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Twin Seasonality in a Rural Catalonian Population

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A B S T R A C T

The seasonality of twinning in the Spanish populations has not been studied until now. Differences between seasonal distribution of the twin conceptions and those of the single births have been observed in other populations. The aim of this work is to explore the frequency of twinning in a rural population from Catalonia during the nineteenth century, as well as the seasonality patterns characterizing each of the twinning types. Data corresponding to all births recorded at Tortosa (South Catalonia) from 1801 to 1900 have been analyzed in order to study the twinning distribution. The distribution of the moving averages of the monthly rates of twins shows a peak in autumn. Twinning distribution differs from the total births' distribution in Tortosa. This fact is very clear in the case of unlike-sexed twins that have their greater incidence in the last quarter of the year, while the total maternities have their peak in the first one.

Key words: *seasonality, twins, rural Catalonia, 19th century*

Introduction

During the nineteenth century, Tortosa was one of the most populated municipalities of Spain, and their socio-economic, cultural and political influence expanded into southern Catalonia and large portions of the neighbouring regions of Valencia and Aragón. The city was also an important fluvial port, and since the eighteenth century their economic development was largely based on the dry-farmed crops (wheat, olive and carob). The north hemidelta of the Ebro River belonged to the Tortosa's municipality during the 19th century and the beginning of the 20th century when the settlement of the Delta was consolidated after the crop of the rice.

At the beginning of the 19th century, the Tortosa population size was around 11–12,000 inhabitants, reaching 16,467 persons in 1830, 20,573 during the deca-

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de of 1840–50. To the end of the 19^{th} century, the population size was 24,452 inhabitants[1].

A previous analysis of the nineteenth century birth archives from the Tortosa's Cathedral (Tarragona) detected a seasonal pattern of twinning births, which differed from the general model of monthly distribution of births in southern Catalonia[2]. The main objective of this work is to further explore the evolution of twinning in this rural population from Catalonia during the nineteenth century, as well as the seasonality patterns characterizing each of the twinning types and the twinning rates. Seasonality of demographic parameters can be determined by several climatic, cultural and biological factors. Previous works of Johnston[3], Lam and Miron[4], Hernández[5] and Fellman and Eriksson[6] among others, tend to explore the interactions between those factors and seasonality.

Material and Methods

All birth archives are well preserved in the Tortosa Cathedral parish, and it served as the source of twinning data for this work. Data from 43,526 births (22,323 males and 21,203 females), recorded at the archive of the Cathedral from 1801 to 1900, have been analyzed. Sex and date of the birth were recorded for twins in order to analyze the seasonality. Seasonal coefficients have been calculated according to the Henry's method[7], and the monthly distribution was compared with the expected in absence of seasonality, taking into account the number of days of each month. To evaluate the significance of the deviation from uniformity, the Pearson's test of goodness of fit has been used, following O'Brien and Holbert[8]. As expected, this procedure will give different significance levels for identical relative frequencies, because it also depends on the population size.

Edwards' methodology[9] was used to compare the observed births' distributions with the sinusoidal patterns. Edwards stated that the simple Pearson's goodness of fit is not sufficient to detect cyclical trends, with equidistant maximums and minimums in the annual recurrence, because »of the (n-1) degrees of freedom only one or two are likely to be necessary to specify any biologically meaningful type of trend, and the remaining (n-2) or (n-3) will produce a cloud of uncertainty«. Taking into account the high number of births considered here, objections of James[10] to the Edwards' methodology can be disregarded.

The Freedman's test[11] has also been applied because it detects seasonal processes following sinusoidal as well as non-sinusoidal patterns. This method is based on the test of Kolmogorov-Smirnov, but it is independent of the first month used[12], thus avoiding the problem outlined by McCullough[13] about the use of the test of Kolmogorov-Smirnov on the study of seasonal phenomena.

In order to minimize differences among the frequencies of successive months that can be due to the fact of treating a continuous temporary phenomenon through the discontinuity that imposes the division of the year in twelve months, moving averages have been used to smooth the month series. All figures in this work are constructed using moving averages distributions calculated with spans of 3 terms.

Results and Discussion

Of a total of 43,526 births registered, 42,825 were simple births, and there was 349 multiple births, representing an 8.08 ‰. From this 349 multiple births, 346 were double births (226 like-sexed and 120 unlike-sexed) and three were triplets.

