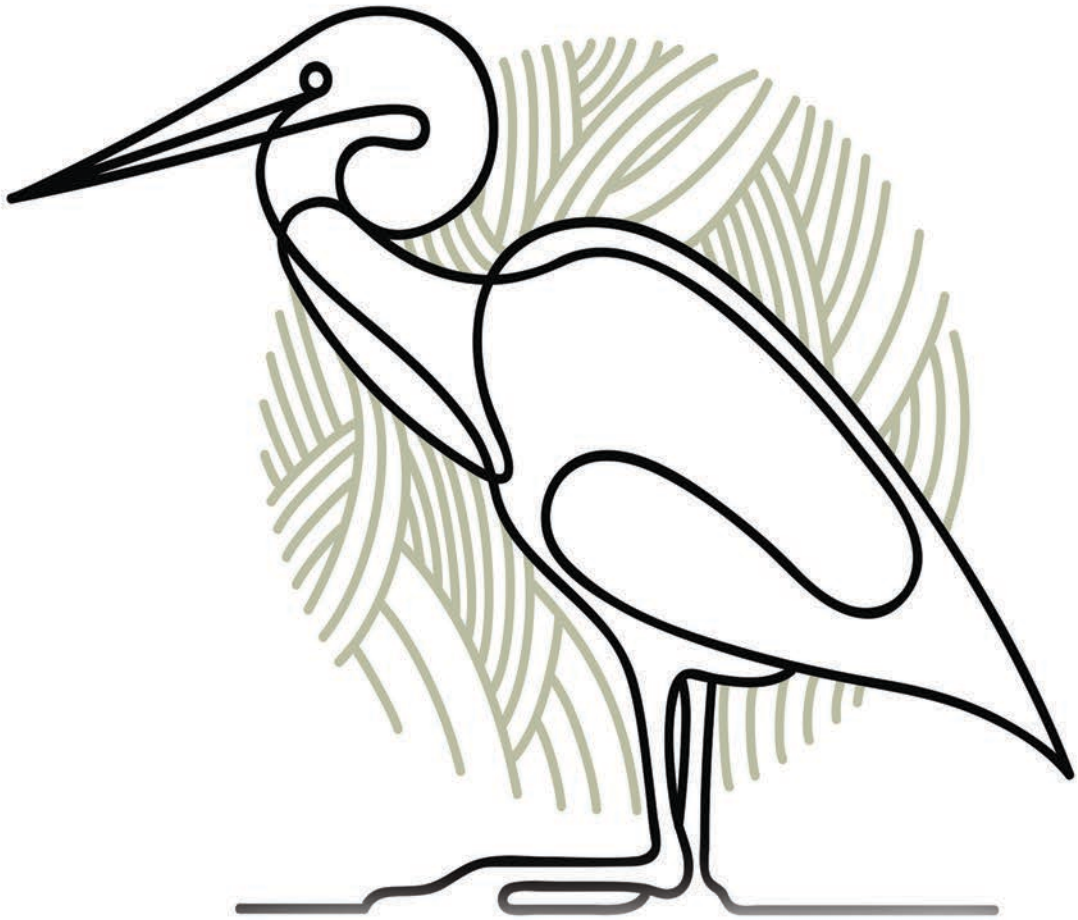
# Census of passerine birds in the reedbeds of Lake Mikri Prespa

Technical report
Action A2



LIFE Prespa Waterbirds
LIFE/NAT/GR/000936

July 2017

SOCIETY FOR THE PROTECTION OF PRESPA

Tour du Valat

NATIONAL OBSERVATORY ATHENS

NATURA 2000

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# Census of passerine birds in the reedbeds of Lake Mikri Prespa

Report under the framework of
LIFE Project “Prespa Waterbirds”
LIFE15 NAT/GR/000936

Anastasios Bounas

July 2017

PRESPA
WATERBIRDS

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# 1. Introduction

Although wetlands cover <9% of the global land area they yet contribute approximately 40% of global annual renewable ecosystem services[1]. Despite their pronounced importance, almost 60% of European wetlands have disappeared during recent decades mainly due to drainage and land-use changes[2]. Thus, the imminent cost of losses to wetland ecosystem services such as water supply, retention of nutrients as well as their value as wildlife habitat is likely to be immense. Because of this, conservation biologists have been increasingly studying and proposing measures to limit or reduce such negative trends. There are many examples of wetlands that have been successfully protected or restored resulting to hotspots for birds, as avian diversity is a good indicator of the general dynamics and overall health of wetland ecosystems[3]. Therefore, many wetland protection and restoration projects have aimed at increasing wetland bird diversity[4].

Common reed (*Phragmites australis*) is a widespread halophyte species of great economic and ecological importance. It often forms extensive stands known as reedbeds. Reedbeds represent an important habitat for plants, invertebrates and birds including many rare and vulnerable species. Regarding birds, passerines such as Moustached Warbler (*Acrocephalus melanopogon*), Reed warbler (*Acrocephalus scirpaceus*), Great Reed Warbler (*Acrocephalus arundinaceus*), Sedge Warbler (*Acrocephalus schoenobaenus*), Bearded Reedling (*Panurus biarmicus*) and Reed Bunting (*Emberiza schoeniclus*) are some of the commonest reed-dwellers[5,6]. In addition, reedbeds provide suitable breeding sites for several vulnerable and rare bird species in Europe including the Dalmatian Pelican (*Pelecanus crispus*), Purple Heron (*Ardea purpurea*), Ferruginous Duck (*Aythya nyroca*), Marsh Harrier (*Circus aeruginosus*) and Great and Little Bitterns (*Botaurus stellaris* and *Ixobrychus minutus*)[7].

However, without management a reedbed will gradually dry out, and develop into scrub and woodland through its colonization by other plant species as reedbeds are, under an ecological perspective, the early stages of succession from open water to woodland[8]. If this is the case, obligate reedbed animals and plants will in time be lost. Reedbed management could slow down -or even reverse- this succession and its effects in order to maintain a balance of different habitat types or to reinstate specific targeted habitats to conserve reed-specific wildlife. Reed management options include cutting, burning and grazing. Various studies have assessed the impact of reed management on reedbed wildlife and evaluated the species' responses to it. For example, densities of some reed-dwelling spider and beetle species, including the most preferred prey species for passerine birds, were lower at cut sites[9]. Contrastingly, other studies showed increase in abundance and distribution of arthropods in cut sites compared to uncut sites[10] or even no effects of reed management on the invertebrate community[11]. The impact of reed cutting on reed-associated birds is generally negative due to the prevention of nest building in early breeding passerines[10], the increased risk of nest predation and the delay in clutch initiation[5]. On the other hand, reed cutting could have positive effects on the richness of plant species[12].

Lake Mikri Prespa is characterized by reedbeds of variable extent and diversity, where at least seven species of reedbed-dwelling birds were found to breed (*Acrocephalus palustris*, *A. arundinaceus, A. scirpaceus, A. schoenobaenus, Panurus biarmicus, Emberiza schoeniclus, Cettia cetti*), whereas two more species (*Acrocephalus melanopogon, Locustella luscinioides*) were formerly known to breed in the area but have not done so since 1989[13]. Reed management in the area is of need due to the limited availability of foraging areas and spawning grounds for wading birds and fish respectively, as well as to the low breeding output caused by reedbed fires. In addition, the expansion of narrow-leaved cattail (*Typha angustifolia*) over reedbeds could in turn threaten breeding sites for pelicans[14].

In this study, observations of birds at 22 census points were used to assess the densities and diversity of passerine bird assemblages in reedbeds around Lake Mikri Prespa. The examination of species' densities, diversity and composition of sites and the evaluation of the differences among them will inform decision-making regarding the management of reedbeds in the area, to be implemented under the framework of LIFE Prespa Waterbirds project (LIFE15 NAT/GR/000936).

