BIRD-BANDING

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USE OF COMPUTER METHODS TO REDUCE ERROR IN COLOR BANDING STUDIES OF LONG-LIVED BIRDS

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INTRODUCTION

Many ornithological studies depend upon recognition of individual birds from a distance and achieve this by the use of combinations of colored and numbered leg bands. The number of color bands used varies. In some cases both legs are given the same combination; in others they are different. Sometimes the position of the metal band is used, so that, for example, right leg: black/blue/metal, left leg: black/blue is a different bird from right leg: black/blue, left leg: black/blue/metal. In all cases the aim is to give each bird a unique combination of bands so that it may be identified without being recaptured. While in theory it is easy to create separate combinations, in practice it is difficult to avoid some duplication, especially in long-term studies in which it becomes necessary to replace old bands. The purpose of this paper is to describe simple computer methods that reduce the risk of erroneously duplicating combinations and simplify the production of color combination charts.

EXAMPLE

The continuing study of breeding Fulmars (*Fulmarus glacialis*) on the island of Eynhallow, Orkney, initiated in 1950 by Dr. Robert Carrick and Prof. George M. Dunnet, illustrates the method (Carrick and Dunnet, 1954; Dunnet and Anderson, 1961; Dunnet et al., 1963; Dunnet, 1975; Dunnet and Ollason, 1975). Breeding birds and their nest sites are given permanent register numbers (metal band numbers and colored band combinations may change, but the register numbers do not). The Fulmars are banded with either (1) a triple color combination, the same on both legs, with the position of the metal band irrelevant; or (2) a double color combination the same on both legs, in which the position of the metal band is relevant. Originally 10 colors were used in double combinations (200 combinations) and 7 were used in triples (343 combinations). At the beginning of the study, plastic spring coil bands sealed with acetone were used. But over the years the plastic tends to fade and becomes worn. Pink and light blue tend to fade to white, and consequently their use was discontinued. More recently, instead of plastic we began using Darvic bands (8 colors) of a similar design, but made of thicker material; they do not fade, and do not need sealing.

Certain features of the study that lead to problems in color banding include the following:

1. The period in which banding is carried out is normally only three or four days per year and several groups of workers may be catching and banding birds simultaneously. This has sometimes led to combinations being duplicated by mistake. Such errors can be avoided by giving each group an exclusive set of available color combinations (e.g., double combinations to one group and triple to another).

2. The study has been continuing for 27 years and over 600 adults have been caught and banded. The mean annual adult survival rate is high (at least 0.96, mean adult life expectancy about 26 years, Cormack, 1973; Dunnet and Ollason, 1978). Therefore, to provide sufficient color combinations, it was formerly necessary to re-use combinations from birds thought to be dead. A minimum interval of 10 years since the last sighting of a bird was used as the criterion of death. Subsequently a frequency histogram of elapsed time between observed breeding attempts (i.e., intervals of one year or more) has shown that intervals of 10 years or more occur with a frequency of only 2/3193 (0.06%) (Table 1).

TABLE 1

Frequency of gaps between sightings (minimum of 1 year) of Fulmars on Eynhallow, Orkney, between 1950 and 1976

Gap size, years	Frequency	Probability of occurrence
1	2399	0.7513
2	508	.1591
3	151	.0473
4	69	.0216
5	34	.0106
6	15	.0047
7	8	.0025
8	6	.0019
9	1	.0003
10	2	.0006
11+	0	0.0
Total	3193	

3. Band replacement. The problems arising from metal band wear are widely recognized (e.g., Poulding, 1954; Coulson and White, 1955; Ludwig, 1967; Mills, 1972; Coulson, 1976), but the durability of color bands has been less discussed (Anderson, in prep.). Because Fulmars are long-lived, it is necessary to replace both color and metal bands regularly.

Faded bands can lead to an incorrect reading of color. It is also possible for plastic bands that have become unsealed to pass through one another, reversing their positions, or for loss of one color band from both legs in a triple combination to cause it to be mistaken for a double combination. In all these cases, replacement of the bands with an apparently similiar combination could result in a duplicate combination. Finally a color combination may be identified and replaced correctly without it being realized that the combination has already been duplicated.

A method of avoiding these errors is to verify in the field that the color combination corresponds to the metal band number of the bird caught.

