Factors affecting the number of pairs and breeding success of Mute Swans *Cygnus olor* in an area of south Staffordshire, England between 1961 and 1985

A.E. COLEMAN, C.D.T. MINTON and J.T. COLEMAN

The population of Mute Swans in a 1440 square kilometre area of south Staffordshire has been studied since 1961. Considerable fluctuation in the number of swan pairs and their breeding success has been noted. The decline within the Birmingham/Wolverhampton conurbation has been a cause for concern, human influence being a major factor. Most pairs retained the same mate from the previous season, 87% of this segment of the paired population laid eggs. Overall clutch failure was 45%, humans being the chief cause; failure in the industrial conurbation was 22% more than in the rural area. The number of cygnets fledged per breeding pair was significantly less in the industrial conurbation. Rearing success was uniform and tended to decrease with brood size. Over 50% of the broods were reared without loss. Highest mortality after fledging occurred during the first year with peak periods in October and March. Overhead wires were the commonest cause of known death. An average maximum mortality rate of 21% was calculated for breeding birds and 31% for non-breeding paired birds with deaths due to vandalism highest in the breeding birds. A low immigration of breeding birds was recorded.

Since 1961 the Mute Swan *Cygnus olor* has been studied in a 1440 square kilometre area chiefly in south Staffordshire but with parts of Warwickshire, Worcestershire and Derbyshire also included. The area extends 40 kilometres north and 36 kilometres east of National Grid co-ordinates SO 900 900.

Except for the heavily industrialised conurbation of Birmingham/Wolverhampton the area is largely rural: none of the other towns are as heavily industrialised or large.

The area (Fig. 1) contains a variety of habitats including gravel pits, streams, rivers, canals, reservoirs and a large number of small pools, typically of 0.2-1 hectare. Most of the pools in the industrial area have resulted from mining subsidence, others are industrial flashes.

Throughout the study considerable fluctuations in the total number of swan pairs have been noted (Fig. 2) and this paper attempts to analyse the factors involved together with those affecting breeding success.

Methods

Catching and monitoring methods have been described in previous publications (Minton 1968, 1971, Coleman & Minton 1979, 1980) and have continued almost unchanged.

Between 1961 and 1985 inclusive a total of 5,360 swans have been ringed including 2,157 cygnets hatched within the area. From 1969 large plastic leg rings, readable at a distance with binoculars, have been used (Ogilvie 1972) and all birds caught since 1979 have been sexed cloacally.

A bird is regarded as being in its first year up to the end of August of the year after hatching. A breeding pair is one which nests and lays eggs, a non-breeding pair holds territory, or holds territory and builds a nest without producing eggs.

An assessment of immigration and emigration has been attempted based on the paired birds since they are monitored closely, with almost 100% of them ringed. All paired birds ringed in 1961-65 were regarded as residents thereby establishing a base population. In subsequent years, apart from birds wearing rings from other areas, only unringed adults i.e. age 2+ were regarded as immigrants, as first and second year birds may be unringed cygnets hatched within the area. It is unlikely that a paired bird will remain undetected and unringed within the area for over two years. The authors accept the limitations of the assessment, the paired birds being relatively sedentary (Minton 1971) represent a biased sample and adults of 2+ years may also be birds hatched within the area that have returned. Assessment of immigrants forms part of the methodology of the study and produces a more accurate assessment than for emigrants which, being based on other