# 2. Methods

## *2.1. Study area*

Lake Mikri Prespa (Figure 1) covers an area of 47 $km^2$ and is located at around 850 m above sea level[15]. It is characterized by marshy areas with rich aquatic vegetation, extensive stands of reeds, whereas areas of dry land and wet meadows (depending on the year and rainfall levels) are patchily found among the reedbed. Around the lake, mainly in east (Mikrolimni, Karyes and Lefkonas) and west (Pyli), agricultural land dominates the landscape along with the draining ditches, a part of the irrigation system that runs through the cultivated areas. Although livestock breeding is scarce around the lake it is more conspicuous in the southern areas (Agathoto, Latsista) and some herds graze in the northern areas around Vromolimnes. The helophytic marshy vegetation is the most widespread and ecologically important vegetation type in this wetland. Helophytes cover the perimeter of the lake spreading to its interior up to a depth of 2.5 m, if not deeper[16]. Among the most representative helophytes in the study area are the species *Phragmites australis* and *Typha angustifolia* followed by *Scirpus lacustris* and *Carex pseudocyperus*. The most dominant helophytic community around the lake constitutes of *Phragmites australis* that grows in dense stands and extends purely and coherently in southern, eastern and some northern parts of Mikri Prespa (Agathoto, Latsista, Mikrolimni, Karyes, Lefkonas, Bouskani). On the other hand, *Typha angustifolia* extends in the areas of Opaya, Vromolimni, Diavlos and Pyli. A very characteristic feature of communities where both Phragmites and Typha coexist, is that vegetational stands are somewhat fragmented with one type encircling another whereas clearings and patches of marshy hydrophilic vegetation grow among them[16]. This mosaic of vegetation can be clearly seen in the north part of the lake around Vromolimni.

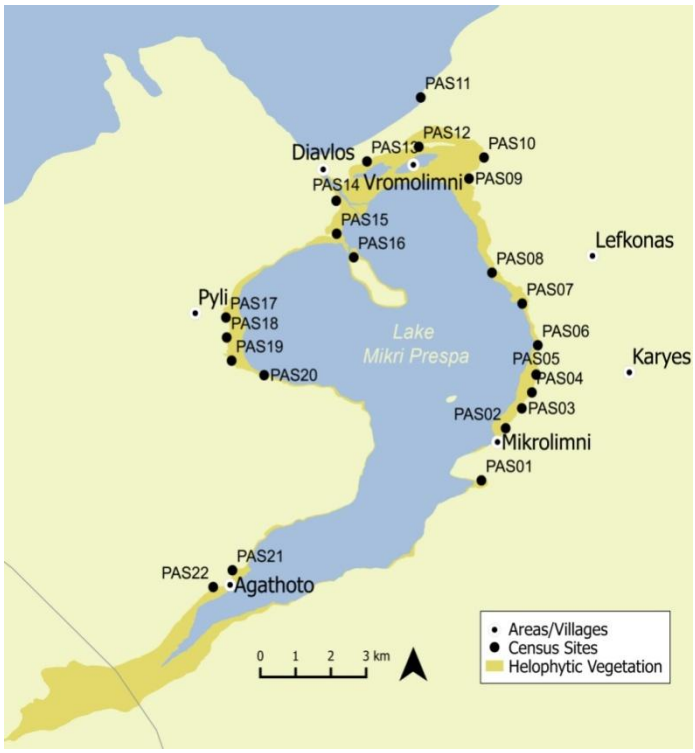


**Figure 1**. Map of the study area including census sites and areas or villages mentioned in the text. Shaded areas show the helophytic vegetation around the lake.

## *2.2. Bird censuses*

A point-count inventory technique was used in order to assess the bird community in the reedbed habitats around the Lake. The established 22 fixed census points (hereafter called 'sites') were distributed systematically across the entire study area (Figure 1) in order to cover most types of reedbed structure (as described in 2.1.). All but one site (PAS11) were established around Mikri Prespa. The minimum distance between adjacent sites was at least 300 m to avoid the risk of double counting, as the Great Reed Warbler (*Acrocephalus arundinaceus*) has a powerful voice that can be heard at distances of 250 m[17]. Each site was visited four times during the breeding season: 12-13 May, 31 May-1 June, 18-19 June and 7-8 July. Visits took place during the three hours after sunrise. At each visit, I waited for two minutes prior to commencing the census - to allow acclimatization of birds to my presence - followed by a 6-minute period of recording all individuals heard or seen within a radius of 100m. For each observation I recorded the distance of the bird in bands of 0-25m, 25-50m, 50-100m and >100m. Since it is difficult to observe all birds at a site during a 6-min period[18], the maximum number of individuals of each bird species detected on any one of the four sampling dates was used in all subsequent analyses. All birds observed outside the census duration were also recorded in order to compile an observation list.

## *2.3. Data analysis*

For the analysis to be as informative as possible, I included only passerines that are obligate reed-dwellers, at least at some part of their annual circle. Therefore, nine species were included in all subsequent analyses: Cetti's Warbler (*Cettia cetti*), Savi's Warbler (*Locustella luscinioides*), Sedge Warbler (*Acrocephalus schoenobaenus*), Marsh Warbler (*Acrocephalus palustris*), Reed Warbler (*Acrocephalus scirpaceus*), Great Reed Warbler *(Acrocephalus arundinaceus*), Bearded Reedling (*Panurus biarmicus*), Penduline Tit (*Remiz pendulinus*) and the Reed Bunting (*Emberiza schoeniclus*).

For each of the above species we calculated the density and relative abundance in each site as well as for larger reedbed blocks (Table 1). Although density could be obtained by simple extrapolation on area unit, modifications were made in order to reduce bias in density estimates[19-22]: Due to the fact that at each census site, a half-circle (180°) was examined for presence of birds, rather than a full circle, the area (A) of a half-circle is calculated as:

$$A = (\pi r^2)/2 \quad (1)$$

where r stands for the radius. Density of a species (d) may be computed as the ratio of the number of observations per counting unit (N) to the area within the radius (r):

$$d = N/\pi r^2$$

Having in mind the equation (1) the density in our case is calculated as:

$$d = N/(\frac{\pi r^2}{2})$$

It has been proposed that radius (r) can be species-specific depending on the biology of each species. In the case of reedbeds, the Great Reed Warbler is an easily heard bird whereas the smaller warblers are far more inconspicuous. This can have a serious effect in the detectability of individuals from point counts. Thus densities for Great Reed Warbler were calculated for an area of 100m radius whereas densities for all other species were calculated using a radius of 50m (This can be easily seen when examining the raw data, the only species observed in the 50-100m band was the Great Reed Warbler). In addition, since territorial males were counted for the Great Reed Warbler density can be expressed as pairs/ha. For the rest of species since a lot of visual observations were made we express the density as individuals/ha. Relative abundance was analysed as the number of detections per unit area express as percent (%). In this case relative abundance could be analogous to "frequency of occurrence" but due to the ambiguity of this term, hereafter I only use "Relative abundance".

**Table 1**. Reedbed blocks and neighboring sites pooled for the analysis

| Reedbed block | Sites pooled |
|---|---|
| Latsista | PAS01 |
| Mikrolimni-Karyes-Bouskani | PAS02+PAS03+PAS04+PAS05+PAS06 |
| Lefkona | PAS07+PAS08 |
| Vromolimnes | PAS09+PAS10+PAS12+PAS13 |
| Krina | PAS14+PAS15 |
| AgAchilleios | PAS16 |
| Pyli | PAS17+PAS18 |
| Daseri | PAS19+PAS20 |
| Agathoto | PAS21+PAS22 |

For each site and for larger reedbed blocks the following indices were calculated: **Species Richness (S)** as the number of different species present in each site. **Dominance (D)** ranging from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely). **Shannon index (H)**, a diversity index, taking into account the number of individuals as well as number of different taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. A bootstrap sample of 10000 replicates was used in order to compare the diversity between sites. To compare the composition of bird communities among sites we calculated the Bray-Curtis index for abundance data and subsequently performed a hierarchical clustering analysis (site PAS11 was excluded from any comparison analysis as the focus of this study are only the reedbeds of Mikri Prespa). The analysis produced an unweighted pair-group average (UPGMA) dendrogram where clusters are joined based on the average similarity (Bray-Curtis) between all members in the two groups. All analyses were performed using R 3.2.2., PAST v.3 and QGIS v.2.12.3.

