QUANTITATIVE AND QUALITATIVE AGE AND SEX CRITERIA OF THE STARLING, *STURNUS VULGARIS*, IN MARCH

by

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ABSTRACT

Age and sex criteria are studied of 74 Starlings, 39 ♂♂ (14 first-year) and 35 ♀♀ (27 first-year), in March.

Weight, bill length, wing length, lengths of the iridescent parts of the throat and breast feathers, lengths of the white tips on the breast and abdomen and the amount of black colour on the bill are treated quantitatively.

Qualitatively treated are: gloss of the plumage, gloss on the lesser secondary coverts, gloss on the breast, pointedness of breast and abdominal feathers, length of the throat feathers, gloss on the end of the outer web of the secondaries, colour of the under wing coverts and form of the upper tail coverts.

Skull ossification was expected to be completed in March, but finding 7 birds with an incompletely ossified skull, this character has been included in our study.

INTRODUCTION

Since the publication of Kessel (1951), ornithological literature contains numerous data about age and sex criteria of the Starling *Sturnus vulgaris* Linnaeus, 1758, especially for the use of bird migration studies in autumn. However, it is questionable whether the quantitative and qualitative characters, which can be used as age and/or sex criteria in autumn, are reliable as such in March.

In connection with a study into the muscle weights of the Starling, those characters which are indicative of the body size, viz. body weight and wing length, are of primary importance. As shown in the study of muscle weights of the hindlimbs in rats (Davids et al., 1964) variability of muscle weights is influenced by body size.

Body size depends on age and sex and therefore we were interested in their interrelations.

MATERIAL AND METHODS

March 9, 1972 fifteen hundred Starlings, coming from a roost in Baexem (near Roermond, province of Limburg, The Netherlands) had been caught by means of a bow net. This capture took place during a study of the effects of different sounds on these animals, undertaken by Drs. Renssen & Drs. Scheffner, of the Institute for Ecological Research, Arnhem, The Netherlands.

After a few hours 150 birds that appeared to be very thin, died. Seventy-four of these formed the material for this part of our study.

The population of roosting Starlings consisted of both resident and migratory birds. This might have had consequences with regard to the state of development of the gonads and secondary sex characters (Bullough, 1942; Berthold, 1964; Wydoski, 1964). However, since the birds were not banded, it was impossible to tell both components apart. Consequently, the concept "population" must be interpreted in the statistical sense.

In determining the sex, the iris colour was used (Rüppell, 1935; Banzhaf, 1937; Kessel, 1951; Cornwallis & Smith, 1960; Delvingt, 1961; Perdeck & Speek, 1968; Arnhem & Arnhem, 1969; Svensson, 1970), being in complete agreement with the nature of the gonads. In the majority of cases, the under tail coverts also gave a correct indication of the sex (Berthold, 1964). Together with Arnhem & Arnhem (1969) and Svensson (1970) we arrived at the conclusion that, in March, the base of the under bill is an unreliable sex character, although Banzhaf (1937), Cornwallis & Smith (1960) and Perdeck & Speek (1968) used it as such in their material.

The form of the black distal part of the throat feathers appeared to be the only character which could be used in making an absolute classification according to age. The throat feathers of first-year Starlings are broad and rounded and the black colour is not continued to the tip of the feather, whereas those of adult Starlings are pointed and the black colour is continued to the very tip. Illustrations of this can be found in the publications of Bullough (1942), Delvingt (1961), Berthold

(1964) and Perdeck & Speek (1968).

So the Starlings examined consisted of 39 ♂♂ (14 first-year) and 35 ♀♀ (27 first-year). The birds were thin and all belonged to fat class 0 (Busse & Kania, 1970; Helms & Drury, 1960).

Eight quantitative and eight qualitative external characters were used in our study. Moreover, the degree of skull ossification was ascertained.

Quantitative characters

I. Weight, determined to within 0.1 g.
II. Bill length, measured to within 0.1 mm.
III. Wing length, measured to within 1 mm.
IV. Length of the iridescent part of the throat feathers, measured as shown in fig. 1 to within 0.1 mm.
V. Length of the iridescent part of the breast feathers, measured as shown in fig. 1 to within 0.1 mm.
VI. Length of the white tips ot the breast feathers, measured as shown in fig. 1 to within 0.1 mm.
VII. Length of the white tips of the abdominal feathers, measured as shown in fig. 1 to within 0.1 mm.
VIII. Amount of black on the bill, compared with the bill drawings published by Bullough (1942). A separate drawing was made if the bill exhibited a different pattern. Up to now, this character was always treated qualitatively; however, in the present study the amount of black was calculated in all cases with the help of the Digitizer of Hewlett-Packard and stated as a percentage of the total surface.

