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BIRTH SEASONALITY IN THE OLD ORDER AMISH

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Summary. The Old Order Amish are a healthy and well-nourished natural fertility population, so that the timing of births is not influenced by behaviours to limit family size, undernutrition or disease. The present study examines the monthly distribution of 8160 births occurring between 1920 and 1991 in the Geauga Settlement in north-east Ohio, USA. The monthly distribution of births in the Geauga Settlement is bimodal, with a major peak extending from August to October, a minor peak in February, and a major trough from April to June. This pattern is almost identical to the pattern found in the US in 1943. The monthly distribution of first births appears to be influenced to some extent by a highly significant seasonal pattern of weddings. The pattern of births in the Old Order Amish is consistent with the hypothesis that the spring trough in US births is at least partially caused by a decrease in coital frequency and/or a decrease in fecundability as a result of hot summer temperatures but is not consistent with the hypothesis that the fall peak in US births is primarily due to an increase in coital frequency during the Thanksgiving and Christmas holiday seasons.

Introduction

Most human populations exhibit some seasonality in the patterning of births, in response to a variety of environmental and cultural factors (Lam & Miron, 1991). The most important environmental factors that influence the monthly distribution of births are seasonal variability in temperature (Seiver, 1985, 1989; Madrigal, 1993; Lam & Miron, 1991, 1996; Lam *et al.*, 1994), rainfall (Malina & Himes, 1977; Leslie & Fry, 1989), light availability (James, 1990; Lam & Miron, 1991; Rojansky *et al.*, 1992; Lam & Miron, 1996), and infections (Bantje, 1987; Miura, 1987; Nonaka *et al.*, 1990). According to Lam & Miron (1991), the primary cultural factors that influence birth seasonality include (a) preferred marriage seasons (Johnson *et al.*, 1975; Scaglion, 1978; Mosher, 1979; Nonaka *et al.*, 1990); (b) agricultural cycles affecting primarily labour demand and food availability (Nurge, 1970; Malina & Himes, 1977;

Scaglion, 1978; Clark & Thompson, 1987; Huss-Ashmore, 1988; Bailey *et al.*, 1992; Garcia-Moro *et al.*, 2000); (c) other economic variables such as seasonal out-migration (Thompson & Robbins, 1973; Chen *et al.*, 1974; Huss-Ashmore, 1988; Panter-Brick, 1996); and (d) annual holiday seasons and religious observances (Cowgill, 1966; Nurge, 1970; Odegard, 1977; Spencer & Hum, 1977; Mosher, 1979; Holland, 1989; Panter-Brick, 1996). Birth seasonality has also been shown to be influenced by socioeconomic status (Pasamanick *et al.*, 1959, 1960; Warren & Tyler, 1979; Bobak & Gjonca, 2001).

Presumably as a result of the numerous factors that can potentially influence birth patterns, there is considerable variability between populations, as well as change over time within populations, in the seasonal patterning of births (Lam & Miron, 1991). Nevertheless, there are some fairly longstanding patterns. One of these is found in the US where there is a peak of births in August–September and a trough of births in April–May, corresponding to a peak in conceptions in November–December and a trough in conceptions in July–August (Fig. 2; Pasamanick *et al.*, 1959, 1960; Cowgill, 1966; Rosenberg, 1966; Warren & Tyler, 1979; Seiver, 1985, 1989; Clark & Thompson, 1987; Arcury *et al.*, 1990; James, 1990; Lam & Miron, 1991). This pattern of birth seasonality began to be established in the US in the mid 19th century and, although it has undergone slight changes in recent decades, the basic pattern has remained intact for well over a century (Pasamanick *et al.*, 1960; Cowgill, 1966; Rosenberg, 1966; Warren & Tyler, 1979; James, 1990). The autumn peak is generally attributed to an increase in coital frequency during the Thanksgiving and Christmas holiday seasons while the summer trough has been hypothesized to be at least partially influenced by a decrease in coital frequency and/or a decrease in fecundity in response to high summer temperatures (Pasamanick *et al.*, 1959, 1960; Cowgill, 1966; Rosenberg, 1966; Warren & Tyler, 1979; Seiver, 1985, 1989; Clark & Thompson, 1987; James, 1990; Lam & Miron, 1991, 1996; Lam *et al.*, 1994).

The present report describes the seasonality of births in a US population with characteristics that make it useful for testing hypotheses about the nature and causes of the US pattern of birth seasonality, or an Old Order Amish settlement centred in Geauga County, Ohio, USA. The Old Order Amish are similar to the general US population in being healthy and well-nourished but differ from the general US population in being a natural fertility population (Cross & McKusick; 1970; McKusick *et al.*, 1978; Hostetler, 1993; Greksa, 2002). As a result, the timing of Old Order Amish births is not influenced by behaviours to limit family size, undernutrition or disease. In addition, because they are a genetic and cultural isolate with a distinctive belief system grounded in their religion, the Old Order Amish are much more genetically, culturally and economically homogeneous than the general US population (Kraybill, 1989; Hostetler, 1993).

Study population

The Amish church was established in 1693 when some Mennonites under the leadership of Jacob Ammann split from the Mennonite church because they felt it was becoming too liberal (Nolt, 1992). In response to religious persecution in Europe, there were two primary Amish migrations to North America (Nolt, 1992). The first major migration occurred between 1727 and 1770, with most migrants settling in Pennsylvania (Nolt, 1992; Hostetler, 1993). Beginning in about 1808 some of the Amish living in Pennsylvania began migrating to Holmes County, Ohio. These migrants were joined by Amish migrating directly from Europe to Ohio as part of the second wave of Amish migration to North America between 1815 and 1860 (Nolt, 1992; Hostetler, 1993). The first Amish to settle in Geauga County migrated primarily from Holmes County, beginning in 1886, but some also came from western Pennsylvania and Indiana (Nolt, 1992; Byler, 1997).

