THE EFFECTS OF WINTER CLIMATE ON THE SIZE OF THE CATTLE EGRET (*BUBULCUS IBIS* L.) POPULATION IN THE CAMARGUE

Heinz HAFNER*, Olivier PINEAU* and Jonathan P. WALLACE*

The population of Cattle Egrets in the Camargue, delta of the river Rhône in southern France, has been monitored since the species first successfully bred in 1969 (Hafner, 1970). Cattle Egrets nest in trees with Little Egrets (*Egretta garzetta*), Night Herons (*Nycticorax nycticorax*) and Squacco Herons (*Ardeola ralloides*) and until now the Camargue has remained the species' only regular breeding site in France. The next nearest breeding area, the Ebro delta, Spain, lies 460 km to the south-west.

A 22-year run of data (1970-1991) on numbers of breeding Cattle Egrets reveals marked changes in population size during this period. Numbers do not fluctuate in parallel with those of any of the other three species of tree-nesting herons. This may be related to factors which operate outside the breeding season. The Night Heron and the Squacco Heron nesting in the Palearctic are long-distance migrants, most of them wintering south of the Sahara (Cramp and Simmons, 1977 ; Voisin, 1991). Little Egrets originating from the Camargue winter mainly along the Mediterranean coast of France and Spain, and to less extent in North Africa and tropical West Africa (Pineau, *in press*). The proportion attempting to overwinter in the Camargue ranges from 10 to 25 % of the total population (adults and young) present at the end of the summer. In contrast, 60-70 % of the Camargue Cattle Egrets winter on or close to their breeding area (Hafner, in Yeatman-Berthelot, 1991). Studies on Cattle Egrets wintering in temperate climates of the Palearctic are few (Bredin, 1983, 1984 ; Ruiz, 1985) and winter survival in these areas has not been investigated. It has been shown that cold winters increased mortality of Grey Herons (*Ardea cinerea*) in Britain (North, 1979), and that the population declines after severe cold spells (Reynolds, 1979). The winter climate in the Camargue is characterised by wide temperature variations. Some winters are extremely mild e.g. 1987-88, with minimal temperatures of − 1.5 °C recorded only three times. Others are severe e.g. 1984-85, when temperatures fell below − 10 °C and even saline waters remained frozen for two weeks. It is likely that these unpredictable conditions affect the size of this rather isolated and non-migratory population. This paper examines the relationship between winter climate in the Camargue and the numbers of wintering and breeding Cattle Egrets.

* Station Biologique de la Tour du Valat. Le Sambuc, 13200 Arles, France.

Rev. Ecol. (Terre Vie), vol. 47, 1992.

I. — STUDY AREA AND METHODS

From 1970 to 1991 the size of the breeding population of Cattle Egrets in the Rhone delta and its surroundings has been determined annually. Each year in spring, aerial surveys were carried out in order to ensure that all breeding sites had been located. During the course of this 22-year study, a number of nesting sites ceased to be used and new ones were established. In each breeding colony census work was carried out on a weekly basis between May 15th and August 15th. Such repeated visits during the breeding season are necessary because nesting of this species takes place over a long period (Hafner, 1980). The counting method aimed at direct and absolute nest counts through visual and auditive contacts. The census has been carried out, using the same method each year, by the same observer. Differences in the numbers of breeding Cattle Egrets between years do not, therefore, reflect differences in either the area covered or in the census methods.

In order to gather information on the number of overwintering birds, monthly counts were made from December 15th to February 15th of all known roosts in the area. Whenever possible, roosts were counted simultaneously by ornithologists from the Tour du Valat Biological Station, the Réserve Nationale de Camargue and the Conservatoire de l'Espace Littoral et des Rivages Lacustres. The lowest numbers of Cattle Egrets were usually recorded in January, sometimes in February. For each year, this minimum count is used as an index of the number of birds having survived the Camargue winter, and referred to as the number of overwintering birds.

The data on population size was examined in relation to the amount of rainfall (absolute values, mm), wind speed (monthly means, m/sec) and minimum temperatures (absolute value for each day when the minimum temperature fell below 0 °C) in December, January and February. The effects of these climatic variables were examined according to the following combinations of months : December, January, February, December and January, January and February, December, January and February. The measure of winter severity used was the sum of the absolute values of the minimum temperature below 0 °C for all the days between December 1st and February 28th.

Data on bird numbers and climatic variables were log-transformed : Log $(N + 1)$ to approximate to a normal distribution. The data were submitted to linear and multiple step-wise regression analysis, adjusting the undefined value (Log $\times$) by the method of least squares (Foucard and Lafaye, 1983).

