Reproduction of a Newly-established Population of the Great Cormorant in Northeastern Italy

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Abstract.—A study of the breeding biology of the Great Cormorant (*Phalacrocorax carbo sinensis*) was carried out during 1993-1998 in the Po River Delta, a major wintering area in northeastern Italy. The first of five colonies was founded in 1993, and breeders increased from 69 pairs in 1994 to 285 pairs in 1998. The period of egg-laying lasted from early March to late July, but 65% of all clutches were initiated between late March and the end of April. The average clutch size (± SD) was 3.83 ± 0.65 eggs (range two to six). The survival rate of entire nests, evaluated by the Mayfield method, was always higher during the nestling stage than during incubation. The majority of losses occurred during the egg stage due to predation by Hooded Crows (*Corvus corone cornix*). During the five years, hatching success was 72-91% and total nest success, 67-86%. The number of young fledged per successful nest ranged between 2.3 and 2.9. The reproductive parameters of Great Cormorants recorded in the Po Delta lay at the upper range reported for NW Europe populations and are close to the estimated values for newly-established colonies in Italy and for growing colonies in the traditional breeding areas. Unlike other Italian colonies, the availability of breeding sites and food presently do not limit expansion of the breeding population in the Po Delta. If no control measures are undertaken, it is likely that this southern population will continue to grow. *Received 10 April 1998, accepted 26 July 1998.*

Key words.—Breeding success, clutch size, colonization, Great Cormorant, Italy, reproduction, *Phalacrocorax carbo sinensis*, Po River Delta.

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The distribution of the continental subspecies of the Great Cormorant (*Phalacrocorax carbo sinensis*) in Europe has considerably changed during the last one hundred years (Cramp and Simmons 1977). Around the middle of the 20th century, they completely disappeared from most European countries due to human persecution, habitat changes and chemical pollution (Lindell *et al.* 1995; van Eerden and Gregersen 1995). After protection measures were undertaken, first in The Netherlands (1965) and Denmark (1971), then in most countries subscribing to the European Community Bird Directive (1979), Great Cormorants of the *sinensis* race breeding in western and central Europe rapidly increased, allowing the recovery of all European populations and colonization of previously abandoned regions (Gromadzki and Gromadzka 1997; Baccetti and Cherubini 1997). After almost a century (Brichetti 1982), continental Italy was recolonized in 1985 (Spina *et al.* 1986) and, since then, permanent colonies have become established in areas formerly used only for wintering (Carpegna *et al.* 1997).

Data on the breeding biology of the *sinensis* race of the Great Cormorant are relatively scarce and only limited information has been published from colonies outside the traditional breeding range in north-west Europe (Bregnballe *et al.* 1997b). Recent observations from major colonies in Denmark and The Netherlands outlined a reduction in bird recruitment and changes of reproductive parameters, suggesting that density-dependent mechanisms operate (van Eerden and Gregersen 1995; van Eerden and Zijlstra 1995; Bregnballe and Gregersen 1997). It may be useful to compare reproductive parameters from old and stable colonies in northern Europe with new and expanding ones in southern areas to understand the future dynamics of populations and the potential range expansion of Great Cormorants in southern Europe. This becomes particularly important when measures to manage cormorant numbers involve either prevention of new colony establishment or reduction of the available nesting sites in the northern colonies (Bregnballe *et al.* 1997b; Bregnballe and Gregersen 1997).

In this paper, I report data on colony growth, timing of breeding and reproductive success of Great Cormorants nesting in the Po River Delta, a major wintering area in north-eastern continental Italy (Boldreghini *et al.* 1997).

STUDY AREA AND METHODS

The study was carried out from 1993 to 1998 in the coastal area between the mouth of the Adige River and the town of Ravenna, including the present and historical Po Delta (Fig. 1). Data on reproduction were collected at three colonies: Valle Bertuzzi (44°48'N, 12°13'E), Valle Mandriole (44°32'N, 12°12'E) and Punte Alberete (44°30'N, 12°10'E). Valle Bertuzzi is a 1,890 ha shallow brackish lagoon, on average 50 cm deep, managed for fish exploitation (Ardizzone *et al.* 1988). Valle Mandriole and the adjacent Punte Alberete are two freshwater wetlands located ten km north of Ravenna. They are the remains of a previously-larger marshland, filled up by the Lamone River, which originally covered a surface of 8,000 ha. Valle Mandriole is a 250 ha marsh where broad stands of graminoids and sedges, mainly Reedmace (*Typha* spp.) and Common Reed (*Phragmites australis*), are interspersed with patches of Willow (*Salix cinerea*) bushes and areas of open standing water, 0.2-20 ha wide. Punte Alberete is a 186-ha swamp forest, seasonally flooded according to management practices. An arboreal or shrubby hygrophilous vegetation stands on emerged fossil dunes, and emergents and floating plants occur in the depressions between the dunes.

