance (W)	
Class	%	Class	%	Class	%
Sporadic	D1< 1	Very rare	C1=0-10	Incidental	W1A<0.001
Subrecent	D2=1-2	Rare	C2=10,1-25	Accidental	W1< 0,1
Recent	D3=2-4	Accessory	C3=25,1-45	Accessory	W2=0,1-1
Subdominant	D4=4-8	Constant	C4=45,1-70	Associate	W3=1-5
Dominant	D5=8-16	Euconstant	C5=70,1-100	Complementary	W4=5-10
Eudominant	D6>16			Characteristic	W5=10-20
				Main	W6>20

The field investigations were carried out between January - August 2020, covering the entire nesting season of the 26 species of **colonial waterbirds** in the DDBR. The study area was represented by the entire surface of the DDBR.

Numerical estimation in colonies was performed by direct counting of individuals and active nests (when this was possible) from the point with the best visibility over the colony. All identified colonies were mapped in GIS based on GPS points and tracks collected on field. In the case of inaccessible colonies, the mapping of the colony was based on recent satellite and aerial images (collected by drones). The nesting periods for the colonial bird species in DDBR is different according to species and environmental characteristics in that year. In 2020 the nesting started in late January for some of the Great Cormorant (*Phalacrocorax carbo*) and in early August we recorded a very late breeding for the Sandwich Tern (*Sterna sandvicensis*).

The results of the evaluations carried out in this study were structured in the form of a database in GIS (Geographic Information System) which is a very useful tool in the management of information on colonial waterbird species in the DDBR. Based on the GPS points and tracks recorded in the field, all the colonies investigated this year were mapped in GIS as polygons.

In order to study the distribution and breeding status of **bird species of conservation interest** - *Cettia cetti*, *Bubo bubo*, *Crex crex*, we used a playback protocol (Bibby et al 2000) that involves the broadcasting of the species calls and the response from the wild birds. We also used a passive acoustic protocol that involves the deployment of a recording stations that records the ambient sounds in the specific habitat and listening in the laboratory for the target species.

The investigations of the 9 **mammal** species of Community interest from ROSCI0065 "Delta Dunării" and ROSCI0066 "Delta Dunării - Zona Marină" and surroundings, were carried out by the method of transects, the method of inventory of signs of presence, the method of inventory of shelters, the method of capture with live traps (Bibby et al. 2000; Monterroso et al. 2013; Ionescu et al. 2013; O'Brien et al. 2003; Tobler et al. 2008; Kays et al. 2011; Wearn et al. 2016; Swann et al. 2004). The research was carried out by direct, free observations or with the help of specific optical instruments (binoculars and telescopes) and indirect, auditory observations (recognition of the sound emissions of different species), or by recognition of furs, burrows, traces, markings and of excrement. The trips in the field on the terrestrial area were made with the help of the vehicle and for the aquatic areas the boats from the INCDDD were used. Garmin 62S GPS (Global Positioning System) devices were utilized to accurately locate the observations. The investigations were carried out between January and November 2020. The frequency was calculated using the formula $100 \times \text{no. individuals} / \text{no. of investigated areas}$ (Stan, 1995).

A comparative analysis was performed based on endogenous **economic-financial indicators** to determine the degree of regional development of the Territorial Administrative Units bordering the Chilia (Ceatalchioi, Pardina, Chilia Veche and C.A. Rosetti) and Sulina (Maliuc, Crișan, Sulina) branches. This analysis was based on the results of the previous phases and aims to highlight the potential for socio-economic revitalization of these units.

In order to calculate the degree of regional development and to highlight the local economic disparities, a series of performance indicators based on endogenous economic-financial factors were identified as follows:

- Availability of productive capital determined on the basis of capital and labor
- Employed population interpreted by the endogenous labor force
- The quality of human capital interpreted according to the endogenous investment factor
- Public spending on infrastructure, an indicator based on the public capital factor

The calculation formulas used for each indicator can be consulted in ^{***}, 2020 (INCDDD- Tulcea. Tulcea, Romania, 2021)

Because **tourism activity** is difficult to measure (Vanhove, N., 2005), in recent years, efforts have been made to establish a system for collecting more complex statistical data to indicate the magnitude of the effects of tourism.

In this study, the research was carried out collecting data and indicators from the General Tourism Information System (SIT), from the website of the National Institute of Statistics (Tempo Online), from the website of the Ministry of Tourism (data on the accredited accommodation units) and information taken from the tourist promotion sites for the Danube Delta Biosphere Reserve. In 2020, the trips and field observations were made during the spring-summer and summer-autumn sampling, and focused on the identification of new accommodation units, the number of tourists and overnight stays, in the tourist areas of Jurilovca, Crisan-Murighiol and Vadu-Corbu, as well as on the way of organizing the touristic activities (tourist routes and recreation activities).

RESULTS AND DISCUSSIONS

Habitats

The Gorgova - Uzlina complex is part of the river delta. The depression is located south of the Sulina arm and at the Dranov ridge, between the Sontea (north), Dranov (south) and Rosu (east) depressions. Within this perimeter, there are a series of water surfaces (gorges and canals, lakes and japs), in a total area of approx. 2219 ha, as well as a number of dammed enclosures, totaling approx. 14431 ha. The depression is furrowed by three main water arteries: Litcov Canal, Rusca Canal, Perivolovca Canal totaling approx. 106.3 km. From these main arteries, a number of other 17 secondary arteries branch out (approx. 152.8 km). For monitoring in the study, were chosen: Ciamurlia, Macuhova, Fastic Taranova, Rusca Perivolovca and Litcov (which crosses the entire depression, being perhaps the most circulating channel).

The Matia-Mehei complex is characterized by the presence of numerous lakes that occupy almost the entire central part of the depression. They are interconnected, participating in the exchange of water, which is generally done in good conditions. Poor clogging of the depression leads to an almost total lack of soils, and the vegetation consists of well-developed homogeneous reed in the central area and a mixture of reed, rush and sedges towards the periphery. This complex is framed by the great Chilia and Letea ridges to the west and east, it stretches between the Chilia arm (the Chernovca arm and the Chilia Field) to the north and the Old Danube of the great "M" to the south. The surface of the waters in the

Matița-Merhei complex is 5701.74 ha out of a total of 106 lakes. Among the lake basins are: Merhei 1137.47 ha, Matița 641.83 ha, Trei Iezere 433.5 ha, Bogdaproste 400.19 ha, Babina 427.35 ha. Characterized by a low average altitude (+0.718 mMMN, the value corresponding to the complex), 40.25% of the total area is below sea level. This fact indicates that, in the not-too-distant past, it was a maritime lagoon that is clogged in the present.

The Rosu-Puiu lake complex is, from a geomorphological point of view, a meadow in the process of being filled with fluvial sediments. The formation of the peat is limited to the most isolated places of the swamp. The canals, in the river delta, are accompanied by river ridges. The beams separate the channel bed from the swamps behind them.

During floods (which usually occur from mid-April to mid-June), vegetation retains suspended sediment. The largest amount of sediment, including the coarsest material (fine sands), is stored in the immediate vicinity of the river, so in ridges. The forests of *Salix alba* with *Fraxinus excelsior* and *Populus alba* are the natural vegetation of the ridges.

The high areas of the ridges are covered with forests or meadows, both growing on well-drained calcareous alluvial soils. As the elevation decreases, the vegetation is replaced by meadow forests or meadows, on glued alluvial soils. Below, in the swamps, grows reeds; reed swamps are found on periodically flooded / emerging clay soils.

The vegetation of the river ridges is affected in many places by anthropogenic exploitation. Where both cattle breeding and deforestation are practiced, the forest has been replaced by meadows. In this situation, conditions for the development of the species *Amorpha fruticosa* are created.

