Processing moult card data with reference to the Chaffinch *Fringilla coelebs*

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Results of the 1970 moult inquiry in Finland are reported. A computer programme system for processing the data is briefly described and the results of this concerning the moult of the Chaffinch *Fringilla coelebs* ar egiven.

Understanding many phases in birds' life presupposes exact knowledge about all important periods. The moult is one phase of the less well known. The time when birds moult is on many occasions known although there is much confusion; see eg. the moulting periods given for certain warblers by WITHERBY *et al.* (1958) and WILLIAMSON (1963). The latter is an identification guide intended for bird ringers. In countries where birds are strictly protected only ringers are able to collect enough precise material about the moult for it to be possible to explain other features of the moult than the mere time it occurs.

Collecting large quantities of moult data for many species is possible only by using an inquiry. Because many people make moult observations a satisfactory method of coding the moult is needed. The most suitable way is to give figures to each feather according to its stage of renewal. The description of body moult is more difficult in practice and it will not be dealt with in this paper.

Recording the moult data for large numbers of individuals is facilitated if special moult cards are used. This makes the coding of the moult more rapid and helps in processing the data. Moult cards have come into extensive use especially since the British Trust for Ornithology began the British moult inquiry in 1960 (SNOW 1965).

Processing moult card data gives rise to many arithmetical operations most of which are very simple. If much of this kind of work is to be done, it is reasonable to use a computer. I have made a programme system for processing moult data for passerines accumulated from the moult inquiry I sent in the spring of 1970 to Finnish ringers. It is presented in this paper using the material from that year and the Chaffinch *Fringilla coelebs* as a representative species.

Materials and methods

The moult inquiry sent to Finnish ringers in 1970 contained advice on recording the wing and tail moult of passerines. Cards very similar to those used in the British Isles (SNOW 1967) were used. The stage of moult in wing and tail feathers was recorded in accordance with the method recommended by CORNWALLIS & SMITH (1963). Old feathers are marked by the figure 0 and new feathers by the figure 5 and those in growth by a figure between these according to their length.

Moult cards returned were punched (72 columns per card) and listed. The listing was checked against the original moult cards and punching errors corrected.

Programmes used in the calculations given in this paper were written using FORTRAN IV programming language and the processing of data was done on an IBM 1130 computer, a small computer with a core memory of 16 K. This meant that the longest programmes had to be split into separate parts and connected by means of links. Statistical parts were programmed using SNEDECOR & COCHRAN (1968) and HYRENIUS (1962).

Two permanent files, the Latin names of passerines and the names of Finnish ringers, were stored in disc storage.

Annual summary 1970

Results of inquiries like this are based largely on voluntary help from ringers. The inquirer therefore has certain duties to this informants. One of the most important is to tell them how the work is progressing. For this purpose I made a programme giving an annual or long-term summary of the cards. It gives three tables (Tables 1, 2 and 3) which indicate how successful the 1970 moult inquiry was. Table 1 gives the numbers of cards each informant returned. Table 2 gives the area distribution of cards returned and Table 3 the numbers of cards according to species and age class.

TABLE 1. Participants in the 1970 moult inquiry in Finland.

Ahola J.	12
Dahlqvist M.	11
Hakala J.	18
Halonen J. V. A.	20
Haukioja E.	248
Helo P.	31
Hollsten J.	115
Hyytiä K.	150
Jaakola H.	38
Jaanu E.	8
Kaakinen E.	2
Kaakinen K.	45
Kalinainen P.	381
Karhumäki J.	12
Karlsson L.	18
Karlsson R.	26
Kaukola A.	10
Kivivuori O.	10
Kolunen H.	21
Laaksonen A.	1
Lahtonen I.	118
Lehikoinen E.	99
Lokki J.	93
Mikkonen A. V.	14
Mäkisalo I.	8
Niemelä P.	120
Poutanen T.	4
Saarinen S. I.	67
Sarkanen M.	3
Sihvo Y. O.	39
Tiussa J. T.	13
Tuominen M.	3
Virtanen J.	110
Hakila R.	36
Myrsky H.	16
Hakala T.	78
Pietiäinen H.	10
Iikkanen M.	1
Oksala I.	2
Mikkonen E.	6
Ferm A.	149

Analysis of the wing and tail moult

Using figures for each wing and tail feather as the basis of analyses is unsuitable. Figures which indicate the stage of moult are therefore needed.