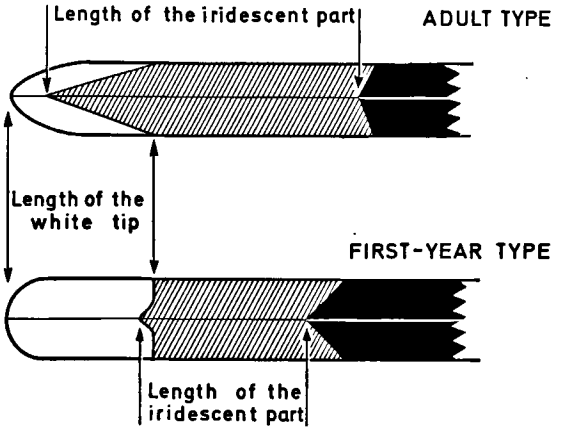

Fig. 1. Methods for determining the length of the iridescent part and of the white tips on the throat, breast and abdominal feathers.

Qualitative characters

IX. The plumage is always glossy but there are nuances; we distinguished: the gloss of the plumage strong or weak. The juvenile brown plumage, which is not glossy, no longer occurs in March.
X. The gloss on the lesser secondary coverts was distinguished either as strong and sharply limited, or as weak and not sharply limited.
XI. The gloss on the breast feathers was distinguished as very strong, strong, not so strong or weak.
XII. The black part of the tips of the abdominal and breast feathers was distinguished as tapering over a considerable distance into the white, hardly penetrating the white or showing a stage between these extremes.
XIII. The throat feathers were distinguished as long, moderately long or short.
XIV. The end of the outer web of the secondaries was distinguished as showing a strong iridescent gloss, some gloss, or little or no gloss.
XV. The under wing coverts were distinguished as having a dark centre with a contrasting buff margin or a brown centre showing little contrast with the buff margin. An intermediate stage between these two extremes was distinguished also.
XVI. The upper tail coverts were distinguished as either pointed with narrow buff margins or blunt with broad buff margins.

From literature we knew what to expect concerning the distribution of the qualitative characters. The distribution for our population is given (table V). In this table we attempted to place Starlings with the same plumage (same vertical pattern) beside each other in such a way that the changes in the state of development per character (horizontal arrangement) are minimal.

Remark: the number of observations per group fluctuates as the qualitative characters of some birds could not be appreciated.

Skull ossification (see fig. 2)

After removing the skin the ossification of the skull could be examined. We were able to determine the surface of the non-ossified part by tracing it on tape. Later, with the help of the Digitizer, this surface was determined from the tape.

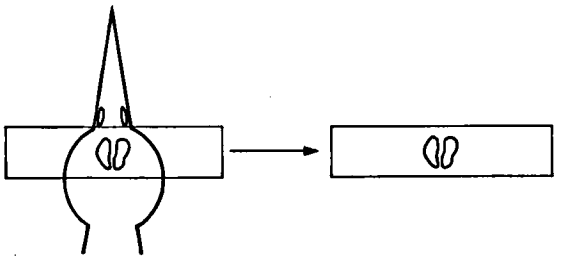

Fig. 2. Method for determining the area of the non-ossified part of the skull by tracing the pattern on a piece of tape.

Statistics

With regard to the quantitative characters we calculated for every character the mean in the four groups: ♂♂ adult, ♂♂ first-year, ♀♀ adult and ♀♀ first-year. Using Student's *t* test we determined whether there was a significant difference between the means of the four groups. The number of degrees of freedom depended on whether the variances of the groups were alike or not. Variance discrimination was made with the help of the *F* test.

The statistical program based on Sokal & Rohlf (1969) was made by Drs. P. C. Diegenbach and performed on the Digital (PDP-12) computer of the Zoological Laboratory.

A two-way analysis of variance for inequal subclass numbers (Steel & Torrie, 1960) was used to demonstrate simultaneously the influence of either sex or age on the quantitative characters.

RESULTS

Quantitative characters

Table I shows for each character the means and the ranges of the four groups. Table II gives the results of the Student's *t* tests and of the analyses of variance. Group means are on the left hand side of this table and the arrows indicate if there is a significant difference and are directed towards the lowest mean. The significance levels of the various *t* tests are given in table III. The results of the analyses of variance are on the right hand side of table II.