# 3. Results

A total of 54 species were observed in all areas, 14 of them during the census points. (**Table 2**, **Table 3**). Of the nine species included in the analysis (see 2.3), the Great Reed Warbler (*Acrocephalus arundinaceus*) was the most common one, being present in all sites, followed by the Reed Warbler (*Acrocephalus scirpaceus*), found in 18 out of the 22 sites. Other species observed were: the Bearded Reedling (*Panurus biarmicus*) spotted in 14 sites, Reed Bunting (*Emberiza schoeniclus*) spotted in 12 sites, Penduline Tit (*Remiz pendulinus*) in 8 sites, Marsh Warbler (*Acrocephalus palustris*) in 6 sites, and Cetti's Warbler (*Cettia cetti*) present in 5 sites. Both Sedge Warbler (*Acrocephalus schoenobaenus*) and Savi's Warbler (*Locustella luscinioides*) had a single observation (**Table 3**). The Great Reed Warbler displayed the highest relative abundance, dominating (relative abundance >50%) 16 out of the 22 sites (**Table 4**). However, its abundance was much lower mainly in the northern part of the lake, from Opaya to Vromolimni and Viro. A graphical summary of the different relative abundances of species and their composition in each site can be found in **Figure 2**.

The highest calculated densities in the study area were those of the Bearded Reedling in Agios Achilleios, Vromolimnes and Ekvoli (see **Table 1** for reedbed groupings) with 12.7, 5.1 and 5.1 individuals/ha respectively. The Reed Warbler displayed the highest population density in the area of Vromolimni followed by Latsista and Agios Achilleios (5.7, 5.1 and 5.1 individuals/ha respectively) whereas Great Reed Warbler populations were found to be more dense in Agathoto, Daseri and Latsista (5.4, 4.8 and 4.5 pairs/ha). Species densities in each site and in larger reedbed blocks can be found in **Table 5** and **Table 6**. In addition, projected densities of the six commonest species in the area are shown in **Figure 3**. Species richness was lowest in the sites of Daseri (PAS20), Agios Nikolaos (PAS18) and Latsista (PAS01) with two species present at each of them. On the other hand high number of different species was found in the sites around Vromolimni including Slatina (PAS12), Opaya (PAS09) and Platy (PAS10). Bird diversity followed a similar pattern with the areas mentioned above being the lowest and highest diverse respectively (**Figure 4**). The dominance index showed that the most even area regarding the bird community was Vromolimni area, whereas reedbeds of Latsista, Agathoto, Pyli, Daseri and Lefkonas showed increased dominance by one species, the Great Reed Warbler (**Table 7**, **Table 8**). The Bray-Curtis index based in species composition and abundance revealed high similarity (>0.9) between the two sites located in Agathoto (PAS21, PAS22), a site in Daseri and one in Lefkona (PAS20, PAS07), Mikrolimni (PAS03) with Agios Nikolaos (PAS18) and a site in Lefkona (PAS07), Bouskani and Pyli (PAS06, PAS17) and finally Platy (PAS10) and a site in Mikrolimni (**Table 9**). When sites were grouped into larger reedbeds the highest similarities were observed between the reedbeds of Pyli and Krina as well as the reedbeds of Agathoto and Daseri, whereas rest of the sites showed lower levels of similarity (**Table 10**). Hierarchical clustering dendrograms using the UPGMA algorithm along with Bray-Curtis similarity values can be seen in **Figures 5 &6**.

**Table 2**. List of all bird species observed outside the census duration

| | PAS 01 | PAS 02 | PAS 03 | PAS 04 | PAS 05 | PAS 06 | PAS 07 | PAS 08 | PAS 09 | PAS 10 | PAS 11 | PAS 12 | PAS 13 | PAS 14 | PAS 15 | PAS 16 | PAS 17 | PAS 18 | PAS 19 | PAS 20 | PAS 21 | PAS 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Anser anser* | | | | | | + | | + | | | | + | | | | + | | | | | | |
| *Anas platyrhynchos* | | + | | | | | | | | | | | | | | | | | | | | |
| *Phalacrocorax pygmaeus* | | + | | | | + | | + | | | + | | | | | + | | | | | | |
| *Phalacrocorax carbo* | | | | | | + | | + | | | + | + | | | | + | | | | | | |
| *Ixobrychus minutus* | | + | | | | | + | + | | | | | | | | + | | | | | | |
| *Nycticorax nycticorax* | | + | | | | | | | | | | | | | | | | | | | | |
| *Ardeola ralloides* | | + | | | | | | | | | | | | | | | | | | | | |
| *Ardea cinerea* | | + | + | | | + | | + | | | | | | | | + | | | | + | | + |
| *Ciconia ciconia* | | | | | | | | | + | + | | + | | | | | | | | | | |
| *Plegadis falcinellus* | | | | | | | | | | | | | | | | + | | | | | | |
| *Circus aeruginosus* | | | | | | | | | + | + | | + | + | + | | | | | | | + | + |
| *Accipiter nisus* | + | | | + | | | | | | | + | | | | | | | | | | | + |
| *Buteo buteo* | | | | | | | | | + | | + | + | + | | | | | | | + | | + |
| *Falco tinnunculus* | + | | + | | + | | | | | | + | | | | | | | | | + | + | |
| *Gallinula chloropus* | | | | | | | + | | | | | | | | | + | | | | + | | |
| *Himantopus himantopus* | | | | | | | | | | | + | | | | | | | | | | | |
| *Actitis hypoleucos* | | + | | | | | | + | | | + | | | | | | | | | | | |
| *Tringa erythropus* | | | | | | | | | | | + | | | | | | | | | | | |
| *Streptopelia turtur* | | + | + | + | + | + | | | + | + | | | | | | | | + | + | + | + | + |
| *Cuculus canorus* | + | | + | | + | + | | | + | + | | | | | | | | | + | + | + | + |
| *Caprimulgus europaeus* | + | | | | | | | | | | | | | | | | | | | | | |
| *Apus melba* | | | | | | | | | + | + | + | + | + | | | | | | | | + | |
| *Merops apiaster* | | | + | | | | | | | | + | | | | | | | | | + | | |
| *Upupa epops* | + | + | + | + | + | + | | | + | | + | + | | | | | | + | | + | + | + |
| *Dendrocopos minor* | | | | | | | + | | | | | | | | | | | | | | | |
| *Riparia riparia* | | | | | | | | | + | + | + | + | + | + | | | | | | | | |

**Table 2**. cont.

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Anthus pratensis* | | | | | | | | | | | | + | | | | | | | | | | |
| *Luscinia megarhynchos* | + | + | + | + | + | + | + | + | + | + | + | | | | + | + | | + | | + | + | |
| *Sylvia nisoria* | | | | | | | | | | | + | | | | | | | | | | | |
| *Parus major* | + | | | | + | | + | + | | + | | | | | + | + | | | + | | + | + |
| *Aegithalos caudatus* | | | | | | | + | | | + | | | | | | | | | + | | | |
| *Oriolus oriolus* | | | + | | | | | | | | + | | | | | | | | | | | |
| *Lanius collurio* | + | + | + | + | + | + | + | + | + | + | + | | + | | + | + | + | + | + | + | + | + |
| *Lanius minor* | | | | | | | | | | | | | | | | | | | | | + | + |
| *Garrulus glandarius* | + | | | | | + | + | | | | | | | | | + | | | + | + | + | + |
| *Sturnus vulgaris* | | + | + | | | + | | | + | + | + | + | + | | | + | | | | + | + | + |
| *Fringilla coelebs* | + | | | | | + | + | | | | | | | | | + | | | + | + | + | + |
| *Emberiza cirlus* | + | | + | | | + | | | | | + | | | | | | | | | + | + | |
| *Emberiza melanocephala* | | | | | | | | | | | + | | | | | | | | | | | |
| *Emberiza calandra* | | + | + | + | + | + | + | + | + | + | + | + | + | | | | + | + | | + | + | + |

**Table 3**. List of all bird species observed in the 6-minute point counts in each site. Red-list category and protection status is also noted for each species.

