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Seasonality of Conception in Human Populations in Chile

by

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ABSTRACT. — Seasonality of conceptions in human populations in Chile was studied for a period of 30 years (1945-1974). Clear seasonal conception courses exist in the country, exception made of the northern and southern extremes. Seasonal flux is concentrated mainly in January, but also secondary increases in April and June were observed. Along the 30-year period a general pattern of decreasing seasonality is observed. Conception is significantly related to temperature and photoperiod in this country, the maximum rates of conceptions being observed in coincidence with the maximum temperatures and photoperiods. Nonclimatic factors which may be affecting seasonality of conceptions are also discussed.

INTRODUCTION

The study of human conception under a seasonal perspective and its relation with some variables of the physical environment has been a somewhat neglected field of investigation in Chile. The country, along its 4 200 km of extension, shows a gradient of bioclimates, from the desertic and Altiplano types with subtropical influence in the north, through mediterranean types dominating a large area, up to the oceanic and subpolar influences in the southern part of it. Extended work has been published on Chilean regional bioclimates (Di Castri and Hajek, 1976; Hajek and Di Castri, 1975).

These different climatic patterns of the country make it a very attractive site for gradient studies and their influences on human conception.

The knowledge of seasonal courses of some of the vital statistics is, on the other hand, a powerful planning tool for the development of population strategies and for the setup of medical and general social infrastructure. Also, studies of seasonality could promote important research on the etiology of congenital malformations (Jongbloet, 1975).

It is a well-known fact that seasonal variations in birth rates exist in human populations, but the general pattern is not universal. Various concentrations of births in different seasons have been detected (Macfarlane, 1970) and the latitude and some environmental factors, mainly temperature and photoperiod, seem to play some role (Chang et al., 1963; Rosenberg, 1966), as well as nonclimatic factors, like the season of marriage.

The purpose of this paper is to analyze if seasonality of conceptions exists in human populations in Chile. If this occurs, to determine its relation with latitude and some climatic and non-climatic factors.

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MATERIALS AND METHODS

Monthly data of births for the old 25 administrative provinces of Chile were obtained for the period 1945 to 1974 from the records of the Instituto Nacional de Estadísticas, Santiago (INE, 1945-1974). A total of approximately 7 millions births was analyzed. The monthly rate of births (expressed as percentages from the total) was related to the expected percentage of annual mean monthly birth rate (8.3%). For the computation, it was assumed that conception took place 9 months before birth. No correction was made for length of month. The conceptions were plotted as percentage deviations from the annual mean, beginning in October. For the computational analysis, it was considered adequate enough to work with the mean latitude of the province. An Analysis of Variance with a Scheffé test a posteriori (Snedecor and Cochran, 1969) was made for detecting possible differences between months for each of the provinces. For this purpose the arcsine of the square root of percentages of conceptions was used. The value of F was used to define the intensity of seasonality. It was assumed that the higher the F value, the higher was the seasonal course of conceptions per province.

Also, the maximum positive deviation from the mean was used as a "seasonality index" (I_o), to compare different provinces along a latitudinal gradient and to analyze the course of seasonality along time. Five-year moving means were used also for this purpose.

Temperature data were obtained from the records of the Oficina Meteorológica de Chile (Hajek and di Castri, 1975). Daylength was calculated by astronomical methods. Temperature data used correspond to the localities with the highest percentage of births in each province.

Correlations between temperature and conception and between photoperiod and conception were computed. Also multiple regression analysis was made using these physical factors as independent variables.

RESULTS

In Fig. 1 the annual course of conceptions is shown for the 25 provinces of Chile. In the northern provinces (approximately from 19 to 25 degrees of latitude), the seasonality is not very marked, but shows some peaks in correspondence with the months of January, April and June. From the province of Aconcagua (Lat. 32°30'S) southwards the general pattern of the central zone correspond to a maximum of conceptions taking place in summer. This is opposed to the information provided by Macfarlane (1970) who states that winter maxima occur in Chile.

Summer conception rates are mainly concentrated in January. The minimum is observed in late autumn (May) and in some provinces, in mid-winter (July). From latitudes 42°30' southwards the seasonality begins to decrease, this being particularly noticeable in the provinces of Aysén (45°30') and Magallanes (53°). A special and up to now unexplainable pattern is evidenced in Chiloé (42°30'), a province where more than 85% of the population lives on the Isla Grande de Chiloé (Great Island of Chiloé) in an area of about 9000 km^2. In this province, the maximum flux of conceptions is observed in April (mid-autumn), the minima in March (early autumn) and May (late autumn).

