Post-fledging habitat selection of a Purple Heron *Ardea purpurea* revealed by GPS/GSM telemetry

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Abstract - The Purple Heron is a species of conservation concern in Europe, mainly threatened by the progressive degradation and reduction of wetlands. For future conservation practices, it is of pivotal importance to gather detailed knowledge of its habitat preferences. In June 2018, a nestling of Purple Heron from a sub-Alpine Lake in Northern Italy was equipped with a GPS/GSM device. Habitat selection during the post-fledging period (mid-July to mid-October) was analysed by superimposing the GPS locations to a fine-grained field-based map, discerning 14 habitat classes as well as narrow (<2 m) and wide (≥2 m) ditches. The contours of the home range were defined as the 99% kernel calculated on all the gathered locations, which were successively sub selected only retaining 2,017 locations representing the position of the bird every hour and all day long. Within the home range, the habitat availability was estimated by generating 10,000 random distributions of the locations. We firstly verified whether wide ditches were more frequently used by the heron if compared to narrow ones. Eventually, we calculated the ratio between the number of true and random locations falling into the different habitat classes, obtaining a series of class-specific selection ratios. We found a significant preference towards wide ditches compared to narrow ones. Freshly renewed reedbeds and cattail beds were strongly favoured, while high-bearing sedges and Black Alder were also significantly preferred but with lower indices. All the remaining habitats, including mature reedbeds, were significantly avoided. Our results reinforce the indication that the protection of minor landscape elements as ditches and small patches of wet habitats may be of pivotal importance to foster the long-term conservation of bird communities linked to the residual wetlands of the sub-Alpine belt

Keywords: *Ardea purpurea*, ditches, inland wetlands, movement ecology, *Phragmites australis*, waterbirds, *Typha* sp.

INTRODUCTION

Temperate inland wetlands include some of the most threatened habitats in the world and a considerable proportion of species of high conservation concern, but their extension is suffering a global contraction, up to 60-70% during the 20th century, mainly due to anthropogenic pressures (Brinson & Malvárez 2002, Dixon et al. 2016). Indeed, wetland contraction is faster in highly anthropized areas, due to higher water drainage (Prigent et al. 2012). Overall, birds inhabiting inland wetlands are suffering worldwide population declines (Wang et al. 2018, Wetlands International 2020). Vast nature protection networks aim to contrast biodiversity loss, and the European 'Natura 2000' network of protected areas, established in 1992, has partially reached this goal, at least for certain taxa (Trochet & Smeller 2013). However, wetlands cannot be simply 'protected', since they are naturally evolving areas that must be correctly managed over the long-term, in order to maintain their role as suppliers of invaluable ecosystem services (Zedler & Kercher 2005). Specifically, the management should ideally target to maintain a right proportion of some key habitat classes as well as optimal habitat structures.

The structure and the composition of the habitats crucially affect bird communities in the belt of wetlands that characterise the landscape of the sub-Alpine northern Italy (Morganti et al. 2019, Brambilla et al. 2020). The use of target species to infer the ecological status of wetlands is a well-suited practice, and the best indicators for this purpose are top predators strictly dependent on specific habitat features (i.e. Morganti et al. 2019). Herons (order: Pelecaniformes, family: Ardeidae) include top predators of conservation interest but, despite their conspicuous body size and their numeric abundance that make them much more visible if compared to other wetland specialists, many aspects of their ecology are still obscure (Kushlan & Hafner 2000).

The advent of individual tracking technology has revolutionized the study of animal ecology in recent years (Kays et al. 2015). However, because herons are difficult to capture, surprisingly few species and individuals have been tracked to date, especially if compared to other colonial waterbirds. This holds for Purple Heron *Ardea purpurea*, a medium-sized species (~1,200 g, Demonging 2016) with a vast range in Eurasia and Africa. This species breeds scattered in hundreds of small colonies, which makes it vulnerable to habitat degradation and loss (Kushner & Hafner 2000, Barbraud et al. 2002). It is currently classified as of conservation concern in Europe as 'SPEC 3' with 31,600 – 40,000 breeding pairs worldwide (Birdlife International 2017), and it is listed in Annex 1 of the 'Birds Directive' (Directive 2009/147/CE).