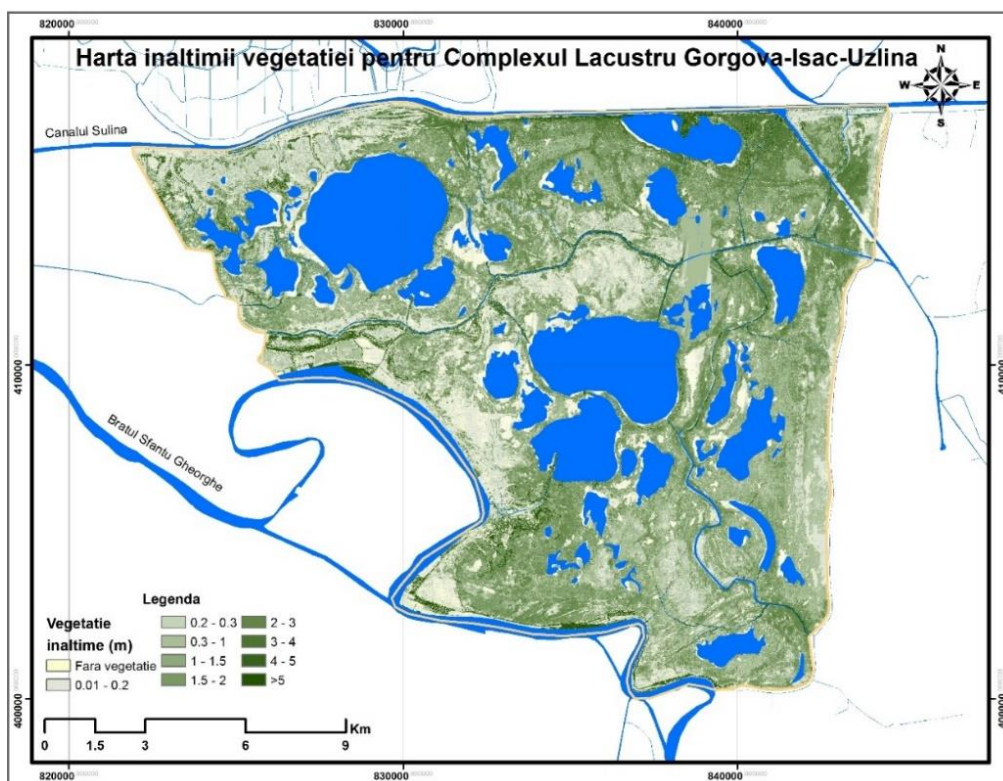


Fig 1. Vegetation height map for the Gorgova - Uzlina lake complex

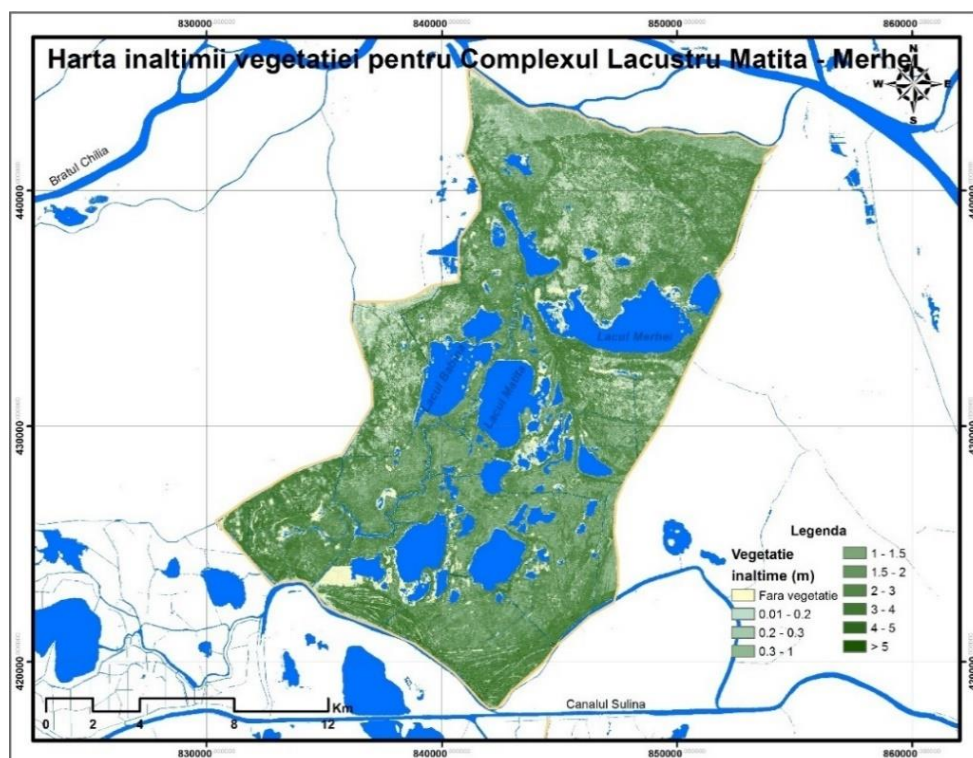


Fig 2. Vegetation height map for the Matița-Mehei lake complex

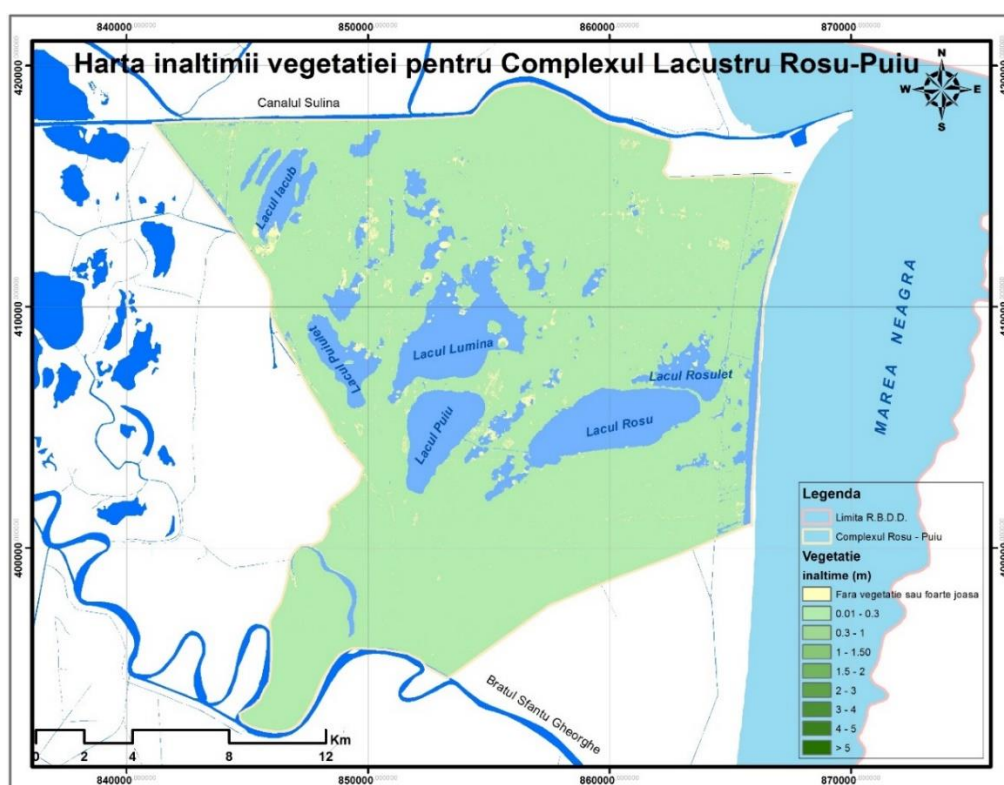


Fig 3. Vegetation height map for Rosu-Puiu lake complex

Regarding the Gorgova - Uzlina lake complex (fig 1). 19 types of habitats classified in the Romanian system were identified (R2202, R2203, R2205, R2207, R2210, R2211, R2213, R3715, R3716, R4406, R4407, R4408, R5301, R5303, R5304, R5305, R5306, of which 11 habitat types are classified in the Natura 2000 system in 5 habitat types (3150, 3160, 3130, 92A0, 3270). 3 are forest habitats, 4 aquatic, 2 meadows and 10 marshes.

From a conservative point of view, 6 habitat types have high and very high value (R2203, R2207, R2213, R4407, R4408), 10 habitat types have moderate value (R2202, R2205, R2211, R3716, R4406, R5301, R5303, R5304, R5306, R5309) and 4 habitat types have low value (R2210, R3715, R5305, R5312).

Regarding the Matita - Merhei lake complex (**fig. 2**). 17 types of habitats classified in the Romanian system were identified (R2202, R2203, R2205, R2207, R2210, R2211, R2213, R3716, R4406, R4407, R4408, R5301, R5303, R5304, R5305, R5306 of which R5309) of habitats are classified in the Natura 2000 system in 5 types of habitats (3150, 3160, 3130, 92A0, 3270). 3 are forest habitats, 4 aquatic, 2 meadows and 10 marshes. From a conservative point of view, 6 habitat types have high and very high value (R2203, R2207, R2213, R4407, R4408), 10 habitat types have moderate value (R2202, R2205, R2211, R3716, R4406, R5301, R5303, R5304, R5306, R5309) and 2 habitat types have low value (R2210, R5305).

In the Romanian classification system for the Rosu-Puiu lake complex (**fig. 3**). 19 types of habitats classified in the Romanian system were identified (R2202, R2203, R2205, R2207, R2210, R2211, R2213, R3715, R3716, R4406, R4407, R4408, R5301, R5303, R5304, R5305, R5306, of which 11 habitat types are classified in the Natura 2000 system in 5 habitat types (3150, 3160, 3130, 92A0, 3270). 3 are forest habitats, 4 aquatic, 2 meadows and 10 marshes. From a conservative point of view, 6 habitat types have high and very high value (R2203, R2207, R2213, R4407, R4408), 10 habitat types have moderate value (R2202, R2205, R2211, R3716, R4406, R5301, R5303, R5304, R5306, R5309) and 4 habitat types have low value (R2210, R3715, R5305, R5312).

During the field works, regarding the vegetation mapping, 37 vegetal associations (Gorgova-Uzlina), 33 vegetal associations (Matita-Merhei) and 33 vegetal associations (Roşu-Puiu) were identified, of which 20 are aquatic and marshy. The most common plant association is *Scirpo - Phragmitetum* W. Koch 1926 (R5309). The relatively common aquatic plant associations with relatively high coverage for the Gorgova - Uzlina complex are: *Lemnetum minoris* Soó 1927, *Lemnetum trisulcae* Knapp et Stoffers 1962 (R2202), *Hydrocharitetum morsus-ranae* Van Langendonck 1935 (R2205), *Trapaetum natantis* V. K2). Within the Matita-Merhei lake complex, 33 vegetal associations have been identified, of which 15 are aquatic and marshy. Particular attention, in order to preserve them, must be paid to plant associations: *Myriophyllo verticillati - Nupharetum luteae* W. Koch 1926, *Nymphoidetum peltatae* (Allorge 1922) Bellot 1951, *Eleocharidetum acicularis* W. Koch 1926 emend. Oberd. 1957 and the association *Nymphaeetum albae* Vollmar 1947. The only woody association with relatively large cover is *Salicetum albae-fragilis* Issler 1926 em. Soó 1957 classified in three habitat types (R4406, R4407, R4408).

Vegetal resources

2020-year research works identified 4 species of edible mushrooms.

Not entire Danube Delta Biosphere Reserve (D.D.B.R.) territory is proper for these species, but only 9155 ha. The areas are diverse, depending on the species of mushrooms being in agricultural land, forest, or mixed. From these areas a total quantity of 203 tons of mushrooms can be harvested sustainably, distributed as follows: *Agaricus arvensis* - 61 tons, *Agaricus silvaticus* - 22 tons, *Agaricus campestris* - 47 tons, *Pleurotus ostreatus* - 17 tons.

