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Winter roosts of great cormorant *Phalacrocorax carbo sinensis* in Campania region: distribution and multi-year analysis of the population, from 1998 to 2022

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Abstract

The great cormorants' (*Phalacrocorax carbo sinensis*) habit of gathering in roosts in winter makes it easier to monitor the wintering populations. In Campania region (Southern Italy) winter roosts have been counted since the 1980s. However, since January 1998 the monitoring has been standardized and made constant over the years. Therefore, there is a 25-year historical series on which analyzes were carried out on the trend, periodicity, nature of the various roosts monitored in the considered period, and the geographical origins of the wintering specimens. A moderate increasing trend emerged, also confirmed by the comparison of the median number of animals present in the decade 2003-2012 with those of the decade 2013-2022. No periodicity phenomenon was found.

Keywords: Great cormorant, wintering roosts, trend, periodicity

Riassunto

L'abitudine dei cormorani (*Phalacrocorax carbo sinensis*) di radunarsi in inverno in dormitori rende più semplice il monitoraggio delle popolazioni svernanti. In Campania (Italia

meridionale) si effettuano conteggi ai dormitori invernali dagli anni '80 del XX secolo. A partire dal gennaio 1998 però il monitoraggio è stato standardizzato e reso costante negli anni. Si dispone oggi quindi di una serie storica di 25 anni sulla quale si sono effettuate analisi sull'andamento, la periodicità, la natura dei vari dormitori monitorati nel periodo preso in esame, e le origini geografiche degli esemplari svernanti. Ne è emersa una tendenza moderata all'incremento, confermata anche dal confronto del numero mediano di animali presenti nel decennio 2003-2012 con quelli del decennio 2013-2022. Non si è riscontrato un fenomeno di periodicità.

Parole chiave: Cormorano, dormitori invernali, andamento, periodicità

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Introduction

During winter, several species of birds use to gather at sunset in roosts to spend the night. This attitude makes it possible to carry out easily the censuses of the wintering populations in a specific territory. The great cormorant, *Phalacrocorax carbo* is among them.

In Campania region (Southern Italy) the subspecies *P. c. sinensis* appears to be migratory, wintering, breeding, and summer breeding (Fraissinet 2015; Fraissinet & Usai 2021). Nesting began in 2007 in the WWF Oasis Lake Campolattaro (Giannotti et al., 2011).

The first news of the regular wintering of the great cormorant in Campania dates to the first half of the 1980s (Mancuso et al., 2001). At the same time, the first counts of animals in roosts began in the mid-1980s. In the period between winter 1984/1985 and winter 1986/1987, as part of the monitoring of the wintering aquatic avifauna in 14 inland or coastal wetlands in Campania region, the species was found in 7 localities, approximately sited by the coast except for WWF Oasis of Serre - Persano, located in the middle course of the Fiume Sele (Fraissinet et al., 1988). Starting from the winter of 1997/1998, regular and standardized monitoring was carried out throughout the whole region. In the decade from winter 1997/98 to winter 2006/2007, the species was monitored in the months of December, January, and February, following the protocol of the IUCN/Wetlands International Cormorant Research Group (Fraissinet et al., 2003). A first analysis of the trends related to the first decade of standardized monitoring of dormitories was published in 2008 (Fraissinet et al., 2008).

The continuation of the monitoring allowed us to acquire data for 25 consecutive years. Therefore, we considered it appropriate to carry out an updated analysis on the distribution, the environmental characteristics of the roosts, and the trend of

the overall population present in the dormitories.

Materials and Methods

The study area is the entire Campania Region, whose extension is 13,595 square kilometres (Fig.1). The count in the roosts was carried out from one hour before sunset to nightfall.

The counts were carried out through the visual census technique and were performed each January from 1998 to 2022. The dates of the counts are placed within the time window set by the IWC - International Waterbird Census - for monitoring wintering waterbirds. Since the counts were carried out during IWC monitoring, the protocol for such monitoring was followed, which provides for a very limited time interval in which to carry out the counts, therefore each dormitory was visited only once in January of each year.