A major schism occurred within the Amish church in 1865 when a group of conservative Amish officially separated from the Amish church (Nolt, 1992). This group was given the name Old Order Amish because they wished to maintain the traditional patterns of behaviour of the Amish (Kraybill, 1989). There are now over 150,000 Old Order Amish living in over 200 settlements in North America (Kraybill & Hostetter, 2001), with about one-third of all Old Order Amish residing in two settlements in Ohio, USA: one centred in Holmes County (the largest Amish settlement) and a second centred in Geauga County (4th largest settlement). The Geauga Settlement consisted of 9572 individuals in 1998 (Greksa, 2002).

Old Order Amish society has been undergoing a transformation during the past 50–60 years from one based almost completely on small, largely self-sufficient family farms to one which is increasingly based on wage labour (Kreps *et al*., 1994; Meyers, 1994; Kraybill & Nolt, 1995). This transition appears to be a response to rapid population increases in conjunction with substantial increases in the cost of land, making it increasingly difficult for families to purchase farm land (Ericksen *et al*., 1980; Hostetler, 1993). Some Old Order Amish have responded to this challenge by establishing new settlements in rural areas with more affordable land (Luthy, 1994). An increasing number of Amish, however, are giving up farming for various wage labour occupations (Meyers, 1991; Kreps *et al*., 1994; Kraybill & Nolt, 1995; Greksa & Korbin, 2002). This transition has been particularly rapid in the Geauga Settlement, where only 31% of the heads of household reported that they were farmers in 1973 and this was reduced to only 17% by 1993 (Greksa & Korbin, 2002).

The basic unit of organization among the Old Order Amish is the congregation, which consists of families that worship together (Kraybill, 1989; Hostetler, 1993). Since the Old Order Amish do not have an organized church hierarchy (Hostetler, 1993), several informal strategies for maintaining contact with families in other congregations have developed over time. One of these is the regular publication by most settlements of a directory of its members (Greksa, 2002).

Methods

The present report is based on the directory for the Geauga Settlement, which covers the period up to January 1st 1993. Previous population studies based on directories have found them to be about 98% complete (Cross & McKusick, 1970; Acheson, 1994). The month of birth of 8160 children born between January 1st 1920 and December 31st 1991 to 1462 couples were obtained from the 1993 directory. Births for 1992 were not included since it appears that births late in that year were not always included in the directory. Month of conception was estimated as occurring 9 months

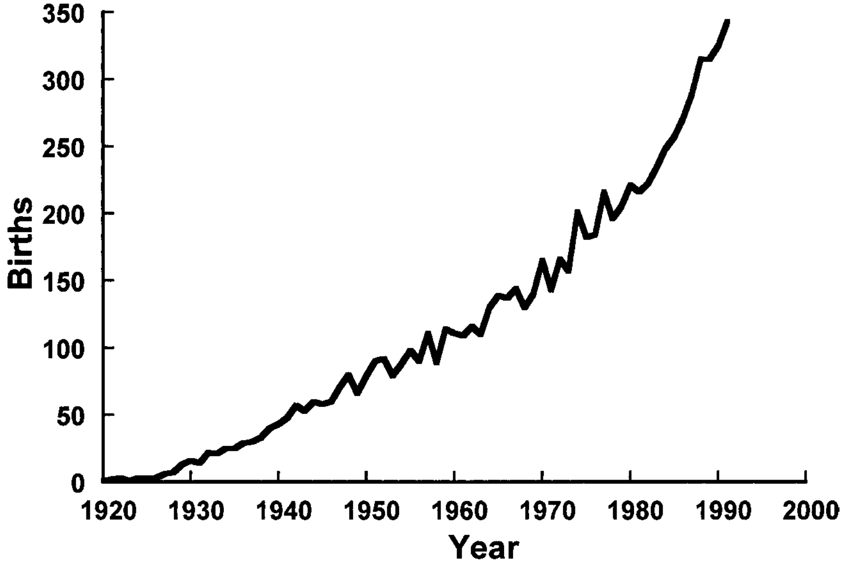

Fig. 1. Annual births in the Geauga Settlement between 1920 and 1991.

before the month of birth. The actual gestation length for humans is slightly shorter than 9 months but this estimate has proved effective in previous studies (e.g. Seiver, 1985; Huss-Ashmore, 1988; Leslie & Fry, 1989; Garcia-Moro *et al.*, 2000). The annual frequency of births during this time period is described in Fig. 1.

In order to control for the different lengths of months, the number of births per day per month was calculated by dividing the total number of births in a month by the number of days in that month (using 28·25 for February). Next, a birth ratio was calculated by dividing the number of births per day per month by the annual average births per day (total births divided by 365·25). A birth ratio of greater than 1·00 indicates that the number of births during a month was greater than the annual average while a birth ratio of less than 1·00 indicates that the number of births during a month was less than the annual average.

