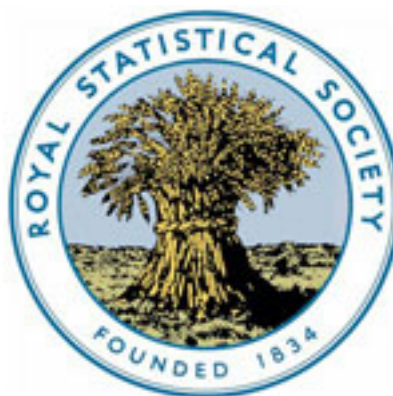


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FEBRUARY, 1914.

The FERTILITY of MARRIAGE in SCOTLAND : a CENSUS STUDY. BY
JAMES CRAUFURD DUNLOP, M.D., F.R.C.P. Edin., *Superintendent*
of the Statistical Department of the Office of the Registrar-General
for Scotland.

[Read before the Royal Statistical Society, January 20, 1914,
the President, Professor F. Y. EDGEWORTH, M.A., F.B.A., in the Chair.]

I THINK I am right in asserting that it was principally on the initiative of this Society that questions relative to the fertility of marriage were inserted in the householders' schedules of the recent census, and the fertility of marriage thereby made a subject of censal study. Under these circumstances I feel that I am not called on to make any preliminary remarks either in defence of the interest or importance of the subject, or in defence of my asking you to give me a hearing.

I shall endeavour firstly to explain the methods of tabulation employed for the purposes of this study in Scotland, and secondly to indicate some of the more interesting results. I feel that it is unnecessary in this paper to reproduce the lengthy tables which were prepared for the Third Volume of Report on the Twelfth Census of Scotland (Cd-7163), as that volume is now published, and the tables are available to all interested. The tables I include in this paper—Tables XIV to XVIII excepted—are merely short abstracts of those appearing in the Census Report.

The tabulation of facts regarding the fertility of marriage.

The tabulation of the censal information regarding the fertility of marriage has been no simple task, but a complex one, and was so partly on account of the number of variables concerned and partly on account of the wide limits through which each varies. The primary

tabulation was concerned with four of these, three being independent, and one dependent. They are :—

(1) The number of children in the families. This is the dependent variable, and facts regarding it were directly obtained from the householders' schedules, the figures being those given in answer to the question regarding the number of children born, no matter whether alive at the census date or not. The reported sizes of families extended up to 20 children, and in a few exceptional cases beyond that figure. The largest families reported were 3 of 21 children, 4 of 22 children, 1 of 23 children, and 1 of 25 children. In some instances, not many, the information regarding the number of children in the householders' schedules was palpably incorrect and indicative of confusion, and when this was so the marriages were excluded from the tabulation. These were mostly cases where recently married women or women married late in life, were reported to have had families of considerable size, there having been included in the family of the existing marriage either children of a previous marriage or children born before marriage.

(2) The age of the wife at marriage. This variable was not directly reported on the schedules but was ascertainable by deducting the years of duration of marriage from the age at census date of the wife. This being a study of the fertility of marriage it was useless to include in it any marriage in which the women were past child-bearing age at the time of marriage, and consequently all marriages in which the wives were aged 45 or over at that time were excluded. This limit is no doubt arbitrary, and may not be in absolute harmony with physiological fact, but is defensible as being a good working limit, for childbirth after that age is so far exceptional that the inclusion of such marriages would mask rather than show normality.

(3) The age of the husband at marriage. This age, like that of the wife, was not directly reported, but was ascertainable by a comparison between the age at the time of the census and the durations of the marriage. A certain number of marriages had to be excluded from the study by reason of the absence of this information, as was the case when the husband was not enumerated on the same schedule as the wife on account of temporary, or permanent, absence from home on census day.

(4) The duration of marriage. Facts regarding this variable were directly reported on the schedules.

The total number of married women enumerated in Scotland was 762,835, and the total number of marriages dealt with in this study was 686,684, 76,151 being the total number excluded for one

or other of the before-mentioned reasons. The included marriages amount to fully 90 per cent. of the maximum possible, and may be accepted as being thoroughly representative of what exists in the country.

The Hollerith system of card sorting and card counting was used for the tabulation. The reported facts regarding each of the 686,684 marriages were by suitable perforations recorded on specially prepared cards, and these cards were mechanically sorted into groups and afterwards counted, the numbers being recorded in a tabular manner.

In the principal tabulation, that dealing with the correlations between the three independent variables and the one dependent variable, the cards were first sorted by the years of duration of marriage into groups. These groups were afterwards subdivided first by the age of the wife at marriage, and afterwards by that of the husband. In this manner groups homogeneous so far as the independent variables are concerned were obtained, and these groups were counted by the number of children in the families. This tabulation was very lengthy and complex, and this was so on account of the large number of combinations of the variables, these combinations amounting approximately to 25,000. So lengthy was this tabulation that its publication in full in the Census Report was not practicable, and recourse to publication by abstract was necessitated. (Sample sheets of the original tabulation exhibited.) Although this original tabulation is not published it is not lost for purposes of study and research, for the sheets will be preserved in the Office of the Registrar-General of Scotland, and will be available for study or abstraction to any interested.

The contingency tables of this first tabulation gave for each combination of duration and age of wife the number of children in the families in correlation to the age of the husband. Having this, the next step was to transcribe the entire tabulation, collecting on the sheets facts regarding the families of each combination of duration and age of husband, and showing the correlation between the age of wife and number of children. This second series of tables (sample exhibited) was also too long for publication.

From these two sets of tables those published in the Third Volume of the Census Report were abstracted, the principle of abstraction being the elimination of first one variable, then another, and lastly a third. For instance, in Table XXXIII of the Report, figures are given which show for each year's duration of marriage the numbers of families of specified sizes resulting from the marriages of women of specified ages without taking any cognizance of the

ages of the husbands, and Table XXXIV gives similar information for marriages of specified ages of husband without cognizance of the ages of wives. In Table XXXII the size of family is the variable eliminated, it being replaced by a mere statement of the average size of family resulting from the marriages of persons of specified ages after specified durations. By a continuation of this process of elimination short general summary tables, which include all the marriages of the study, were produced.

For special purposes further tabulations were made and will be referred to later in this Paper, but it is here convenient to refer to one of them. This consisted in the division of all the reported marriages into two classes, the one including all marriages in which the wife had on census day attained age 45 and in which the fertile period was complete, and the other including all marriages in which the wives had not attained that age and in which the fertility was a continuing quantity. The statistical facts regarding each of these classes were separately abstracted. In the case of marriages of completed fertility the tabulation was comparatively simple for it was concerned with two independent variables only, the ages of the wives and husbands at the time of marriage, but the tabulation for the marriages of continuing fertility was more complex for the third independent variable, the duration of the marriage, was additional. Tables XXXV to XLV of the third volume of the Census Report deal with the statistics of these two classes.

Before passing on to describe the influence of the independent variables, the ages of the parents and the duration of the marriages, on the number of children born, it is convenient to briefly refer to two statistical methods used in studying the figures of the above-quoted groups of marriages for the purpose of ascertaining the influence of each varying factor, and for the purpose of constructing fertility tables capable of predicting the probable fertility of marriage in the same manner as life tables predict the probable duration of life. The first method used for this purpose was that of multiple correlation, the actual working being carried out as described in Mr. Udny Yule's book entitled *An Introduction to the Theory of Statistics*. The resulting coefficients, regressions and formulæ are published in Appendix I of the third volume of the Census Report. This method, however, was found not to be entirely satisfactory for the purpose on account of some non-linearity of regressions, and though the figures obtained no doubt give a fair approximation, they were found to be not sufficiently accurate for the purposes of the construction of fertility tables. A method of calculating multiple correlations from non-linear regression was required,

and this being a matter of great difficulty, was not attempted in the Census Office, but was referred to Mr. George Rae, B.Sc., Assistant to the Professor of Mathematics in Aberdeen University, and the problem was worked out by him. He devised the necessary method and applied it to the two classes of marriages referred to above, those of continuing and of completed fertility. I shall refer presently to his results, but I shall make no attempt either to demonstrate or to prove his method, for he has done these for himself in a memorandum which is appended (Appendix II) to the Census Report. Tables XXXVIII and XLV of that report consist of predicted fertility figures prepared by him, Table XXXVIII dealing with completed, and Table XLV with continuing fertilities.

Results of the study.

Size of family.—This is best studied from the tabulation of the group of marriages of completed fertility. The number of marriages included in this group is 239,943, and as the children born to them number 1,316,995, the average family amounts to 5.49 children.

The following table (Table I) shows the number of families of specified sizes found in this group of marriages, and the percentage these families form of the total. In it there may be seen that of the 239,943 marriages of completed fertility, 27,478, or 11.5 per cent., were sterile, while children were born to 212,465, or 88.5 per cent. Marriages to which only one child was born constituted 5.9 per cent. of the total, which proportion was 7.0 per cent. in the case of

TABLE I.—*Number of children to marriages in which the fertile period is complete.*

Number of children in family.	Number of families.	Per cent. of total.	Number of children in family.	Number of families.	Per cent. of total
0	27,478	11.5	14	1,667	0.7
1	14,100	5.9	15	657	0.3
2	16,910	7.0	16	293	0.1
3	19,648	8.2	17	132	0.1
4	21,759	9.1	18	53	0.0
5	22,189	9.2	19	19	0.0
6	22,529	9.4	20	6	0.0
7	21,316	8.9	21	3	0.0
8	20,229	8.4	22	4	0.0
9	17,529	7.3	23	1	0.0
10	14,129	5.9	24	0	0.0
11	9,681	4.0	25	1	0.0
12	6,299	2.6			
13	3,311	1.4	Total	239,943	100.0

families of 2 children, 8.2 per cent. in the case of families of 3 children, 9.1 per cent. in the case of families of 4 children, 9.2 per cent. in the case of families of 5 children, and reaching a maximum of 9.4 per cent. in the case of families of 6 children. With increasing numbers of children in the family this proportion falls; it is less than 8 per cent. for 9 children, less than 6 per cent. for 10 children, less than 3 per cent. for 12 children, and less than 1 per cent. for 14 children. Twenty or more children were born to only fifteen of these marriages, or approximately once in 16,000 marriages.

Order of birth.—The tabulation of marriages by the number of children in the family enables calculations to be made as to what proportion of children are first-born children, what proportion second-born, and so on, and figures relative to this are collected in Table II. In it two sets of figures are given, the one derived from the tabulation of all marriages existing and enumerated at the census, and the other exclusively to those marriages in which the fertile period had then been completed. Taking the children born to all existing marriages, it is found that 21.6 per cent. are first-born children; 18.4 per cent., second children; 15.0 per cent., third children; 12.1 per cent., fourth children; 9.5 per cent., fifth children; and 7.3 per cent., sixth children. Eleventh children constitute 1.0 per cent. of the total, and from there onwards the proportions rapidly decline, twelfth children constituting 0.6 per cent.; fifteenth children, 0.05 per cent.; and twentieth children, 0.001 per cent. When these proportions are studied among the children of marriages of completed fertility it is found, as might be expected, that those of the earlier-born children are less while those of the later-born children are more. For instance, first children constitute only 16.1 per cent.; second children, 15.1 per cent.; and third children, 13.8 per cent., all of which are less than found among the children of all existing marriages, while the proportion constituted by fourth children is little different—12.3 as against 12.1 per cent.—and that constituted by fifth-born children is 10.6 per cent.; by tenth-born children, 2.8 per cent.; and by fifteenth-born children, 0.09 per cent., all of which are greater than among the children of all existing marriages. Taking the children of all existing marriages, it is found that the chance, or odds in favour, of a person or child being born not later than a second child is 40 to 60; not later than a third, 55 to 45; not later than a fourth, 67 to 33; not later than a fifth, 77 to 23; not later than a sixth, 84 to 16; not later than a seventh, 89 to 11; not later than an eighth, 93 to 7; not later than a ninth, 96 to 4; not later than a tenth, 98 to 2; and not later than an eleventh, 99 to 1.

