AN ANALYSIS OF THE SEX RATIO OF LIVE BIRTHS IN THE UNITED STATES, 1942-1963

By

CHE-FU LEE

Bachelor of Science

The National Taiwan University

Taipei, Taiwan

1963

Submitted to the faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1967

AN ANALYSIS OF THE SEX RATIO OF LIVE BIRTHS

IN THE UNITED STATES, 1942-1963

Thesis Approved:

Sara Smith Sutter
Thesis Adviser

Richard J. Larson

N N Durham
Dean of the Graduate College

ACKNOWLEDGEMENT

The author wishes to express his thanks to Dr. Sara Smith Sutker, Associate Professor of Sociology, for assistance and guidance throughout his program of graduate study and the preparation of this thesis.

Special recognition is extended to Dr. James D. Tarver, Professor of Sociology at the University of Georgia, for the initiation of this study.

Further appreciation is also extended to Dr. Richard F. Larson, Associate Professor of Sociology, and Dr. Gerald R. Leslie, Head and Professor of Sociology, for their suggestions during the course of this study.

The author also desires to thank Professor Gene F. Acuff for continuous help and encouragement.

Finally, he extends sincere gratitude to his wife, Ling, and his parents, who have made all this possible.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE PROBLEM

This thesis is to explore the relationships between sex ratio at birth and several population variables considered to be relevant. Based upon past studies on this subject, color, parental age, and birth order of child have been selected as independent variables. These will be considered concomitantly with the variations in sex ratio at birth among live births in the United States, 1942-1963, as found in the records of vital statistics.

Sex composition is one of the important population characteristics, and sex ratio at birth is the most important determinant of sex composition of a population, if the composition is not affected by migration. But, the study of the sex of human births has been overwhelmingly taken over by biologists.

Biologists have been very successful in exploring new facts about the determinants of sex in reproduction, and their work is being reported in the popular press. Artificial breeding of livestock has long been practiced. Work to separate sperms in order to control the sex of livestock births is being undertaken.[1] Yet, for human beings the birth of a boy or a girl has been kept in the domain of chance until

---

[1] Tulsa Daily World, February 28, 1966, p. 7.

recent decades.[2] Social scientists today should be more concerned with the problem of population characteristics, because "biologists will soon be able to make it possible for society to decide how many boys and how many girls will be born each year."[3]

Along with the advances of biology, the social implication of this is that chance would be eliminated, and efforts should now be made for society to cope with problems such as predetermining the sex of children. According to Dudley Kirk, "Today the potential of selectivity is falling rapidly . . . . The combined opportunity for selection from both mortality and reproductive components is probably smaller than it has been in man's biological history."[4] In other words, man's wishes and ideals, which are socially and culturally determined, are playing a more and more important role over biological factors in determining man's quality, even that which is biological in nature.

The proposed study is not to demonstrate any of the biological theories about determinants of the human sex ratio at birth. Nor is it a longitudinal investigation of biological effects on sex ratio of human births of a group (or cohort) of parents and their offspring. Rather, in using the data of cross-sectional observation by calendar years, the purpose of the study is to observe the variability of live-birth sex

---

[2]J. D. Ratcliff, "New Facts About Human Reproduction." Reader's Digest, December 1966, pp. 119-121.

[3]Tulsa Daily World, November 10, 1966, Section 2-B.

[4]Dudley Kirk, "Demographic Factors Affecting the Opportunity for Natural Selection," Population Index, 32-3 (July, 1966), p. 319.

ratio in terms of specifications of the selected variables - color, parental age, and birth order of child - and to ascertain the patterns or directions in which the significant variables (if any) are associated with the sex ratio of births.

CHAPTER II

REVIEW OF LITERATURE

Little writing, at least relative to other subjects in population studies, has been done on the human sex ratio at birth. The following review of literature, instead of providing definite findings on which to base hypotheses, serves more as a rationale for the selection of the variables in this study.

The balance between males and females in a population is known to be a very stable one. It has been subjected to so little change that it was earlier believed that "Nature" compensates for the loss of males during war years by producing more male births. The theories of divine intervention and natural compensation have been refuted by Panunzio, Myers, and McMahan.[1] McMahan, for example, observed by studying live births in the United States from 1915 to 1948 that the sex ratio at birth did not consistently change as a direct influence of war either during the war years or immediately thereafter. He further insisted

---

[1] C. Panunzio, "Are More Males Born in Wartime?" The Milbank Memorial Fund Quarterly, XXI-3 (July, 1943), pp. 281-291.

R. J. Meyers, "Effect of the War on the Sex Ratio at Birth," American Sociological Review, 12-1 (February, 1947), pp. 40-43.

C. A. McMahan, "An Empirical Test of Three Hypotheses Concerning the Human Sex Ratio at Birth in the United States: 1915-1948," The Milbank Memorial Fund Quarterly, XXIX-3 (July, 1951), pp. 271-293.

that the slightly higher sex ratio at birth during and immediately after World War II resulted from the increase in the proportion of first births coming from the rise of marriage rates during that period.[2]

It has been estimated that at the moment of human conception males may outnumber females by 160 to 100. Many males perish in the womb, but even at the time of birth the ratio still averages from 105 to 106 males to 100 females.[3] According to the United States Department of Health, Education, and Welfare, the sex ratios at birth in the United States for the last three decades are as follows:[4]

	1940	1950	1960	1963
Total Population	105.4	105.4	104.9	105.3
White	106.0	105.8	105.5	105.7
Non-white	101.9	102.5	101.8	103.0

It has been noted that the sex ratio of white births is always slightly higher than that of the non-white in the United States. Thompson and Lewis in their textbook attribute the lower sex ratio of Negro births to both underenumeration and higher prenatal death rates among the Negro population.[5]

Excess mortality for the male has been found in fetal life, as well as at virtually every age during the whole life span. These higher

---

[2]C. A. McMahan, pp. 282-283.

