VIE ET MILIEU - LIFE AND ENVIRONMENT, 2021, 71: 1-6

WETLAND MONITORING USING WINTERING RALLIDS (GRUIFORMES): POINT COUNTS PROVIDES RELIABLE ESTIMATES WHEN COMPARED TO TIME-EXPENSIVE CENSUS METHOD

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FULICA ATRA
GALLINULA CHLOROPUS
ABUNDANCE
SAMPLING METHODS
TIME EFFORT
INDICATORS

ABSTRACT. – The census of common water-related species as indicators is strategic for its ecological implication on assessing the status of wetlands. Here, we carried out a study on the abundance of the most common wintering rallids (Eurasian Coot, *Fulica atra* and Common Moorhen, *Gallinula chloropus*) in a remnant Mediterranean wetland (central Italy), comparing two largely used sampling methods: point counts and total census method (comparable to a mapping method). We performed a Generalised Additive Model (GAM), which indicated that both sampling methods gave similar results, *i.e.*, point counts allow us to obtain reliable data when compared to a more fine-grained and time-consuming total census method. The use of GAMs to monitor the abundance of wintering rallids considers the sampling dates and the auto-correlated nature of the sampling data. Therefore, we suggest rapid surveys of wintering rallids could be carried out by using point counts.

INTRODUCTION

Despite occupying only 2-3 % of the Mediterranean basin area and exhibiting a small size, wetlands ecosystems are home to more than 30 % of Mediterranean vertebrate species (Geijzendorffer *et al.* 2019) and, in human-dominated landscapes, they host a large part of specialist waterbirds (BirdLife International 2004). Moreover, remnant wetlands represent a large proportion of the total amount of wet ecosystems in the Mediterranean basin and show a high ecological value (Gallego-Fernandez *et al.* 1999). These ecosystems are highly vulnerable to many anthropogenic threats acting on many ecological targets: in this regard, a critical conservation target is represented by waterbirds, sensitive to a large set of human-induced disturbances (water stress, fires in reedbeds, illegal poaching, pollution, edge related disturbances, etc.; Battisti *et al.* 2008, 2009). In this regard, the estimations of bird abundance are essential to assess the status and trends of species, particularly when they show an ecological interest.

Among Gruiformes, rallids represent an interesting group composed by 131 wetland species, particularly sensitive to human-induced water stress (Zacchei *et al.* 2011). Eurasian Coot (*Fulica atra*) and Common Moorhen (*Gallinula chloropus*) are the most common and widespread species of the rails family: the Coot is highly gregarious in winter and fiercely territorial during the breeding season (Cramp & Simmons 1980), while the Moorhen breed monogamously but, as they also indulge in a wide range of breeding strategies, including polyandry, polygyny and polygynandry, their mating systems and ecological correlates have attracted much attention (Wood 1974, Petrie 1983, Gibbons 1986, McRae 1995, McRae 1997, Brambilla & Rubolini 2003, Forman & Brain 2004, Forman 2005, Samraoui *et al.* 2013).

In Mediterranean wetlands, these two rallids are sedentary (Ledant *et al.* 1981, Allouche & Tamisier 1984, Isenmann & Moali 2000, Samraoui & Samraoui 2007, Conigliaro *et al.* 2011, Meniaia *et al.* 2014, Talbi *et al.* 2020). Because of their pervasiveness in any wetland, common rallids can be easily recorded and, consequently, used to assess the general ecological status of wetlands (Bharucha & Gogte 1990, Mansouri *et al.* 2014, Ogden *et al.* 2014). Indeed, because of this close relationship with wetlands, they represent a good ecological indicator *sensu* Heink and Kowarik (2010), *i.e.*, a component or a measure of environmentally relevant phenomena – used to depict or evaluate environmental conditions or changes. Indeed, these two species meets many of the criteria requested for a biological indicator (Noss 1990): (i) they have a stable zoological systematic and taxonomy; (ii) are relatively generalist, common, widespread, and medium-sized species, relatively easy to detect and to sample with a minimum field and economic effort; (iii) are sensitive to a specific variable (in our case, water stress and other water-related disturbances; (iv) these common diffused species show a similar ecology inside their geographical range, so that information is universally applicable and spatially comparable; (v) interpretation and communication of indicator results may easily be carried out through simple, quantitative, and reproducible univariate metrics as, for example, frequency of occurrences.