Figure 1: Location of the Campania region on the Italian peninsula.

The substrates on which the cormorants roosted were also noted and classified into 4 categories: trees near lake or riverbanks, sea crags, dead trunks emerging from the water in basins where the flooding killed the pre-existing trees, and anthropogenic structures (cranes, buoys, etc.).

The research was carried out to bring together all the reports of marked specimens found in Campania region, to know the origin of the wintering populations.

The study of the overall trend was verified through the linear correlation between the counts of the sites surveyed each year. Since this turned out to be high every time, to avoid cases of incorrect estimation due to the variation in the number of sites over the years, it was decided to divide the total number of animals investigated each year by the total number of sites investigated in the same year, to have an average value for each year in every sites independent the number of sites investigated.

To apply the exponential trend estimation method of the TRIM calculation program (Pannekoek & van Strien 2013) of the averages calculated each year, only the whole number was considered, excluding the decimals, to prevent the program from giving errors. Once the data were obtained, it was possible to estimate the exponential growth model through the TRIM program. This model was then used to detrend the historical series and verify if components of this series were present with the turning points test (ps), and the test of the sign of differences (SDI) (Di Fonzo & Lisi 2013). For the comparison between the median

number of animals present in the decade 2003-2012 with those of the decade 2013-2022, the non-parametric Wilcoxon-Mann-Whitney test was used (Siegel & Castellan 1988).

Results

In the period under consideration, 25 dormitories were identified (Fig. 2), with an annual average of 9 dormitories, distributed throughout the region with a prevalence for the coastal areas, in particular for the Campi Flegrei area. Five dormitories have registered continuous attendance for 20 years or more and are still occupied (Tab.1).
Figure 3 shows the trend in the number of dormitories and specimens counted overall for each year. The average in the period under review was 1155.16. A first increase can be observed from 2003, reaching its maximum in January 2007 with 2788 specimens. The following year, 2008, the lowest value was recorded, but this could be explained by the lower number of dormitories monitored in that year due to logistical difficulties. A new increase has been recorded starting from January 2013. The overall trend shows an exponential growth rate of 4.61% ± 1.85% ($p < 0.05$) equivalent to TRIM to moderate increase (Fig.4).
The search for any periodicity of the time series employing the test of turning points (ps) and the sign of differences (SDI), did not reveal significant results, resulting respectively: ps = 0.84 p = 0.401 and SDI = 0.35 p = 0.729.