[3]J. D. Ratcliff, p. 119.

[4]United States Department of Health, Education, and Welfare, (US HEW), "White-Nonwhite Fertility Differentials in the United States," Indicators, September, 1965, pp. 10-11.

[5]W. S. Thompson and D. T. Lewis, Population Problems, 5th Ed., New York: McGraw-Hill, 1965, p. 131, and US HEW, Indicators, September, 1965, p. 11.

mortality rates could result in a lower sex ratio.[6] Such a theory seems to be supported by the evidence of live births in plural deliveries. The ratio of plural deliveries is smaller than that in single confinements, because the former has a higher probability of fetal deaths.[7]

Prenatal death rates are closely connected with prenatal care, which is influenced by a number of social factors. An inverse relationship has been found between social class and pregnancy wastage.[8] Winston concluded that "any factor which operates to diminish prenatal mortality tends to raise sex ratio at birth."[9] The lower sex ratio of live births among non-white, thus, could be assumed to be associated with a higher prenatal death rate, and the higher death rate might be attributed to a less favorable socio-economic environment of the non-white population.[10]

Biological evidence has been searched to prove and explain observations such as the preponderance of males over females. Biologically the sex of a child is determined by the male alone, because the egg contains only female-producing X chromosomes. Shettles in 1962 investigated

---

[6]For example, R. Thomlinson, Population Dynamics, 1965, Random House, N. Y., p. 131; and US HEW, Indicators, September 1965.

[7]Metropolitan Life Insurance Company, Statistical Bulletin, Vol. 46 (May, 1965), pp. 4-5.

[8]A. Yankaner, K. G. Gross, and S. M. Romeo, "An Evaluation of Prenatal Care and Its Relationship to Social Class and Social Disorganization," American Journal of Public Health, 43 (August, 1953), pp. 1001-1010.

[9]S. Winston, "The Influence of Social Factors Upon the Sex Ratio at Birth," American Journal of Sociology, XXXVII-I (July, 1931), p. 21.

[10]US HEW, Indicators, September, 1965, pp. 10-11.

human spermatozoa by a special technique and found two distinct populations of the spermatozoa in respect to their nuclear size, shape, and content. These types were considered in relation to the conception and birth sex ratio.[11]

Szilard further assumed the association between the aging of father and the loss of functioning Y chromosomes, which produce male offspring. Based on his theory, an inverse relation between the age of father and sex ratio at birth was expected.[12]

In spite of the biological theory which emphasizes the paternal side in determining the sex of offspring, in population study, possibly because of the way vital statistics are recorded, age of mother is studied in association with sex ratio of human births. It may be assumed for human beings, moreover, that the age of father and the age of mother are, in general, positively associated, i.e., one can be the index of the other. In addition, birth order of child has been associated with parental age in considering their relationships with the sex ratio of births.

McMahan concluded from the data of live births in the United States for the period 1915 to 1948 that "there is a tendency for the sex ratio among live births to decrease as the age of the mother increases." He also noted that "there is a slightly greater tendency for the first-born child to be male than for later-born children."[13] Myers, further

---

[11] L. B. Shettles, "Human Spermatozoan Populations," International Journal of Fertility, 7-2 (1962), pp. 175-184.

[12] L. Szilard, "Dependence of the Sex Ratio at Birth on the Age of the Father," Nature, 186-4725 (May 21, 1960), pp. 649-650.

[13] C. A. McMahan, p. 288.

analyzing the data from 1942 to 1950, postulated that although sex ratio relates inversely to age of mother and birth order when they are considered independently, birth order might be the controlling factor if the correlation between age of mother and birth order are considered.[14] The Natality Statistics Analysis (1962) by the United States Department of Health, Education, and Welfare also indicated that "a higher sex ratio has been associated with younger parents and/or with lower birth orders." However, "this relationship usually did not hold true for a classification of any single birth order with any five-year age-of-mother group."[15]

Parental age and birth order of child are of interest in this study, not so much because of biological causality, but because of the possible effect on sex ratio at birth of parental sex preference for their offspring in the practice of birth control. Winston in 1932 noted that a selected group of socially superior parents, by the prevalence of the desire for male offspring, together with their knowledge of methods of birth control, appeared to have a significantly higher sex ratio at birth.[16] Goodman in 1961 reviewed the earlier studies and developed mathematical formulae for sex ratio as dependent upon, among others, the particular kinds of preferences for male or female offspring that influence married couples in the population and the particular ways

---

[14]R. J. Myers, "The Effect of Age of Mother and Birth Order on Sex Ratio at Birth," The Milbank Memorial Fund Quarterly, XXXII-3 (July, 1954), pp. 275-281.

[15]US HEW, Natality Statistics Analysis, 1962, p. 29.

[16]S. Winston, "Birth Control and Sex Ratio at Birth," American Journal of Sociology, XXXVIII-2 (1932), pp. 225-231.

in which these preferences affect the parents' decisions as to whether or not to have another child.[17]

The effect of sex preference on size of family has been noted. Sheps in 1963 presented formulae and numerical calculations for the average size of family, assuming that a couple wish to have a specified minimum number of boys and of girls, and continue to have children until these minimum numbers are reached. He also noted that in most cases there was more than an even chance that the family size would be larger than the sum of the minimum desired number of boys and girls.[18] Westoff and his associates, who were primarily interested in the study of family size, also concluded that the sex preference operated to affect family size if the desired sex composition was not readily achieved and that sex of first offspring usually affected the length of the subsequent birth interval.[19]

It seems apparent that the preference and postulated behavior would have no effect on the sex ratio of births if a constant and equal probability that a child would be a male or female is assumed.[20] But, in fact, more males than females are conceived and born.[21] Moreover it

---

[17]L. A. Goodman, "Some Possible Effects of Birth Control on the Human Sex Ratio," American Human Genetics, 25-1, (1961), pp. 75-81.