From the results of the *F* tests, it appears that the weight and the amount of black on the bill are characters clearly influenced by sex. Age alone influences the length of the white tips on the breast and abdominal feathers.

Age and sex have a simultaneous but separate influence on the wing length, the length of the iridescent part of the throat feathers, and the length of the iridescent part of the breast feathers. Using the *t* test these three characters showed a division into three groups. This well-known tripartition (1: adult ♂♂, 2: first-year ♂♂ + adult ♀♀, 3: first-year ♀♀), described by many authors, can be explained with the results of the analysis of variance. The means of the four groups must differ when age and sex do not exercise an equal influence. Actually we found an insignificant difference between the means of the adult ♀♀ and the first-year ♂♂. Thus, we concluded the

Table I. Means and ranges (in parentheses) of the quantitative characters.

	adult ♂♂	first-year ♂♂	adult ♀♀	first-year ♀♀
I. Weight (g)	67.8 (55.2—80.4)	67.0 (54.7—94.9)	61.4 (52.6—78.5)	60.1 (52.2—71.2)
II. Bill length (mm)	27.2 (25.1—29.1)	25.8 (25.4—29.1)	27.2 (25.5—29.1)	26.3 (24.2—27.6)
III. Wing length (mm)	131 (127—135)	129 (126—131)	128 (126—131)	126 (122—131)
IV. Length of iridescent part of throat feathers (mm)	9.1 (5.9—12.5)	6.9 (4.0—8.9)	6.7 (5.8—7.3)	4.0 (0.7—7.4)
V. Length of iridescent part of breast feathers (mm)	10.0 (6.0—13.4)	8.3 (4.8—12.3)	7.8 (5.9—9.2)	5.0 (0.0—9.8)
VI. Length of white tips of breast feathers (mm)	1.8 (0.0—4.0)	3.0 (2.0—3.8)	2.6 (0.0—3.7)	3.2 (0.0—5.2)
VII. Length of white tips of abdominal feathers (mm)	3.4 (2.8—4.5)	3.7 (2.8—4.9)	3.5 (2.5—3.9)	4.2 (3.0—7.0)
VIII. Amount of black on the bill (%)	9 (0—24)	9 (0—41)	26 (7—50)	28 (2—72)

Table II. Quantitative characters. Results of the *t* tests and the analyses of variance. Columns 2 and 3 indicate the group means and standard deviations (in parentheses) for the adult and first-year males and females, respectively. An arrow indicates a significant difference between the means of two groups and is directed toward the lowest mean. On the right hand side are the results of the analyses of variance: column 4 shows the source of variation, column 5 the degrees of freedom (df), column 6 the mean square, and column 7 the *F* values.

	adult	first-year	source of variation	df	mean square	*F*
I. Weight (g)	♂♂ 67.80 (7.47)	67.04 (9.31)	sex, adjusted for age	1	694.29	13.62***
			age, adjusted for sex	1	14.79	0.29
			sex-age interaction	1	1.14	0.02
	♀♀ 61.40 (8.56)	60.08 (4.75)	error	70	50.98	
II. Bill length (mm)	♂♂ 27.18 (1.03)	25.78 (5.64)	sex, adjusted for age	1	4.41	3.86
			age, adjusted for sex	1	2.14	1.87
			sex-age interaction	1	3.51	3.07
	♀♀ 27.24 (1.10)	26.28 (1.11)	error	70	1.14	
III. Wing length (mm)	♂♂ 130.60 (2.06)	129.00 (1.57)	sex, adjusted for age	1	101.15	26.35***
			age, adjusted for sex	1	37.90	9.87**
			sex-age interaction	1	0.01	0.00
	♀♀ 128.00 (1.51)	126.44 (2.14)	error	70	3.84	
IV. Length of iridescent part of throat feathers (mm)	♂♂ 9.09 (1.96)	6.90 (1.43)	sex, adjusted for age	1	111.70	37.77***
			age, adjusted for sex	1	89.28	30.19***
			sex-age interaction	1	1.23	0.41
	♀♀ 6.74 (0.45)	3.97 (1.82)	error	70	2.96	
V. Length of iridescent part of breast feathers (mm)	♂♂ 10.00 (2.22)	8.31 (2.05)	sex, adjusted for age	1	127.51	23.45***
			age, adjusted for sex	1	71.73	13.19***
			sex-age interaction	1	5.30	0.97
	♀♀ 7.84 (1.13)	4.95 (2.76)	error	70	5.44	
VI. Length of white tips of breast feathers (mm)	♂♂ 1.75 (1.44)	2.98 (0.53)	sex, adjusted for age	1	3.06	2.43
			age, adjusted for sex	1	14.24	11.31**
			sex-age interaction	1	1.19	0.95
	♀♀ 2.59 (1.27)	3.22 (0.95)	error	66	1.26	
VII. Length of white tips of abdominal feathers (mm)	♂♂ 3.44 (0.57)	3.70 (0.47)	sex, adjusted for age	1	1.73	3.41
			age, adjusted for sex	1	2.95	5.82*
			sex-age interaction	1	0.85	1.68
	♀♀ 3.47 (0.46)	4.24 (0.96)	error	66	0.51	
VIII. Amount of black on the bill (%)	♂♂ 9.02 (6.92)	8.96(11.66)	sex, adjusted for age	1	5120.66	20.21***
			age, adjusted for sex	1	18.10	0.07
			sex-age interaction	1	29.07	0.12
	♀♀ 25.63(12.63)	28.39(22.96)	error	70	253.39	