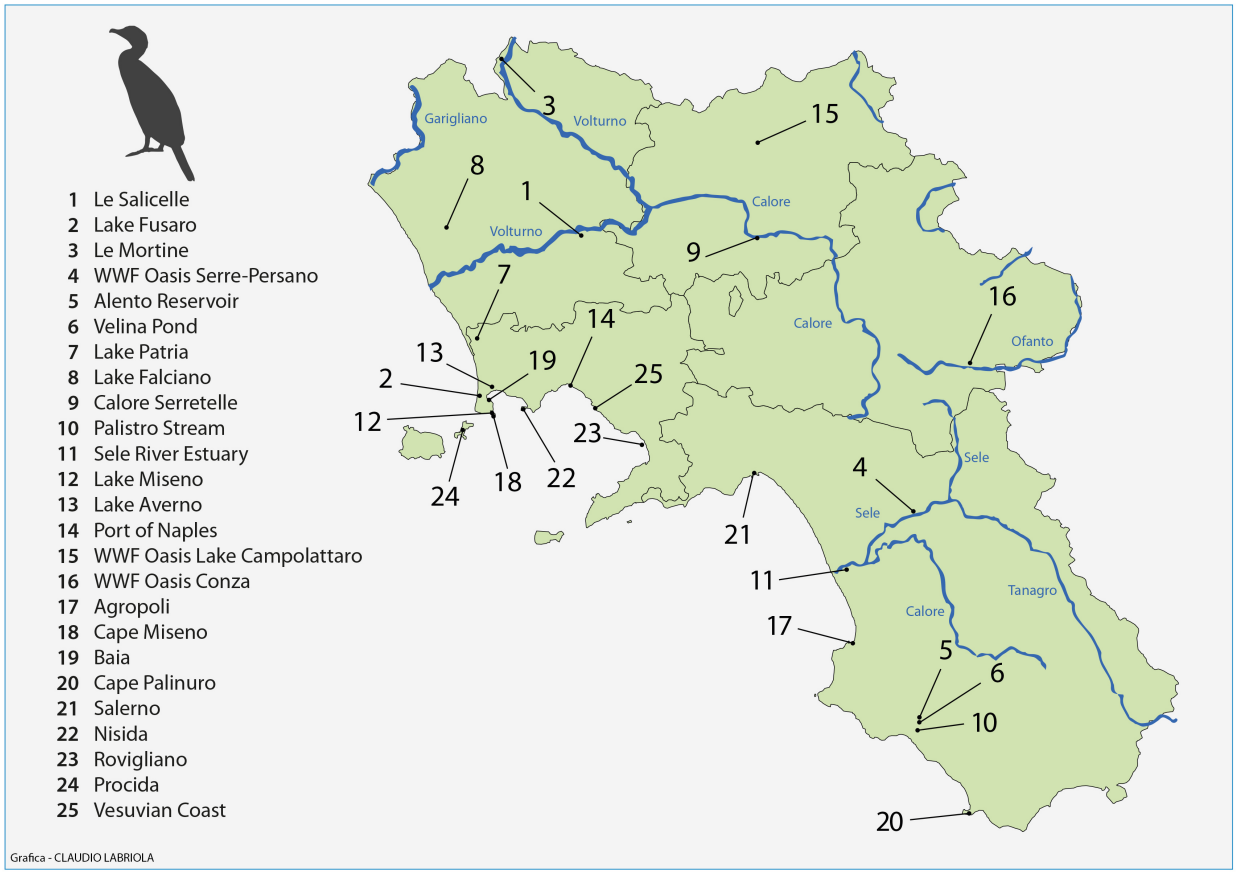

Figure 2: Location of the roosts on the regional territory.

Table 1: Number of years of actual use of the roost.

roost	number of years of use
Le Salicelle	11
Lake Fusaro	24
Le Mortine	20
WWF Oasis Serre - Persano	25
Alento Reservoir	9
Velina Pond	6
Lake Patria	10
Lake Falciano	4
Calore Serretelle	10
Palistro Stream	2
Sele River Estuary	1
Lake Miseno	7
Lake Averno	4
Port of Naples	3
WWF Oasis Lake Campolattaro	22
WWF Oasis Conza	25
Agropoli	1
Cape Miseno	2
Baia	2
Cape Palinuro	2
Salerno	10
Nisida	9
Rovigliano	11
Procida	1
Vesuvian Coast	2

Besides, in the decade 2003-2012, the median number was 99 specimens, while for the decade 2013-2022 it was 169 specimens. The ratio between the median of average number of animals in the roosts in the decade 2013-2022 with that of the decade 2003-2012 is equal to 1.71, thus showing an almost doubling of the population (Fig. 5).

Most dormitories are positioned on trees located on the banks of rivers or lakes, with a prevalence of *Populus nigra*, and on sea cliffs. There are dormitories located on man-made structures such as artificial breakwater cliffs, port cranes, and floating buoys in mussel farming facilities. In a couple of cases, in the WWF Oases Conza and Campolattaro the cormorants exploit trunks of dead trees emerging from the waters of the artificial basin (Fig.6).

