The Floristic Composition of Irrigation Ponds and Water Reservoirs in Albania after the Long Persistent Drought of 2016–2017

Attila Rigó 1* and Zoltán Barina 2

1 Department of Nature Conservation & Landscape Ecology, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary; rigo.attila@hallgato.uni-szie.hu
2 H-1095 Budapest, Ipar utca 3., Hungary; quercusbz@gmail.com
* Correspondence: rigo.attila@hallgato.uni-szie.hu

Abstract: The occurrence of temporary wetland habitats was once frequent in Europe, especially in the Mediterranean region, but attenuating nowadays. The role of anthropogenic aquatic habitats (such as irrigation ponds) in biodiversity and nature conservation has recently become more important. Small irrigation ponds and greater water reservoirs are common parts of the landscape in Albania. The persistent drought of 2016–2017 allowed us to explore the floristic diversity of the beds of dried irrigation ponds and reservoirs. The timing of the field survey was early autumn based on knowledge of the expected appearance of mud vegetation. We recorded the physical parameters of the ponds (location, altitude, the slope angle of the embankment, and bedrock). The cover of each species, water surface, and mud has been estimated by circuiting the whole reservoir. Altogether 129 ponds and reservoirs were studied, more than 3400 new floristic records referring to 324 vascular plant species (of which 35 are adventive) were recorded. Most of the dried irrigation ponds were rather sparsely colonized. Irrigation ponds can serve as a refuge for plants that are connected to wet habitats, but grazing and manuring in and around them can be a threat by promoting the spread of invasive and nitrophilous plants.

Keywords: Albania; anthropogenic aquatic habitats; invasive plant species; irrigation pond; mud vegetation; water reservoir

1. Introduction

The abundance and biodiversity of natural aquatic ecosystems is decreasing [1]. The occurrence of temporary wetland habitats was once frequent in Europe, especially in the Mediterranean region, but attenuating nowadays [2]. Man-made aquatic ecosystems (e.g. irrigation ponds, water reservoirs) can be a refuge for plant and animal communities that are connected to aquatic habitats [3]. The role of these small artificial water bodies in biodiversity and nature conservation is important [4]. Besides being a refuge, these anthropogenic sites can be a threat by providing habitat to invasive plants [5].

Mud vegetation can be developed on the dried beds of artificial water bodies [6]. Exposed mudflats are nutrient-rich ephemeralous habitats with favourable edaphic conditions, thus pioneer mudflat species are usually short-lived annuals, which are germinating almost simultaneously and finish their life cycle in a very short time (only few weeks) if the circumstances (decreasing water level) allow it [7–8]. There are numerous publications worldwide that aim to study the vegetation in anthropogenic wetland sites [7, 9–11]. The review of Deil [8] summarized our knowledge on ephemeral wetland habitats around the world (including anthropogenic ephemeral wetlands).

Albania is rich in waters, there are 152 rivers and streams, 247 natural lakes and about 800 artificial water reservoirs (in Albanian: rezervuar) and ponds (in Albanian: pellg) [12]. The artificial water reservoirs and irrigation ponds – according to their size – have major role in flood protection,
producing hydro-power, water supply and irrigation in agriculture [13]. The persistent drought of 2017 in Albania [14] offered us an opportunity to examine the mud vegetation on the dried bottoms of different-sized irrigation ponds and water reservoirs. There were some remarkable findings in reservoirs on previous expeditions [15], but their flora has not been systematically studied previously as far as we know.

The aim of our research was to explore the floristic and habitat diversity of these ephemeral stands and evaluate their biogeographical and nature conservation role. The main questions of our research were the followings: (1) What are the ecological requirements and life forms of the plants that colonize water reservoirs? (2) Are there alien species in the reservoirs and what is their role when compared to native species? (3) Do the type of bedrock, the size, the altitude, the range of water surface or the biogeographical environment have any effect on the composition of the flora of water reservoirs? (4) Do reservoirs have a significant role in nature conservation by conserving some rare species?