Graphic evaluation of seasonality was accomplished by examining plots of birth ratio by month of the year. Quantitative assessment of the magnitude of birth seasonality is generally either evaluated with the Edwards test (Edwards, 1961) or a one-sample chi-squared test. The Edwards test is best suited for detecting simple sinusoidal patterns while the chi-squared test can detect patterns with dual peaks. Since similar results were obtained from both tests and since all of the patterns examined in the present study are bidmodal, the chi-squared test was used to detect significant seasonality. Kendall's coefficient of concordance (*W*) was used to compare the patterns of the monthly distribution of births between the Amish and the general US population, as well as between different Amish subsamples. Kendall's coefficient of concordance, which is tested with a chi-squared distribution with $n-1$ degrees of freedom, measures the strength of association between the rankings of 2 or more variables and thus varies from 0 (no association) to 1·00 (perfect association) (Sokal & Rohlf, 1991).

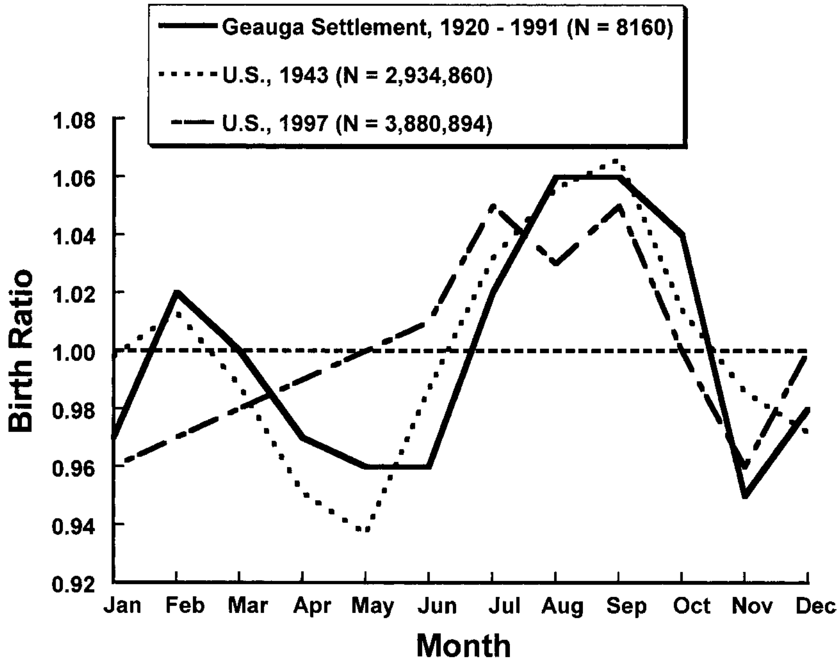

Fig. 2. Monthly distribution of births in the Geauga Settlement and the United States (National Center for Health Statistics, 1997; Rosenberg, 1966: Table 1).

Results

The monthly distribution of births in the Geauga Settlement is bimodal, with a major peak (about 6% above the annual average) extending from August to October (with the maximum in August–September), a minor peak (about 2% above the annual average) in February, and a primary trough (about 4% below annual average) extending from April to June (with the minimum from May to June) (Fig. 2). This pattern of births corresponds to a major peak in conceptions from November to January and a nadir in conceptions from July to September. A one-sample chi-squared test indicates that this seasonal pattern of births is not statistically significant ($\chi^2 = 11{\cdot}5$, $p > 0{\cdot}05$).

The monthly distributions of births in the US in 1943 and 1997 are also included in Fig. 2. Two points are noteworthy. First, the monthly distribution of births in the US is highly significant for both 1943 ($\chi^2 = 6200{\cdot}9$, $p < 0{\cdot}001$) and 1997 ($\chi^2 = 3280{\cdot}9$, $p < 0{\cdot}001$). Second, the monthly distribution of births in the Geauga Settlement is moderately but insignificantly similar to that for the US in 1997 ($W = 0{\cdot}70$, $\chi^2 = 15{\cdot}5$, $p > 0{\cdot}05$) and almost identical to that for the US in 1943 ($W = 0{\cdot}98$, $\chi^2 = 21{\cdot}6$, $p < 0{\cdot}05$).

Birth seasonality was evaluated in three 20-year birth cohorts in order to determine if the seasonal pattern of births in the Geauga Settlement has changed over time (Fig. 3). The monthly variation in births was statistically insignificant in each of these cohorts (Table 1, $p > 0{\cdot}05$). The pattern of birth seasonality is somewhat erratic,

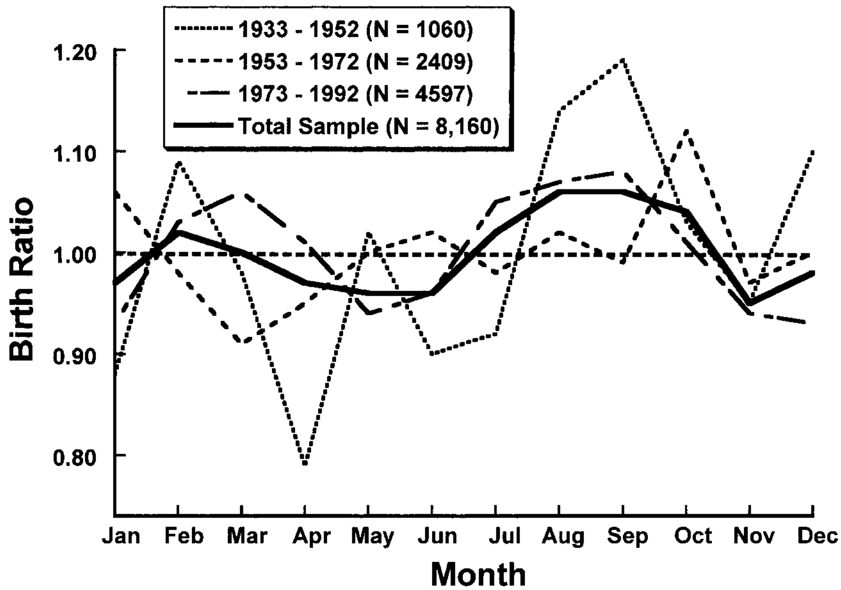

Fig. 3. Monthly distribution of births in the Geauga Settlement in three birth cohorts.