There are only nine reports of ringed specimens, all from abroad (Fig.7). Four specimens have been ringed in Germany, two in Denmark and Estonia, and one in Hungary. All the reports were from the wetlands of the Caserta coast and refer to

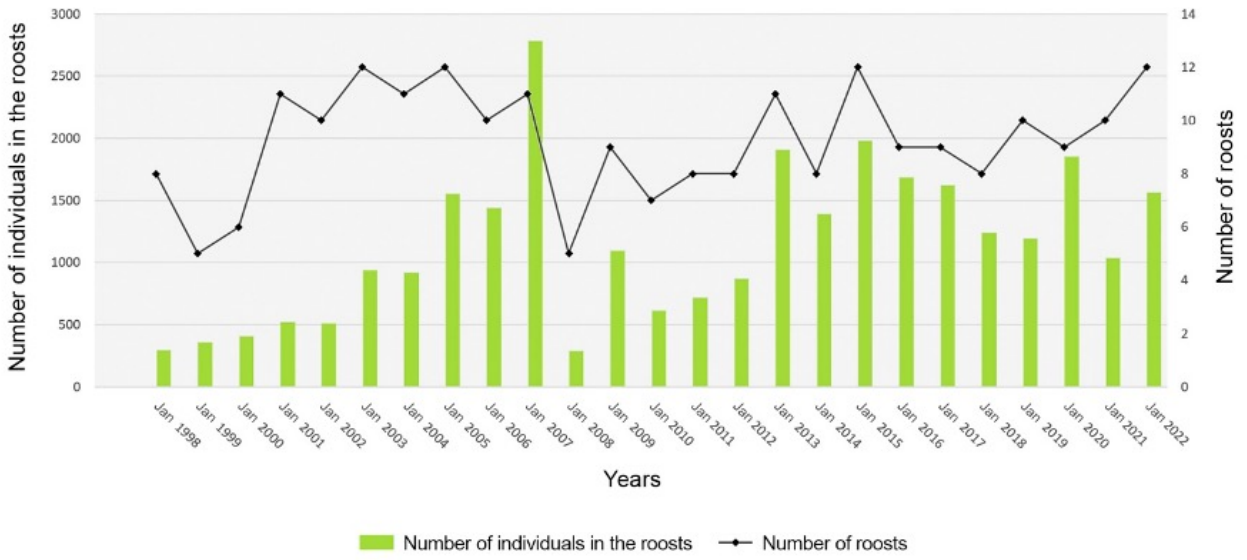

Figure 3: Total number of individuals in dormitories and number of dormitories for each monitoring year.

