WEIGHT AND GROWTH RATES OF MORPHOLOGICAL CHARACTERS OF *CYGNUS OLOR*

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Introduction

Study of *Cygnus olor* of the Swedish west coast has emphasized a biometrical background to movements, reproduction and survival, as well as to different behaviour patterns. Especial attention has been paid to: a) growth and maturity; b) sexual dimorphism; c) physical condition, both normal and pathological; d) population characters and e) ecological adaptation.

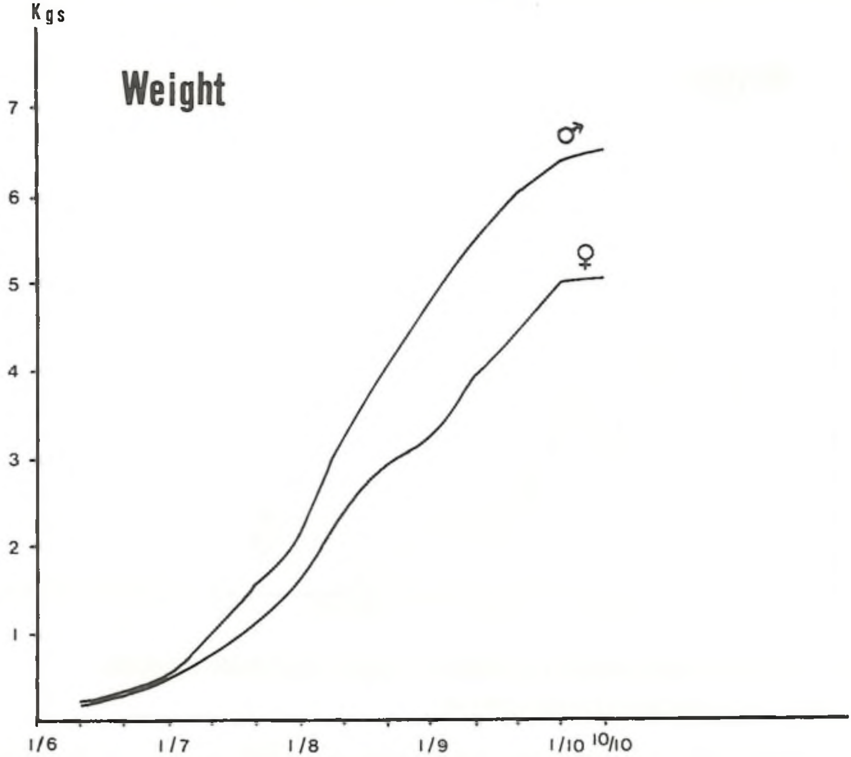

Fig 1. Weight of cygnets as an average of five females and five males measured every second week from hatching to fledging.

Horizontal axis shows date by ten-day periods.

Our working *proformae* therefore include, beside identification codes (ring numbers, neck-collar numbers, colour-rings, etc), columns for: 1) sex; 2) age; 3) weight; 4) size of bill knob; 5) length of fore-arm, neck, tarsus, bill, 5th primary; 6) width of foot web; 7) width and length of bill nail and 8) colour of bill (four grades).

Growth of cygnets

The cygnets of both sexes start their lives at similar body weights, the females from the beginning, however, being slightly lighter than the male cygnets (Fig 1). As time goes on, a clear sex differentiation is observed. At the time of fledging, the middle of October, males are on average 28% heavier than females.

The weight increase from period to period, up to the time when the cygnets are able to fly, is uneven (Fig 2). During their first weeks of life, when they put weight