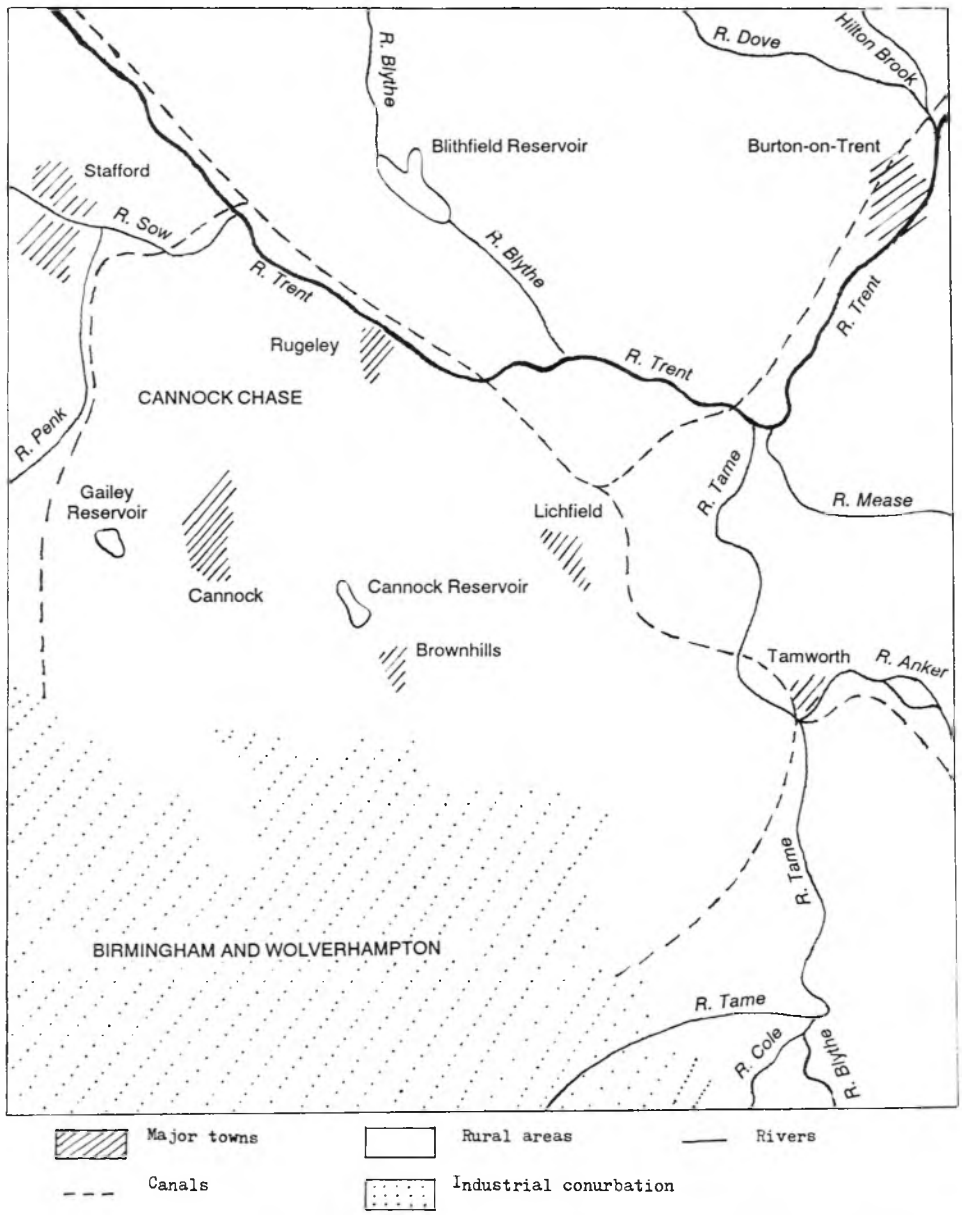

Figure 1. The study area showing canals, rivers, reservoirs, major towns and the industrial conurbation of Birmingham and Wolverhampton. For simplicity the canal system in the industrial conurbation has been excluded.

observers' reports, is not as comprehensive. Determination of annual emigrant numbers is also complicated by mortality, paired birds disappearing between seasons may have died and remained undetected within the area. Minimum numbers are determined from actual sightings, alive or dead, outside the area; maximum numbers are calculated by adding to this all other paired birds never subsequently seen.