[18]M. C. Sheps, "Effect on Family Size and Sex Ratio of Preferences Regarding Sexes of Children," Population Studies, XVII-I, (July, 1963), pp. 66-72.

[19]C. F. Westoff, R. G. Potter, Jr., and P. C. Sagi, The Third Child: A Study in the Prediction of Fertility, Princeton, 1963, p. 207.

[20]See footnotes 17 and 18.

[21]See footnotes 3 and 11.

was concluded by Renkonen in 1956 and Edward in 1961 from the analysis of sequential births collected from a large number of families that there was a positive association between the sexes of successive children in a family. This led them to suppose that the tendency to have all male or female children in a family may come primarily from the couple's hereditary traits.[22] Shettles, who looked at family trees and investigated semen samples of selected individuals, found that the proportion of male- and female-producing sperm remained constant in an individual. This seemed to substantiate the supposition that these ratios of male- to female-producing sperm are inheritable.[23]

From the above review of literature, the author assumes that sex ratio at birth may vary in terms of color, parental age, and birth order of child. The selected variables may or may not be themselves biological factors directly affecting the sex of births. Sex ratio at birth, however, could be differentiated by different categories of the selected variables as the results of socio-economic differences or interplay of socio-psychological and biological factors. For example, sex ratio of white births may be higher than the non-white because of more favorable socio-economic environment and, therefore, lower prenatal mortality rate of white population. Sex ratio may vary among live births born to parents of different age and in different ordinal

---

[22]K. O. Renkonen, "Is Sex Ratio Between Boys and Girls Correlated to Sex of Precedent Children?" Annual of Medical Experiment (34), pp. 447-451.

A. W. F. Edward, "A Factorial Analysis of Sex Ratio Data," Annuals of Human Genetics, London, 1961, pp. 117-121.

[23]J. D. Ratcliff, p. 121.

position of birth as the result of different patterns of fertility behavior such as parental preference and birth control which may in turn be affected by the couples' inheritable tendency to bear male or female offspring.

CHAPTER III

METHOD OF ANALYSIS

The Data

Data for this study have been obtained from tables titled "Live Births by Age of Mother, Live-Birth Order, Sex of Child and Color" in the Vital Statistics of the United States, Volume I, for each year from 1942 to 1963, except the volume for 1945, in which the above tabulation was not published.[1]

Live births not stated for age of mother and live-birth order were excluded from consideration. They were assumed to be randomly distributed among all categories.

The variables are defined as follows:

1. Sex ratio of live births is expressed by the number of male births per 1,000 female births, which is calculated by dividing the number of female births into the number of male births and multiplying by 1,000.

2. Color refers to the dichotomized classification of white and non-white populations, without being further broken down into ethnic groups.

3. Parental age in this study is indicated by age of mother only,

---

[1]Published by National Office of Vital Statistics before 1949 and the U. S. Department of Health, Education, and Welfare from 1950.

because age of father tabulated with the birth order of child is not available in vital statistics, and paternal age and maternal age are, in general, assumed to be closely associated.

4. Birth order of child refers to the order position in which children are born among other live births in a family.

Color, age of mother, and live-birth order were reclassified and coded as follows:

Code Number	Color	Age of Mother	Live-Birth Order
1	White	Under 25	First
2	Non-white	25-29	Second
3		30-39	Third
4		40 and Above	Fourth
5			Fifth and Above

Statistical Analysis

The total number of live births in the twenty-one years (1942-1963, excluding 1945) was first considered. Sex ratio under each of the classifications by color, age of mother, and live-birth order was calculated for a survey of differential sex ratio by each of those variables among the total live births in the twenty-one years.

A factorial analysis of variance was employed to investigate the variations in the sex ratio concomitantly across the categories of the three factors - color, age of mother, and live-birth order. The fixed model of the factorial design was used because the factors were coded into fixed categories. The analysis was to see the variations in sex ratio accounted for by the selected factors within the collected data. No inference will be made from the sample to a wider population so that the assumption of normality and randomness seems not to be necessary.

Calendar year was taken for the replication of cases which were the observations of sex ratio classified by the factors of color, age of mother, and live-birth order. The homogeneous variance was assumed for each case in the yearly replications, an assumption which was supported by the relative homogeneity among those possible interactions with the factor of calendar year.[2] The mean squares of each factor which accounts for the variations in sex ratio were tested against the residual mean squares, obtained by pooling the possible interactions with yearly replications. In other words, the significance (by variance ratio or F-value) of a factor is relative to the magnitude of yearly variations of a factor and/or interaction of factors.

The effect of any factor which was shown to be significant in the analysis of variance was further investigated by orthogonal comparisons.[3] The sums of squares of those significant factors were partitioned to see if the variation of sex ratio from one level of a factor to another was in linear, quadratic, or other form. Partial analyses, utilizing the Pearsonian correlation coefficient, were calculated to show the degree of linear association between significant factor and sex ratio.

A further check was made by analysis of yearly variation in sex ratio and its relation to the selected variables. The correlations were calculated to show how sex ratio of the total number of births in

---

[2]See Table V for those mean squares below the residual mean squares.

[3]See Steel and Torrie, Principles and Procedures of Statistics, McGraw-Hill, 1960, pp. 222-229.

a year was affected by the proportion of the number of live births born to a particular category or categories which were assumed, according to the analysis of variance above, to have a higher or lower sex ratio to the total number of births in that year.