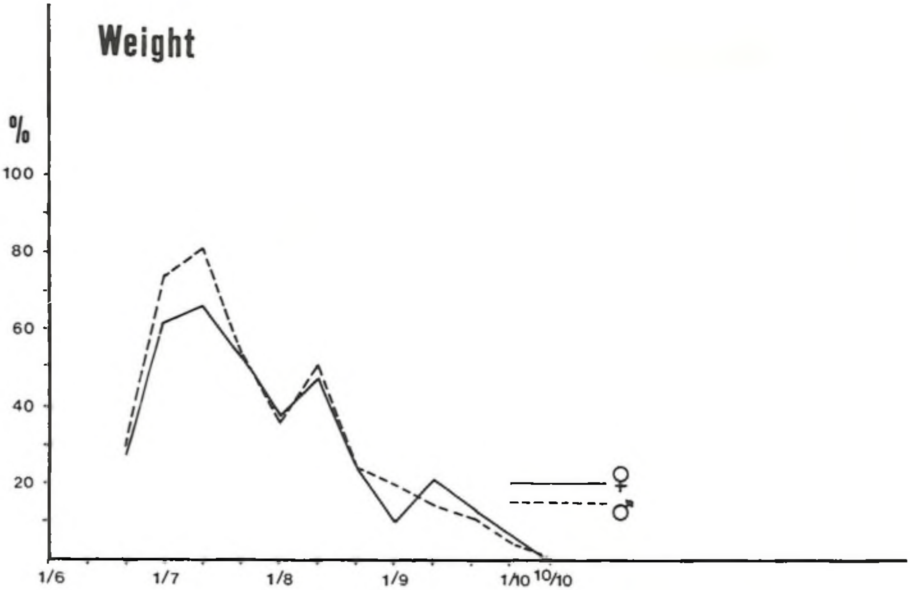

Fig 2. Percentage weight increase in female and male cygnets.
Horizontal axis shows date by ten-day periods.

on proportionally more than later, they increase by 60% to 75%. In the middle of August and in the middle of October increased growth rates are again found.

In this context it is also interesting to consider the growth of other characters. Fig 3 shows that the tarsus length as well as the length of the neck have a similar growth pattern, their growth starting early and plateauing out comparatively soon. The fore-arm (radius and ulna) begins to grow rather late, the 5th primary still

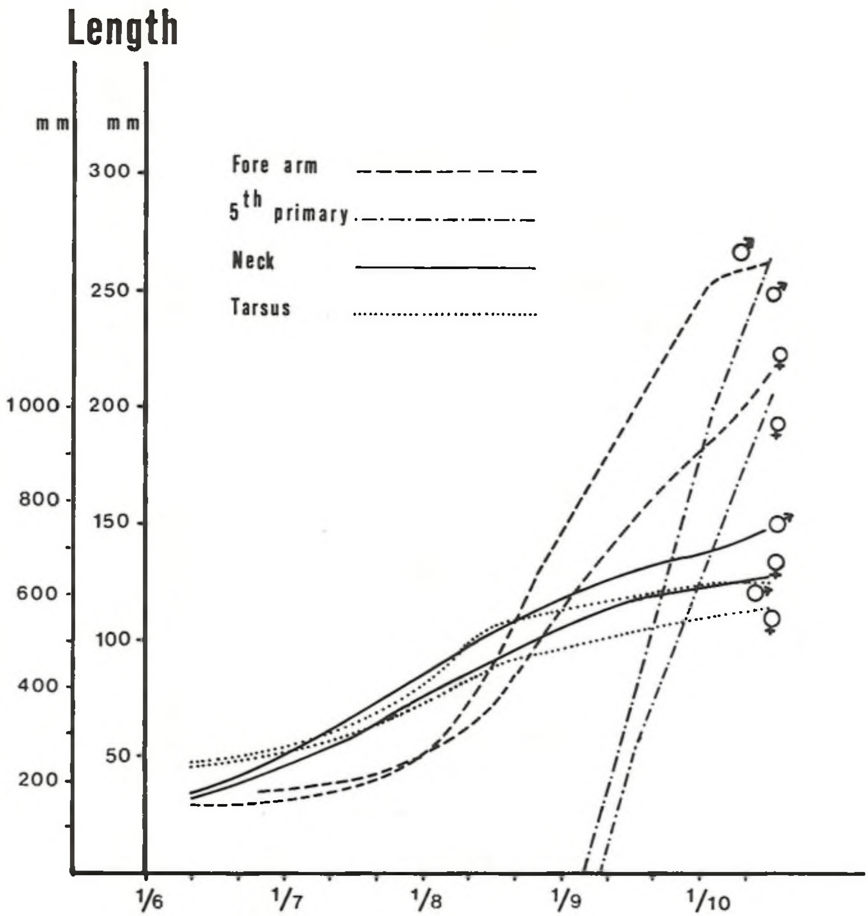

Fig 3. Growth of different anatomical parts of the body of the cygnets.

