# Geographical Differences in the Seasonality of Births in Japan

Shinya MATSUDA[1] and Hiroaki KAHYO[1]

[1]*Department of Preventive Medicine and Community Health, School of Medicine, University of Occupational and Environmental Health*
*Iseigaoka 1-1, Yahatanishi, Kitakyushu 807-8555, Fukuoka, Japan*
*Tel : 81-93-691-7244, Fax : 81-93-603-4307, E-mail : smatsuda@med. uoeh-u. ac. jp*

**ABSTRACT**

Seasonal variations in births in the 47 prefectures of Japan are analyzed using Vital Statistics from 1974 to 1983.

The first births show a bimodal pattern, which has two peaks in winter (December to February) and summer to early autumn (August to September). The seasonality of first births presents the statistically significant correlation with a seasonality in marriage with 9+12*n (n=0, 1, 2, 3) lag months.

For subsequent births, the seasonal pattern is quite different from that of the first births, that is, it is a unimodal pattern. Furthermore, there is a common trend in seasonality of subsequent births with a late spring peak in the northernmost prefecture of Japan giving way to an early autumn peak in the southernmost prefecture.

These findings suggest that seasonal variations of marriage play some role in the causation of seasonality of first births, while other factors such as environmental factors could be associated with the seasonal variation in subsequent births.

**Key words** : births, geographical difference, Japan, seasonality

It is well known that the number of births shows a seasonal variation, which differs markedly from region to region, and from time to time (Dosono, 1934 ; Takahashi, 1952 ; Pasamanick *et al.*, 1959 ; Pasamanick *et al.* 1960 ; Chang *et al.*, 1963 ; Takahashi, 1964 ; Cowgill, 1964 ; Cowgill,1966 ; Erhardat *et al.*, 1971 ; Stoeckel, 1972 ; Malina, 1977 ; Odegard, 1977 ; Parker, 1978 ; Bernard *et al.*, 1978 ; Mosher, 1979 ; Ogum & Okorafor, 1979 ; Warren & Tyler, 1979 ; Becker, 1981 ; Shimura *et al.* 1981 ; Mathers & Harris, 1983 ; Ayeni, 1986 ; Bantje, 1987 ; Huss-Ashmore, 1988 ; Holland, 1989 ; Matsuda & Kahyo, 1992 ; Matsuda *et al.*1992). A tremendous number of studies have been conducted to explain this complicated phenomenon.

Roughly speaking, there are two types of theory to explain the seasonality of birth ; cultural theory which emphasizes cultural factors such as marriage, festivals, agricultural cycles, etc., and the biometeorological theory which intends to analyze this seasonality in light of biometeorological factors such as temperature, light, humidity, etc.

Among social factors, the seasonality of marriage has been frequently referred to as one of the most likely factors (Stoeckel & Alauddin Choudhury, 1972 ; Odegard, 1977 ; Holland, 1989 ; Matsuda *et al.*, 1992). If marriage is an important factor in creating the seasonality of births, as some researchers have emphasized, such an effect should be more apparent in first births. It is, therefore, desirable to analyze the seasonality of births for first births and for subsequent births separately.

On the other hand, if climatic factors have some influence on this seasonality, an observation on how the seasonality differs among climatically different regions in a relatively homogeneous country should be useful to yield insights into biometeorological factors. Fortunately, Japan meets this condition. There is considerable difference in the climate from region to region because of the country's length of 3000 km which puts one end in the sub-arctic zone and the other in the sub-tropical zone, and the cultural and ethnic backbone is relatively homogeneous (Figure 1).

In this study, we documented seasonal variations of births stratified by the birth order in the 47 climatically different prefectures of Japan to construct hypotheses with which the seasonality of births in Japan could be sufficiently explained.

## 1. MATERIALS AND METHODS

### 1. Data source

The source of the data used for this investigation was Vital Statistics of Japan for the 10 year period from January 1974 to December 1983 provided by the Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare, Japan. We limited this analysis to live singletons only.

All monthly data were adjusted to allow for the varying numbers of days in each month, and then the daily average number of births and marriages were used for time-series analysis.

