Trend and periodicity of the wintering population of Ferruginous Duck (Aythya nyroca) in Campania (Southern Italy)

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Abstract

The study of trend and periodicity of the Ferruginous Duck wintering population in Campania can provide useful information for the management of a species with a non-optimal conservation status. At the same time it can indicate a reference value of periodicity for those who want to investigate this aspect, for this species or other birds wintering in the Mediterranean basin, also considering the few number of research carried out on wintering waterbird populations. The TRIM method, used to study the trend, and the Fourier analysis, used to highlight all the harmonics present in the time series, allowed us to establish that the Ferruginous Duck shows in Campania a moderate increase in the winter period and that the wintering populations have a mid-term periodicity equal to a value of 2 years.

Keywords: Ferruginous Duck, wintering, trend, periodicity, Fourier analysis

Riassunto

Lo studio dell'andamento e della periodicità della popolazione svernante di Moretta tabaccata in Campania può fornire utili indicazioni per la gestione di una specie che presenta uno

stato di conservazione non ottimale e, nel contempo, indicare un valore di riferimento, per quanto attiene la periodicità per chi vorrà approfondire tale aspetto per questa specie o altre svernanti nel bacino del Mediterraneo, in considerazione anche delle poche ricerche finora effettuate sulle popolazioni di uccelli acquatici svernanti. L'utilizzo del metodo TRIM per lo studio dell'andamento e l'analisi armonica o di Fourier per evidenziare tutte le armoniche presenti nella serie storica ha permesso di stabilire che la specie in Campania, in periodo invernale, presenta un moderato incremento e che le popolazioni svernanti presentano una periodicità di medio periodo pari un valore di 2 anni.

Parole chiave: Moretta tabaccata, svernamento, trend, periodicità, analisi armonica di Fourier

Introduction

The existence of regular cycles in animal abundance was first observed in late 1800s (Begon *et al.,* 1986). Animal population cycles can be induced by periodic environmental fluctuations or as a consequence of internal demographic processes that imply a delayed or overcompensating dependence on density. However, these density-dependent processes must be particularly intense so that they are not masked by random fluctuations in weather conditions (Begon *et al.,* 1986).

Over the years, the study on cycles has mainly focused on cyclical trends in animal populations of epidemiological agents or on populations of invasive species belonging to the Class Insecta and the Class Mammalia as regards vertebrates (Norrdahl, 1995;

Blomqvist *et al.*, 2002; Erdakov and Litvinov, 2014).

There are only few information about birds and our research has focused on breeding populations, with particular attention to waterbirds (Blums *et al*., 1993; Soderholm, 2006; Selivanova *et al*., 2017).

The periodicity of wintering waterbird populations is little investigated although the study of populations is very effective in winter. In fact, since most of waterbirds winter in large flocks in wetlands, their count provide an size estimate of the different wintering populations faster and more complete than that provided by breeding counts, which are complex due to the difficulty in finding nests and their dispersion in very large territories, sometimes hard to reach. Obviously it must be taken into account that winter populations can be the

composition of different reproductive populations. A study on the periodicity of some Ardeidae and Suliformes populations wintering in Campania has been carried out only recently (Fraissinet, 2020).

Understanding of the population dynamics assumes a considerable importance for conservation of species showing alarming declines and contraction of range (Fox, 2005) or specie having an unfavourable conservation status.

The Ferruginous Duck (*Aythya nyroca*) is classified as Near Threatened (NT) in the IUCN Red List, as Endangered (EN) in the Italian Red List (Gustin *et al.,* 2019), as Critically Endangered (CR) in the Campanian Red List (Fraissinet and Russo, 2013) and it is listed as SPEC1 (BirdLife, 2017).

In Campania it is a migratory, wintering and breeding species (Fraissinet *et al.,* 2019; Fraissinet and Usai, 2021). In particular, it appears to be a regular winter visitor, and it is regularly monitored in winter since 2006 (Fraissinet, 2017). There is no information about geographical origin of wintering populations due to absence of reports of ringed birds in South Italy (Spina e Volponi, 2008).

In consideration of the conservation status of the Ferruginous Duck and the importance of wintering waterbird monitoring, we advised appropriate to study the trend and the periodicity of the wintering population of this species in Campania, also to provide a further contribution to knowledge of the population dynamics of Ferruginous Duck and to provide reference information for those who wish to undertake similar research on other wintering populations of this species in the Mediterranean.

