

THE RECORDING AND RETRIEVAL OF BILL PATTERN VARIATIONS IN *CYGNUS COLUMBIANUS BEWICKII*

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Introduction

Studies of wild animals are greatly facilitated if individuals of the population can be identified by natural characteristics. It is difficult to catch and artificially mark all individuals, and undue stress can be caused by the process. Differences in features have therefore been used to identify giraffes (Foster 1966), zebras (Petersen 1972), lions (Pennycuik and Rudnai 1970) and red deer (Clutton-Brock and Guinness 1975).

Individual differences in the black and yellow bill patterns of *Cygnus columbianus bewickii* were first reported by Acland (1923). The artist, Tunnickliffe, sketched a few of the variations in 1946 (Tunnickliffe 1979). G routet (1962 and 1963) and Sermet (1963) made similar observations in Switzerland. In 1964 when wild *C. c. bewickii* started to winter regularly at the Wildfowl Trust, Slimbridge, Gloucestershire, (P Scott 1966), recognition of individuals by their bill pattern was first used for an extensive study of the population. This proved to be a facile and rapid means of identification, particularly useful in studying behavioural encounters (eg D K Scott 1978a) when instant recognition is necessary.

To assess the accuracy of this identification system, Bateson (1977) asked an experienced swan watcher, D K Scott, to identify swans from slides taken two weeks earlier. She correctly named 29 out of 30 good quality slides and 23 out of 30 less clearly portrayed. Evans (1977) devised a recognition test which showed that swans can be reliably identified over a period of years.

Between the winters of 1963/64 and 1978/79 the number of swans wintering at Slimbridge rose from 24 to 721, with some 3000 adult and second-winter birds being identified by their bill patterns. An accurate recording system had to be constructed so that individuals could be recalled in subsequent years without relying on human memory, particularly since birds may return after spending a number of winters elsewhere (Evans 1978).

The methods used for recording and filing the bill patterns of different swans have already been described in detail (D K Scott 1978b). Every unknown bird is first recorded by drawing its bill pattern on a form (Fig 1). This is kept in a folder with details of the bird's movements, associations and, if possible, head photographs. The folders are filed alphabetically according to the names given to the swans to help memorize pairings and, sometimes, characteristics.

Adult <input checked="" type="checkbox"/>	Yearling	Probable	Name	R	L
Plastic Ring No: 844 (R)		Sex: ♂	FLIT	D	
Metal Ring No: Z27370 (L)				O	
INITIALS OF CODER				FD	
SIZE OF SWAN:				E	
Large				Y	7-3
Medium <input checked="" type="checkbox"/>				FY	4-23
Small				T	2-2
BILL COLOUR:				Q	4
Pale				G	1-2
Lemony <input checked="" type="checkbox"/>	Bright <input checked="" type="checkbox"/>	Date of Drawing: 28.10.79	Artist's initials: ECR	M K N S	
Yellow <input checked="" type="checkbox"/>	Dull	Locality of drawing: Slimbridge	Notes: 1975 Flip/Turtle cygnet	0	
Orange		Consorting with:	Other characters:	1	
SIDE OF LOWER MANDIBLE:				2	
Much pink				3	
Narrow pink <input checked="" type="checkbox"/>				4	<input checked="" type="checkbox"/>
None				5	
BILL:				6	
Turned up				7	
Turned down				8	
EYELIDS:				9	
Yellow top				L	O TD
Yellow both				B	IP
No yellow				C	UP
				CF	UY
					US
					UB
				PRR	PRL
				MRR	MRL

Fig 1. Form for recording *Cygnus columbianus bewickii* bill markings.

When new observers take up the study, swans which have previously visited the site will probably be unknown to them. Birds with experience of Slimbridge may, to a certain extent, be discerned by their behaviour. They are generally more confident and know the best places in which to look for food, whereas birds new to Slimbridge tend to swim away from the buildings, looking alert and anxious, particularly when the food barrow is brought round. However, only ringed birds, associates of ringed birds and individuals pointed out by experienced observers will be identified. It was therefore important that a method be evolved for systematically ordering bill pattern types. Then, when a new bird arrived, it would be possible to refer to swans with similar markings and see if any matched. Theoretically, this would enable anybody unfamiliar with a bird to discover if it had previously been recorded.

