Geographical variation in the bill patterns of Bewick's Swans

D. K. SCOTT

Introduction

Observations of Whistling Swans *Cygnus columbianus columbianus* in North America (W. Sladen, pers. com.) have suggested that there may be clinal variation across the arctic in the amount of yellow on the bill, those in the east typically having little yellow and those in the west typically having more yellow (Figure 1), with the exception of the Aleutian population which appear to have little yellow. If this cline exists, it may be associated with gene flow across the Bering Straits between western Whistling Swans and eastern Bewick's Swans, the latter having significantly more yellow on the bill (Evans & Sladen 1980; Figure 2). Several instances of hybrid pairs and of sightings of Bewick's Swans on the Pacific coast of North America have recently been reported (Stallcup & Winter 1975, 1976; Winter & Maolis 1978; Evans & Sladen 1980).

It seems possible that this cline might continue across the Soviet arctic through Bewick's Swans *C.c. bewickii*. In the western population of Bewick's Swans wintering in Britain, individuals with much yellow on the bill (yellownebs: Figure 2c) outnumber those with little yellow (darkies and pennyfaces: Figures 2a & b) by two to one (Evans & Sladen 1980). However, no quantitative evidence is available concerning the ratio of yellownebs to darkies, or any other measure of darkness of bill pattern, among eastern Bewick's Swans. If a cline exists, the eastern population of Bewick's Swans (sometimes considered a separate race of larger, longer-necked swans: see Scott *et al* 1972) might be ex-

Figure 1. Variation in bill patterns of Whistling Swans. Individuals from the western population may typically have more yellow than those from the eastern population.

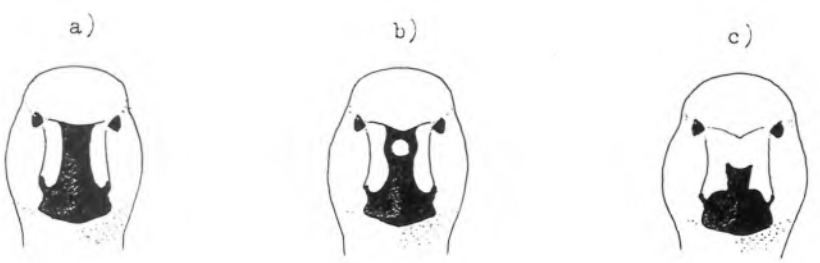

Figure 2. Illustration of the three main bill pattern types among Bewick's Swans. a) 'Darky' = individual in which centreline of upper mandible is black from feathering of forehead to tip of bill. b) 'Pennyface' = individual in which a line other than the centreline can be traced on black from the feathering of the forehead to the tip of the bill. c) 'Yellowneb' = individual in which a line on yellow can be traced from the yellow patch on one side of the bill, over the culmen, to the yellow patch on the other side of the bill.

pected to contain a higher proportion of darkies.

During studies of Bewick's Swans in U.K. the remarkable variation in bill pattern has been used to identify individuals (P. Scott 1966; Evans 1977; D. Scott 1978b; Rees, in press), and methods of defining different types of pattern have now been developed and refined to a point where it is possible for a trained observer to categorize an individual's pattern as yellowneb or darky after only a few seconds of observation.

Detailed studies of the variation in bill pattern among Bewick's Swans have shown that some aspects of the bill pattern are heritable: offspring resemble their parents more than would be expected by chance (Bateson *et al.* 1980). In addition, the bill pattern appears to be related to social dominance (D. Scott unpub. data). There is also preliminary evidence that partners of pairs may be more dissimilar than expected in some aspects of bill pattern (Bateson *et al.* 1980). However, these results need to be set in a wider context by investigating geographical variation. For example, if there is any clinal variation, the dissimilarity of mates may perhaps be a result of the normal phenomenon of dispersion by one sex away from the natal area to breed, and not as initially seems more plausible, due to active choice of dissimilar partners by individuals. This paper reports on the bill patterns of eastern Bewick's Swans in winter flocks in Japan.

Study site and methods

Flocks of Bewick's Swans together with Whooper Swans *Cygnus cygnus cygnus* were observed at five sites on the main island of Japan, Honshu, between 12 and 17 February 1980. These were on lakes at Hyoko, Toyanogata, and Fukushimagata (Niigata Prefecture); Izunuma (Miyagi Prefecture) and on a river on the outskirts of the city of Fukushima. At three of these sites, Hyoko, Izunuma and Fukushima, the swans were regularly fed by the public or a swankeeper, and it was possible at each site to observe more than 100 Bewick's Swans at close range (<150 m). At Izunuma, the swans were fed at several points around the lake and were also observed while feeding on natural vegetation (lotus roots) within 150 m of the road. At Toyanogata, where the swans were not fed, observations of bill patterns were hampered by a heavy snowfall which severely reduced visibility. The only site where it was not possible to make observations of bill patterns was at Fukushimagata.