Only three tracking studies have been performed to date on Purple Herons (van der Winden et al. 2010, 2012; Jourdain et al. 2008). In Europe, Purple Herons are considered fully long-distance migrants, with only exceptional wintering cases in Mediterranean countries (e.g. Italy, see Spina & Volponi 2008). They perform fast (5-7 days on average) migration of almost 4,000 km, crossing the Mediterranean Sea and the Saharan desert with a few or no stopovers up to their Western Sahelian wintering grounds (van der Winden et al. 2010, Morganti et al. unpub. data). This migration represents a considerable behavioural challenge that requires adequate fuel as energy stores accumulated during the post-breeding period (van der Winden et al. 2012). Mortality while crossing the Sahara can reach 30-50% in inexperienced juvenile raptors (Strandberg et al. 2010), and the few available data suggest that such mortality could be similar or even higher in both Purple Herons (van der Winden et al. 2010, Jourdain et al. 2008, Morganti et al. unpub. data) and Night Herons *Nycticorax nycticorax* (Ledwon & Betleja 2015). Therefore, individuals need to select a post-breeding area with adequate food availability to thrive and to fuel their autumn migration. This is especially true for first-year birds that are likely to be less efficient foragers than adults (Recher & Recher 1969, Campos & Lekuona 1997). Moreover, juveniles are thought to establish feeding areas segregated from those of the adults to reduce intraspecific competition

(Kushlan & Hafner 2000), even if tracking data only partially support this suggestion (van der Winden et al. 2012). In a wide ecological perspective, it is of interest to study habitat selection in the sensitive post-fledging period. Additionally, conservationists call for high-quality data to support the protection of specific habitats in wetlands management. For these purposes, we tracked a Purple Heron during its post-fledging period, throughout a wetland in a region registering one of the highest densities of human population in Europe (over 2,100 inhabitants/km^2, ISTAT 2020), located 40 km North of Milan, Italy. We mapped at a high resolution a detailed range of wetland habitat classes in the study area. We then used a randomization approach to obtain a robust estimation of habitat availability, and we calculated class-specific selection ratios. Overall, with the limits given by the fact that data belongs to a single individual, we offer a first insight into the habitat selection of this sensible species of conservation concern, and we provide information that could be used for local wetland management.

MATERIALS AND METHODS
Study area and GPS device deployment
The study area included the lake Annone (province of Lecco, Northern Italy, 45.81°N, 9.35°E, Fig. 1), a small subalpine lake (~360 ha) between the large Lake of Como, and its surroundings with a series of small lakes and wetlands of variable extension. The lake lays at ~300 m a.s.l. with a 'wet temperate' climate (climate-data.org), a mean annual temperature of 12.3°C and mean annual rainfall of 1,118 mm. In 2018, we monitored the Purple Heron colony in a reedbed area scattered with willow bushes on the shores of the Annone Lake from mid-April when the first adults were spotted. This heronry had 7-12 nests of Purple Herons from 2000 to 2018 (E. Viganò pers. comm.).

On the 7 June 2018, a nestling of Purple Heron of 29 days old (exact age known due to previous repeated checking of the nest) was captured and equipped with a 22 g Gipsy GSM/3G device produced

by Technosmart Europe and secured to the bird with a 5 g Teflon harness. The bird weighed 865 g at capture, thus the device (with harness) weighed 2.9% of the bird's body mass. The device was set to take GPS-quality locations at variable frequencies every 15 minutes to 1 hour over the 24 h. At every GPS location, instantaneous accelerations were also recorded on the X, Y, and Z axes. The location data were transmitted through the GSM network, while the accelerometer data were remotely downloaded via an Ultra High-Frequency antenna. The bird abandoned the nest on 18 July 2018 and was tracked until 17 October, when was found poached. All the activities were carried out following the ASAB/ABS (2020) guidelines and with capture permit N°1736 of 12 February 2018 by the Lombardy wildlife management service.