The development of a coding system

P Scott (1966) suggested a formula in which a swan's bill pattern was divided into 11 variable features. Each feature was given a letter code and each variation of a feature was allocated a number. It was therefore possible to describe a swan's bill pattern by a list of letters and figures.

In 1971 this formula was greatly modified and became what is now called the 'Old Code' (P Scott 1971 unpub). All adult and second-winter swans identified at

Slimbridge between 1963/64 and 1977/78 had their bill patterns identified by this system. The 'Old Code' was further revised and simplified by P Harvey (1977 unpub) into a purely digital form, particularly suitable for computerization. D K Scott (1978a) used this clearly defined version in her study of the social behaviour of *C. c. bewickii* at Welney, Norfolk.

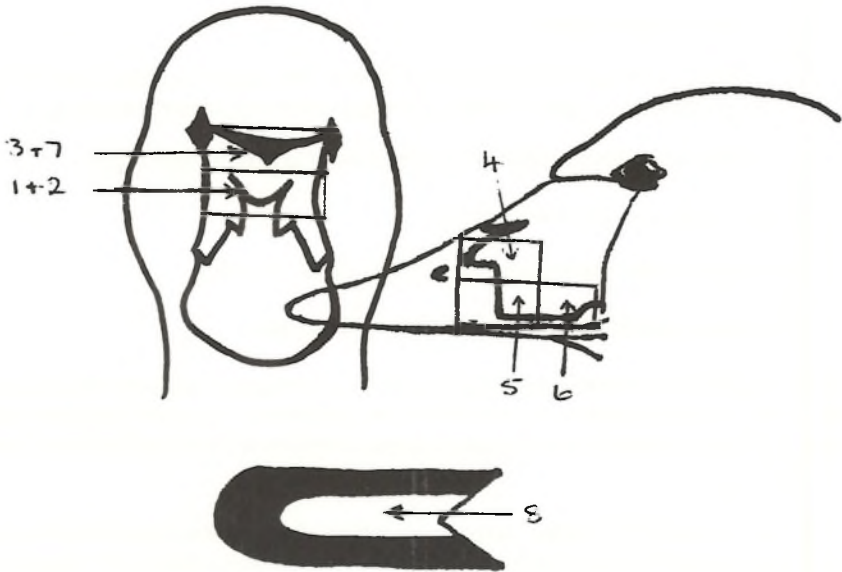


Fig 2. The location of the eight major characters used in coding bill patterns.

In both versions of the code, bill patterns are divided into eight major characteristics, including coloration on the under-bill (see Fig 2). These characteristics are subdivided into the different variations in markings which can occur within each section. A numerical code is allocated to each type of pattern.

The eight major coding items are as follows:

- 1 The front. Each swan is placed in one of the three major categories: Darkies, Yellownebs or Pennyfaces.

Darkies (code letter D) are swans where the centreline of the upper mandible is black from the feathering of the forehead to the tip of the bill.

Pennyfaces or Off-centreline Darkies (code letter O) are swans where a line other than the centreline can be followed on black from the browline to the tip of the bill.

Yellownebs (code letter Y) are swans where a continuous line of yellow stretches across the bill, linking the yellow patches on either side.

- 2 The shape of the central black trunk.
- 3 Markings on the browline.
- 4 The yellow protrusion towards the nostril in the sector indicated (see Fig 2). This may be absent, vary in shape or be cut off as an isolated yellow spot.
- 5 The angle of the black edges in the front lower quadrant (see Fig 2).
- 6 'Gape' (ie the corner of the mouth).
- 7 The shape of the edge of the feathering between the eyes.
- 8 Coloration on the underside of the lower mandible.

Possible variations of these characteristics are diagrammatically represented on a key sheet. Once the bill pattern of a swan has been sketched, the coder compares each section of the bill pattern with the appropriate diagrams on the key sheet and notes down the code.