| | PAS 01 | PAS 02 | PAS 03 | PAS 04 | PAS 05 | PAS 06 | PAS 07 | PAS 08 | PAS 09 | PAS 10 | PAS 11 | PAS 12 | PAS 13 | PAS 14 | PAS 15 | PAS 16 | PAS 17 | PAS 18 | PAS 19 | PAS 20 | PAS 21 | PAS22 | IUCN | SPEC | Bern Convention | 79/409 EEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rallus aquaticus* | | | | | | | + | | | | + | | | | | + | | | | | | | LC | - | III | IIB |
| *Fulica atra* | | | | | | | + | | | | | | | | | | | | | | | | LC | - | III | IIA/IIB |
| *Motacilla flava* | | | | | | | | | | | | + | | | | | | | | | | | LC | - | II | - |
| *Cettia cetti* | | | | + | | | | + | | + | | | | | | + | | | | | + | | LC | - | II | - |
| *Locustella luscinioides* | | | | | | | | | | | | | | | | | | | + | | | | LC | - | II | - |
| *Iduna pallida* | | | | | | | | | | | | | + | | | | | | | | | | LC | 3 | II | - |
| *Acrocephalus schoenobaenus* | | | | | | | | | | | | + | | | | | | | | | | | LC | - | II | - |
| *Acrocephalus palustris* | | | | | | | | | + | | + | + | + | + | + | | | | | | | | LC | - | II | - |
| *Acrocephalus scirpaceus* | + | + | | + | + | + | + | | + | + | + | + | + | + | | + | + | | + | + | + | + | LC | - | II | - |
| *Acrocephalus arundinaceus* | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | LC | - | II | - |
| *Panurus biarmicus* | | + | + | + | | | | + | + | + | + | + | + | + | + | + | | + | + | | | | LC | - | II | - |
| *Parus caeruleus* | + | | | | | | + | + | | | | | | | | + | | + | | | + | + | LC | - | II | - |
| *Remiz pendulinus* | | + | + | | | | + | + | + | + | | + | | | | + | | | | | | | LC | - | III | - |
| *Emberiza schoeniclus* | | + | | | + | + | | | + | + | + | + | | + | | + | + | | | | + | + | LC | - | II | - |

**Table 4**. Relative abundance (%) of each species in all sites.

| | PAS01 | PAS02 | PAS03 | PAS04 | PAS05 | PAS06 | PAS07 | PAS08 | PAS09 | PAS10 | PAS11 | PAS12 | PAS13 | PAS14 | PAS 15 | PAS 16 | PAS 17 | PAS 18 | PAS 19 | PAS 20 | PAS 21 | PAS 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cettia cetti* | - | - | - | 9 | - | - | - | 13 | - | 11 | - | - | - | - | - | 7 | - | - | - | - | 9 | - |
| *Locustella luscinioides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8 | - | - | - |
| *Acrocephalus schoenobaenus* | - | - | - | - | - | - | - | - | - | - | - | 6 | - | - | - | - | - | - | - | - | - | - |
| *Acrocephalus palustris* | - | - | - | - | - | - | - | - | 9 | - | 18 | 13 | 14 | 8 | 17 | - | - | - | - | - | - | - |
| *Acrocephalus scirpaceus* | 22 | 13 | - | 27 | 11 | 14 | 13 | - | 18 | 11 | 9 | 25 | 29 | 17 | - | 13 | 17 | - | 15 | 14 | 9 | 9 |
| *Acrocephalus arundinaceus* | 78 | 50 | 71 | 55 | 67 | 71 | 75 | 63 | 36 | 44 | 45 | 19 | 43 | 58 | 67 | 33 | 67 | 83 | 69 | 86 | 73 | 82 |
| *Panurus biarmicus* | - | 13 | 14 | 9 | - | - | - | 13 | 18 | 11 | 18 | 25 | 14 | 8 | 17 | 33 | - | 17 | 8 | - | - | - |
| *Remiz pendulinus* | - | 13 | 14 | - | - | - | 13 | 13 | 18 | 11 | - | 6 | - | - | - | 7 | - | - | - | - | - | - |
| *Emberiza schoeniclus* | - | 13 | - | - | 22 | 14 | - | - | 18 | 11 | 9 | 6 | - | 8 | - | 7 | 17 | - | - | - | 9 | 9 |

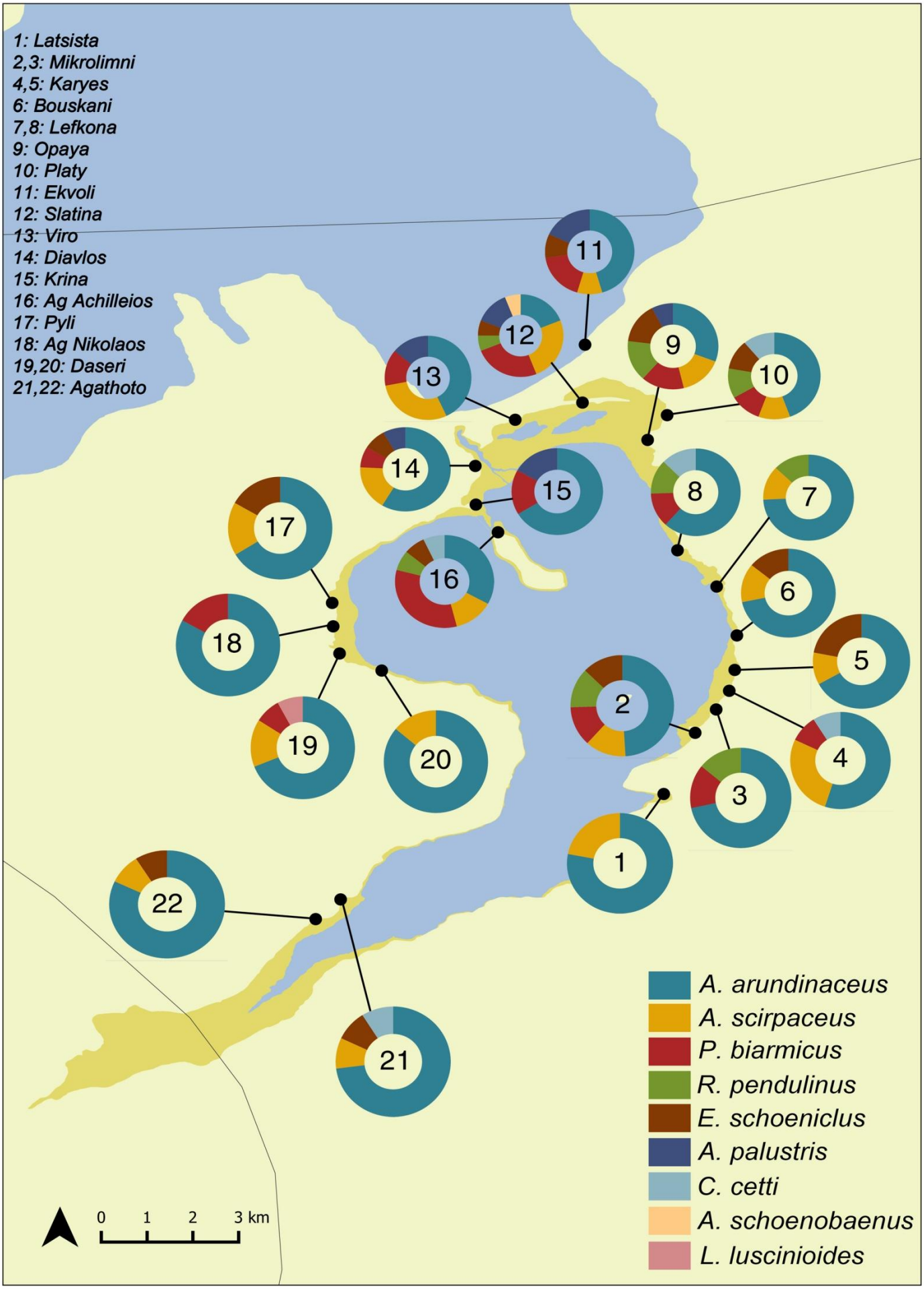


**Figure 2**. Graphical summary of the relative abundance of every species observed in each site. Numbers correspond to site codes (see upper left corner)

**Table 5**. Densities of bird species (individuals/ha) in all census sites. Note that only in the case of the Great Reed Warbler (*Acrocephalus arundinaceus*) density can be expressed as pairs/ha.