INFORMATION REQUIRED IN THE FIELD

To check color combinations in the field, certain information is required which must be up-to-date and ideally should be easy to handle. The information must include:

1. A list of unused color combinations;
2. A list of color combinations that may be re-used;
3. A chart relating color combinations in current use to metal band numbers (or bird register numbers);
4. An index relating metal band numbers (or bird register numbers) to color combinations in current use;
5. A list of color combinations, which have already been duplicated (and which therefore need to be removed), together with the corresponding metal band numbers and bird register numbers.

TABLE 2

Example of a section of a double color combination chart in which the postion of the metal band is used as part of the combination. For explanation see text.

	Metal band Postion	Left	Right		Left	Right
Top color	Orange			Pink		
Lower color	Dk Blu	O	396	Dk Blu	410	O
	Lt Blu	−1	115	Lt Blu	125	561
	Brown	612	608	Brown	O	O
	Green	316	424	Green	444	O
	Orange	592	317	Orange	−1	416
	Pink	408	413	Pink	417	437
	Red	290	O	Red	480	330
	White	421	493	White	411	419
	Yellow	494	326	Yellow	335	O

In the Fulmar study, items 1, 2, 3 and 5 are combined on charts of double and triple color combinations (Table 2). Currently used color combinations have the bird register number entered, unused and available combinations are indicated by O, and duplicated combinations are indicated by -1 and listed separately. Item 4 is also listed separately. Thus all the information is provided in a compact form which may be taken into the field.

METHOD OF PRODUCING INFORMATION REQUIRED

It would be possible, but very laborious, to produce these charts and lists by hand, and to keep them error-free by amending them whenever a bird is banded or rebanded. Instead, the current color combination, and position and number of the metal band of each bird is punched on a computer card. The cards are stored in order of bird register number. Item 4 is produced simply by listing the deck of cards. Items 1, 2, 3 and 5 are produced by computer programs and appear in chart form, one for double combinations and one for triples. The generalized flow diagram for the programs is given in Figure 1. The programs use the deck of cards listed as item 4, and they can be adapted to deal with any colors since the colors used are read as data at the start of each run.

OTHER BENEFITS

In this study the deck of current color combinations is used as data for a number of other programs. Accumulated breeding data about birds and their (labelled) nest sites have been converted into numerical codes and stored in the form of a database (an example of the Aberdeen University Database Management System, which is a subset of the CODASYL DBTG proposal, April 1971). Using these data as well, programs have been written that produce:

1. A list, in order of bird register number, based on the latest × years' data (conveniently about 5), which shows the color combination and metal band number of each bird and its mate(s), and the nest site number(s) at which they bred;
2. A list, in order of nest site number, based on the latest × years' data, which shows the pair(s) of birds which bred at that site and gives their color combinations and metal band numbers.

These lists are used after each field session to help locate errors in identification. Each observation of bands is assigned a quality, on a 5-point scale, according to its certainty. Thus observations including a metal band number receive the highest quality code; very doubtful sightings (e.g., a flash of colors) receive the lowest, and never enter the database. Unexpected or odd color combinations are pin-pointed and the observation repeated as soon as possible.

The computer is also used for numerous other checking procedures. After the data have been numerically coded, but before they enter the database, programs are run that detect inconsistencies within single observations (e.g., a bird that is weighed, but not recorded as handled).