TABLE II.—*Order of birth of children.*

Order of child in family.	Marriages of completed fertility.		All marriages* existing on census day.	
	Number of children.	Per cent. of total.	Number of children.	Per cent. of total.
1st	212,465	16·133	588,857	21·584
2nd	198,365	15·062	501,624	18·386
3rd	181,455	13·778	410,381	15·042
4th	161,807	12·286	328,845	12·053
5th	140,048	10·634	258,852	9·488
6th	117,859	8·949	200,115	7·335
7th	95,330	7·238	150,312	5·510
8th	74,014	5·620	109,137	4·000
9th	53,785	4·084	74,911	2·746
10th	36,256	2·753	48,144	1·765
11th	22,127	1·679	28,302	1·037
12th	12,446	0·945	15,474	0·567
13th	6,147	0·467	7,452	0·273
14th	2,836	0·215	3,396	0·125
15th	1,169	0·089	1,395	0·051
16th	512	0·039	599	0·022
17th	219	0·017	258	0·009
18th	87	0·007	104	0·004
19th	34	0·002	41	0·002
20th	15	0·001	17	0·001
21st	9	0·001	9	0·000
22nd	6	0·000	6	0·000
23rd	2	0·000	2	0·000
24th	1	0·000	1	0·000
25th	1	0·000	1	0·000
Total	1,316,995	—	2,728,235	—

* Some marriages were excluded from all these tabulations, vide text.

Influence of woman's age at marriage on size of complete family.—

This is shown both directly by the tabulation, and also indirectly by the results obtained by the correlation studies. The average number of children, as already stated, in the completed families was found to be 5·49. When the woman at the time of marriage was young the average family is found to be greater than this, but when she is older at that time it is found to be less. Thus marriages in which the wives were aged 17 at the time of marriage are found to produce families averaging 9·02 children, while that average in the case of women marrying at 40 is less than one child. At age 20 this average is 7·86; at age 25, 5·66; at age 30, 3·89; at age 35, 2·29; and at age 40, 0·86. By the application of the method of simple correlation (linear) it is found in the case of these marriages of completed fertility that the regression equation is

$$C = 14·724 - 0·355 W,$$

where C = the number of children in the family, and W = the age

of the wife at marriage. This equation indicates that the effect of one year's delay of marriage is to reduce the average family by fully one-third of child, or that three years' delay may be expected to result in the family being one child less. This result may be fairly correct in general, but it cannot be strictly applied, for the crude observations show that the effect of one year's delay is not constant throughout the fertile period of the woman's life, but is greater for the younger and less for the older ages. Thus a year's delay when the woman is aged from 20 to 25 averages 0.45 of a child, 0.37 when she is aged 25 to 30, 0.32 when she is aged 30 to 35, 0.29 when she is aged 35 to 40, and 0.19 when she is aged 40 to 45.

TABLE III.—*Age of wife at marriage and average size of complete family.*

Age of wife at marriage.	Average children in family.		
	Observed.	Graduated.	
		Linear regression.	Curve of second degree.
17	9.02	8.69	9.14
18	8.66	8.33	8.68
19	8.30	7.98	8.23
20	7.86	7.62	7.78
21	7.41	7.27	7.35
22	6.98	6.91	6.93
23	6.52	6.56	6.51
24	6.07	6.20	6.10
25	5.66	5.85	5.71
26	5.28	5.49	5.32
27	4.92	5.14	4.95
28	4.56	4.78	4.58
29	4.21	4.43	4.22
30	3.89	4.07	3.87
31	3.58	3.72	3.54
32	3.16	3.36	3.21
33	2.93	3.01	2.89
34	2.63	2.65	2.58
35	2.29	2.30	2.28
36	1.93	1.94	1.99
37	1.64	1.59	1.71
38	1.38	1.23	1.44
39	1.18	0.88	1.18
40	0.86	0.52	0.93
41	0.66	0.17	0.68
42	0.50	—	0.45
43	0.31	—	0.23
44	0.22	—	0.02

Influence of age of husband at marriage on average size of family.—

This also may be studied in the group of marriages of completed fertility, and a scrutiny shows that the younger the husband

at the time of marriage the larger is the average number of children born to the marriage. The average family of all these marriages amounts to 5.49 children. For marriages of men, or boys, aged 18 this average is 8.25, and gets less and less as the age of the husband increases. It falls below 8 when the husband is aged 20, below 7 when he is aged 23, below 6 when he is aged 26, below 5 when he is aged 30, below 4 when he is aged 34, below 3 when he is aged 39, below 2 when he is aged 46, and below 1 when he is aged 54. The apparent effect of a year's delay of marriage when the man's age is between 20 and 25 averages 0.34 of a child; when he is aged 25 to 30, 0.27; when he is aged 30 to 35, 0.23; when he is aged 35 to 40, 0.24; when he is aged 40 to 45, 0.15; when he is aged 45 to 50, 0.12; when he is aged 50 to 55, 0.09; and when he is aged 55 to 60, 0.04. The influence of delay is thus a decreasing quantity as the husband's age advances.

TABLE IV.—*Age of husband at marriage and average size of complete family.*

Age of husband.	Average children in family.		Age of husband.	Average children in family.	
	Observed.	Graduated (linear regression).		Observed.	Graduated (linear regression).
17	8.11	8.02	35	3.66	3.95
20	7.85	7.34	38	2.94	3.28
23	6.82	6.67	41	2.52	2.60
26	5.83	5.99	44	2.06	1.92
29	5.06	5.31	47	1.74	1.24
32	4.33	4.63	50	1.36	0.56

The above figures indicate a high correlation between the age of the husband at marriage and the number of children born to the marriage, one not much less than is found between the age of the wife at marriage and the number of children—calculation shows that in the case of the wife this correlation is approximately 0.58, and in the case of the husband, 0.44—and it is not without interest to find out how much of this high correlation is due to the well-known existence of a high correlation between the ages of the husband and wife at the time of marriage—found in this study to be 0.71—and how much due directly to decreasing procreative power of man with advancing years. This problem is answered by multiple correlation formula. Let C = the average number of children born, W = the age of the wife at marriage, and H = the

age of the husband at marriage, and the influence of the two variables W and H on C is shown by the following three formula (calculated from lineal regressions)—

$$C = 14.72 - 0.355 W$$

$$C = 11.68 - 0.226 H$$

$$C = 14.889 - 0.332 W - 0.028 H$$

A comparison between these three formulæ shows that when the influence of the husband's age is separated from that of the wife's age the influence of the latter is little reduced, but when the influence of the wife's age is taken away from that of the husband's age the effect is much greater, for the influence of the husband's age is thereby reduced by approximately nine-tenths. From the multiple correlation formula it may be gathered that a delay of three years on the part of the wife reduces the average size of the family approximately by one child, and that it requires a delay of something like forty years on the part of the husband to effect the same reduction.

The influence of duration of marriage on the size of the family.—

To study this the figures of the tabulation of marriages of continuing fertility—i.e., those in which the wife has not attained age 45—must be considered. These marriages number 440,741, and as the total number of children born to them is 1,411,240, the average family is found to amount to 3.20 children. As might be expected, the average size of family increases as the duration of marriage increases. In the third year of married life children in the family average 1.03; in the sixth year, 2.03; in the tenth year, 3.43; in the fourteenth year, 4.26; in the seventeenth year, 5.06; in the twenty-first year, 6.23; in the twenty-fourth year, 7.25; in the twenty-seventh year, 8.20; and in the thirtieth year, 9.04. These years of duration apply exclusively to fertile years, which are years of marriage previous to attainment of age 45 by the wife, and take no cognizance of the continuation of marriage after that date. The increases of these averages by all years of durations are not equal; they are relatively large in the early years, fall as the duration increases, and increase again with the longest durations. Thus the additions to the average size of family caused by the first five years of duration of married life average 0.35; those of the second five years of married life, 0.29; of the third five years, 0.26; of the fourth five years, 0.31; and of the fifth five years, 0.35.

TABLE V.—*Showing average size of family for specified age of wife at marriage at specified durations of marriage.*

Age of wife at marriage.	Duration of marriage.							
	3.	6.	9.	12.	15.	18.	21.	24.
17	1·65	2·84	3·95	4·84	5·63	6·81	7·46	8·48
20	1·72	2·78	3·71	4·74	5·52	6·07	7·00	7·20
23	1·48	2·48	3·24	4·08	4·72	5·34	5·76	—
26	1·32	2·23	2·99	3·52	3·98	4·57	—	—
29	1·21	2·03	2·53	3·05	—	—	—	—
32	1·10	1·89	2·42	2·72	—	—	—	—
35	0·91	1·35	1·94	—	—	—	—	—
38	0·64	1·15	—	—	—	—	—	—
41	0·23	—	—	—	—	—	—	—
All ages	1·39	2·29	3·06	3·75	4·33	4·89	5·42	5·76

Giving C, W and H, the same significances as in the previously quoted formulæ, and letting D = the years of duration of marriage, the following are the linear regression formulæ showing the influence of the duration on the size of family:—

$$\begin{aligned}
 C &= 0.338 + 0.291 D \\
 &= 2.862 - 0.095 W + 0.268 D \\
 &= 1.968 - 0.057 H + 0.280 D \\
 &= 2.968 - 0.076 W - 0.024 H + 0.272 D.
 \end{aligned}$$

From these formulæ it will be seen that the calculated influence of one year of marriage is to raise the average by approximately 0.29 of a child, or, in other words, that the birth of three children may be expected on an average in each ten years of duration. It may also be seen that the effect of duration is largely a direct one and is little affected by the elimination of the influences of the ages of the parents at the time of marriage; when calculated by simple correlation the effect of one year's duration is found to be 0.29, and when calculated by multiple correlation, and the influences of the ages of the parents at marriage separated, that amount is only reduced to 0.27.

Fertility tables.—Tables for predicting the most probable fertility of marriage, or more strictly for predicting the most probable average fertility of a number of similar marriages, in the same manner as a life-table may be used for predicting the most probable duration of life, have been constructed by Mr. Rae and are incorporated in the Census Report. Short abstracts of these tables are given below. (Tables VI and VII.) These fertility tables are two in number, the one giving the most probable size of the complete family in correlation with the ages of the husband and

TABLE VI.—*Predicted fertility of marriage for selected ages of wife and husband. Complete families.*[Abstracted from Mr. Rae's table (xxxviii) in *Census Report*.]