*** = P≤0.001; ** = P≤0.01; * = P≤0.05.

effects of sex and age must be approximately equal.

The length of the bill appeared to be the only character which was not influenced by age or sex.

As already mentioned, body weight and wing length are considered an indication for body size. There exists and influence of sex on the wing length and the body weight and of age on the wing length. If we wish to eliminate these effects, any further research will have to be done on Starlings from one of the four groups.

Qualitative characters

Table IV shows to what extent expectations derived from literature data concerning the external morphology of an age-sex group are fulfilled. Furthermore, it appears that in March none of the qualitative characters can be used as sex or age criterion. This will be further detailed for each character in the discussion.

In table V the various characteristics of the plumage within each group are arranged in such

Table III. Significance levels of the various *t* tests shown in table II.

	adult ♂♂ first-year ♂♂	adult ♂♂ adult ♀♀	adult ♂♂ first-year ♀♀	first-year ♂♂ adult ♀♀	first-year ♂♂ first-year ♀♀	adult ♀♀ first-year ♀♀
I.	ns	ns	***	ns	*	ns
II.	ns	ns	*	ns	ns	*
III.	**	**	***	ns	***	ns
IV.	***	***	***	ns	***	***
V.	***	*	***	ns	***	***
VI.	***	ns	***	ns	ns	ns
VII.	ns	ns	***	ns	*	ns
VIII.	ns	**	***	**	**	ns

*** = $P \leqslant 0.001$; ** = $P \leqslant 0.01$; * = $P \leqslant 0.05$; ns = not significant.
The meaning of the roman numerals is as in table II.

a way that those birds that look alike are placed beside each other. As seen in this table, adult ♂♂ show the most uniform plumage.

The other three groups exhibit a great variation. It is striking that the various characters do not develop simultaneously. The changes are so random that each Starling looks different (with the exception of two first-year ♂♂ and two first-year ♀♀, which two and two had an identical plumage). It is remarkable that adult ♀♀ show a greater variation in plumage than adult ♂♂.

We have decided to choose in our further studies Starlings from one of the four groups in order to eliminate age and sex effects on the body size. Since we believe the uniformity of the plumage to be important, we have chosen in the first instance adult ♂♂ for the muscle weight study.

Skull ossification

On 9 March 1972, 2 of the 14 first-year males (14%) and 5 of the 27 first-year females (19%) had an incompletely ossified skull.

Table VI gives the surface of the non-ossified part in mm². The standard deviation and the mean were also calculated. The image of an incompletely ossified skull corresponds with Harrison's drawing 14, diagram 3 (1961: 15), or is more capriciously patterned. The non-ossified parts are shown in fig. 3.

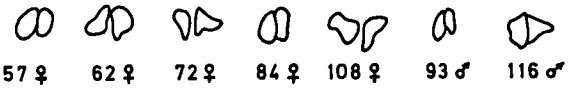

Fig. 3. Patterns of the non-ossified parts of the skull.

DISCUSSION

Quantitative characters (see tables I & II)

I. Weight: Berthold's graph (1967) indicates that the mean weight of a Starling is less in March than in October, November or December. The average weight of our Starlings was another 10 g less than that given in Berthold's graph. The average weight in July (Svensson, 1964) was closer to that of our Starlings than the weight in October, November or December (Kessel, 1951) which differed 20 g from our measurements. In general, these authors found ♂♂ heavier than ♀♀, which agrees with our data.

Our birds, dead soon after capture, proved to be in a bad condition: fat condition 0, i.e. no fat at all. Our weights can not be compared without comment with the data of those authors who paid no attention to the fat condition.

