

## SUBSPECIFIC IDENTITY OF PREHISTORIC BALTIC CORMORANTS *PHALACROCORAX CARBO*

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Cormorants of the subspecies *Phalacrocorax carbo sinensis* breed in large numbers in the Baltic Sea. They migrate to the Mediterranean region to winter and are then replaced in the Baltic by wintering individuals of the Norwegian population of the nominate subspecies *carbo*. Cormorants bred in the Baltic during prehistoric times too, but as evident from a comparison of skeletal measurements in present-day and prehistoric Cormorants, these individuals belonged to the nominate subspecies *carbo*. The Swedish subfossil record of the Cormorants available for study, does not include any remains small enough to suggest the presence of *sinensis*. Precisely when the subspecies *sinensis* immigrated into the Baltic is unknown, but it must have occurred sometime between 1500 and 1800 AD.

Key words: Sweden - Baltic Sea - *Phalacrocorax carbo sinensis* - subspecies - faunal history

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### INTRODUCTION

In Europe, the Cormorant *Phalacrocorax carbo* is represented by two subspecies. The nominate subspecies *carbo* breeds along the north Atlantic coasts while Cormorants in central and southern Europe belong to the subspecies *sinensis*. The two subspecies are distinguished primarily by their different breeding plumages and by the smaller size of *sinensis* (Vaurie 1965, Cramp & Simmons 1977). In the Baltic, Cormorants occur year round, but only *P. c. sinensis* breeds here. Most Baltic *P. c. sinensis* migrate south to central Europe and the Mediterranean region rather soon after the breeding season. These Cormorants are then replaced in the Baltic by large numbers of wintering *P. c. carbo*. There is only a handful of records of supposedly breeding *P. c. carbo* in the Baltic, which are restricted to the coast of northern Sweden.

The Baltic history of the subspecies *sinensis* has recently been summarized by Lindell & Jansson (1994). In the late 18<sup>th</sup> and early 19<sup>th</sup> century,

Cormorants that based on their breeding plumage obviously belonged to this subspecies, inhabited Skåne and Blekinge. Partly because of human persecution by nest destruction and hunting, Cormorants became locally extinct in Sweden at c. 1909 (Sveriges Ornitologiska Förening 1990). About 40 years later, in 1948, a small colony was established in Kalmarsund. Numbers of Cormorants remained low until the early 1980s after which the population size has increased very rapidly. Similar recent increases in population sizes have been reported from other parts of the distribution area of *P. c. sinensis*, e.g., The Netherlands and Denmark (van Eerden & Gregersen 1995, Lindell *et al.* 1995).

Throughout the Holocene, Cormorants seem to have been common along the Swedish coast, including the Baltic. The oldest archaeological records are from a c. 9000 years old (the Boreal chronozone) settlement at the Swedish west coast (Ryhag 1989). Cormorant remains have been found from all subsequent archaeological epochs

**Table 1.** The Swedish subfossil record of the Cormorant *Phalacrocorax carbo* ssp. For each locality, the parish name is given first.