Age of husband.	Age of wife.								
	17.	20.	23.	26.	29.	32.	35.	38.	41.
17	9.58	8.24	6.85	5.41	3.92	2.38	0.79	—	—
20	9.31	8.09	6.82	5.49	4.12	2.69	1.20	—	—
23	8.99	7.88	6.72	5.51	4.25	2.93	1.57	0.15	—
26	8.60	7.61	6.56	5.46	4.31	3.11	1.86	0.56	—
29	8.15	7.27	6.34	5.35	4.32	3.23	2.10	0.91	—
32	7.63	6.87	6.05	5.18	4.26	3.29	2.27	1.19	0.07
35	7.06	6.40	5.70	4.95	4.14	3.28	2.37	1.41	0.40
38	6.42	5.88	5.29	4.65	3.96	3.21	2.42	1.57	0.67
41	5.71	5.29	4.81	4.29	3.71	3.08	2.39	1.67	0.88
44	4.95	4.64	4.27	3.86	3.40	2.88	2.32	1.70	1.03
47	4.12	3.92	3.67	3.38	3.03	2.63	2.17	1.67	1.11
50	3.23	3.14	3.01	2.83	2.59	2.30	1.97	1.58	1.14

wife at the time of marriage, and the other the most probable size of family after varying numbers of years of marriage between husbands and wives of equal age. The second table is supplemented by a formula for adjusting the figures for any difference of age there may be between the husbands and wives. In the short tables given, only figures relative to every third year of age and every third year of duration are given; but in the original tables, those in the Census Report, figures for all years are shown.

The formulæ used by Mr. Rae in the construction of these tables were as follows, the first being that used for the construction of the table of completed fertility, and the second for the table of continuing fertility:—

$$C_{WH} = 20.149493 - .555812 W - .173804 H \\ - .002846 W^2 - .003494 H^2 + .012675 WH.$$

$$C_{WHD} = 6.571791 - .297399 W - .087090 H + .314894 D \\ + .004307 W^2 + .000955 H^2 - .002118 D^2.$$

The quantity to be added to the numbers in the table of continuing fertility, for differences of age between husbands and wives, is:—

$$(H-W) \{- .087090 + .000955 (H + W)\}.$$

The figures in these tables are found to correspond fairly closely with the crude figures of the observations, and have the advantage over them of smoothness, the oscillations constantly associated with crude figures of observation having been eliminated. Reading the figures of these tables would to a large extent be a repetition of

what I have already tried to demonstrate, for they deal with the same statistical facts as those already considered. They show, for instance, the greater influence of the wife's age than of the husband's age on the average size of the family; they show the varying influence of delay of marriage; and they show other facts already drawn attention to.

TABLE VII.—*Predicted fertility of marriage at end of specified durations, ages of husband and wife being the same.*

[Abstracted from Mr. Rae's table (xlv) in *Census Report*.]

Years of duration of marriage.	Age of wife and husband.								
	17.	20.	23.	26.	29.	32.	35.	38.	41.
1	2.02	1.45	0.98	0.60	0.31	0.12	0.03	0.03	0.12
4	2.93	2.36	1.89	1.51	1.22	1.03	0.93	0.93	1.03
7	3.80	3.23	2.75	2.37	2.09	1.90	1.80	1.80	—
10	4.63	4.06	3.59	3.21	2.92	2.73	2.63	—	—
13	5.42	4.85	4.38	4.00	3.71	3.52	—	—	—
16	6.18	5.61	5.13	4.75	4.47	—	—	—	—
19	6.89	6.32	5.85	5.47	—	—	—	—	—
22	7.57	7.00	6.53	—	—	—	—	—	—
25	8.21	7.64	—	—	—	—	—	—	—
28	8.81	—	—	—	—	—	—	—	—

Sterile marriages.—Of the 239,943 marriages in which the fertile period was complete at the date of the census, 27,478, or 11.5 per cent., were sterile, and 212,465, or 88.5 per cent., were fertile. The percentage of marriages found to be completely sterile varies with the age of the wife at marriage, the older that age the higher being the rate. Among marriages in which the wife is aged 17 to 19 at the time of marriage this rate is found to be less than 3 per cent.; when that age is 22 or less the rate is less than 5 per cent.; for age of wife at marriage 25, the rate is 7 per cent.; for age 28, 10 per cent.; for age 30, 13 per cent.; for age 35, 25 per cent.; for age 40, 57 per cent.; and for age 43, more than 80 per cent.

For studying the question of the chance of fertility of marriage after specified periods of sterility recourse to averaging marriages of several years of age of the wife was found to be necessary, for, on account of comparative paucity of numbers, figures dealing with single years of that age were found to oscillate too much to show conclusions. Marriages of continuing fertility, and which were of wives who at the time of marriage were aged 20 to 25, were selected for this purpose, and in all numbered 245,221.

TABLE VIII.—*Proportion of fertile and sterile marriages by age of wife at marriage.*

Age of wife at marriage.	Fertile marriages.		Sterile marriages.	
	Number.	Per 100.	Number.	Per 100.
17	2,846	97·4	77	2·6
18	6,213	97·7	149	2·3
19	10,574	97·0	324	3·0
20	17,420	96·4	646	3·6
21	17,634	96·4	663	3·6
22	18,748	95·6	859	4·4
23	18,439	94·9	983	5·1
24	17,693	94·3	1,077	5·7
25	16,279	93·3	1,178	6·7
26	14,042	92·5	1,134	7·5
27	12,232	91·3	1,167	8·7
28	10,439	90·2	1,129	9·8
29	8,454	88·4	1,113	11·6
30	7,920	87·2	1,165	12·8
31	5,796	86·6	896	13·4
32	5,048	83·1	1,024	16·9
33	4,239	81·3	976	18·7
34	3,561	79·0	949	21·0
35	3,103	75·3	1,019	24·7
36	2,552	70·5	1,067	29·5
37	2,039	66·0	1,052	34·0
38	1,676	58·6	1,182	41·4
39	1,359	54·5	1,134	45·5
40	1,031	42·9	1,370	57·1
41	689	35·7	1,242	64·3
42	486	27·2	1,302	72·8
43	279	18·4	1,238	81·6
44	213	14·0	1,312	86·0

Of these marriages, those of women aged 20 to 25, 73·3 per cent. were found to be childless when the duration was reported to be less than one year, 36·7 when it was reported to be more than one but less than two years, 15·9 when more than two but less than three years, 10·6 when more than three but less than four years, and less than 10 per cent. when the duration exceeded four years. In each thousand of these marriages a first child was born during the first year in 267 instances; during the second year in 366, during the third year in 208, during the fourth year in 53, during the fifth year in 15, and during each subsequent year in 10 or less.

Of a thousand marriages childless at the end of the first year, 500 are found to become fertile before the end of the second year, and of each 1,000 childless at the end of the second year, 566 become fertile before the end of the third year. After the third year this proportion falls; the proportion of previously childless wives

having children during the fourth year is 334 per 1,000; during the fifth year 141 per 1,000; during the sixth year, 80 per 1,000; and less in the ninth and tenth years. In Table IX, where the chances of birth among childless women after varying durations of marriage are shown, oscillations in some of the later years are evident; these oscillations are probably not significant of real differences, but attributable to paucity of observation.

TABLE IX.—*Showing chance of fertility during first ten years of married life.*

Year of marriage.	Per 100,000 marriages.		Childless at beginning of year but subsequently fertile.	Chance of 1st birth during year.	Chance of 1st birth during year or later.
	Sterile at beginning of year.	Fertile at end of year.			
1st	100,000	26,700	94,702	·267	·947
2nd	73,300	63,314	68,002	·500	·928
3rd	36,686	84,073	31,388	·566	·856
4th	15,927	89,398	10,629	·334	·667
5th	10,602	90,891	5,304	·141	·500
6th	9,109	91,621	3,811	·080	·418
7th	8,379	92,636	3,081	·121	·368
8th	7,364	93,288	2,066	·089	·281
9th	6,712	93,603	1,414	·047	·211
10th	6,397	94,040	1,099	·068	·172
Subsequent years	5,960	94,702	662	—	·111

From the same set of figures the chances of fertility after a childless period of marriage at any subsequent time may be calculated. The chance of fertility at the time of marriage among women of these ages is found to be 0·947; at the commencement of the second year, or, for it is the same, at the end of the first year, it is 0·928; at the end of the second year, 0·856; at the end of the third year, 0·667; at the end of the fourth year, 0·500; at the end of the fifth year, 0·418; at the end of the sixth year, 0·368; at the end of the seventh year, 0·281; at the end of the eighth year, 0·211; at the end of the ninth year, 0·172; and at the end of the tenth year, 0·111. Thus the probability of a child after a childless period in these marriages is more than a level chance when the marriage has not lasted for more than four years, but after the expiry of four years it is less than a level chance, and steadily decreases as the duration increases.

Occupational fertilities.—This term is adopted to describe the fertility of groups of marriages associated with particular occupations, or groups of occupations, of the husbands. For the studying

of it recourse was had to sampling, as a full tabulation for the fertilities of each occupation, such as was made of all marriages, by reason of length and complexity, was practically an impossibility. The samples taken from the tabulation cards of each occupation included all marriages in which the wives were aged at the time of marriage more than 22 but less than 27, and of which the durations were at least fifteen years. This group of ages was selected because it includes the years of age most frequently associated with the marriage of women. The limit of fifteen years' duration was taken to exclude the majority of marriages to which the complete families had not been born, and to include the majority of those to which the complete families were born. Stricter limits might have been taken, but by seriously reducing numbers they would not have been entirely advantageous. In all 133,960 marriages, and 779,301 children were dealt with in this tabulation. These were divided into 142 occupational groups. The average family in all these selected marriages is 5.82.

For each occupational group the number of families of each size of family was counted, and from the figures thus got the total number of children in each of the occupational groups, and the average number of children in all the marriages of the groups, were calculated.

Although in some of the occupational groups the number of marriages dealt with was large, this was not always so, and some method of differentiating significant differences from differences due to sampling variations was necessary. The method adopted for this was to ascertain the differences of the mean size of family of all the marriages included in the study and of the marriages in the groups, and only to accept differences as significant when the amounts were at least three times as great as their probable errors. The formula used for calculating the probable errors of the differences between these means was—

$$e = 0.6745 \sqrt{\frac{\Sigma^2}{N} + \frac{\sigma^2}{n} \left(1 - \frac{2n}{N}\right)}$$

where Σ = the standard variation of the general mean, σ = the standard variation of the mean of the group, N = the number of marriages in the study, and n = the number of marriages in the group.

By the use of this test the occupational groups were divided into three classes, those with an average family significantly greater than the general mean, those with an average family neither significantly greater nor significantly less than the general mean, and those with an average family significantly less than the general mean.

Figures relative to the whole 142 groups are published in the Census Report, but for brevity here I only reproduce figures relative

to the average family of those occupational groups of which that average is significantly large, or significantly small, omitting all reference to the numbers of families of specified size, and figures relative to the average families of those groups of which the averages are not significantly different from the general mean.

TABLE X.—Occupational fertilities. Showing occupational groups with fertilities significantly greater and significantly less than the general mean.