2. Materials and methods

2.1. Study areas

Altogether 129 different sized water reservoirs from almost all regions of Albania were involved in the research. We located water reservoirs by using geoinformatics (Google Earth and QGis). Only artificially dammed water bodies (water reservoirs and irrigation ponds) were included in the research, the research was restricted to the strict territory of reservoirs (up to the possible water level). We excluded natural lakes, quarry ponds and tarns. The field work was achieved between 4th and 14th September 2017. The following data has been recorded for each reservoir: exact location (vicinity, GPS coordinates, altitude), gradient interval, size, type of bedrock, ratio of water surface, bare soil (mud), vegetation and composing taxa. Each reservoir was photodocumented.

2.2. Floristic procedures

The ratio of each species, water surface and mud surface has been estimated by circuiting the whole reservoir, no random plots have been established. For the identification of the species we used [16–26]. Nomenclature follows [15].

2.3. Data management and mapping solutions

We used Google Earth to track the loss of water of each reservoirs and ponds, as for most reservoirs, images of both wet and dry periods are available. We recorded the bedrock type on the field, and the field observations were specified by using the geological map of Albania. The gradient intervals of the slope angles of the reservoir dams were estimated in the field.

3. Results

3.1. General results

During the field research we carried out floristic surveys of 129 reservoirs in 9 of the 12 counties of Albania, the distribution of the surveyed reservoirs by region is not uniform (Table 1.). Based on the total dimensions (before drying) of the reservoirs, the visited reservoirs show a large variation in size, but the vast majority of the reservoirs have an area of less than 10 hectares (Table 2.). The altitude of the reservoirs varies from 11 to 1030 m a.s.l., 38.8% of them are located below 200 m a.s.L, 27.1 % between 200 and 600 m a.s.L, while 34.1% above 600 m a.s.l. More than 2/3 of the surveyed reservoirs were on some sedimentary rock, a total of 41 reservoirs were on flysch, 11 on limestone, and 36 on other, younger sediments. The remaining one-third is roughly evenly distributed among the following categories: serpentine, sand and clay (Table 3.). One of the reservoirs were on andesite bedrock. The water level and drying degree of reservoirs show significant variance, only 10 reservoirs
were fully dried and 5 reservoirs were full of water. However, a significant proportion of reservoirs were at some degree of drying.

Table 1. Distribution of reservoirs by county.

| County     | No. of reservoirs |
|------------|-------------------|
| Dibër      | 25                |
| Shkodër    | 5                 |
| Lezhë      | 8                 |
| Durrës     | 12                |
| Elbasan    | 16                |
| Korçë      | 25                |
| Tirana     | 13                |
| Fier       | 7                 |
| Gjirokastër| 18                |

Table 2. Size of the surveyed reservoirs.

| Full size of reservoir (ha) | No. of reservoirs |
|-----------------------------|-------------------|
| <0,1                        | 15                |
| 0,1-1                       | 23                |
| 1-10                        | 51                |
| 10-100                      | 36                |
| 100-1000                    | 2                 |
| >1000                       | 2                 |

Table 3. Distribution of reservoirs by bedrock.

| Bedrock     | No. of reservoirs |
|-------------|-------------------|
| Flysch      | 41                |
| Other sediments | 36            |
| Sand        | 14                |
| Serpentine  | 13                |
| Clay        | 13                |
| Limestone   | 11                |
| Andesite    | 1                 |

3.2. New distribution records

We have found 4 new species for Albania, these are: Ammannia coccinea Rottb., Dysphania pumilio (R.Br.) Mosyakin & Clemants, Lindernia procumbens (Krock.) Philcox and Verbena supina L. [27], and confirmed the presence of Cyperus serotinus Rottb. in Albania. The latter has been found in the reed of an irrigation pond near Renc (Shkodër county). We also found a new locality for Oldenlandia capensis L., a plant native in Africa and the Middle-East, and within Europe so far only found on the muddy shores of Shkodra Lake. The plant was found in a reservoir near Shkodër, not far from its formerly known occurrences on the mud of Lake Shkodra and some surrounding reservoirs.