The colonies were regularly monitored each year from mid winter to August. Data on nest contents were collected once every 10-15 days from mid March to mid July. In 1995, the colony of Valle Bertuzzi was also visited in August and September to collect regurgitated pellets. At Punte Alberete, cormorant nests were mainly monitored by a 20-60× telescope to avoid disturbance to a nearby heronry (Volponi and Emiliani 1995). Visits to the colonies lasted one to four hours, depending on the number and location of nests as well as on the breeding stage. During each visit, every effort was made to limit disturbance to the group of nests under inspection. Breeding cormorants, usually quite unafraid of observers, and birds outside a radius of 30-50 m around the observer returned to their nests within a few minutes. During each visit, the whole breeding area was monitored, newly-occupied nesting trees or artificial structures were marked with numbered flags and a diagram was made of all newly-built nests. A five-m ladder and a mirror mounted on a telescopic pole were used to inspect the nest contents, which were recorded on each subsequent visit.

Data on nest contents were entered on a nest survival worksheet (Mayfield 1961), from which the periods of nest exposure were calculated. Data were analyzed according to the Mayfield-40% method (Johnson 1979), to calculate nesting success for infrequently-visited nests. This method, which has been already applied to colonial waterbirds (Moser 1986; Post and Seals 1991) is both robust and easier to calculate than other methods (Johnson 1991).

Survival was examined for whole nests during both incubation and nestling stages. No attempt was made to determine the incubation period for the studied population, but I assumed that Great Cormorants laid eggs, on average, at intervals of two days, had an average incubation period of 29 days and that incubation started as soon as the first egg had been laid (Cramp and Simmons 1977). I also assumed that the nestling period lasted 30 days and young of this age or older were considered to have fledged (Boudewijn and Dirksen 1995). No young of four weeks or older were found dead. As young stayed in their nesting trees, which were isolated from each other, young that moved from the nest before fledging could generally be associated with specific nests.

Because the initiation dates of most clutches were not directly observed, the laying dates of first eggs were back-calculated from the date when the clutch or the brood was first encountered. The age of the brood was also estimated from the age of the oldest nestling (from the eyes closed or open, and the stage of down and feather development).

Census totals are based on the maximum number of simultaneously occupied nests (i.e. containing eggs or young) found during the breeding season (Pratt and Winkler 1985). A brood was defined as "initiated" if at least one egg was laid, and a clutch was defined as "successful" if at least one young fledged. Conventional nesting success (defined as the percentage of the largest number of eggs recorded in the nest that hatched and produced fledged young) and productivity (defined as the number of young raised per breeding pair) were calculated for both initiated and successful clutches to allow comparison with other studies.

Clutch size was analyzed from nests which showed either the same number of eggs on two consecutive visits, or which were visited once during incubation and subsequently after hatching, when the number of chicks present on the second visit did not exceed the number of eggs recorded on the first. Data on clutch size should be accurate since unhatched eggs were often seen in nests with downy young and most clutch losses due to predators involved the whole nest. Whenever fragments from unhatched eggs were found close to the nests or underneath the trees, these clutches were excluded from the analysis.

RESULTS

Colony Formation and Growth

The first breeding was recorded in 1993, when on 21 May, 16 nests were found on a 0.2 ha woody islet located at the center of Valle Bertuzzi. The nests were built in dying or dead Elms (*Ulmus minor*) and Black Locusts (*Robinia pseudoacacia*), as well as in living Holm Oaks (*Quercus ilex*), 5-14 m above the ground. Breeding failed because all nests were destroyed by local fishermen to prevent colony establishment. Since then, however, no further deliberate actions have been taken to reduce the reproductive output. In 1994, the site was reoccupied and breeding was suc-

