The Breeding Success and Distribution of Whooper Swans *Cygnus cygnus* Wintering in Japan

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INTRODUCTION

Weather is a major ecological factor affecting breeding success in all the northern geese and swans. All large sub-arctic and arctic waterfowl suffer widely varying productivity from year to year, caused mainly by climatic factors. Periodically such birds experience years of almost complete breeding failure. Low production is normally associated with later than normal melting of ice and snow which prevents birds from occupying their nesting territories. By the time the thaw comes in a "late" season, the time before the autumn freeze may be too short for nesting, incubation and fledging, leading either to reduced clutch size or non-breeding (see Ogilvie 1978). Widely varying productivity from year to year has also been observed in Whooper Swans *Cygnus cygnus*, in particular, both a reduced percentage of cygnets in winter flocks and a reduced brood size after a very poor breeding season (Brazil 1981a).

The northern swans, including the Whooper Swan, breed at low densities with usually only one pair to a single body of water (see Hansen *et. al.* 1971; Bulstrode *et. al.* 1973; Brazil 1981a) although exceptions have been reported by Banko (1960) and Brazil (1981a). Because of their low density and the political, logistical, and economical problems involved in any attempt to survey a large breeding population of the northern swans, the most practical method of studying the variation in breeding success from year to year is to examine the structure of the wintering flocks, when birds are concentrated at relatively few sites, taking into account the size of each flock, the percentage of cygnets and the brood sizes (e. g. Hewson 1964; Brazil 1981a). Studies in Britain and Ireland have shown that 1979 was a very poor breeding season for Whooper Swans (Brazil 1981a; 1982). Since the spring and summer in north-west Europe were very cold, nesting was delayed and the breeding success was the lowest on record. The normal proportion of cygnets to be expected in the British and Irish wintering population is in the region of 13—26% (Hewson 1964; Brazil 1981a), however, annual surveys in a central Scottish study site showed a marked decrease in the proportion of cygnets from 1978 to 1979, reflecting the bad breeding season; only 3.7% were recorded in winter 1979—1980 (Brazil 1981a). The result from this local study was supported by a national survey conducted in November 1979 which found that cygnets represented between 3.3 and 5.1% of the wintering population of the British Isles and Ireland (Brazil & Kirk unpubl.).

In the interests of the conservation of the Whooper Swan it is important to know the size of populations breeding and wintering in all the various areas, and to understand the factors which affect their breeding success. The world population is estimated as being between 60,000 and 100,000 (Brazil 1981a). In some areas, such as western Europe and Japan,

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counts are made frequently, while in others, such as the Caspian and Black Seas, Korea and China, counts are much less frequent or are in fact only estimates. Thus it is only in Japan and western Europe where there is the potential for recording the size of the respective populations and their changes from year to year. A population wintering in a particular area is not necessarily isolated, thus changes in the size of a population depend on factors other than just variation in breeding success, such as immigration and emigration. The proportion of cygnets in flocks and brood size, however, are dependent on breeding success, unless it can be shown that there is selective migration by families, as opposed to non or failed breeders, or by families of different sizes.

The Whooper Swans breeding in Iceland, northern Europe and western USSR and wintering in western Europe may be so far removed from the population which winters in eastern Asia as to be affected by completely different factors during any particular breeding season. The aim of this brief study, therefore, was to establish whether the population in Japan in the winter of 1979—80 showed any signs of having suffered from the same poor breeding season that had affected the British and Irish wintering population. Birds in northern Europe and western USSR are believed to have also suffered the same reduction in breeding success (the same severe weather was noted from Danish wintering grounds in spring 1979 for example (Preuss 1981)) but I am unaware of data from the 1979 breeding season from these areas.

STUDY AREAS

Flocks of Whooper Swans were observed in Japan in February and March 1980: at Odaito in eastern Hokkaido; at Kominato and Ominato (Aomori-ken); at Lake Izunuma (Miyagi-ken) and at Hyoko (Niigata-ken) (see Fig. 1). Odaito, Kominato and Ominato are all tidal, marine sites (see Brazil 1981a), Izunuma is a natural fresh-water lake and Hyoko a man-made, water-storage reservoir.

In Scotland birds were observed throughout winters 1977—78, 1978—79 and 1979—80 (except for February and March) and a national count was made in November 1979 (Brazil 1981a; Brazil & Kirk unpubl.)

