Stressor Effects on Sex Ratios and Births in the Maltese Population during the First Half of the 20th Century

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ABSTRACT

Background: The sex ratio at birth (male/total = M/F) is expected to approximate 0.515. Stress is known to reduce livebirth M/F. In the first half of the 20th century, Malta was stressed by two World Wars.

Objectives: This study was carried out in order to analyse changes in reproductive performance and M/F of stillbirths and livebirths in Malta during this period.

Methods: Livebirth and stillbirth data (1910–1951) were obtained from official published Maltese government reports. Stillbirths were defined as any antenatal loss after 28 weeks of gestation.

Results: This analysis studied 347,562 live and 11,662 stillbirths. For 1919–1951, M/F at birth was 0.517, stillbirth M/F was 0.664, implying 28/40 M/F = 0.522. Assuming conceptional M/F = 0.5, estimated M/F for fetal wastage before 28 weeks was approximately 0.434. There was a decrease in the overall birth rate starting after 1911 to 1921, more marked for 1941–1943 followed by an overshoot in 1943–48. There was a statistically significant drop in M/F livebirths during the periods 1916–21 and 1934–45. Stillbirths decreased significantly after 1935 (M>F). A stillbirth M/F drop in 1937–45 and rise in 1946–51 were statistically significant.

Conclusions: Birth rate drops in both wars were ascribed to conscription, adverse living conditions and decreased fertility from nutritional restrictions. Both conflicts resulted in short post-war baby booms. The decrease in stillbirths is attributed to increase in antenatal attendances, hospital births and special food rations for pregnant women. The M/F observations suggest that the selective survival of both healthier female and male foetuses is favoured during times of stress.

KEYWORDS

birth rate/trends; sex ratio; Malta; infant, newborn; starvation

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INTRODUCTION

The sex ratio at birth (M/F) is expected to approximate 0.515 (1). It is estimated that circa a quarter of conceptions are lost (2, 3), and the greater preponderance of male livebirths suggests that there is some form of mechanism whereby proportionately more female than male fetuses are lost during pregnancy (4). The exact nature of this mechanism is undetermined. Stress is known to reduce livebirth M/F but the ratio still favours male births suggesting that proportionately more male fetuses are lost during times of stress (5). This accords with the Trivers-Willard hypothesis (TWH) which avers that evolution has favoured parents who are able to bias M/F according to the circumstances encountered during pregnancy (6). TWH postulates that in a polygnous species, wherein males have multiple mating opportunities and thus a greater ability to pass on parental genes, a healthy mother should bias M/F towards male births. On the other hand, mothers in a poor state of health would have a greater propensity to abort male pregnancies since these are less likely to survive to term, and should they do so, are more likely to be frail and not survive childhood. If they do survive to adulthood, they would compete poorly for mating opportunities against more robust males. On the other hand, the female foetus is more likely to survive pregnancy under poor conditions and on reaching adulthood, will almost certainly be fertilised. Spontaneous miscarriage of a male fetus during a stressful pregnancy may therefore result in a greater proportion of females encountering males who may be more successful at reproducing the species (6). The antenatal timing for the disproportionate loss of male fetuses during times of stress has however not been fully elucidated (4, 7).

During the first half of the twentieth century, the Maltese population was subject to periods of marked physical and mental stress. The second decade included the First World War (June 1914 – November 1918) and this was very quickly followed by the Spanish Flu epidemic. During the war, Malta was a British base and was only indirectly affected. However, a significant number of men joined the British Services while the country experienced an economic depression. The end of that conflict coincided with the onset of H1N1 influenza pandemic which affected the Maltese population in three major waves that ended in 1925 (8).

The 1940s were characterised by Italian expansionism led by the Italian dictator Benito Mussolini. The Maltese Islands located just south of Sicily, still under British dominion, viewed these expansionist activities with anxiety. The first concern related to the Abyssinia Crisis of 1935 involving the Kingdom of Italy and the Empire of Ethiopia leading to the Second Italo-Ethiopian War (1935–1937). The fear of being involved in this conflict was sufficient to drive the Maltese health authorities to draw up an emergency war scheme and provide for medical equipment and medications in case of a prolonged siege. The onset of direct hostilities in the Second World War involving the Maltese population occurred in June 1940 initiating the Siege of Malta which lasted until November 1942 (8). During the siege, Axis forces attempted to capture Malta due to its strategic location. The constant bombing resulted in hardship, privation and hunger for the Maltese until the Axis lost the Second Battle of El Alamein and Allied forces landed in Morocco and Algeria in 1942 (8, 9). The adverse effects of the Siege of Malta persisted in the subsequent years until social conditions returned to normality. This conflict had significant effect on the reproductive performance of the Maltese population with a significant drop in birth rate during the period (10, 11).