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BOREAL (c. 9000-8000 BP)		
Västergötland	1	Mölnadal, Balltorp (Mesolithic $^{14}\text{C}$ 8890 $\pm$ 105-9080 $\pm$ 110 BP)
ATLANTIC (c. 8000-5000 BP)		
Skåne	2	Tullstorp, Skatchholm I (Mesolithic 5500-7000 BP)
Bohuslän	3	Dragsmark, Rottjärnslid (Rotekärnslid) (Mesolithic)
	4	Tanum, Otterö (> 5500 BP)
Västergötland	5	Västra Frölunda, Bua Västergård (Mesolithic 8100-7500 BP)
SUBBOREAL (c. 5000-2500 BP)		
Blekinge	6	Torhamn, Björkärr (Middle Neolithic Pitted Ware Culture)
Öland	7	Köping, Köpingsvik, Klinta, (Middle Neolithic Pitted Ware Culture)
Gotland	8	Eksta, Stora Karlsö, Stora Förvar (Neolithic to Bronze Age)
	9	Eksta, Ajvide (Middle Neolithic Pitted Ware Culture)
	10	Hangvar, Ire (Middle Neolithic Pitted Ware Culture $^{14}\text{C}$ 3850 $\pm$ 100-4280 $\pm$ 100 BP)
Bohuslän	11	Skee, Dafter (Middle Neolithic Pitted Ware Culture)
	12	Skee, Ånneröd (Middle Neolithic Pitted Ware Culture)
	13	Tanum, Rörvik (Middle Neolithic Pitted Ware Culture)
Uppland	14	Bälinge, Oxsätra, Anneberg (Early Neolithic)
	15	Övergran, Apalle (Late Bronze Age 1200-800 BC)
SUBATLANTIC (c. 2500 BP-recent time)		
Skåne	16	Brunnby, Kullen, Lahebiagrottan (Medieval-Subrecent)
	17	Löderup, Hagestad (Medieval)
	18	Ystad, kv Tankbåten (Early Medieval)
Öland	19	Gräsgård, Eketorp II (c. 400 $\pm$ 50-700 $\pm$ 50 AD) and Eketorp III (c. 1000 $\pm$ 50-1300 $\pm$ 50 AD)
	20	Köping, Hässleby (Migration Period-Late Iron Age)
	21	Köping, Skedemosse (Early Iron Age?)
	22	Köping, Övra Wannborga (c. 600-1000 AD)
Gotland	8	Eksta, Stora Karlsö, Stora Förvar (Iron Age-Subrecent)
	23	Västergarn, Kronholmen (Viking Age)
Uppland	24	Adelsö, Björkö, Birka, Black Earth (Viking Age c. 800-975 AD)
	25	Sigtuna, KV Trädgårdsmästaren (975-1200 AD)
UNCERTAIN OR UNKNOWN AGE		
Skåne	26	Brunnby, Krapperup (unknown)
	27	Stora Hammar, Lilla Hammar (Bronze Age-Late Iron Age)
Gotland	8	Eksta, Stora Karlsö, Stora Förvar (unknown)
Bohuslän	28	Askum, Nödö, Sotenkanalen (unknown)

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(Table 1, Fig. 1). The occurrence of poorly ossified bones of non-fledged individuals in the archaeological samples from two Swedish localities, one on the island Stora Karlsö off Gotland and one in Lake Mälaren (pers. obs.), both situat-

ed outside the present distribution of *P. c. sinensis*, suggests a much wider, past Baltic distribution. Cormorants were also common and well known in the 16<sup>th</sup> century (Olaus Magnus 1555). This, combined with the observation of an obvi-

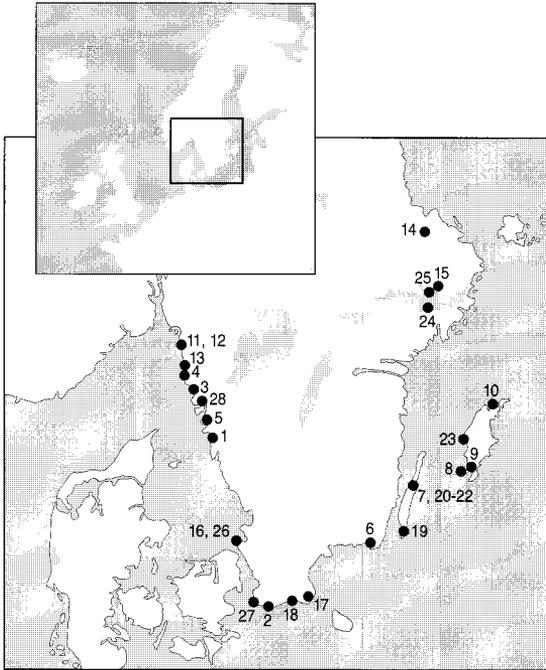


Fig. 1. The Swedish archaeological find places of *Phalacrocorax carbo* ssp. (the figures refer to Table 1).

ously very long history of breeding Cormorants in the Baltic, led to the commonly accepted idea that *P. c. sinensis* has reproduced in the Baltic region since ancient times. It has also been postulated that the nominate subspecies *carbo* has wintered in the region as it does today for at least as long (Löppenthin 1967).

This paper sheds new light on the history of the Baltic Cormorants by identifying the subspecific status of archaeologically recovered Cormorant remains, mainly those found at excavations of Stora Förvar at Stora Karlsö. We are not aware of any previous attempt of subspecific determination of archaeological Cormorants in Scandinavia.