| | PAS 01 | PAS 02 | PAS 03 | PAS 04 | PAS 05 | PAS 06 | PAS 07 | PAS 08 | PAS 09 | PAS 10 | PAS 11 | PAS 12 | PAS 13 | PAS 14 | PAS 15 | PAS 16 | PAS 17 | PAS 18 | PAS 19 | PAS 20 | PAS 21 | PAS 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cettia cetti* | - | - | - | 2.5 | - | - | - | 2.5 | - | 2.5 | - | - | - | - | - | 2.5 | - | - | - | - | 2.5 | - |
| *Locustella luscinioides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2.5 | - | - | - |
| *Acrocephalus schoenobaenus* | - | - | - | - | - | - | - | - | - | - | - | 2.5 | - | - | - | - | - | - | - | - | - | - |
| *Acrocephalus palustris* | - | - | - | - | - | - | - | - | 2.5 | - | 5.1 | 5.1 | 2.5 | 2.5 | 2.5 | - | - | - | - | - | - | - |
| *Acrocephalus scirpaceus* | 5.1 | 2.5 | - | 7.6 | 2.5 | 2.5 | 2.5 | - | 5.1 | 2.5 | 2.5 | 10.2 | 5.1 | 5.1 | - | 5.1 | 2.5 | - | 5.1 | 2.5 | 2.5 | 2.5 |
| *Acrocephalus arundinaceus* | 4.5 | 2.5 | 3.2 | 3.8 | 3.8 | 3.2 | 3.8 | 3.2 | 2.5 | 2.5 | 3.2 | 1.9 | 1.9 | 4.5 | 2.5 | 3.2 | 2.5 | 3.2 | 5.7 | 3.8 | 5.1 | 5.7 |
| *Panurus biarmicus* | - | 2.5 | 2.5 | 2.5 | - | - | - | 2.5 | 5.1 | 2.5 | 5.1 | 10.2 | 2.5 | 2.5 | 2.5 | 12.7 | - | 2.5 | 2.5 | - | - | - |
| *Remiz pendulinus* | - | 2.5 | 2.5 | - | - | - | 2.5 | 2.5 | 5.1 | 2.5 | - | 2.5 | - | - | - | 2.5 | - | - | - | - | - | - |
| *Emberiza schoeniclus* | - | 2.5 | - | - | 5.1 | 2.5 | - | - | 5.1 | 2.5 | 2.5 | 2.5 | - | 2.5 | - | 2.5 | 2.5 | - | - | - | 2.5 | 2.5 |

**Table 6**. Densities of birds (individuals/ha) in larger reedbed blocks. Groupings were done according to Table 1. Note that only in the case of the Great Reed Warbler (Acrocephalus arundinaceus) density can be expressed as pairs/ha.

| | Latsista | Mikrolimni-Karyes-Bouskani | Lefkona | Vromolimnes | Ekvoli | Krina | Agios Achilleios | Pyli | Daseri | Agathoto |
|---|---|---|---|---|---|---|---|---|---|---|
| *Cettia cetti* | - | 0.5 | 1.3 | 0.6 | - | - | 2.5 | - | - | 1.3 |
| *Locustella luscinioides* | - | - | - | - | - | - | - | - | 1.3 | - |
| *Acrocephalus schoenobaenus* | - | - | - | 0.6 | - | - | - | - | - | - |
| *Acrocephalus palustris* | - | - | - | 2.5 | 5.1 | 2.5 | - | - | - | - |
| *Acrocephalus scirpaceus* | 5.1 | 3.1 | 1.3 | 5.7 | 2.5 | 2.5 | 5.1 | 1.3 | 3.8 | 2.5 |
| *Acrocephalus arundinaceus* | 4.5 | 3.3 | 3.5 | 2.2 | 3.2 | 3.5 | 3.2 | 2.9 | 4.8 | 5.4 |
| *Panurus biarmicus* | - | 1.5 | 1.3 | 5.1 | 5.1 | 2.5 | 12.7 | 1.3 | 1.3 | - |
| *Remiz pendulinus* | - | 1 | 2.5 | 2.5 | - | - | 2.5 | - | - | - |
| *Emberiza schoeniclus* | - | 2 | - | 2.5 | 2.5 | 1.3 | 2.5 | 1.3 | - | 2.5 |

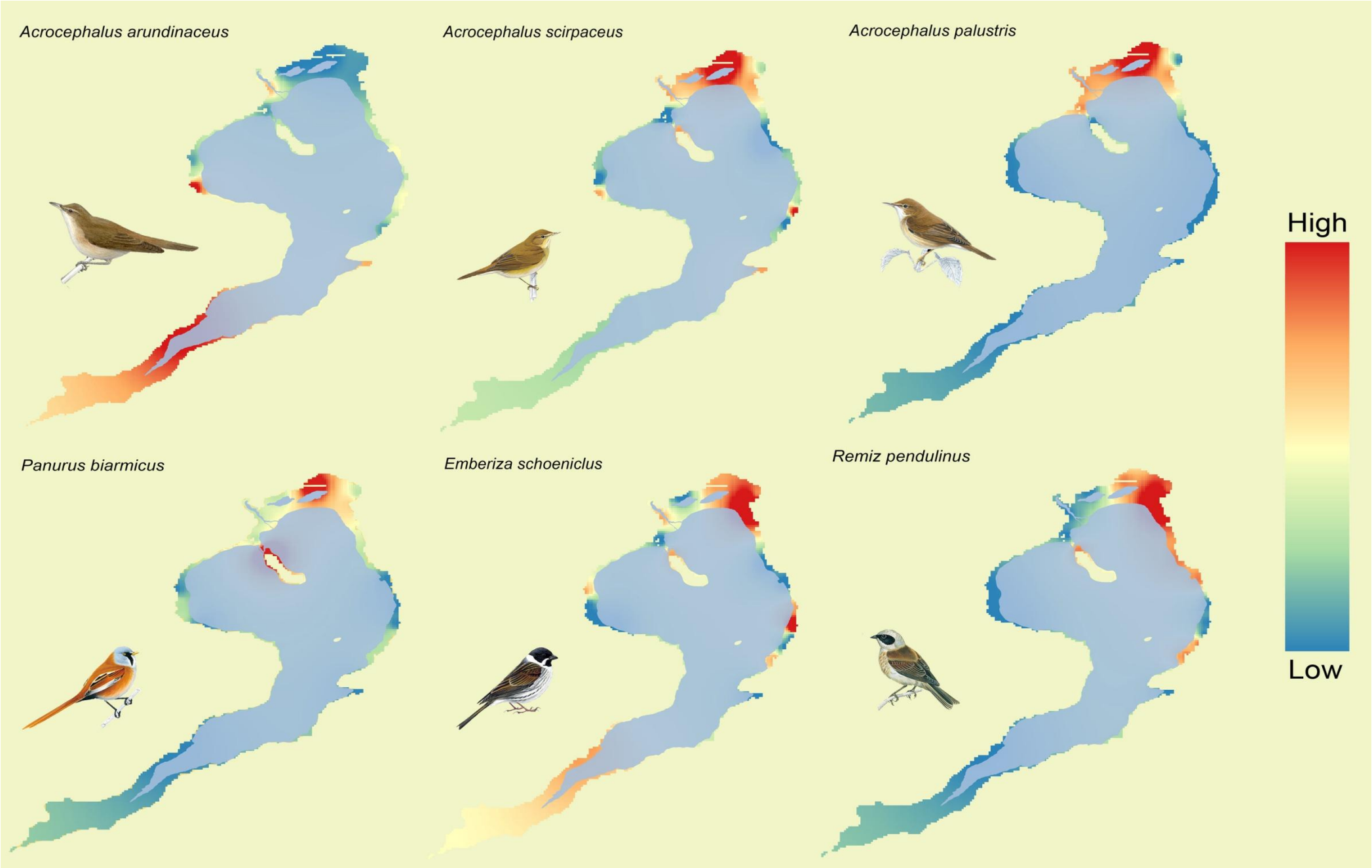


**Figure 3**. Projected densities of the six most common passerines in the study area. Blue and red areas indicate low and high population density respectively.

