closed by the ice, the swans become very trusting and can be caught by hand, up to 300 in a day. A good part of these are Swedish and Baltic swans. When the winter becomes extremely cold even *Cygnus cygnus cygnus* can be caught. We managed to ring more than 100 of them, with neck-collars.

The ice-winter increased mortality drastically and we actually collected nearly 3000 dead swans in all stages of decomposition. Most of them are still in cold storage, awaiting veterinary and chemical analysis.

Summary

Swan research in Denmark is organized by the Copenhagen Zoological Museum but largely carried out by amateurs. The paper describes a typical year in the life of a subject of the Kingdom of Elleore, with emphasis on catching of colonial swans and operations in ice-winters.

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THE USE OF ELECTRONIC DATA PROCESSING (EDP) IN DANISH SWAN RECORDING

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Introduction

During the ice-winter of 1962/63 the first large-scale ringing of Danish swans was carried out (1500 individuals). In the winter of 1969/70 a further 5000 swans were ringed. In the early 1970s we started catching the moulting swans by boat, and today, after the ice-winter of 1978/79, the total number ringed has exceeded 23 000. In 1971 the use of neck-collars was adopted as a supplement to the normal rings.

The ringing of such large numbers of such big birds in a densely populated area, and especially the use of neck-collars, led to more than 70 000 reports. This caused serious administrative troubles for the ringing centre at the Zoological Museum in Copenhagen.

Design of the EDP system

In 1974, when the total number of reports had reached 50 000, it was decided to establish an EDP system for maintenance of the data on Danish ringed swans and foreign swans observed in Denmark. The EDP system, designed with a potential of 200 000 reports, performs the following functions: 1) Stores all data obtained by ringing, recapture and resighting of ringed swans, including place, time, sex, age, status (moulting, breeding, etc), biometrical information (weight etc), number of eggs and cygnets, partner and other information; 2) Performs translation from neck-collar into ring number; 3) Handles exchange of rings and neck-collars; 4) Converts mnemonic location codes for places into co-ordinates; 5) Writes a letter to the observer, containing a list of all known information about the actual bird, other than some biometrical data.

In the initial phase, the main task was to reorganize and simplify the administration of data on ringing and observations but the long-term goal was to organize the data in a way suitable for later statistical analysis.

The author accepted the designing and implementing of the system. Risø National Laboratory offered free computer time for the project. The design and coding of the system was performed in close collaboration with P Andersen-Harild.

Operation of the system

The next stage was the major task of keypunching all old data from the files of the Zoological Museum. It was done by the Department of Ringing in collaboration with P Andersen-Harild and was completed within two years. Initially, ringing data on neck-collared swans was entered. After that, all new observations of these swans were handled by the system, relieving the administration at the ringing centre at an early stage. Secondly, ringing data for the rest of the swans were entered and, finally, the old observations were punched. Some minor corrections and improvements were made but very soon the system became stable and has since been used unaltered.

The computer programme accepts data coded on punched cards, creates records, and merges these with previous records on magnetic tape. Other transactions make it possible to update or correct existing records or cancel erroneous records. When all transactions have been handled, the computer writes a letter regarding every swan for despatch to the observers, together with a leaflet giving a short description of the project. A more detailed description of the programme is given in the Appendix.

Before the ice-winter of 1978/79 all information had been entered into the system. During that winter 3000 new swans were ringed, more than 10 000 observations

were received and quite a few rings were exchanged. The EDP system did not cause any trouble at all, but the keypunching and distribution of the letters heavily loaded the personnel at the ringing centre. However, we succeeded in dispatching a great number of letters before the start of the very cold period which encouraged a lot of people to make an extra effort in collecting more observations. The last observations were not answered before late summer. Without the EDP system it would have been impossible to handle 13 000 records within one winter.

Advantages of the system

The administrative work consists of two functions. First, a card is punched for each observation (two cards if the swan has been measured), and then the computer-generated letters are dispatched to the observers. The latter is the bottleneck of the system but it is the basis for stimulating interest among observers, without whom we could not collect so many observations. For example, one 14-year-old boy collected nearly 3000 observations during the winter of 1978/79.

The storage of data on magnetic tape facilitates the use of EDP for the scientific analyses, which are actually performed by another amateur, P Foldkjaer, in collaboration with P Andersen-Harild.

