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ECOSYSTEM SERVICES ASSOCIATED WITH TROPHIC ANALYSIS OF THE AVIFAUNA OF THE DAM LAKES IN THE MIDDLE AREA OF THE ARGEȘ VALLEY

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Abstract
Ecosystem services are becoming an integral part of science and biodiversity conservation strategies, however, our knowledge is limited to only a few services and in the study area they were not yet evaluated. Birds are ecologically diverse and more beloved and well-known than other vertebrate groups. Some bird species are useful in applications such as environmental quality and are used as early warnings of environmental change and climate change assessment. The economic relevance of birds is not widely quantified and appreciated, and the economic relevance to human society of the ecological roles of birds is neglected. Our research contributes to the improvement of knowledge about birds in the area, to the quantification of some services provided by birds through the trophic analysis of avifauna. This research is useful in understanding their importance to ecosystems and the people who benefit from them, as well as in developing conservation strategies for birds and their habitats. Of the 207 bird species identified in the study area, belonging to 17 orders and 49 families, species with a zoophagous - polyphagous trophic regime and insectivorous species predominate. Thus, representatives of seven food guilds were found, with the predominance of zoophagous - polyphagous and insectivorous species, and the food guilds with the lowest number of species were the piscivorous and vegetarian dietary guilds. The majority (34 - 51 %) of insectivorous species populate the habitats of forests and riparian forests and localities (building area), while among zoophagous – polyphagous (43) and omnivores (19) species dependent on wetlands; most of the insectivorous species are summer visitors (35). Most of the bird species studied also are important from an ecological and economic point of view, providing numerous ecosystem services and play a vital role in agriculture and forestry by managing pest and rodent populations. Thus, insectivorous species (55 species) have a special role in controlling pest insects, in reducing insect populations, and nocturnal birds of prey (with a zoophagous – polyphagous and carnivore - predator trophic regime) have a role in managing rodent populations harmful to agriculture. Some bird species, omnivorous or vegetarian, pollinate or disperse the seeds of plants, and others (Sturnus vulgaris) clean the bodies of other animals (sheep, goats etc.). Corvids and some larids have a certain role on garbage ramps. Birds in the study area also have a cultural role, they are emblematic of nature, they are loved, observed, monitored (birdwatching - recreational activity), fed and used as artistic inspiration and with traditional value in the study area. On the other hand, huge flocks of anseriformes, in the winter aspect, feed on arable land, but they cause damage to farmers, ecosystem disservices, and it is necessary to grant a subsidy per land surface for feeding goose species. By determining the contributions of birds (and biodiversity in general) to humans, their value can be better understood and appreciated at the level of strategies regarding the conservation of biodiversity with special benefits for people.

Keywords: avifauna, ecosystem services, trophic analysis

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1. INTRODUCTION

Ecosystem services are becoming an integral part of science and biodiversity conservation strategies, however, our knowledge is limited to only a few services (Carucci et al, 2022) and in the study area they were not yet evaluated. Ecosystem services represent all the benefits and advantages generated by the existence of a natural area. Observing this accumulation of benefits is not a simple endeavor, because nature acts on multiples, providing a wide range of benefits. They are most often classified into four major categories namely: production services, regulation services, support services and cultural services (Adamescu et al., 2016).

This ecosystem services classifications devised is understandable given the complexity of the task, it is also benefic considering the range of socio-ecological contexts, biodiversity and ecosystem services indicators, scientific exploration, economic development, policy development etc. Ecosystem services are the aspects of ecosystems utilised (actively or passively) to produce human well-being. However the term ecosystem services was coined, according to most sources, in 1981 by Paul and Anne Ehrlich (Busch et al., 2012; Braat and Groot, 2012).

Birds are ecologically diverse and more beloved and well-known than other vertebrate groups. Birds devour pest insects, pollinate flowers, disperse seeds, cycle nutrients, and modify the environment in ways that benefit other species. Birds are also loved, observed, monitored, fed and used as artistic and religious inspiration by millions of people around the globe. Assessing these ecosystem functions of birds directly as ecosystem services has greatly increased over the past two decades and the ecological relevance of birds is well established. However, the economic relevance of birds is not widely quantified and appreciated, and the economic relevance to human society of the ecological roles of birds is even less understood (Whelan et al., 2015; Conete, 2018; Conete, 2021; Carucci et al., 2022).