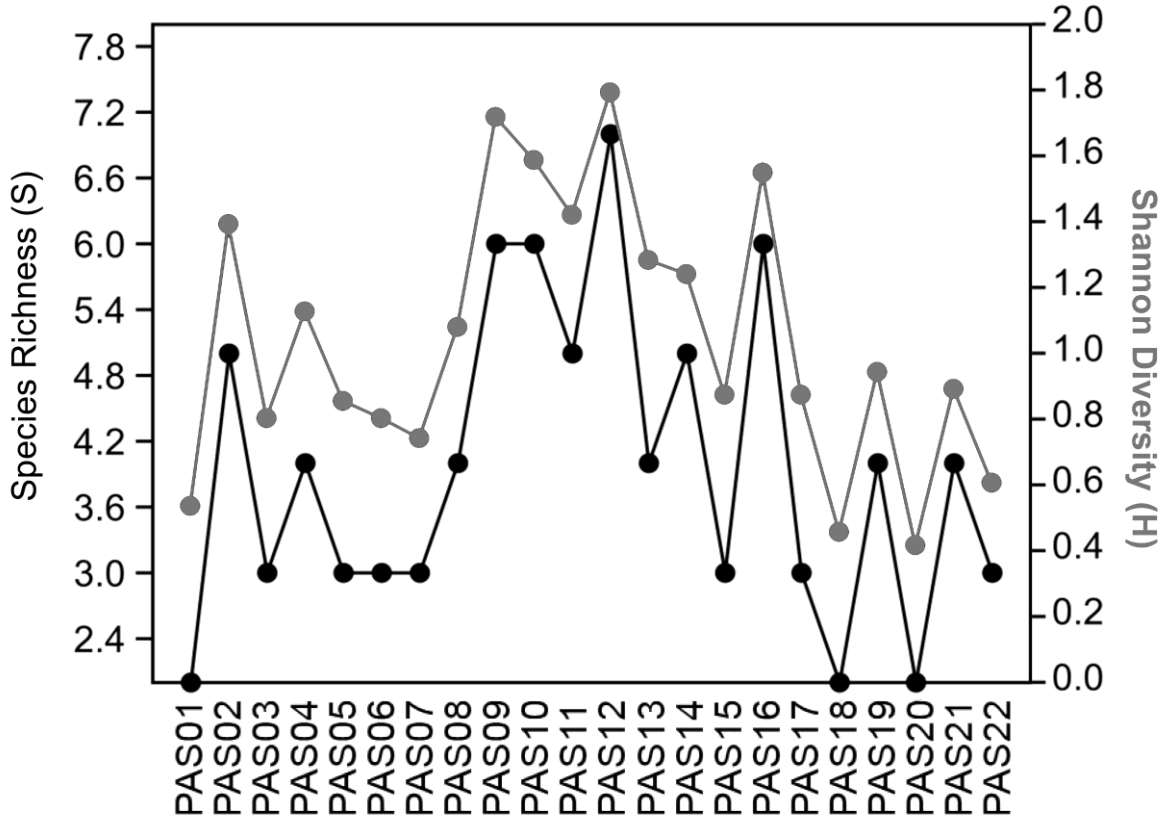


**Figure 4**. Mean species richness (S) and Shannon diversity (H) for each census site after bootstrapping with 10.000 replicates.

**T**

**Table 7**. Species richness (S), Dominance index (D) and Shannon diversity index (H) for all census sites.

| point_code | area | S | D | H |
|---|---|---|---|---|
| PAS01 | Latsista | 2 | 0.65 | 0.53 |
| PAS02 | Mikrolimni | 5 | 0.31 | 1.39 |
| PAS03 | Mikrolimni | 3 | 0.55 | 0.80 |
| PAS04 | Karyes | 4 | 0.39 | 1.12 |
| PAS05 | Karyes | 3 | 0.51 | 0.85 |
| PAS06 | Bouskani | 3 | 0.55 | 0.80 |
| PAS07 | Lefkona | 3 | 0.59 | 0.74 |
| PAS08 | Lefkona | 4 | 0.44 | 1.07 |
| PAS09 | Opaya | 6 | 0.20 | 1.71 |
| PAS10 | Platy | 6 | 0.26 | 1.58 |
| PAS11 | Ekvoli | 5 | 0.29 | 1.41 |
| PAS12 | Slatina | 7 | 0.19 | 1.79 |
| PAS13 | Viro2 | 4 | 0.31 | 1.28 |
| PAS14 | Diavlos | 5 | 0.39 | 1.23 |
| PAS15 | Krina | 3 | 0.50 | 0.87 |
| PAS16 | AgAchilleios | 6 | 0.25 | 1.54 |
| PAS17 | Pyli | 3 | 0.50 | 0.87 |
| PAS18 | AgNikolaos | 2 | 0.72 | 0.45 |
| PAS19 | Daseri | 4 | 0.51 | 0.94 |
| PAS20 | Daseri | 2 | 0.76 | 0.41 |
| PAS21 | Agathoto | 4 | 0.55 | 0.89 |
| PAS22 | Agathoto | 3 | 0.69 | 0.60 |

**Table 8**. Species richness (S), Dominance index (D) and Shannon diversity index (H) for reedbed blocks.

| Reedbed block | Sites pooled | S | D | H |
|---|---|---|---|---|
| Latsista | PAS01 | 2 | 0.65 | 0.53 |
| Mikrolimni-Karyes-Bouskani | PAS02+PAS03+PAS04+PAS05+PAS06 | 6 | 0.42 | 1.22 |
| Lefkona | PAS07+PAS08 | 5 | 0.50 | 1.04 |
| Vromolimnes | PAS09+PAS10+PAS12+PAS13 | 8 | 0.19 | 1.81 |
| Krina | PAS14+PAS15 | 5 | 0.41 | 1.19 |
| AgAchilleios | PAS16 | 6 | 0.25 | 1.54 |
| Pyli | PAS17+PAS18 | 4 | 0.58 | 0.84 |
| Daseri | PAS19+PAS20 | 4 | 0.59 | 0.80 |
| Agathoto | PAS21+PAS22 | 4 | 0.62 | 0.78 |