This twinning rate for the nineteenth century Tortosa is lower than the value of 9.3 ‰ reported by Gutiérrez and Houdaille[14] in the rural France between 1790 and 1829. In the second half of the XIX century the same authors detect considerable levels of twinning rate diversity between several French regions, with figures fluctuating between 6 ‰ in Gironde and a 13 ‰ in the Vendée region.

The relative frequency of multiple births is low, even in the context of Spanish populations[15]. According to the sex distribution of double births, and following the reasoning of Weinberg[16], the observed data evidences a frequency of monozygotic twins of 2.5 ‰, versus a frequency of 5.6 ‰ of dizygotic twins.

The distribution of the 43,174 maternities along the year does not fit a uniform distribution along the twelve months (considering the number of days of each month): $\chi^2_{(11)}$ =590.514 (p<0.0001). This evidence for a seasonal distribution is also supported by the Freedman test (Freedman=10,036; p<0.01). When monthly distribution along the XIX century is compared with the model of Edwards, it becomes clear that data fit well with a pattern of simple harmonic variation, with maximums in February and minimums in August ($\chi^2_{(2)}$ =397.620; p<0.0001).

The seasonal birth-pattern in Tortosa (from 1801 to 1900) is highly congruent with the 19th century European one, presenting a maximum around the end of the winter and at the beginning of the spring, and with a maximum of fecundations in spring, around May[2,17]. Nevertheless, monthly distribution of the twin births rates presents maximums in October and November, thus reflecting fecundations at the beginning of the year. The distribution of the moving averages of the monthly rates of twins showing a peak in autumn is displayed in Figure 1.

It is important to remark that birth seasonality obviously depends of conception seasonality (necessarily mediated by embryonic and foetal losses), which can be not uniformly distributed along the year because of environmental fluctuations[5,18–21].

In the 19th century population of Tortosa, seasonal distribution of monozygotic and dizygotic twins shows marked differences (Table 1). While monozygotic twins have higher frequencies in spring and summer, dizygotic twins tend to birth more frequently in autumn and winter.

Monthly seasonal coefficients for the variables presented in Table 1 were computed taking into account the number of days for each month, and listed in Table 2.

As a whole, distribution of multiple births achieves a maximum in November

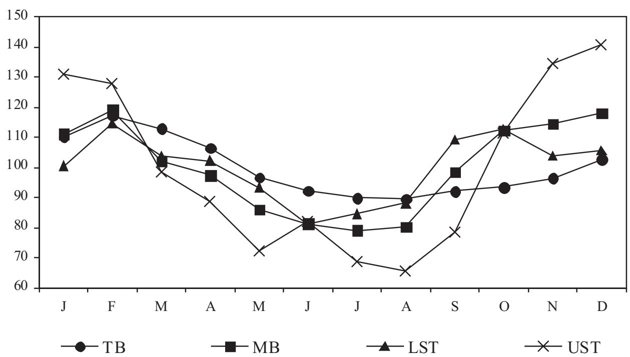

Fig. 1. Seasonality coefficients (moving averages) of the total number of births (TB), multiple births (MB), unlike-sexed twins (UST) and like-sexed twins (LST).

TABLE 1
MONTHLY DISTRIBUTION OF MATERNITIES (MATER), LIKE-SEXED TWINS (LST), UNLIKE-SEXED TWINS (UST), TOTAL NUMBER OF MULTIPLE PREGNANCIES (TP), AND RATES (OVER 1,000 MATERNITIES) OF MONOZYGOTIC (MT), DIZYGOTIC (DT) AND TOTAL TWINS (TT)

Month	MATER (N)	LST (N)	UST (N)	TP (N)	MT (rate)	DT (rate)	TT (rate)
January	4100	23	15	38	1.95	7.32	9.27
February	4171	21	12	33	2.16	5.75	7.91
March	4376	21	12	33	2.06	5.48	7.54
April	3651	17	6	23	3.01	3.29	6.30
May	3465	20	9	29	3.17	5.19	8.37
June	3318	16	7	23	2.71	4.22	6.93
July	3174	10	9	19	0.32	5.67	5.99
August	3209	22	5	27	5.30	3.12	8.41
September	3290	18	6	24	3.65	3.65	7.29
October	3441	22	13	35	2.62	7.56	10.17
November	3359	24	15	39	2.68	8.93	11.61
December	3620	13	13	26	0.00	7.18	7.18
Total	43174	227	122	349	2.43	5.65	8.08

and January, while the peak of total births is reached between February and March. Twinning and total maternity distributions by quarterly periods show differences (Table 3). This fact is particularly evident in the case of unlike-sexed twins, which are more frequent in the last quarter of the year, while the total maternities are more frequent in the first one.