The primary score (sum of the moult stages for primaries 1—9) is probably the best because it increases quite linearly in a population and is therefore suitable as a basis for simple calculations of the duration of the (primary) moult (see NEWTON 1967). Birds with old primaries have a primary score of 0 and those with new primaries 45. Other usable figures are the secondary and tail scores. By these are meant in this paper the sum of feather figures in the secondaries and half of the tail respectively. Both of these rise from 0 to 30 as the moult proceeds. The fourth characteristic of the moult is the raggedness of wing as proposed by HAUKIOJA & KALINAINEN (1971). By this is meant the sum of the figures for primaries and secondaries where 0 indicates a feather of full length (old or new), 4 a feather at the first stage of growth, 3 a feather at stage 2, 2 a feather at stage 3 and 1 a feather at stage 4. Their sum is 0 for a full wing and, in a hypothetical case where all wing feathers are lost, it is 60. Actual values found in moulting passerines have been between 0 and 32 (unpublished).

TABLE 2. Area distribution of moults cards in the 1970 moult inquiry in Finland.

Latit. North	Longit. East												
	19	20	21	22	23	24	25	26	27	28	29	30	31
70—									0				
69—		0	0	0			0	0	705	0	0		
68—		0	0	0	0	0	3	0	0	0	0		
67—					0	0	0	0	0	0	0		
66—					0	0	0	0	0	0	0		
65—						0	0	0	0	0	0	0	
64—					0	93	0	20	31	47	0	0	
63—		0	0	0	0	0	0	0	0	0	0	0	0
62—			0	0	7	0	0	0	0	0	20	0	0
61—			77	40	86	163	34	0	0	3	14	0	
60—	66	0	52	381	12	2	299	0	0	0			
59—	0	0	2	0	0	9							

Moult cards for passerines which normally moult during the summer were run through the computer using a programme which calculated the four figures mentioned above for each card if all the necessary data were available in the first 72 columns of the card. These values (primary score, secondary score, tail score and raggedness of wing) were then punched by the computer in columns 73—80 of the cards.

Afterwards the following data on the cards were filed on a disc: number of species (EURING-code without the last digit), age and sex codes, ring number, co-ordinates of the place, day, month and year, number of the ringer, primary, secondary and tail scores and the raggedness value. Cards of several species can be stored in an arbitrary order in the same file. After this the data was ready for processing.

With the aid of a computer-connected plotter the programme used in the analysis first makes a graph where the primary scores are plotted against the date (Fig. 1). A regression equation is then computed for the primary scores using one of the following methods: 1) primary score regression on date using all specimens in moult, 2) primary score regression on date using a shorter period than that covered by moult records and 3) date regression on primary scores.

The first procedure is used when observations begin and end when practically the whole population is passing through the moult phase or when neither of the latter two methods is appropriate.

The second procedure is used in order to deal with situations where the bulk of the population either has not yet begun or has ended its moult but some are moulting. This means that score distribution against dates are not normal during these periods. However, computing a regression equation assumes a normal distribution of points. The error can thus be eliminated by omitting those periods during which the distributions are clearly skew. If this procedure is not used and moult records extend beyond the beginning or the end of the moult, too long a duration for the moult is arrived at.

The third procedure is used when moult records cover more or less evenly the whole moulting period. In this case the mean dates for each primary score are used in the regression computations;

TABLE 3. Species-list of moult cards accumulated in the 1970 moult inquiry in Finland.

Species	Ad	Juv	Fl	Total
Alauda arvensis	1	4	1	6
Delichon urbica	2	0	0	2
Garrulus glandarius	1	0	0	1
Parus major	44	36	15	95
Parus caeruleus	7	6	0	13
Parus montanus	14	0	2	16
Cinclus cinclus	1	0	0	1
Erithacus rubecula	10	2	1	13
Luscinia svecica	34	1	0	35
Phoenicurus phoenicurus	25	1	0	26
Saxicola rubetra	8	0	0	8
Oenanthe oenanthe	9	0	0	9
Turdus merula	13	1	0	14
Turdus pilaris	46	0	0	46
Turdus iliacus	82	0	1	83
Turdus philomelos	26	0	0	26
Locustella naevia	1	0	0	1
Acrocephalus scirpaceus	0	0	1	1
Acrocephalus dumetorum	1	0	0	1
Acrocephalus schoenobaenus	1	0	4	5
Sylvia atricapilla	9	0	0	9
Sylvia borin	3	2	0	5
Sylvia communis	18	0	0	18
Sylvia curruca	1	0	0	1
Phylloscopus trochilus	162	2	0	164
Phylloscopus collybita	5	0	0	5
Muscicapa striata	30	0	0	30
Ficedula hypoleuca	15	0	0	15
Ficedula parva	2	0	0	2
Prunella modularis	3	0	0	3
Anthus pratensis	37	0	1	38
Anthus trivialis	7	0	1	8
Motacilla alba	46	5	1	52
Motacilla flava	58	1	4	63
Bombycilla garrulus	50	0	0	50
Sturnus vulgaris	159	401	1	561
Passer domesticus	8	20	17	45
Chloris chloris	7	3	0	10
Carduelis carduelis	2	2	11	15
Carduelis spinus	20	1	4	25
Carduelis flammea	221	0	0	221
Pyrrhula pyrrhula	15	0	0	15
Pinicola enucleator	21	0	0	21
Fringilla coelebs	137	4	1	142
Fringilla montifringilla	141	0	0	141
Emberiza citrinella	18	2	0	20
Emberiza rustica	0	2	2	4
Emberiza schoeniclus	76	2	0	78
Calcarius lapponicus	3	0	0	3
Total	1600	498	68	2166