II. Bill length: Like Kessel (1951) we found neither age nor sex influencing the length of the bill.

It is interesting that Kessel, and in a lesser degree Wydoski (1964), found the bill of adult Starlings to be shorter than that of our birds. The average difference was 2—3 mm and 1 mm, respectively.

III. Wing length: According to Kessel (1951) the average wing length of the four groups appeared to be almost the same as that of our Starlings. We found the same tripartition.

Table IV. Comparison between expected and observed distributions of the qualitative characters. The number of animals is given in Roman type, the character class is indicated by italic numerals.

	group	distribution expected	literature on which expectation is based	observed distribution				
IX. Gloss on the plumage (*3*=strong gloss, *2*= weak gloss)	adult ♂♂	25×*3*	Witherby et al. (1945)	25×*3*				
	first-year ♂♂	14×*2*		14×*3*				
	adult ♀♀	8×*3*		8×*3*				
	first-year ♀♀	27×*2*		15×*3*	12×*2*			
X. Gloss on the lesser secondary coverts (*1*=strong and sharply limited, *0*=weak and not sharply limited)	adult ♂♂	24×*1*	Perdeck & Speek (1968)	24×*1*				
	first-year ♂♂	13×*1*		13×*1*				
	adult ♀♀	8×*1*		8×*1*				
	first-year ♀♀	27×*0*		13×*1*	2×½	9×*0*		
XI. Gloss on the breast (*4*=very strong, *3*=strong, *2*=not so strong, *1*=weak)	adult ♂♂	25×*3*	Perdeck & Speek (1968)	2×*4*	23×*3*			
	first-year ♂♂	14×*3*		1×*4*	10×*3*	3×*2*		
	adult ♀♀	8×*3*			7×*3*	1×*2*		
	first-year ♀♀	26×*1*			6×*3*	8×*2*	12×*1*	
XII. Tips of breast and abdominal feathers (*1*=black part penetrates the white, *0*=hardly penetrates the white)	adult ♂♂	24×*1*	Delvingt (1961)	23×*1*		1×*0*		
	first-year ♂♂	14×*0*	and Arnhem & Arnhem (1969)	5×*1*		9×*0*		
	adult ♀♀	8×*1*		4×*1*	2×½	2×*0*		
	first-year ♀♀	27×*0*		3×*1*	1×½	23×*0*		
XIII. Length of throat feathers (*3*=long, *2*=moderately long, *1*=short)	adult ♂♂	25×*3*	Perdeck & Speek (1968)	24×*3*		1×*2*		
	first-year ♂♂	14×*2*	and Arnhem & Arnhem (1969)	7×*3*	2×*2*½	5×*2*		
	adult ♀♀	8×*2*		3×*3*		5×*2*		
	first-year ♀♀	27×*1*		1×*3*	1×*2*½	15×*2*	10×*1*	
XIV. Gloss on the ends of the outer web of the secondaries (*3*=iridescent, *2*=intermediate stage, *1*=little or no gloss)	adult ♂♂	25×*3*	Arnhem & Arnhem (1969)	25×*3*				
	first-year ♂♂	14×*2*		11×*3*		3×*2*		
	adult ♀♀	8×*2*		1×*3*	1×*2*½	5×*2*	1×*1*½	
	first-year ♀♀	27×*1*		1×*3*	2×*2*½	4×*2*		16×*1*
XV. Under wing coverts (*3*=dark centre with buff margin, *2*=intermediate stage, *1*=brown centre with buff margin)	adult ♂♂	24×*3*	Arnhem & Arnhem (1969)	21×*3*	3×*2*			
	first-year ♂♂	14×*2*		8×*3*	6×*2*			
	adult ♀♀	8×*2*		2×*3*	5×*2*		1×*1*	
	first-year ♀♀	26×*1*		1×*3*	12×*2*	2×*1*½	11×*1*	
XVI. Upper tail coverts (2=tapered with narrow buff margins, *1*=blunt with broad buff margins)	adult ♂♂	25×*2*	Delvingt (1961)	23×*2*	2×*1*			
	first-year ♂♂	14×*1*	and Arnhem & Arnhem (1969)	8×*2*	6×*1*			
	adult ♀♀	8×*2*		7×*2*	1×*1*			
	first-year ♀♀	26×*1*		11×*2*	15×*1*			

Table V. Variations in the plumage. Change is indicated by a dash (—). For the meaning of the different numerals, see table IV.