### 2. Statistical analysis

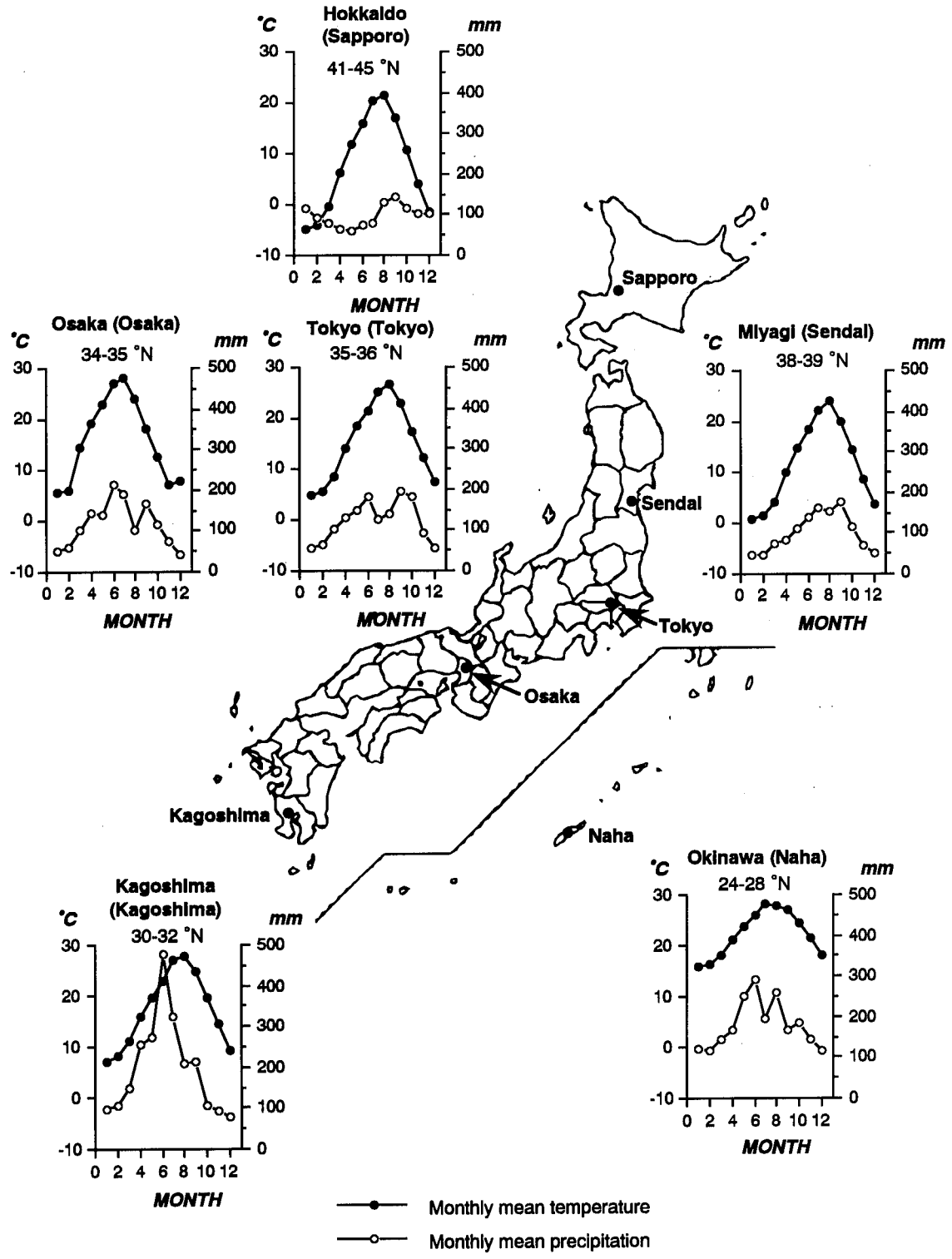


**Fig. 1** Monthly mean temperatures and monthly mean precipitation of six different prefectures in Japan (1951-1980)

Traditional methods of time-series analysis which decompose the variation in a series into trend, seasonal variation, other cyclic changes, and the remaining irregular fluctuations, were used for the present investigation (Chatfield, 1982). The procedure of analysis was as follows :

1) Time-series for the monthly data of first births, subsequent births, and marriage were plotted and then examined for linear trends by least square regression.