As well as the coding of the bill pattern, a number of additional characteristics help to identify a swan. These include size, bill shape, head shape, presence or absence of yellow around the eyes and coloration on the sides of the mandible. The bill colour is usually a cadmium yellow but paler and orangey shades can occur. Such variations may be seen on swans where the yellow was quite normal the previous year (Evans 1977). Therefore this characteristic can aid identification for only one season.

Since 1967/68 all swans caught at Slimbridge have been marked with large plastic leg-rings inscribed with digits or letters, which can be easily read at a distance. Most of the swans caught have their photographs taken from right, left and centre. These photographs are studied when coding bill patterns to augment and verify the drawings. Photographs of unringed swans are taken whilst they are swimming on Swan Lake, enabling observers accurately to code swans which cannot be identified by rings. Cygnets, ringed or unringed, are not generally photographed as bill patterns are often ill-defined until the second winter (Evans 1977).

Ordering the data

In 1972, following the development of the 'Old Code', a number of methods for

storing and retrieving the coded information were considered. They included the use of edge-punched cards and 'Peek-a-boo' (pattern-punched) cards (M E Evans pers comm). Punch cards would be based roughly on the formula described, with a drawing of each individual xeroxed onto the card. However, although the card would be coded from the drawing, as the number of variables is so high, inaccuracy in just one section could result in the correct card being missed. Another problem is that punch cards become worn.

'Peek-a-boo' cards would be cheaper and easier to store. However, drawings could not be attached to the cards because the hole patterns would be obscured, so all the results obtained would have to be checked from the original records.

It was eventually decided that a code-book was the most effective method for storing and retrieving bill pattern data. A copy of a swan's code was placed into one of three books according to facial type, Darkies, Yellownebs or Pennyfaces. These books were subdivided into sections representing variations in the shape of the central black trunk (character 2), then again into 'tooth shape' (character 4), markings at the browline (character 3), shaping at the lower forward quadrant (character 5) and 'gape' (character 6). The ordering of the characters was based on their assumed importance in differentiating between individuals.

Limitation of the 'Old Code' and code-book systems

D K Scott (1978b) observed that the accuracy of the bill pattern drawings and therefore the ease and accuracy of recognition depend on a number of factors. These include the skill, practice and patience of the observer, the lighting conditions at the time of drawing and the distance of the swan. Whenever possible, photographs should be used.

The 'Old Code' formula and the code-book storage system also have a number of inherent failings. Although D K Scott (1978) showed that coding is unaffected by personal reliability, problems arise when one observer looks for a bird coded by another. Unless the code is clearly defined, differences in perspective may make it difficult to retrieve the correct pattern. In the case of the 'Old Code' the most subjective area is in defining the central column of black (Fig 2, section 2). This may (1) have parallel edges, (2) be wider at the top, (3) be wider at the bottom, (4) be wider at some intermediate point and (5) be narrower in the middle. However, within these reasonably clear definitions, further categories showing different shapings are represented only diagrammatically. Some of these diagrams are very similar and are open to misrepresentation both if the drawing is slightly inaccurate and in the way different observers relate the diagrams to the drawings. Since these central markings are important items in differentiating between individuals and were the first factor to determine a swan's position in the code-book, all the categories have to be made exclusive and clearly defined.

As much information as possible should be used when retrieving a face to help compensate for slight inaccuracies in the drawings and any slight changes in bill patterns over the years. A major failing of the code-book system is that only the right side of the face was used for filing faces. Many of the patterns are asymmetrical so attempts to classify and retrieve the data using both sides would be slow and complicated. Pennycuik (1978) demonstrated that only 29% of the swans have sufficient information in their markings on the right side alone for accurate identification. The 'Old Code' and code-book systems are therefore unreliable. However, by utilizing the left side and features other than bill patterns, the amount of information about each bird would be raised, increasing the proportion which could be reliably identified.

The 'New Code' system

In 1979, P Scott, D K Scott and the author formulated a 'New Code' system (Appendix 1). This version is based on the 'Old Code' and 'Harvey's Code', revising the more subjective areas of the former and utilizing more information than the latter.