Our knowledge on the distribution of several rare species in Albania has expanded. One such species is Chenopodium rubrum L., which has so far had 2 occurrence data from Albania, but 10 new localities have also been found in the research. The survey evinced the inland occurrence of Eclipta prostrata (L.) L. – a rarely naturalized plant Albania – the plant had only 2 known localities near the seashores, but we have found it in 7 inland reservoirs.
In the case of some species that are under-mapped in [15], it can be stated that, contrary to our previous knowledge, they are not uncommon in Albania. Such a species is, for example, *Conyza bonariensis* (L.) Cronquist, a species naturalized in Albania, was found in the mud vegetation of 24 reservoirs during the research and was first found in the eastern part of the country. *Euphorbia chymaesyce* L. previously had only 2 known occurrences in Albania, however we have found the species in more than 30 reservoirs, this species is probably also not uncommon in Albania.

3.3. Vegetation character

As a result of the research, 3473 floristic data referring to 324 vascular plant species were collected. Of the species found, 35 are non-native in Albania (17.8% of the alien species found in the country). In addition to 161 annual species, 163 perennial plant species were found. On average we found 25.9 species per reservoir. The maximum number of species per reservoir were 76, but there were 3 reservoirs without any terrestrial vegetation. A total of 124 species were found only in one reservoir. Most of the reservoirs were rather sparsely colonized, in 119 reservoirs the coverage of vegetation was less than 30% and maximum 90% of a reservoir was covered with vegetation. The presence of cultivated plants in the reservoirs was prominent, 7 (edible) cultivated species (e.g. *Citrullus lanatus* (Thunb.) Matsum. & Nakai) appeared as casual ephemers on the dried bed of reservoirs. The species found in the reservoirs belong to 55 plant families. Asteraceae, Poaceae and Fabaceae are represented by the largest number of species. Of the 10 most common species registered, all occur in more than 40% of reservoirs and 6 of them in more than half of the reservoirs (Table 4.). Of the most common species, there is only one adventive plant, *Paspalum paspaloides* (Michx.) Scribn. The floristic composition of reservoirs established on different bedrocks is slightly different (Table 5.). There is significant overlap between the most common species. Significant differences can be observed only in the case of the flora of reservoirs formed on serpentine, sand and clay in terms of the most common species.

### Table 4. The 10 most common species found in water reservoirs in Albania

| Species                  | Found in % of reservoirs |
|--------------------------|--------------------------|
| *Mentha pulegium*        | 58.91                    |
| *Echinochloa crus-galli* | 57.36                    |
| *Cynodon dactylon*       | 57.36                    |
| *Polygonum lapathifolium*| 55.04                    |
| *Portulaca oleracea*     | 52.71                    |
| *Verbena officinalis*    | 50.39                    |
| *Paspalum paspaloides*   | 49.61                    |
| *Digitaria sanguinalis*  | 48.84                    |
| *Plantago major*         | 41.86                    |
| *Polygonum aviculare*    | 41.86                    |

### Table 5. The 20 most common species on different substrates

| Serpentine Species | Found in % of reservoirs | Limestone Species | Found in % of reservoirs |
|-------------------|--------------------------|-------------------|--------------------------|
| *Cyperus fuscus*   | 69.23                    | *Plantago major*  | 54.55                    |
| *Cynodon dactylon* | 61.54                    | *Echinochloa crus-galli* | 45.45                 |
| *Digitaria sanguinalis* | 61.54                  | *Typha angustifolia* | 45.45                  |
| *Echinochloa crus-galli* | 61.54                | *Eleocharis palustris* | 36.36                 |
| *Paspalum paspaloides* | 61.54                   | *Equisetum palustre* | 36.36                  |
Polygonum lapathifolium 61.54  Mentha pulegium 36.36  
Portulaca oleracea 53.85  Heluchloa schoenoides 36.36  
Bidens tripartita 46.15  Polygonum lapathifolium 36.36  
Juncus articulatus 46.15  Portulaca oleracea 36.36  
Inula britannica 38.46  Potamogeton pectinatus 36.36  
Eleochloa palustris 38.46  Verbena officinalis 36.36  
Euphorbia chamaesyce 38.46  Alisma lanceolatum 27.27  
Polygonum aviculare 38.46  Xanthium strumarium 27.27  
Holoschoenus romanus 30.77  Inula viscosa 27.27  
Pycreus flavescens 30.77  Polyca oleracea 27.27  
Juncus inflexus 30.77  Sonchus oleraceus 27.27  
Mentha pulegium 30.77  Tussilago farfara 27.27  
Lythrum salicaria 30.77  Bolboschoenus maritimus 27.27  
Gratiola officinalis 30.77  Cyperus fuscus 27.27  
Plantago major 30.77  Euphorbia chamaesyce 27.27  