2) The observed value ($y_t$) for each month ($t=1, 2, \cdots, 120$) was divided by the corresponding expected value ($y_t'$), which was estimated by the regression line, in order to calculate the index value for each month ($100 \times y_t/y_t'$). The average over 10 years of the index values of each calendar month was calculated, and then accommodated in a way by which the sum of the average value of 12 calendar months became 1200 % using the weighed average in order to calculate a seasonal index for each calendar month. The formula is as follows :

$$SI_i = \frac{A_{ij}}{10} \times \frac{1200}{T}$$

where $SI_i$ = seasonal index of i th month (i=1, 2, 3, ……, 12),

$A_{ij}$ = index value of i th month (i=1, 2, 3, ……, 12) of j th observed year (j=1, 2, 3, ……, 10),

$T = \Sigma\Sigma A_{ij}/10$

3) The existence of seasonal variation was attested by the Friedman two-way analysis of variance (Siege, 1956).

4) To determine the existence of a meaningful relationship between births and marriage, a correlation analysis between marriages and lagged births was employed.

## 2. RESULTS

Figures 2-1, -2, and -3 describe seasonal indices of the daily average number of births of the 47 different prefectures. First births have a bimodal pattern with two peaks, one in late summer to early autumn and the other in winter, and two troughs in late spring and late autumn, except for in Okinawa. In case of the subsequent births, it shows unimodal pattern with one peak which presents a common trend with a late spring peak in the northernmost prefecture giving way to an early autumn peak in the southernmost prefecture. In the case of Okinawa, both the first births and the subsequent births present an unimodal pattern which has a peak in September and a trough in early spring (April for the first births ; March for