The 'Old Code' attempted to cover all possible variations of a character by giving a wide range of choices in the key. As variations in markings shade into each other along a continuum, many of the diagrams presented closely resembled each other. This, and the lack of detailed definitions, led to ambiguity between the divisions and therefore errors in coding. In forming the 'New Code' we limited the variations available, grouped similar characters together and inserted a clear description of each item. For instance, amendments were made to the choice of shapes for the central black column (character 2) in Yellowneb swans. To the broader definitions of the 'Old Code' (see page 2) we added the subdivisions:

- (1) No prongs going upwards
- (2) Short, thin prongs upwards
- (3) Short, thick prongs upwards
- (4) Long prongs upwards.

Under these guidelines, similar patterns which were given different code numbers under the old system are grouped together. Variations 2.1 and 2.2, for example, are both 7.1 in the new version (Fig 3).

There does remain the problem of deciding at what point thick becomes thin and short becomes long. It will always be difficult to segregate all the variations, so if a swan does fall between two intermediate patterns, both figures may be entered, divided by a slash.

'Old Code'
(No further
definitions)



'New Code'

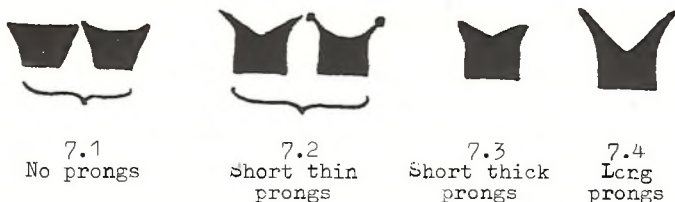


Fig 3. Some variations of the central black column, with trunk widest at top.

To increase the amount of information used to re-identify a bird (recommended by Pennyquick 1978) we made two amendments.

- (1) We bisected the three frontal characteristics – basic bill pattern type, shape of trunk on central column of black and forehead markings – by drawing an imaginary line down the centre of the bill. This enabled us to code both sides separately and so fully to describe asymmetrical patterns in numerical terms (Fig 4).



Character	Right	Left	Character	Right	Left	Character	Right	Left
Fr	Y	Y	Fr	01	Y	Fr	Y	Y
E	8.2	7.1	E	4.1	8.3	E	8.3	8.3
F	2.23	2.23	F	4.20	4.21	F	4.1	4.22

Fig 4. *Cygnus columbianus bewickii* with asymmetrical markings and the appropriate codes for the frontal characters.

- (2) We added a number of characters to the code other than bill markings. In choosing these we were careful to select ones which are unlikely to change from year to year. Bill colour, however, was included as it is a useful aid for identifying swans within a season.

The computerization of *C. c. bewickii* face patterns

At the end of June 1979, the Wildfowl Trust acquired a 'Research Machines' 380Z micro-computer, with data storage on 8-inch floppy disks. Information is typed in via a keyboard and is displayed on a television screen. Print-outs of stored data can be obtained from a teletype printer.

Computerization of *C. c. bewickii* bill patterns would clearly assist subsequent recognition. When an unknown swan arrives, its code would be typed into the computer and compared with the codes of swans already incorporated into the data bank. The computer would then print out details of three or four swans with codes that approximate closely that of the new bird, enabling the observer to decide if it had been recorded previously. If the swan is not on record its code would be saved for future reference along with any relevant data such as name, arrival date, etc.

Professor R Sibson and his colleagues at Bath University kindly agreed to devise two computer programs:

- (1) to enable an observer to retrieve information about swans with bill patterns similar to that of an unknown bird; and
- (2) to translate the 'Old Code' into the 'New Code', enabling us to put onto computer some 3000 patterns described by the 'Old Code', without re-coding them manually. Only the 'New Code' will continue to be used.

Bill pattern codes have to be typed onto computer in a set order so that the computer can organize and search the data. The format used is described in Appendix 2.

Opportunities for further study

The computerization of *C. c. bewickii* bill patterns offers more than just an efficient storage and retrieval technique.