METHODS

At each locality the total number of swans present and the number of cygnets was counted, where possible. Where the total could not be counted, as large a sub-group as possible was counted instead, so that a reasonable measure of the percentage of cygnets present could be made (Table 1). Brood sizes were also determined for as many broods as possible. Family groups are not continuously cohesive units, however, especially where large numbers of birds are concentrated in a small area. As a consequence relatively few broods were counted, thus the total number of cygnets comprising the broods counted, does not equal the total number of cygnets counted in the flock at the same locality. Cygnets were watched to ascertain the size of the brood they belonged to. The period of observation varied depending on the degree of isolation of the family from the main flock. It was never an instantaneous observation and rarely of less than one minute, unless a family was well known. Birds of the same brood are more similar to each other in plumage colour than are cygnets from different broods; the colour of cygnets was frequently used as an easy means

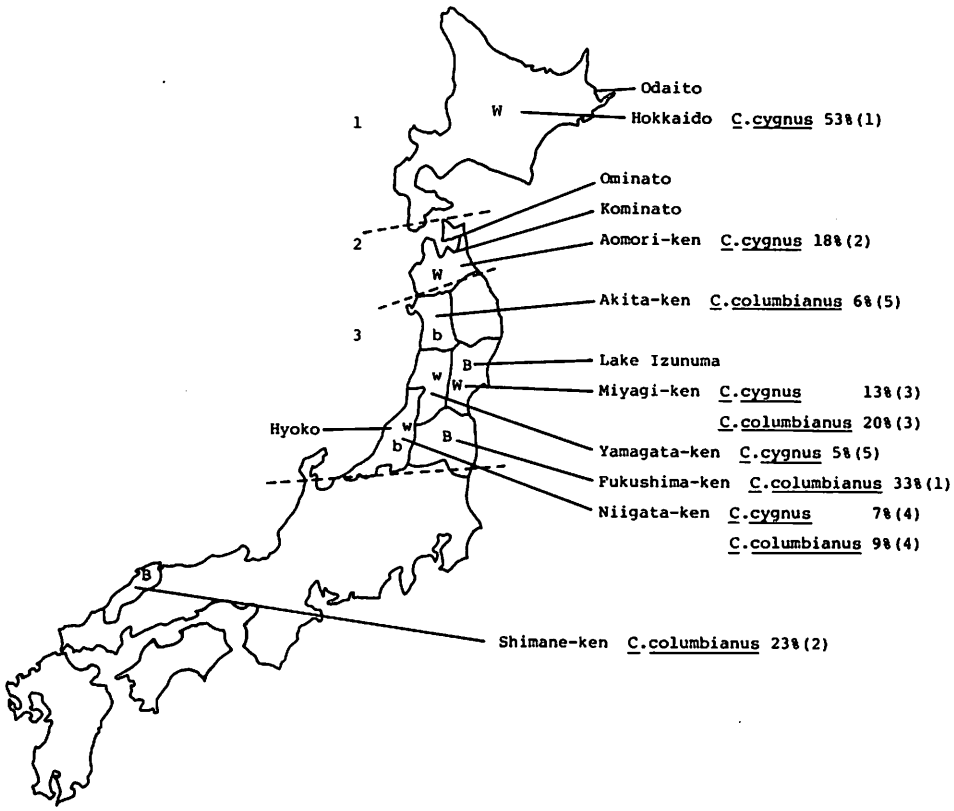

Figure 1 Map of Japan showing distribution of *Cygnus cygnus* and *C. columbianus bewickii*. - - - Marks the boundaries of regions, 1, 2 & 3 referred to in the text. For each Prefecture the percentage of the overall wintering population is given for *Cygnus cygnus* and *C. columbianus*. The rank number of each site is given in brackets. W & B denote prefectures holding more than 10% of the winter population of *C. cygnus* (W) and *C. columbianus* (B). w & b denote prefectures holding less than 10%. 96% of the wintering population of *C. cygnus* and 91% of *C. columbianus* occur in just five prefectures (see Horiuchi 1981).

Table 1 The proportion of cygnets at four sites in Hokkaido and Honshu, in February and March 1980.

Locality	Date	Total No. counted	No. of Cygnets	% of Cygnets
Kominato	28—2—80	434	85	19.6
	29—2—80	447	86	19.2
Ominato	1—3—80	221	31	14.0
	4—3—80	115	20	17.4
Izznuma	9—3—80	512	109	21.3
Hyoko	12—3—80	396	68	17.2
	13—3—80	509	125	24.6
	14—3—80	569	123	21.6

of establishing which family a cygnet belonged to. A bias towards the recording of small broods is to be expected, firstly because a shorter time is required to locate a small brood and secondly, the larger the brood the more likely it is that one or more cygnets will wander away from it. Such bias, however, should apply equally to all sites thus any differences recorded between localities in the proportion of certain brood sizes should be real.