87 plant species of medicinal herbs were identified as well on the entire territory of D.D.B.R. (***, 2020). The total estimated harvestable quantity is about 19496 kg of dried biomass.

The distribution of these species is also diverse depending on the species biotope request: meadows, wetlands, forests, even fallow lands.

Another important vegetal resource is beekeeping important plant species, which counts 64 species all over the D.D.B.R. territory. In this case, we cannot estimate on every administrative unit the need of the beekeepers, but having recommendations of standardized potential as vegetation units (CÎRNU I., 1980): willow(wetland) forests – 20 kg honey/ha, natural wetland meadows 50 kg honey/ha, wetland pastures – 5 kg honey/ha, reed (*Phragmites australis*) surfaces (mildew honey) – 20 kg honey/ha.

Based on this, the study recommends 8 beekeeping routes that professional beekeepers can follow to have good harvests, accessibility, and sustain properly the bee families all over the vegetation season. The map of the proposed routes can be found in the study report (***, 2020).

The most capitalized vegetal resources are plant species that are grazed by domestic animals in the natural pastures – 184 species (***, 2020). These areas cover about 27500 ha from the total 580.000 ha of the D.D.B.R. territory. The estimation of the pasture grazing potential is given in livestock unit per

ha (LSU/ha) in every district of D.D.B.R. (***, 2020). On average, the pastures in D.D.B.R. are mediocre, with an average biomass production/year of 17,2 tons/ha and 0,73 LSU/ha.

The reed bed (*Phragmites australis*) areas are another vegetal resource that is present on large scale in D.D.B.R. – about 170000ha. The reed harvesting activity is organized by concession in 16 proposed areas. The effective harvestable reed is about 48500 ha with a medium value of harvestable potential – 8,3 to/ha, summing up a total biomass of about 87000 tones. (***, 2020).

Invertebrates of Community Interest

Regarding Invertebrates of Community Interest, between April and October 2020, on the *outer (southern) side of the DDBR (fig. 4)*, investigations were carried out in the areas: Luncavița, Rachelu, Revărsarea, Isaccea, Somova, Parcheș, Minerii, Tulcea, Nufăru, Bălteni, Murighiol, Plopu, Sarichioi, Enisala, Zebil, Jurilovca, Capul Doloșman, Cetate Histria and Vadu.

During warm season 2020, *inside the DDBR (fig. 4)*, investigations were carried out in the areas: Grindul Caraorman, Iacub Lake, Litcov Canal, Matița – Merhei complex, Lopatna Channel, Draghilea Channel, Furtuna Lake and Nebunu Lake (near to Periprava).

The red dots indicate the investigation areas visited before 2020, representing the classic investigation points, from which data related to the specific entomofauna of at least 10 years are collected.

In Luncavița, during the vernal period (June, 2020), 1 specimen belonging to the species of community interest *Lycaena dispar* (Haworth, 1802) was observed, north of the locality. In the Parcheș area, the presence of the species was also reconfirmed, this being observed here previous year. Also, during the investigations carried out in this area (this year), the presence of the gastropod species *Anisus vorticulus* (Troschel, 1834) was reported, after a long period of time marked by the lack of data on the presence. In the Tulcea, Zebil and Enisala areas, the species *Lycaena dispar* was observed - 1 specimen, 3 specimens respectively 1 specimen for the investigated areas.

Also, inside the DDBR, *Lycaena dispar* was observed on the eastern shore of the Crișan - Caraorman Channel (floating ferry crossing area), during the vernal period, this being a reconfirmation of previously collected data. The species of Community Interest *Anisus vorticulus* (Troschel, 1834) was also observed inside the Danube Delta in the ponds between the Draghilea Canal and Lake Marcu.

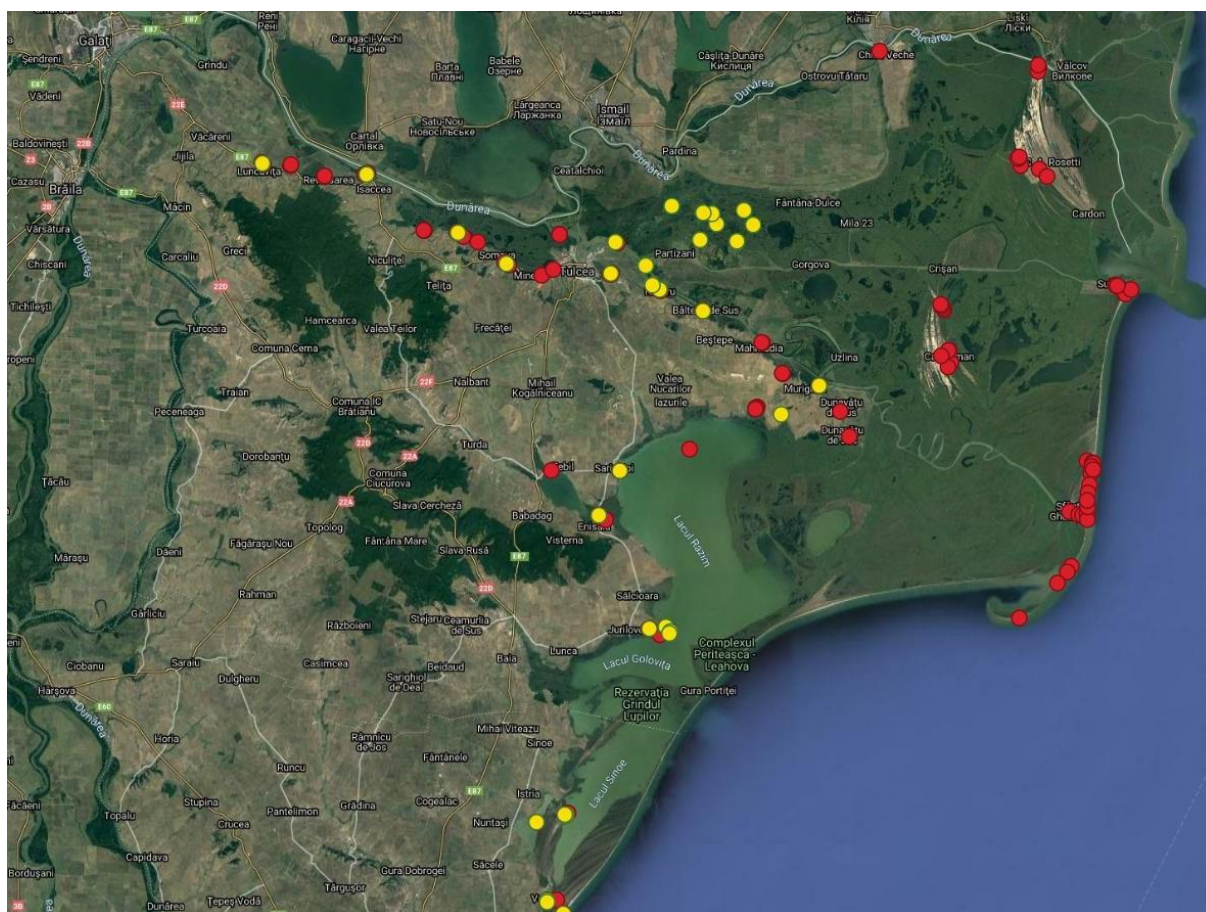


Fig. 4 Investigation points: July - September 2020 (yellow dots)

In the warm season 2020, only two species of invertebrates of Community Interest were found out of the 9 indicated in the Standard Data Form of the Danube Delta SCI (ROSCI0065). For most of them, there are big gaps in the presence and distribution data within the DDBR. The investigations carried out within the project (previously nominated) may bring, until the end, additional new data related to the presence and distribution of these species but also in terms of their conservation status.

The list of invertebrate species of Community interest observed during 2020 indicates a fairly accurate picture of the presence, distribution and abundance of entomofauna species in general, both for the terrace area and for the interior areas of the Danube Delta Biosphere Reserve. This period was characterized by fairly wide climatic extremes but also fluctuations in the same way in terms of water level, which most likely influenced the ethology of invertebrate species, depending on the consistency of the influence of abiotic factors.

Ichthyofauna and Fishery resources

In the autumn of 2020, 36 species of fish and 2 species of crustaceans (*Pontastacus leptodactylus* and *Eriocheir sinensis*) were caught in the river-maritime delta from the Roșu-Puiu lake complex. Overall, the ichthyofauna of the complex is dominated by limnophilous and stagnophilic-reophilous or reophilic-stagnophilic species such as *Blicca bjoerkna* (white bream), *Alburnus alburnus* (bleak), *Scardinius erythrophthalmus* (rudd) and *Rutilus rutilus* (roach), followed by characteristic-associated species. such as *Pelecus cultratus* (ziege), *Perca fluviatilis* (perch), *Clupeonella cultriventris* (Black Sea sprat), *Rhodeus amarus* (bitterling), *Leuciscus aspius* (asp) and *Carassius gibelio* (gibel carp), but most species are sporadic in the complex, some being accidentally-incidentally found here, with differences between sampling methods (Tab. 2). There is an increase in the number of species compared to previous years, but especially the appearance in the Roșu Lake of the Chinese mitten crab (*Eriocheir sinensis*) a non-native species that was first recorded relatively recently in the ecosystems of the Danube Delta, also for Romania was first publication about the presence of species in 1997 (Skolka 1998, Oțel 2003-2004).