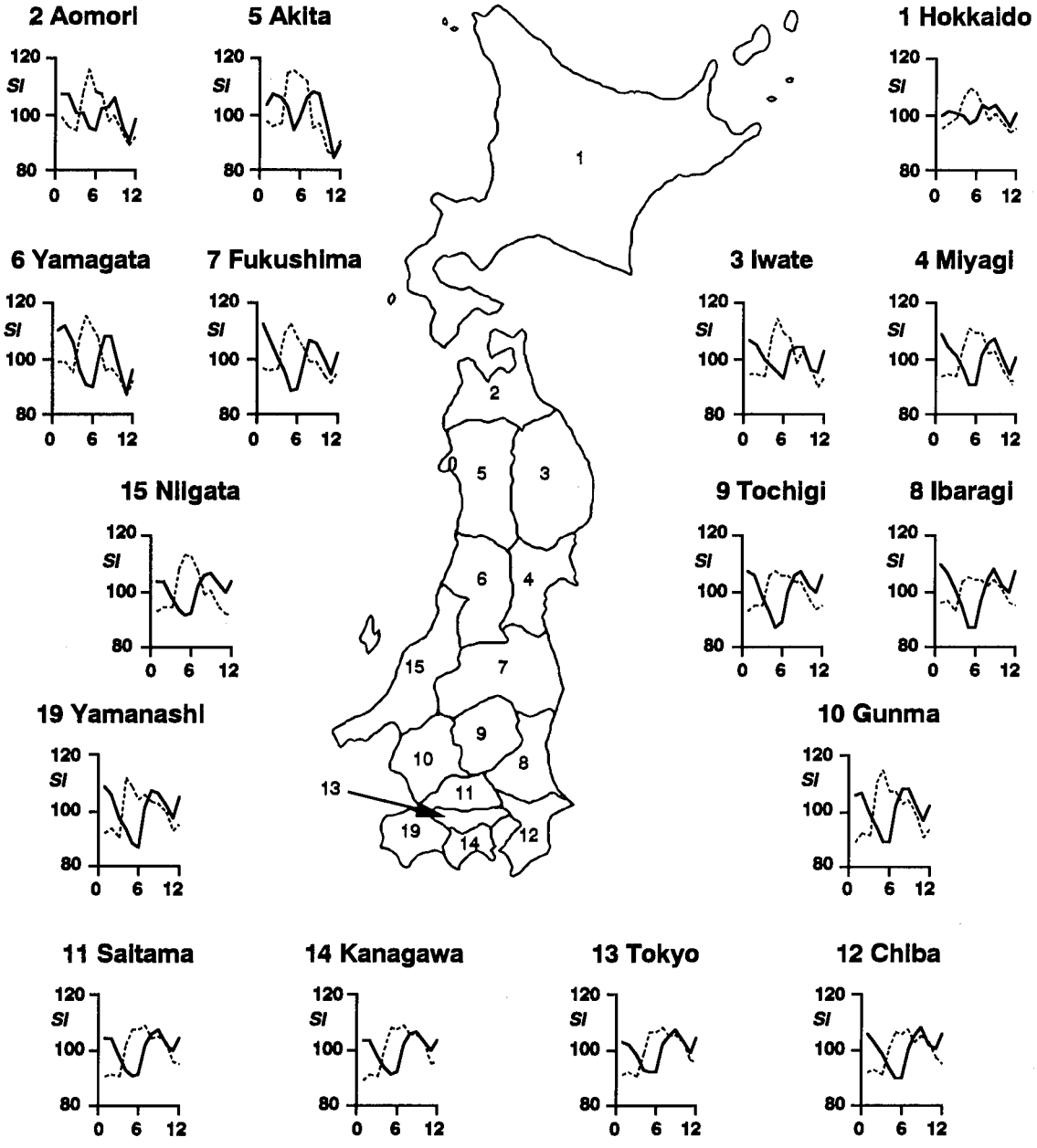


Fig. 2-1 Geographical changes in seasonality of births (Northern and Eastern Japan)

The horizontal axis : Month, The vertical axis : Seasonal Index (SI) ——— Primiparae