Data cleaning and selection
All the data collected between the 18 July and the 16 October 2018 (last day of movements) belonged to the post-breeding period. To obtain a high-quality set of location data, we discarded all the points with HDOP value >1.3 (a measure of the Horizontal Dilution Of Precision of GPS location, as declared by Technosmart Europe), thus retaining only data with accuracy within 15 m. Furthermore, we used accelerometer data to calculate the VeDBA value (Vectorial Dynamic Body Acceleration). VeDBA is a good proxy of the movement status of the tracked individual and was calculated as $VeDBA = sqrt(A_x^2 + A_y^2 + A_z^2)$, as proposed by Qasem et al. (2012): sqrt indicates the square root, A the acceleration and x,y,z the axes to which the acceleration is referred. After the calculation of the instantaneous VeDBA for each location, we retained only locations that were associated with very low VeDBA values (<1.5) thus expressing static positions. Given the behaviour of the Purple Heron, these data included both feeding areas (i.e. those where the bird used its typical hunting technique, waiting or very slow walking, Campos & Lekuona 1997) and resting locations. Habitat selection was analysed via selection ratios

(Manly et al. 2004), a comparison between used and available habitat classes.

After this data selection, we eventually retained 16,747 locations, and on this dataset we estimated the individual home range through kernel density estimators (KDE, Kie et al. 2010), eventually retaining the 99% isopleth (the contour that includes 99% of the probability of observing the individual during the study period, Smouse et al. 2010), overall extended for 272.5 ha. We used the *adehabitatHR* package for R (Calenge 2006), with the 'reference bandwidth' method to estimate the h (smoothing parameter) value. This method is widely used and robust, despite its tendency of a certain oversmoothing (estimating larger areas than other methods, see Bauder et al. 2015). This 99% kernel was used as a reference area for habitat mapping, in which to estimate habitat availability. After kernel calculation, we operated two further data selections. First, we only retained all the location points laying within the 99% kernel. Then we sub-sampled the position data, to obtain a dataset regularly spaced in time, with one observation point for every hour. The sub-setting frequency of 1 h is considered to account for the behaviour of the heron that has long periods of resting in the same or very near positions. As well as most of the behavioural data (Boyce et al. 2010), also the movement of this heron was likely to be strongly spatially autocorrelated. We, therefore, checked the degree of spatial autocorrelation in the data through the widely used Moran's I test (Ord & Getis 1995). Specifically, we compared the observed Moran's I with the value expected in case of the absence of autocorrelation with the Moran.I function of the *ape* package for R (Paradis & Schliep 2019). We verified whether different datasets built by sub-sampling the original locations determined different degrees of spatial autocorrelations at a range of different frequencies (respectively frequencies of 1 h, 4 h, 8 h, 12 h, 16 h, 20 h and 24 h). We found that the degree of spatial autocorrelation increased significantly with decreasing sampling frequency (from a mean ± SD of -0.052 ± 0.001 in the dataset with locations

subsampled at the frequency of 1 h to 0.255 ± 0.033 in the datasets subsampled at 24 h), in all the databases despite the subsampling rate. This may seem counterintuitive (spatial autocorrelation may reduce and not increase in a more spaced dataset), but it likely reflects the use of the same habitats at different times of the day. Since our main aim was to gather information on habitat selection, we eventually opted to maintain the most frequently sampled dataset among those tested (i.e. 1 location per hour) as suggested by Johnson & Ganskopp (2008). This subsetting was the one showing the minimum degree of spatial autocorrelation in the data. After this data sub-sampling, we retained only 2,017 of the original data points (12%, Fig. 1). The dataset on which is based the current study is available in the Movebank Data Repository, https://doi.org/10.5441/001/1.6tn1208h (Morganti et al. 2021).