Born of unlike-sexed twins, all of them dizygotic, occur in a 65.58 % of cases between October and March, while the remaining 34.42 % take place in the central period of the year (from April to September). This fact is also reflected in the rate of dizygotic twins, which reach higher values in the first and last quarterly period. Since those results are referred to unlike-

TABLE 2
SEASONALITY COEFFICIENTS OF THE VARIABLES DISPLAYED IN TABLE 1

Month	MATER	LST	UST	TP	MT	DT	TT
January	111.73	119.20	144.81	128.15	78.97	130.40	114.72
February	124.73	119.43	127.12	122.12	87.48	102.43	97.89
March	119.25	108.83	115.85	111.28	83.43	97.62	93.31
April	102.81	91.04	59.85	80.15	121.90	58.61	77.96
May	94.43	103.65	86.89	97.80	128.38	92.46	103.58
June	93.44	85.69	69.83	80.15	109.75	75.18	85.76
July	86.50	51.83	86.89	64.07	12.96	101.01	74.13
August	87.45	114.02	48.27	91.05	214.65	55.58	104.07
September	92.65	96.40	59.85	83.63	147.82	65.02	90.21
October	93.77	114.02	125.50	118.03	106.11	134.68	125.85
November	94.59	128.53	149.64	135.90	108.54	159.09	143.67
December	98.65	67.37	125.50	87.68	0.00	127.91	88.85

TABLE 3
QUARTERLY DISTRIBUTION OF THE MATERNITIES (MATER), LIKE-SEXED TWINS (LST), UNLIKE-SEXED TWINS (UST), TOTAL NUMBER OF MULTIPLE PREGNANCIES (TP), AND RATES (OVER 1,000 MATERNITIES) OF MONOZYGOTIC (MT), DIZYGOTIC (DT) AND TOTAL TWINS (TT)

Quarter	MATER	LST	UST	TP	MT (rate)	DT (rate)	TT (rate)
Jan.-March (N)	12647	65	39	104	2.06	6.17	8.23
%	29.29	28.63	31.97	29.80			
April-June (N)	10434	53	22	75	2.97	4.22	7.19
%	24.17	23.35	18.03	21.49			
July-Sep. (N)	9673	50	20	70	3.10	4.14	7.24
%	22.40	22.03	16.39	20.06			
Oct.-Dec. (N)	10420	59	41	100	1.73	7.87	9.60
%	24.14	25.99	33.61	28.65			

sexed twins, and in consequence dizygotic, then data points to a seasonality of multiple ovulations[10]. Conversely, monozygotic-twins rates present a maximum frequency in the period between April and September. Given that dizygotic twins are more frequent, the total twinning rate reaches their highest figures in autumn-winter and their lowest ones during the spring-summer period. Evidently, computation of frequencies is restricted to the relative frequency of born-alive individuals (baptized), since no data is available concerning the loss of multiple pregnancies.

If considering that the seasonal phenomenon of twinning is not related with a seasonal intrauterine mortality, that is, considering only the seasonality of fertilizations as the single factor causing twinning seasonality, then it is clear that fertilization in the first half of the year produces most of total dizygotic twins.

Following Fellman and Erikson[6], the lagged monthly twinning rates were calculated because »if we assume that the length of gestation for twins is about 4 weeks shorter than for singletons, the monthly twinning rates should be defined as the number of twin maternities in a given month divided by the number of general maternities for the next month«. When consider monthly distribution of the »delayed« twinning rates, their seasonality coefficients show no differences with the pattern previously found.

The already described seasonality pattern does not change substantially, and October (10.08) and November (11.13), in the last quarter of the year, presents the maximum values of seasonal coefficients of twin births, and July (5.92) the minimum one. These results are very similar to the figures showed in Table 1.

Results of the statistical tests used to evaluate seasonality are listed in Table 4. Pearson's goodness of fit c^2-test[8], the Edwards' test of simple harmonic seasonality[9], and the seasonal variation test of Freedman[11] were applied in order to test statistically the seasonality of the observed twinning distributions.