Details of the calculation of SI are presented in the text. ------- Multiparae

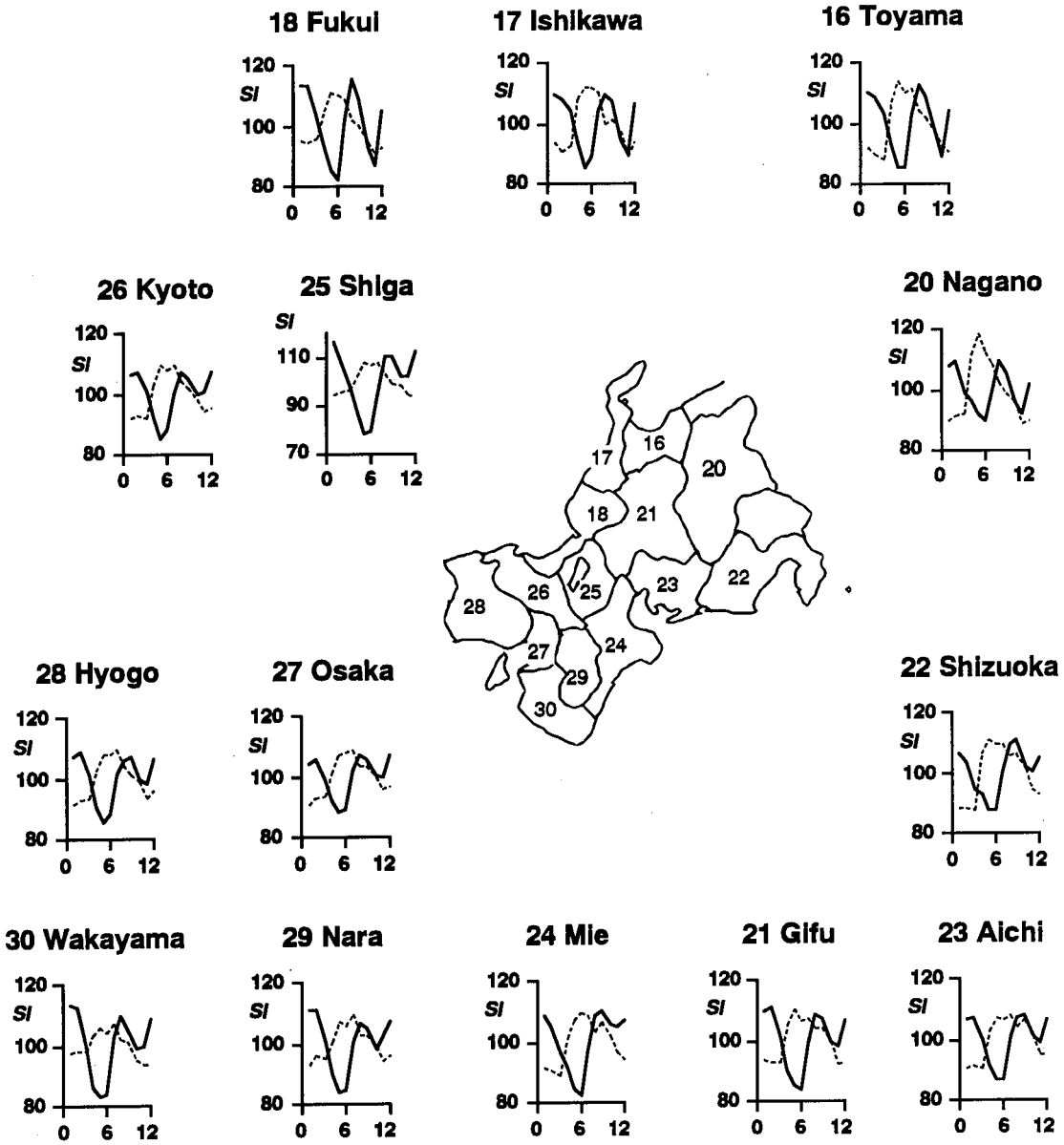


Fig. 2-2 Geographical changes in seasonality of births (Central Japan)

The horizontal axis : Month, The vertical axis : Seasonal Index (SI)

——— Primiparae
------- Multiparae

the subsequent births). Results of Friedman two-way analysis of variance assume the existence of the statistical significance of these seasonalities for all cases ($p<0.05$).

According to results of lagged correlation analysis between the daily average number of marriages and that of lagged births, for the first births, correlation coefficients have peaks at 9 or $10+12\times n$ ($n=0,1,2,3$) lag months for all of the prefectures.

## 3. DISCUSSION

As previous literature has documented, there is a clear seasonal periodicity of births in Japan. More interestingly from the present results, there are three additional original observations. Firstly the seasonal pattern is different between first and subsequent births ; i. e. while first births show a bimodal pattern in forty-six prefectures (but not in Okinawa), the pattern is unimodal in subsequent births for all prefectures. This suggests that mechanisms associated with seasonality are different in first and subsequent births.

Secondly in Japan, the seasonality of marriage may play a role in creating the seasonal variations in first births as shown by the high correlation coefficients between the two time series.

Thirdly, there is a common trend in seasonality of subsequent births with a late spring peak in the northernmost prefecture of Japan (Hokkaido) giving way to an early autumn peak in the southernmost prefecture (Okinawa). Using international data, Takahashi (1964) reported that the peak of the seasonal variation of birth rates moves from spring in a subarctic climate to winter in subtropical countries (Takahashi, 1964). Mathers and Harris (1983) also reported a general trend in shift of peaks in the seasonality of births with latitude in Australia. These systematic changes of peaks in seasonal variation of births suggest that environmental factors play an important role in creating the seasonal fluctuation in subsequent