Comparing the use of narrow and wide ditches

As a first test, paralleling the analysis of true habitat selection, we verified whether the purple heron used more frequently wide than narrow ditches. To this aim, we firstly mapped and digitalized in a linear shapefile all the segments of permanently inundated ditches, discerning between wide (≥2 m) and narrow (<2 m) ditches. At this step, we could identify 45 ditch segments of a mean (± SD) length of 205.75 (± 187.32) m, with segments of wide ditches significantly longer than narrow ones. Out of the total, 26 ditches (57.78%) were classified as 'narrow' while the remnant 19 (42.22%) were classified as 'wide'. Overall, narrow ditches extended for 4,107 m in the area, while wide ones extended for 5,152 m. Successively, for each ditch segment, we counted the number of GPS locations that fell within a 25 m buffer from the ditches and we eventually divided this number for the length of each ditch, previously divided by 100. In this way, we obtained an index (number of locations for every 100 m of ditches) expressing the density of locations around every ditch segment. This variable was no longer a count variable
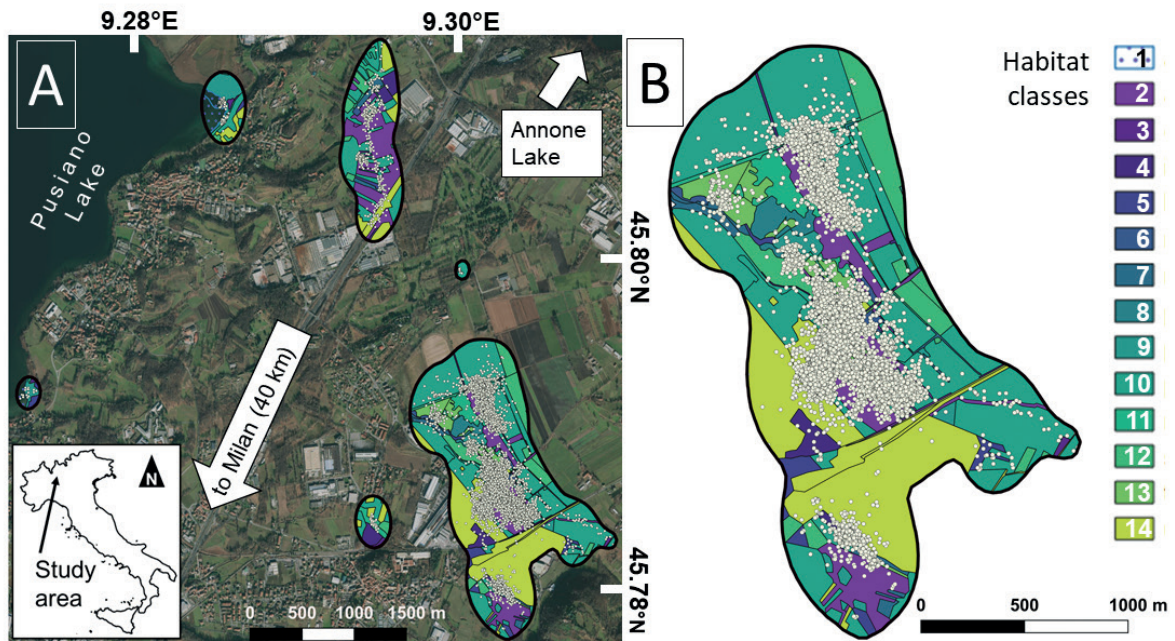
Figure 1. The sector of the study area where the Purple Heron spent its post-fledging period (July-October 2018). A: satellite photo with contours representing the extension of the home range (99% kernel), consisting of six separated areas. Dots represent true GPS locations. B: enlargement of the major kernel area with locations and habitat classes (numbers correspond to the habitat classes listed in Table 1).

(that would have required a Poissonian model) but a continuous one, and therefore eventually entered as dependent in a linear model testing whether wide ditches were significantly more used than narrow ones. The ditch type (i.e. narrow vs wide) was entered in the model as a categorical predictor.

Habitat mapping

As a second step, we studied which habitat classes were selected by our study bird within the study area. A fine habitat mapping was performed over the 272.5 ha of the home range. We firstly clipped the DUSAF 6.0 map (Regione Lombardia 2019) using the boundaries of the home range. DUSAF 6.0 is a detailed vectorial map produced by the local regional entity, based on photointerpretation and well distinguishing the borders of different habitat classes at a true scale (e.g. single crops, small vegetation patches, single buildings). However, because we aimed to study in detail which habitats were selected, we realized a

series of field visits in which we checked whether the contours of the polygons were correct, modifying it when needed and eventually splitting in a range of new habitat classes the polygons originally generically classified under the class 'wetland vegetation' (level code 411 of DUSAF). To do so, we realized field visits within the home range of the heron, while having the DUSAF map available on a tablet, and compared the contours and the classification of each polygon with what observed in the field. Overall, we distinguished 14 habitat classes, listed and described in Tab. 1.