Taking sex ratio of total number of births in a year as a unit of observation was considered to be a check of consistency with the analysis of variance which might have been distorted by the relatively small number of births under some categories of maternal age and live-birth order. For example, in the case of small number of births born to older mothers and lower order position of birth, the sex ratio could be more erratically varied by the changes in number of births than those cases of large number of births under the classification of young mother and low birth order or old mother and high birth order.

CHAPTER IV

FINDINGS

A survey of sex ratios of the live births in the United States from 1942 to 1963 (excluding 1945) shows that the sex ratio is relatively stable from one year to another, both for white and non-white population. But the difference between the sex ratios of white and non-white births is evident, and the sex ratio is consistently higher for the white than non-white in each year. Considering the sum of the male and female births in the total twenty-one years, the sex ratio of white births is 1057 (33,706,276 males and 31,890,274 females) and the sex ratio of non-white births is 1023 (5,518,882 males and 5,393,435 females). (See Tables I and II.)

By classifying the total number of live births in the twenty-one years into the categories of age of mother and order of live births, a trend of negative association with sex ratio was found, both for the age of mother and birth order. Sex ratio tends to decrease with the increase of age of mother and order of birth. This is true for both white and non-white population. (See Tables III and IV.)

The factorial analysis of variance was used to test the significance of the variables accounting for the variations in sex ratio at birth, considering each cell under the particular categories of color, age of mother, and birth order as a case of observation. F-tests indicate that color, age of mother, and birth order are all statistically

TABLE I

NUMBER OF LIVE BIRTHS AND SEX RATIO FOR WHITE POPULATION, 1942-1963*

Year	Male	Female	Total	Sex Ratio
1942	1,216,524	1,145,758	2,362,282	1061.7
1943	1,267,970	1,197,443	2,465,413	1058.8
1944	1,196,156	1,127,797	2,323,953	1060.6
1946	1,420,669	1,335,972	2,756,641	1063.3
1947	1,602,886	1,513,297	3,116,183	1059.2
1948	1,508,674	1,426,366	2,935,040	1057.7
1949	1,532,590	1,447,329	2,979,919	1058.9
1950	1,522,489	1,438,764	2,961,253	1058.1
1951	1,609,402	1,521,754	3,131,156	1057.5
1952	1,650,186	1,561,022	3,211,208	1057.1
1953	1,670,670	1,579,042	3,249,712	1058.0
1954	1,712,218	1,620,572	3,332,790	1056.5
1955	1,718,448	1,627,324	3,345,772	1055.9
1956	1,761,804	1,669,064	3,430,868	1055.5
1957	1,798,754	1,705,472	3,504,226	1054.6
1958	1,773,916	1,682,718	3,456,634	1054.1
1959	1,788,064	1,695,252	3,483,316	1054.7
1960	1,788,518	1,696,478	3,484,996	1054.2
1961	1,789,262	1,695,904	3,485,166	1055.0
1962	1,682,778	1,599,968	3,282,746	1051.7
1963	1,694,298	1,602,978	3,297,276	1056.9
Mean Sex Ratio				1057.1
Total	33,706,276	31,890,274	65,596,550	1056.9

*Excluding 1945

TABLE II

NUMBER OF LIVE BIRTHS AND SEX RATIO FOR
NON-WHITE POPULATION, 1942-1963*

Year	Male	Female	Total	Sex Ratio
1942	157,809	152,729	310,538	1033.2
1943	165,038	160,402	325,440	1028.9
1944	163,996	160,511	324,507	1021.7
1946	179,218	174,961	354,179	1024.3
1947	204,746	199,885	404,631	1024.3
1948	219,656	213,627	433,283	1028.2
1949	236,826	231,796	468,622	1021.7
1950	244,813	239,041	483,854	1024.1
1951	256,222	251,702	507,924	1017.9
1952	260,474	257,626	518,100	1011.0
1953	272,716	266,434	539,150	1023.5
1954	286,724	280,822	567,546	1021.0
1955	294,208	288,461	582,669	1019.9
1956	309,808	301,766	611,574	1026.6
1957	317,600	309,282	626,882	1026.8
1958	316,220	309,128	625,348	1022.9
1959	324,394	317,090	641,484	1023.0
1960	328,670	322,782	651,456	1018.2
1961	334,738	327,288	662,026	1022.7
1962	321,772	314,260	636,032	1023.9
1963	323,234	313,838	637,072	1029.9
Mean Sex Ratio				1023.5
Total	5,518,882	5,393,435	10,912,317	1023.2

*Excluding 1945

TABLE III

NUMBER OF BIRTHS AND SEX RATIO FOR TOTAL TWENTY-ONE YEARS
BY COLOR AND AGE OF MOTHER

Age of Mother	Male	Female	Total	Sex Ratio
		White Population		
Under 25	14,954,755	14,102,543	29,057,298	1060.4
25-29	9,387,711	8,879,565	18,267,276	1057.2
30-39	8,598,985	8,174,867	16,773,852	1051.9
40 and Above	764,825	733,299	1,498,124	1043.0
		Non-White Population		
Under 25	2,914,019	2,839,440	5,753,459	1026.3
25-29	1,267,636	1,240,355	2,507,991	1022.0
30-39	1,214,107	1,190,934	2,405,041	1019.4
40 and Above	123,120	122,706	245,826	1003.4

TABLE IV

NUMBER OF BIRTHS AND SEX RATIO FOR TOTAL TWENTY-ONE YEARS
BY COLOR AND LIVE-BIRTH ORDER

Live-Birth Order	Male	Female	Total	Sex Ratio
		White Population		
First	10,803,647	10,136,127	20,939,774	1065.8
Second	9,394,152	8,884,547	18,278,699	1057.3
Third	6,084,904	5,778,883	11,863,787	1052.9
Fourth	3,354,640	3,194,002	6,548,642	1050.3
Fifth and Above	4,068,933	3,896,715	7,965,648	1044.2
		Non-White Population		
First	1,337,169	1,299,574	2,636,743	1028.9
Second	1,112,176	1,082,570	2,194,746	1027.3
Third	858,297	837,003	1,695,300	1025.4
Fourth	640,650	627,512	1,268,162	1020.9
Fifth and Above	1,570,590	1,546,776	3,117,366	1015.4

significant ($p<0.05$) in accounting for the variation of sex ratio. No significant interaction was found between variables of color, age of mother, and birth order. (See Table V.)