Table 2. Fish species richness and Ecological parameters in the river-maritime delta of Roșu-Puiu lake complex in autumn 2020 (SN = Nordic gillnets, Electric = Electric fishing, AVA = commercial gillnets with mesh size a>45 mm, P = present, D = dominance, C = constancy, W = ecological significance index)

No	SPECIES	SN (a=5-55 mm)			AVA (a>45 mm)			Electric			Others fishing tools
		D class	C class	W class	D class	C class	W class	D class	C class	W class	
1	<i>Abramis brama</i>	D1	C1	W1	D2	C2	W2				P
2	<i>Alburnus alburnus</i>	D6	C5	W6				D6	C4	W5	
3	<i>Alosa tanaica</i>	D2	C3	W2							
4	<i>Pontastacus</i>	D1	C3	W2	D3	C2	W2				
5	<i>Atherina boyeri</i>	D1	C1	W1							
6	<i>Ballerus sapa</i>	D1	C1	W1							
7	<i>Bentophilus stellatus</i>	D1	C1	W1							
8	<i>Blicca bjoerkna</i>	D5	C5	W5	D5	C3	W3	D4	C5	W3	P
9	<i>Carassius carassius</i>	D1	C1	W1				D1	C2	W1	
10	<i>Carassius gibelio</i>	D1	C3	W2	D6	C4	W6	D5	C5	W4	P
11	<i>Clupeonella cultriventris</i>	D3	C3	W3							
12	<i>Cobitis elongatoides</i>	D1	C1	W1							
13	<i>Cyprinus carpio</i>	D1	C1	W1	D3	C3	W3	D2	C3	W2	P
14	<i>Eriocheir sinensis</i>				D1	C1	W1				
15	<i>Esox lucius</i>	D1	C2	W1	D3	C2	W2				P
16	<i>Gasterosteus aculeatus</i>	D1	C1	W1							
17	<i>Gymnocephalus</i>	D1	C2	W1							
18	<i>Hypophthalmichthys</i>				D3	C1	W2				

No	SPECIES	SN (a=5-55 mm)			AVA (a>45 mm)			Electric			Others fishing tools
		D class	C class	W class	D class	C class	W class	D class	C class	W class	
19	<i>Lepomis gibbosus</i>	D1	C1	W1				D5	C4	W4	
20	<i>Leucaspis delineatus</i>	D1	C1	W1				D1	C2	W1	
21	<i>Leuciscus aspius</i>	D2	C3	W2	D2	C2	W2				P
22	<i>Misgurnus fossilis</i>							D1	C2	W1	
23	<i>Neogobius fluviatilis</i>	D1	C2	W1							
24	<i>Ponticola kessleri</i>	D1	C1	W1				D1	C2	W1	
25	<i>Pelecus cultratus</i>	D1	C1	W1							
26	<i>Perca fluviatilis</i>	D5	C5	W4	D5	C3	W3	D3	C5	W3	P
27	<i>Perccottus glenii</i>	D1	C1	W1				D2	C4	W2	
28	<i>Petroleuciscus</i>	D1	C2	W2				D3	C4	W3	
29	<i>Proterorhinus</i>							D3	C4	W3	
30	<i>Pseudorasbora parva</i>	D1	C1	W1							
31	<i>Rhodeus amarus</i>	D2	C3	W2				D3	C5	W3	
32	<i>Rutilus rutilus</i>	D5	C5	W5	D1	C1	W1	D6	C4	W5	P
33	<i>Sander lucioperca</i>	D1	C2	W1							
34	<i>Scardinius</i>	D5	C5	W5	D2	C2	W2	D5	C5	W4	P
35	<i>Silurus glanis</i>	D1	C2	W1	D1	C1	W1	D1	C2	W1	P
36	<i>Syngnathus abaster</i>							D1	C2	W1	
37	<i>Tinca tinca</i>	D1	C2	W1				D1	C2	W1	
38	<i>Vimba vimba</i>	D1	C2	W1	D1	C1	W1				
36+2		33 species			14 species			18 species			10

Regarding Official captures (according to Danube Delta Biosphere Reserve Administration) from commercial fishing landing in 2020) it observed that big catches of freshwater fish species (92% of total fishery resources) were dominated by the non-predator's species as Giebel carp (54%), the bream category (common bream + white bream) 6.2% and the roach category (roach + rudd) 6% and surprisingly the carp species with 6.5% followed by two predatory species, catfish (4.4%) and pike (4.2%). Catches of marine fish were very small (0.4%), while migratory fish (without sturgeons because are prohibited) had a significant share in the total catch (7.2%) and was dominated by pontic shad (99.6%) (**tab.3.**).

Table 3 Categories structure on fish species from official catches (in tonnes) in 2020 from the Danube Delta Biosphere Reserve (DDBR)

SPECIES	TOTAL	% from total	% from category
<i>Carassius gibelio</i> (giebel carp)	1225	53.9	59
<i>Abramis brama</i> category (common bream+white bream)	141	6.2	7
<i>Rutilus rutilus</i> category (roach+rudd)	137	6.0	7
<i>Sander lucioperca</i> (pike-perch)	22	1.0	1
<i>Silurus glanis</i> (wels catfish)	101	4.4	5
<i>Esox lucius</i> (pike)	96	4.2	5
<i>Cyprinus carpio</i> (carp)	147	6.5	7
Others freshwater species	223	16.3	9
Total Captures Freshwater fish species	2092	92.0	100
PMM (Small marine fish)	7	0.3	76
Other marine species	2	0.1	24

SPECIES	TOTAL	% from total	% from category
Total Captures Marine fish species	9	0.4	100
<i>Alosa immaculata</i> (pontic shad)	163	7.2	99.6
<i>Alosa tanaica</i> (Azov shad)	1	0.0	0.4
Total Captures Migratory fish species	163	7.2	100
<i>Pontastacus leptodactylus</i> (crayfish)	10	0.4	100
Total Captures from DDBR	2274	100.0	100

Colonial waterfowl species

In 2020 a total of 140 colonies (plus an extra 7 probable locations) was found, holding 43193 - 64051 breeding pairs of 26 species. The most abundant species were Great White Pelican (12000 - 15000 pairs), Great Cormorant (9950 pairs) and Pygmy Cormorant (5130-6530 pairs).

Followed at a relatively large difference by Night Heron (2740-3840 pairs), Caspian Gull (2955 pairs), Squacco Heron (2100-2900 pairs), Little Egret (1800-2300 pairs) and Common Tern (1829 pairs).

The results of field investigations this season were compared with those of 2019 and previous years (5 seasons: 2015-2019) to identify changes over a longer period of time and to identify population trends. This season there was an absolute minimum of only 1420 pairs for the Whiskered Tern (*Chlidonias hybrida*), that represent a decrease of almost 6 times the average of 2015-2019 (8155 pairs) and a halving of the nesting numbers from 2019.

This season saw a 10% drop in the number of large cormorant (*Phalacrocorax carbo*) colonies in the R.B.D.D. but overall, the number of nesting species of the species is higher, amounting to 9950 pairs in 2020.

The very low water level in the spring of 2020 in Sinoie Lake led to an extense of Ceaplace Island surface of approx. 30%. This particular phenomenon favored nesting of 120 pairs of Dalmatian Pelican on this island and 200 juveniles were observed in this colony. This is a record number of juveniles recorded in this colony. Another important factor that significantly contributed to the reproductive success of the species in the Ceaplace colony this season was the low level of disturbance caused by tourists in the nesting season compared to previous years due to mobility restrictions imposed by the COVID-19 pandemic.

The special hydrological conditions recorded during this breeding season have generally favored ichthyophagous bird species in the way that the trophic resource has been more accessible.

However, there are also situations in which fish stocks in some areas have decreased and fishing efficiency has not covered the energy needs of all members of the colony. The environmental factors in 2020 breeding season were highlighted by a particularly low water level in spring and early summer and a sharp rise in the level in early July with severe negative influences on the distribution and reproduction of marsh tern species (*Chlidonias niger*, *Chlidonias hybrida*, *Chlidonias leucopterus*), Black-headed Gull and Common Tern, especially in the western part of the Danube Delta where the amplitude of floods is higher. The sudden rise in level in early July led to the abandonment of all colonies of all these species in areas with free flooding regime from the western half of Danube Delta.

For a more accurate assessment of the nesting populations of reed-breeding large heron species like Great Egret (*Ardea alba*), Purple Heron (*Ardea purpurea*) and Gray Heron (*Ardea cinerea*) in the RBDD perimeter, it is necessary to use the high-resolution aerial images collected during that breeding season (beginning of May). In recent years, the drainage of former fish farms and conversion to arable land led to the extinction of significant surfaces of important nesting and feeding habitats for the populations of colonial waterbird species in DDBR.

Wild fires (especially in March-May) are a significant threat for populations of reed-breeding species (*Ardea cinerea*, *Ardea purpurea* and *Ardea alba*).

Musura Island present a similar case with Ceaplace Island, so there is a strict corelation between the size of the colonial waterbirds breeding populations the available nesting surface and the degree of disturbance in the colonies.

The Romanian sector of Musura Island registered the largest number of nesting pairs of Pallas's Gull (*Larus ichthyaetus*) observed so far, respectively 270 pairs. This season, the disturbance during the nesting period of the species was very low due to the lack of tourists in the area until mid-June due to the mobility restrictions imposed by the Covid pandemic 19.

A new colony with 120 pairs of Sandwich Tern (*Sterna sandvicensis*) was discovered in 2020 by the INCDDD team along the Black Sea coastal line. This is the second nesting location of the species beside Musura Island. This new colony was also the only nesting site for the Little Tern (*Sternula albifrons*) in 2020.

Bird species of conservation interest

In 2020 we identified the presence of *Cettia cetti* in a single location near Isaccea, at the end of May, based on visual and audio observations. Following this, the area was investigated on a daily schedule in order to confirm the breeding of the species. The individual sang for a week, after which disappeared, proving that it did not breed in the area.