and therefore more difficult to interpret, in these smaller subsamples, although all three cohorts exhibit a peak of births between August and October. The trough in births generally occurs between March and June. Kendall's coefficient of concordance suggests a low to moderate, but statistically insignificant, level of similarity between the monthly pattern of births in these cohorts ($W=0{\cdot}40$, $\chi^2=13{\cdot}1$, $p>0{\cdot}05$). On the other hand, there is also no evidence for any consistent change over time in the seasonal patterning of births (Fig. 3).

The monthly distribution of births by parity is described in Fig. 4. Birth seasonality was statistically significant for first births ($p<0{\cdot}05$) but insignificant for all other births (Table 1, $p>0{\cdot}05$, Table 1). There is a low and insignificant level of association between the patterning of the first four births ($W=0{\cdot}27$, $\chi^2=12{\cdot}0$, $p>0{\cdot}05$). If only the first and second births are considered, the relationship is somewhat stronger but still insignificant ($W=0{\cdot}45$, $\chi^2=9{\cdot}8$, $p>0{\cdot}05$).

The seasonal pattern of total births in non-farmers (wage labourers) is significant (Table 1, $p<0{\cdot}05$) and almost identical to that for the entire sample ($W=0{\cdot}95$, $\chi^2=20{\cdot}9$, $p<0{\cdot}05$), with a minor peak in February, a major peak in the autumn, and a trough in the late spring and early summer (Fig. 5). The seasonal pattern of births in Amish farmers, however, which displays three peaks in births – one in April, another in June and July, and a third in November (Fig. 5) – is not statistically significant (Table 1, $p>0{\cdot}05$). Not unexpectedly, the seasonal patterns of birth in farmers and non-farmers are not similar ($W=0{\cdot}14$, $\chi^2=3{\cdot}7$, $p>0{\cdot}05$). Given the unusual pattern of birth seasonality in farmers, it seems likely that this pattern may be influenced by either sampling error or confounding by other variables. In order to test this possibility, the seasonal pattern of first births was also compared between

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Table 1. Results of one-sample chi-squared test of birth seasonality, by cohort, parity and occupation

	n	χ^2
Birth cohort		
1933–1952	1060	13·6
1953–1972	2409	6·4
1973–1992	4597	14·0
Parity		
1	1408	22·3*
2	1273	11·8
3	1143	10·4
4	981	10·4
5–6	1495	12·0
7–8	964	11·8
≥9	896	10·5
Occupation (total births)		
Farmer	1721	11·4
Non-farmer	6360	22·8*
Occupation (first births)		
Farmer	249	7·5
Non-farmer	1149	24·7*

*$p < 0{\cdot}05$.

farmers and non-farmers (Fig. 6). Once again, birth seasonality was significant in non-farmers ($p < 0{\cdot}05$) but not in farmers (Table 1, $p > 0{\cdot}05$). Although still insignificant, the level of association between the patterning of first births in farmers and non-farmers is moderate ($W = 0{\cdot}53$, $\chi^2 = 11{\cdot}8$, $p > 0{\cdot}05$).

There are two major peaks of weddings in the Geauga Settlement (May–June and September–November), with a 150–160% difference between the high points of the spring and autumn peaks and the low point of the summer trough (Fig. 7). A one-sample chi-squared test indicates that the pattern of seasonality in weddings is highly significant ($\chi^2 = 454{\cdot}2$, $p < 0{\cdot}001$). Given that the Old Order Amish exhibit a pronounced seasonal pattern in weddings and are a natural fertility population, one would expect to find a reasonably strong relationship between wedding month and the month of conception of the first child. In fact, both distributions exhibit peaks and troughs during similar months (Fig. 7), resulting in a level of association between patterns that approaches statistical significance ($W = 0{\cdot}81$, $\chi^2 = 17{\cdot}9$, $p < 0{\cdot}10$). Both distributions are bimodal, with modes of equal amplitude (Fig. 2). Finally, the amplitude of the monthly distribution of first conceptions is substantially greater than for total births (Figs 2 and 7; 20–25% vs 4–6% above the annual average) but is nevertheless substantially less than for the distribution of wedding month.