On arrival at each new flock, a rough count of the number of adults and cygnets of each swan species was made and if time permitted, a more detailed count made subsequently. Following this, the flock was scanned slowly and each individual Bewick's Swan in which the top of the culmen on the bill was visible, was categorized as yellowneb, pennyface or darky (see Figure 2 for definitions). It was possible during categorization to form a short-term memory of each pattern and therefore to compensate for some movement of individuals by recognizing and avoiding swans that had already been categorized.

During a flock scan, a proportion of birds could not be categorized because their bill patterns were not visible (e.g. if they were asleep or facing away), and this proportion varied with activity and with imminence of a regular feeding time. Around 30% of the bill patterns in a flock could usually be categorized during one scan, but the proportion ranged from 10–90%. For example, 9 scans at Hyoko gave a mean of 34·4% categorized (s.d. 16·0) and 9 at Fukushima 42·2% (s.d. 21·7). For this reason, as many scans as possible were made at each site in order to observe the bill patterns of as many different individuals as possible.

For sites where several scans were made, the scan in which the largest number of faces were categorized was used in the analysis. However, the variance in proportions of different bill pattern types obtained from different scans at the same place was relatively small. Thus the Hyoko scans gave a mean of 46·2% darkies + pennyfaces (s.d. 5·6), the Fukushima ones 39·8% (s.d. 2·7). A total of 31 flock scans were made by eye in the study and the maximum number of different individuals whose bill pattern was observed was 312.

Flock scans were supplemented by photography. At two sites where the swans were observed at close range, Hyoko and Fukushima, a series of photographs across the flock was taken in which effort was concentrated on minimizing overlap. Ratios of darkies, pennyfaces and yellownebs were calculated from these photographs, and as with observations, the scan at each site in which the largest number of faces could be categorized was used.

Ten flock scans were made with the camera and from the photographs, a maximum of 65 different individuals could be categorized. The proportions obtained from categorizing individuals from photographs were similar to those obtained from observational data (Table 1).

Results

General appearance of eastern Bewick's Swans

Initial observations did not indicate striking differences in the appearance of eastern Bewick's Swans from western Bewick's Swans (Figures 3 & 4). There was no immediately apparent preponderance of birds with bill patterns intermediate between those of Bewick's and Whistling Swans (see Evans & Sladen 1980, for illustrations of possible intergrades). Nor were there any obvious differences in body size or proportions. But conclusive evidence will only be forthcoming when an adequate sample of weights and measurements of individual eastern Bewick's Swans is available for comparison with the data available on western Bewick's Swans (Scott *et al.* 1972).

Proportions of bill pattern types

The 312 individuals whose bill patterns were categorized in Japan, (Table 2) gave proportions significantly different from those recorded at Slimbridge, where, over a ten-year period, 2,400 different adults were recorded. (Evans & Sladen 1980) ($\chi^2 = 56{\cdot}5$, $p < 0{\cdot}001$). The proportion of darkies in Japan is higher and of yellownebs lower than at Slimbridge. This was also true when the proportions observed in Japan were compared with those observed at Welney in Norfolk, U.K., a wintering site with little interchange of individuals with Slimbridge (D. Scott 1978a). At Welney, over 3 years, 300 different adults were recorded, ($\chi^2 = 24{\cdot}9$, $p < 0{\cdot}001$).

The proportion of pennyfaces was lower in Japan than at Slimbridge ($\chi^2 = 6{\cdot}5$, $p < 0{\cdot}02$) or at Welney ($\chi^2 = 2{\cdot}76$, $p < 0{\cdot}1$). However, it seems likely that this is due to unavoidable differences in study methods. In U.K., the bill patterns of all swans recorded have been drawn in considerable detail from close range—where a small yellow patch in the centre of the culmen would be easily distinguished. In Japan, the bill patterns were categorized after only a brief look at the culmen usually from a greater distance.

Table 1. Proportion of different bill pattern types, photographic results compared with those by eye, at Hyoko and Fukushima.

	% Darky	% Pennyface	% Yellowneb	N
Observation	30·8	11·4	57·8	185
Photographs	32·3	12·3	55·4	65

Figure 3. Eastern Bewick's and Whooper Swans at Fukushima in Japan.