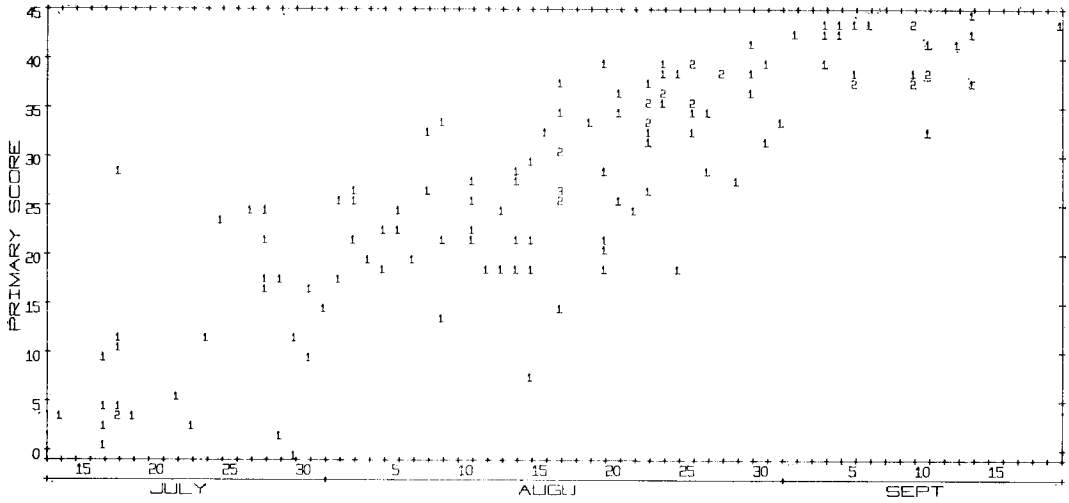


FIG. 1. Primary scores of adult Chaffinches *Fringilla coelebs* in the 1970 moult inquiry in Finland.

in the first two cases mean primary scores are used for each date. The third procedure is superior if scatter in the start of moult is great.

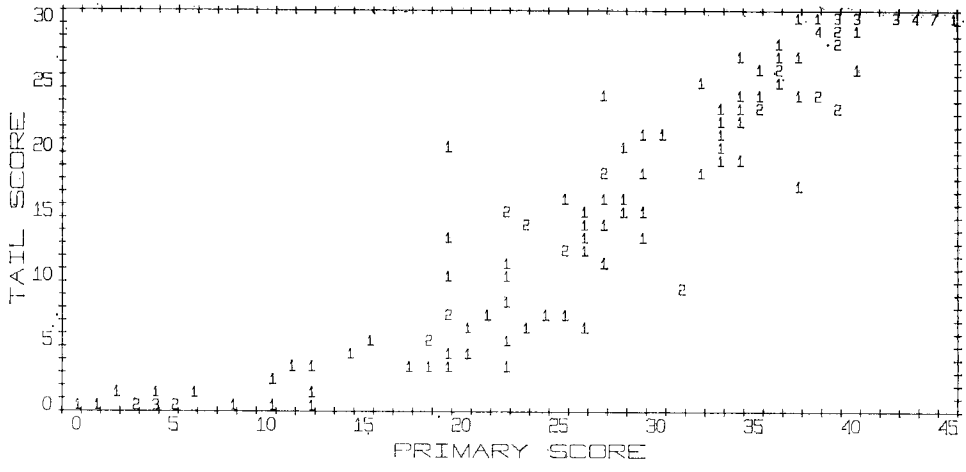
The programme chooses one of the three methods according to the data available but it is also possible to override this by using data switches in the computer and, in cases when the second method is used, it is also possible to decide the desired period through the keyboard.