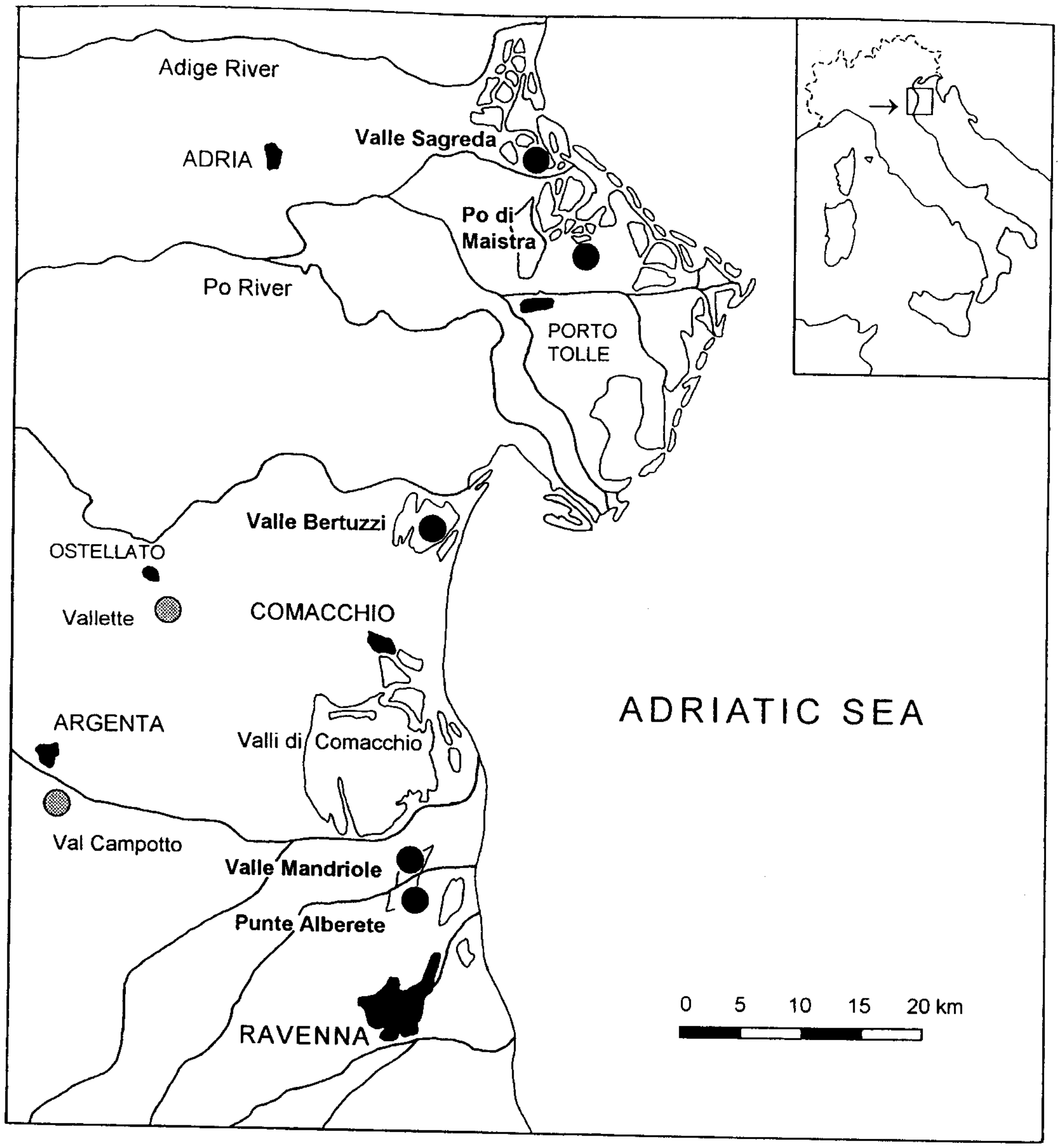

Figure 1. Map of the Po Delta and neighboring wetlands showing the locations of the research colonies (black circles) and other breeding sites outside the studied area (shaded circles).

cessful (Table 1). In the same year, three pairs settled at Valle Mandriole, breeding on isolated poles and abandoned hunting blinds. In 1995, five pairs again occupied those structures while 19 nests were built on heaps of dead aquatic vegetation along the fringes of the reedbed. Nests were in a permanently-flooded area at the center of the large and scattered mixed colony of Grey (*Ardea cinerea*) and Purple (*A. purpurea*) herons. In 1996-1998, only one-four solitary pairs bred at Valle Mandriole; most of the breeders moved to Punte Alberete. Here, nests were placed 6-12 m high up in living White Poplars (*Populus alba*), ashes (*Fraxinus oxycarpa*) and White Willows (*Salix alba*) at the edge of the heronry and about 1.5 km from the Valle Mandriole colony. In 1998, single pairs bred in two new sites, Po di Maistra (45°59'N, 12°22'E) and Valle Sagreda (44°59'N, 12°22'E), located in the northern Delta, respectively 25 and 31 km from Valle Bertuzzi (Fig. 1).

