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Sex Ratio and Individual Variability Analysis Within Mountain Communities of the Western Alps

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Introduction

The sex ratio at birth, defined as the ratio between the numbers of male and female neonates, varies from one population to another and in time. The difference at birth between the number of males and females has interested scholars for centuries. John Graunt noted that in London between 1628 and 1662 around 14 males were born for each 13 females (SR = 1.07). Sussmilch devoted a whole chapter of his book "Die Göttliche Ordnung" to the sex ratio at birth, in which he was the first to establish the mean value of 1.05 for European populations. Globally, the sex ratio at birth is ca. 1.055. The causes of sex ratio variations are poorly known, although a certain genetic influence is recognized, particularly on the part of the father. Individual variability has a preponderant effect on the sex ratio at the population level. It seems to be influenced by the amount of circulating gonadotropins, whose excess seems to be related to the preferential conception of females; the production of gonadotropins seems to be seasonal (James, 1984). Moreover, particular diets in which the (Na+K)/ (Ca+Mg) ratio is higher cause an increase of the sex ratio in favour of males, while the opposite occurs when this ratio decreases. Factors such as age of the parents, birth order and socio-economic status also seem to play a role in the sex ratio at birth (Jacobsen *et al.*, 1999; Garenne, 2002).
The sex ratio has been found to be lower in black populations of the USA, and the same has generally been observed in urban environments, while the opposite has been recorded in rural populations (James, 1987; Garenne, 2004).
The observed sex ratio is rarely 1:1 but the values differ from parity in relation to population size: the confidence interval for groups of neonates increases as the number of neonates decreases (Leti, 1977).

Materials and Methods

In the present study, we investigated the temporal trend of the sex ratio and the seasonality of conceiving in two populations of the Western Alps: Chiomonte and Argentière la Bessée.
Chiomonte is in the Upper Susa Valley (Turin) at 750- 800 m asl. Argentière la Bessée is an important town of the Hautes-Alpes department in the Fournel Valley at 1040 m asl.
For Chiomonte, we examined 14,944 individual records from parish registers of baptisms for the period 1670 to 1865 and from civil registers of births for the period 1866 to 1929.
The sources of 8,380 individual records for Argentière la Bessée were the municipal registers of births for the period 1690 to 1889. A certain number of acts were "gender missing", particularly in the records of the 17th and 18th centuries. These births were excluded from calculation of the sex ratio.
The analysis of seasonality was performed by standardizing monthly values according to the method of Leridon (1973), involving calculation of the mean number of births per day. We then deduced the period of conception from the seasonality of births. An analytical measure of the intensity of seasonality was obtained by means of the Ũh coefficient, which estimates the degree of oscillation of the seasonality of conceptions (Gonzáles-Martín, 2008).

Results

Table 1 shows the number of births by sex for 40-year periods and the values of the sex ratio. In Chiomonte, the sex ratio (x100) calculated for the entire observation period is 105.9.
The sex ratio always favours males, except in the first period in which the value is close to parity. Between 1770 and 1869, there were ca. 110 males born for each 100 females, while in the more recent period the sex ratio was close to the expected value of 105. The sex ratio sequence of Argentière is very similar to that of Chiomonte, with the highest values in the first half of the 19th century and an

CHIOMONTE				
PERIOD	**MALES**	**FEMALES**	**UNIDENTIFIED**	**SEX RATIO (x100)**
1670-1719	1,395	1,400	29	99.6
1720-1769	1,432	1,364	56	105.0
1770-1819	1,476	1,350	52	109.3
1820-1869	1,729	1,563	0	110.6
1870-1929	1,585	1,513	0	104.8
TOTAL	7,617	7,190	137	105,9
ARGENTIERE				
PERIOD	**MALES**	**FEMALES**	**UNIDENTIFIED**	**SEX RATIO (x100)**
1690-1739	879	881	5	99.8
1740-1789	917	871	74	105.3
1790-1839	1,224	1,111	29	110.2
1840-1889	1,237	1,144	8	108.1
TOTAL	**4,257**	**4,007**	**116**	**106,2**

Tab. 1. *Number of births by gender and sex ratios for 40-year periods.*

overall sex ratio of 106.2. The neonates of unidentified sex could have affect the calculated values but probably did not cause particularly significant oscillations.

The reduction of sex ratio fluctuations and the approach to parity in more recent periods have also been observed in other populations, although a convincing explanation of the causes of this trend has yet to be given. James (1987) hypothesized a slight correlation of the sex ratio trend with the decreased foetal mortality rate due to improved hygienic-sanitary conditions, which impact on the quality of pregnancy.

Some authors have hypothesized that the seasons can influence the sex ratio, favouring a higher number of conceptions of the one or the other sex. Therefore, we analysed the sex ratio according to the month of conceiving, aware of the fact that these analyses require very large samples in order to provide truly reliable results.

In Chiomonte, the conceptions occurred mainly in the winter and spring months, while the lowest values were in July and August (Fig. 1). This agrees with the fact that two factors that hinder fertility are accentuated in summer: the higher temperatures and the physical stress of the women working in the fields. To these are added socio-economic factors: in mountain environments, the months of July and August are those in which transhumance takes place, with the consequent absence of the husbands.