Methods

Study area

The Campania region extends for 13,595 km^2 and it is located on the Tyrrhenian side of the central-southern portion of the Italian peninsula (Fig. 1). The surface of the regional natural lakes, mainly located along the coast, does not exceed 20 km^2 Instead, there are numerous artificial water bodies, originated by the construction of barriers across rivers and mainly located in inland areas. Of the total 2000 hectares of assessed wetland, 76.4% are currently manmade (Conti *et al*., 1992).

Figure 1: The Campania region in the Italian peninsula (*drawing by C. Labriola*).

Field census work

The censuses were conducted in January in the context of the International Waterbird Census (IWC) from 2006 to 2021 in the wetlands of the entire region, with an average of 35 locations visited per year. The counts were carried out from the shore using 20 - 60 x telescopes. Every year the observations were carried out from the same points and, whenever possible, the same observers were employed. From January 2014 in the wetlands of the province of Caserta and at Patria Lake (which is in Naples province) the counts were made simultaneously in a single day, involving several teams distributed in the various wetlands, in order to avoid double counting of birds that could move from one wetland to another during the day. Since January 2016, the simultaneous censuses have also been extended to the wetlands of the province of Benevento. Almost all the Ferruginous Ducks wintering in Campania are concentrated in these territories (Fraissinet *et al.,* 2014; Fraissinet, 2017).

Statistical analysis

The trend pattern was analyzed using TRIM software, which also considers the heteroskedasticity and autocorrelation of the time series data. The software always adapts an exponential function to the time series, then testing the significance of the exponent. To analyze the time series cyclicity and make it stationary, the trend was first subtracted from all values. Once obtained the stationary time series, we checked if the oscillations had a random nature or not by testing the sign of the differences (Di Fonzo & Lisi, 2012). After verifying the non-randomness of the oscillations, a harmonic or Fourier analysis was carried out to highlight all the harmonics present in the time series. The calculated harmonics were 8, i.e. equal to the number of census years divided by 2, in order to faithfully reconstruct the entire time series using the model. The theoretical model was obtained using OLS (Ordinary Least Squares), and the correlation between the model and data was then verified using the R^2 index (Battaglia, 2007; Di Fonzo & Lisi, 2012). Each harmonic has a coefficient quantifying its absolute weight. In order to calculate the relative weight of each harmonic, the individual absolute weights were first squared, the result was then divided by the total of the squared weights. So we obtained a value between 0 and 1 which was multiplied by 100 to give the relative percentage weight (Battaglia, 2007; Di Fonzo & Lisi, 2012).

Results

An average of 18.1 wintering individuals per year (SD 10.2) was registered in the considered period, with maximum peaks of 44 in January 2015 and 39 in January 2020. The growth trend was statistically significant

with an increase rate, evaluable as moderate, equal to 6.4% (p <0.05) (Fig. 2).

The test on the sign of differences, used to verify if the oscillations of the detrended time series had a random nature or not, resulted very significant (| td (n) | = 2.6, P-value = 0.009).

perfect correlation between the theoretical model and data. Figure 4 shows both the observed real oscillations (represented by black bars) and the theoretical model (represented by a continuous line). We can see the exact match between the real data
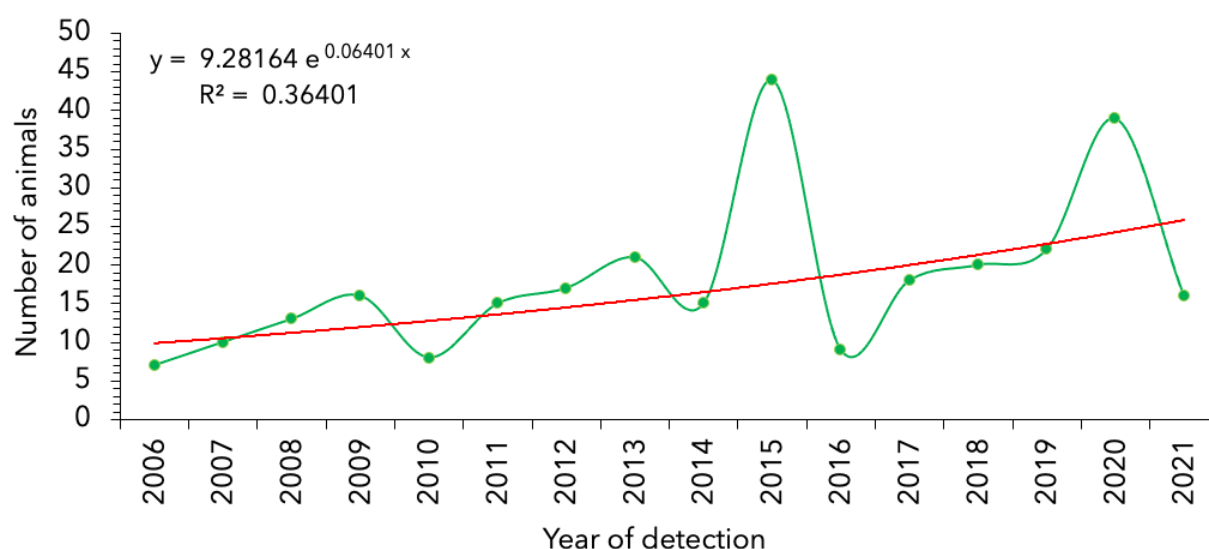