## MATERIAL

### Recent comparative material

The Cormorants of the nominate subspecies studied all derive from the North Atlantic popula-

tion. The sample ( $n = 37$ ) consists of birds from Greenland, Iceland, Faroes, Norway and Sweden, predominantly individuals that were actively collected or that died in oil spills, etc., in the Skagerrak and Kattegat. The specimens are housed at the Swedish Museum of Natural History, the Natural History Museum of Gothenburg, and the Zoological Museum of University of Copenhagen.

In 1994, the Swedish Museum of Natural History received a large number of *P. c. sinensis* from the Kalmarsund population ( $n = 150$ ) that were shot in spring and early autumn the same year in an attempt to reduce the local number of Cormorants. A large proportion of the autumn birds were juveniles. The mean size of the *humeri* of these individuals does not differ significantly from the corresponding values for the adults (Table 2), and all spring and autumn birds (i.e. individuals of all ages) were pooled in the analyses. There is a significant sexual dimorphism in size in Cormorants and the sexes are treated separately.

### Archaeological sample

The bulk of the archaeological sample derives from the limestone cave Stora Förvar. Several thousand kilograms of bones have been recovered from the nearly 4.5 m thick cultural layer in the cave but only a minor part of this material has as yet been analysed. The material is kept at the Museum of National Antiquities, Stockholm. A small sample of *P. c. sinensis* from the Neolithic (c. 3000 BP) of Bulgaria, kept at the Institut für Paläoanatomie, Domestikationsforschung und Geschichte der Tiermedizin der Universität München, is also included in the study.

The cave Stora Förvar has been used intermittently by humans during at least 8000 years, i.e. from the late Boreal to recent time (Possnert & Lindqvist 1993, G. Possnert and Chr. Lindqvist pers. comm.). The resulting stratigraphy can be partially divided into chronological subgroups (Rydh 1931, Schnittger & Rydh 1940, Knappe & Ericson 1983 & 1988). The utilization of the cave has varied substantially between different periods but it is uncertain how this has affected the composition of the avian material. It can be assumed

**Table 2.** Descriptive statistics of *humeri* of ♂♂ and ♀♀, adult and juvenile Cormorants *Phalacrocorax carbo sinensis* from Sweden.

	Adults				Juveniles				<i>t</i>	<i>df</i>	signif.
	<i>n</i>	min-max	mean	SD	<i>n</i>	min-max	mean	SD			
♂♂											
greatest length	42	151-170	161.6	4.35	22	150-166	160.7	4.10	0.835	62	N.S.
distal breadth	40	16.0-18.0	17.0	0.52	22	15.6-18.0	16.9	0.52	0.796	60	N.S.
♀♀											
greatest length	72	144-162	151.4	3.93	14	144-156	150.6	4.31	0.617	84	N.S.
distal breadth	69	15.1-17.3	15.9	0.43	14	14.8-16.3	15.7	0.51	1.985	81	N.S.

that a significant part of the bird bones has been naturally deposited in the cave by carnivorous mammals and birds. That Cormorants have been hunted is obviously shown by the many bones with cut marks from human tools.

Although the cave Stora Förvar was used on and off for almost 8000 years, the bulk of the Cormorant remains derives from the last half of this time span. Archaeologically this corresponds to the period from the late Stone Age until the Medieval. During this period the Baltic was connected to the North Sea through the Öresund and the Great Belt. The most significant ecological change of the Cormorant environment in this period was probably the transition from the more saline Litorina Sea into the present day, brackish Baltic (Donner 1995, and references therein). The decrease in salinity was caused by the land upheaval that made the Öresund and Great Belt shallower, thus decreasing the influx of ocean water.

In addition to the Stora Förvar material, a small number of Cormorant remains from the Iron Age sacrificing area Skedemosse on Öland, Sweden (Lepiksaar 1967), and the Viking Age town Haithabu in Schleswig-Holstein, Germany (Reichstein & Pieper 1986), are included in the sample.

## METHODS

A brief comparison of the skeletal dimensions of *P. c. carbo* and *P. c. sinensis* revealed that a major difference in general size exists. For the purpose of determining the subspecific identity of subfossil Cormorants, we chose to examine the humerus, the most frequent skeletal element in the archaeological sample. The greatest length and distal breadth was measured following the definitions of von den Driesch (1976).