Our research contributes to the improvement of knowledge about birds in the area, to the **quantification of some services provided by birds** through the trophic analysis of avifauna. This research is useful in understanding their importance to ecosystems and the people who benefit from them, as well as in developing conservation strategies for birds and their habitats.

The Argeș River is one of the most important watercourses in Argeș County and a main tributary of the Danube, originating at the confluence of the Buda and Capra streams (Barco and Nedelcu, 1974). A series of reservoirs were created along its course a few decades ago, a successive dams: Vidraru, Zigoneni, Curtea de Argeș, Vâlcele, Bascov, Pitesti, Golești, etc. (Fig.1). These reservoirs had a significant impact on the surrounding landscape and influenced the structure and temporal and spatial dynamics of the bird species living in the area (Mătieș, 1969; Munteanu and Mătieș, 1983; Gava, 1997; Gava et al., 2004; Conete, 2011; Conete, 2019).

The beginnings of the research on the aquatic avifauna of this reservoirs created in the upstream or midstream regions are due to Dan Munteanu (1961-1966), who continued his work together with Mătieș (1969-1982). Since 1999, the local avifauna was intensively studied, numerous articles have been published, especially regarding the Vâlcele-Golești area, which later became a component of the Nature 2000 network (Gava, 1997; Conete et al., 2008; Mestecăneanu et al., 2013; Conete, 2011; Conete, 2019 etc.).

In the last 50 years, the area of natural wetlands has been reduced by more than 80%. Taking this into account, artificial wetlands can contribute to the conservation of biodiversity. Key bird species may be affected in the study area due to **anthropogenic pressure, degradation and fragmentation of the habitats, due to climate changes**. In this context, it is vital to understand

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and appreciate the services provided by birds in the development of conservation strategies for birds and their habitats.
Concrete actions are needed from the local community, from the responsible institutions, from competent **people dedicated to the conservation of biodiversity** (http://www.iucnredlist.org/; Munteanu D., 2009; Conete, 2011; Conete, 2018).

2. MATERIALS AND METHODS

The research was conducted in the Arges river valley comprising the following reservoirs: Vâlcele (408 ha), Budeasa (412 ha), Bascov (162 ha), Pitești (122 ha) and Golești (649 ha), which are important wintering, significant feeding, passage and nesting areas for many bird species (Fig.1; fig.2).
The Vâlcele, Bascov, Budeasa, Pitesti and Golești Reservoirs are part of the Argeș River Reservoirs (ROSPA0062 - „Lacurile de acumulare de pe Argeş"), a site that is included in the Natura 2000 network (Gava et al., 2007; Papp and Fântănă, 2008; Conete, 2011, Conete, 2017). The establishment of the Natura 2000 network is the result of the Habitats Directive and the Birds Directive, legislation designed to protect the most threatened habitats and species in Europe (Papp and Fântână, 2008). The large number of individuals and key species monitored here each winter is the most important justification for its inclusion in this network.

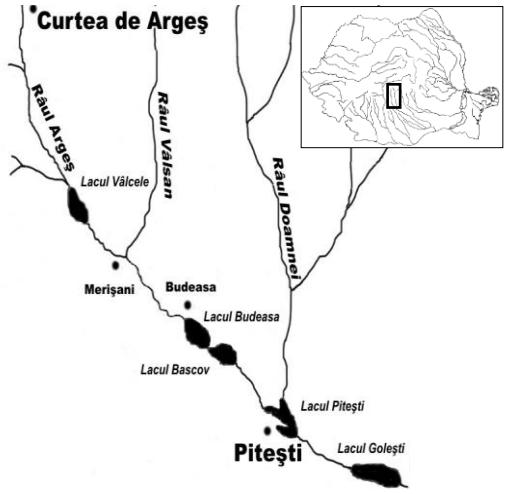

Figure 1. The middle basin of the Argeș River

Due to the silting process and development of vegetation, the newly created reservoirs have become favorite areas for some species of birds. Some species come here to nest and to feed, mostly to spend the winter, and other species stop here during their passage, because the middle valley of the Argeș River is a continuation of the Rucăr – Bran corridor, one of the corridors used by migratory birds for crossing the Carpathians. Thus, this area includes one of the most important aquatic ecosystems of the Arges river basin and, subsequently, the highest concentrations of birds in the region (Mătieș, 1969; Conete, 2011).
Regarding the climate characteristic of the area is temperate-continental with cold winters and hot summers with hilly characteristics (Barco and Nedelcu, 1974). The vegetation in the lake area is typical of the hill area in the south.