Horizontal axis shows date by ten-day periods.

later. In other words, the cygnets, being nidifugous, must be able to swim before they can fly. At the time when the cygnets actually are able to fly, their weight is about 70% to 75% of that of adult breeding birds. Consequently, they still put on weight after fledging.

The first weeks with very strong weight increase are connected with losses of

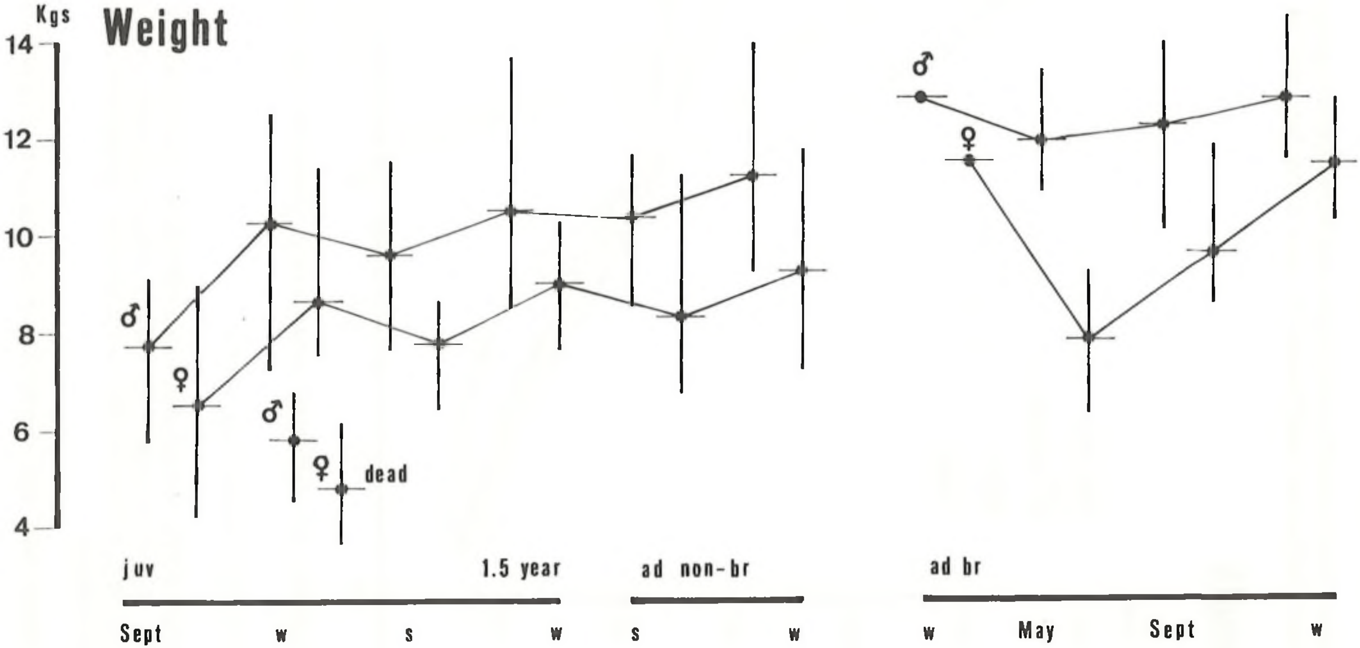

Fig 4. Weight curves of the two sexes showing the weight changes throughout life. Weights of winter-dead swans are also illustrated.

Table 1. Morphological and biometrical characters of *Cygnus olor* of different age classes and categories.