II. — RESULTS

The number of breeding birds (n nests $\times$ 2) counted each year and the number of birds recorded during the preceding winter are plotted out in Fig. 1. After the first successful breeding by two pairs in 1969 (Hafner, 1970) there was a rapid increase followed by a period of fluctuations around a plateau, then a sharp decline from 352 nests in 1984 to 74 nests in 1985. Numbers remained low during three summers (1985-1987) and then the population increased again to reach 580 nests in 1991.

The number of overwintering birds reveals an almost identical pattern which correlates strongly with the number of nests recorded the following summer (Table I).

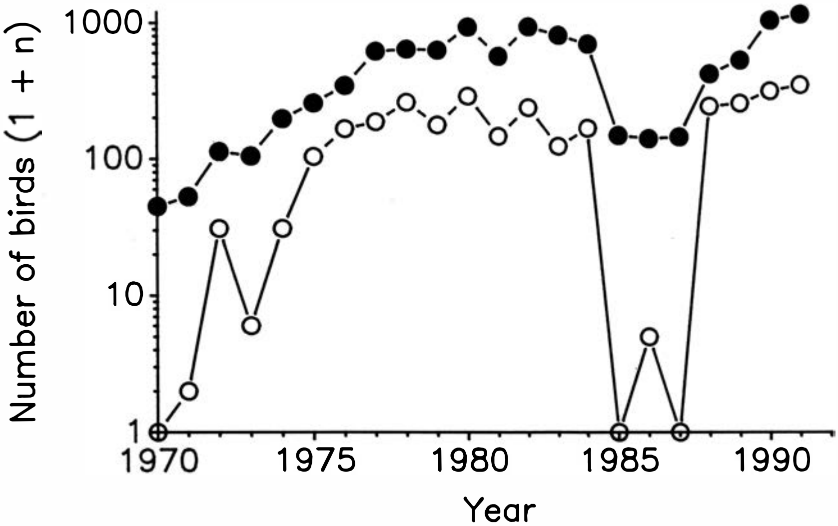

Figure 1. — Numbers of Cattle Egrets wintering (white squares) and breeding (dark squares) the following summer (log scale).

A similar, strong correlation exists between the number of breeding pairs and the number of individuals still remaining in the area the following December (Table I). These are the birds attempting to overwinter ; certain years many do not succeed (Fig. 1) and the correlation between the number of breeding pairs and the number of individuals recorded the following mid-winter (January-February) is therefore weaker (Table I).

TABLE I

Correlation coefficients, r, for the relationship between the size of the breeding population and numbers of birds counted in December and in mid-winter.

	Log breeding pairs next summer	Log breeding pairs preceding summer
Log individuals in December	0.81 $p < 0.001$ $n = 22$	0.91 $p < 0.001$ $n = 22$
Log overwintering birds	0.88 $p < 0.001$ $n = 22$	0.56 $p = 0.008$ $n = 21$

The measure of winter severity is the only climatic variable which revealed a linear relationship with the year to year development of the breeding population. Proportional change between consecutive seasons in this population correlates strongly with the measure (the sum of temperature deficits below 0 °C) during the intervening winters (Fig. 2). The correlation is negative as high values indicate a cold winter. A negative correlation was also detected on the numbers of overwintering birds ($r = -0.44$, $n = 21$, $p < 0.05$).

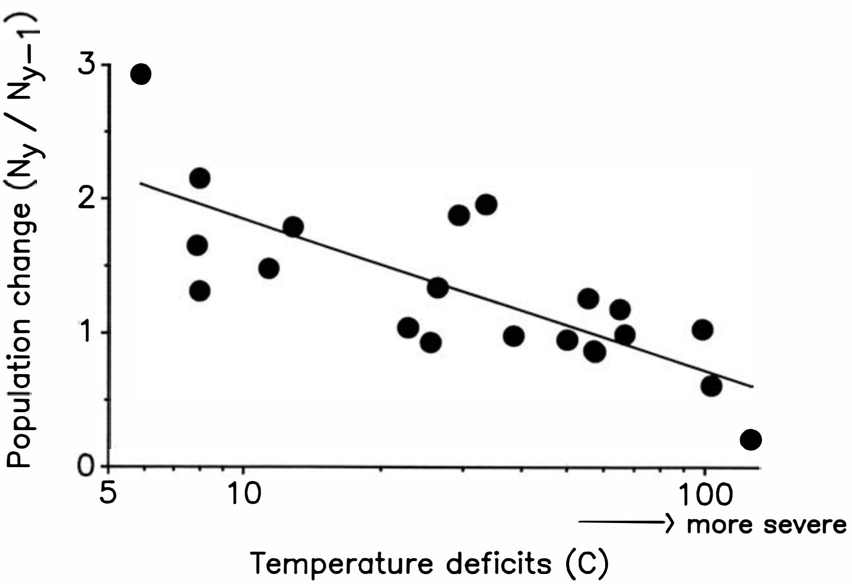

Figure 2. — Relationship between the change in the population size of Cattle Egrets from one year (Ny − 1) to the next (Ny), and the severity of the intervening winter. $n = 21$, $r = -0.76$, $p < 0.001$.