**Table 9.** Pairwise table of Bray-Curtis similarity index among all sites. High similarity values in bold.

| | PAS01 | PAS02 | PAS03 | PAS04 | PAS05 | PAS06 | PAS07 | PAS08 | PAS09 | PAS10 | PAS12 | PAS13 | PAS14 | PAS15 | PAS16 | PAS17 | PAS18 | PAS19 | PAS20 | PAS21 | PAS22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAS01 | - | 0.59 | 0.63 | 0.80 | 0.78 | 0.75 | 0.82 | 0.59 | 0.55 | 0.56 | 0.40 | 0.63 | 0.86 | 0.53 | 0.58 | 0.67 | 0.67 | 0.82 | 0.88 | 0.80 | 0.80 |
| PAS02 | | - | 0.80 | 0.63 | 0.71 | 0.80 | 0.75 | 0.75 | 0.76 | **0.94** | 0.58 | 0.67 | 0.70 | 0.71 | 0.70 | 0.86 | 0.71 | 0.57 | 0.67 | 0.63 | 0.63 |
| PAS03 | | | - | 0.67 | 0.63 | 0.71 | 0.80 | **0.93** | 0.60 | 0.75 | 0.43 | 0.57 | 0.63 | 0.77 | 0.64 | 0.62 | **0.92** | 0.60 | 0.71 | 0.56 | 0.56 |
| PAS04 | | | | - | 0.70 | 0.67 | 0.74 | 0.74 | 0.58 | 0.70 | 0.52 | 0.67 | 0.78 | 0.59 | 0.69 | 0.59 | 0.71 | 0.75 | 0.78 | 0.73 | 0.64 |
| PAS05 | | | | | - | 0.88 | 0.82 | 0.59 | 0.64 | 0.67 | 0.40 | 0.50 | 0.76 | 0.53 | 0.58 | 0.80 | 0.67 | 0.64 | 0.88 | 0.80 | 0.80 |
| PAS06 | | | | | | - | 0.80 | 0.67 | 0.60 | 0.75 | 0.43 | 0.57 | 0.74 | 0.62 | 0.64 | **0.92** | 0.77 | 0.60 | 0.86 | 0.78 | 0.78 |
| PAS07 | | | | | | | - | 0.75 | 0.57 | 0.71 | 0.42 | 0.53 | 0.70 | 0.57 | 0.61 | 0.71 | 0.71 | 0.67 | **0.93** | 0.74 | 0.74 |
| PAS08 | | | | | | | | - | 0.57 | 0.82 | 0.42 | 0.53 | 0.60 | 0.71 | 0.70 | 0.57 | 0.86 | 0.57 | 0.67 | 0.63 | 0.53 |
| PAS09 | | | | | | | | | - | 0.73 | 0.69 | 0.70 | 0.72 | 0.63 | 0.71 | 0.63 | 0.53 | 0.54 | 0.50 | 0.50 | 0.50 |
| PAS10 | | | | | | | | | | - | 0.56 | 0.63 | 0.67 | 0.67 | 0.75 | 0.80 | 0.67 | 0.55 | 0.63 | 0.70 | 0.60 |
| PAS12 | | | | | | | | | | | - | 0.61 | 0.57 | 0.45 | 0.71 | 0.45 | 0.36 | 0.41 | 0.35 | 0.37 | 0.37 |
| PAS13 | | | | | | | | | | | | - | 0.74 | 0.77 | 0.55 | 0.62 | 0.62 | 0.60 | 0.57 | 0.44 | 0.44 |
| PAS14 | | | | | | | | | | | | | - | 0.67 | 0.67 | 0.67 | 0.67 | 0.80 | 0.74 | 0.78 | 0.78 |
| PAS15 | | | | | | | | | | | | | | - | 0.48 | 0.67 | 0.83 | 0.53 | 0.62 | 0.47 | 0.47 |
| PAS16 | | | | | | | | | | | | | | | - | 0.57 | 0.57 | 0.57 | 0.55 | 0.62 | 0.54 |
| PAS17 | | | | | | | | | | | | | | | | - | 0.67 | 0.53 | 0.77 | 0.71 | 0.71 |
| PAS18 | | | | | | | | | | | | | | | | | - | 0.63 | 0.77 | 0.59 | 0.59 |
| PAS19 | | | | | | | | | | | | | | | | | | - | 0.70 | 0.75 | 0.83 |
| PAS20 | | | | | | | | | | | | | | | | | | | - | 0.78 | 0.78 |
| PAS21 | | | | | | | | | | | | | | | | | | | | - | **0.91** |
| PAS22 | | | | | | | | | | | | | | | | | | | | | - |

**Table 10**. Pairwise table of Bray-Curtis similarity index among grouped reed blocks. High similarity values in bold.

| | Latsista | Mikrolimni-Karyes-Bouskani | Lefkona | Vromolimnes | Krina | AgAchilleios | Pyli | Daseri | Agathoto |
|---|---|---|---|---|---|---|---|---|---|
| Latsista | - | 0.35 | 0.64 | 0.33 | 0.67 | 0.58 | 0.76 | 0.62 | 0.58 |
| Mikrolimni-Karyes-Bouskani | | - | 0.55 | 0.69 | 0.53 | 0.46 | 0.44 | 0.61 | 0.69 |
| Lefkona | | | - | 0.52 | 0.76 | 0.58 | 0.79 | 0.72 | 0.68 |
| Vromolimnes | | | | - | 0.57 | 0.50 | 0.42 | 0.55 | 0.57 |
| Krina | | | | | - | 0.61 | **0.80** | 0.74 | 0.70 |
| AgAchilleios | | | | | | - | 0.59 | 0.46 | 0.49 |
| Pyli | | | | | | | - | 0.69 | 0.65 |
| Daseri | | | | | | | | - | **0.81** |
| Agathoto | | | | | | | | | - |