Adult ♂♂

IX.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
X.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	?	1	1	1
XI.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3—4		4—3	3
XII.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	?	1	1	1	1	1—0	
XIII.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3—2		—3	3	3	3
XIV.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
XV.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	?	3	3—2		2	2
XVI.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2—1		1

First-year ♂♂

IX.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
X.	?	1	1	1	1	1	1	1	1	1	1	1	1	1
XI.	4—3		3—2		—3	—2	—3	3	3	3—2		—3	3	3
XII.	1	1—0		0	0	0	0—1		1—0		0	0	0—1	
XIII.	2½-3		3—2		2	2—3		3	3	3—2		2—3	—2½	
XIV.	3	3	3	3	3	3	3	3	3	3	3—2		2	2
XV.	3	3	3	3	3	3—2		2	2	2	2	2	2	2
XVI.	2	2	2	2	2—1		1	1	1—2		2—1		1—2	

Adult ♀♀

IX.	3	3	3	3	3	3	3	3
X.	1	1	1	1	1	1	1	1
XI.	3	3	3	3	3	3—2		—3
XII.	1	1—½		½	—1	—0	—1	1
XIII.	3	3	3—2		2	2	2	2
XIV.	3—2		—2½	—2	—1½	—2	2	2
XV.	3—1		—2	—3	—2	2	2	2
XVI.	2—1		—2	2	2	2	2	2

First-year ♀♀

IX.	3	3	3	3	3—2		2	2	2	2—3		3	3—2		2—3		3	3	3—2		2—3		3	3—2		2	2
X.	1	1	1	1	1	1—½		—0	—1	1	1	1	?	1	—0	—½	—?	?	0	0	0	0	0—1		1—0		0
XI.	3	3	3	3—2		2—1		1	1	1	?—3		3—1		1—2		2—1	—2		2—1		1	1—2		2—1		1
XII.	0	0	0	0	0—½		—0	—1	—0	0	0	0	0	0	—1	—0	0	0	0	0	0	0	0—1	—0	0	0	0
XIII.	2—3		3—2	—2½	—2	2	2	—1	—2	2	—1	—2	2	2	—1	—2	2	2	2	—1	1	1	1	1	1	1	1
XIV.	3—2½		2½—2		2	?—1		1	1	1—?—2			2—1		1	1	?	?	1	1	1	1	1	1	1	1	1
XV.	2—3	—2	2	2	2	2	2	2	2—1½	—2	—1		1—2	—1	1	?	1	1	1—2		2—1	—1½	—1	1	1		
XVI.	1—2		2	2	2	2	2	2	2	2—1	—2	—1	1	1—2	—?	1	1	1	1	1	1	1	1	1	1	1	1

Table VI. Surface of the non-ossified part of the skull in mm².

Sex and no.[1])	Left area (L)	Right area (R)	Difference between left and right area (L—R)
♀ 57	13.6	15.5	—1.9
♀ 62	17.4	18.1	—0.7
♀ 72	9.0	15.5	—6.5
♀ 84	12.3	9.7	+2.6
♀ 108	23.9	16.8	+7.1
mean	15.5	16.1	0.0
standard deviation	5.8	3.2	5.2
♂ 93	9.0	7.1	+1.9
♂ 116	20.0	19.3	+0.7
mean	14.5	13.2	+1.3
standard deviation	7.8	8.6	0.9

[1]) numbers from 51 through 124.

Niethammer (1937) divided the Starlings into two groups, i.e. ♂♂ and ♀♀. The means and ranges of the ♂♂ and the ♀♀ correspond with our own measurements when we classify the Starlings in the same way.

IV. Length of the iridescent part of the throat feathers: When we compare our measurements with those of Berthold (1964), it appears that he finds a higher mean for adult ♂♂ + ♀♀ and young ♂♂. Kessel (1951) found even higher means.

Berthold mentioned that he has measured the iridescent part of the under throat feathers, while we took the upper throat feathers. This may explain the difference.

However, agreement exists with regard to the following points:

a) the tripartition in adult ♂♂, first-year ♂♂ + adult ♀♀, first-year ♀♀;
b) the mean for the first-year ♀♀ being almost the same, regardless of whether the iridescent part of the upper or under throat feathers was measured.

V. Length of the iridescent part of the breast feathers: Comparable material is not available since exact data are lacking in the existing publications. However, Bullough (1942) and Kessel (1951) have treated this character qualitatively and arrived at the same tripartition as shown for the throat feathers.

Berthold (1964) measured the entire breast feather and also found this tripartition. His method for measuring the length of the entire breast feather is very valuable as it is easily done and results in a distinct separation of the groups (no overlap).