Furthermore, the measure of winter severity was the only explicative variable retained by a multiple step-wise regression analysis to explain variation ($R2 = 0.54$) in proportional change in the breeding population from one year to the next. Rainfall, windspeed and the number of overwintering birds did not contribute in explaining variation.

When replacing the dependent variable, proportional change, by the absolute number of breeding pairs, two of the explicative variables (acting during the preceding winter) were retained. The first, the number of overwintering birds, explained 75 % of variation in population size. The second was again winter severity, the two variables combined representing an R value of 0.91, thus explaining 82 % (R2) of the variation. This suggests that prolonged freezing conditions in winter depress the Camargue Cattle Egret population while rainfall and windspeed have no significant effect.

Mortality becomes apparent only during severe and prolonged cold spells : 32 corpses were found in the 1980-81 winter (Bredin, 1983), and 80 corpses in January 1985 (Cezilly, 1985). In the Camargue, dead birds are rapidly found by ground predators (Boar, Fox, rats) but in January 1985, 56 freshly dead Cattle Egrets could be measured (Wallace, unpublished). Body weight related to wing length, an independent measure of size, was used for a comparison with 12 free-living birds which had been caught on their nests. There were considerable weight differences between the birds caught in summer and those found dead in winter (Fig. 3). In contrast to the summer birds ($n = 12$, $r = 0.86$, $p < 0.001$) the body mass of the 56 corpses did not correlate with wing length ($r = 0.16$) since weights of all except one bird were abnormally low, regardless of size.

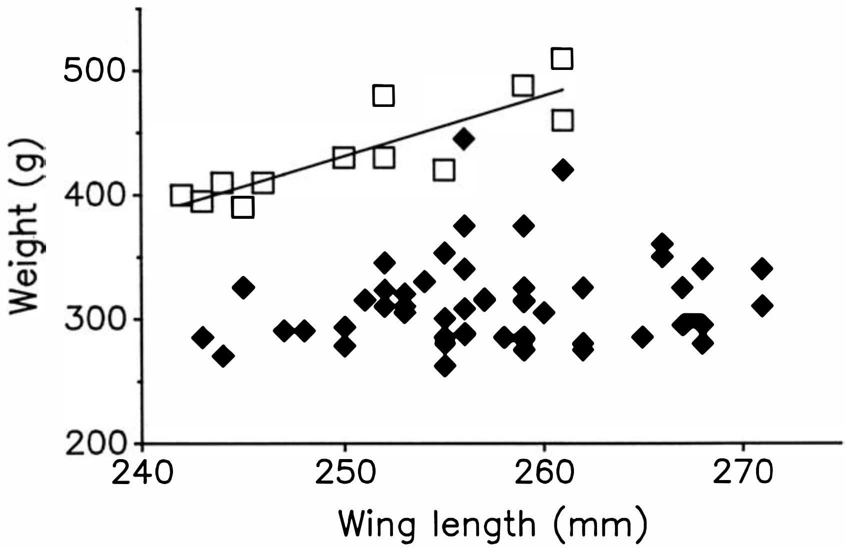

Figure 3. — Weights of Cattle Egrets in relation to wing length. Open symbols represent breeding birds ($n = 12$, $r = 0.86$, $p < 0.001$) and dark symbols freshly dead birds in winter ($n = 56$, $r = 0.16$, ns).

III. — DISCUSSION

Cattle Egrets normally survive the Camargue winter. They are extremely adaptive (see review by Arendt, 1988) and use a wide range of feeding habitats. When earthworms, a common winter food in the Camargue, become inacessible because of freezing conditions, these birds switch to small rodents which remain a major prey as long as cold weather persists (Bredin, 1984). A highly opportunistic feeding behaviour was also observed in the Ebro delta (Ruiz, 1985), where mice consumption peaked in November. This was followed by a marked increase of the bird's lipid reserves until December and a progressive decline in January and February. Ruiz (1985) attributes this decline to feeding stress during the winter months. Besides food availability, fundamental requirements are shelter against high winds and dense stands of trees near water for spending the cold winter nights. The birds tend to rest as close as possible to water, often using overhanging branches. According to Bredin (1983) this site selection may be linked to the slightly higher temperatures above water and not only to the presence of predators.