Results

Numbers of swan pairs

Figure 3 summarises the relationship between paired and unpaired birds indicating how numbers within the area may be reduced, reinstated or increased, and shows the importance of a substantial reservoir of unpaired flock birds in

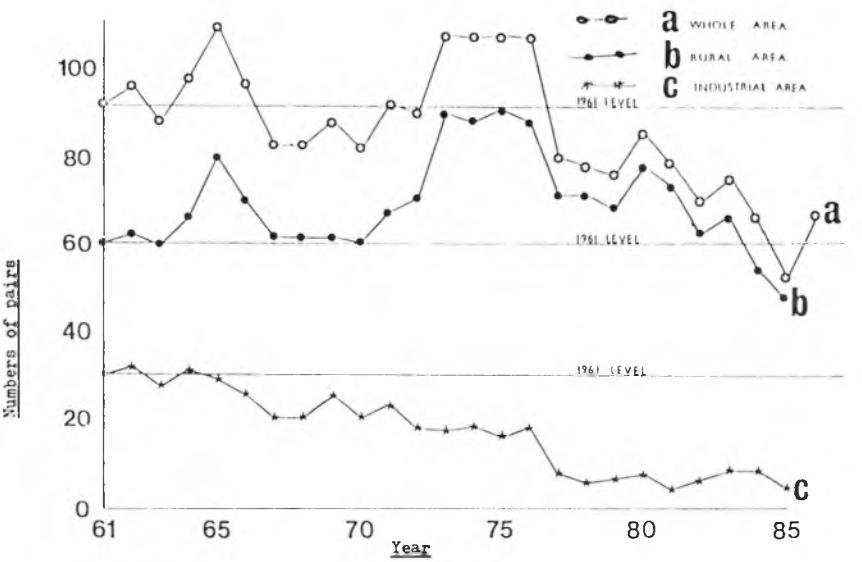

Figure 2. Numbers of Mute Swan pairs 1961-85.

maintaining numbers of paired birds.

The oiling incidents in July 1966, October 1974 and February 1978 (Fig. 4), involving a moulting herd and two wintering herds respectively resulted in a serious reduction in the number of flock birds and a loss in condition of the surviving birds including non-breeding and failed breeding pairs that had returned to the flocks to moult and/or overwinter.

The pair bond status

Most swan pairs (Table 1) are established pairs ($\chi^2 = 879.0$, df = 3, $P<0.001$) and analysis of the breeding and non-breeding pairs within each category shows that 87% of the established pairs, 54% of the pairs with a mate change and 36% of the new pairs laid eggs ($\chi^2 = 644.82$, df = 2, $P<0.001$). Within the rural and industrial areas the figures' are similar.

Hatching and rearing success

The number of cygnets fledged has been recorded since 1961 but prior to 1966 the number of young hatched was not recorded.

Breeding success (Table 2) is indicated by the number of cygnets fledged per breeding pair and is considerably less in the industrial area. Since fledging success is very uniform, cygnet produc-

Table 1. The pair bond status in Mute Swans 1962-85

	Rural area		Industrial area		Whole area	
	N	%	N	%	N	%
Pairs retaining same mate from previous season (established pairs)	873	52	224	53	1097	52
Pairs with mate change	323	19	82	20	405	19
New pairs (both paired for first time)	311	19	80	19	391	19
Not known	173	10	33	8	206	10
Total sample	1680		419		2099	