This study was carried out to determine whether the observed changes in reproductive performance in the period before, during and after these conflicts affected the male-to-female ratios of stillbirths and livebirths in Malta.

METHODS

Malta's population currently approximates half a million. The total number of livebirths and livebirth rate data (1910–1951) were obtained from the published Maltese Department of Health annual reports for the period. Sex identified data was only available for the period 1916–1951 allowing for the calculation of the annual sex-differentiated birth rates and the M/F ratios (11). Stillbirth data was obtained by compiling the fortnightly mortality data published by the Department of Health for the period. During the period under review, stillbirths were defined as any antenatal loss after 28 weeks of gestation. Stillbirth data was unavailable for the period 1910–1918 (12).

The quadratic equations of Fleiss were used for the calculation of 95% confidence intervals for ratios (13). Statistical analysis was performed using bespoke Excel spreadsheets, namely Pearson correlation (14). A p value ≤ 0.05 was taken to represent a statistically significant result.

RESULTS

This analysis studied 347,562 live births and 11,662 stillbirths. For the period when sex data for both livebirths and stillbirths was available (1919–1951), the M/F ratio at birth was 0.517, while the M/F ratio for stillbirths was 0.664, implying that at 28 weeks gestation, M/F ratio stood at 0.522 (Table 1). Assuming a < 28 week miscarriage rate of about 25% of total conceptions, the total conceptions in Malta during the period 1919–1951 approximated 396,052. If the primary sex ratio at conception is 0.500, then equal numbers of males and females are conceived. The estimated M/F ratio for fetal wastage before 28 weeks of pregnancy would therefore approximate 0.434 (Table 1).

LIVE BIRTHS

Births for both sexes increased throughout the period studied except for a dip that coincided with WW2 (Figure 1). There was a decrease in the overall birth rate starting after 1911 and continuing through the WW1 period extending to around 1921. A more marked drop in overall

Tab. 1 Actual and estimated fetal wastage by sex >28 and <28 weeks gestation.

	Male	Female	M/F ratio	Proportionate conceptional fetal loss
Livebirths	147,359	138,018	0.516	
Observed fetal wastage >28 weeks	7,749	3,913	0.664	3rd tri: 11,662-- 2.9%
At 28 weeks gestation	155,108	141,931	0.522	
Assumed fetal wastage <28 weeks*	42,918	56,095	0.434	1/2nd tri: 99,013 – 25.0%
Estimated conceptions	198,026	198,026	0.500	

* assumed at 25% of conceptions

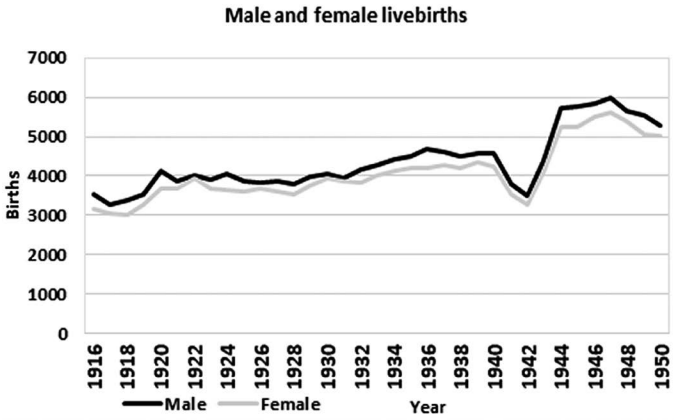

Fig. 1 Absolute number of male and female livebirths and stillbirths in Malta, 1910–1951.

birth rates is evident during the WW2 period starting in 1941 and extending to 1943 followed by an overshoot in birth rate during 1943–48 period. The observed changes in overall birth rates is very closely mirrored in the rates for both sexes (Figure 2). There was a statistically significant gradual increase in births of both sexes from 1916–1951 (Pearson correlation, males r = 0.8, p < 0.0001, females r = 0.82, p < 0.0001).

After visual inspection, grouped data analysis suggest statistically significant changes during different periods with a rise in M/F ratios during the period 1916–21 and 1934–45 (Table 2).

Tab. 2 M/F and 95% confidence intervals for livebirths by sex for the period 1916–1951.