Due to its relative isolation and small size, the Camargue population of Cattle Egrets can be measured very precisely. This small population is of Spanish origin as confirmed by a first ringing recovery in 1972 (Hafner, 1975) and another in 1985 (French National Ringing Centre). These two Cattle Egrets found in the Camargue had been ringed as chicks near Valencia in Spain. Generally, small populations at the edge (Camargue) of their range, risk extermination after extreme weather conditions causing starvation (Elkins, 1983). January 1985 was extreme : virtually all the open water in the Camargue (including many of the saline lagoons) froze over for a period of two weeks, with minimal temperatures reaching − 10.6 °C. Numbers of Cattle Egrets dropped from 254 recorded at the beginning of January, just before the cold spell, to a single bird seen on January 18th. However it took the population only 3 years to recover (Fig. 1). Similarly, a 2-3 year recovery rate after a crash due to severe weather has been observed for Cattle Egrets in Texas (Telfair, 1983). Grey Herons in Britain took 2 to 3 years to regain the mean population level after cold spells in the 1940s, but 7 years in the 1960s (Reynolds, 1979). This rather long recovery rate was probably due to difficulties the species was apparently facing in the 1960s, when there was an increase in adult mortality rates, possibly related to an increased use of pesticides (Mead *et al.*, 1979).

The mean clutch size (4.3 ± 0.71 s.d., n = 51) and mean brood size just before fledging (3.4 ± 0.79 s.d., n = 335) of Camargue Cattle Egrets are higher than the figures in Ranglack *et al.* (1991) for 28 different breeding areas in North America, Africa and Australia. In the Camargue, one double brood could be confirmed in 1970 (Hafner, 1970) and preliminary results of a recently initiated marking scheme indicate a high degree of philopatry and early breeding, when only about one year old. This is the only evidence of such early breeding since Siegfrieds' (1966) observation of several marked Cattle Egrets in South Africa which bred when they had reached an age of about one year. Early breeding, philopatry and good breeding success are important features in population dynamics. But these mechanisms were clearly not solely responsible for the rapid recovery rate since there were no birds left after the hard winter 1984-85. In 1989, a census of all known breeding colonies in Spain revealed 52 000 Cattle Egret nests (Fernandez-Alcazar and Fernandez-Cruz, 1991). The same year 25 000-28 000 nests were counted in Portugal (Dias, 1991). The Iberian Peninsula has the largest Cattle Egret colonies in the Palearctic (Fernandez-Alcazar and Fernandez-Cruz, 1991) and it is likely that these breeding areas are saturated. The surplus of birds from this substantial reservoir of some 80 000 breeding pairs and their offspring is more likely to move north rather than south where the density of Cattle Egrets is extremely high. When the young Cattle Egrets fledged in the Spanish colonies start to disperse in late summer, drought conditions affect many breeding areas, particularly in the south, and this may also initiate emigration in a northerly direction. Cattle Egrets ringed as chicks in the Albufera de Valencia have produced 89 recoveries so far, 2 of which in France, 67 (75 %) in the Ebro delta 170 km to the north, and only 2 to the south (Prosper-Candel, *pers. comm.).* In the case of the Camargue population, movements from further south undoubtedly play a crucial role in population persistence. Spanish (and soon Portuguese) biologists are colour marking Cattle Egrets, in collaboration with the Camargue research team. It is hoped that this marking scheme will help to provide insight into the question of exchange between different breeding areas.

SUMMARY

The numbers of Cattle Egrets breeding in the Camargue have been determined annually from 1970 to 1991. Each year 60-70 % of the birds present at the end of the summer (adults and young) tend to overwinter in the Rhone delta and the neighbouring areas. Winter temperature is a key variable affecting the size of the Camargue population in subsequent years. Immigration from further south plays a crucial role in population persistence, particularly after a cold winter.

RÉSUMÉ

La population nicheuse de Hérons gardebœufs de Camargue a été suivie de 1970 à 1991. Chaque année, 60 à 70 % des oiseaux présents en fin d'été (adultes et jeunes) ont tendance à hiverner dans le delta du Rhône et ses environs. Les températures hivernales affectent la taille de la population nicheuse les années suivantes. L'afflux d'oiseaux issus de populations situées plus au Sud joue un rôle important dans le maintien de cette espèce en Camargue, particulièrement après un hiver rigoureux.