The conceptions in Argentière show a different seasonality (Fig. 3): they are mainly concentrated in the spring months, while the decrease in the summer months is not as marked. There are also very low values in December and January on account of the temporary absence of many farmers

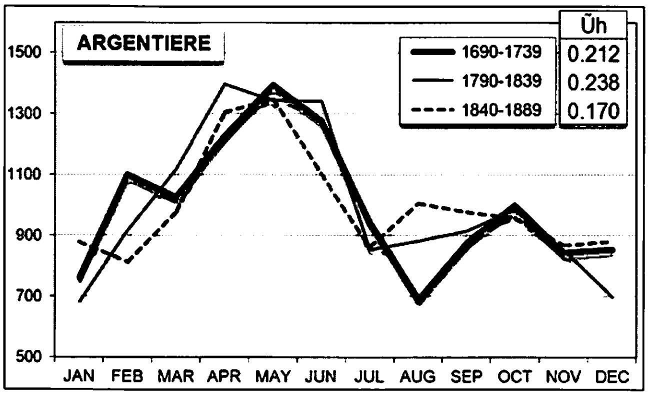

Fig. 2. *Seasonality of conceptions in Argentière La Bessée.*

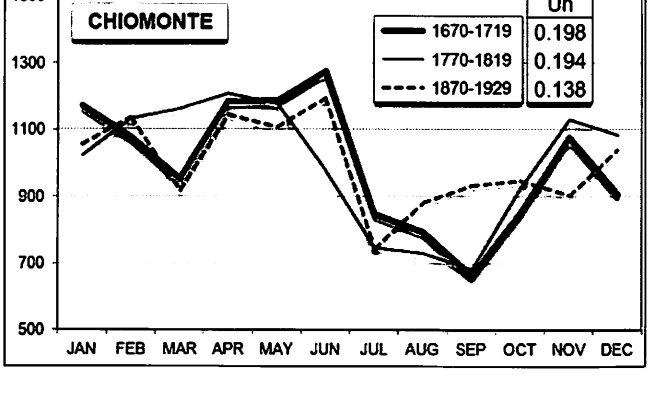

Fig. 1. *Seasonality of conceptions in Chiomonte.*

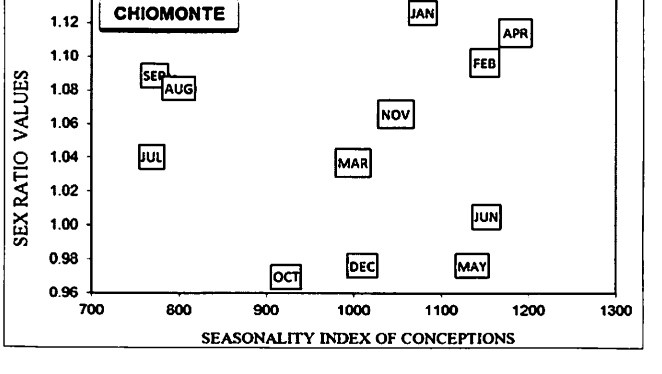

Fig. 3. *Correlation of seasonality index of conception vs monthly sex ratio in Chiomonte.*

who, being inactive in the winter months, leave Argentière to work at seasonal jobs elsewhere.
The Ũh coefficient of seasonality measures the dependence of conceptions on seasonality, with higher values indicating stronger seasonality effects and Ũh values close to zero indicating absence of seasonality of conceptions. The coefficients of seasonality (Ũh values in Figg. 1 and 2) are fairly similar in the first two periods for both communities, but they show a substantial decrease in the last 40-year period. However, there does not seem to be a precise link between the seasonality index of conceptions and the monthly sex ratio values: in Chiomonte (Fig. 3), the winter months with a high seasonality index of conceptions have sex ratios strongly in favour of males (Jan, Feb), while in the late spring (May, Jun), also with high Ũh values, the ratios are around 1:1. Moreover, these results are not confirmed in Argentière (Fig. 4).

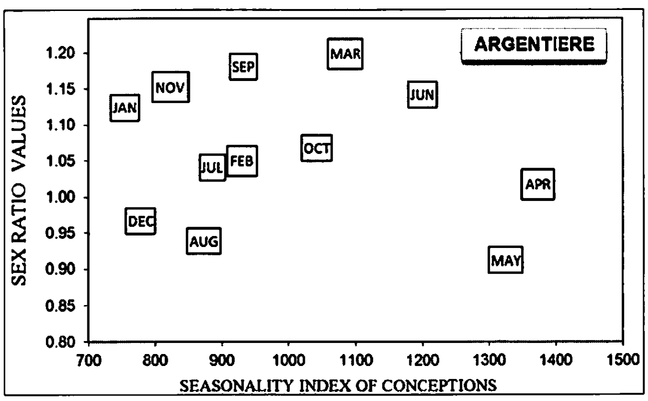

Fig. 4. *Correlation of seasonality index of conception vs monthly sex ratio in Argentière.*

Discussion

The sex ratio values for the two towns fall well within the range of variation for communities of similar size (Leti, 1977), also in the periods in which a high number of newborns of unidentified sex was recorded. In both towns, there is strong seasonality of conceptions, leading to a marked increase of births in January and February.
This seasonality differs from the theoretical European model which predicts increases of births in spring, in particular April-May, and locally also in September, accompanied by substantial decreases in late autumn and early winter (Lam and Miron, 1996; Manfredini, 2009). Although some authors have suggested a correlation between seasonality of conceptions and the sex ratio (Hajek *et al.*, 1981; James, 1984; Lerchl, 1998, Cagnacci *et al.*, 2003), this does not seem to be true for the communities of the Susa and Fournel valleys. These results are in agreement with the substantial work of Lerchl 1998 on births in Germany from 1946 to 1995.

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