Sex	No	Age	Length of fifth primary (in mm)	Weight (in kg)	Length of neck (in mm)	Length of tarsus (in mm)	Width of foot web (in mm)	Bill nail (in mm)	Bill colour	Length of bill (in mm)	Height of knob (in mm)	Length of fore-arm (in mm)	Time of year/status
Male	41	juvenile	374	7.7	779	130	182	10.9 x 19.7	1	101	5.8	286	January–March
	72	1 year		10.0	814	131	189	11.4 x 20.5	1	101	9.2	294	July–August (moulting)
	20	1½ year	387	8.3	825	132	186	11.2 x 19.6	1–2	99	8.1	291	January–March
	40	2 year		10.2	823	131	189	11.6 x 21.0	1.5–3	100	10.7	292	July–August (moulting)
	47	adult		10.5	825	130	191	11.5 x 20.7	3–4	100	10.9	293	July–August (moulting), knob <13 mm
	90	adult		10.8	831	131	191	11.9 x 21.0	4	101	15.4	297	July–August (moulting), knob >13 mm
Female	46	juvenile	357	6.7	713	119	167	10.4 x 17.8	1	94	6.8	264	January–March
	33	1 year		7.8	739	119	172	10.8 x 19.2	1	94	8.1	270	July–August (moulting)
	29	1½ year	364	7.3	755	120	175	10.9 x 19.2	1–2	95	10.5	269	January–March
	38	2 year		8.2	746	120	175	10.9 x 19.6	1.5–3	94	9.8	270	July–August (moulting)
	44	adult		8.1	751	119	174	11.0 x 19.4	3–4	95	11.0	272	July–August (moulting), non-breeder
	49	adult		8.6	760	119	177	11.0 x 19.6	4	94	10.6	272	July–August (moulting), breeder

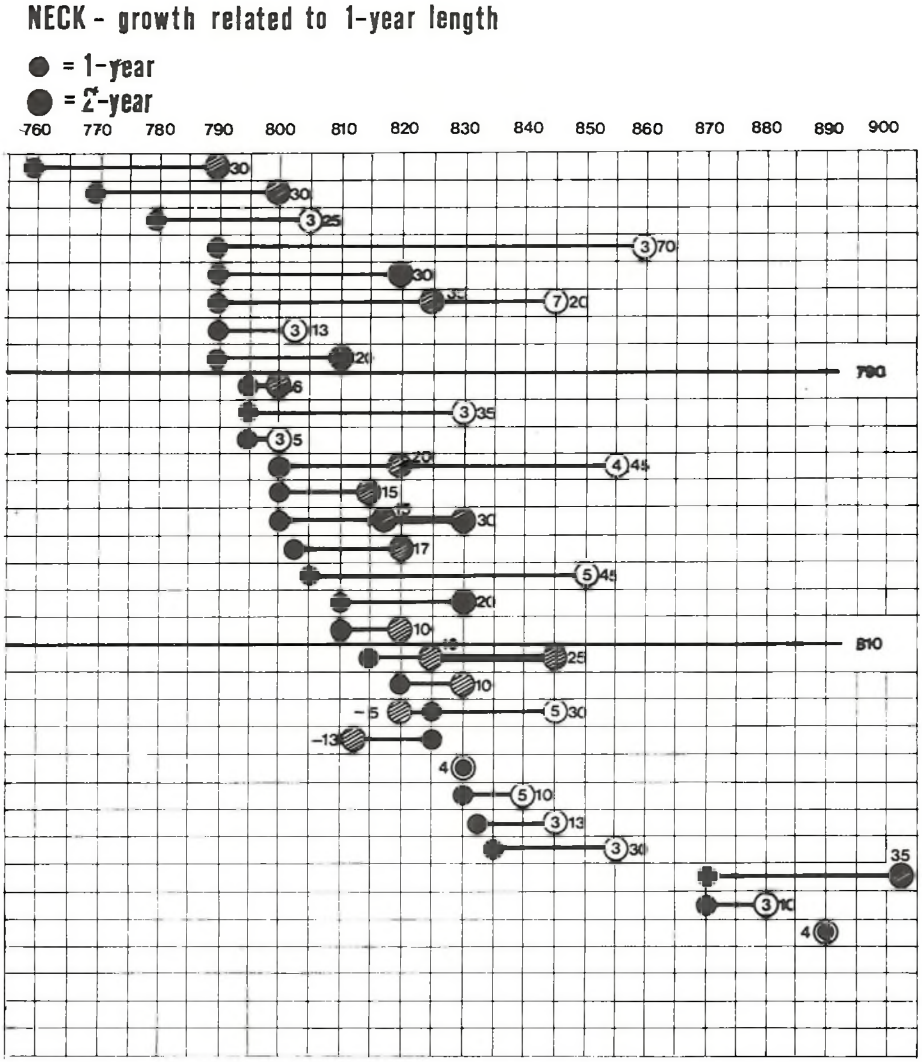

Fig 5. Neck growth between first and second year, in some cases also between the age of one year and higher ages (the number in the circle).

cygnets. In fact, the strongest reduction in numbers of cygnets is recorded here. However, there are normally no differences between the sexes. At the time of fledging (in October) they come out 50:50.