Statistical tests of sample means used Student's-*t*. In the subfossil sample the sex ratio is unknown and given the large sexual size dimorphism in the Cormorant, the observations in this sample cannot be expected to be normally distributed. In tests of mean values involving the subfossil sample the non-parametrical Mann-Whitney test was used.

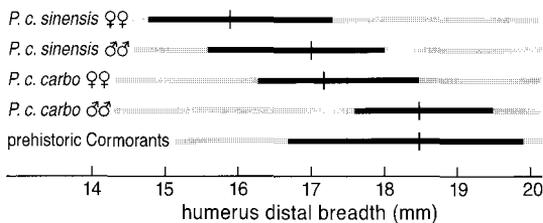
## RESULTS

### Metricral differentiation between recent populations of the subspecies *carbo* and *sinensis*

The *humeri* of the two subspecies differ significantly in the mean size, *carbo* being larger than *sinensis* (Table 3). The large sexual size dimorphism in the Cormorant obscures the subspecific differentiation, in that ♀♀ of *carbo* and ♂♂

**Table 3.** Descriptive statistics of the Cormorant subspecies *Phalacrocorax c. carbo* and *P. c. sinensis* (adults only).

	<i>n</i>	min-max	mean	SD
<i>Phalacrocorax c. carbo</i>				
♂♂				
greatest length	12	165-182	172.1	4.76
distal breadth	12	17.6-19.5	18.5	0.59
♀♀				
greatest length	25	152-171	160.0	4.80
distal breadth	25	16.3-18.5	17.2	0.44
<i>Phalacrocorax c. sinensis</i>				
♂♂				
greatest length	64	150-170	161.3	4.26
distal breadth	62	15.6-18.0	17.0	0.52
♀♀				
greatest length	86	144-162	151.2	3.97
distal breadth	83	14.8-17.3	15.9	0.45
prehistoric cormorants (both sexes)				
greatest length	17	154-174	165.7	6.07
distal breadth	42	16.7-19.9	18.5	0.88



**Fig. 2.** Minimum-maximum ranges of the distal breadth of the humerus in ♂♂ and ♀♀ of *Phalacrocorax c. carbo* and *P. c. sinensis* and a pooled sample of prehistoric Cormorants from the Baltic. The mean value is indicated by a vertical bar.

of *sinensis* overlap considerably in size (Fig. 2). An individual bone is therefore impossible to allocate to either subspecies unless it is of a small *sinensis* ♀ or a large *carbo* ♂.

### Temporal variation within the archaeological sample

In order to study the temporal size variation of Baltic Cormorants, the archaeological material was divided into two groups. No thorough stratigraphic analysis of the cave Stora Förvar has been undertaken (see Knape & Ericson 1988, however). The division of this material into temporal subgroups was tentatively based on the published information and personal experience of the archaeological artifacts and the faunal composition. The first subsample was chosen to represent time periods earlier than the Iron Age/Medieval deposits, while the second subsample comprises remains dated to the Iron Age and Medieval. The remains from Skedemosse and Haithabu were included in the second group.

Despite the large time span of the material, c. 8000 years, no statistically significant difference in the mean size of Cormorants from the two time intervals was found (humerus greatest length: Mann-Whitney-*U* 22.00,  $P = 0.900$ , humerus distal breadth: Mann-Whitney-*U* 115.50,  $P = 0.872$ ).

Lacking of an adequate prehistoric *P. c. sinensis* sample, we here assume that also this subspecies has remained of constant size during the Holocene. The correctness of this assumption is suggested by the prehistoric *P. c. sinensis* remains we have been able to study, three bones from the Neolithic of Bulgaria. These three bones fall well inside the range of *P. c. sinensis* and outside that of *P. c. carbo*.

### Subspecific allocation of Prehistoric Cormorants in the Baltic

From Fig. 2 it can be concluded that the minimum and maximum values of the archaeological sample roughly coincide with those of the *P. c. carbo* sample. A very large proportion of the *P. c. sinensis* sample, 99% of the ♀♀ and 31% of the ♂♂, falls outside the range of the archaeological sample. The range of the archaeological sample is 3.20 mm which is similar to the ranges of the *P. c. carbo* and *P. c. sinensis* samples when the sexes are pooled, 3.29 and 3.20 mm, respectively. In another measure of the sample homogeneity, the co-

efficient of variation for the breadth of the distal humerus in the archaeological sample (4.7%) is of the same magnitude as the 4.4% of both the *P. c. carbo* and *P. c. sinensis* samples after pooling the sexes.