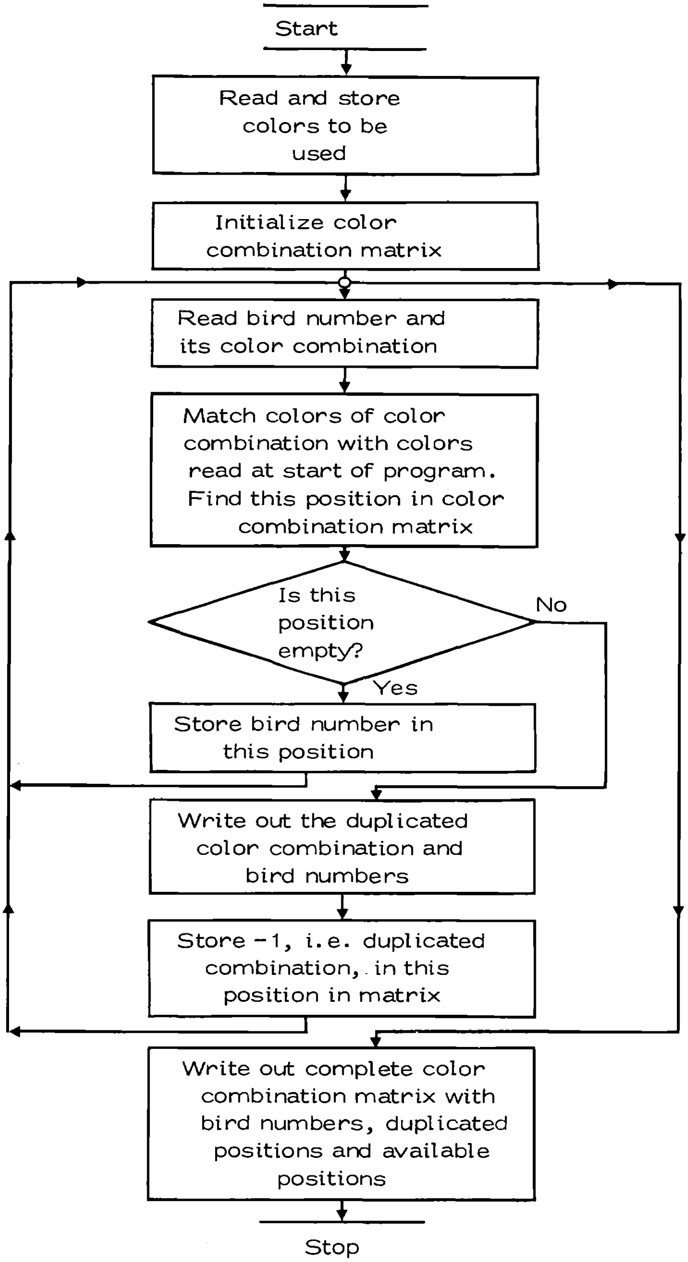

FIGURE 1. Generalized flow diagram for computer programs producing color band combination chart. Arrow: direction of flow. Closed box: executable statement. Open circle: decision point. Diamond: question.

Such observations are re-checked from field notebooks and if still unsatisfactory they are given the lowest quality code and discarded (this happens rarely). Although this method may result in a small loss of data, it prevents addition of incorrect information. Once the annual addition of data to the database is complete, a second set of checking programs is run that detect inconsistencies between observations (e.g., a record of a bird formerly found dead). It is occasionally necessary to refer to field notebooks and quality codes again, and to make corrections to the database. In this way the data are checked for consistency before any analyses are attempted.

CONCLUSION

The methods described have been used in the Fulmar study for the last two years. In this time, of the 453 combinations in current use, the number of duplicated color combinations has been reduced from 29 to 16, and 9 of these involve birds not seen for at least 5 years. Computer techniques have made unnecessary the re-use of color combinations after 10 years elapsed time between observations.

Although some of the procedures adopted are useful only in the Fulmar study, it is possible to generalize a number of the techniques, in particular the system in which each bird has its color combination and metal band number on one punched card. This basic card deck can be used as data for programs producing color combination charts. It is quicker, easier, and more accurate to run this program at regular intervals than to amend hand written charts. If accumulated data are also available on computer, it is easy to write other programs giving information based on past data in conjunction with the color combination card deck. If the data are to be stored in a computer, rigorous consistency checks can also be carried out. Thus it is possible to ensure accuracy of data collected.

SUMMARY

This paper describes methods of information verification by computer which improves the accuracy of data collected from color banding studies.

The study of breeding Fulmars, on Eynhallow, Orkney, from 1950 onwards, is an example of use of color band combinations in a long-term project. Circumstances likely to cause accidental duplication of color combinations are identified. This problem and others can be solved by verifying color combinations and metal band numbers in the field whenever a bird is handled. A simple computer method of producing compact color combination charts and other lists is described. Further benefits are possible if past data have been stored in a computer. The main advantages are the speed and accuracy with which new charts and listings can be produced and the resultant reduction in errors at the data collection stage.

NOTE

Fortran IV source copies of the programs producing double and triple color combination charts are available on request from the author.

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