Occupations or occupational groups.	Number of marriages.	Mean number of children.	Standard variation.	Difference from general mean ($m-M$)	Probable error of difference (e)	Ratio: $\frac{m-M}{e}$
1. Occupations in which fertility is significantly greater than the general mean.						
Crofters	2,669	7.04	2.9228	1.22	0.0382	31.94
Plasterers' labourers	96	7.01	3.1507	1.19	0.2169	5.49
Coal, shale and ironstone miners	9,182	7.01	3.0882	1.19	0.0213	55.87
Old age pensioners (occupation not stated)	203	6.95	3.3058	1.13	0.1563	7.23
Fishermen-crofters	722	6.93	2.6754	1.11	0.0671	16.54
Coalheavers, coal porters, labourers.....	262	6.61	3.2786	0.79	0.1364	5.79
Glaziers	72	6.49	2.7333	0.67	0.2173	3.08
Agricultural labourers, farm servants	4,063	6.42	3.0467	0.60	0.0324	18.52
Coal, shale, &c., mine owners, agents, managers	251	6.41	2.8820	0.59	0.1227	4.81
Fishermen	2,887	6.41	3.1020	0.59	0.0387	15.25
Ship-platers and other workers (in iron)	1,442	6.38	3.0697	0.56	0.0544	10.29
Stone, slate miners, dressers, quarriers	1,104	6.38	3.0951	0.56	0.0629	8.90
Shepherds	928	6.35	3.0176	0.53	0.0668	7.93
Navvies, mine sinkers, road labourers.....	1,147	6.33	3.1812	0.51	0.0629	8.11
Builders', bricklayers', masons' labourers	740	6.31	3.1792	0.49	0.0786	8.11
General labourers	2,092	6.29	3.3000	0.47	0.0482	9.75
Iron and steel manufacture	1,994	6.26	3.0398	0.44	0.0457	9.63
Others in agriculture	352	6.25	3.0346	0.43	0.1092	3.94
Scavenging and disposal of refuse	266	6.23	3.2112	0.41	0.1325	3.09
Manufacturing chemists	374	6.21	2.9550	0.39	0.1029	3.79
Farmers, graziers	4,846	6.20	3.0701	0.38	0.0294	12.93
Dock, quay labourers	1,109	6.19	3.2539	0.37	0.0658	5.62
Plasterers	353	6.17	2.9512	0.35	0.1014	3.45
Retired from business (not army or navy)	5,772	6.17	3.3719	0.35	0.0294	11.90
Builders, bricklayers, masons	2,513	6.16	2.9816	0.34	0.0399	8.52
Farm—grieves, foremen	1,285	6.16	2.9799	0.34	0.0540	6.30
Engine—drivers, stokers, &c. (not railway or marine)	1,474	6.15	3.0610	0.33	0.0535	6.17
Ironfounders	2,367	6.08	3.0696	0.26	0.0426	6.10
Blacksmiths, strikers	2,609	6.00	3.0596	0.18	0.0405	4.44
Road transport service.....	4,818	5.91	3.0214	0.09	0.0294	3.06

TABLE X.—*Occupational fertilities.—Contd.*

Occupation or occupational groups.	Number of marriages.	Mean number of children.	Standard variation.	Difference from general mean ($m-M$)	Probable error of difference (e)	Ratio : $\frac{m-M}{e}$
2. Occupations in which fertility is <i>significantly less</i> than the general mean.						
Tailors; dress, stay, shirt makers	1,966	5.68	3.0711	-0.14	0.0467	3.00
Carpenters, joiners	3,599	5.62	2.8959	-0.20	0.0324	6.17
Railway service	5,078	5.59	2.9732	-0.23	0.0278	8.27
Painters, paperhangers, decorators	1,297	5.57	3.0215	-0.25	0.0564	4.52
Erectors, fitters, turners	1,758	5.54	2.9275	-0.28	0.0467	6.00
Flax, linen manufacture	625	5.52	3.0116	-0.30	0.0812	3.69
Butchers, fishmongers, game dealers	1,221	5.49	2.9917	-0.33	0.0576	5.21
Plumbers, gasfitters	1,043	5.45	2.9107	-0.37	0.0607	6.10
Labourers and other or undefined workers in engine and machine making	2,936	5.45	2.9390	-0.37	0.0405	9.14
Manufacture of mixed or unspecified textile materials	923	5.44	2.9565	-0.38	0.0654	5.81
Furniture makers, dealers	1,402	5.44	2.9932	-0.38	0.0540	7.04
Insurance agents	620	5.34	3.0893	-0.48	0.0837	5.73
Police	642	5.33	2.7544	-0.49	0.0727	6.74
Stationery manufacture, paper bag makers, workers in paper	128	5.33	2.6958	-0.49	0.1607	3.05
Pattern makers	375	5.32	2.8161	-0.50	0.0977	5.12
Waiters (not domestic)	123	5.24	2.9825	-0.58	0.1814	3.20
Coppersmiths	103	5.24	2.9034	-0.58	0.1930	3.01
Domestic outdoor service	2,598	5.20	2.8855	-0.62	0.0381	16.27
Greengrocers, fruiterers	329	5.19	3.2378	-0.63	0.1154	5.46
Hairdressers	226	5.15	2.8519	-0.67	0.1340	5.00
Wool and worsted manufacture	1,037	5.14	2.9232	-0.68	0.0553	10.33
Indiarubber, guttapercha workers	206	5.12	2.9190	-0.70	0.1373	5.10
Municipal, parish and other local or county officers	668	5.07	3.0054	-0.75	0.0784	9.57
Postmen, other Civil Service messengers	563	5.06	2.8485	-0.76	0.0704	10.80
Dealers in hardware, metals, machines	488	5.03	3.0867	-0.79	0.1315	6.01
Barmen, cellarmen	248	4.99	2.7460	-0.83	0.1176	7.06
Land, house, ship surveyors	57	4.98	2.8322	-0.84	0.2530	3.32
Electric fitters, electricians (undefined)	276	4.97	2.8633	-0.85	0.1162	7.31
Caretakers, &c. (not Government)	498	4.96	3.2848	-0.86	0.0992	8.67
Others connected with education	203	4.94	3.1083	-0.88	0.1472	5.98
Eating-house, boarding-house keepers	146	4.90	2.9856	-0.92	0.1666	5.52
Grocers; tea, coffee, provision dealers	1,772	4.87	2.6289	-0.95	0.0421	22.57

TABLE X.—Occupational fertilities.—Contd.

Occupations or occupational groups.	Number of marriages.	Mean number of children.	Standard variation.	Difference from general mean ($m - \bar{M}$)	Probable error of difference (e)	Ratio: $\frac{m - \bar{M}}{e}$
Printers, lithographers, bookbinders	1,316	4.87	2.7626	-0.95	0.0514	18.48
Scientific, surgical and photographic instrument and apparatus makers	146	4.85	2.9198	-0.97	0.1630	5.95
Indoor service (domestic, club, institution)	293	4.84	2.8955	-0.98	0.1141	8.59
Innkeepers, publicans, wine and spirit merchants, agents	990	4.78	2.8580	-1.04	0.0611	17.02
Watchmakers, dealers in jewellery, &c.	398	4.77	2.7189	-1.05	0.0920	11.41
Publishers, booksellers, stationers	421	4.75	2.8671	-1.07	0.0942	11.36
Navigation service (on shore)	149	4.74	3.0125	-1.08	0.1665	6.49
Private means	434	4.71	3.2301	-1.11	0.1043	10.64
Drapers, clothiers, hosiers	1,334	4.68	2.7917	-1.14	0.0514	22.16
Commercial occupations	2,515	4.63	2.7943	-1.19	0.0337	35.31
Tobacco manufacturers, dealers.....	135	4.53	2.6044	-1.29	0.1512	8.53
Soldiers and Non-commissioned officers	60	4.52	2.4869	-1.30	0.2166	6.00
Men of the navy and marines	42	4.48	3.0802	-1.34	0.3203	4.18
Civil, mining engineers.....	106	4.43	2.6027	-1.39	0.1706	8.15
Chemists, druggists	228	4.39	2.7116	-1.43	0.1212	11.80
Clerks (Civil Service, law, commercial, bank and insurance)	3,390	4.38	2.6914	-1.44	0.0309	46.60
Ministers, clergymen.....	598	4.33	2.8399	-1.49	0.0784	19.01
Art, music, drama.....	560	4.27	2.8584	-1.55	0.0815	19.02
Schoolmasters, teachers	763	4.25	2.6573	-1.57	0.0647	24.27
Literary and scientific pursuits.....	162	4.09	2.7875	-1.73	0.1478	11.71
Veterinary surgeons	33	4.00	2.8391	-1.82	0.3333	5.46
Advocates, solicitors	403	3.92	2.5859	-1.90	0.0869	21.86
Physicians, surgeons	285	3.91	2.6726	-1.91	0.1068	17.88
Dentists (including assistants)	51	3.86	2.2753	-1.96	0.2149	9.12
Army officers (effective and retired)	86	3.76	2.5282	-2.06	0.1840	11.20

A scrutiny of the tables here given shows that among the groups of high fertility, labouring, mining, and agricultural occupations predominate, while among those of low fertility are included professional occupations, and some of the more skilled manual occupations. Crofters and coal miners are found to have average families of more than seven children, while the families of the legal and medical professions, and of army officers, average less than four children. The following are a few notes about some of the occupational groups.

Professional and allied occupations. These without exception are found to be occupations of low fertility, and to have average families significantly less than the general mean and among them may be mentioned the clerical, legal, medical, and teaching professions, officers of the army and navy, artists, men with literary and scientific pursuits, land surveyors, civil engineers, dentists, veterinary surgeons, and pharmaceutical and dispensing chemists. The occupational groups named in Table X are arranged in order of magnitude of the crude average family, and it may there be noticed that of the twelve named as having the smallest families eleven are professional, while the twelfth, consisting of civil service, law, and other clerks is closely allied thereto.

Labouring classes. These are in marked contrast to the foregoing for the majority are found to be of high fertility. Table X shows that coal heavers, navvies, builders' labourers, dock labourers, and general labourers, all constitute occupational groups with average families significantly greater than the general mean.

Agricultural and fishing occupations. The majority of these are found to be of high fertility, some are found to be of fertility not significantly different from the general mean, but none are found to be of low fertility. Among those of significantly high fertility there are crofters, fishermen-crofters, agricultural labourers, fishermen, shepherds, farmers, and farm grieves and foremen. Among those with fertilities not significantly different from the general mean there are foresters, nurserymen and dairymen.

Workers in mines and quarries. These are found to be of significantly high fertility, and include coal and shale miners, stone and slate miners, and stone dressers and quarriers.

Transport workers. Dividing these into three groups it is found that one, carters and other workers in road transport, are of significantly high fertility, one, railway servants, are of significantly low fertility, while the third, which includes seamen and others concerned with transport by water, is of a fertility neither significantly greater nor significantly less than the general mean, the class excluded from Table X.

Commercial and clerking occupations. These are all found to be of significantly low fertility. Among them may be mentioned insurance agents, clerks (civil service, law, commercial, bank, and insurance), and persons engaged in commerce.

Tradesmen. A general scrutiny of results shows that tradesmen are found in all three classes of fertility, high, low, and not significantly different from the mean. Among those of high fertility may be mentioned glaziers, plasterers, masons and builders, iron-

founders, blacksmiths, and engine drivers and stokers (not railway or marine), and among those of low fertility, tailors, carpenters, painters, engineers, patternmakers, plumbers, coppersmiths, hair-dressers, electricians, instrument makers, and printers.

Domestic and allied services. Occupations of this nature are found without exception to be of low fertility, and to have average families which are significantly less than the general mean. Among them are indoor and outdoor domestic servants, waiters, barmen, innkeepers, publicans, and keepers of boarding, lodging and eating houses.

Public services. Occupations connected with these services, with the exception of scavengers, are found either to have fertilities not significantly different from the general mean, or to have low fertilities. The average fertility of scavengers is found to be high, or at least significantly greater than the general mean. Occupations of this class with low fertility include police, postmen, municipal and parish officers, soldiers, and men of the Royal Navy.