Habitat selection

The selection of specific habitat classes was estimated as selection ratios: a comparison between used and available habitats (Manly et al. 2004). To estimate the availability of each habitat class we simulated 10,000 distributions of 2,500 random points each (a number of points just above the number of the true locations of the heron), all within the home range, for a total

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Table 1. List and description of the 14 habitat classes mapped in the study area. Prog: progressive numeration of the habitat classes.

Prog	Habitat	Description	Prog	Habitat	Description
1	Water	Wide water areas (lake, ponds)	8	Fresh reedbed	Young beds of *Phragmites australis* (<3 yrs). Characterised by spaced stems and often flooded
2	Alder	Woodland patches, often inundated, dominated by European Black Alder *Alnus glutinosa*	9	Mature reedbed	Beds of *Phragmites australis* dense and dry, with accumulated older stems and some intrusions of *Salix sp.* bushes
3	Shrubs	Generic mixed shrubs not explicitly related to wetland habitats. Main species: *Corylus avellana*, *Crataegus monogyna*, *Rosa canina* and others. Includes a patch of the invasive *Amorpha fruticosa* nested in a reedbed	10	Meadow	Common meadows, regularly harvested for fodder production, characterised by common herbaceous
4	Fallow	Abandoned meadows non regularly harvested and constituted of mixed G*raminaceae*	11	Riparian	Wooded belts bordering water areas and channels, represented by mixed trees and shrubs of variable height
5	Mixed wood	Mixed deciduous wood with very scarce or absence of Alder. In the area these woods are mainly constituted by *Fraxinus excelsior*, *Salix caprea*, *Platanus x acerifolia*	12	Arable	Arable crops, mostly cultivated with Corn *Zea mais* in the area
6	Magnocarex	Temporarily flooded areas dominated by tall sedges (> 80 cm) sedges belonging to the *Carex* genus. Main species in the area: *C. riparia, C. elata, C. pendula, C. acuminata.* Typically accompanied by *Eleocharis sp.* or *Juncus sp.*	13	Cattail	Temporarily flooded patches dominated by Cattail *Typha latifolia*
7	Microcarex	Permanently wet meadows almost exclusively composed by *Carex sp.* of low bearing (<30 cm)	14	Urban	Roads, industries, human settlements, private gardens

of 250,000 random points. Successively, we assigned each point to a habitat class (both for true and for random locations) with the extract function of the *raster* package (Hijmans 2020).

As a first test, we checked whether the proportions among the different classes were the same in the set of the used and in those of the available habitats. To do so, we ran a multinomial goodness-of-fit (likelihood ratio) test in the *XNomial* package for R (function xmonte, Engels 2015). A significant result of this test indicates a non-random selection of the used habitat classes. Then, we quantified

the selection ratios for each specific habitat class (Manly et al. 2004). Our study fits into the Manly et al. (2004) categorization 'Design III' since we had one individual, and the available habitats were fully mapped. Habitat availability (i.e. the expected habitat distribution in case of no selection by the bird) was calculated as the mean number of locations falling in each habitat class among those produced in the 10,000 random distributions. Selection ratios with relative 95% confidence intervals (CI) were estimated using the Koopman's score method, with the ci-prat function of the *asbio* package (Aho 2014) as recommended in Aho & Bowyer (2015). Selection ratios (including CIs) above 1 indicate a preference for a given habitat class, whereas values below 1 indicate avoidance (Manly et al. 2004). When CIs interval includes the value 1, there is neither active selection nor avoidance. All the analyses were run in QGIS version 2.18.28 (QGIS development team 2020) and R 4.0.2 (R Development Core Team 2020).