RESULTS AND DISCUSSION

The results of the counts showed clearly that the percentage of cygnets in flocks in Japan was much higher than in Britain during the same winter. The proportion ranged from 14% to 24.6% at the four localities, compared with 3.3% to 5.1% in the British Isles and Ireland (Brazil 1981a; Brazil & Kirk unpubl.). Brood size data for the same four localities reflected some potentially interesting features (see Table 2). The brood size range was from one to five and broods of five were very uncommon, none were recorded from the northernmost site Odaito, one was recorded at Ominato, Kominato and Izunuma and two were recorded at Hyoko. Broods of two were commonest, followed by broods of one, three and four, the latter were commonest at Hyoko. At Odaito, broods of one represented half of all the broods recorded; a much higher frequency than at any other site and consequently this site had the lowest mean brood size. In Japan the percentage of cygnets in flocks, after the summer of 1979, was much higher than in Britain and Ireland thus showing that in a wide ranging species such as the Whooper Swan factors leading to a bad breeding season may only affect birds in part of their range. It is not known whether the eastern and western parts of the population are reproductively isolated, although it is known that bill patterns for example differ significantly between the eastern and western populations (Brazil 1981b); the extent of movements between the two regions cannot be known, however, without further extensive ringing.

The first migration and winter are likely to be periods of high mortality among young Whooper Swans. Wintering sites are to a large extent traditional and birds may be inflexible enough to suffer from this during periods of unusually severe weather. For example, large numbers have been known to freeze to death at Odaito in east Hokkaido. The reduction of juveniles during the winter from 50% in October to 20% in March (Fujimaki and Matsuoka 1972) and the low proportion of juveniles in February at Odaito (Abe 1968) (and this study) may indicate winter mortality, as suggested by Fujimaki & Matsuoka (1972), but many other

Table 2 Brood sizes at four sites in Hokkaido and Honshu in winter 1980.

Locality	1	2	3	4	5	Total Broods	Total Cygnets	Mean brood
Odaito	14	8	5	1	0	28	49	1.75
Kominato	5	9	7	3	1	25	61	2.44
Ominato	2	2	3	2	1	10	28	2.80
Izunuma	10	11	6	3	1	31	67	2.16
Hyoko	6	13	3	5	2	29	71	2.44
Total	31	43	24	14	5	123	276	2.24

factors may be involved. Boyd & Eltringham (1962) made the same suggestion to explain a decline in the percentage of cygnets in Britain in early winter after initial autumn arrivals. Both in Britain and Japan there may be continued arrival of adult birds during the winter especially in severe winters if conditions further north force them south. Thus at sites where a decline in the proportion of cygnets has been observed this could have been a result of dilution caused by the arrival of more adults (see Brazil 1981a) or by the selective migration of families. In addition, fast maturing cygnets attain their adult white plumage before the end of the first winter thus at ranges where the pale yellow of the bill is not noticeable they may be identified as adults by mistake thereby contributing to an apparent reduction in cygnets. Cygnets are both smaller and lighter than adults (Preuss 1981) and are thus more likely to be affected by severe cold weather. It seems reasonable to assume that the further north a family winters the greater the risk of cygnet mortality, furthermore it would be expected that families which moved south to escape the hard weather might leave more surviving offspring in the long term. To my knowledge such movements have not been reported, but could help to explain a decline in the proportion of cygnets in the north during the course of the winter.

Assuming that birds wintering in colder areas might lose more offspring than those further south, that brood sizes might be smaller or that flocks might contain a smaller proportion of cygnets, if the sites which were studied are ranked simply in order of the expected severity of winter weather from north to south and its potential effect on survivorship we have: 1) Odaito, 2) Ominato, 3) Kominato, 4) Izunuma, 5) Hyoko. No data are available for Odaito, but for the other four localities, the rank of percentage of cygnets is in the order: 1) Ominato, 2) Kominato, 3) Izunuma, 4) Hyoko. Although the differences are only slight, the order is the same as was predicted. Any difference in mean broods size might be expected to follow the same pattern, however, that was not the case (see Table 2). The difference in mean brood size between Izunuma, Hyoko, Kominato and Ominato is small but the difference between those sites and Odaito is more pronounced. The lower mean brood size at Odaito may reflect a real difference in survivorship between this site where birds may regularly experience extremely low temperatures (sea-ice is typical of this site in winter) and those sites further south. This difference deserves further examination. My own data refer to only four sites, however, the Swan Society of Japan (SSJ) (1980) present data for 53 sites. Since their data include details of adults and cygnets for most localities it is possible to calculate the percentage of cygnets present for different regions of Japan. For comparison with my own data I have grouped these localities as: 1) Hokkaido (including Odaito), 2) Northernmost Honshu(including Ominato and Kominato), 3) North Honshu (including Izunuma and Hyoko). The boundary between regions 1 and 2 is topographical, the Tsugaru strait through which runs Blakiston's line (an important biogeographical line delimiting the distribution of many species in Japan (see Yamashina 1982)) separates the island of Hokkaido from Honshu. The boundary between regions 2 and 3 represents a line separating the zone where Whooper Swans predominate from the zone where Bewick's Swans *C. columbianus bewickii* predominate (see Fig. 1 and Horiuchi 1981).