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The hills bordering the lakes are covered with vast areas of deciduous forests (oak - *Quercus robur* L., linden - *Tilia cordata* Mill., beech - *Fagus sylvatica* L., hornbeam - *Carpinus betulus* L., etc.) and orchards with fruit trees, which support a relatively rich avifauna. This rich avifauna can also be observed on the water mirror, where birds come in search of food. Thus, the study area consists of a mosaic of habitats: vast expanses of water with reed belts, stretches of rivers, smooth hills covered with forests, meadows, shrubbery, meadow forests and orchards with agricultural plots. As regards the vegetation of the area of the reservoirs, this is represented by *Phragmites sp.*, *Typha sp.*, *Carex sp.*, *Juncus sp. Salix sp.*, *Alnus incana*, *Populus alba*, *Rosa canina*, *Rubus sp. Ceratophillum*, *Myriophyllum* etc. The process of silting (especially in the area of Pitești and Bascov Lakes) permitted the establishment of the reed beds *(Phragmites*, *Typha)* and of the other typical wetland plants (Conete, 2011; Conete, 2019). The fauna is rich, the vertebrates being represented by fish (*Esox lucius*, *Cyprinus carpio*, *Perca fluviatilis*, *Leuciscus cephalus*, *etc.*), amphibians (*Bombina variegata*, *Rana ridibunda*, *Salamandra salamandra etc.*), reptiles (*Emys orbicularis*, *Natrix natrix*, *Natrix tessellata*, *Lacerta viridis*, *Anguis fragilis*) and mammals (*Talpa europaea*, *Apodemus agrarius*, *Arvicola terrestris*, *Ondatra zibethica*, etc.).
The attractiveness of reservoirs (anthropogenic aquatic ecosystem) for avifauna is different. Thus, it is based on the size of the surface of the water body (Fig.2), but also on the heterogeneity of the habitats adjacent to the reservoirs under research. In accordance with the degree of availability of food resources and nesting places, as well as with the more or less significant presence of predators and, above all, with anthropogenic disturbance, the highest richness of breeding species was recorded in the upstream lakes by Pitesti. The greater the habitat diversity and the structural complexity or heterogeneity in a study area, the greater the bird species diversity (Conete, 2011).

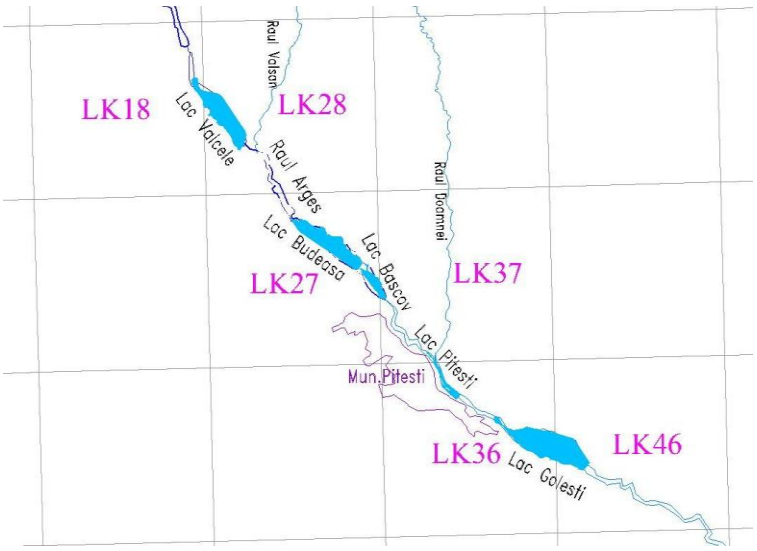

Figure 2. The division of the middle basin of Arges in 10x10 km² areas according to the UTM (Universal Transverse Mercator) network and their numbering (after Lehrer & Lehrer, 1990 – modified Conete, 2011)

For the trophic analysis of avifauna, the research was focused on bird communities in wetland habitats, open habitats (meadows and shrubbery), in forest habitats found in the immediate vicinity of the reservoirs and in built-up areas. We used the following methods: the itinerary method (routes

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along the shores and dams), the fixed-point observation, and also the observation on the move on the lakes and in the shrubbery, using the boat.
Research in the field had been permanently made on these lakes and around them, starting with February 2003 until 2011, covering all of the six phonological seasons and only in some seasons until 2019.
The observations were made with the naked eye, by their auditory sounds and using a foto camera. The counting was done using a terrestrial telescope and binoculars (10 x 42), with the help of the illustrated *Hamlyn Guide* to the Birds of Romania and Europe and *Collins Guide* (Bruun et al., 1999; Svensson et al., 2009; Baltag et al., 2017).