The orthogonal comparisons, assuming the equal intervals for the levels of factors, were performed for the age of mother sum of squares and birth-order sum of squares. For the age of mother, effect on the variations of sex ratio can be accounted for by both the linear and quadratic forms, significant at 0.01 and 0.05 levels respectively. (See Table VI, Part A.) That is to say, the change of sex ratio by levels of the age of mother from under 25, 25-29, 30-39, to 40 and above cannot be explained by a constant rate of linear change only. For the effect of birth order only, the linear form was significant ($p<0.05$). (See Table VI, Part B.) This means that the changes of sex ratio from the first-born children to the second, third, fourth, and fifth and above are more in a constant rate than other forms of variations.

Partial analyses were made by correlating sex ratio with age of mother (stratified by birth order) and with birth order (stratified by age of mother). The association between sex ratio and age of mother was shown to be significant for white births of the third child ($p<0.01$) and fifth and above ($p<0.01$), and for non-white births only for the fifth child and above ($p<0.05$). Correlations between sex ratio and age of mother are negative for all orders of births except the second child, for which the correlation coefficients are close to zero for both white and non-white. (See Table VII, Part A.) From the above, which supports the orthogonal comparisons for the effects of age of mother on the variation of sex ratio, no generalized linear association between sex ratio and age of mother can be concluded, although sex ratio at birth

TABLE V

ANALYSIS OF VARIANCE FOR SEX RATIO OF LIVE BIRTHS BY COLOR, AGE OF MOTHER, LIVE-BIRTH ORDER, AND CALENDAR YEAR

Sources of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	Calculated Variance Ratio, F
Total (corrected for mean sum of squares)	839	1559.2		
Calendar year	20	25.1	1.25	--[2]
Color	1	231.4	231.40	147.39***
Age of Mother	3	21.1	7.04	4.48***
Live-birth order	4	27.7	6.93	4.41
(Color) x (Age of mother)	3	4.7	1.56	--
(Color) x (Birth order)	4	7.0	1.76	1.12
(Age of mother) x (Birth order)	12	12.1	1.01	--
(Color) x (Age of mother) x (Birth order)	12	5.4	.45	--
Residual[1]	780	1224.6	1.57	
(Year) x (Color)	20	22.6	1.13	
(Year) x (Age of mother)	60	49.3	.82	
(Year) x (Birth order)	80	126.1	1.58	
(Year) x (color) x (Age of mother)	60	67.0	1.12	
(Year) x (Color) x (Birth order)	80	137.9	1.72	
(Year) x (Age of mother) x (Birth order)	240	390.7	1.63	
(Year) x (Color) x (Age of mother) x (Birth order)	240	431.0	1.80	

***For $p<.005$ (From B. Ostle, Statistics in Research, 2nd Ed., The Iowa State University Press, 1963, Appendix 6, p. 542.)

[1]Pooled from those below the residual term.

[2]F-value not calculated for those less than 1.

TABLE VI

ORTHOGONAL COMPARISONS FOR PARTITIONS OF THE SUMS OF SQUARES

Effect	Degrees of Freedom	Sums of Squares	Mean Squares	Calculated Variance Ratio, F[1]
	A. Age-of-Mother Sum of Squares			
Linear	1	13.5	13.5	8.59**
Quadratic	1	6.9	6.9	4.39*
Cubic	1	.7	.7	--[2]
Total	3	21.1		
	B. Birth-order Sum of Squares			
Linear	1	22.8	22.8	14.51**
Quadratic	1	.2	.2	--
Cubic	1	2.9	2.9	1.87
Remainder	1	1.8	1.8	1.15
Total	4	27.7		

*For $p<.05$

**For $p<.01$ (From B. Ostle, Appendix 6, p. 542)

[1]Residual mean square in Table V was taken for the denominator.

[2]F-value not calculated for less than 1.

TABLE VII

PARTIAL ANALYSIS BY CORRELATION COEFFICIENTS

A. Between Sex Ratio and Age of Mother Stratified by Birth Order[1]

	Correlation Coefficients, r's	
Birth Order	White	Non-white
First	- .135	- .146
Second	.047	.057
Third	- .323**	- .126
Fourth	- .078	- .198
Fifth and Above	- .406**	- .236*

B. Between Sex Ratio and Birth Order Stratified by Age of Mother[2]

	Correlation Coefficients, r's	
Age of Mother	White	Non-white
Under 25	- .480**	- .314**
25-29	- .643**	- .238*
30-39	- .693**	- .114
40 and Above	- .247*	- .048

*For $p<.05$ and ** for $p<.01$ (From J. P. Guilford, Fundamental Statistics in Psychology and Education, McGraw-Hill, 1965, Appendix B, Table 6, pp. 580-581.

[1] N = 84 for each correlation coefficient.

[2] N = 105 for each correlation coefficient.

varies significantly with mothers of different age groups as indicated by the analysis of variance.

The association between sex ratio and the order of births was found to be significant for white births of those born to mothers under 25, 25-29, and 30-39 years of age ($p<0.01$) and 40 and over ($p<0.05$); and for non-white births of those born to mothers under 25 ($p<0.01$) and 25-29 ($p<0.005$). The directions of the correlations were all shown to be negative. (See Table VII, Part B.) It may be concluded that the higher the order position of births, the lower is the sex ratio. This linear correlation is more consistent for white population than for non-white. These correlations demonstrate more clearly the orthogonal comparisons for the effects of birth order on sex ratio, which are discussed above.