Table 3 The proportion of cygnets in Japan, winter 1980 calculated from SSJ (1980).

Region	Name	No. of Aults	No. of Cygnets	% of Cygnets
1	Hokkaido	3,568	599	14.4
2	Northernmost Honshu	1,801	491	21.4
3	North Honshu*	343	213	30.8

* N. B. The total for region 3 is lower than to be expected because for two important wintering sites (Lake Fukushima 112 birds and Hyoko 451 birds) only total counts were made; separate numbers for adults and cygnets were not recorded.

The earlier suggestion that survivorship might be lower at the northerly wintering sites was based on limited data from only four sites. Table 3, however, has been compiled from data from sites included in the 13 January 1980 count (SSJ 1980). Considering the population as outlined above, that is from three regions, the results show a marked variarion in the percentage of cygnets present. The lowest figure, 14.4%, is for Hokkaido and is comparable with figures from Britain in a normal winter. The highest figure, 38%, is for North Honshu, the southernmost of the three regions, and is much higher than normal in Britain and suggests that selective migration of families may occur. There are well documented records of neck-collared birds moving south during the course of the winter (Matsui *et. al.* 1981; Nakanishi 1981; Brazil 1983) but unfortunately these only report individual adults, not cygnets or families. Nakanishi 1981, however, has shown that the number of swans at Hyoko is correlated with decreasing temperature, both in Hokkaido and Russia. Although there is as yet no direct evidence of families moving south during the winter, it does seem highly likely that the lower percentage of cygnets in the north is due to a combination of mortality *and* onward migration, both caused by cold weather.

In both Britain and Japan the distribution of the Bewick's Swan is to the south of the wintering area of Whooper Swans. In the summer the smaller size of the Bewick's Swan enables it to breed further north than the Whooper Swan, where the ice-free period is shorter (a case of reversed Bergmann's rule). In the winter the smaller size of the Bewick's Swan may act to its disadvantage since it will require more energy to maintain its body temperature because of its higher body surface to volume ratio. As a consequence it would be expected to winter further south. This general pattern is shown in Britain by Atkinson-Willes (1981) and in Japan by Horiuchi (1981). Bewick's Swans are smaller than Whooper Swans, and Whooper Swan cygnets are also smaller than adults, thus the same factors may well be affecting their distribution within their wintering range. Clearly observations of onward migration of known families are required to support this theory. Since geese and swans in Japan are concentrated in relatively few areas, as few as 82 sites for swans in some winters (Horiuchi 1981), the protection of wintering sites is very important (WBSJ 1982). It should be noted, hewever, that since there is a higher proportion of young birds at more southerly sites, these are of prime importance.

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日本で越冬するオオハクチョウの繁殖成功率と分布（抄訳）

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はじめに

北方のガンやハクチョウ等，大型水鳥の繁殖の成功，不成功は，その年ごとの気象条件に左右されることが多い．オオハクチョウも例外ではない．1979年，英国とアイルランドの越冬群の中の若鳥の率は，13～26%であるが，1979～1980年の調査では，僅かに3.7%が記録されたに過ぎない．これはその年の春，夏の気温が非常に低く，営巣や孵化がおくれたためと考えられる．オオハクチョウ保護のためには，各地域での越冬や繁殖する群の大きさと，繁殖成功率に影響する諸条件を知る事が大切である．現在，オオハクチョウは世界中に約6万～10万羽が分布すると考えられているが，日本と西ヨーロッパを除く他の地域ではカウントが頻繁に行われていないので，年ごとの変化を記録するのはむずかしい．1979～1980年に，日本での越冬群が，英国，アイルランドの越冬群と同様に，低調に終った繁殖期の影響を受けたか否かを調べるのが，この調査の主な目的である．