Juvenile and pre-breeding growth

The cygnets continue to grow after fledging (Table 1 and Fig 4), the juvenile sub-adults putting on weight up to the age of 4 to 6 years, when they reach the age of reproductive maturity. Table 1 also shows that in the same period the bill knob is increasing in size and the bill turning orange-red from grey.

From their second summer (one year old) their neck may still increase in length (cf Table 1 and Fig 5), while bill, tarsus, fore-arm and bill nail have stabilized. The length of the primaries is still increasing.

Study of the subsequent neck length of juvenile males (Fig 5), from the time when first caught and measured in their second summer (one year old) to ages of two or more years, shows that those with long necks (more than 810 mm) grow on average 7.7 mm (n = 7), those of middle length (790 to 810 mm) grow 15.8 mm (n = 7) and those with the shortest necks (less than 790 mm) grow 28.3 mm (n = 6). There is thus some adjustment to an appropriate neck length range, which is obviously genetically determined.

Fig 6 illustrates the sizes of fore-arm, tarsus and length of neck among 90 juvenile males caught at their first visit (one year old) to the moulting ground of Kungsbackafjorden. Increasing length of one character is generally associated with increased length of the other two. The normal distribution curve of the dimensions of fore-arm and tarsus as compared with the uneven distribution of the neck lengths (a skew to the small side) reflects the stabilization of the former and the continued growth of the latter.

The bigger males (fore-arm more than 300 mm, 27% of the total number) recur at the moulting ground at the same rate as smaller ones but at higher ages; thus 28% of the bigger ones returned in their second year to the moulting ground, against 56% of the smaller ones. None of the bigger ones were found to shift moulting ground, but six of the smaller (6.7% of the total) did. None of the bigger was reported dead. On the other hand, two of the bigger swans were later on found breeding, but none of the smaller was. These differences, however, need further investigation.

Size and life of adult swans

As shown in Tables 2A and 2B and Fig 4, there is a well-defined difference in weight and in the size of the knob of old breeding swans, as compared with non-breeders in the summer. The knob size is correlated to body weight. An old breeding male has, on an average, a knob which is more than 6 mm higher than a non-breeder of the same age and he is 1.3 kg heavier. The two categories are of similar size according to length of neck and fore-arm. There is also a good correlation between the physical state of the swan and the size and shape of the knob (Table