An investigation of asymmetries in bill markings would be of particular interest. Pennycuick (1978) points out that correlations may exist between the two sides. As the correlation increases, the markings on one side will predetermine those on the other, so less information is obtained from the second side. If two characters correspond exactly throughout the population, only one is useful for identifying individuals. It would be useful to see how frequently asymmetry occurs in the population, which characters do correlate and how strong are these correlations.

Similarly, a repeat of Pennycuick's test (1978) but using the new code and all those swans which are fully coded would determine which characters are most useful for reliable identification and which are too common to be used on their own. This

would improve the retrieval of birds whose codes are not completely recorded. Swans with rare features may be recalled even if drawings of their markings are incomplete.

Evans (1977), by comparing photographs of 20 adult birds in two successive years, showed that small changes in bill pattern may occur, usually in the upper part of the culmen. Further evidence on changes in markings can be obtained by recoding swans each winter and comparing them with codes of the same birds from previous years. Photographs would be useful in providing an ongoing resource-library.

The question arises of whether certain characters are inherited. Bateson, Lotwick and Scott (1979) investigated similarities between the faces of both parents and offspring in *C. c. bewickii* and also the differences between mates. They concluded, on observing 12 pairs and 20 of their offspring, that the latter resemble both their fathers and mothers more closely than would be expected by chance. They also indicated with less certainty that mates are less similar than would be expected if swans paired at random. Both tests should be re-run for a much larger sample to confirm those characters which are similar in relatives and to test the 'diversity of mates' hypothesis.

D K Scott (1980 submitted) showed that pairs with Darky or Pennyface males are more dominant and aggressive than pairs where the male is a Yellowneb. Female bill pattern type did not relate to the position of the pair in the hierarchy. However, female *C. c. bewickii* seldom enter into physical combat (D K Scott 1978a). If threats are also considered, Darky and Pennyface females may prove to be more aggressive than Yellowneb females.

Summary

Studies of *Cygnus columbianus bewickii* at the Wildfowl Trust, Slimbridge, Gloucestershire, are largely dependent on the identification of individuals by their black and yellow bill markings. Attempts have been made to describe these markings in numerical terms, enabling observers to identify birds which have been previously recorded. The 'Old Code' and code-book systems used to store and retrieve bill pattern information between 1971 and 1979 are shown to be subjective and inefficient. A 'New Code' is proposed which limits these failings. Computerization of the markings is recommended for the effective recall of 'known' birds and for further analyses of swan bill patterns.

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Appendix 1

CODE FOR THE IDENTIFICATION OF INDIVIDUAL BEWICK'S SWANS

The normal starting point for coding a swan is a drawing based on the standard outline on a loose-leaf form. Whenever possible, the swan should be coded as soon as the drawing is complete.

Coding consists of filling in with a number or a tick the appropriate spaces on the right of the drawing form.

NB For all of the first 12 characters (up to and including G), the right and left sides of the bill must be coded separately. Thus for the frontal characters Fr (1 & 2), E (3 & 4) and F (5 & 6), a centreline down the bill may be imagined to help code each side separately. In each case, the right side should be coded first (to correspond with input to computer).

The coder is required to decide which of the definitions with accompanying diagrams most closely resembles the swan's pattern. In the case of intermediate patterns, two figures may be entered on the form, divided by a stroke. At this stage, all black spots surrounded by yellow and all tiny yellow dots on the 'trunks' of darkies should be disregarded altogether, and all 'mushy' areas (confused patches of black dots on yellow or yellow on black) on central culmen should be treated as yellow. They are then later recorded under Sp and M respectively.