Results of both, the Edwards and Freedman's tests are congruent and evidence the seasonality of monthly distributions in the twin births ($p<0,05$) and the birth of unlike-sexed twins ($p<0,01$). Conversely, the monthly distribution of like-sexed twins showed a pattern that doesn't significantly departs from monthly uniformity through year. When the goodness of fit test is performed, neither of the twin distributions presents statistical significant seasonality. However, we must re-

TABLE 4
RESULTS OF THE STATISTICAL TESTS OF SEASONALITY

	Goodness of Fit		Edwards Test		Freedman Test	
	$\chi^2_{(11)}$	p	$\chi^2_{(2)}$	p	Test	p
Total of maternities	590.514	<0.0001	397.62	<0.0001	10.036	<0.01
Multiple births	16.290	0.1307	8.46	0.0146	1.599	0.01<p<0.05
Unlike-sexed twins	14.129	0.2260	10.03	0.0066	1.733	<0.01
Like-sexed twins	10.934	0.4488	1.86	0.3946	0.851	0.5<p<0.6

mark that this method is very insensitive to low populations sizes when, at the same time, the number of categories (twelve in this case) is high.

As stated by Reijneveld[12], Edwards and Freedman's tests are more adequate for datasets with low population sizes. The significance values obtained with the Edwards' method enables us to conclude that seasonality observed in the multiple births and in the unlike-sexed twins respond to sinusoidal patterns of distribution, with a period of maximums and another of minimums along the year.

If the quarterly maternity distribution is considered (Table 3) taking into account the number of days of each one of them, χ^2 tests produce significant differences between the quarters for the unlike-sexed twin births ($\chi^2_{(3)}$=12.099; p=0.0071). However, the number of like-sexed twin births does not significantly differ from one quarter to another ($\chi^2_{(3)}$=2.598; p= 0.4578). When the number of both, like-sexed and unlike-sexed twin births are jointly considered, quarterly differences are significant ($\chi^2_{(3)}$=10.614; p=0.0140).

A disruption between seasonal distribution of the twin-conceptions and those of the single births is also observed in Italy (1980–1985)[22], where the twin conception reaches a maximum value between March and August. James[23] also found that the maximum of twin-conceptions in England and Wales (1940–72) occurred during November. These results, however, differ from those obtained by us in Tortosa (1801–1900), where the maximum incidence of twinning is in the final and first months of the year, whereas the results of James[23] point to a significant excess of twin births in the second half of the year.

Nonaka et al.[24] reported a decreasing of twin-births between May and July among the Hutterites. Greater rates of twin-births in winter and summer were detected by Richter et al.[25] for Görlitz (Germany) between 1611 and 1860, and those rates differed from the seasonal pattern of total births. Nonaka and Miura[26] detect different patterns in London (1581–1760) and Manchester. Philippe[27] reported a major frequency of twin conceptions during the spring and beginning of the summer in Isle-aux-Courdes (Quebec).

Results presented here and elsewhere reflect the existence of a seasonal distribution of the twinning, which clearly departs from the distribution of the single births, and also suggest the lack of a general pattern of twinning seasonality common to different populations. Moreover, our results evidence the large influence of unlike-sexed twins in the configuration of seasonality patterns.

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SEZONALNOST BLIZANAČKIH TRUDNOĆA U RURALNOJ POPULACIJI KATALONIJE

SAŽETAK

Do danas nije istraživana sezonalnost blizanačkih trudnoća u populaciji Španjolske. U nekim su populacijama uočene razlike u sezonalnoj distribuciji blizanačkih i jednoplodnih trudnoća. Svrha ovog istraživanja je bila istražiti frekvenciju blizanačkih trudnoća u ruralnoj populaciji Katalonije u 19. st., kao i sezonalne karakteristike tipova blizanačkih trudnoća. Za analizu distribucije blizanačkih trudnoća korišteni su podaci o svim trudnoćama zabilježenim u Tortosi (južna Katalonija) od 1801. do 1900. godine. Distribucija »moving averages« mjesečnih stopa za blizanačke trudnoće pokazuje porast blizanačkih trudnoća u jesen. Distribucija blizanačkih trudnoća razlikuje se od distribucije ostalih trudnoća u Tortosi. To se posebice vidi u blizanaca različitog spola koji imaju najveću incidenciju u zadnjem kvartalu u godini, dok je ukupnih trudnoća najviše u prvom kvartalu godine.