RESULTS

The mean distance from a ditch of all the true (subsampled) locations was 22.87 m (± 25.14 SD; n= 2,017). Wider ditches were significantly more used than narrow ones since the density of true locations was significantly higher around wider (mean ± SD= 12.59 ± 21.74 locations every 100 m) than narrow ditches (mean ± SD= 0 ± 1.81); LM parameters: $\beta \pm$ se= 11.80 ± 4.272, F_{43}= 7.65, t= 2.77, P= 0.008, n= 45. The goodness-of-fit test showed that the distribution of the real locations among the habitat classes was significantly different from those of the random points (LLR= -1317.08, P< 0.001), indicating active discrimination towards certain habitats. The Manly's selection ratios showed that fresh reedbeds (*Phragmites australis* at early growth stage) and patches of cattail (*Typha latifolia*) scored a mean selection ratio of 7.56 (95% CI: 5.34 to 10.70) and 7.27 (95% CI: 5.85 to 9.04) respectively, meaning that these habitats were used more than seven times above their availability (Fig. 2). Patches of 'Magnocarex' (areas of mixed high-bearing sedge

grasses i.e. *Carex sp.* >80 cm tall, belonging to the *Magnocaricion elatae* alliance) and woodland patches of Black Alder (*Alnus glutinosa*) were both significantly and positively selected with a mean selection ratio of 2.48 (95% CI: 1.49 to 4.12) and 1.70 (95% CI: 1.51 to 1.92) respectively. Patches of 'microcarex' (areas of small sedge grasses, <30 cm) were used proportionally to their availability, since the confidence interval associated to their selection ratio overlapped with the threshold value of 1. All the other habitat classes were avoided, that is, their use was lower than expected from their availability class (i.e. disproportionally unused compared to their availability), as represented in Fig. 2.
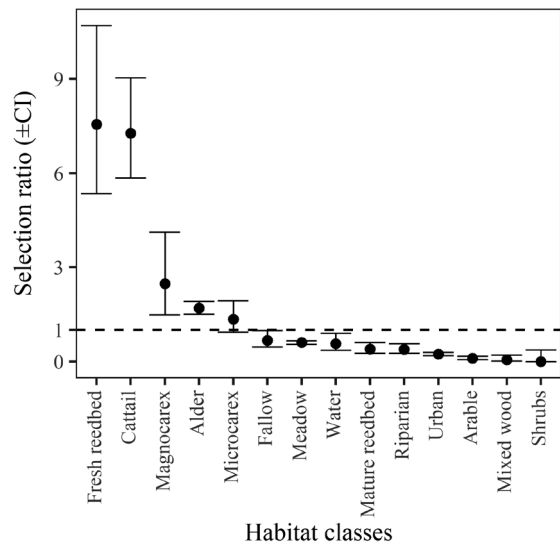

Figure 2. Manly's selection ratios on 14 habitat classes by the juvenile Purple Heron during its post-fledging period (mid-July to mid-October 2018). Whiskers represent 95% confidence intervals (CI) calculated with Koopman's method. Selection ratios (with CI) including the value of 1 mean that the habitat is used in proportion to its availability. Selection ratios >1 mean significant selection, <1 mean significant avoidance.

DISCUSSION

In this work, we presented a first insight on the post-fledging habitat selection of Purple Heron, based on GPS-quality tracking. Albeit our results have to be considered as explorative, since they are based on a single bird, may contribute to suggesting the

Table 2. Habitat selection of a juvenile Purple Heron over 14 habitat classes during the post-fledging period. For each habitat class, it is reported: the number of real locations, the mean number of random locations across the 10,000 simulations, the Manly's selection ratio and the 95% confidence intervals of the ratio (calculated with Koopman method). Habitat classes are ordered from the most (top of the table) to the least preferred.

Habitat	True Locations (n)	Random Locations (mean n ± SE)	Selection ratio	Lower 95% CI	Upper 95% CI
Fresh reedbed	218	35.74 ± 0.06	7.56	5.34	10.70
Cattail	515	87.83 ± 0.09	7.27	5.85	9.04
Magnocarex	43	21.50 ± 0.05	2.48	1.49	4.12
Alder	516	375.49 ± 0.18	1.70	1.51	1.92
Microcarex	59	54.15 ± 0.07	1.35	0.94	1.94
Fallow	41	75.14 ± 0.09	0.68	0.47	0.98
Meadow	432	890.15 ± 0.24	0.60	0.54	0.66
Water	26	56.64 ± 0.07	0.57	0.36	0.90
Mature reedbed	29	89.78 ± 0.09	0.40	0.27	0.60
Riparian	33	105.28 ± 0.1	0.39	0.26	0.57
Urban	89	476.88 ± 0.20	0.23	0.19	0.29
Arable	14	172.62 ± 0.13	0.10	0.06	0.17
Mixed wood	2	45.16 ± 0.07	0.05	0.01	0.20
Shrub	0	12.85 ± 0.04	0.00	0.00	0.37

direction of future research efforts. Our findings confirm that purple herons tend to have elusive habits, and suggest that simple visual observations may be largely insufficient to achieve a satisfactory knowledge of this species, as also stressed by van der Winden et al. (2012).