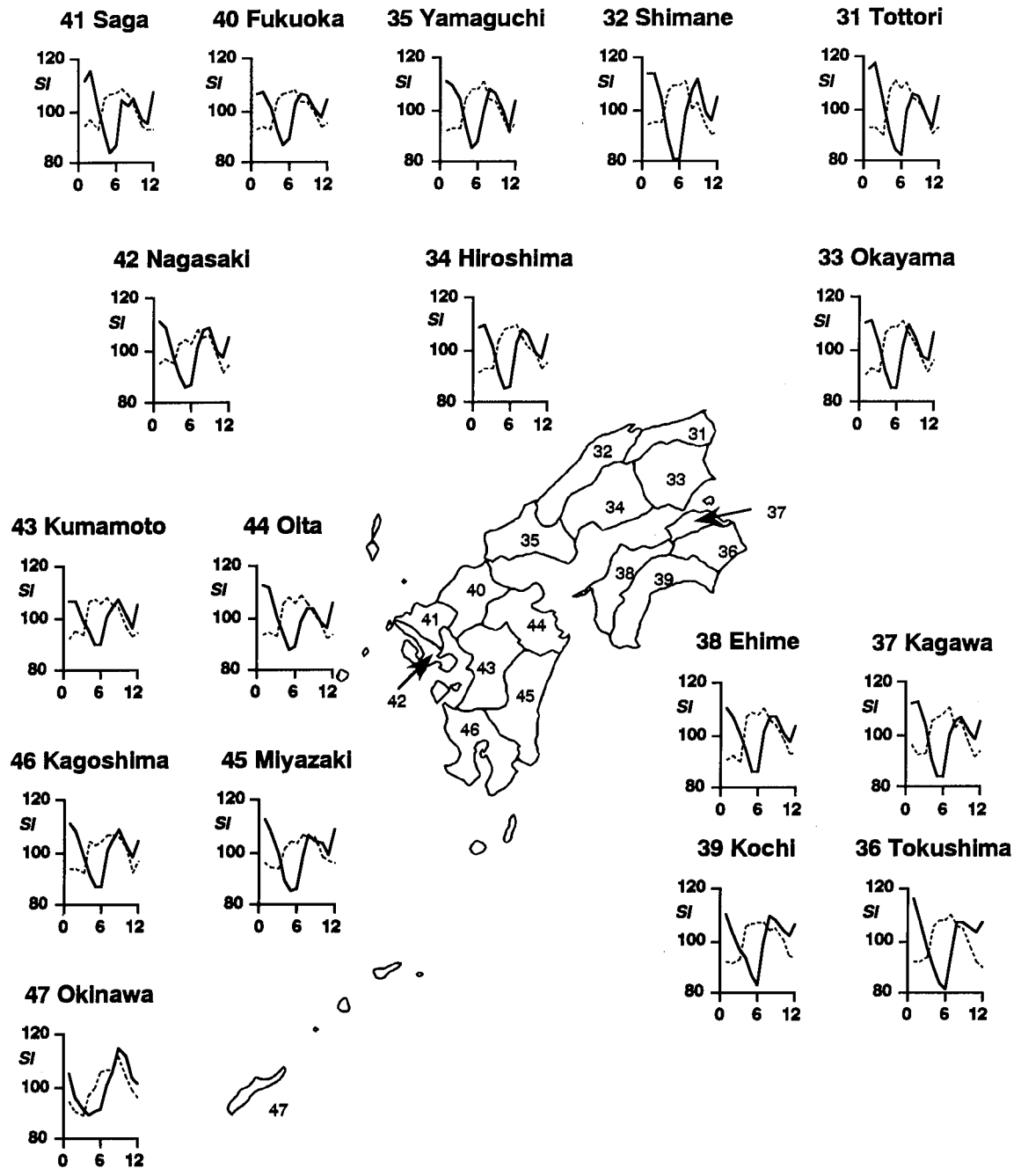


**Fig. 2-3** Geographical changes in seasonality of births (Western and Southern Japan)

The horizontal axis : Month, The vertical axis : Seasonal Index (SI) ——— Primiparae ------- Multiparae

births. Some researchers estimate that the seasonal temperature variation affects fertility rates and that there is an optimal temperature for conception (Dosono, 1934 ; Pasamanick *et al.*, 1959 ; Pasamanick *et al.*, 1960 ; Chang *et al.* 1963 ; Takahashi, 1964 ; Stoeckel, 1972 ; Parker, 1978 ; Bernard *et al.*, 1978 ; Shimura *et al.* 1981 ; Mathers & Harris, 1983 ; Ayeni, 1986). Temperature may affect the seasonality in births because discomfort during summer may reduce sexual activity, or the germinal tissue of the gonads may be affected either directly or indirectly.

Another plausible bio-meteorological hypothesis is that fetal loss may result from hyperthermia during the early stage of gestation. Miller *et al.* (1978) reported a higher risk of anencephaly among mothers affected by hyperthermia due to sauna bathing and febrile illness. Accordingly, the high frequency of influenza in winter may lead to a diminution of births in summer because of its deleterious effect on the fetus. Our evidence does not support this, there being an increase in the number of subsequent births in summer.

No single explanation for the seasonality of births will suffice for the different results obtained in various countries as well as at different periods of time. The physiological and psychological mechanism by which the meteorological and socioeconomic cycle are translated into reproductive behavior should be different among different cultures and periods, therefore, this phenomenon should be thoroughly analyzed by a well

planned comparative epidemiological study in order to yield insights into the underlying causal chains.

Furthermore, experimental studies are also necessary in the field of reproductive biology and chronobiology, since it seems that more acceptable explanations may be developed by laboratory experimentations rather than by simple observational studies if emphasis is placed on the biological theory.

## REFERENCES


Ayeni, O. (1986) Seasonal variation of births in rural southwestern Nigeria. Int. J. Epidemiol. **15** : 91-94.