Table 1. Growth of Great Cormorant colonies in the Po Delta, 1993-1998.

	Number of nests					
Colony	1993	1994	1995	1996	1997	1998
Valle Sagreda	0	0	0	0	0	1
Po di Maistra	0	0	0	0	0	1
Valle Bertuzzi	12	66	76	141	122	148
Valle Mandriole	0	3	26	4	1	1
Punte Alberete	0	0	1	47	96	134
Total	12	69	103	192	219	285

From 1994 to 1998, the overall breeding population increased by a factor of four due to formation of four new colonies and growth of the old one (Table 1).

Duration and Timing of Breeding

In the Po Delta, breeding extended from early March, when the first eggs were laid, to September, when the last young fledged. Most of the nesting activity was from late March to the end of June. Of 674 nests for which the date of clutch initiation was established (Fig. 2), 105 clutches were started in the first twenty days of March, while the bulk of egg-laying, 440 nests (65.3%), occurred from late March through April. The remaining 129 clutches were spread over May (15%), June (3.6%) and July (0.6%).

The pattern of clutch initiation dates showed significant variations between years and colonies (Kruskal-Wallis ANOVA, $H_{9,674} = 150.7$, $P < 0.0001$). However, in all three colonies, nest initiations commenced earlier in the years following the first breeding season. At Valle Bertuzzi, the tenth percentile of clutch initiation shifted from mid May in 1993, to early March in 1998 ($R_s = -0.81$, $P = 0.0499$). In this colony (Fig. 3), the median period of initiation varied between early May in 1993 to late March in 1997. In 1995, nesting activity commenced in mid March, but strong winds and a sharp drop in temperature in the last week of March caused nest failures. Egg-laying was delayed to early April and continued until early June. A similar trend was observed in 1996 when first egg-laying began in the late March, peaked in the second half of April and then tailed off from May through mid June. In 1997, some egg-laying began in the first days of March, even earlier than in previous years, peaked by the end of March and then declined through April, a pattern similar to 1994. In 1998, most clutches were initiated by mid April, but a proportion (24%) occurred later, between late April and mid June, in a second distinct period.

At Valle Mandriole, breeding occurred in two separate periods: nesting on the artificial structures commenced egg-laying in the first half of March, while nesting at water level on the reedbed edge laid their eggs between mid April and early May, with a pronounced peak (80% of the clutches) during the second ten days of April.

In their first breeding attempt, Punte Alberete Great Cormorants settled as late as mid June. In the following years they started breeding in early March and by mid April, between 77% (1996) and 88% (1998) of the overall nests had been initiated.

Late nest initiations were recorded in two colonies: at Valle Bertuzzi, where on 20 September 1995, three unfledged young were observed, and at Punte Alberete in 1996 and

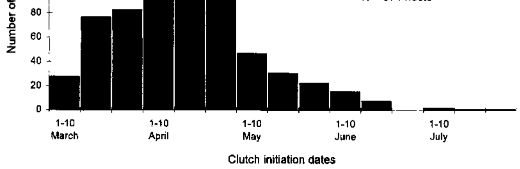

Figure 2. Seasonal distribution of clutch initiation dates for Great Cormorants breeding in the Po Delta. Data from Valle Bertuzzi (1993-1998), Valle Mandriole (1994-1996) and Punte Alberete (1995) colonies were combined.