| Sand | Found in % of reservoirs | Other sediments | Found in % of reservoirs |
|------|-------------------------|-----------------|-------------------------|
| Verbena officinalis | 71.43 | Mentha pulegium | 63.89 |
| Cynodon dactylon | 64.29 | Verbena officinalis | 63.89 |
| Echinochloa crus-galli | 64.29 | Echinochloa crus-galli | 61.11 |
| Portulaca oleracea | 64.29 | Polygonum lapathifolium | 58.33 |
| Xanthium strumarium | 57.14 | Portulaca oleracea | 50.00 |
| Mentha pulegium | 57.14 | Cynodon dactylon | 47.22 |
| Lycopus europaeus | 50.00 | Sonchus oleraceus | 44.44 |
| Plantago major | 50.00 | Polygonum aviculare | 44.44 |
| Polygonum lapathifolium | 50.00 | Convolvulus arvensis | 41.67 |
| Sonchus oleraceus | 42.86 | Plantago major | 41.67 |
| Cyperus fuscus | 42.86 | Paspalum paspaloides | 38.89 |
| Juncus articulatus | 42.86 | Potentilla reptans | 38.89 |
| Heluchloa alopecuroides | 42.86 | Xanthium spinosum | 36.11 |
| Paspalum paspaloides | 42.86 | Cyperus fuscus | 36.11 |
| Pulicaria dysenterica | 35.71 | Bidens tripartita | 33.33 |
| Pulicaria vulgaris | 35.71 | Holoschoenus romanus | 33.33 |
| Xanthium spinosum | 35.71 | Chrozophora tinctoria | 33.33 |
| Heliotropium europaeum | 35.71 | Digitaria sanguinalis | 33.33 |
| Corrigiola litoralis | 35.71 | Solarum nigrum | 33.33 |
| Citrullus lanatus | 35.71 | Xanthium strumarium | 30.56 |

| Flysch | Found in % of reservoirs | Clay | Found in % of reservoirs |
|--------|-------------------------|------|-------------------------|
| Mentha pulegium | 65.85 | Paspalum paspaloides | 76.92 |
| Cynodon dactylon | 63.41 | Polygonum lapathifolium | 76.92 |
| Digitaria sanguinalis | 60.98 | Lycopus europaeus | 69.23 |
| Echinochloa crus-galli | 58.54 | Mentha pulegium | 69.23 |
| Polygonum lapathifolium | 56.10 | Cynodon dactylon | 69.23 |
The composition of the flora of reservoirs is determined by substrate (e.g., *Eclipta prostrata* (L.) L. grows on clay and *Chenopodium rubrum* L. grows on sand) and by altitude (e.g., *Lippia nodiflora* (L.) Michx. in the lower Mediterranean regions).

It has been observed that some adventive species spread regionally (e.g., *Dysphania pumilio* R. Br. is found only in the south).

Even if these ephemeral mudflats presence is hectic, yet plants that are connected to wetland habitats appear when the conditions are favourable for them [8].
In addition to experiencing high species richness, the ratio of adventive species is high, especially if we take into consideration the fact that Albania is the least infected country in Europe by aliens [28]. The reasons for this may be that these bare soil surfaces can easily be colonised by aliens [29] and grazing and manuring in and around reservoirs can help the spreading of alien (potentially invasive) species [28], but grazing can also prevents or reduces the spread of invasive plants [30].

5. Conclusions

Overall, we can significantly expand our knowledge of the flora of a given region through a targeted study of a habitat type. In the case of such a globally attenuating ephemeral habitat, this is of high importance. The collected records enable us to evaluate the reservoirs as ephemeral habitats in further viewpoints. Further research perspectives may include: the connection between the rate of annuals and biennials/perennials and the length of drought, and investigating the connection between the spectrum of floristic elements and the reservoir’s geographical location.

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