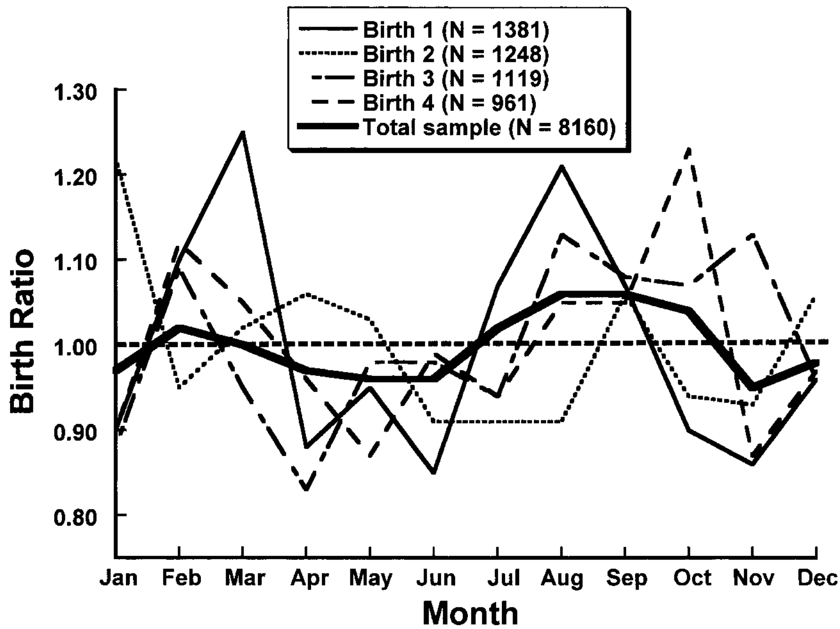

Fig. 4. Monthly distribution of 1st to 4th births in the Geauga Settlement.

Discussion

The present study describes the seasonal pattern of births in the Old Order Amish. The Old Order Amish are useful for testing hypotheses about the nature and causes of birth seasonality for several reasons. First, they are a healthy and well-nourished natural fertility population (Cross & McKusick, 1970; McKusick *et al.*, 1978; Hostetler, 1993; Greksa, 2002). The subjects in studies in developed societies tend to be healthy and well-nourished but utilize modern contraceptives while those in developing societies generally don't utilize modern contraceptives but are less likely to be healthy and well-nourished. The Old Order Amish are thus unusual in that the timing of births is not influenced by undernutrition, by disease or by the use of modern contraceptives. Second, most studies of birth seasonality are based on large national samples which are genetically and socially heterogeneous and occupy a wide range of physical environments (Malina & Himes, 1977; Scaglion, 1978). The Old Order Amish on the other hand live in geographically constrained regions and are fairly genetically, socially and economically homogeneous (McKusick *et al.*, 1978; Kraybill, 1989; Hostetler, 1993). Third, due to their emphasis on simplicity and separation from the world, the lifestyle of the Old Order Amish differs from that of the surrounding non-Amish population (Kraybill, 1989; Hostetler, 1993). Finally, the Old Order Amish are undergoing a transition away from an economic system based on small largely self-sufficient family-owned farms to one based on wage labour (Kreps *et al.*, 1994; Meyers, 1994; Kraybill & Nolt, 1995), allowing for the investigation of the impact of social change on birth seasonality.

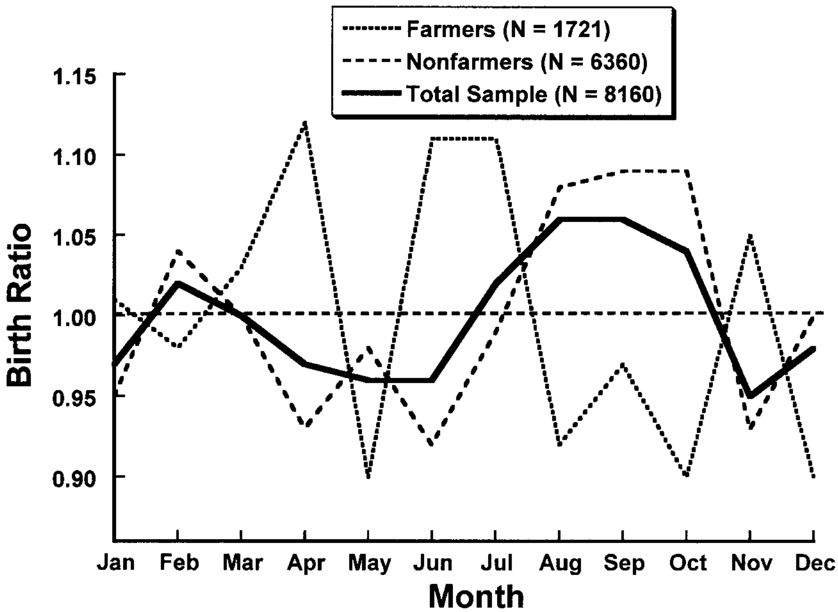

Fig. 5. Monthly distribution of total births in farmers and non-farmers in the Geauga Settlement.

The monthly distribution of births in the Geauga Settlement is bimodal, with a major peak extending from August to October, a minor peak in February, and a primary trough extending from April to June (Fig. 2). Given that the amplitudes of the autumn peak and the spring trough are fairly small (6% and 4% above and below the annual average, respectively), does the monthly distribution of births in the Geauga Settlement differ sufficiently from a uniform distribution to be described as seasonal? The results of a one-sample chi-squared test on total births found the monthly distribution of total births to be statistically insignificant ($p > 0{\cdot}05$), suggesting there is no significant seasonality in births. Although not reported here, the Edwards test with two degrees of freedom produced similar results ($\chi^2 = 3{\cdot}8$, $p > 0{\cdot}05$). However, there is evidence to suggest that the monthly variation in births in the Geauga Settlement (Fig. 2) does reflect real seasonal variation in births. First, although the monthly distribution of total births in the Geauga Settlement does not exhibit significant monthly variation in births, it is almost identical to that for the much larger (almost 3 million) sample of US births in 1943 ($W = 0{\cdot}98$, $p < 0{\cdot}05$), which exhibits a highly significant seasonal pattern of births ($\chi^2 = 6200{\cdot}9$, $p < 0{\cdot}05$). Thus, although the sample for the present study is fairly large ($N = 8160$ births), the statistical tests that are most frequently utilized to detect seasonality may only be capable of detecting significant seasonal variation of fairly low amplitudes with much larger samples. In other words, it is likely that the monthly variation in births would have been statistically significant if the Amish sample size was somewhat larger. Second, if one removes potential confounding by considering only first births or only the subsample of non-farmers, the monthly distribution of births is in fact statistically