VI-VII. White tips on the breast and abdominal feathers: It is difficult to measure the tips of the breast and abdominal feathers, especially in spring when the white tips are wearing away. Nevertheless, these characters are indicative of the age. Delvingt (1961) and Kessel (1951) also considered the white tips on the breast and abdominal feathers an age character.

Although Heinroth & Heinroth (1926) claim that the white tips on the breast of adult ♂♂ are worn completely off in spring, this was the case for only 1/3 of our material. On the abdomen the white tips were never completely worn off and usually they were even longer than those on the breast.

VIII. Amount of black on the total bill surface: The bill of the male usually starts to turn yellow earlier in spring than that of the female. Considerable variation exists within a group in the amount of black on the bill. This is in agreement with Banzhaf's observations (1937).

In literature the Starlings are divided as follows:

1) Continental Starlings that in March still have a considerable amount of black on the bill (Banzhaf, 1937; Berthold, 1964; Bullough, 1942; Delvingt, 1961).
2) British and American Starlings that in March have an almost completely yellow bill (Bullough, 1942; Kessel, 1951; Wydoski, 1964).

Within the continental Starlings regional differences exist in the amount of yellow on the bill, parallel to gonad development. The large variance in our groups can be explained by the presence of birds from various regions (e.g. Starlings from The Netherlands and the Baltic region).

The upper bill is generally more black than the lower bill. Both the upper and lower bill of the ♀♀ are mostly more black than those of the ♂♂.

Qualitative characters (see table IV)

IX. Gloss of the plumage: From June to 15

September the gloss of the plumage is a useful criterion of adultness (Perdeck & Speek, 1968). During this period the juvenile Starlings show a dull brown colour without gloss, while the adults are darker with gloss. According to Witherby et al. (1945) first-year Starlings show less gloss in the winter and summer than adult Starlings; however, our first-year birds had a strong gloss, with the exception of half of the first-year ♀ ♀ which still had a weak gloss.

X. Gloss on the lesser secondary coverts: According to Perdeck & Speek (1968) first-year ♀ ♀ have during the period from September till March a weak and indistinctly circumscribed gloss on the lesser secondary coverts, while the remaining groups have a strong and distinctly outlined gloss on these coverts. However, well over half of our first-year ♀ ♀ showed a strong and distinctly outlined gloss.

XI. Gloss on the breast: As seen in table IV, Perdeck & Speek (1968) expect all animals to have a strong gloss on the breast with the exception of the first-year ♀ ♀ which would exhibit a weak gloss.

Our results are not completely comparable with theirs since their classification does not include "very strong" and "not so strong" and is only applicable till March. The gloss on the breast of our adult and first-year ♂ ♂ and adult ♀ ♀ varies from very strong to less distinct, approximately half of the first-year ♀ ♀ showing only a weak gloss.

XII. Tips of the breast and abdominal feathers: While we could clearly distinguish between first-year and adult Starlings by examining the white tips of the throat feathers, such a division was hardly possible with regard to the white tips of the breast and abdominal feathers, as can be seen in the results. Arnhem & Arnhem's division (1969) is, most likely, only applicable in autumn.

XIII. Length of the throat feathers: The tendency for a tripartition (adult ♂ ♂: long; first-year ♂ ♂ + adult ♀ ♀: moderately long; first-year ♀ ♀: short throat feathers) is latently present.

From Berthold's (1964) measurements of this length it appears that already in autumn the ranges for the four groups are the same. From our data it follows that there is considerable overlap in spring.

XIV. Gloss on the end of the outer web of the secondaries: The adult ♂ ♂ had the expected iridescent gloss on the end of the outer web of the secondaries. Although we expected (in agreement with Arnhem & Arnhem, 1969) the same iridescence in the young males and the adult females in March, the former had already more gloss than the latter. The majority of the young females had little or no gloss. However, in several young females an adult exterior was clearly developing.

XV. Under wing coverts: Our expectations were based on Arnhem & Arnhem's division (1969) but our results rather confirm those of Kessel (1951) and of Delvingt (1961): while the fluctuation within a specific group is fairly large, it is least for the adult males.

XVI. Upper tail coverts: Like Delvingt (1961) we found that almost all adult Starlings had pointed upper tail coverts with narrow buff margins. About half of the young birds had the expected blunt upper tail coverts with broad buff margins, while the other half had a more adult exterior.

Skull ossification

Skull ossification can be used to ascertain the age of a Starling until deep in the autumn (Kessel, 1951; Verheyen, 1953; Harrison, 1961; Delvingt, 1961; Perdeck & Speek, 1968; Svensson, 1970).