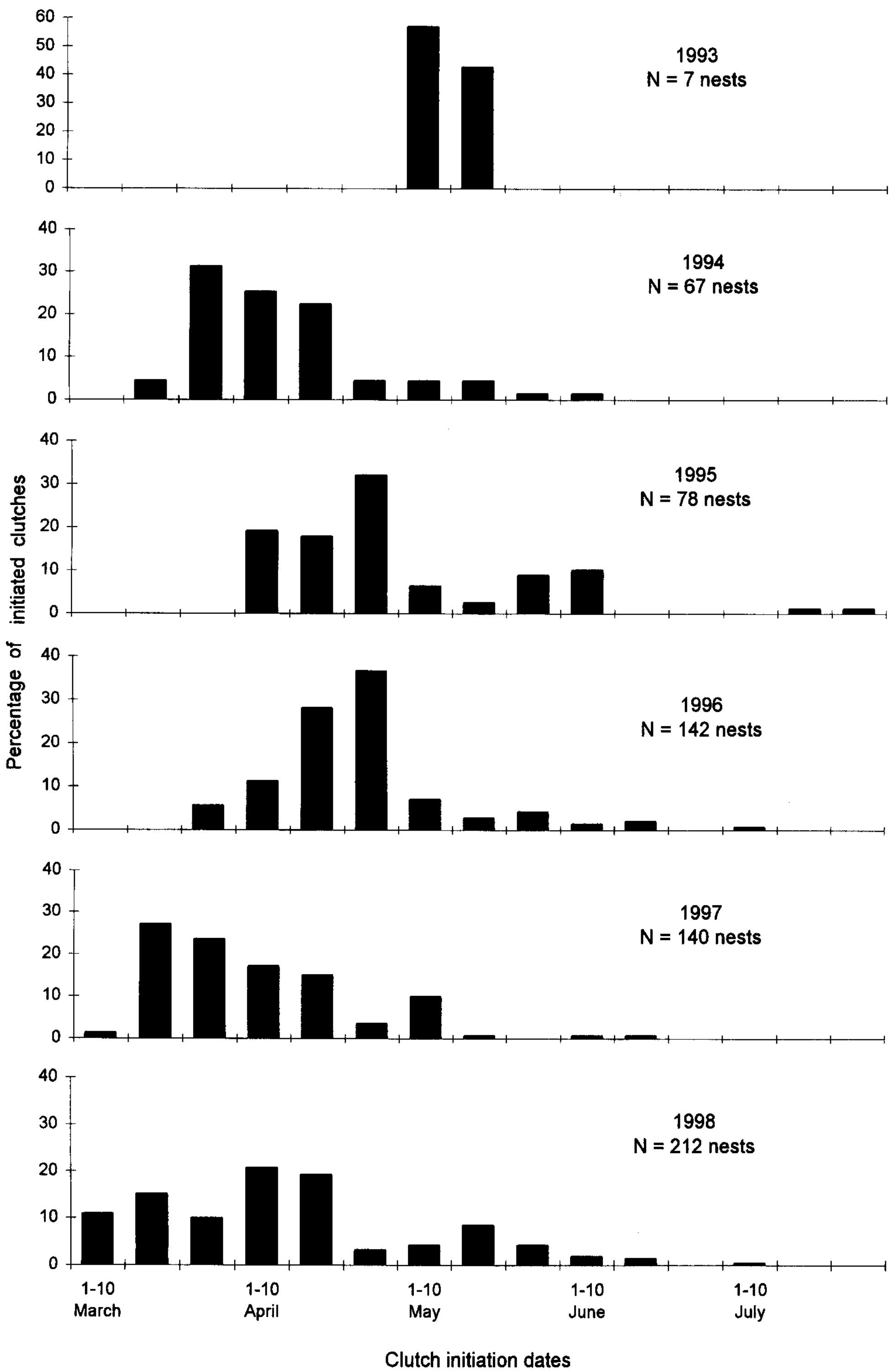

Figure 3. Seasonal distribution of clutch initiation dates for Great Cormorants breeding at Valle Bertuzzi colony in 1993-1998.

1997, where in the last week of August four and three nests holding nestlings 15-30 days old were found.

Clutch Size

Clutch sizes ranged from two to six eggs, with clutches of three and four eggs accounting for 86.8% of those observed (Table 2). The average clutch size (± SD) for all the data combined was 3.83 ± 0.65 eggs (N = 562 clutches) varying from 3.7 to 4.0 according to colony and year. Distributions of the clutches with three-five eggs were similar among years and colony (X^2_{10} = 10.3, P = 0.42). Variations in mean clutch size between colonies and years were not significantly different (one-way ANOVA, $F_{5,556}$ = 1.53, P = 0.18). Clutch size significantly declined with laying date ($F_{6,539}$ = 3.5, P = 0.002) from an average of 4.1 eggs per clutch at the start of the season to 3.3 at the end (Table 3).

Nesting Mortality

Nesting mortality at Valle Bertuzzi in 1994-1998 and Valle Mandriole in 1995 was compared using the Mayfield-40% method (Table 4). The survival of entire nests varied between colonies from 52% to 72% during the incubation stage and from 86% to 98% during the nestling stage. Differences in daily nest survival rates between colonies were mostly not significant except for Valle Bertuzzi. Here, in 1997, nest survival was significantly higher than in previous years during incubation (Z test, P < 0.05) as well as during the nestling stage in 1994 and 1996 (P < 0.05), while in 1998 nest survival was significantly higher than in 1996 during the nestling stage (P < 0.05).