3. RESULTS AND DISCUSSIONS

Birds are an excellent barometer for health environment. They live in many habitats, reflect changes in other animals and plants, are sensitive to environmental changes and exert special attraction. Birds are also more sensitive to environmental contaminants than other vertebrates. Also, birds are some of our most important natural and cultural values, they are indicators of the integrity of the environments that provide us with clean air and water, fertile soils, abundant wildlife and the natural resources on which our economic development relies and depends (Gregory and Strien, 2010). Assessing these ecosystem functions of birds directly as ecosystem services is also necessary in our area, especially since the ecological relevance of birds is well known. Birds are loved, observed, fed and used as artistic and spiritual inspiration by millions of people around the globe. The economic relevance of birds is not widely quantified and appreciated, and the economic relevance to human society of the ecological roles of birds is neglected. (Whelan et al., 2015). Bioindicators are organisms that are used to monitor the health of the environment. Birds eat insect pests, play a role in pollination, disperse seeds, clean the bodies of other animals, cycle nutrients, and modify the environment in ways that benefit other species. Also, birds are valuable bioindicators that react promptly to changes in the environment. Thus, birds are excellent bioindicators of health of biodiversity as well as particular habitat and its productivity.
The increased mobility of birds gives them the ability to exploit space and ensures their access to resources whose temporal and spatial variability is high.
They are also important in monitoring environmental changes because of their ecological diversity.
Birds are widely distributed and occupy a broad range of habitat types and ecological niches.
Regarding the trophic analysis of avifauna, food occupies a very important place for the existence of birds. The trophic spectrum of birds includes plant, animal and mixed food (euriphagous species). Thus, each species can differentiate between a basic food that it consumes in optimal conditions, an occasional food that it resorts to in the absence or insufficiency of the basic one, and an occasional food that it resorts to in the absence of the other two (Cătuneanu et al., 1978). The trophic classification of the avifauna of the dam lakes in the middle area of the Arges valley was focused on the nature of the basic food, according to published data (Cramp, 1983; David, 2008; Conete, 2011).
Of the 207 bird species identified in the study area (86 species dependent on wetlands), belonging to 17 orders and 49 families, species with a zoophagous - polyphagous trophic regime and insectivorous species predominate. The best represented in the avifaunistic spectrum are the passerines with 88 species, representing 42.51% of the total identified species.
Thus, in the composition of the avifauna of the dam lakes in the middle area of the Argeș valley, species with a zoophagous - polyphagous trophic regime predominate, the 62 species (*Ixobrychus*

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minutus, Ciconia ciconia, Pernis apivorus, Athene noctua, Sturnus vulgaris, Motacilla flava) with this trophic regime representing 30% of the total avifauna (43 species dependent on wetlands). In terms of weight, insectivorous species follow (55 species representing 27% of the total avifauna of the researched area) and omnivores (42 species representing 20% of the total avifauna of the study area) (Figure 3).