In order to validate the above findings, a further step was taken to analyze in what way the over-all sex ratio of each calendar year was affected by the proportion of births born to a particular age group of mothers or a particular order position of births, considering white and non-white separately.

In Table VIII, number of live births born to mothers under age 25 and their percentage of the total number of births for each year were presented. For both white and non-white, the percentage of children born to young mothers under 25 seemed to decrease slightly from the 1940's to 1950's and then increase slightly in the 1960's. The association between the sex ratio of live births in a calendar year and the proportion born to mothers under age 25 to the total births of that year have been found significant ($p<0.01$) both for white and non-white.

TABLE VIII

NUMBER OF LIVE BIRTHS BORN TO MOTHERS UNDER AGE 25 AND THEIR PROPORTION TO TOTAL NUMBER OF BIRTHS BY COLOR AND YEAR

	White		Non-White	
Year	Number of Births to Mothers Under 25	% of Total Births(1)	Number of Births to Mothers Under 25	% of Total Births(1)
1942	1,046,189	44.28	178,668	57.53
1943	1,045,232	42.39	184,074	56.56
1944	946,305	40.71	176,675	54.44
1946	1,127,938	40.91	188,986	53.35
1947	1,361,077	43.67	226,004	55.85
1948	1,297,748	44.21	243,632	56.22
1949	1,297,751	43.54	257,636	54.97
1950	1,258,274	42.49	260,699	53.87
1951	1,341,852	42.85	268,132	52.78
1952	1,348,538	41.99	267,480	51.62
1953	1,369,690	42.14	274,624	50.93
1954	1,413,404	42.40	288,818	50.88
1955	1,427,988	42.68	295,887	50.78
1956	1,498,264	43.67	312,130	51.03
1957	1,553,870	44.34	321,372	51.26
1958	1,562,652	45.20	321,750	51.45
1959	1,608,622	46.18	330,658	51.54
1960	1,636,078	46.94	337,032	51.73
1961	1,664,396	47.75	342,500	51.73
1962	1,615,040	49.19	334,770	52.63
1963	1,636,390	49.62	341,932	53.67
Correlation (r) with Sex Ratio (2)		- .646**		.541**

1,2See Tables I and II for total number of births and sex ratio.

**For p<.01 (From Guilford, Appendix B. Table D)

But, for white the higher the proportion of children born to young mothers under age 25, the lower was the sex ratio for a calendar year ($r = -0.646$). For non-white the opposite direction of the relationship was found ($r = 0.541$).

Table IX presents the number of live births born to mothers of age 30 and above and their proportion to the total births of each year. For white a positive correlation ($r = 0.462$) between sex ratio and the percentage of births to mothers 30 years old and older was found to be significant ($p<0.05$), but for non-white this correlation ($r = -0.328$) was negative, although it was not statistically significant.

There seems to be an indication that the relationship between age of mother and the sex ratio of births is a very subtle one. For white, the higher the proportion of children born to young mothers under age 25 in a year, the lower is the sex ratio of the total births in that year, while the higher the proportion of children born to older mothers, 30 and above, the higher is the sex ratio. For non-white the reverse is the case. In short, the variations in sex ratio at birth can be differently accounted for by age of mother in various groups, and no generalized effect of age of mother on the sex ratio of births can be concluded.

The proportion of first-born children to total births for each calendar year was seen to be decreasing in the last two decades (see Table X), while the proportion of children born later than the third order position to the total births was increasing. (See Table XI.) For white, the sex ratio of yearly births was significantly ($p<0.05$) associated with the proportion of first-born children to the total births in each year. The positive correlation coefficient ($r = 0.503$)

TABLE IX

NUMBER OF LIVE BIRTHS BORN TO MOTHERS OF AGE 30 AND ABOVE AND THEIR PROPORTION TO TOTAL NUMBER OF BIRTHS BY COLOR AND YEAR

	White		Non-White	
Year	Number of Births to Mothers 30 And Above	% of Total Births(1)	Number of Births to Mothers 30 And Above	% of Total Births(1)
1942	635,638	26.90	69,523	22.38
1943	706,012	28.63	75,197	23.10
1944	718,272	30.90	79,246	24.42
1946	820,907	29.77	86,513	24.42
1947	854,289	27.41	91,403	22.58
1948	799,886	27.25	94,513	21.81
1949	813,826	27.31	105,075	22.42
1950	826,616	27.91	110,843	22.90
1951	870,822	27.81	119,656	23.55
1952	920,386	28.66	124,842	24.09
1953	936,252	28.81	132,028	24.48
1954	970,258	29.11	140,688	24.78
1955	974,466	29.12	146,260	25.10
1956	981,902	28.61	154,294	25.22
1957	992,542	28.32	158,906	25.34
1958	966,048	27.94	157,950	25.25
1959	957,970	27.50	162,168	25.28
1960	893,944	25.65	165,042	25.33
1961	926,008	26.56	166,898	25.21
1962	835,500	25.45	157,092	24.69
1963	824,432	25.00	152,730	23.97
Correlation (r) with Sex Ratio(2)		.462*		- .328

1,2See Tables I and II for total number of births and sex ratio.