Declining national fertility.—That the fertility of marriage has been decreasing in Scotland may be accepted as an established statistical fact, it having been evidenced by a continuing fall of

TABLE XI.—*Fertility of marriage by Calendar year of marriage.*

Age of wife at marriage.	Periods of marriage.									
	1864 and before.	1865 to 1869.	1870 to 1874.	1875 to 1879.	1880 to 1884.	1885 to 1889.	1890 to 1894.	1895 to 1899.	1900 to 1904.	1905-06.
20	8.48	8.42	8.04	7.88	7.59	7.39	—	—	—	—
21	8.18	8.00	7.82	7.38	7.10	7.00	—	—	—	—
22	7.72	7.52	7.41	7.04	6.81	6.47	—	—	—	—
23	7.40	7.38	7.04	6.59	6.39	5.97	—	—	—	—
24	6.86	6.87	6.66	6.18	5.96	5.68	5.42	—	—	—
25	6.73	6.51	6.24	5.94	5.68	5.23	5.03	—	—	—
26	6.17	6.13	5.96	5.54	5.28	4.98	4.69	—	—	—
27	5.80	5.65	5.82	5.39	5.05	4.60	4.37	—	—	—
28	5.66	5.35	5.45	4.95	4.73	4.30	4.07	—	—	—
29	5.74	5.00	4.98	4.64	4.37	4.19	3.75	3.53	—	—
30	4.94	4.89	4.71	4.43	4.03	3.82	3.48	3.32	—	—
31	4.83	4.39	4.33	4.29	3.71	3.59	3.30	3.04	—	—
32	4.41	3.99	3.84	3.83	3.60	3.10	2.90	2.70	—	—
33	4.00	3.22	3.38	3.68	3.26	3.15	2.77	2.51	—	—
34	3.38	3.68	3.16	3.29	3.16	2.62	2.59	2.23	2.19	—
35	3.82	3.10	2.87	2.87	2.77	2.52	2.30	1.98	1.74	—
36	2.33	2.85	2.60	2.39	2.54	2.05	1.93	1.75	1.55	—
37	3.88	2.00	1.93	2.11	2.02	1.92	1.59	1.42	1.46	—
38	3.13	3.00	2.02	1.66	1.73	1.79	1.41	1.28	1.10	—
39	1.75	2.17	2.16	1.44	1.62	1.48	1.27	1.12	0.97	0.84
40	—	2.00	1.13	1.12	1.18	1.07	0.94	0.85	0.70	0.67

the national birth-rate. It is of some interest, however, to note that figures derivable from this study demonstrate the fact in a clear and conclusive manner.

The tabulation cards of all marriages of completed fertility, *i.e.*, of marriages in which the wife had attained age 45, were taken and sorted into groups according to the year in which the marriage was celebrated. The cards of each group were then counted for the marriages recorded on them and for the number of children born to them, and from the figures thus got the complete average fertility for each age of wife and for each calendar year were ascertained. Figures for single years are published in Table XLVI of the Census Report, and from that table those collected in Table XI have been abstracted.

TABLE XII.—*Showing decline of fertility in twenty years. (Complete families).*

Age of wife at marriage.	Marriages of earlier years.		Marriages of later years.		Decline.
	Date.	Average family.	Date.	Average family.	
20	1866	8.38	1886	7.34	1.04
21	1867	8.01	1887	6.92	1.09
22	1868	7.54	1888	6.34	1.20
23	1869	7.32	1889	5.89	1.43
24	1870	7.00	1890	5.42	1.58
25	1871	6.26	1891	4.85	1.41
26	1872	6.11	1892	4.61	1.50
27	1873	5.85	1893	4.18	1.67
28	1874	5.08	1894	3.97	1.11
29	1875	4.91	1895	3.53	1.38
30	1876	4.57	1896	3.22	1.35
31	1877	4.35	1897	2.87	1.48
32	1878	3.48	1898	2.66	0.82
33	1879	3.76	1899	2.40	1.36
34	1880	3.44	1900	2.19	1.25
35	1881	2.80	1901	1.69	1.11
36	1882	2.40	1902	1.68	0.72
37	1883	2.38	1903	1.18	1.20
38	1884	1.73	1904	0.92	0.81
39	1885	1.78	1905	0.84	0.94
40	1886	1.09	1906	0.55	0.54

The average complete fertility of wives married at 20 previous to 1864 was 8.48; in the quinquennium 1865–69 this fell to 8.42; in the period 1870–74 to 8.04; in the period 1875–79 to 7.88; in the period 1880–84 to 7.59; for the year 1885 it was 7.45; and for the year 1886, 7.34. The figures for this age at marriage for later years are not available for age 45 had not been attained by the wives at the date of the census. Taking age of wife at marriage 25,

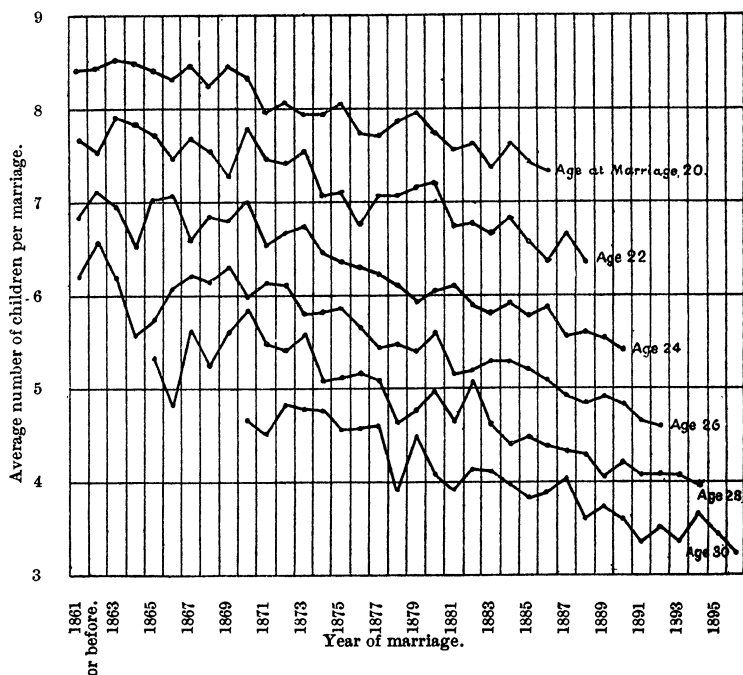
a similar drop is found; the average family of such marriages dating previous to 1865 was 6·73, but this has steadily fallen; for the period 1865-69 it was 6·51; for 1870-74, 6·24; for 1875-79 5·94; for 1880-84, 5·68; and for 1885-89, 5·23. For age at marriage 30 the same is found; the average family of the earliest marriages was 4·94; for period 1870-74, 4·71; for 1880-84, 4·03; and for 1890-94, 3·48.

Again comparing the average complete family for each age of wife of the most recent year available with the corresponding figure for marriages dating twenty years further back, a universal drop is found; it amounts to more than one child per marriage for all ages of wife at marriage under 36, age 32 excepted. The figures of this comparison are collected in Table XII.

The fall of the fertility of marriage within recent years is shown graphically for a few selected years in the chart which is here reproduced.

Marriage fertility since 1861.

Note.—The numbers indicated on this chart are based on marriages that took place in the years mentioned and continued until 1911, and are restricted to those in which the fertile period had been completed.



Child mortality in families of working mothers.—In the census schedule householders were instructed to state how many children born to existing marriages were alive at the time of the census, and by comparing that number with the total born the number then deceased could be ascertained. All reported information on this matter was not, however, of value as indicative of child mortality, for many of the marriages were of long duration, a considerable number had existed for upwards of sixty years, and with such the death of children born is in no way indicative of death during childhood. It was consequent on this consideration that for this purpose only marriages of less than fifteen years' duration were considered.

In Scotland married women with remunerative occupation are not numerous; they in all at the census only numbered 31,465, and as of them only 5,458 were married for less than fifteen years and enumerated on the same schedules as their husbands, the material for making this study was very limited.

The method adopted was one of sampling. The tabulation cards, for other purposes, were grouped by duration of marriage and by age of wife, and the piles were examined for the cards relative to occupied married women, and when each such card was found the card next to it was laid aside as a sample of a marriage in which the wife was not occupied. Each group, working mothers and

TABLE XIII.—*Mortality in families of working mothers.*

[Marriages of less than fifteen years' duration.]

Occupations.	Marriages.	Children.			Percentage.	
		Total.	Living.	Deceased.	Living.	Deceased.
Mothers not working	5,458	13,970	11,908	2,062	85·2	14·8
Mothers working	5,458	12,881	9,790	3,091	76·0	24·0
Domestic servants	102	128	92	36	71·9	28·1
Charwomen	193	468	333	135	71·2	28·8
Laundry workers.....	138	298	221	77	74·2	25·8
Farm servants	152	293	245	48	83·6	16·4
Cotton manufacture	149	364	254	110	69·8	30·2
Wool and worsted manufacture	271	748	619	129	82·8	17·2
Flax, linen manufacture	190	383	318	65	83·0	17·0
Hemp, jute manufacture	1,554	4,618	3,268	1,350	70·8	29·2
Tailors	51	90	67	23	74·4	25·6
Dressmakers.....	156	274	232	42	84·7	15·3
Seamstresses	55	121	99	22	81·8	18·2
Hawkers	205	560	405	155	72·3	27·7
Others	2,242	4,536	3,637	899	80·2	19·8

not-working mothers, consisted of 5,458 records. The total children born to marriages the wives of which were not working numbered 13,970, and to marriages of which the wives were working, 12,881. Of the children of the unoccupied mothers 2,062, or 14·8 per cent., were reported to be dead, while of those of the working mothers 3,091, or 24·0 per cent., were reported to be dead. Thus mortality among the children of occupied married women, or at all events among those living along with their husbands, is approximately 62 per cent. higher than among the children of mothers without remunerative occupation.

In Table XIII figures relative to the individual occupations of the mothers are given, but these on account of smallness of numbers are not very trustworthy.

Previous statistical studies on fertility of marriage.—As this is the first census of Scotland in which details regarding the fertility of marriage have been collected, the best of all facts for comparison, those of a previous study made on similar lines from similar material, are wanting. The tabulation of the fertility facts of the census in England and Wales is not yet published and not yet available for comparison, and that of the Irish census, though published, is also not available for ready comparison because it has been made on very different lines and it does not show many of the points I have been discussing.

Among recent work on the fertility of marriage, and more especially on the decline of that fertility, I may mention the paper by Drs. Newsholme and Stevenson which was read before this Society in 1906, and a contribution by Mr. McKinlay, staff clerk in the Statistical Department of the Office of the Registrar-General for Scotland, and published as a supplement to the Detailed Annual Report of the year 1908. Both these papers clearly demonstrated a decline of the birth-rate, and one which is not entirely associated with delay of marriage, and to that extent their work is fully corroborated by this study.

In Sir Timothy Coghlan's essay on the *Decline of the Birth-rate*, I find some statistical facts given in a manner comparable to those now advanced. Perhaps the most interesting of them is a tabular statement showing the decline in the size of the complete family during recent years. Sir Timothy Coghlan's figures refer to grouped ages at marriage and to grouped years of date of marriage, and for comparison I have collected the census figures into similar groups, and the two sets of figures may be seen in Table XIV. Sir Timothy Coghlan's figures refer to marriages in New South Wales. A scrutiny of his table, while showing that his averages are rather higher than

those found by this census in Scotland, clearly shows that the declines in the two countries have been generally similar, though greater in New South Wales than in Scotland. For instance, the average family of women marrying at 20 to 24 in New South Wales has decreased from 8.32 to 7.02, and during the same period in Scotland from 7.80 to 7.03, the total decrease in the period in New South Wales being 1.30, and in Scotland 0.77. Again, taking ages at marriage 25 to 29, the average family in New South Wales has decreased from 6.41 to 4.97, and during the same period in Scotland from 6.14 to 5.09, the decline in the former country being 1.44, and in the latter 1.05.