Survival rates during the nestling stage were always significantly higher than during the egg stage at Valle Bertuzzi (Z test, P < 0.001), but not at Valle Mandriole (Z = 1.64; P = 0.10).

During each breeding season, 23-32% of the initiated nests lost their entire contents during the egg stage; 3-15% did so after hatching. Replacement clutches (i.e., new egg-laying in a previously failed nest) ranged between 3.5 to 23.6% of the overall initiated clutches.

Actual causes of nest losses were generally difficult to ascertain. At Valle Bertuzzi, during the egg stage, apart from nest collapse, most of the nest mortality was apparently the result of predation by Hooded Crows (*Corvus corone cornix*). Hooded Crow predation on cormorant eggs was observed during colony-monitoring from a blind located at the edge of the islet. There was no direct evidence of predation on Great Cormorant nestlings, but some nest mortality was recorded after the occurrence of summer storms.

At Valle Mandriole, nest survival during incubation was higher than at Valle Bertuzzi (save in 1997 and 1998) and was not significantly different from nest survival during the nestling period. In this colony, egg predators, such as the Hooded Crow and the Magpie (*Pica pica*), are uncommon and nest losses were due mainly to collapsing of the artificial structures and flooding.

Table 2. Clutch size of Cormorant breeding in the Po Delta. Data referring to the season of first colony settlement are not reported.

		Clutch size							
Colony	Year	2	3	4	5	6	Mean	SD	N
Valle Bertuzzi	1994	2	13	48	5	0	3.82	0.60	68
Valle Bertuzzi	1995	1	19	38	3	0	3.70	0.59	61
Valle Bertuzzi	1996	1	26	86	16	1	3.92	0.62	130
Valle Bertuzzi	1997	6	35	70	16	1	3.77	0.76	128
Valle Bertuzzi	1998	2	37	96	16	0	3.83	0.62	151
Valle Mandriole	1995	0	4	16	4	0	4.00	0.59	24
Total							3.83	0.65	562

Table 3. Seasonal variations in the clutch size of Great Cormorants breeding in the Po Delta. Data are from Valle Bertuzzi (1994-1998) and Valle Mandriole (1995) colonies.

	Clutch size							
Period	2	3	4	5	6	Mean	SD	N
1-15 March	0	6	22	9	1	4.13	0.70	38
16-31 March	7	20	69	13	0	3.81	0.73	109
1-15 April	0	46	120	18	0	3.83	0.60	186
16-30 April	0	33	82	16	1	3.89	0.63	132
1-15 May	0	14	26	3	0	3.74	0.58	43
16-31 May	2	10	16	1	0	3.55	0.69	29
1-15 June	1	4	4	0	0	3.33	0.71	9

Breeding Success and Reproductive Output

Hatching success (the percentage of laid eggs hatching per clutch) ranged between 72% and 91%, while total nest success (the percentage of nests from which at least one young fledged) was between 67% and 86% (Table 5). Young production ranged between 1.5-2.3 fledglings for all nests and 2.3-2.9 fledglings for nests that successfully hatched. Hatching and fledgling success were lowest at Valle Mandriole, where success depended on nest location. Great Cormorants breeding on the artificial structures raised almost twice as many young per clutch as did those nesting at the water level along the reedbed (2.40 ± 0.89 vs 1.32 ± 1.29; Mann-Witney, U = 24.5, P = 0.09).

DISCUSSION

The comparison of reproductive parameters of Great Cormorant colonies among different areas is difficult because many factors may influence hatching and fledging success (van Eerden *et al.* 1991; Boudewijn and Dirksen 1995; van Eerden and Zijlstra 1995) and differences in the estimated values from different studies may result from different methodologies (Stenzel *et al.* 1995). However, this study showed that estimates of reproductive parameters from Po Delta colonies, although similar to those reported from the traditional breeding grounds in north-west Europe, mostly fell in the upper range of published values, typical of small, newly-established or growing colonies (Bregnballe *et al.* 1997b).

Table 4. Estimates of the survival probabilities of Great Cormorant nests during the incubation and the nestling periods, using the "40% Mayfield method."