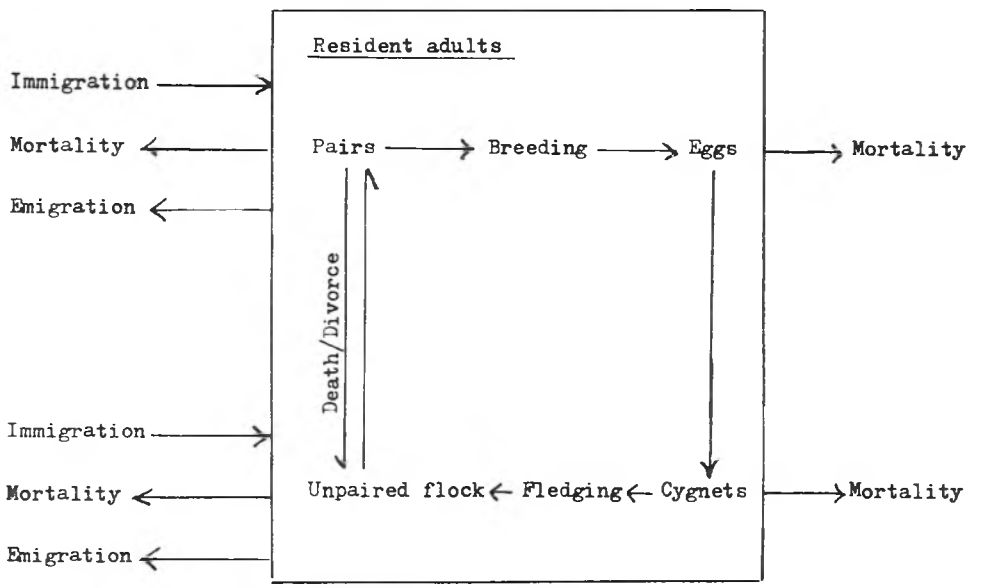

Figure 3. Summary of the relationship between paired and unpaired swans.

tion must be a reflection of hatching success and differs greatly between the rural and industrial areas (χ^2 = 10.39, df = 1, P<0.017).

From 1961-85 overall clutch failure was 45% (n = 1575), failure in the rural and industrial areas being 40% (n = 1249) and 62% (n = 326) respectively. Of the clutches in the industrial area 79% were vandalised by humans, 22% more than in the rural area. Failure due to infertility and unknown causes were not dissimilar accounting for 7% and 13% in the rural area and 4% and 11% in the industrial area respectively. The higher percentage of failures in the rural area attributed to other causes, 22% as opposed to 6% in the

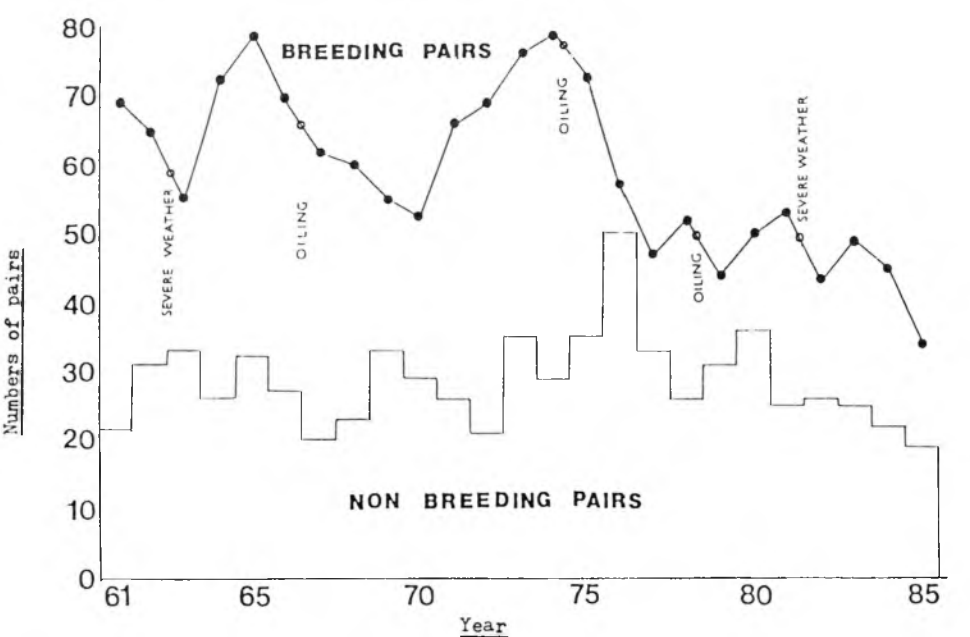

Figure 4. Numbers of Mute Swan breeding and non-breeding pairs 1961-85.

industrial area is mostly due to flooding along rivers and streams. Causes of failure vary significantly between the areas, the bulk of the differences being in the ratio of human and other causes ($\chi^2 = 33.12$, df = 3, $P<0.001$).