調査対象地域

オオハクチョウの群は，1980年2月と3月，次の諸地域で観察された．北海道東部尾岱沼：青森県大湊，小湊：宮城県伊豆沼：新潟県瓢湖（図1参照）．

調査方法

可能な限り，ハクチョウの総数と若鳥の総数を数えた．不可能な場合は，大きなサブ・グループを数え，その中の若鳥のパーセンテージをもとめた（表1参照）．一巣雛数もできるだけ数えたが，1地域でカウントした一巣雛数は，必ずしも群の中の若鳥の数と一致していない．観察は大体1分間以上つづけた．同じ巣から孵化した若鳥は羽色などに共通点が見られるので，どの若鳥がどの家族に属するかを見極めるのに便利であった．記録上の偏りはあり得るが，諸地域を平均すれば大体において，一巣雛数の地域別割合は正しいはずである．

結果

同じ年の冬，英国よりも日本におけるハクチョウ群の中の，若鳥の割合が，ずっと高かった．

日本の4地域での割合は，14%～24.6%，英国およびアイルランドでは，3.3%～5.1%．表2に示されるような興味ある一巣雛数のデータも得られた．結果的には，オオハクチョウのように分布域の広いものでは，繁殖状態の良否は，生息する地域ごとに異なる．

はじめての渡りと冬期は，若鳥の死亡が多い期間である．越冬地は，おおむね定っていて，状況に応じた融通性に欠けるため，特にきびしい冬には凍死することもある．若鳥が，ウトナイ湖で，10月の50%から3月の20%に減少し，2月に尾岱沼で若鳥の割合が少ない事は，冬期の死亡率を示していると言えよう．英国でも日本においても北方の冬がきびしい時は，成鳥の群はより南に移動せざるを得ない．また，若鳥であっても，成長の早い個体は，羽の色が成鳥と余り変らず，嘴の黄色がはっきりしなかった場合，成長と誤認して数えられる場合もある．こうした理由で若鳥の率が少なくなるとも言える．寒さのきびしい地域で越冬する若鳥がより多く死亡し，一巣雛数も低く，群中の若鳥の数も少ないと仮定するならば，我々の調査地域で，単に寒さのきびしさの順位は，1)尾岱沼，2)大湊，3)小湊，4)伊豆沼，5)瓢湖，となる．尾岱沼のデータはないが，若鳥の割合の順位は，1)大湊，2)小湊，3)伊豆沼，4)瓢湖，と，同じ順となる．平均の一巣雛数も同じパターンであると考えられがちであるが，そうとも限らない．表2にみるように，尾岱沼とそれ以南の4地域との差はより顕著であり，これはきびしい寒さにさらされる尾岱沼の群と，それ以南の群との生存率の差となっているとも考えられるが，この点はなお調査の必要がある．

私の調査は4地域に限られているが，日本白鳥の会（ＳＳＪ）は53地域のデータを提供している．このデータでは，あらゆる地方の成鳥と若鳥の割合が計算出来ると考える．私のデータとの比較のため，これらの地域を，1)北海道：2)本州最北端：3)本州北部に分類した．

1) と2)の境界は，地形，すなわち津軽海峡（ブラキストン・ラインが通っている．これは日本の野鳥分布を区切る重要な生物地理的分布ラインである）が，北海道と本州を分ける．2)と3)は，オオハクチョウとコハクチョウのそれぞれが優占する地域をへだてる境界となっている（図1参照）．

先に述べた北の越冬地では生存率が低いと言う示唆は，4地域のデータにもとづいたものであるが，表3は，1980年1月13日にカウントした地域のデータを総合したものである．北海道の若鳥の最も低い率，14.4%は，英国における通常の冬の数字に匹敵する．本州北部（3地域中，最も南寄り）の38%は，英国の率よりはるかに高く，群の選択的な渡りも考えられる．冬期，首輪標識鳥が南に移動することが記録されているが，これは成鳥に限られ若鳥や家族群の記録はない．

中西（1981）は，瓢湖のハクチョウの数は，ロシアと北海道の温度の低下と関係があると記している．家族群が冬期間にさらに南に移動するという実証はないが，北方での若鳥の割合が低いということは，死亡と，寒い冬のため，南に移動するという両方が要因となっていると考えられる．

日本でも英国でも，コハクチョウの分布はオオハクチョウの越冬地より南である．夏期はとにかくとして，冬になると小型のコハクチョウは体温保持のため，南で越冬する．コハクチョウはオオハクチョウより小さく，オオハクチョウの若鳥もオオハクチョウの成鳥よりは小さいので，その冬期の分布は同じようなパターンを示すのであろう．この説を支持するためには，識別可能な家族群の渡りを観察する事が必要である．

日本のガンやハクチョウ類は，限られた地域でのみ越冬するので（ある冬には82地域），越冬地の保護は重要である．しかし，若鳥の割合は，より南の地域が高いということに注目することが重要であろう．