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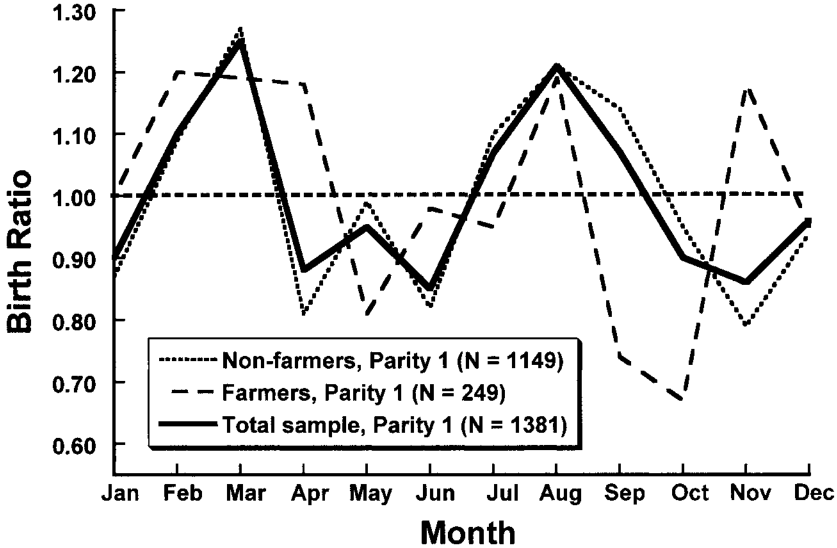

Fig. 6. Monthly distribution of first births to farmers and non-farmers in the Geauga Settlement.

significant (Table 1, $p<0{\cdot}05$). It thus seems reasonable to conclude that, even though the distribution of total births is not statistically significant, there is in fact evidence for real seasonality in the monthly distribution of births in the Geauga Settlement.

The US is characterized by a peak of births in August–September and a trough of births in April–May, corresponding to a peak in conceptions in November–December and a trough in conceptions in July–August (Pasamanick *et al.*, 1959, 1960; Rosenberg, 1966; Seiver, 1985; Clark & Thompson, 1987; Arcury *et al.*, 1990; James, 1990; Lam & Miron, 1991, 1996). As demonstrated in Fig. 2, this pattern has changed somewhat in recent decades, by the loss of a minor February peak and a decrease in the amplitude of the trough. The timing and magnitude of the major peak, however, has remained fairly stable for well over a century (Pasamanick *et al.*, 1960; Cowgill, 1966; Rosenberg, 1966; Warren & Tyler, 1979). As noted earlier, despite the fact that the Old Order Amish are a genetic and social isolate, do not practise family planning, have a highly significant seasonal pattern of weddings, and until recently were subsistence farmers, the monthly distribution of births in the Geauga Settlement is almost identical to that of the US in 1943 ($W=0{\cdot}98$, $p<0{\cdot}05$) and, despite recent changes in the nature of the spring trough in the US, still very similar to that of the US in 1997 ($W=0{\cdot}70$, $p>0{\cdot}05$), especially with respect to the timing and amplitude of the autumn peak in births. Two conclusions can be drawn from these comparisons. First, the forces influencing the timing and amplitude of the autumn peak in births have not changed since the mid 20th century in the general US population and the same forces may be operating on the Old Order Amish. Second, the determinants of the spring trough in US births have changed in recent decades in the general US population but not in the Old Order Amish.

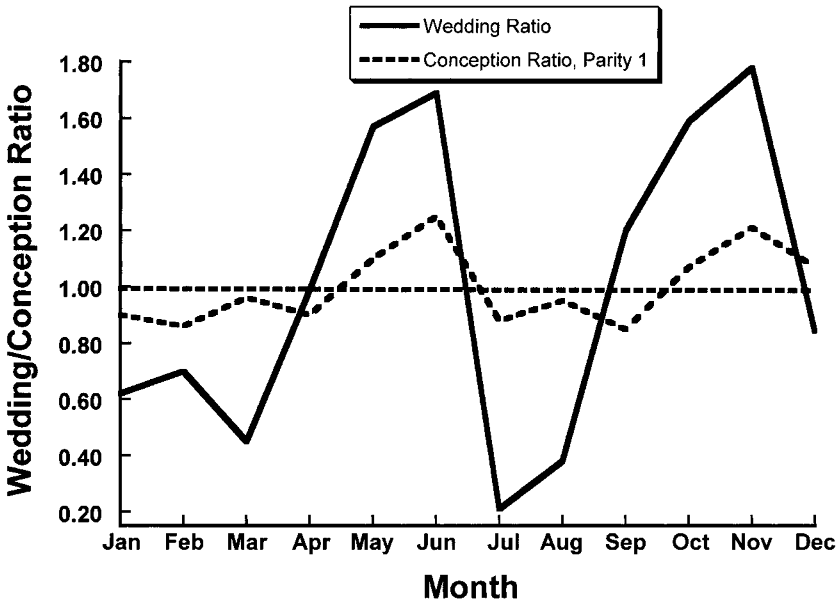

Fig. 7. Monthly distribution of 1381 weddings and first conceptions in the Geauga Settlement.