Incubation period (29 days)					
Colony	Year	Exposure no. nest days	Nests (no.)	Survival (%) per nest day	Survival (%), with 95% conf. limits in parentheses
Valle Bertuzzi	1994	1200	81	98.0	55.7 (44.0-70.3)
Valle Bertuzzi	1995	854	73	97.8	52.1 (38.8-69.7)
Valle Bertuzzi	1996	2759	157	98.2	58.2 (50.2-67.5)
Valle Bertuzzi	1997	2855	136	98.9	72.1 (64.4-80.7)
Valle Bertuzzi	1998	3351	161	98.8	70.6 (63.4-78.6)
Valle Mandriole	1995	388	23	98.5	63.6 (44.2-9.12)
Nestling period (30 days)					
Colony	Year	Exposure no. nest days	Nests (no.)	Survival (%) per nest day	Survival (%), with 95% conf. limits in parentheses
Valle Bertuzzi	1994	1356	53	99.5	85.6 (69.7-94.7)
Valle Bertuzzi	1995	1506	57	99.7	92.3 (81.0-99.8)
Valle Bertuzzi	1996	2752	110	99.5	86.8 (74.6-91.7)
Valle Bertuzzi	1997	2700	102	99.9	96.7 (91.0-100)
Valle Bertuzzi	1998	2329	94	99.7	90.1 (79.2-95.9)
Valle Mandriole	1995	484	20	99.6	88.3 (67.3-100)

Table 5. Reproductive characteristics of Great cormorant colonies in the Po Delta. Differences between colonies were tested using Mann-Witney U tests. Colonies sharing the same letter are significantly different (small p < 0.05, capital P < 0.01).

Colony	Year	Parameter	Mean ± 1SD		Nests (no.)	% Success[1] (nests)	Nest[2] contents	% Success[3] (contents)
Valle Bertuzzi	1994	Eggs/nest	3.84 ± 0.62		57	—	219	—
		Young/successful nest	3.02 ± 0.82		41	71.9	124	56.6
		Fledglings/successful nest	2.47 ± 0.76	a y	38	92.7	94	75.8
		Young/initiated nest	2.18 ± 1.54	b x	41	71.9	124	56.6
		Fledglings/initiated nest	1.65 ± 2.33	c d e β	38	66.7	94	42.9
Valle Bertuzzi	1995	Eggs/nest	3.70 ± 0.60	f g	56	—	207	—
		Young/successful nest	2.94 ± 0.90	h	51	91.1	150	72.5
		Fledglings/successful nest	2.65 ± 0.84	i	48	94.1	127	84.7
		Young/initiated nest	2.68 ± 1.21		51	91.1	150	72.5
		Fledglings/initiated nest	2.27 ± 1.21	c m	48	85.7	127	61.4
Valle Bertuzzi	1996	Eggs/nest	3.91 ± 0.62	f	124	—	485	—
		Young/successful nest	3.28 ± 0.84	h K n	102	82.3	335	69.1
		Fledglings/successful nest	2.94 ± 0.84	a i O p	90	88.2	265	79.1
		Young/initiated nest	2.70 ± 1.47	b s	102	82.3	335	69.1
		Fledglings/initiated nest	2.14 ± 1.50	d t	90	72.6	265	54.6
Valle Bertuzzi	1997	Eggs/nest	3.79 ± 0.78		115	—	436	—
		Young/successful nest	2.99 ± 0.97	n	93	80.9	278	63.8
		Fledglings/successful nest	2.68 ± 0.87	p	90	96.8	241	86.7
		Young/initiated nest	2.42 ± 1.47		93	80.9	278	63.8
		Fledglings/initiated nest	2.10 ± 1.35	d u	90	78.3	241	55.3
Valle Bertuzzi	1998	Eggs/nest	3.85 ± 0.62		116	—	447	—
		Young/successful nest	3.23 ± 0.80	ø	97	83.6	313	70.0
		Fledglings/successful nest	2.88 ± 0.84	æ y	89	91.8	256	81.8
		Young/initiated nest	2.70 ± 1.40	x z	97	83.6	313	70.0
		Fledglings/initiated nest	2.21 ± 1.42	w β	89	76.7	256	57.3

[1]Percentage of nests from which hatched or fledged at least one individual.
[2]Number of eggs, young or fledglings.
[3]Percentage of eggs that hatched or percentage of young that fledged.

Table 5. (Continued) Reproductive characteristics of Great cormorant colonies in the Po Delta. Differences between colonies were tested using Mann-Witney U tests. Colonies sharing the same letter are significantly different (small $p < 0.05$, capital $P < 0.01$).