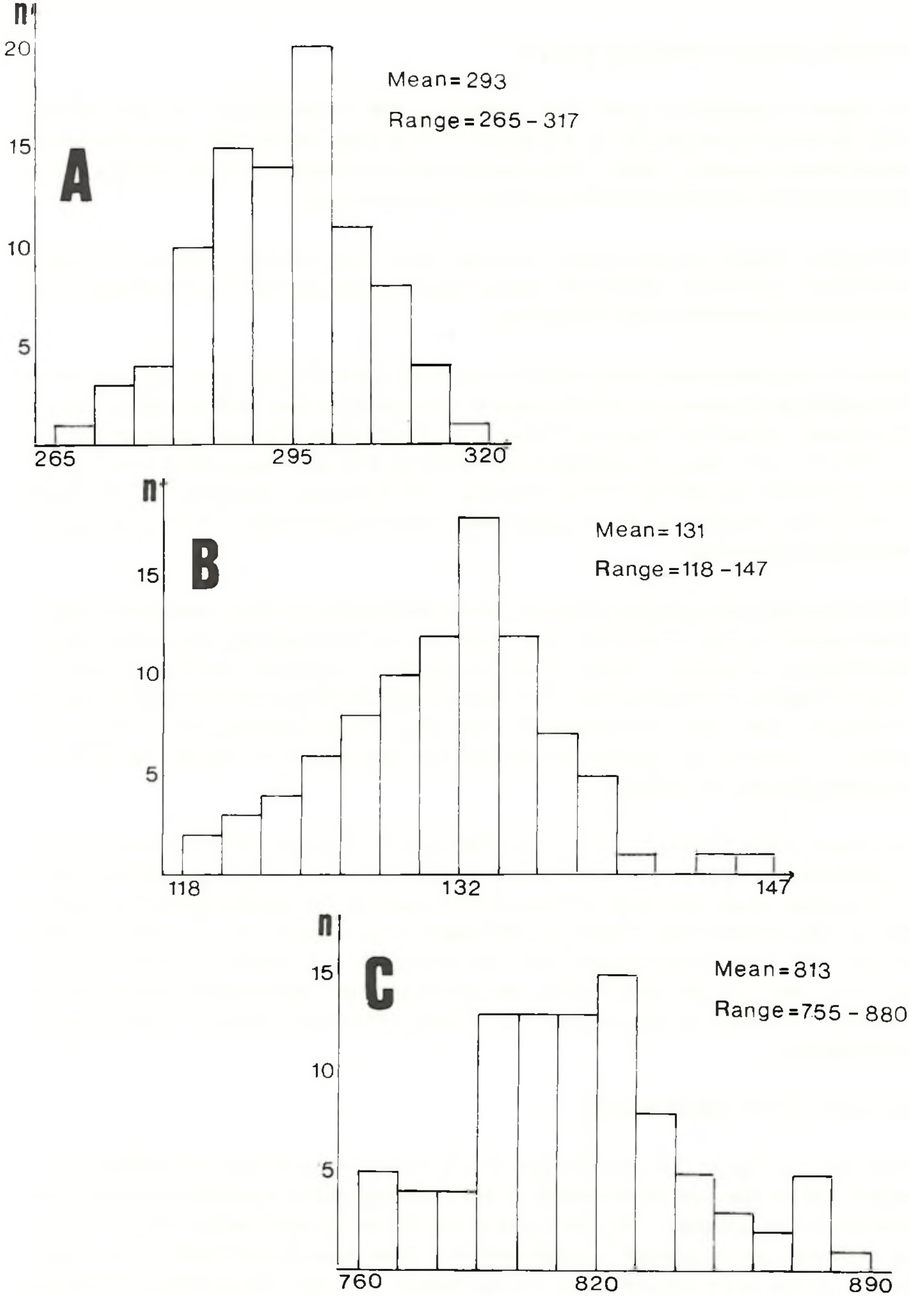

Fig 6. The distribution curves as well as the average and extremes of the dimensions of fore-arms (A), tarsi (B) and neck (C) of 90 one-year-old male *Cygnus olor* caught during moult.

Table 2. Knob dimension in relation to weight, length of neck and length of fore-arm of full-grown swans with bill colour 4, eg more than three years old.

			Knob (in mm)	Weight (in kg)	Length of neck (in mm)	Fore-arm (in mm)
A.	Breeding birds in summer					
	Males	(n = 22—25)	17.4	12.3	827	298.3
	Females	(n = 18—35)	10.7	9.1	758	271.7
B.	Non-breeders in summer					
	Males	(n = 23—24)	11.5	11.0	825	296.1
	Females	(n = 26)	11.0	8.4	754	274.5
C.	Non-breeders with extremely small, shrunk knobs					
	Males	(n = 8)	7.81	9.82	840	289.1
	Females	(n = 17)	7.12	7.77	777	274.1

2C). Adult males with a knob of 7.8, eg less than half the average size of a breeding male, are 2.5 kg (20%) lighter and similar correlations are found among females. These 'small-knobbed, light-weight' adult swans are found in the floating population which circulates between moulting grounds, post- and pre-moulting resting grounds and winter quarters, but does not breed.

If the yearly weight curve of the breeding swans is examined, it transpires that the males display a rather stable curve throughout the year, the females decreasing in weight after egg-laying. The average decrease of the female totals about 30%. When still incubating the females lose about 15% of their body weight (Fig 4). After hatching they must regain the weight losses, which sometimes forces them to move from the nest site to areas with better food supplies. This, however, may result in the death of the offspring because:

a) the transport of the cygnets in this very sensitive period of their lives kills some through food shortage or bad weather;

b) the swans meet competing pairs, causing fights and losses of cygnets. Sometimes the whole clutch or parts of it is kidnapped and adopted by a foreign pair;

c) the swans do not find fully suitable growing grounds for themselves and the cygnets, which reduces the number of the latter.