TABLE XIV.—*Comparing decline of fertility in New South Wales and in Scotland.*

[Averages show size of completed families. Scottish figures relative to period 1861 to 1865 contain some earlier marriages.]

Years of marriage.	Age of wives at marriage.					
	20 to 24.		25 to 29.		30 to 34.	
	N.S.W.	Scotland.	N.S.W.	Scotland.	N.S.W.	Scotland.
1861-65.....	8.32	7.80	6.41	6.14	4.64	4.48
'66-70.....	8.10	7.67	6.45	5.95	4.38	4.24
'71-75.....	7.52	7.30	5.89	5.75	4.15	4.10
'76-80.....	7.02	7.03	5.39	5.39	3.92	3.98
'81-85.....	....	6.75	4.97	5.09	3.40	3.60
'86-90.....	....	....	....	4.72	3.03	3.37
'91-95.....	....	....	....	....	....	3.04

In Sir Timothy Coghlan's essay, on p. 15, there is given a table showing the proportion of marriages which prove sterile at varying ages of the wife at marriage. In Table XV, I reproduce some of his figures, and for purposes of comparison add corresponding figures derived from the census records. Sir Timothy Coghlan's figures were based partly on census returns and partly on the records pertaining to the deaths of married women. Again in this table the conclusions in the two countries are very similar. There is the same increase in the sterility rate with increasing age at marriage, and the rates for each age of wife, more especially when those of Scotland are compared with those of New South Wales for the years 1881-90, are not very different.

TABLE XV.—*Comparing frequency of sterility in New South Wales and in Scotland.*

[Figures show proportion of sterile marriages in 1,000 marriages.]

Age of wife at marriage.	New South Wales.				Scotland, Census 1911.
	1861-70.	1871-80.	1881-90.	1891-97.	
20	30	28	34	52	36
25	37	52	59	81	67
30	77	103	127	148	128
35	155	199	261	294	247
40	281	425	496	590	571

Sir Timothy Coghlan also gives a table showing the periods elapsing between marriage and the date of the first birth. His figures are not strictly comparable with what I have given in Table IX, because in my table the calculations were made for all wives, while his were made for fertile wives only. I have, however, recalculated my figures, and in Table XVI give a fair comparison between his figures and mine. The most evident difference between the two sets of figures is an apparent delay in Scotland of the birth of the first child, they are fewer during the first year, and more numerous during the third year, in Scotland than in New South Wales. The small proportion born after three years of marriage in the two countries are very similar.

TABLE XVI.—*Comparing period of marriage elapsing before birth of first child in New South Wales and in Scotland.*

[Figures show the numbers of such events in 1,000 marriages.]

Period.	New South Wales. Coghlan.	Scotland. Census 1911.	Scotland, 1855. Lewis.
Less than 1 year	428.4	283.9	220.2
1 to 2 years	396.7	389.3	613.0
2 „ 3 „	91.3	220.8	111.2
3 „ 4 „	33.3	56.6	28.2
4 „ 5 „	17.5	15.9	11.3
5 „ 6 „	9.0	7.8	5.5
6 „ 7 „	6.4	10.8	4.2
7 „ 8 „	4.3	6.9	1.8
8 „ 9 „	3.7	3.4	1.1
9 „ 10 „	2.8	4.7	0.7
More than 10 years	6.5	7.0	2.8

In Table XVI, I also give some figures referring to the same point, the time elapsing between marriage and the birth of the

first child, taken from Dr. Lewis' book and based on the Scottish birth registers of 1855. They agree with the figure of this census, and with the New South Wales figures, so far as showing the comparative unfrequency of first birth after three years of marriage, but they disagree with both other series as to the relative frequency of first birth in the first three years of marriage.

Sir Timothy Coghlan's tabulation of children in New South Wales by order of birth is referred to later.

The Scottish birth registers of 1855, the first year of compulsory national registration, contain information regarding the ages of the mothers, and the numerical order in the family of the children, but later registers do not do so. Dr. Matthews Duncan many years ago, and more recently Dr. C. J. Lewis, with the co-operation of his brother Mr. J. N. Lewis, have made and published statistical studies of that information, and in their work I find some figures comparable with those of this census. Dr. Duncan confined his research to the birth registers of Edinburgh and Glasgow, but Dr. Lewis extended his research so as to include all births registered in Scotland during that year. Dr. Lewis' figures being the more comprehensive are those I here use.

Dr. Lewis gives a table showing the distribution of all children registered in Scotland during the year 1855 according to their order in the family, in fact very similar to Table II of this Paper. Sir Timothy Coghlan also gives one, and for comparison, in Table XVII, I have assembled the figures for Scotland in 1855, for Scotland at the present time, and for New South Wales. The interest in this table, and more particularly in the comparison of the figures for Scotland in 1855 and those of the present census, lies in the fact that the greater the fertility of marriage, the greater will be the proportion of children belonging to the higher orders, and the less the proportion in the lower or earlier orders. Consequently, if since 1855 there has been any marked decrease in the fertility of marriage in Scotland it should be shown by an increase in the proportion of first and second children, and a decrease in the proportion of those born later in the families. This is found to be the case. A comparison between Dr. Lewis' figures and those of this census shows that the proportion of children who are first children has increased from 19.0 per cent. to 21.6 per cent., and of those who are second children from 16.1 per cent. to 18.4 per cent., while there have been decreases in the proportions of children born later than second children. Thus in 1855 third births constituted 15.4 per cent.; fourth births, 12.7 per cent.; and fifth births, 10.5 per cent., while at this census these proportions were 15.0, 12.1, and 9.5 per

cent. respectively. The principal declines are found in the case of children extending from fourth to the ninth in the families, for children who are tenth or more now constitute nearly the same proportion among all children as they did in 1855, these proportions being 3·9 and 3·8 respectively. The figures given in Table XVII applicable to New South Wales generally lie between the Scottish figures of 1855 and those of the present date, they however show a larger proportion of children of the higher orders, of children born later than ninth, these amounting to 5·8 per cent.

TABLE XVII.—*Order of birth.*

[Figures show the frequency of each order in 10,000.]

Order of child in family.	Scotland, all marriages. Census 1911.	Scotland, births, 1855. Lewis.	New South Wales, births, 1893-1900. Coghlan.	Order of child in family.	Scotland, all marriages. Census 1911.	Scotland, births, 1855. Lewis.	New South Wales, births, 1893-1900. Coghlan.
1st	2,153	1,899	2,013	12th	57	51	91
2nd	1,837	1,609	1,651	13th	27	21	48
3rd	1,504	1,535	1,396	14th	13	8	24
4th	1,205	1,274	1,157	15th	5	4	12
5th	949	1,049	961	16th	2	1	5
6th	734	824	781	17th	1	1	2
7th	551	632	626	18th	—	—	1
8th	400	462	483	19th	—	—	—
9th	275	314	348	20th	—	—	—
10th	177	185	243	Unknown	—	25	—
11th	104	106	157				

Dr. Lewis gives a table derived from the same registration statistics giving the frequency of complete sterility among mothers of varying ages, and in Table XVIII I compare his figures with those of this census. Dr. Lewis gets his figures by comparing the marriages of women of specified ages during the year 1855 with the numbers of first births registered during that year. Perhaps his data were not so satisfactory as those got from the census returns, and the very evident differences in Table XVIII may be attributable thereto.

TABLE XVIII.—*Proportion of sterile marriages per cent. of all marriages in Scotland in 1855 and 1911.*

Age of wife at marriage.	1855. Lewis.	1911. Census.	Age of wife at marriage.	1855. Lewis.	1911. Census.
20-24	1·51	4·49	30-34	32·30	15·87
25-29	22·47	8·52	35-39	51·10	33·70

I annex a short list of works referred to in preparing this Paper.

Bibliography.

- (1) "Fertility, fecundity, and sterility," Dr. Matthews Duncan, Edinburgh, 1871.
- (2) "Natality and fecundity," C. J. and J. N. Lewis, Edinburgh, 1906.
- (3) "The decline of the birth-rate," Alexander McKinlay, *Fifty-fourth Detailed Annual Report of the Registrar-General for Scotland*, 1908 (Cd-5251).
- (4) "The decline of human fertility in the United Kingdom and other countries as shown by corrected birth-rates," Arthur Newsholme and T. H. C. Stevenson, *Journal of the Royal Statistical Society*, Vol. LXIX, 1907.
- (5) "The decline of the birth-rate, an essay in statistics," T. A. Coghlan, Sydney, 1903.
- (6) "An estimate of the degrees of legitimate natality as derived from a table of natality compiled by the author from his observations made in Budapest." By Joseph Körösi. *Philosophical Transactions of the Royal Society of London*, (B), Vol. 186, 1896.

DISCUSSION on DR. DUNLOP'S PAPER.

MR. T. A. WELTON said that in dealing with the question of birth-rate he himself had adopted a very much more humble method. He had compared simply the number of births with the number of married women under 45. He thought that was the best rough measure that they were able to make use of. In doing that one came to the conclusion that in Scotland there had been a fall of the proportion of the legitimate births to married women as between 27·2 per hundred in 1901 to 23·6 in 1910, viz., more than 10 per cent. decline in ten years. He said he was not in a position to criticise the details of Dr. Dunlop's Paper, but he wished to point out the reasons which induced him to think that a study of this kind for Scotland would be immensely improved if it were sub-divided into three or four parts. The tendency to marry he had elsewhere measured in this way. He had calculated the proportion of bachelors among men of the age of 45 to 55, and he had found it was in England about 10, 11, or 12 per cent.; but the like proportion in Ireland was very high. For the whole of Ireland in 1911 it was 27·3 per cent., in Leinster as high as 30·8, and in England and

Wales in 1911 the proportion was 12·1, which showed that the Irish proportion of bachelors was $2\frac{1}{2}$ times as much as that in England. If they took the Scotch figures, they found that two-thirds of the surface of Scotland, mostly the Highlands and thinly-peopled parts, presented nearly as great a proportion of bachelors as the number they got in Ireland. The average for two-thirds of Scotland was 24·5, and for the other one-third of the surface, much more than a third of the population, it was 14·5. On looking into the matter in greater detail, he was led to think that a study of the facts for the Highland counties, ranging from Caithness to Argyle, for the counties in or near the Tweed valley, and for the colliery counties, ranging from Fifeshire to Ayr, would give results rather different from the average of the whole people. They had plenty of examples in England of the inconvenience of massing together dissimilar elements. He understood from people who resided in Ireland that the reason of the extraordinary number of bachelors was, that a small farmer kept his sons about the home as unpaid labourers, and they did not marry while they were living in the paternal home, though they grew in years considerably; whereas in England, a young man going away to seek his fortune from his parental home was always obliged, if he wanted to have a home at all, to marry at an earlier age, which he thought accounted for the much greater proportion of marriages among young men in England. As regards the fertility of marriages, there was this much to be said, that the proportion in Scotland was much higher in the Highland districts, where marriages were few, than it was in the other districts, where marriages were comparatively more numerous. In the Tweed valley they had Berwick with 19·7 per 100 married women aged less than 45, in Peebles 18·8, in Roxburgh 17·9, Selkirk 16·1; but in Caithness 27, Ross 27, Sutherland 25, Inverness 24, and Argyle 24—really a much higher proportion of births, compared with the number of mothers in the Highland districts, than in the Tweed neighbourhood. The only exception to the rule was in Linlithgow, where there was also a high proportion of births to mothers, which he associated with the same reasons that made the birth rates in Glamorgan and in Durham considerably above the average. In colliery districts the birth-rate was generally found to be governed by social conditions different from what one met with in an agricultural country. On the whole he therefore thought it would be an advantage if they could have figures like those for three or four sections of Scotland, illustrating the habits and character of the people. As regards the question of occupational statistics, he hoped the Society would bear in mind that a man might change his occupation. For instance, the miners in Northumberland very often, after reaching a certain age, turned from the occupation of mining to the cultivation of a patch of land, and spent their old age as small occupiers. Of course, if they were dealing with statistics, whether of fertility or any other subject, they had to consider these changes, which altogether altered the early history of a former collier who to-day was a cottager,

and which had a good deal to do with his prospects in life and everything else affecting him. He hoped he had not fatigued the Society with these points of distinction; but he really felt that as it would be a mistake to mass the Irish and English figures together, so it was a pity to merge the whole of the Scottish figures in one mass, when very likely quite different results would be had by taking the population of the Lowlands and the population of the Highlands separately.