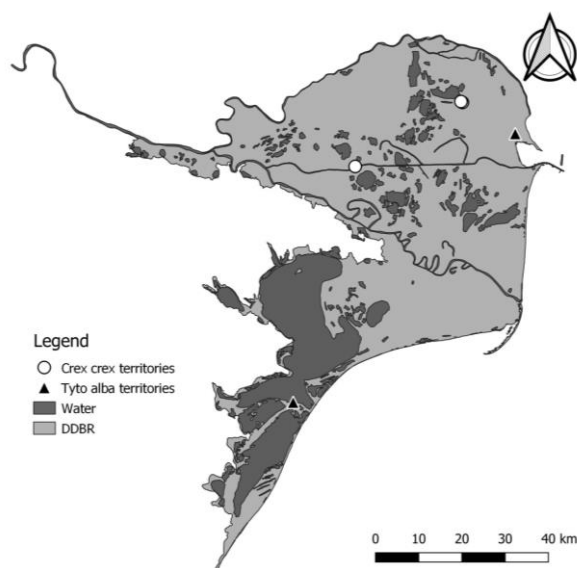


Fig. 5. Territories of *Crex crex* and *Tyto alba* observed in 2020 in DDBR

In 2019 we identified 3 active territories of *Crex crex* in the Danube Delta Biosphere Reserve (**fig. 5**), based on the number of singing males in the month of May: one on the Iulia Channel and 2 in the vicinity of Letea Forests. However, we cannot verify the successful breeding of the species in Danube Delta, in 2019 especially due to the fact that in the month of June the water levels were high, flooding the area close to Letea, where the territories of the two males were identified. In 2020, following the same protocol in the same areas, we did not find any *Crex crex* territory, which suggests that the species can breed in the Danube Delta irregularly.

Despite intensive searching for *Bubo bubo* in Letea Forest, Doloşman and Iancina Cape and Rândunica stone quarry, we didn't find any birds.

Regarding *Tyto alba*, we identified two territories: one near Cardon and one on Grindu Lupilor. In 2020 we record 24 hours long environmental sounds in different areas of Danube Delta Biosphere Reserve. Following the method described by Towsey et al. (2014), we produce false-color long-duration spectrograms. Based on these, we could visualize several acoustic events that are relevant from an ecological point of view: bird morning chorus, orthopteran calls, *Hyla arborea* calls, etc. This is the first step in a pilot study that can use these types of recording in DDBR in order to evaluate the health of the environment and develop a method of studying the climatic changes in this particular environment.

Mammals

The investigation sites (points and transects) of the 9 mammal species of Community interest were carried out in four habitat sections of the study area: fluvial delta (96 sites), fluvial-marine delta (30 sites), littoral area (13 sites) and Razim-Sinoie Laguna complex (25 sites). Here is reported the frequency of observations of these species in the 164 sites in the studied SCI areas and surroundings, in the period of January - November 2020.

As can be seen from **fig. 6.**, 6 of the 9 mammal species of Community interest were observed inside and around ROSCI0065 and ROSCI0066. The other 3 mammal species of Community interest that were not observed this year are *Vormela peregusna*, *Mustela eversmanii* and *Mesocricetus newtoni*.

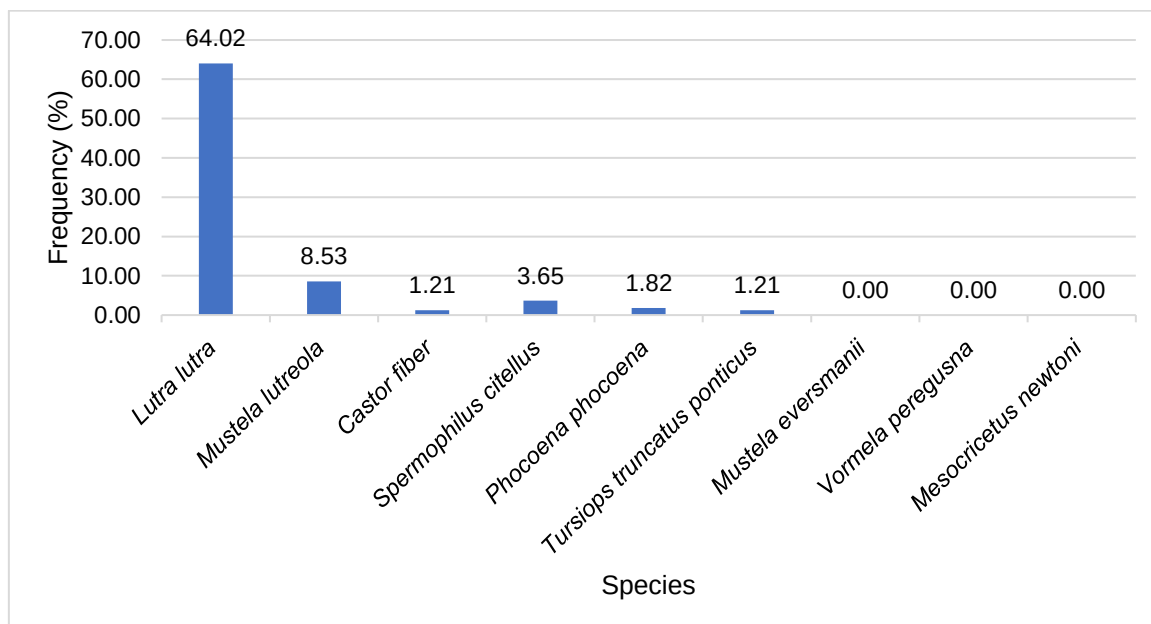


Fig. 6. Frequency (%) of the mammal species of Community interest observed in the 164 sites investigated in the year 2020 inside ROSCI0065 and ROSCI0066 and surroundings

Socioeconomic systems

The details obtained in the previous phases for the Administrative Territorial Units (A.T.U.) riparian to the Chilia and Sulina branches were analyzed. Following the use of the statistical method for interpreting the economic-financial factors, the following results were obtained for the selected performance indicators:

- *Availability of productive capital determined on the basis of capital and labor*

Analyzing the evolution of labor productivity at the level of the 2 branches, we notice a differences for 2016, the A.T.U.s bordering the Chilia branch totaling with 87919 lei less than those bordering the Sulina branch. For 2017, the two branches register close values, and the values registered in 2018 show an increasing trend when for both regions (**fig. 7**).

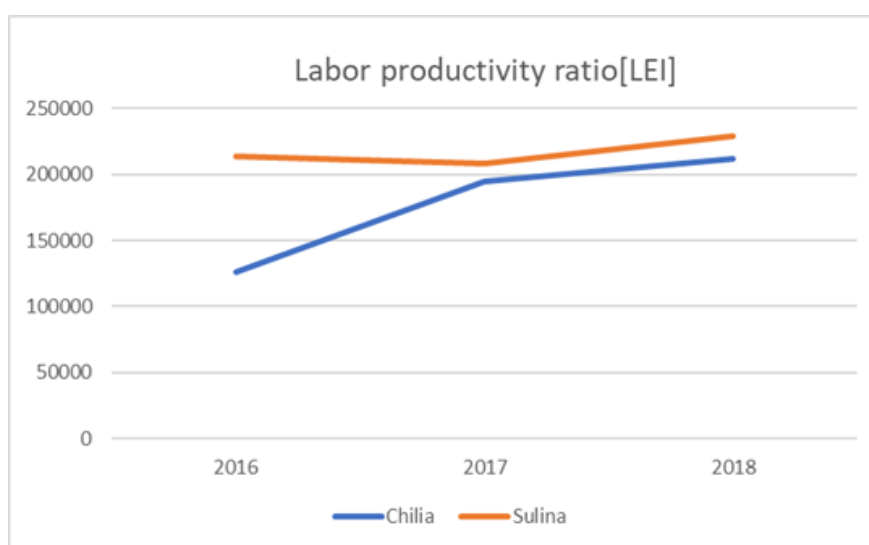


Fig 7. Labor productivity ratio calculated at the leve l of the two branches

The employed population in the studied ATUs							
	Ceatalchioi [%]	Pardina [%]	Chilia Veche [%]	C.A. Rosetti [%]	MALIUC[%]	CRISAN [%]	SULINA[%]
2016	16	11	7	15	16	22	19
2017	8	7	7	11	19	33	17
2018	10	9	6	11	21	35	23
Percentage of education expenditures out of total local expenditures [%]							
2016	17	18	30	45	12	11	25
2017	20	13	13	47	16	41	30

Fig.8. Graphic representing the employed population and education expenditures in the studied ATUs

• *Employed population interpreted by the endogenous labor force*

The graphic of the employed population shows differences between the seven ATUs studied. The weakest evolution is registered by ATU Chilia Veche where a percentage of 7% is registered for the years 2016 and 2017, in 2018 registering a percentage of 6%. The best evolution is recorded by ATU Crişan, increasing from 22% in 2016, to 33% in 2017, respectively 35% in 2018(**fig. 8**).

• *The quality of human capital interpreted by the endogenous factor investments in education*

Following the analysis of the graphic that represents the percentage of education expenditures from the total local expenditure, certain differences are observed between the amounts allocated to the annual investments in education among the seven ATUs studied. ATU Maliuc has the lowest percentage, 12% in 2016, with an increase to 16% in 2017 and the highest percentage is recorded by ATU C.A. Rosetti, allocating 45% in 2016 and 47% in 2017(**fig. 8**).

• *Public spending on infrastructure based on the public capital factor*

Reported at branches level, the ATUs bordering the Chilia arm are more developed in terms of drinking water distribution networks than those bordering the Sulina branch, registering values of 0.471 km / 10e.i. compared to 0.268 km / 10e.i. (equivalent inhabitants). Compared at branches level, there are large differences for the years 2016 and 2017, the ATUs bordering to the Sulina branch registering total quantities of 2062 in 2016 and 3415 in 2017 compared to 380 in 2016 and 972 in 2017 registered by the ATUs bordering the Chilia branch. In 2018, relatively close quantities are observed, 1296 for the Chilia branch and 1690 for the Sulina branch (**fig. 9**).