Bantje, H. (1987) Seasonality of births and birthweights in Tanzania. Soc. Sci. Med. **24** : 733-739.

Becker, S. (1981) Seasonality of fertility in Matlab, Bangladesh. J. biosoc. Sci. **13** : 97-105.

Bernard, R.P, R.V., Bhatt D.M., Potts and R. Padma A. (1978) Seasonality of birth in India. J. biosoc. Sci. **10** : 409-421.

Chang, K. S. F., S. T. Chan, W. D. Low and C. K. Ng (1963) Climate and conception rates in Hong Kong. Human Biology **35** : 366-376.

Chatfield. C. (1982) The analysis of time series-analysis introduction-4th edn. Chapman and Hall, London, 241p.

Cowgill, U. M. (1964) Recent variations in the season of birth in Puerto Rico. Proc. N. A. S. **52** : 1149-1151.

Cowgill, U. M. (1966) Season of birth in man : Contemporary situation with special reference to Europe and the southern hemisphere. Ecology **47** : 614-623.

Dosono, S. (1934) Statistical observation of the conception months of human kind. Minzoku Eisei (Race Hygiene) **12** : 79-86. (in Japanese)

Erhardat, C. L, F. G, Nelson and J. Pakter (1971) Seasonal patterns of conception in New York City. AJPH **61** : 2246-2258.

Holland, B. (1989) Seasonality of births : Stability and change in a developing country. Human Biology **61** : 591-598.

Huss-Ashmore, R. (1988) Seasonal patterns of births and conception in rural Highland Lesotho. *Human Biology* **60** : 493-506.

Malina, R. M. and J. H. Himes, (1977) Seasonality of births in a rural Zapotec Minicipio, 1945-1970. *Human Biology* **49** : 125-137.

Mathers, C. D. and R. S. Harris (1983) Seasonal distribution of births in Australia. *Int. J. Epidemiol.* **12** : 326-331.

Matsuda, S. and H. Kahyo (1992) Seasonality of preterm births in Japan. *Int. J. Epidemiol.* **21** : 91-100.

Matsuda, S., T., Doi T, Sone and H Kahyo (1992) Seasonal variation of mean birth weight and births in Nagano prefecture. Jpn. *J. Hyg.* **47** : 609-617. (in Japanese)

Miller, P., D. W., Smith and T. Shepard (1978) Maternal hyperthermia as a possible cause of anencephaly. Lancet 519-520.

Mosher, S. W. (1979) Birth seasonality among peasant cultivators : The interrelationship of workload, diet and fertility. *Human Ecology* **7** : 151-181.

Odegard, O. (1977) Season of birth in the population of Norway, with particular reference to the September birth maximum. *Brit. J. Psychiat.* **131** : 339-344.

Ogum, G. E. O. and A. E Okorafor (1979) Seasonality of births in south-eastern Nigeria. *J. biosoc. Sci.* **11** : 209-217.

Parker, G. (1978) Season of birth in New South Wales. Med. J. Aust **2** : 563-566.

Pasamanick, B., S., Dinitz and H., Knobloch (1959) Geographic and seasonal variation in births. *Public Health Reports* **74** : 285-288.

Pasamanick, B., S, Dinitz and H. Knobloch (1960) Socio-economic and seasonal variations in birth rates. *Mil. meml. Fund*. Q **38** : 248-254.

Shimura, M., J., Richter and T., Miura (1981) Geographical and secular changes in the seasonal distribution of births. *Soc. Sci. Med*. 15D : 103-109.

Siegel, S. (1956) Nonparametric statistics for the behavioral sciences. McGRAW-HILL KOGAKUSYA, Tokyo, pp166-173.

Stoeckel, J. and Alauddin A. K. M Choudhury (1972) Seasonal variation in births in rural east Pakistan. *J. biosoc. Sci.* **4** : 107-116.

Takahashi, E. (1952) Notes on Japanese birth statistics. *Human Biology* **24** : 44-52.

Takahashi, E. (1964) Seasonal variation of conception and suicide. Tohoku. *J. exp. Med.* **84** : 215-227.

Warren, C. W and C. W., Tyler (1979) Social status and season of births : A study of metropolitan areas in the Southeastern United States. *Soc. Biol.* **26** : 275-288.


(Received April 20 1998, Accepted June 25 1998)