Because of this finding, the data were reanalysed using only two categories: Yellownebs, and darkies plus pennyfaces. There was still a significantly higher proportion of dark types to yellownebs in Japan than at Slimbridge ($\chi^2 = 16{\cdot}9$, $p < 0{\cdot}001$) or at Welney ($\chi^2 = 10{\cdot}6$, $p < 0{\cdot}01$).

Differences between sites within Japan

While among western Bewick's Swans there is no significant difference in the proportions of different bill pattern categories between Slimbridge and Welney, there were marked differences in proportions between different sites in Japan. At Izunuma, there was a higher proportion of darkies plus pennyfaces than at either of the other two main sites, Hyoko or Fukushima and the differences were significant. (χ^2 5·6 & 6·6, $p < 0{\cdot}02$). There was no apparent difference between Hyoko and Fukushima ($\chi^2 = 0{\cdot}15$, $p < 0{\cdot}01$).

Whooper Swan bill patterns

Parallel to the observations of bill patterns of Bewick's Swans, data were collected in the same way on the bill patterns of Whooper Swans *C. cygnus cygnus* (Figure 5) at five sites: Hyoko, Izunuma, Fukushima, and also at Lake Utonai and Odaito in Hokkaido. An estimated 587 individual Whooper Swan faces were seen close

Table 2. Proportion of different bill pattern types in flocks of Bewick's Swans in Japan and England.

Site	% Darky	% Pennyface	% Yellowneb	N
Hyoko	34·0	9·4	56·6	106
Toyanogata	40·0	20·0	40·0	5
Izunuma	43·4	15·6	41·0	122
Fukushima	26·6	13·9	59·5	79
All Japanese	35·9	13·1	51·0	312
Slimbridge	17·9	19·1	63·0	2,400
Welney	18·0	18·0	64·0	300

Figure 4. Western Bewick's and Whooper Swans at Welney in U.K. (*Philippa Scott*)

enough to be categorized. Of these, none were darkies, 6 were pennyfaces and the remaining 581 were yellownebs. A similar result was obtained from analysis of photographs.

These proportions are very different from those among the 312 Bewick's Swans in Japan ($\chi^2 = 325$ $p < 0{\cdot}001$) and confirm quantitatively that Whooper Swans' bill patterns show less extreme variation than Bewick's Swans' bill patterns (D. Scott, 1978a). Comparison of the Japanese data with observations of Whooper Swans at Welney, U.K., suggested that eastern Whoopers might be more consistently yellow on top of the culmen than western Whooper Swans. This has now been demonstrated quantitatively (Brazil 1981).

Discussion

The higher proportion of darkies among eastern Bewick's Swans is consistent with the likelihood of significant gene flow across the Bering Straits between Bewick's and Whistling Swans, as previously suspected from reports of hybrid pairs and of individuals of both sub-species outside their normal range (Evans & Sladen 1980). Quantitative analysis may reveal similar geographical variation in the amount of yellow on the bills of Whistling Swans, those in the west having typically more yellow than those in the east.

The results indicated a marked difference in the proportions of different bill pattern types between one site, Izunuma, and the others. At Izunuma, the flock contained relatively more darkies than at Hyoko or Fukushima. One casual observer also thought it possible that the proportion of darkies at Izunuma changed throughout the winter (M. Kosugi-Otsu, pers. com.). While these differences are difficult to explain, it is possible that the difference between sites is a result of the traditional habits of the birds, combined with the heritability of the bill pattern. In Britain individual Bewick's Swans tend to return to the same wintering grounds in successive years (P. Scott 1966; Evans 1979) and are accompanied by their mates and cygnets. It is therefore possible for particular families where the parents have high breeding success and where the offspring return in successive winters, eventually to represent a substantial proportion of the flock. Since offspring resemble their parents (Bateson *et al.* 1980), it might require only a few particularly successful families where the parents were darkies to account for the situation at Izunuma. While at Slimbridge and Welney, U.K., calculations suggest that the average degree of relatedness among flock members is not high (D. Scott, unpub.) due to the relatively low return rate of individuals in successive winters (Evans 1979), it remains possible that the situation differs in Japan where the number of suitable wintering sites is more restricted.