With a more detailed analysis of the course of conceptions in the Chilean provinces, we could detect secondary peaks in some of them. These corresponded in general to the months of April and June. Nevertheless, as can be observed from Fig. 1, this pattern of secondary increases, mainly in April, is not constant along the whole latitudinal gradient, being marked in the northern part of Chile, disappearing in the central part and again reappearing in the southern portion of the country. The secondary peak of June is present in almost all Chilean provinces.

In Fig. 2 we show the relationship between the value of F and the latitude. As was stated before, the higher the value of F, the more marked is the difference between months and therefore the seasonality. From Fig. 2 we learn that in the northern part of the country, the

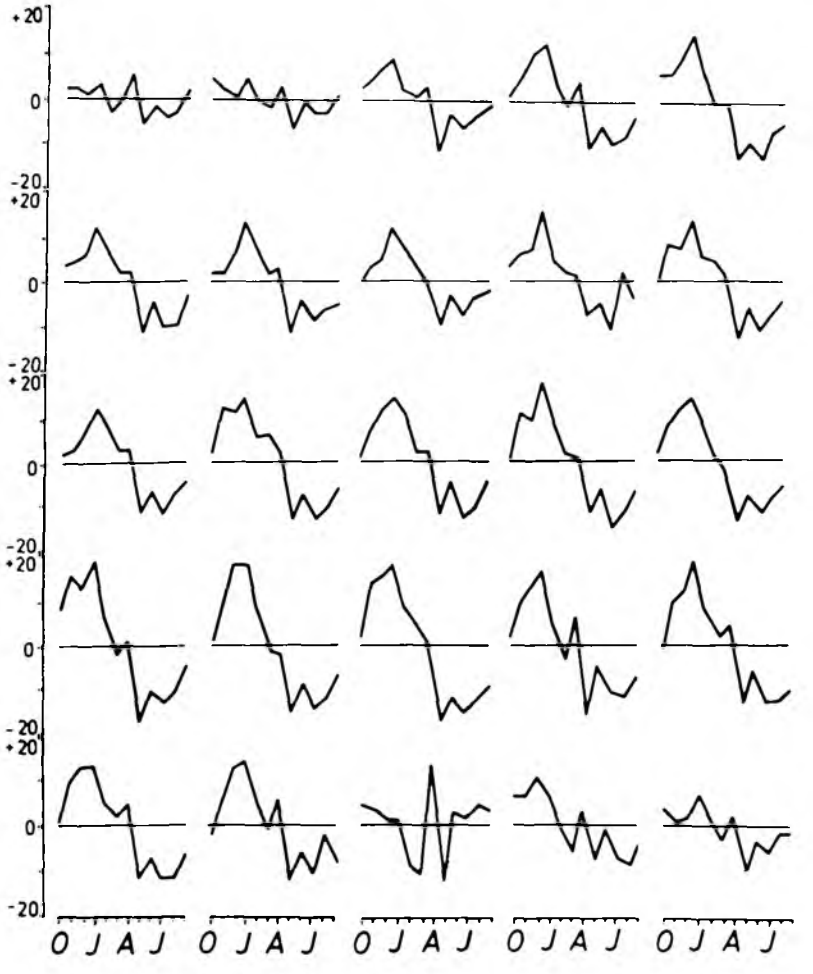

Fig. 1. Annual course of conceptions in human populations for the 25 provinces of Chile. These are, with their corresponding mean latitude in degrees, from left to right:
First row: Tarapacá (19°), Antofagasta (23.5°), Atacama (27°), Coquimbo (30°), Aconcagua (32.5°).
Second row: Valparaíso (33°), Santiago (33°), O'Higgins (34.5°), Colchagua (34°), Curicó (35°).
Third row: Talca (35.5°), Maule (35.5°), Linares (36°), Ñuble (36.5°), Concepción (37°).
Fourth row: Arauco (37.5°), Bio-Bio (37.5°), Malleco (38°), Cautín (39°), Valdivia (40°).
Fifth row: Osorno (40.5°), Llanquihue (41.5°), Chiloé (42.5°), Aysén (45.5), Magallanes (53).