There are many methods to census the abundance of waterbirds, all showing different effectiveness (*e.g.*, line transects, census by mapping methods, point counts, recorded calls: review in Bibby *et al.* 2000, Sutherland 2006). Several studies have compared various bird censusing methods, both in practice and in theory (Emlen 1977, Edwards *et al.* 1981, Whitman *et al.* 1997, Zuberogoitia & Campos 1998, Haselmayer & Quinn 2000, Sedláček *et al.* 2015, Cento *et al.* 2018). Evidently, all these methods have points of strength and weakness depending on external circumstances or species-specific intrinsic features. Counting methods of bird populations exhibit tradeoffs between accuracy and sampling efforts (Solonen & Jokimaki 2011). In addition, bird populations monitoring may differ according to habitats and species (Bibby *et al.* 2000) and the accuracy of the surveys may depend on temporal stochasticity and detectability of individuals (Gordo 2018). Moreover, most authors who compared various methods agreed that tests should be based on data collected simultaneously in the same area for an adequate comparison and the ultimate selection of the best method (Emlen 1977, Edwards *et al.* 1981, Cento *et al.* 2018).

In this paper, we carried out a study of the abundance of the most common rallids (Eurasian Coot and Common Moorhen) in a remnant wetland of central Italy, comparing simultaneously two different and largely used methods: census using a like-mapping method and point counts. Mapping method has been considered the most fine-grained approach to obtain estimates of abundance when compared to other techniques, *e.g.*, point counts or linear transects; Bibby *et al.* 2000). Nevertheless, this method requires a large research effort when compared to more rapid surveys as, for example, point counts (Emlen 1977, Edwards *et al.* 1981, Whitman *et al.* 1997). Indeed, although effective to obtain fine-grained reliable estimates in remnant wetlands (Causarano *et al.* 2009), the mapping method (both the classical method carried out in spring for territorial pairs and the winter mapping method focusing on gregarious species) is a very time-consuming approach to counting individuals and, therefore, it can be too expensive and inefficient for rapid monitoring to detect potential impacts on wetlands (Sutherland 2006). In contrast, point counts are widely used to obtain rapid estimates of waterbirds (Malavasi *et al.* 2009): nevertheless, this approach records relative frequency data, but fails to obtain reliable estimates of absolute abundance (Bibby *et al.* 2000). Thus, we aimed at verifying the effectiveness of point counts as a lesser time-consuming method to obtain a reliable estimation of relative abundance when compared to a more time-consuming census (mapping method).

METHODS

Study area: The study area is included in the "Palude di Torre Flavia" natural Monument (central Italy; 41°57'45.0"N 12°02'50.5"E), a small protected wetland (40 ha) on the Tyrrhenian coast (Special Area of Conservation, according to the EC Directive on the Conservation of Wild Bird 79/409/EC), relict of a larger wetland drained and transformed by land reclamation in the last Century (Battisti 2006, Battisti *et al.* 2006). At landscape scale, this area shows characteristics of a remnant fragment of wetland inside an agricultural and urbanized matrix. On the local scale, it shows a seminatural heterogeneity with *Phragmites australis* reed-beds, channels used for fish farming (prevalently, three species of mullets, *Mugil cephalus, Liza saliens, L. ramada*), flooded meadows with *Carex hirta, Juncus acutus* and Cyperaceae corresponding to *Juncetalia maritimi* habitat type according EC "Habitat" Directive 92/43/EC, dune and backdune areas. Climate is xeric-meso-Mediterranean (Blasi & Michetti 2005). The water in the wetland area is mainly

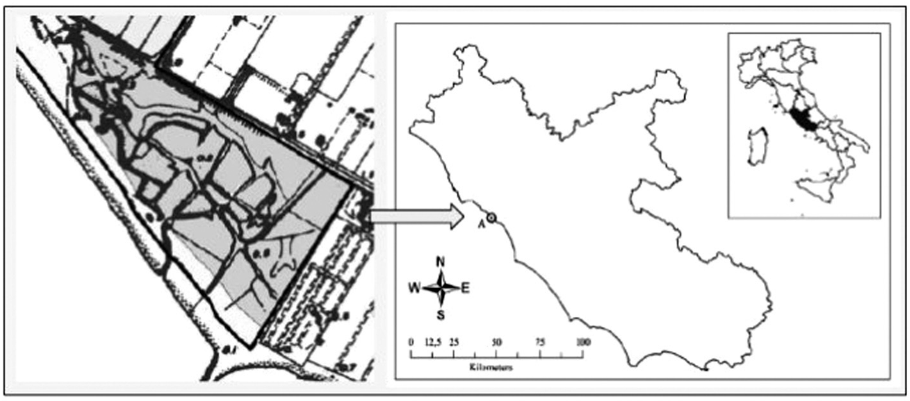

Fig. 1. – The Torre Flavia wetland (central Italy). In grey, the study area.

due to rainfall and seastorms. Flow from surrounding areas is scarce. Depth is variable in time, and no water is present from July to October (Battisti 2006). Water stress is one of the main local direct threats known to Torre Flavia wetland (Battisti 2006, Battisti *et al*. 2008).