Colony	Year	Parameter	Mean ± 1SD		Nests (no.)	% Success[1] (nests)	Nest[2] contents	% Success[3] (contents)
Valle Mandriole	1995	Eggs/nest	4.00 ± 0.59	g	24	—	96	—
		Young/successful nest	2.63 ± 1.01	K ø	19	79.2	50	52.1
		Fledglings/successful nest	2.31 ± 0.79	æ O	16	84.2	37	74.0
		Young/initiated nest	2.08 ± 1.41	s z	19	79.2	50	52.1
		Fledglings/initiated nest	1.54 ± 1.28	m t u w	16	66.7	37	38.5

[1]Percentage of nests from which hatched or fledged at least one individual.
[2]Number of eggs, young or fledglings.
[3]Percentage of eggs that hatched or percentage of young that fledged.

The average clutch size of 3.7-4.0 eggs (Table 2) was similar to or higher than values of 2.7-3.7 eggs/nest in the Netherlands (Boudewijn and Dirksen 1995), 2.9-4.3 in Denmark (Bregnballe *et al.* 1997b) and 2.6 at Lake Gardno, NW Poland (Pajkert and Górski 1996). The mean number of eggs hatched per clutch (Table 5) was generally higher than the values of 0.7-2.9 recorded in seven Dutch colonies where, however, elevated egg mortality was correlated with chemical pollution of the foraging grounds (Boudewijn and Dirksen 1995).

Fledging rates in Po Delta colonies were similar to the mean value of 2.8-3.0 fledglings per successful nest recorded at Val Campotto in 1992-1993 (Nicosia unpubl. data; Grieco 1994) and in the same order of magnitude as in eastern Germany and in Denmark in the 1980s, but higher than in major Dutch colonies (van Eerden and Gregersen 1995; Bregnballe *et al.* 1997b).

The main cause of nest mortality in the Po Delta was Hooded Crow predation. Findings from Valle Bertuzzi colony agree with other studies on cormorants which showed that crows are most harmful during the egg stage, and this is reflected in the significantly lower daily survival rate of eggs compared to that of young.

The Po Delta appears to be a favorable area for Great Cormorants both for wintering (Volponi and Barbieri 1997) and for breeding. Cormorant presence and local environmental conditions apparently did not change before and during the colony formation (Volponi 1994). A breeding attempt was already recorded in the Valli di Comacchio, an important fishing lagoon, in the early 1980s (Baccetti and Brichetti 1992). Repeated instances of nest destruction were reported in 1994 and 1995 from Vallette di Ostellato and Malalbergo (P. Boldreghini, pers. comm.; R. Tinarelli, pers. comm.), two inland fish-pond areas located 25 and 55 km west of Valle Bertuzzi (Fig. 1). Direct disturbance at winter roosts and potential breeding sites were regularly recorded in the northern part of the Delta, where first nesting occurred simultaneously with the beginning of protection of the area.

Unfortunately, no data are available about the origin of Great Cormorants breeding in the Po Delta colonies. They may be emigrants from the oldest colony of Val Campotto, where loss of nesting trees seems to have limited colony growth (Grieco 1997). Wintering birds may also have chosen to nest in the Po Delta instead of migrating northwards. Recoveries and sightings of banded individuals showed that wintering birds originate from the Baltic area, as far away as 900-1700 km (Bendini and Spina 1990; Bregnballe *et al.* 1997a; Volponi unpubl. data), and that individuals from Denmark and Sweden were among the first nesters at Val Campotto (Baccetti and Brichetti 1992).

For migrating birds, and especially for non-breeding floaters, young adults and new recruits, breeding in their southern wintering areas could represent a profitable strategy, combining advantages of reduced competition for food and nesting sites, knowledge of the site safety (Bregnballe and Gregersen 1997) and experience with the foraging grounds acquired during wintering (Voslamber *et al.* 1995), energy-saving and preservation of body reserves not needed for a long migration (van Eerden and Munsterman 1995).

The Po Delta may thus represent an alternative to the apparently saturated main breeding areas in north-west Europe (Bregnballe and Gregersen 1997; Menke 1997). Unlike other Italian colonies whose growth seems to be limited either by the availability of breeding or feeding areas, Great Cormorant colonies in the Po Delta appear to have potential for further expansion.

Currently, the greater Po Delta accommodates about ten Ciconiiformes colonies and accounts for more than 380 km^2 of eutrophic fresh and brackish waters, an environment that may have the capability to sustain up to 2,000 breeding pairs of cormorants (van Eerden and Gregersen 1995). However, any growth of the breeding population will further increase the conflict with fish-farmers, leading to stronger pressure to reduce predation and manage cormorant numbers. Illegal disturbance will likely limit the establishment of new colonies to natural reserves or inaccessible areas, and the breeding population will eventually settle well below its potential maximum.

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