The average duration of ossification in Starlings is estimated at approximately six months (Verheyen, 1953; Harrison, 1961). When we assume that our Starlings with a not completely ossified skull were born about June, the duration of the process is about nine months. There is, however, reason to believe that the process of ossification may be delayed. The bad condition of our Starlings may have caused this delay. But, accepting this as an explanation, it does not exclude the probability of a late or second breeding.

The still unfinished ossification stage is perhaps more common in winter, even till March, than was expected. This phenomenon requires further research during this season.

In our material there were both resident and migratory birds. Regional differences may also play a part in this process. Therefore, in studying the duration of the ossification it is necessary to examine Starlings of known origin.

Table VII shows the state of development of all the characters examined in the seven Starlings with an incompletely ossified skull. It is striking

Table VII. Data of Starlings with an incompletely ossified skull.

	♂93	♂116	♀57	♀62	♀72	♀84	♀108
I. Weight (g)	64.9	94.9	57.6	54.0	52.7	63.8	56.8
II. Bill length (mm)	26.9	25.4	24.9	25.3	27.3	27.1	24.2
III. Wing length (mm)	129	130	125	126	129	122	125
IV. Length of iridescent part of throat feathers (mm)	5.5	6.4	3.0	4.2	5.0	3.2	0.7
V. Length of iridescent part of breast feathers (mm)	6.8	10.7	2.0	4.2	8.5	6.0	2.1
VI. Length of white tips on the breast (mm)	3.2	3.5	3.2	3.1	2.5	2.4	4.2
VII. Length of white tips on the abdomen (mm)	3.8	3.9	4.1	4.5	3.7	3.2	5.5
VIII. Amount of black on the bill	0%	2%	8%	73%	10%	2%	50%
Surface of non-ossified part of the skull (mm^2)	16	39	29	36	25	22	41
IX. Gloss on the plumage	*3*	*3*	*3*	*2*	*3*	*3*	*2*
X. Gloss on the lesser secondary coverts	*1*	*1*	*0*	*0*	*1*	*1*	*0*
XI. Gloss on the breast	*2*	*3*	*1*	*1*	*3*	*3*	*1*
XII. Tips of breast and abdominal feathers	*0*	*1*	*0*	*0*	*0*	*0*	*0*
XIII. Length of throat feathers	*2*	*3*	*1*	*1*	*2*	*1*	*1*
XIV. Gloss on the ends of the outer web of the secondaries	*3*	*3*	*1*	*1*	*3*	*2*	*1*
XV. Under wing coverts	*2*	*3*	*1*	*1*	*2*	*1*	*1*
XVI. Upper tail coverts	*2*	*2*	*1*	*1*	*1*	*2*	*1*

For the meaning of the numerals *0*, *1*, *2* and *3* in the qualitative observations (IX-XVI), see table IV.

to see that the two ♀♀ with a large unossified skull area (36 and 41 mm^2) had a large amount of black on the bill (73 and 50%). Realizing that the amount of black on the bill is correlated with the state of development of the gonads, there could exist a simultaneous progress in the growth of the gonads and the ossification of the skull. Yet male no. 116 with a large non-ossified skull area (39 mm^2) already exhibited a yellow bill. Nevertheless, we assume this hypothesis for the moment, even when we can not explain the case of no. 116.

SUMMARY

This paper gives a survey of the most useful age and sex characters of the Starling in March.

The most important age characters are: the extension of the black colour into the white tips of the throat feathers (Delvingt, 1961) and the length of the white tips of the breast and abdominal feathers.

The iris colour, the weight and the amount of black on the bill are important characters for determining the sex.

The length of the wing and the length of the iridescent part of the throat and breast feathers permit a division of the Starlings into three groups: adult ♂♂, adult ♀♀ + first-year ♂♂, and first-year ♀♀. It is possible to explain this tripartition by an analysis of variance. By this analysis sex and age effects appeared to be equal: in adult ♀♀ it is only sex that counts and in first-year ♂♂ only age. Therefore it is impossible to separate these two groups.

The length of the bill appeared to be the only character which was not influenced by age or sex.

While, according to many authors, a division into four groups is possible in autumn with the help of qualitative characters, such a division is impossible in March. It is shown that only adult ♂♂ have an uniform plumage.

It is striking that while the young Starlings are clearly developing an adult exterior, various cases of a not completely ossified skull still occur.

By using a new method we could study quantitatively the amount of black colour on the bill and the surface of the non-ossified part of the skull.

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