	1916–21	1922–33	1934–45	1946–51
M	21,725	47,765	55,011	33,058
F	19,858	45,173	50,963	31,269
Total	41,583	92,938	10,5974	64,327
UCI	0.5273	0.5172	0.5221	0.5178
M/F ratio	0.5224	0.5139	0.5191	0.5139
LCI	0.5176	0.5107	0.5161	0.5100
p	0.004		0.023	0.992

p-value comparisons with 1922–33

STILLBIRTHS

Absolute number of male stillbirths increased overall throughout the period studied but absolute female still-

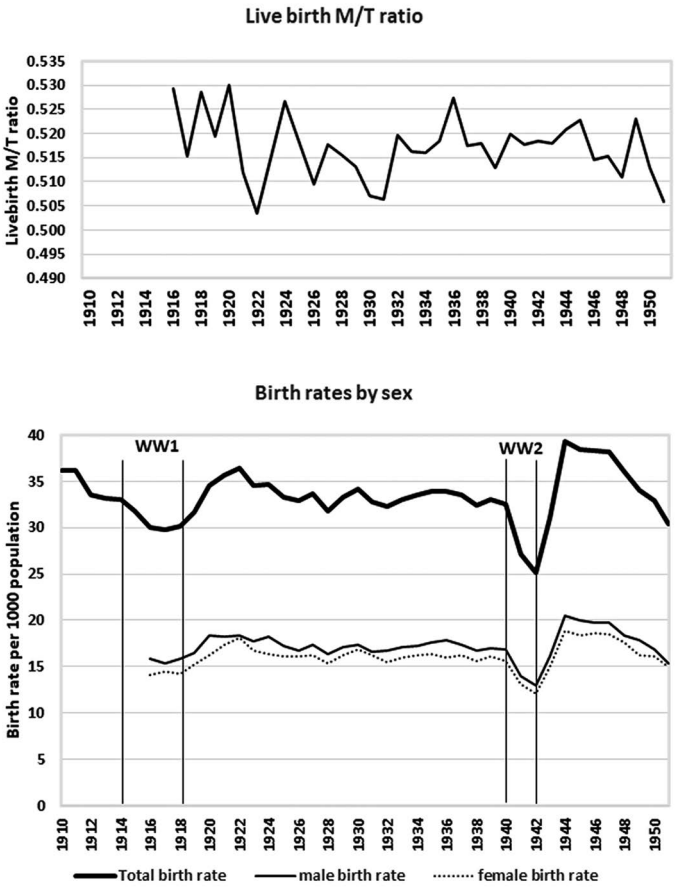

Fig. 2 Male and female livebirths and M/F ratio in Malta, 1910–1951.

births dropped after WW2 (Figure 1). The annual stillbirth rate shows a marked decrease in rate after 1935 maintaining a steady downward trend in the subsequent years. There appeared to be a disproportionately greater increase in male losses throughout the period (Figure 3). The M/F ratio appears to have taken a downward trend after 1936 maintained to 1947, after which a marked rise in M/F ratio is again exhibited. For the period 1919–1947, there was a highly significant correlation between male and female stillbirths (Pearson r2 = 0.73, p < 0.0001). The drop from 1919 to 1951 was significant for both sexes albeit with a poorer fit than the live births presented in the previous section, and with female fit better than male fit (Table 3). Grouped data analysis suggest statistically significant changes during different periods with a fall in M/F ratios during the period 1937–45 and rise in the period 1946–51 (Table 3).

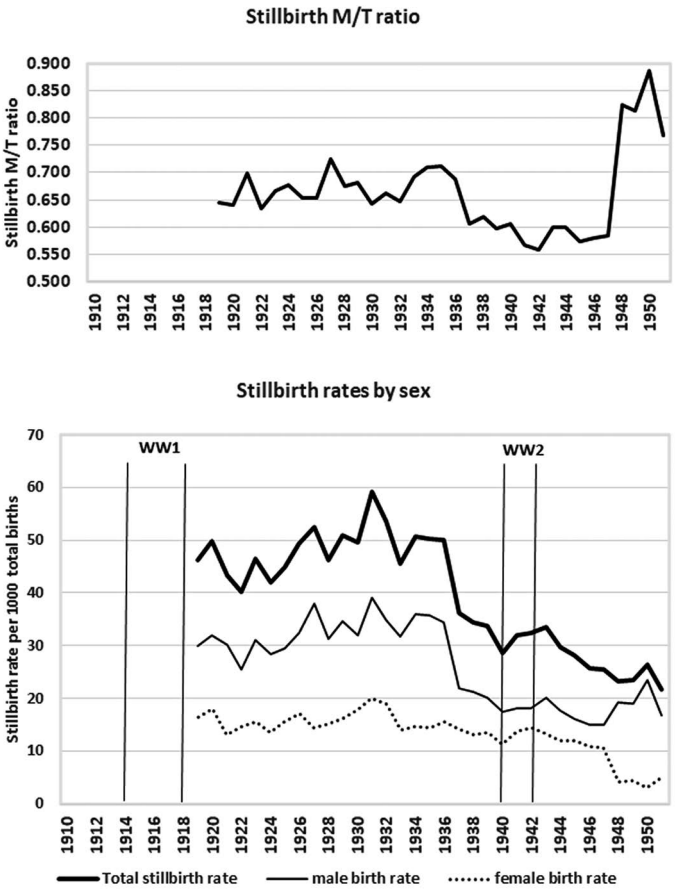

Fig. 3 Male and female stillbirths and M/F ratio in Malta, 1910–1950.