Repeat clutches were recorded most years but were not typical. Of the 104 second clutches, 48% were successful, figures for the rural and industrial areas being 52% ($n = 79$) and 12% ($n = 25$) respectively. Of the failures 63% in the rural area and 88% in the industrial area were again due to human interference. Three pairs laid a third clutch after their second had been stolen. Two were successful but the third was again stolen.

Brood sizes at hatching ranged from 1 to 10 with 3, 4 and 5 (48%) being the commonest ($n = 655$). Rearing success tended to decrease with brood size but 52% of the broods were reared without loss. Brood sizes at hatching for established pairs, new pairs and pairs with a mate change also show 3, 4 and 5 as the commonest but the percentage of broods with one or two cygnets at hatching, 32%, recorded for newly paired birds, was double that recorded for established pairs ($\chi^2 = 76.43$, df = 1, $P<0.001$)

Mortality

a) *Mortality of fledged birds* - minimum survival and maximum mortality calculations for 2157 ringed pulli follow the method adopted in previous papers (Minton 1968, Coleman & Minton 1980) and are based on retraps, controls, sightings of ringed birds and 527 recorded deaths of cygnets hatched within the area. Of the 2,157 cygnets, 43.4% survived their first year with survival rates of 68%, 65.2%, 73.3% and 75.3% being calculated for the second, third, fourth and fifth years. Collisions were the commonest recorded cause of death amongst first year birds, 48% of the birds ($n = 219$) colliding with overhead wires, trees, vehicles and bridges. Mortality peaks for first year birds occurred during October (21% of deaths) and March (19% of deaths). Of the October fatalities 42% occurred within 5 km of the natal site.

Table 2. Hatching and rearing success in Mute Swans 1966-85.

	Rural area	Industrial area	Whole area
TOTALS			
Pairs	1411	297	1648
Nesting pairs	939	192	1131
Cygnets hatched	2626	306	2912
Cygnets fledged	1994	240	2234
MEASURES OF SUCCESS			
Cygnets hatched/pair	1.86	1.03	1.76
Cygnets hatched/ breeding pair	2.79	1.59	2.57
Cygnets fledged/ pair	1.41	0.80	1.35
Cygnets fledged/ breeding pair	2.12	1.25	1.97
Cygnet survival to fledging	75.9%	78.4%	76.7%

Table 3. Causes of mortality in identifiable paired Mute Swans 1961-85.

	Whole area			
	Collisions	Vandals	Others	Not known
Breeding birds	44 24%	33 18%	26 14%	84 45%
Non-breeding birds	30 30%	8 8%	18 18%	44 44%
Breeding males	22 23%	13 14%	11 12%	48 51%
Breeding females	22 24%	20 22%	15 16%	36 39%
Non-breeding males	14 29%	4 8%	10 21%	20 42%
Non-breeding females	16 31%	4 8%	8 15%	24 46%
Total breeding and non-breeding birds	71 25%	41 14%	44 15%	131 46%

b) *Mortality of paired birds* - mortality in breeding and non-breeding paired birds has been analysed separately since differences in their age structure and behaviour could influence their mortality rate. An average maximum mortality rate of 21% ($n = 2877$) was calculated for breeding birds and 31% ($n = 1220$) for non-breeding paired birds. Analysis of the causes of death (Table 3) shows mortality due to collisions was highest in non-breeding paired birds and deaths due to vandalism were more common amongst breeding birds, especially the females. In the rural area 15% of deaths in identifiable breeding birds were due to vandalism ($n = 107$) as opposed to 22% in the industrial conurbation ($n = 80$). Again breeding females were most vulnerable with mortalities of 16% in the rural area ($n = 55$) and 29% in the industrial area ($n = 38$) as opposed to 12% and 16% for males ($n = 51$ and 43) respectively.