Sampling techniques: We used an intensive field sampling during the wintering period 2020 (from the 1st February to 12th March; total: 18 sampling visits), carried out by the same observer (AT), avoiding days with rain and strong wind. At each visit, we used two different approaches: (i) the point counts methods and (ii) the mapping method, applied to wintering period (Bibby *et al*. 2000). Hereafter we refer to the term 'mapping method' to the meaning of 'census method covering all the study area and mapping any individuals of the focal species in wintering period'. Both methods have been carried out in the same 11 ha-wide area, included in the "Torre Flavia" natural Monument (about 6 ha characterized by a *Phragmites australis* reed-bed and about 5 ha within rush-bed habitats corresponding to *Juncetalia maritimi* EU habitat type code 1410). In both methods, we carried out the same number of periodic visits.

Point counts. – Data were collected from 10 sampling points randomly distributed in the study area. We reported the records (*i.e*., the number of sampled individuals of each of the two species) in each sampling point count. We sampled each point count in the early morning (7:00-11:00 a.m.) with sessions of 2 minutes each one. The whole sampling effort was around 360 minutes (6 hours). To avoid data pseudo-replication, we recorded all the birds seen or heard within 50 m from each point count. Distance between surrounding point counts was always larger than 100 m. MGE Coordinate System Operation (MCSO Intergraph – 1995) gave the terrestrial coordinates of each point count (Supplementary materials).

Mapping method. – At each visit, we collected data following a non-linear transect (2,200 m-long) in early morning (07.00 -10.00 a.m.) surveying, as possible, all the study area. The whole sampling effort took around 3240 minutes (54 hours). Contacts (*i.e*., records of each individual bird) were noted on a local map (scale 1: 2,000 from 1:10,000 Technical Regional Map; Regione Lazio 1990). One point was given to any individual species-specific contacts completely inside the study area, estimating the value of the density of both species through the counting of the observed individuals, following the procedure described in Bibby *et al*. (2000).

Data analysis: In both methods, we obtained the total number of individuals (both for Coot and Moorhen)/visit, as a measure of local abundance. We also obtained the mean number of individuals (and standard deviation) of Coot and Moorhen. We used the Past software (Hammer *et al*. 2001).

To test the influence of methods and sampling time (Day-of-Year: DoY) on counts of Coot and Moorhen, we performed a Generalised Additive Model (GAM from the mgcv package with a log-link function and a Poisson error distribution). The GAM is a generalized linear model in which the relationship of the response variable with the covariates is represented by a smoothing function (Hastie & Tibshirani 1990). This technique provides flexibility in uncovering possible nonlinear covariate effects. To deal with the temporal correlation structure of the data, we used Gaussian Process Smoothers, which allow for the auto-correlated nature of the counts. These last analyses were carried out using R (R Development Core Team 2019).

RESULTS

In total, we obtained 403 individual records using the point count method (278 for Coot and 125 for Moorhen: mean number of individual/visit: Coot: 15.44 ± 3.73; Moorhen: 6.94 ± 3.17) and 431 individual records using the mapping method (301 for Coot and 130 for Moorhen: mean number of individual/visit: Coot: 16.72 ± 3.79; Moorhen: 7.22 ± 3.30; Fig. 2).

The GAM analysis indicated that neither the method nor the timing of sampling affected the estimated Eurasian Coot population, whereas for the Common Moor-

Fig. 2. – Pattern of distribution of records of Coot (*Fulica atra*), on the left, and Moorhen (*Gallinula cholopus*), on the right, in the Torre Flavia wetland (central Italy) by mapping method. Single records have been reported in yellow color. Bar represents 100 m in length. Source: aerial photo Regione Lazio.

Table I. – Output for GAM (Generalised Additive Models) analysis for Coot and Moorhen.

	EDF	Ref. df	χ^2	p
Coot				
s(Method)	0.0007	1.00	0.00	0.339
s(DoY)	1.549	1.94	3.98	0.100
Moorhen				
s(Method)	0.0001	1.00	0.00	0.754
s(DoY)	3.587	4.46	14.51	0.009

hen, while there were no differences between the two methods, the number of recorded birds increased initially significantly before stabilizing (Table I, Fig. 3).

DISCUSSION

Our results confirm that both sampling methods give comparable estimates. When we compared the averaged values obtained both from point count method and mapping method we did not obtained significant differences during the wintering period analyzed. Thus, this result is important because of the difference in time duration between the mapping method which requires about 54 hours compared to point counts, which takes 6 hours (about the 11 % of time requested compared to mapping) to complete. In this respect, points count method allowed us to obtain quickly reliable data when compared to the more time-consuming and fine-grained mapping method. However, more investigations are needed to test point counts on a range of rallid densities as previous research has shown that bird density may influence the accuracy of counting methods (Franzreb 1976, Tomiałojć & Verner 1990, Budka & Kokociński 2015). Another source of bias of the adopted sampling technique involves the lack of calculation of a detection probability (Nichols *et al.* 2000, Carrascal 2011). This is particularly true for rallids, some of which are notoriously difficult to record. However, these shortcomings are especially true for species that use long-range acoustic communication (Lefebvre & Poulin 2003, Alldredge *et al.* 2007). Finally, our data could be affected by the small size of this study area, where recorded birds are probably quite close to real numbers in both of methods.