Tab. 3 M/F and 95% confidence intervals for stillbirths by sex for the period 1919–1951.

	1919–24	1925–36	1937–45	1946–51
M	1,367	3,666	1,552	1,164
F	702	1,728	1,062	421
Total	2,069	5,394	2,614	1,585
UCI	0.6810	0.6921	0.6126	0.7558
M/F ratio	0.6607	0.6796	0.5937	0.7344
LCI	0.6398	0.6670	0.5746	0.7118
p		0.133	<0.0001	<0.0001

p-value comparisons with 1919–24

DISCUSSION

The two World Wars led to a significant drop in the overall birth rate of the Maltese population. This has been ascribed to various causes including the calling up of males for military service and, especially during the second conflict when the islands were directly affected, the adverse living environment and decreased biological fertility from nutritional restrictions. Both conflicts were followed by 'post-war baby booms' with a short-lived rise in birth rates (10, 15). Similar observations were made for most European countries including the United Kingdom where the birth rate dropped to its lowest level during the 1940–41 period rising sharply to peak in 1947 (16). Indeed, a dip in fertility (and hence births) has been observed during times of biological stress in several other studies (17–19).

In contrast, the stillbirth rate in the Maltese Islands had started to decrease in the latter half of the third decade of the 20th century, a decrease that was maintained right through the conflict years after. The continued decline in stillbirth rate during the war years has been attributed to the increase in antenatal attendances and hospital births noted during the conflict years and to special rations allocated to expectant women (10, 15). Similar observations were made in the United Kingdom and the Netherlands (20, 21).

While M/F almost invariably demonstrates a male excess, it is known that male fetuses are more likely to be lost during the third trimester of pregnancy than female fetuses (20). The British Perinatal Mortality Study carried out in 1958 reported that the sex distribution of both antepartum and intrapartum stillbirths with a gestational age >28 weeks showed a preponderance of male deaths – calculated M/F ratio of 0.549 and 0.524 respectively. A similar male predominance of early neonatal deaths (M/F of 0.585) was reported (20). Some studies also noted a dip in male births that exceeded female births in accordance with the Trivers-Willard hypothesis, skewing M/F toward females during times of biological and psychological stress (22). Arguably the most notable such study described the Great Leap Forward in China (11/1957–1/1961)(23) with an estimated loss of 18,286,000 births in 1959–61 with a further additional male deficit of 3.2 per 1000 births (24).

This study confirms that at 28 weeks gestation, the sex ratio was similar to that reported for livebirths favouring male offspring. Assuming that at conception, M/F approximates to 0.500 (4), it appears that a proportionate greater female wastage occurs during the first two trimesters of pregnancy (25). A study involving 750 spontaneous miscarriages occurring between the 5–25th week of pregnancy reported a predominance of female pregnancy wastage whether the fetuses were noted to have a normal or a trisomy karyotype (calculated M/F ratio of 0.416 and 0.487 respectively) (25).

With a reported miscarriage rate of approximately 25% and the larger majority occurring in the first trimester (26), the disproportionate loss of female fetuses results in a significant deficit that persists right through the perinatal period even though proportionately more male fetuses are lost during the third trimester and neonatal period. The reasons for the proportionately excessive female wastage in the first trimester have not been completely elucidated (27). However, its evolutionary purpose may be to ensure that the healthiest females survive to ensure effective reproductive capabilities. In times of stress, where the livebirth M/F ratio is reduced, the mechanism may involve either reduced female wastage or increased male wastage during the first trimester (28). Physical or psychological stressor situations have been associated with an increased risk of miscarriages (29), suggesting that the most likely mechanism in play is more likely to be an increase in first trimester male wastage rather than a protective mechanism to reduce female wastage and the mechanism for this may be the observed raised progesterone and cortisol

during times of stress (30). Indeed, even X and Y bearing sperm have different susceptibility to stress (31, 32).

Human evolution may have developed mechanisms whereby the less healthy members of the female species are excluded from the reproductive equation by ensuring a higher female fetal wastage in the first trimester of pregnancy. Since the female of the species bears the main brunt of the reproductive process, this mechanism ensures that more reproductive-capable females are available to propagate the species. The male of the species has a limited role in the reproductive process and less healthy members can still effectively contribute to species survival. In times of biological stress, evolution appears to have favoured the survival, not only of healthier female fetuses, but also healthier males with an apparent increase in first trimester male fetal wastage (33).

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