The graph shows $y = 9.28164\ e^{0.06401\ x}$ and $R^2 = 0.36401$.

Figure 2: Time series of the number of wintering ducks and overall exponential trend.

The Trend was estimated using an exponential equation. It was not necessary to seasonally adjust the data because the annual data does not have a seasonal cycle, the one determined by the seasons of the year.

With regard to the harmonic analysis (Fig. 3), the cyclical components with a period between 1 and 3 years have a relative weight of 58.2%, while the 41.1% consists of cyclical components with a period of less than one year, therefore uninteresting, and the remaining 0.7% comprises the 5.74-year component. In particular, the component with a period of 2.87 years has a relative weight of 17.7% and the component with a period of 1.44 years has a relative weight of 20.5%. The other components have modest relative weights.

The R^2 index was equal to 1, indicating a

and the theoretical model, quantified by the index $R^2 = 1$.

The periodicity of the wintering population in Campania over the period 2006 - 2021 (Figs. 2 and 4) shows that the medium-term components (between 1 and 5 years) determine the periodicity of the wintering population of the species in Campania (Fig. 3).

Discussion

The result shown in Fig. 2, relating to the trend analyzed by TRIM method, confirms an increase in individuals of Ferruginous Duck in the winter period in Campania. However, the increase went from the "strong" level recorded in 2017 (Fraissinet, 2017) to the "moderate" one recorded after 4 years in
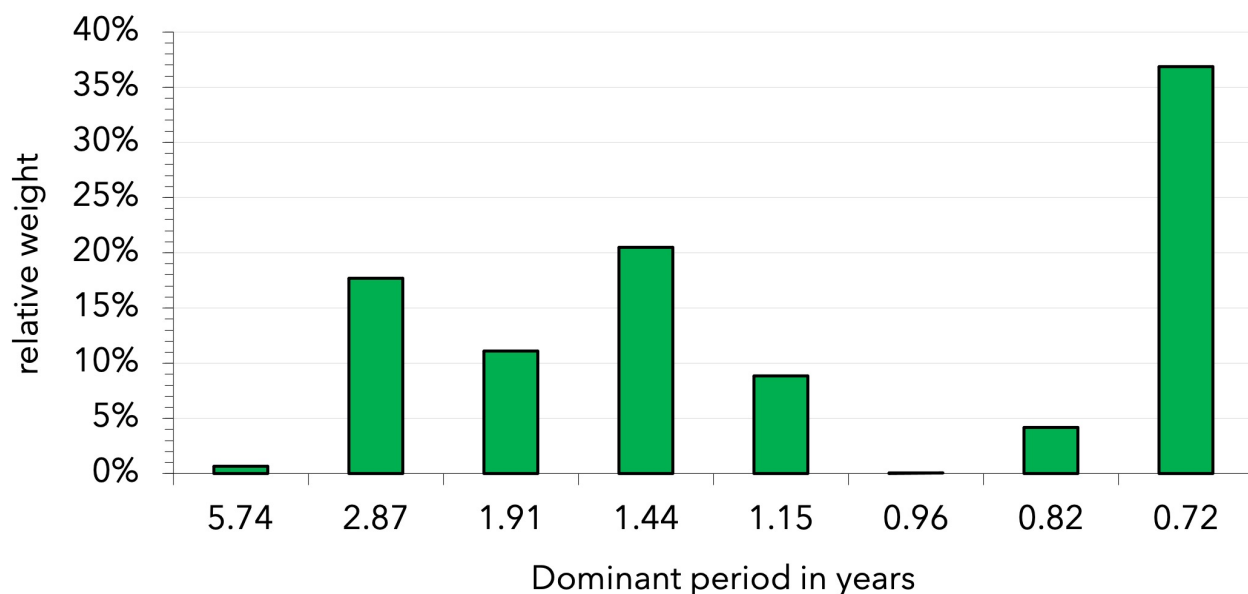
Figure 3: Spectrum of the harmonic components of the detrended time series of the number of wintering ducks.