Total length of the simple drinking water distribution network [km / 10 l.e.]			Collected quantity of household and similar waste [kg / 10 l.e.]		
	Chilia	Sulina		Chilia	Sulina
2016	0.471	0.268	2016	380	2062
2017	0.471	0.255	2017	972	3415
2018	0.475	0.260	2018	1296	1690

Fig. 9. Graphic representing the total lenght of the simple drinking water distribution network and waste collected quantity for the studied branches

Ecotourism

Following the identification of the accommodation units, in Jurilovca tourism and recreation area, there was an increase in the number of accommodation units promoted on specialized site (www.booking.com, www.info-delta.com, www.turistinfo.ro, www.viziteazadelta.ro, www.lapensiuni.ro), by about 350% in 2019 compared to 2008 and by approx. 200% in 2019/2020 compared to 2013. (**Fig. 10**).

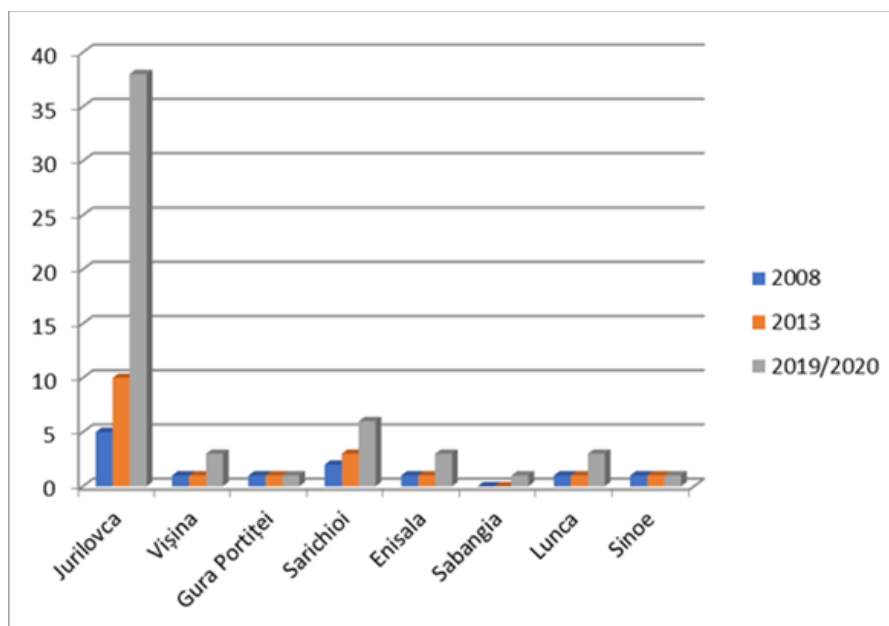


Fig 10. Comparative situation of the accommodation units identified in the Jurilovca area (by main localities) for the years 2008, 2013 and 2019/2020

Regarding the number of accommodation places, the increase is also obvious, their number doubling in 2019/2020 compared to 2008, as can be seen in **fig. 11**.

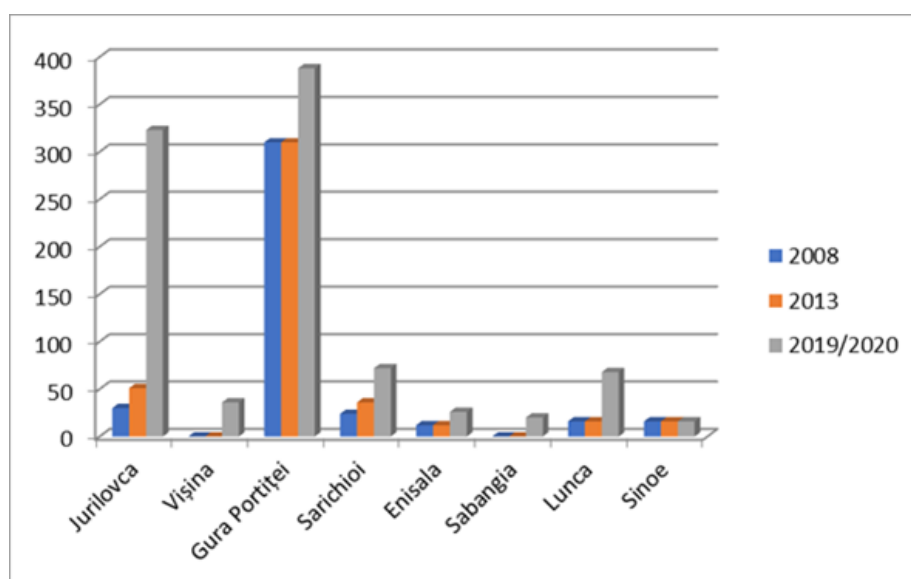


Fig 11. Comparative situation of the accommodation places identified in Jurilovca area (by the main localities) for the years 2008, 2013 and 2019/2020

According to the data provided by the Ministry of Tourism, 18 accommodation units and 826 accommodation places are accredited, representing 31% of the number of units and 87% of the total number of accommodation places identified on the tourist promotion sites. As for the data provided by the National Institute of Statistics, according to it, in Jurilovca area there are 512 accommodation places representing about 54% of the total number identified within the project. The comparative situation of the 3 providers of tourist data is represented in **fig. 12**.

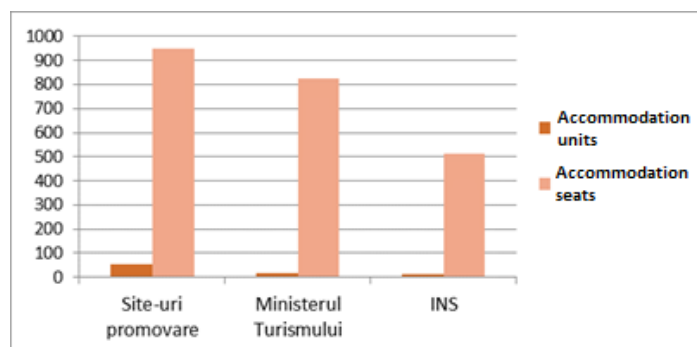


Fig. 12. Data situation regarding the accommodation units and accommodation places in the area of tourism and recreation Jurilovca

Regarding the distribution by localities, the one that stands out is Gura Portiței, however with a single unit providing touristic services (SC Complex EDEN SRL), with 388 beds (divided into several categories of comfort – villas / bungalows of 2 and 3 stars, cottages) in 2019/2020, of which all accredited (**fig. 13**).

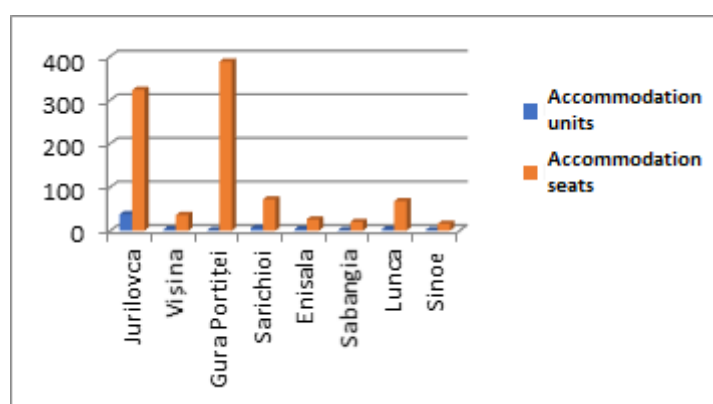


Fig.13. Situation of establishments and accommodation places by component localities

According to the National Institute of Statistics, in the recreation and tourism area of Jurilovca in 2019, a total number of 8190 tourists and 22827 overnights were registered, resulting in an average of about 3 days spent by tourists in delta. This high average regarding the duration of the stay spent in Danube Delta, compared to other areas, is primarily due to the beach at Gura Portiței. The tourist facilities here and the rather difficult accessibility, which make this area not to be chosen by tourists as a weekend destination, but rather one of spending holidays.

Comparing the tourism indicators for Crisan, Murighiol and Jurilovca areas, according to the investigations carried out, the Murighiol area stands out with 239 accommodation units and 5030 accommodation places. In Crisan, were registered 175 accommodation units and 3418 accommodation places and in Jurilovca were 56 accommodation units and 949 accommodation places, as can be seen in **fig. 14**.

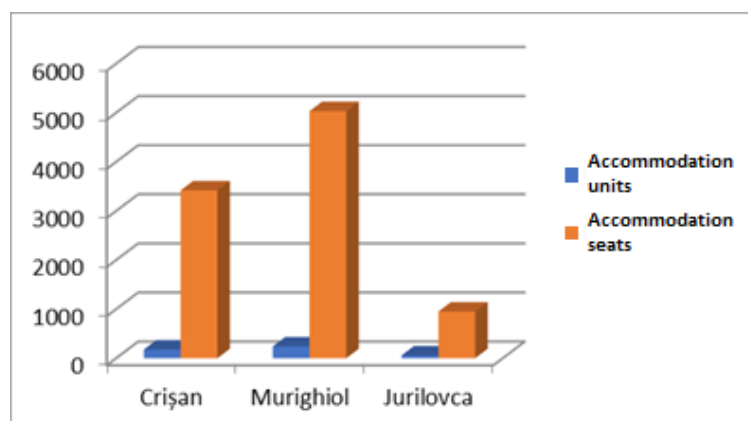


Fig. 14. Accommodation offers for the three recreation and tourism areas

According to the Ministry of Tourism, from the total number of establishments and accommodations identified in the three recreation and tourism areas, 31% are accredited in Crisan area, 65% in Murighiol area and about 85% in Jurilovca area.