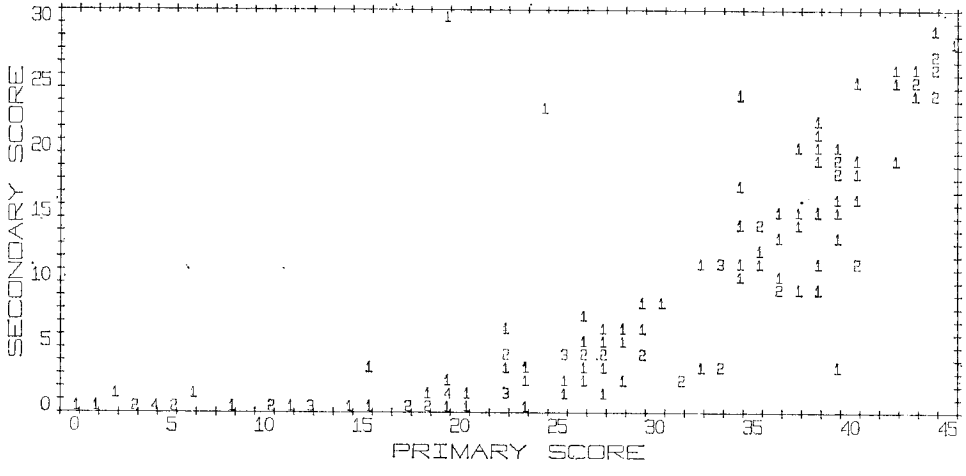
The programme also seeks to find out if the same individuals have been caught more than once during the moult in the same year and computes the mean rise in the primary score per day.

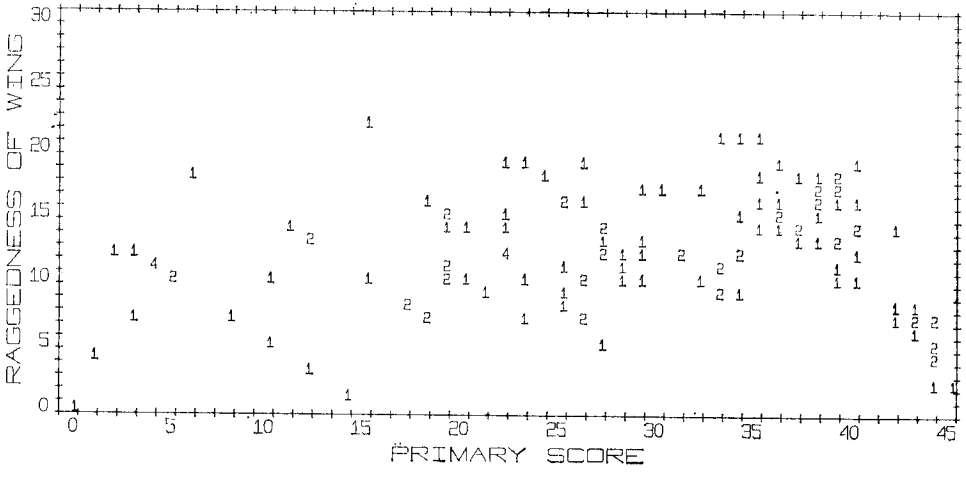
The final results of these computations are presented in a table (Table 4) which gives the summary of the primary moult. Furthermore, it gives list of ringers whose cards were used. On the same run figures depicting tail and secondary scores and raggedness of wing in relation to the primary score (Figs. 2, 3 and 4 respectively) are drawn by the plotter.

Remarks on the moult of the Chaffinch

The duration of primary moult in the Chaffinch is a little more than 70 days as calculated by two different methods. All cards in the 1970 moult inquiry were used in this analysis (Table 4). Because their area distribution is rather large (Table 5) it may be that the course of the moult varies in different parts of Finland. However, it is not possible to test this with the present material. NEWTON (1968) gives a duration of about 70 days for moult in British Chaffinches. It may be mentioned that the length of the moult is about two weeks longer in the Chaffinch than in


TAIL SCORE
PRIMARY SCORE


SECONDARY SCORE
PRIMARY SCORE


RAGGEDNESS OF WING
PRIMARY SCORE

FIGS. 2—4. Tail scores (top), secondary scores (middle) and raggedness of wing (bottom) in relation to primary scores in the Chaffinch *Fringilla coelebs*.

the Brambling *Fringilla montifringilla* in northern Lapland (HAUKIOJA 1971).