In contrast to Bewick's Swans, Whooper Swans show remarkably little variation in bill pattern, the proportion of yellownebs far exceeding those of darkies or pennyfaces. This is despite the longer interface between black and yellow on the bills of Whooper Swans. While this became apparent at Welney in 1976 (D. Scott 1978a), quantitative information has not previously

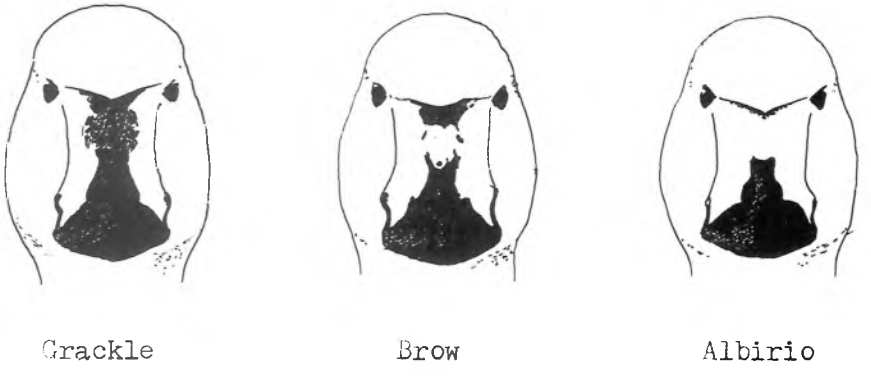

Figure 5. Illustration of extremes of variation in bill patterns of Whooper Swans identified at Welney, 1976.

been available for a large sample of Whooper Swans. The reasons for this difference in variability of bill pattern between Bewick's and Whooper Seans, and also among the other northern swans, remain obscure (see Bateson *et al.* 1980), although one possibility is that the more northerly forms, breeding in more unpredictable environments, show greater variability in many characteristics than the more southerly forms.

Acknowledgements

I am particularly grateful to Noritaka Ichida and Ryozo Kakizawa for their generous help and smooth organization which made this study in Japan possible. I would also like to thank the members of the Wild Swan Society of Japan at Hyoko and the members of the Wild Bird Society of Japan both in Tokyo and at Sendai for all their wonderful hospitality and help. For many helpful and interesting discussions while in Japan, I am indebted to Bill Sladen. Mary Evans kindly read and commented on the manuscript. Finally I am extremely grateful for grants from the Royal Society Japan Program and the Canadian National Sportsmens Show.

Summary

Individual Bewick's Swans *Cygnus columbianus bewickii* differ markedly in the pattern of black and yellow on the bill, and can be categorized into different types according to whether the top of the culmen is predominantly black (darky), intermediate (pennyface), or yellow (yellowneb). The proportion of darkies in Japan was significantly higher and of yellownebs lower than among western Bewick's Swans wintering in England. This is consistent with the likelihood of substantial gene flow across the Bering Straits between eastern Bewick's Swans and the conspecific Whistling Swan *C. c. columbianus* (the latter having considerably less yellow on the bill). Other differences between eastern and western Bewick's Swans and Whooper Swans *C. cygnus* are discussed and a possible reason proposed for the differing proportions of bill types among Bewick's Swans at various sites in Japan.

References

Bateson, P., Lotwick, W. & Scott, D. K. 1980. Similarity between the faces of parents and offspring in Bewick's Swans and the difference between mates. *J. Zool. Lond.* 191: 61–74.

Evans, M. E. 1977. Recognising individual Bewick's Swans by bill pattern. *Wildfowl* 28: 153–8.

Evans, M. E. 1979. Population composition, and return according to breeding status, of Bewick's Swans wintering at Slimbridge, 1963–1976. *Wildfowl* 30: 118–28.

Evans, M. E. & Sladen, W. J. L. (1980). A comparative analysis of the bill markings of whistling and Bewick's Swans and out-of-range occurrences of the two taxa. *Auk* 97: 697–703.

Rees, E. C. (in press). The recording and retrieval of bill pattern variations in the Bewick's Swan. *Proceedings of the 2nd International Swan Symposium, Sapporo, Japan* 1980.

Scott, D. K. 1978a. Social behaviour of wintering Bewick's swans. PhD. thesis, University of Cambridge.

Scott, D. K. 1978b. Identification of individual Bewick's swans by bill pattern. In B. Stonehouse (ed.): *Animal Marking*. London: Macmillan.

Scott, P. 1966. The Bewick's Swans at Slimbridge. *Wildfowl Trust Ann. Rep.* 17: 20–26.

Scott, P. and the Wildfowl Trust, 1972. *The Swans*. London: Michael Joseph.

Stallcup, R. & Winter, J. 1975. Middle Pacific Coast Region. *American Birds* 29: 735–40.

Stallcup, R. & Winter, J. 1976. Middle Pacific Coast Region. *American Birds* 30: 760–4.

Winter, J. & Manolis, T. 1978. Middle Pacific Coast Region. *American Birds* 32: 394–7.

Dr D. K. Scott, Edward Grey Institute, Dept. of Zoology, South Parks Road, Oxford, OX1 3PS.