What are the most likely causes of the peaks and troughs in births in the US, as well as the change in the nature of this trough? Beginning with the trough, there is a general consensus that high summer temperatures contribute to the spring trough in US births as a result of a decrease in coital frequency, a decrease in fecundity, and/or an increased use of birth control by women who do not wish to give birth during the summer (Pasamanick *et al.*, 1959, 1960; Rosenberg, 1966; Seiver, 1985, 1989; Clark & Thompson, 1987; Lam & Miron, 1991, 1996; Lam *et al.*, 1994). Several lines of evidence have been used to support this conclusion. First, the trough tends to be of greater amplitude in warmer southern states than in cooler northern states (Pasamanick *et al.*, 1959, 1960; Rosenberg, 1966; Seiver, 1985; Clark & Thompson, 1987; Lam & Miron, 1991, 1996; Lam *et al.*, 1994). Second, years of lower or higher than normal summer temperatures are characterized by troughs of correspondingly lower or greater than normal amplitude in both northern and southern states (Seiver, 1989; Lam & Miron, 1996). Also, statistically controlling for temperature results in a decrease in the amplitude of the trough, particularly in southern states (Lam & Miron, 1996). Third, Seiver (1985, 1989) has argued that at least one factor responsible for recent changes in the spring trough in the US has been the increasing use of air conditioning. In particular, he has demonstrated that the increasing use of air conditioning has been associated with a decrease in the amplitude of the summer trough, with the magnitude of the effect being greatest in the warmer southern states. Given the strength of the evidence that climate influences the summer trough in the US, one might expect the same pattern to occur elsewhere but that is not the case. Many European nations, for example, actually exhibit a peak in births at the very

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same time that the US exhibits a trough in births (Cowgill, 1966; James, 1990; Lam & Miron, 1991, 1996; Lam *et al.*, 1994). Why such an effect of temperature on the monthly distribution of births should occur only in the US is not clear.

The trough in births in the Old Order Amish occurs from April to June, corresponding to a trough in conceptions between July and September. Although the Old Order Amish are a dynamic society with a history of selectively incorporating new components, particularly technology that is necessary to remain economically competitive, into their cultural system, they have thus far strongly resisted the incorporation of technology that would substantially change their daily lifestyle, such as electricity from power grids (Olshan, 1991; Kraybill, 1989; Hostetler, 1993). Thus, Old Order Amish homes have never been air conditioned. The fact that the timing and amplitude of the trough in births in the Old Order Amish is almost identical to that of the US in 1943, prior to the widespread introduction of air conditioning in the US, and has not changed in the same way over time as in the general US population, is consistent with the hypothesis that the spring trough is related in some way to high summer temperatures and that the decrease in the amplitude of the trough in the general US population may be related to an increased use of air conditioning. Since the Old Order Amish are not likely to ever have air conditioned homes, it can by hypothesized that the amplitude of their summer trough in births will not decrease over time.

The autumn peak in US births is less easily explained than the summer trough (Seiver, 1985; Lam & Miron, 1991). The fact that the autumn peak, unlike the trough, does not exhibit geographic variation (Rosenberg, 1966) argues against it being a response to a single component of the physical environment, as does the fact that birth seasonality in the US is not influenced by cold winter temperatures (Lam & Miron, 1996). The fact that the autumn peak has been in existence for well over a century (Rosenberg, 1966), or a period of time during which there was substantial socioeconomic change in the US, including the introduction of effective birth control, argues against the peak being the result of the consistent operation of any single cultural force. Nevertheless, the fact that the peak in conceptions occurs in November and December suggests that the autumn peak may result from an increase in coital frequency during the Thanksgiving and Christmas holiday seasons, perhaps in conjunction with a greater tendency to not utilize birth control measures (Cowgill, 1966; Rosenberg, 1966; James, 1990; Lam & Miron, 1991). Cowgill (1966) also noted that the exact timing of the peak varied depending on whether Christmas was celebrated in December or January (or whether the celebration of the New Year was of greater importance than Christmas) and that in orthodox countries (Greece, Romania) there is an increase in conceptions following Lent, both of which suggest an association between holiday seasons and conception. On the other hand, the patterns of birth seasonality in Canada and some European nations have become more similar to that of the US over time, without any change in the timing of holidays (Cowgill, 1966; Lam & Miron, 1991; Werschler & Halli, 1992). James (1990) argued that an increase in coital frequency might occur directly as a result of holiday festivities but that the key factor was that families were simply more likely to be together during the holiday season, both as a result of adults manipulating their work schedules and because families that are in the process of considering divorce may be more likely to try to mend fences at this time of the year. Lam & Miron (1991) argued that the holidays are simply a period of increased leisure time, leading to an increase in coital frequency.

Although logical, this hypothesis does not provide a very satisfactory explanation for the Old Order Amish autumn peak in births. First, the Old Order Amish do not celebrate the Thanksgiving and Christmas holidays to any great extent. They may have a family dinner on those days but these holidays are not seen as having any particular ceremonial significance (Hostetler, 1993). As a result, Thanksgiving and Christmas are not seen as extended holidays by the Old Order Amish and thus there is only a minimal increase in leisure time (i.e. the day of the event). In addition, the Old Order Amish do not permit divorce or birth control and Old Order Amish spouses are not any more likely to be together during the holiday season than at any other time of the year (Kraybill, 1989; Hostetler, 1993). In other words, the parameters that would seem to be consistent with an increase in coital frequency in the general US population do not apply to the Old Order Amish. Nevertheless, the timing and amplitude of the autumn peak in births in the Old Order Amish is almost identical to that for the general US population (Fig. 2). Thus, the argument that holiday-related increases in coital frequency explain the autumn peak in US births is reasonable but the results of the present study suggest that other factors may also be operating, although exactly what these factors might be is not clear. Several findings suggest that there is no simple explanation for the autumn peak in US births and that this pattern is most likely due to the complex interactions of multiple cultural and perhaps environmental forces unique to the US, only one of which is a holiday-related increase in coital frequency. First, the autumn peak in births has been maintained for over a century in the US, despite considerable social change (including the introduction of modern birth control) and there is minimal geographic variation in the timing and magnitude of the peak (Rosenberg, 1966; Lam *et al.*, 1994). Second, Old Order Amish culture differs substantially from that of the surrounding US population but the autumn peak is almost identical between these groups. Third, the patterning of births in Canada differs from that of northern US states, despite both groups living in similar physical environments and possessing reasonably similar cultural systems (Cowgill, 1966; Lam & Miron, 1991; Werschler & Halli, 1992).