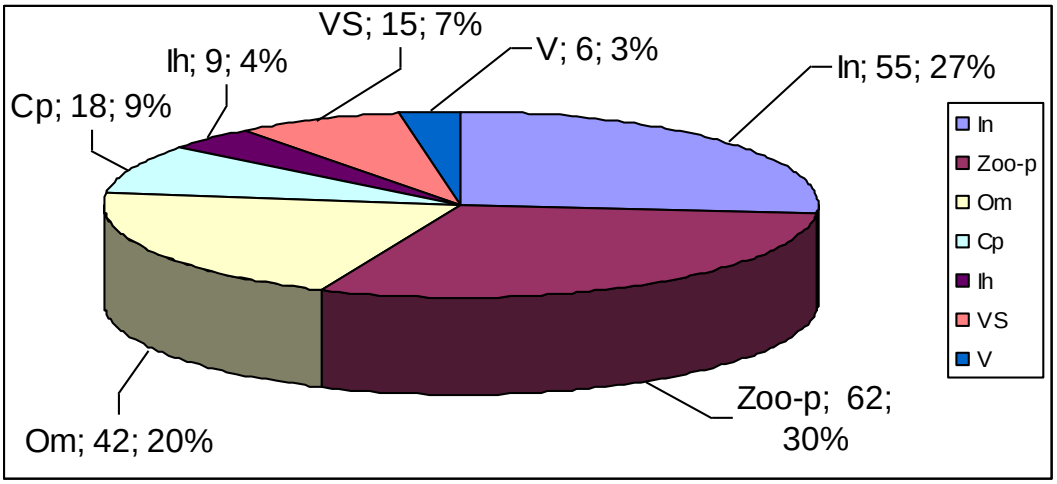

Figure 3. Trophic structure of bird community (% of species) from the middle basin of Arges the during the study period; In- insectivore, Zoo-p - zoophagous-polyphagous, Om - omnivorous, Cp - carnivore - predator, Ih - Ichthyophagous (piscivorous); VS – seminivore vegetarian (granivore), V - vegetarian

Most of the insectivorous species (*Upupa epops, Hirundo rustica, Delichon urbicum, Phylloscopus collybita, Lanius collurio etc.)* are summer visitors (35), others are sedentary (15 - *Picus viridis, Dendrocopos major, Parus major, Aegithalos caudatus etc.*), passing (5 species) or winter visitors species (*Anthus spinoletta).* Some species of birds feed exclusively on insects during the breeding season, but switch to an exclusively vegetal diet during the winter or omnivorous diet.

During our research, a number of 88 species were observed in the **wetlands**, these habitats representing over 80% of the researched area (Table 1). The importance of **forests** is obvious, 67 species are included here, although the area occupied by them is small (over 100 ha), compared to wetlands. The **open spaces** (shrubs, pastures, meadows, here we also include agroecosystems) attract a small number of species (37), although they occupy a relatively large area along the lakes (170 ha), but here too the anthropic influence is a limiting factor, being very strong (pesticides, overgrazing, hunting, tourism, etc.). As a result of the research, we identified 15 species frequently observed in the localities (**building area)** on the shores of the investigated lakes. Most bird species show a high adaptive capacity in relation to feeding and reproduction, and such ecological plasticity results in overlapping communities in ecotonal habitats. Some species of birds, in a certain period of the biological cycle, use several biotopes, from different habitats. The bird species will be presented in the habitats where they have a constant presence, corresponding to the nesting period.

The majority (34 - 51 %) of **insectivorous species** populate the **habitats of forests** and riparian forests while among omnivores species dependent on wetlands (19 species) and forests and riparian forests (10 species) predominate (Tab. 1; Figure 4). Among the 18 carnivorous-predatory (*Stix aluco*) species, the species characteristic of open areas (8) and forests and riparian forests (6) have the highest share. Ichthyophages (9 species) are species dependent exclusively on wetlands, some

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being summer visitors species (4), others winter visitors (4) etc. Seminivorous vegetarian species (15 species representing 7% of the total avifauna in the researched area) are dependent on open spaces (8 species) and forests and riparian forests (7 species). The vegetarian species (6 species representing 3% of the total avifauna), which do not consume seeds, are exclusively species dependent on wetlands.

Table 1. The origin of food resources according to habitats of the birds

Area type	In	Zoo-p	Om	Cp	Ih	VS	V	Total
Localities (intravillage) - **building area**	4	4	6	1	0	0	0	15
Forests and riparian forests	34	10	10	6	0	7	0	67
Open spaces	9	5	7	8	0	8	0	37
Wetlands	8	43	19	3	9	0	6	88
Total	55	62	42	18	9	15	6	207

*Legend. The researched aquatic ecosystems (**wetlands**) are represented by the five researched reservoirs, respectively by the lacustrine biotope, reeds-beds. Terrestrial ecosystems from the perimeter of the researched area were grouped into 3 categories: **forests and riparian forests**, **open spaces** (shrubs, pastures, meadows, here we also include agroecosystems) and localities (intravillage) - **building area**; In - insectivore, Zoo-p - zoophagous-polyphagous, Om - omnivorous, Cp - carnivore - predator, Ih - Ichthyophagous (piscivorous); VS – seminivore vegetarian (granivore), V – vegetarian.*