To illustrate the advantages of using EDP for statistical analysis, the distribution maps shown in Andersen-Harild's paper at this symposium on 'Migration of *Cygnus olor* ringed in Denmark in winter and during moult' were planned, coded, calculated and drawn by the computer within a period of only 14 days of spare time. The calculations included data from 13 500 records

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Summary

Because many swans had been ringed and neck-collared in Denmark, the large numbers of resightings caused administrative problems. Use of an EDP system overcame these problems and enabled quick replies to be sent to observers, thus stimulating their interest. The functions of the system are described and details of the programme given in the Appendix.

Appendix

Technical description of the Danish EDP programme for swan recording

Introduction

This Appendix outlines the technique used in the Danish EDP programme for swan recording. The programme is written in Burroughs Extended Algol for a Burroughs B6700 computer. However, the description is given in general datalogical terms, with no special reference to the actual computer.

Definitions

Identity: Rings are often replaced when they become worn. Thus the ring number is not a unique identification of a swan. The term 'identity' is used for the first ring carried by a swan, while 'ring number' is used for the actual ring.

Record: The information is stored as records on magnetic tape. A record holds the description of one observation, the minimum information being identity, ring number, date and place. Other data are optional, although more are nearly always present.

Transaction: Transactions are used to enter data into the system and are written on punched cards. The programme handles primary, secondary and cancel transactions.

Operation of the system

The transactions are sorted on different keys. The keys are fields of data used to define the ordering sequence of transactions or records. In most cases more than one field is used as a key and an order of precedence is given. Before being merged, two files must be sorted, using the same sorting key(s). Merging the files combines them into a new file according to a rule. The ordering will be maintained in the new file.

A primary transaction can enter the most commonly recorded data into the record.

Mandatory data are:

Transaction type.
Kind of swan.
Date.
Place (co-ordinates or mnemonic).
Ring number (or neck-collar, if this is already entered into the system).

Optional data are:

Neck-collar.
Code for coloured plastic rings.
Code for how the registration was made.
Age.
Sex and colour phase (Grey or Polish).
Activity.
Status (moulting, breeding, etc).
Ring number of partner.
Licence of ringer.
Country code.
A text used for the location field of the letters.

The secondary transaction is used to amend or to correct data in an existing record. The mandatory data are the same as those of the primary transaction and must exactly match those of the record to be altered.

Optional data are:

Number of eggs.
Number of cygnets.
Colour of beak.
Size of beak knob.
Weight.
Total length of swan.
Total length of wing.
Length of first primary.
Length of longest primary.
Length of fourth primary.
Length of neck.
Size of foot.
Ring number(s) of parent(s).
Ring number of partner.
Activity.
Status.
Moulting percentage of young swans.
Number of eggs destroyed by man.
Precision of date.
Ring number of new ring.

The cancel transaction is used to cancel existing records. The mandatory data are the same as those of the primary transaction and must exactly match those of the record to be cancelled.

During read-in, the transactions are read from the card-reader, checked for formal errors and written in a temporary file on disc. The mnemonic location codes are looked up and co-ordinates are substituted. The transactions are then sorted with the neck-collar as primary key and date as secondary key.

The records are then read in from magnetic tape and stored on a disc file. Records containing neck-collars are extracted and sorted with neck-collar as primary key and date as secondary key. Only the oldest record is retained for each neck-collar.

The transactions and the neck-collar subset of records are then merged. Those transactions which have been entered with a neck-collar only will get the ring number substituted.

The transactions are then sorted with ring number as primary key, date as secondary key, co-ordinate as tertiary key and transaction type as quartic key. In the quartic key cancelling goes before primary which goes before secondary transactions. The records are then sorted with ring number as primary key, date as secondary key and co-ordinates as tertiary key.

The transactions are now merged into the records. Primary transactions will create new records, unless a record with the same key already exists. Secondary transactions will update the matching record. For each record created or updated, a key-record will be written to a key-file. The key-record will contain the identity of the swan and a note that a letter should be written for this swan.

The exchange of rings calls for especial attention. When a record is created, the programme checks if the previous record has the same ring number. If not, the ring number is copied into the identity; otherwise the identity is copied from the identity of the previous record. When a ring is exchanged the new ring number is given in a secondary transaction. The old ring number is simply overwritten by the new one. To make sure that no swan gets two identities, we write a key-record to the key-file. This record gets the new ring number as identity and an indication stating that all possible records with that identity must be cancelled.

Now the records are sorted again, this time with identity as primary key, date as secondary key and co-ordinate as tertiary key. The key-records are sorted with identity as primary key and request for cancelling or letter-writing as secondary key. Cancelling goes before letter-writing. The key-records and the main records are now merged. Those identities requiring letters will have a letter printed showing all records in readable Danish. The records are written onto a new magnetic tape, which is stored for input to the next run.

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