*For $p<.05$ (From Guilford, Appendix B, Table D)

TABLE X

NUMBER OF FIRST-BORN LIVE BIRTHS AND THEIR PROPORTION TO TOTAL NUMBER OF BIRTHS BY COLOR AND YEAR

Year	White		Non-white	
	Number of First Born	% of Total Births	Number of First Born	% of Total Births
1942	1,013,376	42.89	91,941	29.60
1943	944,465	38.30	93,087	28.60
1944	824,562	35.48	87,848	27.07
1946	1,089,661	39.52	98,290	27.75
1947	1,339,226	42.97	126,769	31.32
1948	1,130,253	38.50	125,900	29.05
1949	1,048,258	35.17	124,611	26.59
1950	966,308	32.63	120,812	24.96
1951	1,020,538	32.59	123,220	24.25
1952	997,736	31.07	121,444	23.44
1953	977,798	30.08	126,034	23.37
1954	980,438	29.41	133,216	23.47
1955	961,489	28.73	132,641	22.76
1956	983,862	28.67	137,966	22.55
1957	996,248	28.42	139,934	22.32
1958	962,732	27.85	136,166	21.77
1959	953,366	27.36	139,566	21.75
1960	947,692	27.19	142,460	21.86
1961	954,754	27.39	144,934	21.89
1962	909,790	27.71	141,372	22.22
1963	937,222	28.42	148,532	23.31
Correlation (r) with Sex Ratio[2]		.503*		.398

[1,2]See Tables I and II for total number of births and sex ratio.

*For $p<.05$ (From Guilford, Appendix B, Table D)

TABLE XI

NUMBER OF LIVE BIRTHS BORN LATER THAN THE THIRD CHILD AND THEIR PROPORTION TO TOTAL NUMBER OF BIRTHS BY COLOR AND YEAR

Year	White		Non-white	
	Number of Births Later Than the Third Child	% of Total Births	Number of Births Later Than the Third Child	% of Total Births(1)
1942	431,203	18.25	113,375	36.50
1943	472,452	19.16	120,655	37.07
1944	482,856	20.77	125,755	38.75
1946	489,537	17.75	132,048	37.28
1947	491,462	15.77	136,959	33.84
1948	487,387	16.60	145,068	33.48
1949	522,330	17.52	162,457	34.66
1950	539,797	18.22	174,106	35.98
1951	584,562	18.66	190,032	37.41
1952	634,480	19.75	203,030	39.18
1953	675,106	20.77	216.780	40.20
1954	728,922	21.87	232,518	40.96
1955	768,228	22.96	241,619	41.46
1956	812,416	23.67	256,548	41.94
1957	859,122	24.51	265,084	42.28
1958	879,194	25.43	268,438	42.92
1959	918,614	26.37	279,034	43.49
1960	943,470	27.07	283,070	43.45
1961	964,682	27.67	290,414	43.86
1962	916,508	27.91	277,364	43.60
1963	911,962	27.65	271,174	42.56
Correlation (r) with Sex Ratio(2)		-.779**		-.166

[1,2]See Tables I and II for total number of births and sex ratio.

**For p<.01 (From Guilford, Appendix B, Table D)

indicated that the higher the proportion of first-born children, the higher was the sex ratio of the total yearly births.

The proportion of white children born later than the third child to the total white births in a year was found even more significantly ($p<0.01$) associated with the sex ratio of total births in that year. A correlation as high as -0.779 was calculated, which indicated that a lower sex ratio could be significantly accounted for by greater proportion of offspring born to parents after they have had their third children. For non-white, the relationships between sex ratio and the proportions of children born as first child and later than the third child were consistent with the directions as those among the white population of births, although they are not statistically significant.

CHAPTER V

SUMMARY AND CONCLUSION

This study proposes to explore the relationships between human sex ratio at birth and three selected variables, color, age of mother, and order position of births. Vital statistics of the United States recording the number of live births by sex, age of mother, live-birth order, and color for the calendar years from 1942 to 1963 (excluding 1945) have been used for the analysis. First, sex ratio of live births is considered with concomitant variations in color, age of mother, and live-birth order, using the factorial analysis of variance. Second, partial analyses, utilizing the Pearsonian r are employed to investigate the relationships between sex ratio and those selected variables which have been found to be significant in the first analysis of variance. Finally, the sex ratio of total births in each year is used as the unit of observation for investigating the effects of proportion of live births born to particular age groups of mothers and the birth order of children on the over-all sex ratio of the yearly births.

Sex ratio at birth has been found to be significantly different by color, age of mother, and birth order of child. No effect of the interaction between these variables has been found to be significant on the variation in the sex ratio of births. Although these findings are consistent with the earlier studies such as McMahan's and Myers', this

study analyzing the sex ratio at birth on the concomitant variations of the three selected variables seems to be a more adequate approach.

The sex ratio of white births has consistently been higher than that of the non-white. As stated in the review of literature, the difference between white and non-white sex ratio at birth could be explained by their differences in socio-economic environment. Racial differences are complicated and hard to explain because of the inclusiveness of the concept. A more satisfactory explanation, of course, should include consideration of genetic differences, if any, between races. For the moment, however, the finding of differential sex ratio at birth between white and non-white may point to a further exploration of causality between different patterns of fertility behavior (such as prenatal care, birth control, age of bearing children, and number and spacing of births, etc.) and the ratio of male to female which resulted.

The relationship between sex ratio and age of mother is not clear. It varies in different directions for white and non-white and for different birth order of children. The author assumes by this finding that the effect of maternal age on the sex ratio of births could be either negligible or so much associated with factors such as paternal age, birth order of child, and others not being considered that the effect of maternal age itself could not be detected by the simple linear model.

The birth order of child has been found significantly in negative correlation with the sex ratio of births. The over-all sex ratio of the yearly births is found to be affected by the proportion of children born first and of those born later than the third-order position. The higher

the proportion of the first-born children in a year, the higher is the sex ratio of total births in that year, while the higher the proportion of children born in the fourth, fifth position and above, the lower is the sex ratio.