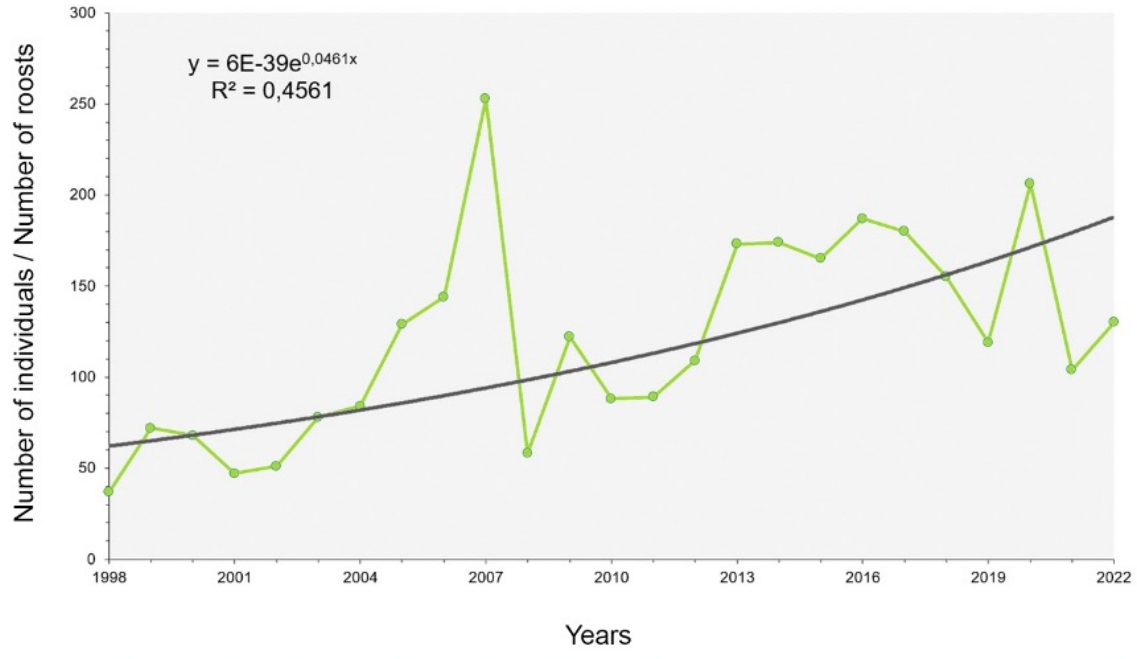

Figure 4: Historical series of the average number of individuals in the roost per year.

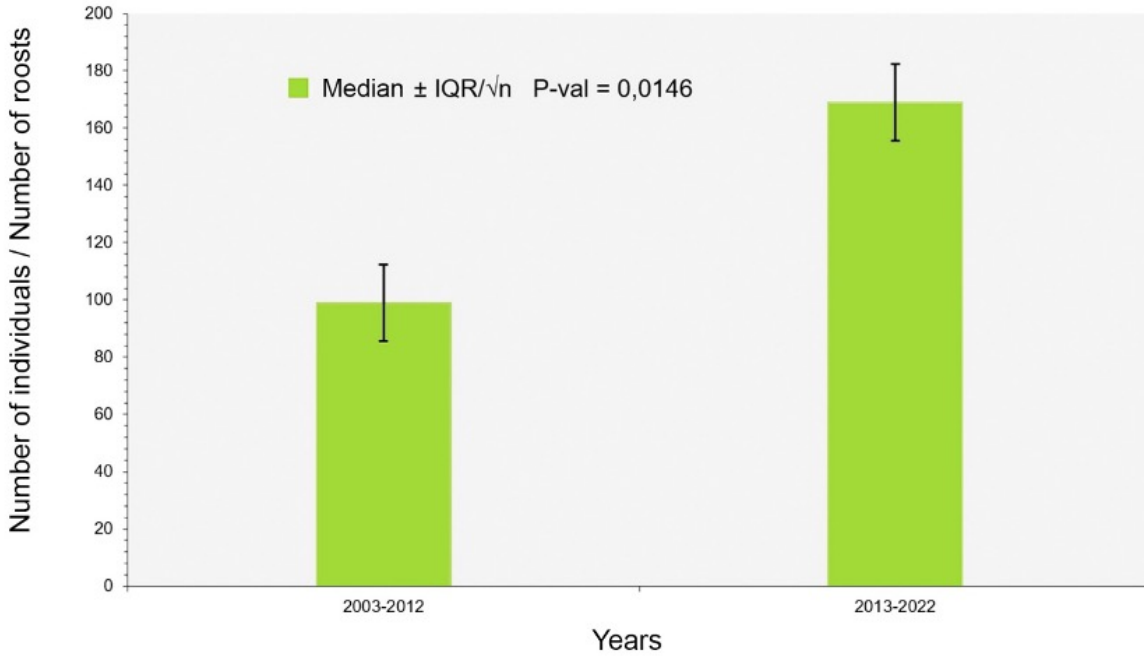

Figure 5: Median ± IQR / √n of the population surveyed at roosts in the two decades 2003/2012 and 2013/2022. IQR = Interquartile Range, √n = square root of the sample size.

killed specimens or, more recently, to the reading of the colored rings from living individuals. One report dates back to 1965 (from Germany), two to the 1980s (from Germany and Denmark), one to 1990 (from Germany), and five in the first two decades of the 21st century (from Denmark, Germany, Estonia, and Hungary). No reading took