Secondary score and tail score in relation to primary score in the Chaffinch as presented in Figs. 2 and 3 closely resemble figures given by NEWTON (1966) for the Bullfinch *Pyrrhula pyrrhula* and are typical of at least most passerines. Raggedness values of the wing plotted against primary scores are rather low which means that flying ability is probably rather good during the moulting period although DOLNIK & BLUYMENTAL (1967) mention that Chaffinches are shy and difficult to trap at that time.

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TABLE 4. Rate, duration and time of the postnuptial moult in the Chaffinch *Fringilla coelebs* in Finland.

AGE	ADULTS
SEX	BOTH
YEAR	1970
LOCALITY	ALL
FIRST BIRD EXAMINED (DATE)	13. 7.
FIRST BIRD IN MOULT EXAMINED (DATE)	13. 7.
LAST BIRD IN MOULT EXAMINED (DATE)	19. 9.
LAST BIRD EXAMINED (DATE)	19. 9.
SAMPLE SIZE (TOTAL)	137
SAMPLE SIZE (MOULTING)	135
REGRESSION EQUATION	Y = 6.7+0.61X
(EQUATION COMPUTED USING ALL DATA)	
LINEARITY TEST	
F 1	51
F 2	82
F	1.32
DAILY INCREASE OF MOULT SCORE	
FROM REGRESSION EQUATION	0.61
SE	0.031
N	135
FROM RECAPTURES	0.62
SE	0.037
N	8
START OF MOULT	2. 7.
95 PER CENT SPREAD (DAYS)	32
END OF MOULT	13. 9.
DURATION OF MOULT (DAYS)	
FROM REGRESSION EQUATION	73
FROM RECAPTURES	72

CARDS USED HAVE BEEN WRITTEN BY FOLLOWING PERSONS

AHOLA J	4	HAKALA J	3
HAUKIOJA E	2	HELO P	3
HOLLSTEN J	11	HYYTIA K	10
JAAKOLA H	2	JAANU E	3
KAAKINEN K	19	KALINAINEN P	7
KARLSSON L	4	KARLSSON R	2
LAHTONEN T	4	LOKKI J	19
MIKKONEN A V	24	NIEMELA P	15
POUTANEN T	1	TIUSSA J T	10
VIRTANEN J	7	HAKILA R	7
OKSALA I	1	MIKKONEN E	2

TABLE 5. Area distribution of moult cards concerning the Chaffinch *Fringilla coelebs* in the 1970 moult inquiry.

Latit. North	Longit. East												
	19	20	21	22	23	24	25	26	27	28	29	30	31
70—									0				
69—		0	0	0			0	0	0	0	0		
68—		0	0	0	0	0	0	0	0	0	0		
67—					0	0	0	0	0	0	0		
66—					0	0	0	0	0	0	0		
65—						0	0	0	0	0	0	0	
64—					0	15	0	5	3	19	0	0	
63—		0	0	0	0	0	0	0	0	0	0	0	0
62—			0	0	3	0	0	0	0	0	0	0	0
61—			9	2	0	21	10	0	0	1	10	0	
60—	7	0	8	22	0	0	0	0	0	0			
59—	0	0	2	0	0	0							

Selostus: **Sulkasatokorttiaineiston käsittelystä.**

Kirjoituksessa selvitellään kesällä 1970 aloitettua sulkasatokorttien keruuta ja aineiston käsittelyä. Rengastajien palauttamat kortit lävistetään, minkä jälkeen käsittely suoritetaan tietokoneella. Taulukossa 1 on mainittuna kunkin rengastajan täyttämien korttien määrä. Taulukossa 2 on asteen tarkkuudella palautettujen korttien aluejakautuma. Taulukossa 3 annetaan palautettujen korttien määrät lajeittain ja ikäryhmittäin. Kuvassa 1 on esitettynä peipon postnuptiaalisen sulkasadon kulkua kesältä 1970. Taulukko 4 sisältää tiivistelmän peipon sulkasadosta. Taulukko 5 esittää peippokorttien aluejakautumaa. Kuvat 2 ja 3 esittävät pyrstön ja kyynärsulkien sulkasatoa suhteessa käsisulkien vaihtoon ja kuva 4 siiven aukkoisuutta sulkasadon eri vaiheissa.

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