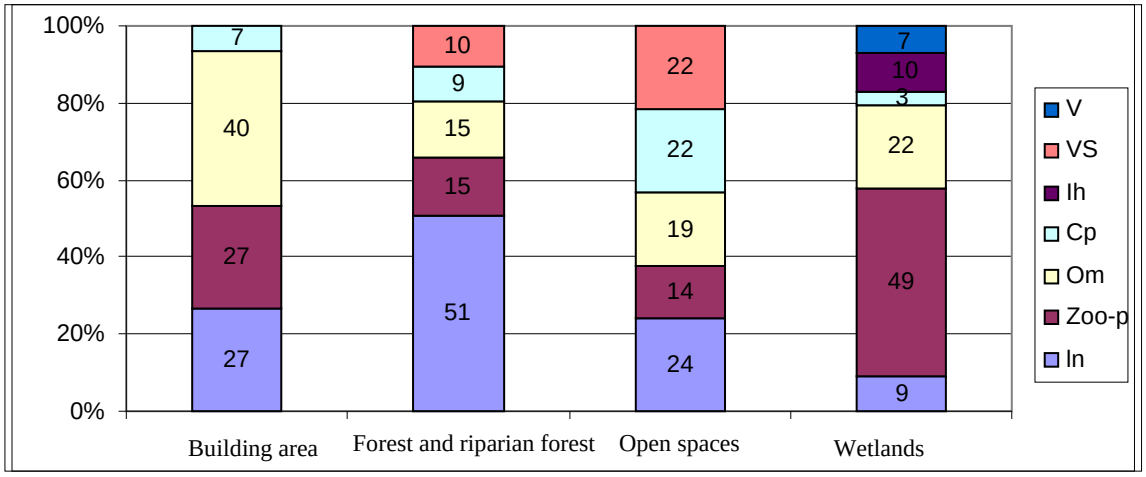

Figure 4. The percentage share of species from the different trophic categories in the four different habitat types of the study area; In- insectivore, Zoo-p - zoophagous-polyphagous, Om - omnivorous, Cp - carnivore - predator, Ih - Ichthyophagous (piscivorous); VS – seminivore vegetarian (granivore), V - vegetarian

The highest specific richness characterizes the prevernal season/spring migration (186 species - 89.86%) and serotinal/autumn migration (169 species - 81.64%), these lakes being located on the route of the Rucăr-Bran migration corridor. Although the existence of birds depends on the food factor, it cannot be qualified, on the investigated reservoirs, as a limiting factor of the species' flocks, especially during the passage period that coincides with the period of abundant food supply, which favors the stationing of high flocks of birds.

However, in the harsher winters, the accessibility of food resources becomes an important factor, although these lakes do not freeze completely, keeping large areas of water surface where many

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species of birds find their food. The degree of diversity of the trophic supply (rodents, amphibians, fish, insect, phytoplankton, etc.), for the various species in these ecosystems, is increased by the trophic resources of the adjacent areas, used agriculturally.
In the winter season, populations of anseriformes appear predominated, due to the very large number of individuals, concentrated in huge flocks of birds on large areas of the water surface (tens of thousands), areas that offer optimal conditions for these aquatic species during the winter. We note, in particular, in the hiemal, prevernal and serotinal seasons, the positive value of the researched reservoirs in correlation with the wide valleys (especially of the Goleşti and Budeasa lakes) provided with various agricultural crops, which provide food for anseriformes. They feed on arable land, but they cause damage to farmers, ecosystem disservices, and it is necessary to grant a subsidy per land surface for feeding goose species.
The attractiveness of these reservoirs for birds is known, less so as providers of ecosystem services. Birds provide ecosystem services from all 4 categories: production services, regulation services, support services and cultural services. Most of the bird species studied are important from an ecological and economic point of view, providing numerous ecosystem services and play a vital role in agriculture by managing pest and rodent populations. Thus, insectivorous species (55 species), from the study area, have a special role in controlling pest insects, in reducing insect populations, and nocturnal birds of prey (with a zoophagous – polyphagous and carnivore - predator trophic regime) have a role in managing rodent populations harmful to agriculture. Some bird species, omnivorous or vegetarian, pollinate or disperse the seeds of plants, and others (*Sturnus vulgaris*) clean the bodies of other animals (sheep, goats etc.). Birds prevent insects' breeding and thus insect harm. Corvids and some larids have a certain role on garbage ramps.
Birds in the study area also have a cultural role, they are emblematic of nature, they are loved, observed, monitored (birdwatching - recreational activity), fed and used as artistic inspiration and with traditional value in the study area.
Birds population trends often mirror those of other species: mammals, reptiles, amphibians, fish, invertebrates (insect) and plants. For example White Stork is a sensitive indicator of anthropogenic influence, such as intensive agriculture, pesticide application, poisoning, habitat fragmentation, loss of wetlands, excessive aridity, etc. Monitoring the local population is important, the White Stork being a good indicator of biodiversity and human health (Conete, 2021). Also, monitoring wetland birds, day and night birds of prey is very important for the health of ecosystems.
These species can be directly or indirectly related to the fitness of many other species and play a critical role in the maintenance natural ecosystems.