However, while our results might not scale up to other taxa or habitats (Guareschi *et al.* 2015), we advocate a simple but trusted method for quick surveys of wintering rallids in remnant wetlands: using a representative number of randomly located point counts may allow reliable estimations of the populations. Moreover, the regular estimation of population sizes of rallids would provide systematic quantitative data that would prove essential in wetland conservation and waterbird management (Tamisier & Dehorter 1999, Guillemain *et al.* 2014). Thus, rapid and accessible methods (Newson *et al.* 2008) that would grant access to baseline information on birds would be of the utmost interest in countries that lack trained ornithologists or with fewer resources for research (Green *et al.* 2002, Al-Obaid *et al.* 2017). Considering that common rallids, strictly linked with water-related habitats, have been considered good bioindicators of the status of wetlands (Bharucha & Gogte 1990, Mansouri *et al.* 2014), we think that rapid surveys using point counts could be widely utilized also for obtaining general ecological information on the status of these remnant ecosystems.

Acknowledgments. – CB and AT designed the study, AT carried out the field sampling, BS and FS performed the analyses. All the authors wrote and revised the manuscript. We thank E De Angelis and C Galimberti (rangers of "Palude di Torre Flavia" natural Monument for their support during the field sam-

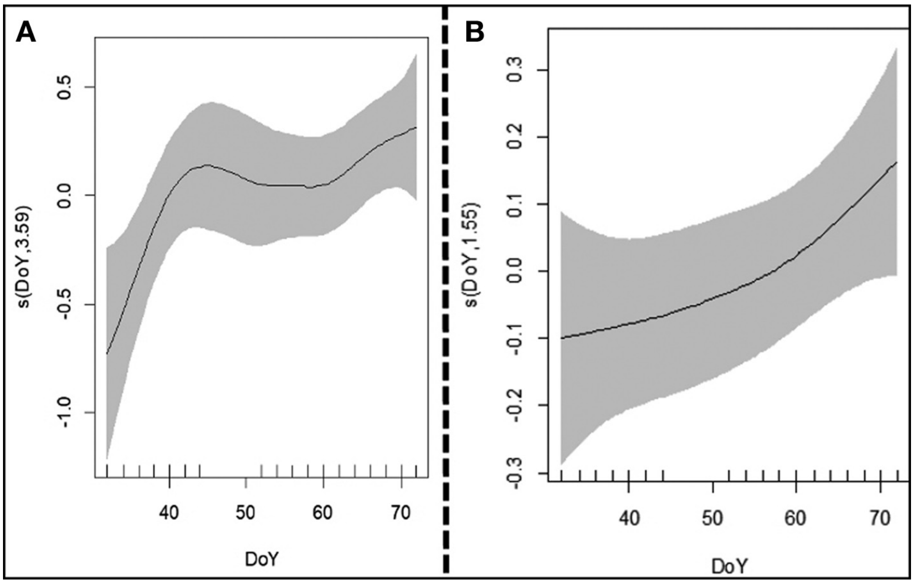

Fig. 3. – Effects of the timing of sampling on the number of Moorhens (**A**) and Coots (**B**) at Torre Flavia wetland (GAM analysis). DoY stands for Day of the Year (1 = 1 January).

pling. We are also most grateful for the Algerian Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (MESRS) for material support. This study has been carried out inside the research activities of the Torre Flavia LTER (Long Term Ecological Research) Station. Two anonymous reviewers and Editors (V Arnaud and F Lartaud) provided useful comments and suggestions, which improved the first draft of the manuscript. A third anonymous reviewer further improved a second draft of the manuscript.

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Received on June 25, 2020
Accepted on June 9, 2021
Associate editor: F Lartaud

Supplementary materials

MGE Coordinate System Operation (MCSO Intergraph – 1995) gave the terrestrial coordinates of each point counts (**P1:** 41.959219 12.051761 ; **P2:** 41.958824 12.051225 ; **P3:** 41.958912 12.050764 ; **P4:** 41.959199 12.050211 ; **P5:** 41.958402 12.050463 ; **P6:** 41.958745 12.048666 ; **P7:** 41.959207 12.047996 ; **P8:** 41.959822 12.047550 ; **P9:** 41.961732 12.046858 ; **P10:** 41.960815 12.047996).