We found a strict dependence of Purple Heron from very specific habitats (fresh wet beds of reeds, cattail and Carex sp.) occurring in the landscape scattered over extremely small patches. The preference towards such small-scaled landscape elements can only be detected if the grain size of the habitat map is fine enough, and this is hardly achieved if not building up an ad-hoc map of the study site based on accurate field visits. We also found a preference of our study bird towards wide ditches, suggesting that this landscape element may significantly contribute to offering foraging areas and shelter to both purple herons and other waterbirds, especially in densely anthropized areas. The possible occurrence of

individual variability in habitat selection, as observed in other study systems (e.g. Leclerc et al. 2016) may furtherly hinder the generality of our conclusions that are unfortunately based on a single individual. However, the same authors show that most of the variance in habitat selection preferences is explained by consistent selection among individuals (Leclerc et al. 2016). Therefore, an individual randomly picked out from the population has a good chance to report some indications on the general habitat preference of its population. In the specific case of this study, the selective use of wide ditches is likely to be a diffuse behaviour in the local population and not an individual habit. The bird did not stay on the lake shores but moved away from the colony area. This behaviour is possibly adaptive since it could prevent competition with adults (i.e. Kushlan & Hafner 2000, van der Winden et al. 2012). Ditches are a common feature of highly anthropized areas originally dominated by wetlands (suggestively

defined as '*wetlandscapes*' by Thorslund et al. 2017). These ditches are man-made elements but, in the studied area, they date back to the first half of the 20th century in the most recent cases and are nowadays well-vegetated with natural elements (i.e. alder, cattail and native shrubs). Therefore, they offer shaded areas, less disturbed than nearby lake shores where human activities are more intense. Our findings suggest that wide ditches (>2 m) should be regarded as key elements to support the biodiversity conservation of the local wetlands. These ditches are neither protected landscape elements nor fall into protected areas. The only protection is due to their relation with the alluvial forests, a habitat class of special conservation interest (i.e. Annex 1, EU Habitats Directive 92/43/CEE, habitat code: 91E0). Similarly, the strength of the preferences towards fresh reedbeds, cattail and tall sedge beds belonging to the *Phragmito australis-Magnocaricetea elatae* alliance, suggest that this is probably more than a mere individual feature. Again, it should be noted that none of the abovementioned habitats is listed among those of conservation interest. Specifically, the use of fresh vs. mature reedbeds was found to be substantially different in our study, but such distinction is rarely considered in the guidelines for wetland management or in scientific literature.

Our results concur with those of recent studies (Morganti et al. 2019, Brambilla et al. 2020) in suggesting that fresh and wet reedbeds may play a major ecological role for wetland birds of conservation interest. Purple Herons need wet reedbeds for some activities (probably to forage) whereas select mature, generally dry reedbeds for other activities as nesting (Barbraud et al. 2002, Morganti et al. 2019). Similarly, the threatened Bitterns (*Botaurus stellaris*) were found to need mature reedbeds with 5-6 years old stem to breed (Gilbert et al. 2005). Overall, a mixed mosaic of (a few) old mature patches of reedbed and most freshly renewed reedbeds is probably the ideal habitat composition not only for Purple Heron but for most of the wetland specialist birds (Thorslund et al. 2017, Morganti et al. 2019, Brambilla et

al. 2020). The shreds of evidence reported here, although preliminary, suggest that the landscape planning of highly anthropized areas should favour the occurrence of minor natural elements (as ditches and small inundated beds of *Phragmites* and *Typha*), aiming to favour the long-term persistence of healthy water-related ecosystems.

Acknowledgements

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