ACKNOWLEDGEMENTS

Long-term data sets like the one presented here are unusual; they depend upon long-term commitment. We are greatly indebted to L. Hoffmann for his continuous support and enthusiasm over more than two decades. We also thank our colleagues J. Boutin, Y. Cherain, E. Coulet, A. Johnson, Y. Kayser, H. Kowalski, R. Lamouroux, J.-L. Lucchesi, Ph. Vandevalle and J. Walmsley for helping to count egret roosts. Vincent Boy provided statistical advice, and previous versions of this manuscript benefited from comments by A. Crivelli, P. Grillas and J. Skinner.

REFERENCES

ARENDT, W.J. (1988). — Range expansion of the Cattle Egret (*Bubulcus ibis*) in the Greater Carribean Basin. *Colonial Waterbirds,* 11 : 252-262.

BREDIN, D. (1983). — *Contribution à l'étude écologique d'*Ardeola ibis *(L.) : héron gardebœufs de Camargue.* Thèse de 3ᵉ cycle, Université Paul Sabatier, Toulouse.

BREDIN, D. (1984). — Régime alimentaire du Héron gardebœufs à la limite de son expansion géographique récente. *Rev. Ecol. (Terre & Vie),* 39 : 431-445.

CEZILLY, F. (1985). — Premier bilan de la vague de froid survenue en janvier 1985, pour quelques échassiers hivernant en Camargue. *Faune et Nature,* 27 : 23-24.

CRAMP, S. and SIMMONS, K.E.L. (1977). — *The Birds of the Western Palearctic. Handbook of the Birds of Europe, the Middle East and North Africa.* Vol. I. Oxford University Press, Oxford.

DIAS, P.C. (1991). — Les Ardéidés nicheurs au Portugal : Distribution, Biologie, Conservation. *Alauda,* 59 : 23-26.

ELKINS, N. (1983). — *Weather and Bird Behaviour.* Calton, Poyser.

FERNANDEZ-ALCAZAR, G. & FERNANDEZ-CRUZ, M. (1991). — Situacion actual de las garzas coloniales en España. *Quercus,* 60 : 8-16.

FOUCARD, T. and LAFAYE, J.Y. (1983). — *Régression linéaire sur micro-ordinateurs.* Masson, Paris.

HAFNER, H. (1970). — A propos d'une population de Hérons gardebœufs (*Ardeola ibis*) en Camargue. *Alauda,* 38 : 242-254.

HAFNER, H. (1975). — Sur l'évolution récente des effectifs reproducteurs de quatre espèces de hérons en Camargue. *Ardeola,* 21 : 819-825.

HAFNER, H. (1980). — Etude écologique des colonies de hérons arboricoles (*Egretta g. garzetta,* L., *Ardeola r. ralloides,* Scop., *Ardeola i. ibis,* L., *Nycticorax n. nycticorax* L.) en Camargue. *Bonner Zoologische Beiträge,* 31 : 249-287.

HANCOCK, J. and KUSHLAN, J. (1984). — *The Heron's Handbook.* Croom Helm, London.

MEAD, C.J., NORTH, P.M. and WATMOUGH, B.R. (1979). — The mortality of British Grey Herons. *Bird Study,* 26 : 13-22.

NORTH, P.M. (1979). — Relating Grey Heron survival rates to winter weather conditions. *Bird Stdudy,* 26 : 23-28.

PINEAU, O. (1992). In press. — *Key wetlands for the conservation of Camargue Little Egrets.* In *Proceedings of IWRB Symposium Managing. Mediterranean Wetlands and their Birds for the Year 2000 and beyond.* Grado, Italy, 3-10 February 1991.

RANGLACK, G.S., ANGUS, R.A. & MARION, K.R. (1991). — Physical and temporal factors influencing breeding success of Cattle Egrets (*Bubulcus ibis*) in a West Alabama colony. *Colonial Waterbirds,* 14 : 140-149.

REYNOLDS, C. (1979). — The heronries census : 1972-1977. Population changes and a review. *Bird Study,* 26 : 7-12.

RUIZ, X. (1985). — An analysis of the diet of Cattle Egrets in the Ebro delta, Spain. *Ardea,* 73 : 49-60.

SIEGFRIED, W.R. (1966). — Age at which Cattle Egrets first breed. *Ostrich,* 37 : 198-199.

TELFAIR, R.C. (1983). — *The Cattle Egret : A Texas Focus and World View.* College Station, Texas, U.S.A. The Texas Agricultural Experiment Station.

VOISIN, C. (1991). — *The Herons of Europe.* Poyser, London.