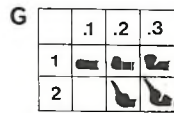
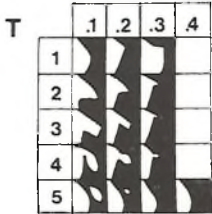
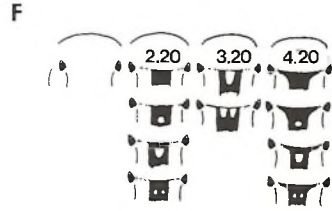
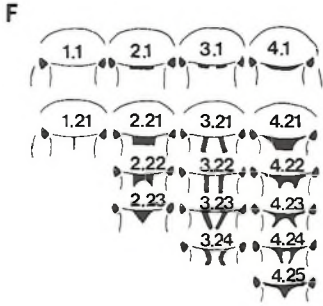
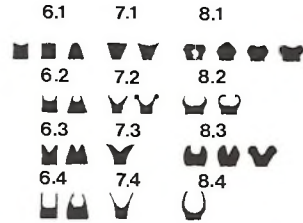
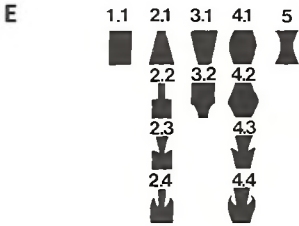
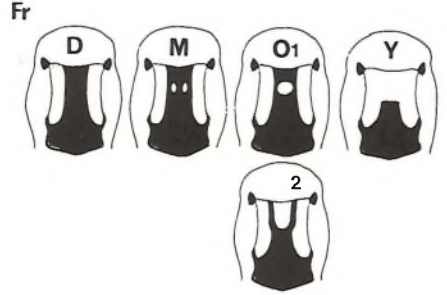
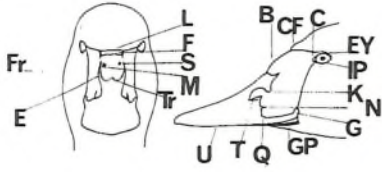
DEFINITION OF CHARACTERS

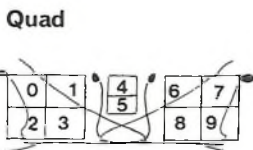
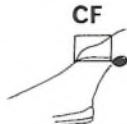
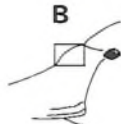
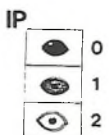
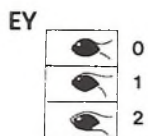
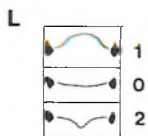
CHARACTER	VALUES	DEFINITIONS
Fr (1&2) Basic bill pattern types	D = Darky M = Mo-type M = Mo-type	Centreline of upper mandible is black from feathering of forehead to tip of bill. (Markings of any other colour than yellow orange i.e. red indicating immaturity or white indicating wear, are deemed black for this purpose). Same as 'D', but with small yellow patches surrounded by black on culmen on either side of centreline. Unless yellow patches are easily visible, this should be coded under Sp (Quad). (Markings of any other colour should be treated as above).

DEFINITION OF CHARACTERS CONTINUED:

CHARACTER	VALUES	DEFINITIONS	
	0 = Penny-face	. . . A line other than the centreline can be traced on black from feathering of forehead to tip of bill.	
	O1	. . . Central yellow patch rounded	
	O2	. . . Central yellow patch shield-shaped	
	Y = Yellowneb	. . . A line on yellow can be traced without interruption from the yellow patch on one side of the bill over the culmen to the yellow patch on the other.	
E (3&4) Shape of 'trunk' on central column of black	1	. . . Edge of trunk straight	
	2	. . . Trunk widest at bottom	
	3	For D.M. . . . Trunk widest at top	
	4	or O. . . . Trunk widest in middle i.e. at some intermediate point between top and bottom	
	5	. . . Trunk narrowest in middle	
	6	. . . Trunk straight or widest at bottom	
	7	For Y Trunk widest at top	
	8	. . . Trunk widest in middle	
		After decimal	.1. . . . No prongs going upwards
		point	.2. . . . Short protrusions upwards, which are thin .3. . . . Short protrusions upwards, which are thick .4. . . . Long protrusions upwards (prongs)
F (5 & 6) Forehead markings	1	. . . . . No black markings on forehead, or single line protruding downwards
	2	. . . . . Part of forehead has black marking on top of culmen
	3	. . . . . Broken black markings on forehead
	4	. . . . . Black markings on forehead are continuous along line of feathering and extend almost to the eyes on either side
		First number	.1. . . No intrusion downwards
		after decimal	.2. . . Intrusion downwards
		point	
		Second number	.20. For Darkies, Mc-types and Penny-faces
		after decimal	.21)
		point	.22) For Yellownebs .23)
T (7 & 8) 'Tooth' is a yellow protrusion towards nostril of the pattern in front of the main yellow patch on the side of the bill. It may be absent, or of varying shape or cut off as an isolated yellow spot (Teardrop).	1	. . . . . No tooth
	2	. . . . . Tooth with entrance being widest point
	3	. . . . . Tooth with sides parallel
	4	. . . . . Tooth with widest point inside entrance
	5	. . . . . Teardrop
		After decimal	.1. (except 1): Large tooth or teardrop
	point	.2. (" "): Medium tooth or teardrop .3. (" "): Small tooth or teardrop .4. Two teardrops	
Q (9 & 10) Lower forward quadrant on side of bill	1	. . . . . Yellow ends with acute angle
	2	. . . . . Yellow ends with right angle
	3	. . . . . Yellow ends with arc
	4	. . . . . Yellow ends with obtuse angle
G (11 & 12) 'Gape' is pattern at corner of mouth	1	. . . . . Black does not continue beyond corner of mouth up cheek feathering
	2	. . . . . Black does continue up cheek feathering
		After decimal	.1 No black bump in pattern
	point	.2 Black bump present .3 Black bump with yellow indentation before it	