If the sex ratio of the first-born children is supposed to be closer to the chance probability, the lower sex ratio of the higher birth-order children could be explained by stating that parents having more than three children are those who have a greater predisposition toward bearing females. This seems to substantiate a combination of the theoretical proposition that parents bearing more than three children are those who are not satisfied with the sex composition of children they have had and the biological one that the tendency toward bearing more children of one sex is an inheritable trait rather constant for a couple. Also the norm of male preference for having more male than female offspring or for having at least one male offspring may be held by a majority of the population in the United States.[1]

The conclusions made are tentative. This study is by no means a complete one. An analysis based upon linear assumptions is but a crude one. Further studies, assuming other models such as quadratic and cubic for analysis and utilizing longitudinal sampling with consideration and control of more factors, are urged.

---

[1]Winston found that the preference for male offspring was even more prevalent in higher social classes. (See Winston, 1932.)

BIBLIOGRAPHY

Clare, J. E. and C. V. Kiser. "Preference for Children of a Given Sex in Relation to Fertility." Social and Psychological Factors Affecting Fertility. Ed. C. V. Kiser and P. K. Welpton. New York: Milbank Fund, 1952, Vol. III, pp. 621-673.

Edward, A. W. F. "A Factorial Analysis of Sex Ratio Data." Annals of Human Genetics, 25 (1961), pp. 117-121.

Goodman, L. A. "Some Possible Effects of Birth Control on the Human Sex Ratio." Annals of Human Genetics, 25 (1961), pp. 75-81.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, 1965.

Kirk, Dudley. "Demographic Factors Affecting the Opportunity for Natural Selection." Population Index, 32 (July, 1966), pp. 318-319.

McMahan, C. A. "An Empirical Test of Three Hypotheses Concerning the Human Sex Ratio at Birth in the United States, 1915-1948." The Milbank Memorial Fund Quarterly, XXIX (July, 1951), pp. 271-293.

Metropolitan Life Insurance Company. Statistical Bulletin, 46 (May, 1965), pp. 4-5.

Myers, Robert J. "Effect of the War on the Sex Ratio at Birth." American Sociological Review, 12 (February, 1947), pp. 40-43.

Myers, Robert J. "The Effect of Age of Mother and Birth Order on Sex Ratio at Birth." The Milbank Memorial Fund Quarterly, XXXII (July, 1954), pp. 275-281.

Ostle, B. Statistics in Research. Ames, Iowa: The Iowa State University Press, 1963.

Panunzio, C. "Are More Males Born in Wartime?" The Milbank Memorial Fund Quarterly, XXI (July, 1943), pp. 281-291.

Ramachandran, K. V. and V. A. Deshpande. "The Sex Ratio at Birth in India by Regions." The Milbank Memorial Fund Quarterly, XLII (April, 1964), pp. 84-95.

Ratcliff, J. D. "New Facts About Human Reproduction." Reader's Digest, December, 1966, pp. 119-122.

Renkonen, K. O. "Is the Sex Ratio Between Boys and Girls Correlated to Sex of Precedent Children?" Annual of Medical Experiment (34), pp. 447-451.

Sheps, M. C. "Effects on Family Size and Sex Ratio of Preferences Regarding Sexes of Children." Population Studies, XVII (July, 1963), pp. 66-72.

Shettles, L. B. "Human Spermatozoan Populations." International Journal of Fertility, 7 (April-June, 1962), pp. 175-184.

Steel, R. G. D. and J. H. Torrie. Principles and Procedures of Statistics. New York: McGraw-Hill, 1960.

Szilard, L. "Dependence of the Sex Ratio at Birth on the Age of Father." Nature, 186 (May 21, 1960), pp. 649-650.

Thomlinson, R. Population Dynamics. New York: Random House, 1965, p. 131.

Thompson, W. S. and D. T. Lewis. Population Problems. 5th Ed. New York: McGraw-Hill, 1965.

Tulsa Daily World, February 28, 1966, p. 7. "Work to Separate Sperms Under Way."

Tulsa Daily World, November 10, 1966, Section 2-B. "Scientists Concerned Over Social Implication of Biology Advances."

United States Department of Health, Education, and Welfare. Indicators, September, 1965, pp. 10-11.

United States Department of Health, Education, and Welfare. Natality Statistics Analysis, 1962, p. 29.

Westoff, C. F., R. G. Potter, Jr., and P. C. Sagi. The Third Child: A Study in the Prediction of Fertility. Princeton: University Press, 1963.

Willie, C. V. and W. B. Rothney. "Racial, Ethnic, and Income Factors in the Epidemiology of Neonatal Mortality." American Sociological Review, 27 (August, 1962), pp. 522-526.

Winston, S. "The Influence of Social Factors Upon the Sex Ratio at Birth." American Journal of Sociology. XXXVII (July, 1931), pp. 1-21.

Winston, S. "Birth Control and the Sex Ratio at Birth." American Journal of Sociology, XXXVIII (September, 1932), pp. 225-231.

Yankaner, A., K. G. Gross, and S. M. Romeo. "An Evaluation of Prenatal Care and Its Relationship to Social Class and Social Disorganization." American Journal of Public Health, 43 (August, 1953), pp. 1001-1010.

VITA

Che-Fu Lee

Candidate for the Degree of

Master of Science

Thesis: AN ANALYSIS OF THE SEX RATIO OF LIVE BIRTHS IN THE UNITED STATES, 1942-1963

Major Field: Sociology

Biographical:

Personal Data: Born in Chia-Yi, Taiwan, December 5, 1941, the son of Lien-Teng and Ying-seng Lee.

Education: Attended grade school in Chia-Yi, Taiwan; graduated from Provincial Chia-Yi High School in 1959; received the Bachelor of Science degree from the National Taiwan University with a major in Agricultural Engineering in June 1963; completed requirements for the Master of Science degree in May, 1967.

Professional experience: Entered the Chinese Army in 1963 and was a second lieutenant in the Infantry; taught at Taipei's Municipal High School in 1964.