According to the data provided by the National Institute of Statistics, the Murighiol area detaches itself from the Crisan area in terms of the number of tourists (number of arrivals) accommodated in the accommodation units from the area, with a maximum reached in 2019 of 36,551 tourists. It should be noted that the data provided by the National Institute of Statistics refers only to those accommodation units registered in the institute's database, the real number of tourists being much higher taking into account the number of accommodation units identified on the touristic promotion sites. In Jurilovca area, a maximum of 9457 tourists were registered in 2013, while in 2019 there were 6268 tourists arriving in the accommodation units in the area.

Regarding the dynamics of the overnight stays, the tourists spent on average three days in Jurilovca area (2.92 days), two and a half days in Crisan area and two days in Murighiol area. Thus, it turns out that Jurilovca and Crisan are areas chosen for slow-nature experiences and Murighiol area is suitable for fast-nature experiences or as a weekend destination.

In the Vadu-Corbu tourism and recreation area, 27 accommodation units and 419 accommodation places are accredited, representing 48% of the number of units and respectively 44% of the total number of accommodation places identified on the tourist promotion sites (63 accommodation units and 943 accommodation places). No accredited accommodation units were found in Vadu. As for the data provided by the National Institute of Statistics, according to it, in the Vadu-Corbu area, at the level of 2020, there are 3 accommodation units and 44 accommodation places representing approximately 5% of the total number identified within the project.

In the area Vadu-Corbu, a total of 323 tourists and 1076 overnights were registered in 2020, resulting in an average of about 3.33 days spent by tourists in the area. This high average length of stay here, compared to other areas from Danube Delta Biosphere Reserve, is primarily due to the beach.

As recreational activities offered in **Crisan** are canal trips, trips to Letea and Sulina, fishing packages, birdwatching, individual or guided tours with canoe and kayaking, rowing trips, and bike rental. The Spa and Relax activity, that did not exist until now and that develops with the advent of resorts attracts a certain category of tourists and can increase the number of staying days in Danube Delta. In **Murighiol** the recreational offers are mainly trips on canals especially in Dunavătu de Jos and fishing in Murighiol, promoted through street billboards. The appearance of fish restaurants, with menu "*a la carte*" helps the development of local tourism (locals from neighboring cities, Tulcea or Constanta, who come for a fishing meal).

Instead, in **Jurilovca area**, the recreational activities have as a central landmark the beach from Gura Portiței but also the touristic packages of fishing, trips to the tourist attractions in the area (Enisala Fortress, Cape Doloșman), bicycle rental, the experience of traditional fish and Lipovan households, folklore and gastronomic festivals.

As distinctive elements, in Corbu, the hostel owners offer programs of windsurfing, kitesurfing, snorkeling, kayaking, canoeing, diving or sport fishing and birdwatching on Corbu Lake.

CONCLUSIONS

From the point of view of **habitats**, the most common plant association is *Scirpo - Phragmitetum* W. Koch 1926 (R5309). The relatively common aquatic plant associations with relatively high coverage for the Rosu-Puiu complex are: *Lemnetum minoris* Soó 1927, *Lemnetum trisulcae* Knapp et Stoffers 1962 (R2202), *Hydrocharitetum morsus-ranae* Van Langendonck 1935 (R2205), *Ceratophylletum demersi*. During the field works, regarding the vegetation mapping, 33 vegetal associations were identified, out of which 15 are aquatic and marsh.

The estimated harvesting potential results of the natural harvestable **vegetal resources** of Danube Delta Biosphere Reserve territory during the year 2020, are an important potential income for the local population. Depending on the market demand this potential will be capitalized or not.

The impulse to capitalize on these harvestable species depend also on the Administration of the Danube Delta Biosphere Reserve. The local jobs as reed harvester and roof craftsmen, herbs and mushroom harvester, beekeeper, grazing animal breeder have to be promoted and well interconnected with the Romanian and international market to have better visibility and demand.

From our field observations, there is much to catch up on harvesting until the optimal limit for some resources such as medicinal herbs, beekeeping important plants, and reed is reached.

The reed resources need harvesting to be better maintained and well developed.

For better results and comparative analyses, this type of natural resources harvesting potential studies has to be done for a longer period of decades (Covaliov, S., 2012).

During this period (warm season 2020: April - October), a series of researches were carried out on **Invertebrates species of Community Interest**, related to their presence and distribution but also to the identification of specific habitats in which investigations are carried out repeatedly during the project. Investigations were carried out in the terrace area and inside of the DDBR.

The species *Anisus vorticulus* (Troschel, 1834) was observed inside the Danube Delta in the ponds between the Draghilea Channel and Lake Marcu, but it is important to mention the observation in the Parcheș area. At the same time the species *Lycaena dispar* (Haworth, 1802) was observed at Luncavița, Isaccea, Parcheș Tulcea, Zebil and Enisala (the terrace area of the DDBR) and on the eastern shore of the Crișan - Caraorman Channel (inside the DDBR).

The warm season period was characterized by wide climatic extremes and similar fluctuations in water levels, which most likely influenced the ethology of invertebrate species, depending on the consistency of the influence of abiotic factors on the species.

The **ichthyofauna** of the river-maritime delta Roșu-Puiu complex lakes is dominated by limnophilous and stagnophilic-reophilous or reophilic-stagnophilic species such as *Bilca bjoerkna* (white bream), *Alburnus alburnus* (bleak), *Scardinius erythrophthalmus* (rudd) and *Rutilus rutilus* (roach), followed by characteristic-associated species such as *Pelecus cultratus* (zige), *Perca fluviatilis* (perch), *Clupeonella cultriventris* (Black Sea sprat), *Rhodeus amarus* (bitterling), *Leuciscus aspius* (asp) and *Carassius gibelio* (gibel carp), with new appearance in the Roșu Lake of the crabs (*Eritrocheir sinensis*) a non-native species that was first recorded relatively recently in Romania and in the ecosystems of the Danube Delta in 1997.

Official captures (according to Danube Delta Biosphere Reserve Administration) from commercial fishing landing in 2020, the category of freshwater fish clearly dominated the catches in the DDBR, especially Gibel carp, followed by migratory fish (pontic shad), and small quantities are present in the categories of marine fish, crayfish and caviar.

Spatial distribution of **waterbird colonies** in DDBR clearly shows that the vast majority are located in the immediate vicinity of aquatic surfaces (sea, lagoon, lake, marsh). Most colonies are located in hard-to-reach areas, whether they are flooded forests, flooded reedbeds, floating islands of reed (plaur) areas, sandy islands or compact surfaces with floating aquatic vegetation. If we consider that the proximity, the surface and the quality of favorable feeding habitats to the location of the colony is reflected by the size of the nesting populations in that colony we can use population assessments for these species as indicators of environmental quality. The quantitative and qualitative changes in the populations of these species reflects the environmental conditions in the area. Thus, the results of this study are useful in describing not only the status of bird species populations but also the environment and the impact that human actions have on the functionality of deltaic ecosystems and the ecological role of these species in DDBR. The results regarding the colonial waterbirds populations numerical trend and distribution and the factors that influence them are key elements in order to design, develop and adapt DDBR strategy and management measures.

From the point of view of **bird species of conservation interest**, we identified the possibility of irregular breeding of *Crex crex* in Danube Delta Biosphere Reserve.

Regarding *Cettia cetti*, we recorded one singing male in the breeding period for a period of one week near Isaccea, however the individual was most likely a migrant bird. We did not identify any territorial *Bubo bubo*, but successfully identified two breeding pairs of *Tyto alba* in Danube Delta Biosphere Reserve in 2020. Based on false-colours long duration spectrograms we conclude that 24 hours audio recording can be used in Danube Delta for ecological and climate change studies.

In the research conducted in 2020, only 6 of the 9 **mammal species** of Community interest were found. Three of them in the fluvial delta, two in the fluvial-marine delta, two in the littoral area and three in the

Razim-Sinoie Laguna complex. It is worth mentioning that of the nine mammal species, only the otter, *Lutra lutra*, was observed in all mentioned habitat sections.

From the point of view of **Socioeconomic Systems**, the comparative analysis of the ATUs at the level of the two studied branches offers a new perspective on the conclusions from previous studies. If in the past it was considered that in the ATUs with a high labor productivity ratio, a high percentage of the employed population is observed, when we report the labor productivity at the level of the two branches, a close value registered for 2018 is observed.

Values for the employed population in ATUs bordering the Chilia branch are much lower than the values recorded by ATUs bordering the Sulina branch, which is visible both graphically and also as a percentage (36% cumulative for the Chilia branch and 79% cumulative for the Sulina branch registered for 2018). These results lead to the conclusion that further studies are needed to highlight the influence of endogenous economic factors on regional development in the Danube Delta.

Following the observations and investigations carried out during 2020, in the **tourist and recreation** areas Crișan, Murighiol, Jurilovca and Vadu-Corbu, it was noticed that tourism is in continuous development and organization. In recent years, new types of tourism have developed, such as the one of "cultural experiences" type and new hostels have appeared that preserve the architectural and traditional elements of "Lipovan households" or that were built by renovating old houses (Jurilovca village). The "Relaxation and Spa" type tourism was also noticed by the appearance of the resort and luxury tourist complexes (four and five stars) with a large accommodation capacity (eg. Lebăda Luxury Resort & Spa) in Crișan area, and boarding houses with swimming pool and related recreational activities (Spa) in Murighiol area.

Also, it was found a better organization of recreational activities such as trips on canals or to Letea and Sulina, through the appearance of resorts in Crisan area and the appearance of fish restaurants with "a la carte" menu in Murighiol area, that favors the development of local tourism.

According to statistical data, the average length of stay is two and a half days in the Crisan area, 2 days in the Murighiol area and almost 3 days in the Jurilovca area (Gura Portiței attracts the largest number of tourists), showing that the recreation and tourism areas Jurilovca and Crisan are areas for slow-nature experiences and Murighiol area is suitable for fast experiences or as a weekend destination.