During winter, breeding as well as non-breeding swans may suffer from food shortage, which influences their future body weight and ability to defend the territory and produce eggs. Fig 7 demonstrates the number of breeding pairs in

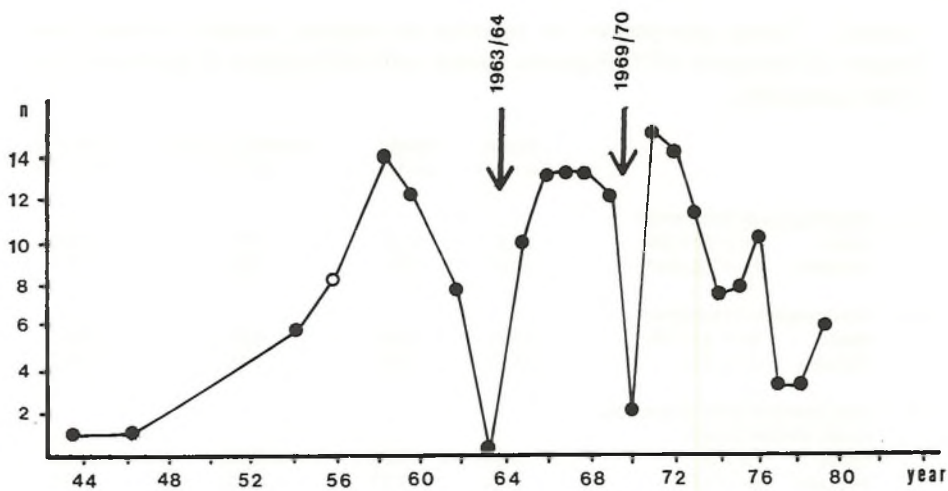

Fig 7. The annual number of breeding pairs of *C. olor* at Lake Kollungerod on the island of Orust on the Swedish west coast. The lowest number of breeding pairs has been found in connection with severe winter conditions.

relation to previous winter condition. It has also been found that the numbers of eggs laid in the clutch show a clear relation to the body weight of the female (Table 3).

Table 3. Number of eggs laid in relation to the body weight of the female in the pre-laying period.

Average and maximum—minimum weight of female before egg-laying	7.5 (7.2–8.1)	10.0 (9.5–10.2)	11.1 (10.6–11.7)	12.7 (12.0–13.2)
Average number of eggs	0	5	6	7.7
Number of females	3	3	4	3

Summary

Studies of *C. olor* have been carried out on the Swedish west coast, mainly in the counties of Halland and Bohuslan. Almost all non-breeders and more than 80% of the breeding pairs occur in shallow coastal bays.

The information is part of an extensive data collection, now being analysed. The examples illustrate the value of some measurable characters for judging the status of certain groups of swans in the process of maturity, which in time is longer for *C. olor* than for most other birds. Examples are also given of the impact of certain physical conditions on reproductive success.

There may be differences in migratory behaviour in relation to the size of juvenile subadults. It is not yet clear whether these differences are related to swans of different geographical origin (different breeding populations) or if they depend on differential growth rates. The necks of short-necked juvenile swans grow more in their second or later years than do those with longer necks. Swans in the study area start breeding comparatively late in life, often not until the ages of 6 to 7 years. Breeding, beside other things, is associated with higher weights than is normal for non-breeders.

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POPULATION GENETICS OF *CYGNUS OLOR*

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Introduction

Genetic variants can be detected from small blood samples by electrophoresis. The proteins in a small blood sample can be separated on starch gels buffered to a specific pH by applying an electric field. The proteins move to different positions and can be located and identified by histological stains. Samples from different individuals may show different patterns on electrophoresis, and some of these differences are genetically determined. In *Cygnus olor* two proteins show such genetic polymorphism — the enzymes esterase and lactate dehydrogenase.

Esterase

Cygnus olor plasma shows three phenotypic patterns for esterase characterized by:

- a) three slow bands, termed *SS;*
- b) six bands, termed *SF;*
- c) three fast bands, termed *FF.*

Blood samples from complete families, both parents and all their cygnets, make it possible to test whether the patterns are inherited. Table 1 shows that the esterase patterns are inherited in a simple Mendelian fashion, behaving as co-dominant alleles at an autosomal locus.

The genotypes occur at similar high frequencies throughout Britain (Fig 1). Since