KEY





DEFINITION OF CHARACTERS CONTINUED:

CHARACTER	VALUES	DEFINITIONS
L (13) Line of feathering	0 1 2	Medium High Low
Tr (14) Trident	0 1	Black protrusion up central yellow in a Yellownebe or Penny-face Black protrusion absent
EY (15) Eyelid colour	0 1 2	No yellow Yellow top eyelid Yellow both eyelids
C (16) Canalicula (red triangle in front corner of eye)	0 1	Canaliculi not prominent Canaliculi prominent
IP (17) Iris colour	0 1 2	Dark Slightly pale Very pale
ES (18) Eye size	0 1 2	Medium Large Small
GP (19) Pink visible in gape when bill is closed	1 2 3	No pink Narrow pink Much pink
UB (20) Underbill	1 2 3	Black Some pink or yellow in spots or stripes (1-4 : different patterns) All or almost all pink or yellow

DEFINITION OF CHARACTERS

CHARACTER	VALUES	DEFINITIONS
EO (21) Bill depth (A-A')	0 1 2	Medium Deep Shallow
EH (22) Bill shape	0 1 2	Straight Turned down Turned up
EL (23) Bill length	0 1 2	Normal Long Short
HS (24) Head size	0 1 2	Medium Large Small
HH (25) Head shape	1 2	Domed Flattened
CF (26) Cat-faced	1 0	Cat-faced Not cat-faced
B (27) Bulgy	1 0	Bulgy Not bulgy
NE (28) Neck length	0 1 2	Medium Long Short
NT (29) Neck thickness	0 1 2	Medium Thick Thin
EP (30) Body posture	0 1 2	Medium Tail turned up Tail turned down
HC (31) Head carriage	0 1 2	Normal Head-in-air Sleepy-head
BS (32) Body size	0 1 2	Medium Large Small
CY (33) Colour of yellow	0 1 2 3	Normal Lemony or pale Orangey Blotchy
CB (34) Brightness of yellow	0 1 2	Normal Very bright Dull

QUAD (35)

Quadrants: The following characteristics can occur on different parts of the bill. The correct letter(s) should be written against the appropriate sector (see diagram). If more than one of these characteristics is present, the letters should be written in the same order as below, in each sector.

- M Mush a confused patch of black dots on yellow or yellow dots on black in the sector indicated. All such patches should be regarded as yellow while coding above.
- Sp Spots black spot or spots surrounded by yellow, or tiny yellow spots surrounded by black on the centre of the culmen on darkies (does not include 'teardrops'). Spots touching forehead should be coded under F.
- K Knob a rounded protrusion of black into yellow not already coded under above characters (e.g. in E for yellowbe)
- N Nick a pointed protrusion of black into yellow, not already coded above.
- D Dent a dent in the bill
- R Recent damage obviously recent injury on bill
- Sc Scar scar, or whitened area indicating trauma