2021. The latter data is in line with data recorded in Italy in winter (BirdLife International, 2017; Brichetti & Fracasso, 2018).

The periodicity of time series does not return a single dominant value, but provides a series of values which, with similar relative weights, lead to consider a medium-term periodicity equal to a value of 2 years.

This result is the first recorded so far for the Ferruginous Duck, therefore it is not possible to make comparisons. Given the trends recorded for the wintering populations in other Italian regions, even without statistical processing similar to ours, we can observe that the periodicity has values similar to those recorded by us (Arcamone *et al.,* 2007; Brunelli *et al,* 2009; Tinarelli *et al*., 2010).
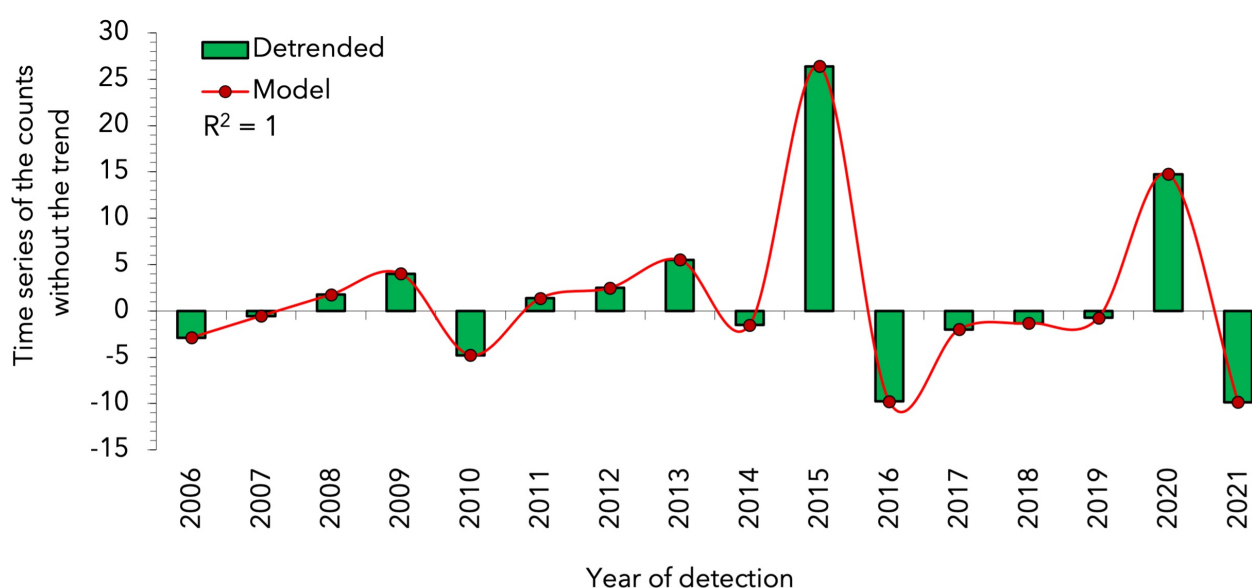

Figure 4: Detrended time series and theoretical model of the number of wintering ducks.

A comparison can only be made with some ardeidae and suliform birds wintering in Campania, for which wider periodicities have been recorded (Fraissinet, 2020), probably due to the greater longevity of the investigated species (Ricklefs, 1990).

A further comparison can be made with studies conducted in Northern Europe on breeding populations of species belonging to the genus *Aythya*, whose results show 5-year values for the breeding populations of Common Pochard (*Aythya ferina*) and Tufted Duck (*Aythya fuligula*) (Soderholm, 2006; Selivanova *et al.*, 2017).

The Authors hope the start work on the periodicity also in other Italian regions in order to be able to male comparisons between the various wintering populations.

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Author contributions

Bruno Dovere, Elio Esse, Maurizio Fraissinet, Vincenzo Mancini, Danila Mastronardi, Alessandro Motta, Stefano Piciocchi, and Filippo Tatino collected data in field work. Maurizio Fraissinet coordinated the monitoring and catalogued data. Stefano Giustino provided the statistical analyses.

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