Dr. GREENWOOD, in seconding the vote of thanks, said the Paper was indeed of great interest from two points of view—that of the statistical specialist and that of the statesman. He said he would first refer to one or two theoretical points. In the first place, it was of great interest to see an application in official statistics of the theory of skew correlation. He was personally interested in that point, because in a Paper, by his colleagues Mrs. Wood and Mr. Brown and himself, which would appear in a forthcoming issue of the *Journal*, they had occasion to refer to this method; and he concluded from the equation given on p. 269 that Mr. Rae had approached the problem by the same route as that they had followed. It appeared to them that the proper way to obtain an equation, when the regression surface was definitely “non-planar,” was simply to extend the analysis given in Professor Pearson’s classical memoir on Skew Correlation to the case of three variables. In that case, one necessarily obtained a regression equation which involved a term in x^2 , a term in y^2 and a term in xy , as well as terms in x and in y . That was the form of the equation Mr. Rae had obtained. In this connection he congratulated Mr. Rae on his success in facing the heroic amount of arithmetic which the application must have involved and before which they had quailed. Further, in that connection, he said it would be very interesting to know whether Mr. Rae’s analysis had led him to the discovery of any single constant which would be comparable in the case of multiple skew correlation with the partial coefficient of correlation, in the ordinary case, because in so many problems what was required to be known was simply the measure of the association between A and B which was independent of their common association with C; in ordinary regression they had the partial coefficient of correlation which was not applicable in the case of skew regression. He (Dr. Greenwood) and his colleagues had not succeeded in obtaining anything in the nature of a true partial correlation ratio comparable with the coefficient of partial correlation, but it was possible Mr. Rae had succeeded better. A second theoretical point which arose was, as to how far the probable errors deduced from the formula on p. 274 were real measures of reliability. The method assumed a normal distribution of the differences of sample-means. It was quite well known that even in the case of a normal population, the means of *small d* samples were not strictly normally distributed,*

* *Biometrika*, vi, 1.

and in the case even of fairly large samples (25, 50 or 100) taken from very skew populations, it had been shown* that the distribution of means was sufficiently skew to render the calculation of errors with the help of a normal curve inappropriate. He said, the particular distribution under notice, that of fertility, was decidedly skew, and hence he should doubt whether the notation of probable errors were appropriate, and he thought Mr. Yule's plan of leaving the standard deviations unconverted would have been preferable. Such a course would put the reader on his guard. Perhaps the probable error nomenclature should not be applied in that case. Passing to the extremely interesting practical results, there was one point which rather blended practice with theory; and he would be interested to know whether it had been followed up in the Census Office—that was raised by “The distribution of the number of children to marriages in which the fertile period is complete,” on p. 263. They would notice that that frequency distribution was of a peculiar character; there were two peaks, and obviously one would not expect a curve of frequency, such, for example, as one of Professor Pearson's family of curves, to fit the distribution. The question suggested itself as to whether the first group (that of zero family) in particular were not heterogeneous. Evidently artificial limitation of fertility complicated the problem, and it would be rather an interesting thing to enquire whether it might be possible to resolve the distribution into homogeneous components. There were, further, two practical points which seemed to him of considerable interest; first, as to how far there was excessive infant mortality in families of working mothers, and as to whether the comparison actually made had any great value in this connection. Perhaps he was misinterpreting the sampling method used, but it seemed to him the things compared were not *in pari materia* at all. No one, he imagined, had ever doubted that the infant mortality in the working classes was very much higher than the infant mortality, for instance, among the Peerage; and surely to have a valid method of determining the influence on infant mortality of the employment of the mother, one must compare the families of occupied mothers with the families of unoccupied mothers in the same social stratum; as it appeared to him the sample comprising the occupied mothers would include persons almost entirely in one social stratum, whereas the controlled sample would include mothers from various other occupations and social classes, and consequently the comparison seemed to him to be invalid. It might be that he had misinterpreted the method actually used. With regard to the occupational fertilities, he took it that the differences in the fertility of those groups evidently depended upon a complex of causes. For example, one would naturally expect that those occupations in which residence together of husband and wife was liable frequently to be interrupted would exhibit low

* *Biometrika*, vii, 505 and 531.

fertility. For example, taking the group of soldiers, non-commissioned officers, men of the navy and marine, and army officers, one would expect, apart from any question of artificial limitation or physiological difference, that it would be fairly low in the scale. Consequently in using the results to determine any question as to the distribution of artificial methods of limitation or of physiological fertility, such occupations he thought must be excluded. There was a very large number of points which arose, and no doubt that which Mr. Welton had raised in opening the discussion as to regional distribution was one which Dr. Dunlop had considered, but, he took it, could not bring within the limits of the Paper. It would probably be within the recollection of many Fellows of the Society that Dr. Brownlee* had drawn attention to the fact that the declining fertility as measured by corrected birth-rates in different parts of Scotland had been, at from the time he wrote, so distributed as to suggest that the importance of artificial methods of limitation as a cause had been exaggerated. The fertility statistics of Scotland by districts would throw considerable light on this problem.

Mr. DE JASTRZEBSKI said that although he could not claim to be an expert, he was extremely conscious of the enormous difficulties which attended the preparation of fertility tables, especially when undertaken for the first time. The field was so complex, the results at which one could aim so varied, that it must in the end come to a question of selection as to what one should attempt to do. He therefore asked Dr. Dunlop to take his criticisms as being qualified and modified very largely by that consideration. Turning to p. 268 of the Paper one sentence read as follows: "From the multiple correlation formula it may be gathered that a delay of three years on the part of the wife reduces the average size of the family approximately by one child, and that it requires a delay of something like forty years on the part of the husband to effect the same reduction." Not being a higher mathematician, he was not at all certain whether he understood what that meant; but to a non-mathematical mind it should mean what it said, that was, that a delay of forty years in the case of a married man would produce the same effect on the size of the family as a delay of three years on the part of the woman. He turned to Table VI, on p. 270, to find some confirmation from the predicted fertility of marriage for selected ages of wife and husband, and if they took the case of equal ages, say 20, there were 8.09 children; if the age of the husband were 50, it had come down 5 children, instead of $\frac{3}{4}$ of a child. Then again, the formula at the end of Table VII for tabulating the effect of varying ages did not agree with Table VI or with the statement, and the point that struck him was that if the result of the application of higher mathematics to data of that sort were to produce three

* "Germinal Vitality," by J. Brownlee, M.D., D.Sc., *Proc. Roy. Philos. Soc.*, Glasgow, April, 1908.

entirely varying results to the poor layman like himself, surely statistics were sufficiently of a morass to most of them to begin with, without making it a Serbonian bog in which they floundered hopelessly. It was just as well that they should bear in mind that Dr. Dunlop had told them durations were probably the least satisfactory part of anything one could do in the matter of marriage fertility in this country. The moment one took duration by individual years, the whole of the statistics would be hopelessly at sea, for the simple reason that the Census Schedule only told them that the marriage was either less than one year or more than one year, and so on. It never accounted for the periods in between, and he took it the figure given—that of 100,000 marriages at the end of the first year in Scotland only 26,700 were fertile—was based on the fallacy that all the marriages of less than one year's duration had been taken and counted as being of one year's duration. In matters of that sort there was a decided interest on the part of the person filling up the Census Schedule to give erroneous particulars. It was quite obvious if they had to fill up a Census Schedule and put down one child at the age of 7 months, it would be very awkward to return the marriage as being under one year. He did not wish to convict his brethren from the north side of the Tweed as being more prone to deviate from the paths of strict veracity than those who lived on this side of it, but he had found that at the time of the Census in Scotland there were 31,307 marriages of under one year's duration, and allowing for the elimination of doubtfuls and those cases where the husband and wife were not enumerated together, there should have been at least 30,000 marriages of under one year's duration in these Census Schedules; as a matter of fact there were only 16,755. He did not know what had become of the other 13,000, but he could guess pretty shrewdly where they had gone. The consequence was that the first figure must be taken not only with a grain, but with a liberal bucket of salt. He was glad to learn that there was no such thing as pre-nuptial conception. Far from that, only about 25 per cent. of Scotch wives conceived during the first three months of their marriage. That disagreed entirely with the experience of other countries where actual data had been obtained. The first year in these returns meant marriages from 0 up to 12 months. The second was an average of only 18 months and not of 2 years, and all the way through they would find the same fallacy at work. It therefore seemed to him in calculating from a Census Return it would be better to group the years together into small groups rather than endeavour to draw up tables on individual years. He did not for a moment advocate asking people to put the date of their marriage on the Census Schedule, for when one asked for duration at all one gave a strong inducement to people to avoid the exact figures; but if one asked them to put the date of marriage on the Census Schedule one offered a stronger inducement still. Körösi's was, as far as he knew, almost the only attempt to find the fall in the procreative faculty in man, and if it had to be made at

all, it seemed to him the attempt must be made with wives of fixed age, and not on the whole of the wives of varying ages. Kőrösi took wives of fixed age, and found a drop in fertility of $22\frac{1}{2}$ per cent., with an increase of 10 years in the average age of husbands, and that with the increase of 20 years in the age of the husband, the drop was 44 per cent. Finally, on the question of the occupational fertility there was a particularly interesting table relating to the relative fertility and infant mortality of working mothers. It was a question which was of great interest at the present time. Unfortunately the figures were rather small, and the only group of working women which was of any size was the textile group, where they got 2,164 marriages with 6,113 children. Of those children 27 per cent. were dead, while of the mothers not working the proportion dead was 14.8. So that the infant mortality in that group was nearly double where the mothers were at work; but the fertility of the mothers who were at work was higher than that of the mothers who were not at work. If they worked it out they would see there were 2.82 children per marriage in the textile group, whereas in the whole group of mothers not working it was only 2.56. One knew that there was an intimate relation between a high rate of infantile mortality and a high birth-rate. But if they went on to the effective fertility, that was the number of children surviving, they would find in the group of women working it was only 2.06, as against 2.19 in non-working women. That brought him to his one serious criticism on the tables, which was that he did not see why the question of the number of dead children had been left out of every one of them, although the Census material was there for them. Effective fertility was quite as important a subject of study as fertility merely calculated on the number of children born. It was far more important for the State that a woman should bear six children and rear five than that she should utter the cry of the Lancashire woman, "I have buried eight." If we had the data of the number of children deceased it would undoubtedly be of very great assistance in getting at some facts on that point.