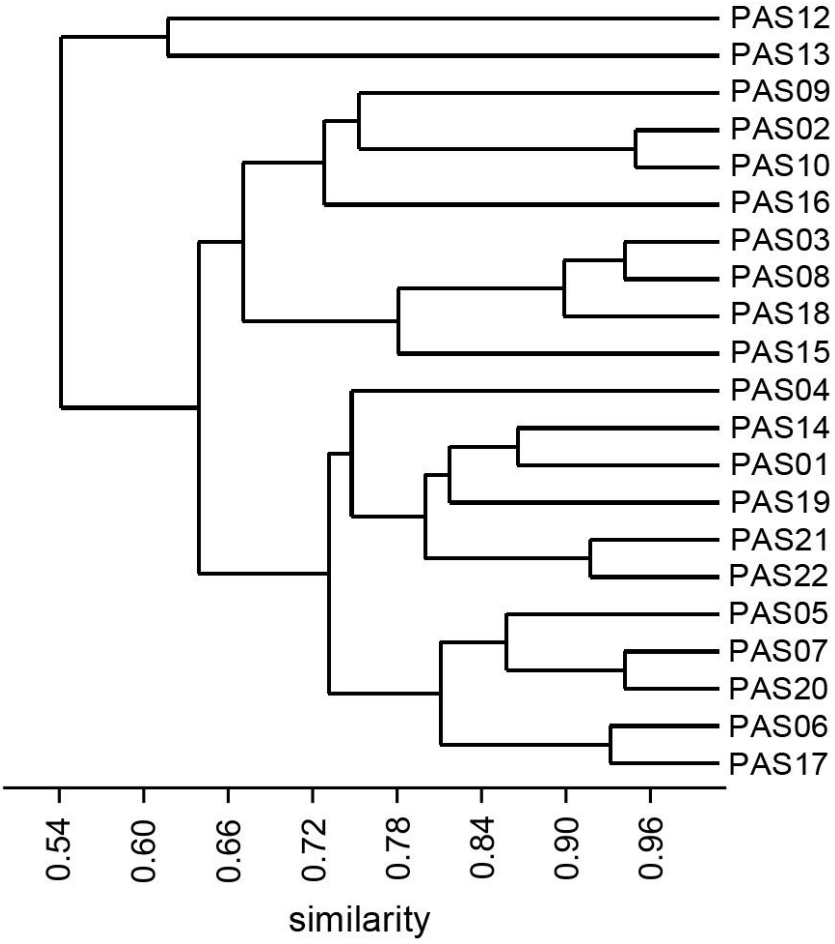


**Figure 5.** UPGMA dendrogram based on between-site similarity regarding the composition and abundance of birds

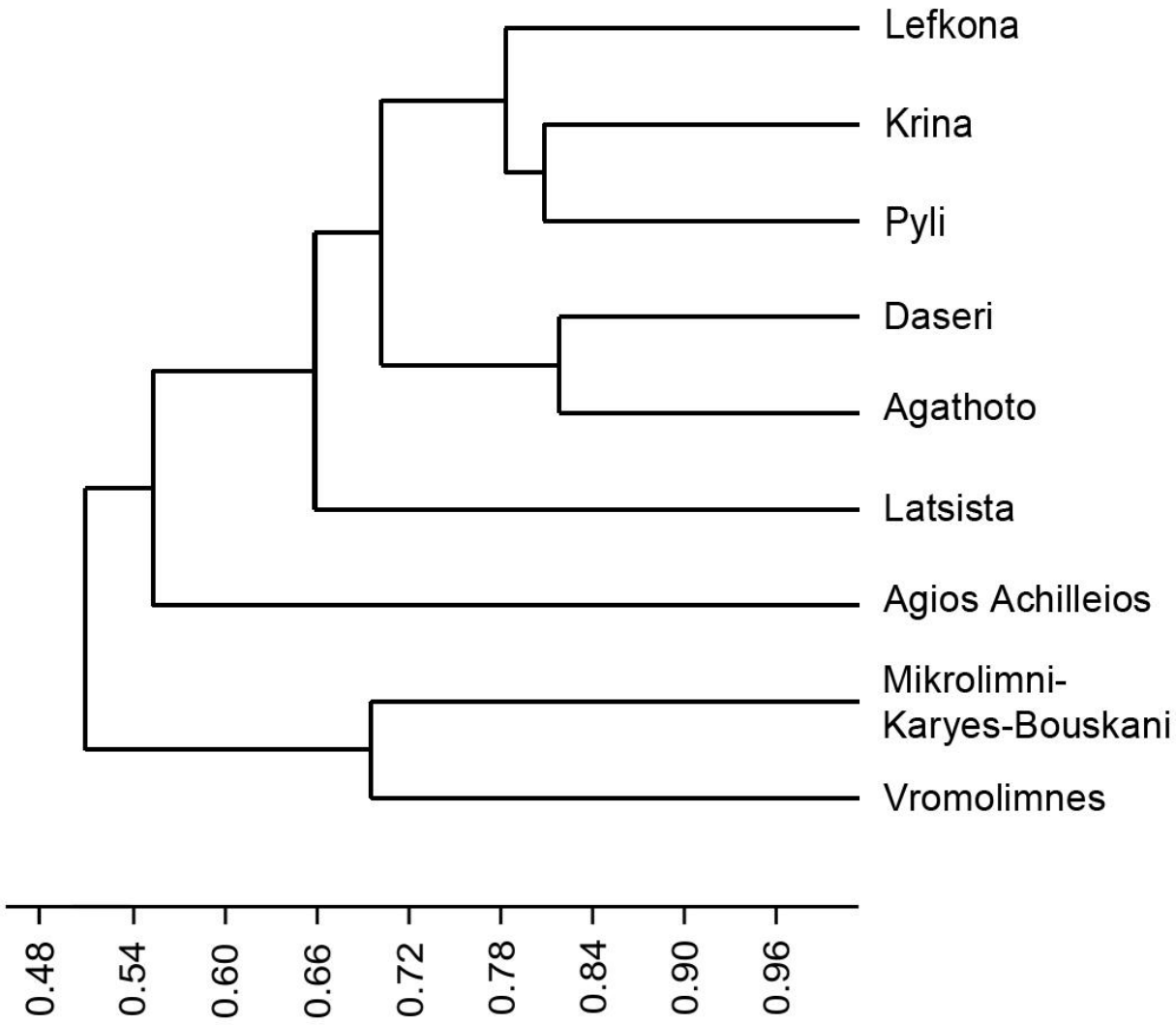


**Figure 5.** UPGMA dendrogram based on between-reed blocks similarity regarding the composition and abundance of birds

# 4. Discussion

The results of this study regarding the species present in the reedbed of Prespa are in general agreement with previous studies in the area[13]. The Great Reed Warbler was the most widespread and abundant reed bird in most areas except the Vromolimni complex where the Reed Warbler dominated. In addition, small sized reedbeds scarcely held more than two breeding passerine species. However, some differences to previous studies were detected: Sedge Warbler was observed just once in the Slatina site whereas it was far more common in the area. Except from the apparent explanation, that the species has declined (due to unknown factors), we should keep in mind that mist-netting is a far more suitable method for examining abundance of reedbed species[23], especially for some species that are not so conspicuous. Notably, the one Sedge Warbler individual observed was detected by visual observation as it did not display any territorial or breeding behaviour by singing/calling. Such behaviour is not surprising as for example in another Mediterranean wetland 30% of sampled birds were silent[23]. On the other hand, Marsh warbler was not observed in the area in the past, but in this study it was found -almost exclusively- in the northern parts of the lake. The Marsh Warbler uses reedbeds mainly for feeding purposes but usually nests in shrubs. Indeed, two cases of nesting Marsh Warblers were recorded during this study in Krina and Ekvoli, that both involved dense shrubs in the vicinity of the reedbed. A hypothesis could be that habitat change in the Northern part of the Lake could have facilitated the growth of bushy vegetation that resulted to the expansion of the species in this area. However, this remains to be examined. Finally, a most interesting observation was a single Savi's Warbler in Daseri area. This species requires large homogeneous reedbeds, but has not bred in the area since 1989[13]. Although the observation was made at the late breeding season (8 July) future fieldwork will confirm if this is indeed a breeding species or a vagrant individual.

The results of this study are insufficient to properly explain any spatial patterns of abundance and density of the observed species in the area. This would need further research, including abiotic factors (mainly regarding reedbed structure at sampling sites). However, a comparison of the results of this report with published information on the habitat requirements and management responses of the species could shed some light on the most efficient decision-making regarding the reedbed management. The abundance of the Great Reed Warbler has been found to be greatest in tall, permanently flooded and almost monospecific *Phragmites australis* reedbeds[17]. The species may prefer tall *Phragmites* stands because only the strongest stems can support the weight of their nests[24]. In addition, this species is one of the few that have actually shown preference for cut areas[25]. This could be due to the formation of edges from reed cutting, creating suitable breeding place for the species. The Reed Warbler generally displays some levels of plasticity, being abundant in monospecific stands as well as in dry reedbeds enclosing several terrestrial plants, but also being common in reedbed types that were not optimal for other species[6]. For this species too, cutting might have a slighly positive effect (depending on the cutting strategy) as monospecific reedbeds

with tall stems are typical of cut reedbeds. Both the above species have rather similar habitat requirements, and could display a pronounced intraspecific competition[26,27]. Also, due to the fact that both species are migratory, winter reed cutting could have minimal effect on their abundance[10]. In our study, the Great Reed Warbler indeed showed the highest densities in the flooded, extensive *Phragmites* stands of Latsista, Daseri, and Agathoto. On the other hand the Reed Warbler, although present in the above sites, had higher densities in the Vromolimni area, as well as some localized high presence in Karyes and Agios Achilleios. As mentioned above *Acrocephalus* species are migratory thus late breeders and possible to adapt in management changes. Resident species however should be the focus when designing such actions. The Bearded Reedling is an early breeder that depends upon reedbeds having a dense cover of thin, dry reed stems to conceal its nests. It generally prefers flooded areas as it includes a high proportion of aquatic larvae in its diet[28] during the breeding season. Such dense, short and thin reed stems are typical of reedbeds growing under stressed conditions and that could be a possible reason for the high density of the species in Agios Achilleios area. As the species could probably require a continuous reedbed area of at least 4 ha to settle in reedbed cutting should be expected to have a negative effect on the species' abundance[6]. As a general rule, characteristics of bird communities can reflect the differences in habitat type with less vegetation-diverse habitats proving to be the ones with less rich and diverse bird community[17]. Food limitation could be a main reason for this since invertebrate abundance (including main prey species for passerines) has been found to be much lower in managed sites compared to unmanaged sites[8]. Some practices (water inputs and cutting) that are commonly used for conservation purposes[11] are associated with increased abundance of reed warblers. However, such change could be at the expense of other (possibly vulnerable) species and thus result in an impoverishment of the passerine community. Therefore the conservation implications of management actions must be evaluated for each particular case and decisions made according to the conservation priorities in the particular area under consideration.

# 5. Management Implications

A meta-analysis of studies on the impact of reed management in wildlife[8] has showed that there is an overall negative effect of reed management on the bird and invertebrate communities. However this effect is associated with a change in reedbed structure due to management, a change that could be visible after long-term management (after 4 consecutive years). Therefore, a rotation of short-term management regime (1-2) years could be an efficient strategy in order to preserve birds and invertebrates in reedbeds. This would involve maintaining a mosaic of reedbed patches differently managed in terms of cutting/no cutting. This way, overwintering arthropods from uncut patches would then have the possibility to colonize neighboring cut patches of reedbed[10]. Such a management strategy could even lead to an increased diversity[29]. On the other hand, if huge homogenous cut areas are formed, it can make the recolonization process of arthropods (the main food resource for reed-nesting passerine species in spring and summer) very slow[9].

Based on all the above discussion and the results of this study, it seems that areas of low diversity, dominated by the Great Reed Warbler would make reasonably good candidates for management. Such areas would be the reedbeds of Pyli as well as parts of the area from Mikrolimni to Bouskani. Great Reed Warbler abundance will most probably be slightly affected while opportunities for other species to colonize the areas could arise. Daseri could also be included in the candidate sites, but the incidence of breeding Savi's Warbler should be addressed first. It would be advisable that cutting in areas of high densities of resident birds such as the Bearded Reedling and Reed Bunting should be avoided, as well as in sites of high bird diversity such as Slatina, Opaya and Platy. Finally, although the areas of Latsista and Agathoto showed relatively low diversity, the existence of extensive, unfragmented reedbeds still holds conservation value and should remain present in the area.

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