Despite its high improbability, a worst case scenario for the composition of the subfossil sample will be analysed: let us assume that all archaeological Cormorants were  $\sigma\sigma$ . According to descriptive statistics, the subspecies *sinensis* is most different from the archaeological sample, but what happens if we consider the  $\sigma\sigma$  only? A test of the mean values of the archaeological material ( $\bar{x} = 18.5$ ,  $n = 42$ ) and that of male *P. c. sinensis* ( $\bar{x} = 17.0$ ,  $n = 62$ ), proves them to be significantly different ( $t = 11.24$ ,  $P < 0.0001$ ).

It can be safely assumed that the sample of prehistoric Baltic Cormorants, spanning a time period of perhaps 8000 years, is drawn from one and the same subspecies. The underlying assumption is that the size of the two Cormorant subspecies occurring in the Baltic today has remained constant during the Holocene as suggested by the sample from Stora Förvar. If this is correct, it is here concluded that the subfossil Cormorants should be allocated to the nominate subspecies *carbo*.

## DISCUSSION

The realization that prehistoric Baltic Cormorants belong to a subspecies that does not breed in the Baltic today, raises the question of how long Cormorants have bred in the region. The archaeological record tells us that it is most likely they began to breed here as soon favourable breeding conditions became available at ice-free shorelines c. 10 000-12 000 years ago. Bone remains of nestlings and juveniles have been found at Skedemosse (Lepiksaar 1977), Stora Förvar and Birka (Ericson pers. obs.), indicating breeding on both Öland and Gotland, as well as in the Stockholm archipelago. Thus, it is plausible that the nominate subspecies of the Cormorant has been rather widely distributed in the Baltic during most of the Holocene.

The subspecies *carbo* must have become extinct in the late Medieval (c. 1500 AD) at the earliest, however, and replaced by *sinensis* to which subspecies the few breeding colonies in south Sweden in the last century belonged.

The reason why the breeding distributions of the two subspecies has changed is unknown, but their different ecological adaptations might be important. The nominate subspecies typically prefers a marine habitat, and is restricted in Scandinavia to the Norwegian coast where it nests on cliffs. The subspecies *sinensis* prefers a limnic rather than a marine environment for breeding, and, typically nests in trees. The salinity of the Baltic has decreased considerably over the last c. 8000 years, and it is lower than ever today. Although the salinity level *per se* may not be what is most relevant to the Cormorants, the decreasing salinity might covary with some other resource critical to them. Maybe the salinity sank below some threshold value after 1500 AD causing the *P. c. carbo* to cease breeding in the Baltic. Simultaneously, the environment slowly transformed into that preferred by *P. c. sinensis*, which seems to have colonized the region soon after.

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## SAMENVATTING

De Aalscholvers, die tegenwoordig rond de Oostzee broeden, behoren tot de ondersoort *Phalacrocorax carbo sinensis*. Ze verlaten de Oostzee na het broedseizoen om te overwinteren in Z. Europa. Aalscholvers uit Noorwegen, behorend tot de grotere ondersoort *carbo*, gebruiken de Oostzee juist om te overwinteren. Aalscholvers kwamen al in de prehistorie voor in de Oostzee en tot nu toe werd steeds aangenomen dat het hierbij om dezelfde ondersoorten ging, die hier broedden, respectievelijk overwinterden. Analyse van subfossiele botten van Aalscholvers, afkomstig uit diverse archaeologische vindplaatsen in Zweden en Duitsland, laat nu zien dat in prehistorische tijden uitsluitend Aalscholvers van de ondersoort *carbo* in het gebied voorkwamen. Deze vogels broedden hier in een situatie, waarin de 'Oostzee' nog veel meer een marien karakter had. In de loop der tijd zijn de toegangen tot de Oostzee, de Öresund en de Grote Belt, minder diep geworden, waardoor de wateruitwisseling met de Noordzee afnam en de Oostzee steeds brakker werd. Vermoedelijk voelde de 'moerasondersoort' *sinensis* zich hier beter thuis dan de meer Atlantische ondersoort *carbo*, wat er uiteindelijk toe leidde dat de plaats van *carbo* werd overgenomen door *sinensis* als broedvogel in de Oostzee. (MFL)

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