4. CONCLUSIONS

The ecological and economic roles of birds and, therefore, ecosystem services, are vital for the health of the studied ecosystems and bring multiple benefits to local communities (health, well-being, etc.). Some bird species are useful in applications such as environmental quality and are used as early warnings of environmental change and climate change assessment. Quantifying the services provided by birds is crucial to understanding their importance to ecosystems and the people who benefit from them.
Through the trophic analysis of birds, we identify part of the services and disservices of birds, being able to better evaluate the consequences on the environment, the trends of population growth, their decline, protected species, and we can also transmit these findings to the public and decision-makers for conservation of birds and their habitats.

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Regarding the trophic analysis of avifauna, food occupies a very important place for the existence of birds. Following the observations made in the study area, 207 bird species were identified. They belong to 17 orders and 49 families, predominating species with zoophagous - polyphagous trophic regime and insectivorous species. Thus, representatives of seven food guilds were found, with the predominance of zoophagous - polyphagous and insectivorous species, and the food guilds with the lowest number of species were the piscivorous and vegetarian dietary guilds.

Four habitat types have been studied and have shown positive results for a greater diversity of birds, especially insectivorous species. The majority (34 - 51 %) of **insectivorous** species populate the **habitats of forests** and riparian forests and **localities (building area**), while among zoophagous – polyphagous (43) and omnivores (19) species dependent on wetlands. Most of the insectivorous species are summer visitors (35) and nesting species, because insects are a resource available mainly in the warm season, being the most important food for the growing chicks.

The dam lakes on the middle valley of Argeș host, in the different seasons of the year, the vast majority of wetland-dependent birds (86 species), and in the ecotonal areas they provide varied biotopes resulting in a great diversity of avifaunistic composition. The highest specific richness characterizes the prevernal season/spring migration (186 species) and serotinal/autumn migration (169 species), these lakes being located on the route of the Rucăr-Bran migration corridor.

In accordance with the degree of availability of trophic resources and nesting sites, as well as with the more or less significant presence of predators and anthropogenic disturbance, the highest specific richness of nesting birds was recorded on Bascov reservoir (122 species), where forest habitat predominate. Many of these species are insectivorous. In this sense, it is important to maintain and preserve the shelterbelts (forest habitat) along the shore of the lake and the reed surfaces.

The bird species studied provide ecosystem services from all 4 categories: production services, regulation services, support services and cultural services.

Birds exist near the top of the food chain, making them sensitive to changes at lower levels of the food chain and environmental pollution. Thus, birds are excellent bioindicators of health of biodiversity as well as particular habitat and its productivity.

Most of the bird species studied are important from an ecological and economic point of view, providing some ecosystem services and play a vital role in agriculture and forestry, by managing insect pest and rodent populations. Many bird species are considered pollinators and seed dispersers of crop plants, thus maintaining ecosystems. Birds in the study area also have a **cultural role**, they are loved, observed, monitored (**birdwatching - recreational activity**), fed and used as artistic inspiration and with traditional value in the study area. On the other hand, huge flocks of anseriformes, in the winter aspect, feed on arable land, but they cause damage to farmers, ecosystem disservices, and it is necessary to grant a subsidy per land surface for feeding goose species.

Birds are our natural and cultural alarm clocks — they are indicators of the health of the environments that provide us with clean air and water, fertile soils, abundant wildlife, and the natural resources upon which our economic development is based. This research is useful in understanding their importance to ecosystems and the people who benefit from them, as well as in developing conservation strategies for birds and their habitats.

Understanding and evaluating the ecosystem services and disservices provide by birds through careful research on species diversity, trophic analysis, seasonal dynamics, interaction with the environment, etc. we can better assess the environmental consequences of the decline and

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disappearance of some bird species and inform decision makers, involving the community in conservation activities for birds and their habitats. By determining the contributions of birds (and biodiversity in general) to humans, their value can be better understood and appreciated at the level of strategies regarding the conservation of biodiversity with special benefits for people.

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