Immigration and emigration

From 1966-85 a total of 272 immigrant paired birds (9%, $n = 3071$) were recorded, 91 of them breeding birds (5%, $n = 2077$) and 181 non-breeding paired birds (18%, $n = 994$). New immigrant breeding birds totalled 74 for the rural area and 17 for the industrial conurbation, figures for non-breeding paired birds being 146 and 35 respectively. Between 1976 and 1980 no new immigrant breeding birds were recorded in the industrial area. Only 32 definite records of emigrant breeding and non-breeding paired birds were recorded over the period of the study.

Discussion

The decline in the number of paired birds in the Birmingham/Wolverhampton conurbation has been a cause for concern. It may be argued that this decline is either a reflection of a general decline within the whole study area or a natural decline as a result of a considerably inflated population at the beginning of the study. The different patterns in Figure 2 indicate that neither argument is likely to be true; the former is not likely since the large increase in the number of pairs in the whole area between 1973-76 is not reflected in the industrial conurbation despite a prior fall of 40% in that segment of the population, which also indicates that the latter argument is also unlikely.

It is unlikely that any single factor can be responsible for this decline but undoubtedly a major factor must be the influence of man and the environmental pressure created by the high density human population.

Although oiling incidents have not directly affected the breeding pairs their consequences are reflected in the non-breeding herds and through them to the number of non-breeding pairs.

The low numbers of breeding pairs in 1963 and 1982 is the result of mortality in breeding birds during the preceding severe winters and from 1977-85 there was little sign of recovery in the number of breeding pairs with an average of only 45.8 breeding pairs per year recorded.

The relationship between established pairs and breeding potential indicates that factors such as mortality directly reducing the number of established pairs also reduces the potential for cygnet production.

Excess clutch failure in the industrial area has led to a low hatching success and is clearly due to the high percentage of nesting sites in close proximity to human habitation. Failure of repeat clutches also indicates the vulnerability of nesting sites.

Collisions with obstacles is directly related to aerial activity (Perrins & Reynolds 1967, Coleman & Minton 1980), whereas acts of vandalism are usually perpetrated while birds are either swimming or on land. Clearly, strongly territorial and more sedentary breeding birds are more susceptible to the latter especially in the industrial area, while the more mobile, nomadic and less territorial non-breeding paired birds are more susceptible to the former. Females are most at risk during the long incubation period.

Fledging success was remarkably uniform throughout the area and survival rates tended to increase with age. Mortality peaks for first year birds in April and October coincided with periods of aerial activity associated with first flights (October) and flock activity (March) as a result of increasing daylight hours.

Sixty-seven percent of all new immigrants were recorded as members of non-breeding pairs, undoubtedly due to their mobile nature. Availability of suitable territories, especially in the industrial area may be a factor in determining the number of immigrant breeding birds but it is recognised that each year several territories on which previous pairs nested successfully remain unoccupied. The very low number of emigrant breeding and non-breeding paired birds recorded make it impossible to draw any valid conclusions.

We are grateful to the many individuals and organisations who have helped over the years with field work and financial aid and to those who have allowed us access to private land to pursue the study.

References

Coleman, A.E. & Minton, C.D.T. 1979. Pairing and breeding in Mute Swans in relation to natal area. *Wildfowl* 30:27-30.

Coleman, A.E. & Minton, C.D.T. 1980. Mortality of Mute Swan progeny in an area of south Staffordshire. *Wildfowl* 31:22-28.

Minton, C.D.T. 1968. Pairing and breeding of Mute Swans. *Wildfowl* 19:41-60.

Minton, C.D.T. 1971. Mute Swan flocks. *Wildfowl* 22:71-88.

Ogilvie, M.A. 1972. Large numbered leg bands for individual identification of swans. *J. Wildl. Mgmt.* 36:1261-1265.

Perrins, C.M. & Reynolds, C.M. 1967. A preliminary study of the Mute Swan *Cygnus olor*. *Wildfowl* 18:74-84.

A.E. Coleman and J.T. Coleman, 67 Park Lane, Bonehill, Tamworth, Staffs, England.
Dr C.D.T. Minton, 165 Dalgetty Road, Beaumaris, Melbourne, 3193, Australia.