The average amount of spending a stay in Vadu-Corbu recreation and tourism area is 3.33 days, a high average compared to other areas of the Danube Delta Biosphere Reserve, due to the beach and for recreational activities involving the practice of water sports and the use of sailboats. This area has become very attractive for tourists eager to camp or for those who prefer stays with caravans, however, it risks being threatened with the destruction of habitats due to the huge number of tourists who enter by car or who camp uncontrollably on the beach.

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The entire team of researchers from the Danube Delta National Institute for Research and Development Tulcea expresses its thanks for the essential contribution made to the Romanian research and also the sadness for the loss of our friend and colleague:

Diana Gabriela BOTA (23.05.1967-21.10.2021).



When someone becomes a memory, the memory becomes a treasure.

REFERENCES

- Allan, J.D., Abell, R., Hogan, Z.E.B., Revenga, C., Taylor, B.W., Welcomme, R.L. & Winemiller, K. 2005. Overfishing of inland waters. *BioScience*, 55: 1041–1051;
- Bibby C.J., Burgess N.D. et Hill D.A., 2000: *Bird Census Techniques*. Academic Press, London, 2nd edition;
- Bibby C., Jones M., Mardsen S., Munteanu D., 2000. Metode de teren pentru studiul păsărilor. Metode de evaluare a abundenței păsărilor. *BirdLife International*. S.O.R. Cluj. p. 12-122;
- Borza, A., Boșcaiu N. 1965. Introducere în studiul covorului vegetal. Editura Academiei R.P.R., București;
- Braun-Blanquet, J. 1932. *Plant sociology* (Transl. G. D. Fuller and H. S. Conrad). McGraw-Hill, New York. 539 pp;
- CIRNU I., 1980, *Flora meliferă*, Ed. CERES, Buc.;
- Covaliov (S.), Doroftei (M), Negrea (B.M.), 2012, Assessment of vegetal resources in Danube Delta, *Advances in Agriculture & Botany - International Journal of the Bioflux Society*, vol. 4, nr. 2, pag. 57-72, Cluj Napoca, IC TM 2011 5,22;
- Cristea, V. 1993. *Fitocenologie și vegetația României*. Universitatea Babeș-Bolyai, Cluj Napoca;
- Cristea, V., Gafta D., Pedrotti F. 2004. *Fitocenologie*. Editura Presa Universitară Clujeană, Cluj Napoca;
- Dinu, M 2005 *Ecoturism: Coduri etice și norme de conduită*, CD Press, 96 pp, ISBN 975-7989-35-X;
- Doniță N., Popescu A., Paucă-Comănescu M., Mihăilescu S. & Biris I.A., 2005. *Habitatele din România*. Bucuresti, Romania: Editura Tehnică Silvică;
- Gafta D., Mountford O., 2008. *Manual de interpretare a habitatelor Natura 2000 in Romania*, Editura Risoprint, Cluj-Napoca;
- Ionescu V., Apetrei M., 1988 – *Îndrumător practic pentru cunoașterea insectelor*. Colectare – Preparare – Conservare. Complexul Muzeal Neamț, Muzeul de Științe ale Naturii Piatra Neamț, 223 pp.;
- Ionescu O., Ionescu G., Jurj R., Cazacu C., Adamescu M., Cotovelea A., Pașca C., Popa M., Mirela I., Stan, G. 1995. Metode statistice cu aplicații în cercetări entomologice (VII). *Bul. inf. Soc. lepid. rom.*, 6 (1-2): 67-96.
- Iorgu I. Ș., 2015 – *Ghid sintetic pentru monitorizarea speciilor de nevertebrate de interes comunitar din România*. Material editat de Asocieria S.C. Compania de Consultanță și Asistență Tehnică S.R.L. și SC Integra Trading SRL., București, 159 pp.;
- Kays, R., Tilak, S., Kranstauber, B., Jansen, P.A., Carbone, C., Rowcliffe, M. 2011. Camera traps as sensor networks for monitoring animal communities. *Int. J. Res. Rev. Wirel. Sens. Networks*, 1, 19–29;
- Monterroso P., Castro D., Silva T. L., Ferreras P., Godinho R., Alves P., 2013. Factors affecting the (in) accuracy of mammalian mesocarnivore scat identification in South-western Europe. *Journal of Zoology*, vol. 289, pag. 243-250;
- O'Brien, T.G., Kinnaird, M.F. & Wibisono, H.T. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Anim. Conserv.*, 6, 131–139.;
- Oțel V., 2003-2004. The presence of *Eriocheir sinensis* Milne-Eduards, 1835 (CRUSTACEA, DECAPODA) in the Danube Delta Biosphere Reserve area. *Scientific Annals of the Danube Delta Institute*, vol. 10, Tulcea (Romania), p. 45-48;
- Sîrbu I., Benedek A. M., 2004 – *Ecologie Practică*. Editura Universității Lucian Blaga, Sibiu, 260 pp.;
- Sîrbu G., Chiriac S., Pop M., Attila Ș. și Deju R., 2013. Ghid sintetic de monitorizare pentru speciile de mamifere de interes comunitar din România. Editura: Silvică, ISBN: 978 - 606 - 8020 - 37 – 2. p. 7-165;
- Skolka M., 1998. Increase of biodiversity by immigration – new species in the Romanian fauna *Beroe ovata*, *Corbicula fluminea*, *Doridella obscura*, *Eriocheir sinensis*, *Callinectes sapidus*. *Studii și Cercetări de Biologie*, Univ. Bacău, 4: 235-240;
- Swann, D.E., Hass, C.C., Dalton, D.C. & Wolf, S.A. 2004. Infrared-triggered cameras for detecting wildlife: an evaluation and review. *Wildl. Soc. Bull.*, 32, 357–365;
- Tobler, M.W., Pitman, R.L., Mares, R. & Powell, G. 2008. An evaluation of camera traps for inventorying large- and medium-sized terrestrial rainforest mammals. *Anim. Conserv.*, 11, 169–178;
- Towsey M., Zhang L., Cottmans – Fields M., Wimmer J., Zhang J., Roe P., 2014 Visualization of Long-duration Acoustic Recordings of the Environment. *Procedia Computer Science* 29:703 – 712;
- Vanhove N., 2005 *The Economics of Tourism Destinations*, Butterworth–Heinemann, Oxford ISBN 0-7506-6637-4;

- Wearn, O.R., Carbone, C., Rowcliffe, J.M., Bernard, H. & Ewers, R.M. 2016. Grain-dependent responses of mammalian diversity to land-use and the implications for conservation set-aside. *Ecol. Appl.*, 26, 1409–1420;
- Zlinszky, A., Heilmeyer, H., Balzter, H., Bálint C., Pfeifer, N., 2015, Remote Sensing and GIS for Habitat Quality Monitoring: New Approaches and Future Research, *Remote Sens.* 2015, 7, 7987-7994; doi:10.3390/rs70607987;
- *** 2007 - Ordonanță de Urgență nr. 57 din 20 iunie 2007 privind regimul ariilor naturale protejate, conservarea habitatelor naturale, a florei și faunei sălbatice.
- *** 2009 - Strategie de Vizitare, Andrei Blumer și Alois Lang, Asociația de Ecoturism din România, Jamil Benabdallah, Détente Company / Consultants.
- *** 2009 - Zonarea pentru recreere și turism în RBDD – Componentă a strategiei de turism și management a vizitatorilor, Andrei Blumer și Alois Lang, Asociația de Ecoturism din România, Jamil Benabdallah, Détente Company / Consultants, Liliana Ivancenco, Cristina Pârciog, ARBDD.
- *** 2016 - PRIMA CONTRIBUȚIE NAȚIONALĂ LA ELABORAREA STRATEGIEI UNIUNII EUROPENEPENTRU REGIUNEA DUNĂRII. Bucuresti: Ministerul Afacerilor Externe.
- *** 2018 - Comunicarea Comisiei „Gestionarea siturilor Natura 2000 Dispozițiile articolului 6 din Directiva 92/43/CEE (Directiva Habitate)”, Bruxelles, 21.11.2018 C(2018) 7621 final.
- *** 2019 - Cercetări privind starea și conservarea biodiversității, habitatelor, exploatarea sustenabilă a resurselor naturale, impactul speciilor non-native și implicațiile socio-economice din Rezervația Biosferei Delta Dunării, 120 pagini. Raport Faza 1 / martie/2019, al proiectului nr. PN 19 12 01 03 01 (coord. Ion NĂVODARU) al contractului nr. 41N/2019/MCI, executant: INCDDD - Tulcea. Tulcea, România.
- *** 2020 - Cercetări privind starea și conservarea biodiversității, habitatelor, exploatarea sustenabilă a resurselor naturale, impactul speciilor non-native și implicațiile socio-economice din Rezervația Biosferei Delta Dunării, XX pagini. Raport Faza 3 / sept /2019, al proiectului nr. PN 19 12 01 01 03 (coord. Ion NĂVODARU) al contractului nr. 41N/2020/MCI, executant: INCDDD - Tulcea. Tulcea, România.
- *** 2021 - Raport Faza 8 / noiembrie / 2021, al proiectului nr. PN 19 12 01 03 (coord. Gabriel LUPU) al contractului nr. 41N/2019/MCI, INCDDD- Tulcea. Tulcea, România.
- *** www.ecotourism.org
- *** www.ecotourism-romania.ro
- *** www.booking.com
- *** www.info-delta.ro
- *** www.primaria-corbu.ro
- *** www.viziteazădelta.ro
- *** www.turistiinfo.ro
- *** www.lapensiuni.ro
- *** www.descoperadeltadunarii.ro
- *** www.ddbra.ro