Subsistence agricultural populations often exhibit a pattern of birth seasonality that is related to the demands of the agricultural work cycle and/or the availability of food (Nurge, 1970; Thompson & Robbins, 1973; Malina & Himes, 1977; Scaglion, 1978; Mosher, 1979; Lam & Miron, 1991; Bailey *et al.*, 1992; Garcia-Moro *et al.*, 2000). Since the Old Order Amish have been undergoing a transition from subsistence farming to wage labour, this economic transition might be expected to be associated with at least a change in the amplitude of peaks and troughs, if not a major change in the pattern of birth seasonality. There is some stability in the timing of the autumn peak across birth cohorts (Fig. 3) but the overall pattern of birth seasonality in the Geauga Settlement is only moderately similar between birth cohorts ($W = 0{\cdot}40$, $p > 0{\cdot}05$). On the other hand, there is definitely not any consistent change in the patterning of births, even though the families of most of those in the youngest birth cohort (1933–1952) were farmers while the majority of the families of those born in the most recent birth cohort (1973–1992) were wage labourers. A comparison of the seasonal pattern of total births between farmers and non-farmers would seem to suggest this economic transition has influenced birth seasonality ($W=0{\cdot}27$, Fig. 5). However, since the seasonal pattern of total births in farmers is idiosyncratic and the seasonal pattern of first births was moderately similar between farmers and non-farmers ($W=0{\cdot}53$; Fig. 6), it is likely that the pattern of total births in farmers is either being influenced by sampling error or is being confounded by unknown factors. Taken together, the analyses of temporal changes in the pattern of birth seasonality and comparisons between farmers and non-farmers do not provide any evidence that substantial socioeconomic change has resulted in any consistent change in the pattern of birth seasonality in the Old Order Amish. As noted earlier, the autumn peak has also remained constant in the general US population for well over a century, despite the US undergoing much more socioeconomic change than the Old Order Amish (Cowgill, 1966; Rosenberg, 1966). Lam & Miron (1991) came to a similar conclusion in their review of secular changes in birth seasonality in industrialized nations.

There is often significant seasonality of weddings in developed societies. In the US, for example, there is about a 60% difference between the high point of the peak and low point of the trough in weddings (Lam *et al.*, 1994). However, since the monthly distribution of births is similar at all parities in such countries and since the monthly distributions of legitimate and illegitimate births are similar, wedding seasonality appears to have little influence on birth seasonality in developed nations (Rosenberg, 1966; James, 1990; Lam & Miron, 1991; Lam *et al.*, 1994). However, the timing of weddings can have a significant impact on birth seasonality in societies with a highly distinct wedding season (Johnston *et al.*, 1975; Mosher, 1979; Scaglion, 1978; Huss-Ashmore, 1988). Since the Old Order Amish are a natural fertility population with a highly significant bimodal seasonal pattern of weddings (Fig. 7), one would thus expect a significant relationship between month of wedding and month of the first conception. In fact, first births exhibit significant seasonality (Table 1) and the monthly distribution of first conceptions is very similar to that for the monthly distribution of weddings ($W=0{\cdot}81$, $p<0{\cdot}05$; Fig. 7). In addition, only first births exhibit two peaks of equal amplitude (Figs 4 and 7), with those peaks occurring in the same months as the two peaks in weddings. However, the peak-to-trough difference in weddings is about 150% while the corresponding value for first births is only about 35% (Fig. 7). Thus, the seasonal distribution of first births in the Old Order Amish is clearly influenced to some extent by the existence of distinct wedding seasons but, given the difference in amplitude between the pattern of first births and weddings, first births (and presumably others as well) are also influenced by other factors.

Finally, some authors have found an indirect effect of wedding seasonality on birth seasonality operating through parity. In particular, it is argued that a distinct pattern of wedding seasonality can influence the timing of the first birth, which then has a lag effect on the timing of later births in a natural fertility population (Huss-Ashmore, 1988; Garcia-Moro *et al.*, 2000). Results consistent with this hypothesis have been found by some researchers (Odegard, 1977; Lam & Miron, 1991; Garia-Moro *et al.*, 2000) but not by others (Bobak & Gjonca, 2001). The present study found a low level of association between the monthly distribution of the first four births ($W = 0{\cdot}27$, $p > 0{\cdot}05$; Table 1) and a somewhat stronger relationship if only the first two births are considered ($W = 0{\cdot}45$, $p > 0{\cdot}05$). The reason for these contradictory findings is not clear but one possible explanation is that a consistent (and therefore detectable) lag effect would require some constancy both between groups and between parities in the length of the period of lactational amenorrhoea, which is unlikely.

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