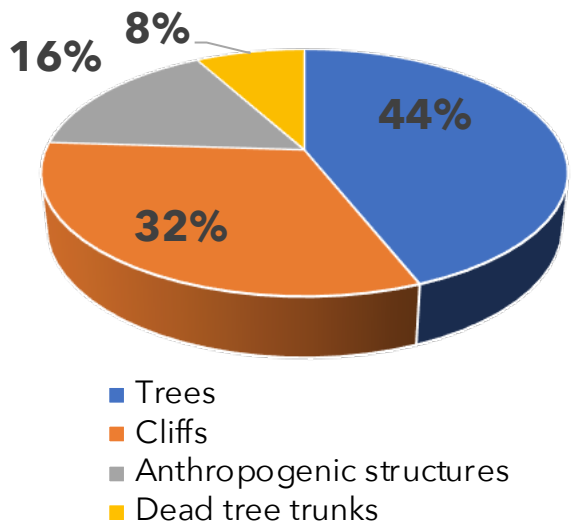

Figure 6: Substrates of the different Campanian dormitories.

place in the roosts. This can be due to the difficulties of finding and reading the rings for the twilight time and the position that the animals assume in the roosts, especially if laid on trees and then shielded by branches or other specimens.

Discussion

The roosts are in different places in the region, in areas characterized by high fishing, irrespective of their coastal or inland position (Fig.2). Of the total of 25 dormitories found during the 25 years of monitoring, only 5, 20%, were frequented continuously for more than 20 years (Tab.1). Most perches consist of riparian tree formations and sea cliffs (Fig. 6).

As for the trend of the monitored population in the roosts over time, there is a moderate increase with a growth rate of 4.6% per year. Deepening the analysis with the comparison between the last two decades confirms the growth, with almost a doubling of the median annual value per dormitory in the second decade. The increase in the wintering population is in line with BirdLife International (2017) in Europe, although the growth rate registered by us is less than 5%, a value that TRIM classifies as moderate.

Therefore, the graph in Fig. 4 allows to hypothesize a first consistent growth as a possible consequence of the conservation measures at the European level (see Marzano et al., 2013). Then, a slowdown follows probably imputable to saturation of resources. In any case, the wintering population in Campania region is in line with the moderate growth reported by recent literature (Frederisken et al., 2018).

The small number of marked individuals does not allow to make many assessments on the origins of wintering stocks in Campania region (Fig.7).

We note the absence of ringed individuals in Italy and that the origins of these specimens are from central-northern and central and north-eastern Europe. Frederisken et al. (2018), and more recently Bregnballe et al.

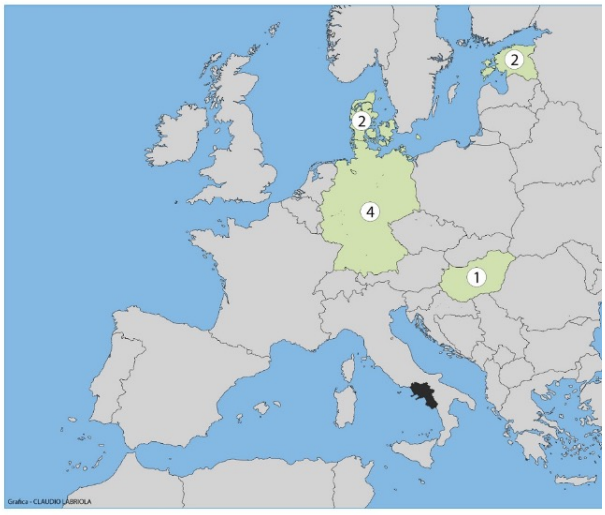

Figure 7: Putative origin of the cormorant specimens in winter. Green areas indicates the countries in which the specimens have been ringed. The number indicates how many recaptures come from that country.

(2021), report a change over the years, as a result of both climate change and the increase of great cormorant breeding populations on the Baltic Sea coasts. It can be hypothesized that in Italy the populations from Holland, Denmark and Norway are shifting their wintering sites towards France and the British Isles, whereas the Baltic population is increasing.

The three specimens from Central and North-Eastern Europe found since 2006 are still too few to confirm the data of literature, therefore it is desirable that future readings of colored rings will help to better understand the current origin of the wintering populations in Campania region.

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Author contributions

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