Dr. Snow suggested a possible alternative partial explanation of the figures discussed in the section headed *Declining National Fertility*, and given in Tables XI, XII and XIV. These figures referred to the families of those surviving in 1911 who were married at various periods—before 1864, 1864–69, etc. If it could be demonstrated that the mortality of parents with large families after the period when the family was completed was less than that of parents with small families, it would follow that the small families derived from early marriages were not represented in the proper proportion among the surviving parents in 1911. If this were true the figures stated exaggerated the fertility of the marriages occurring before 1880, in comparison with that of the later ones. Some evidence that such differential mortality is operative was published

fourteen years ago,* and he believed, therefore, that the method adopted was not altogether a satisfactory one for demonstrating the decline in fertility. Indeed, seeing that the average size of family from marriages of 1866-70 appeared to be smaller than that for marriages of 1861-65, both for Scotland and for New South Wales, while the birth-rate did not fall appreciably in those countries until 1881-91, he was prepared to accept the figures given for marriages before 1870 as *evidence* of the higher mortality of the parents with small families. Although the sample dealt with included as many as 90 per cent. of the total number of marriages, he thought it important to examine the method of selection of the sample to see if it were truly representative of the total population and also if the results from it could be used for comparison with those from other countries. If, for instance, the 10 per cent. omitted included an excessive proportion of large families, the average family stated would be below the true figure. In the first place, cases in which the family was not stated were necessarily left out. Was there any tendency for these to belong to large families rather than to small ones. Figures from Australia showed that the size of family was left unstated proportionally more by old parents than by young, and therefore probably more by parents of large families than by those of small ones. If this were true of Scotland, the average stated would be slightly below the true figure. In the second place, although it was probably an advantage to omit cases in which the wife was over 45 at time of marriage, this had not been done in the returns from Australia and New Zealand, and the comparison of the figures for Scotland with those for the other countries was affected. Such marriages, however, were but 1 per cent. of the total, and the discrepancy introduced was probably negligible. It was interesting to note that the number of sterile marriages in Australia was only 8.2 per cent., compared with 11.5 per cent. in Scotland. He was satisfied that the 90 per cent. of marriages dealt with gave results practically identical with those which would have been reached had the whole 100 per cent. been available.

Sir JAMES PATTEN MACDOUGALL said he was very glad to have been there and heard the observations which had been made upon their statistics. He confessed he was not a higher mathematician. Dr. Dunlop was at the head of the statistical branch of the Registrar-General's Department in Scotland, and he deserved all the credit for the report which he had produced. He was satisfied it was a report which would create a very large amount of interest, and he

* See Beeton, Yule and Pearson "On the correlation between duration of life and the number of offspring." *Proceedings, Royal Society*, vol. 67 (1900), p. 159. The material used in this investigation was derived from genealogical records. The same conclusion, however, can be derived from the vital statistics of a whole nation, but it is not possible to give here a short summary of the results.—[E.C.S.].

was satisfied the statistical branch of the Department in Scotland had devoted a large amount of time, skill and attention to the work. Whether the statistics were of very much importance practically was another matter. He did not know whether, when the time came for another Census, the country and Parliament would feel that the addition of the fertility column in the Census Schedule of 1911 had been justified to the extent that they hoped. He trusted that it would be so, because although they might not be of much practical advantage he was sure they were of very considerable interest to the country at large, in view of the undoubted fact, common to this country and to many others, that the birth-rate was sensibly diminishing year by year.

Mr. YULE desired to join in the expression of thanks to Dr. Dunlop. With regard to the paragraph at the bottom of p. 268, he enquired whether the effects broadly attributed to duration of marriage were not in fact partly the effect of the age of the wife at marriage. He understood that the figures were based upon wives of all ages under 45 at Census. The longer durations in that case would consequently surely mean that the wives were younger at marriage, while the shorter duration would refer to wives of more varied ages at marriage, and consequently on the average rather older. The resulting figures were consequently a complicated function both of duration and of age of wife at marriage, and that would account for the rather paradoxical result that was mentioned in the paragraph.

Dr. DUNLOP agreed.

Mr. YULE then said, as regards the data for occupational groups, that although it appeared fairly clearly that the age of husbands at marriage was of quite minor importance, nevertheless it was of some effect, and would tend to diminish the differences between the professional classes and the labouring classes, given on p. 275, because the husbands in the professional group would probably be older than the husbands in the case of the artisan classes. If then the ages of the husbands were equalised in the two groups, the fertility of the professional group would be thrown up slightly. He also said he hoped public notice would be taken of the average size of families of ministers and clergymen, as shown in the table on p. 277. Married people in this country of late years had been preached at somewhat frequently by clergymen, and he hoped that they would note that the average size of their own families was much the same as the average of the families of persons in the same social class. He wished that Mr. Rae had been present so that he might have been personally congratulated on his interesting work on the regression equations, and also that one or two questions could have been put to him on some points of the work. Comparing the two equations at the foot of p. 270, for example, he had noticed that the first equation for the case of marriages of "completed fertility" included a product

term for ages of wife and husband, while the second equation for marriages of incompleted fertility, taking duration also into account, did not include any product term, and he would like to enquire the reason.

The PRESIDENT said that he agreed with Dr. Greenwood and others in their praise of Dr. Dunlop's Paper. He hardly knew whether more to admire the practical or the theoretical part of the work—the edifice with its numerous compartments, as it were, built up into space of many dimensions, or the methods of construction which were applicable to other sites in other regions of statistics. It was a peculiarity of such structures that the edifice was in a sense stronger than the foundation. Not that anything weighty was based upon nothing; but that the entire weight of the edifice did not rest on the ground immediately underneath—the basis of specific experience. A collateral support was obtained from a sort of buttress or cross-bar, which rested indeed on a basis of experience, but on one that was not quite adjacent. It was thus that the actuary when constructing a life-table for a particular—perhaps not very large—population brought to bear on the irregularities of the data the general knowledge that mortality in the aggregate varied continuously from year to year. Even the uncertainty of female ages was not fatal to the construction of life-tables. The sort of advantage obtained by thus smoothing the data was presented by the formulæ for correlation which Dr. Dunlop had adduced. There might also be claimed for the formulæ connecting age and fertility the more familiar advantage of deductive reasoning; to bring out in an available form what is implicit in the data. He could wish that these advantages were purchaseable at a less cost of labour. He looked with alarm on the determination of constants involving products of the fourth power of one variable with the first power of another. There had been suggested a method of representing correlation which would not require so many constants, such high powers and such laborious calculations. The method consisted in determining a normal (not in general symmetrical) surface (more generally hyper-surface); and so projecting it as to make it approximately coincident with the given skew shape. He thought that some of the experiments recorded by Professor Pearson in a recent paper (on Theories of Association) countenanced the presumption that this method of *translation* might be safely applied to a large class of skew frequency-surfaces.

Dr. DUNLOP, in reply, expressed his grateful thanks not only for the reception that had been given to him, but also for the opportunity of bringing the Paper before them. He said that Mr. Welton, who had passed a very friendly criticism on the Paper, had suggested that some work might have been done on the study of local fertilities, by making comparisons between those of the larger divisions of Scotland. He thought that a perfectly good

suggestion. But it, along with many other conceptions, had been fully considered before the main tabulation was started, and it, along with others, was dropped because it was considered to be better to concentrate on the one big issue—the fertility of marriage in general—rather than attempt any over complication. The main tabulation was very elaborate and very lengthy, and a repetition of it, even for a few divisions of the country, was hardly possible. Mr. Welton also made reference to the expression of birth-rates per 1,000 women of child-bearing age; this, for some years past, has been done in the reports of the Registrar-General for Scotland. He specially thanked Dr. Greenwood for his appreciation of the statistical methods used, and he was sure that Mr. Rae would be greatly flattered and pleased to hear such appreciation of his work. Dr. Greenwood had asked whether Mr. Rae had found a way of expressing partial correlations from skew regressions; the answer was in the negative, and hence the use of the partial correlations derived from linear regressions in the Paper. Dr. Greenwood had also suggested that it would have been better to use standard deviations rather than probable errors in the table of occupational fertilities; that might be so, but, after all, those preferring standard deviations could readily obtain them by dividing the probable errors by 0.6745, which was the multiplying factor used for the conversion of the standard deviations into the probable errors. Dr. Greenwood had also made some interesting remarks on the distribution in Table I, drawing attention to the existence of two maxima, the one being for sterile marriages, and the other for a six-child family, and from that arguing that sterility was a complex quantity. Doubtless that was the case. It might be due to some inherent defect on the part of the woman, or to disease of the woman, or it might be due to bad health of the man, or indeed to many other causes. An expression of opinion as to the cause was outside the scope of the Paper. The method of sampling used in the study of the effect of the mother's occupation on the life of the children was questioned, and it was suggested that a full tabulation of all marriages would have been preferable. Dr. Dunlop pointed out how that the facts regarding working mothers were too few to justify such a course, and argued from the fact that the samples showed very similar numbers of children, that they were fairly made and satisfactory. Mr. de Jastrzebski's criticisms had interested him very much. Dr. Snow has promised to explain to Mr. Jastrzebski the significance of partial correlations. The question of the significance of the numbers reported as married for less than one year was difficult to answer. A scrutiny of the numbers given in the Census Report (Table XXVII) showed that marriages of duration of more than one but less than two years numbered, approximately, 27,000, while those of less than one year only numbered, approximately, 17,000, a comparison suggesting a transference of something like half the marriages of the 0 to 1 duration to the 1 to 2 duration. But the fact that duration 1 to 2 was not overburdened but had a number of marriages only

slightly different from those of durations 2 to 3, 3 to 4 and 4 to 5, indicated that the transference of marriages to duration 1 to 2 from duration 0 to 1 was balanced by a similar transference from duration 1 to 2 to duration 2 to 3, and also indicated compensating transferences to and from the subsequent durations. But further there was no distinct indication that the marriages transferred from the shorter to the longer durations were those of the latter half, or of any special part, of the shorter duration, and consequently no endeavour was made to allow for this evident imperfection of observation, it being considered better to deal with each duration as a fair sample rather than adjust for an imperfectly understood quantity. Dr. Snow had drawn attention to an interesting point in connection with the observed decline of fertility, viz., that it was conceivable that the apparent high fertilities of the earlier marriages might be associated with the fact that the marriages of the earlier years tabulated were those of the healthiest parents, and such parents might have produced families larger than the average. He (Dr. Dunlop) pointed out that while the theory might be feasible it was probably insufficient to explain the entire drop. Dr. Snow referred to the exclusion of marriages of which the size of the family was not stated. That was not done, such marriages being treated as childless. The marriages excluded on the ground of confusion were those in which there was evident error, as, for instance, cases of women marrying at ages over 40 being reported as mothers of seven or eight children, the probable explanation being the inclusions of children of first marriages. With regard to the use of the age 45 as the limit of the fertile period Dr. Dunlop pointed out that he was quite aware that it might be questioned, but he claimed that it was a good working limit, childbirth after that age being more abnormal than normal.

The following Candidates were elected Fellows of the Society :—

Archibald Brown.

Hubert Greenwell.

Augustus Kahn, M.A.

J. A. Robertson.

H. E. Soper.