overall seasonality is only slightly marked, no month showing significant difference. The highest value of seasonality is encountered in the central zone (about Lat. 36°S) declining in the south. This is also evident in Fig. 3 where the maximum and minimum percentages of

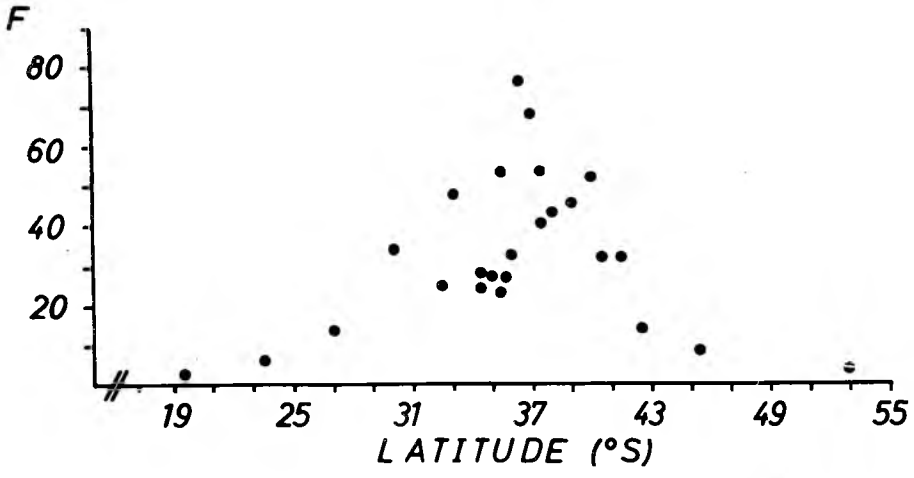

Fig. 2. Relation between the F value considered as a seasonality evidence and the latitude. Greater dispersion of values is observed in the central part of the country, due to location of coastal and inland provinces.

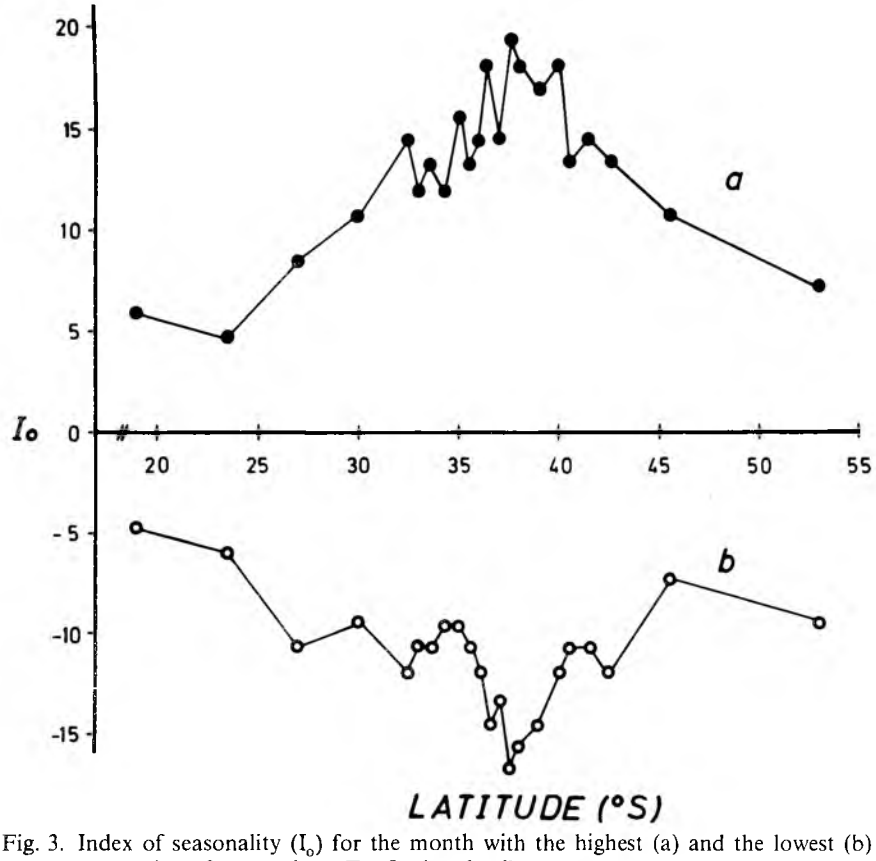

Fig. 3. Index of seasonality (I_o) for the month with the highest (a) and the lowest (b) proportion of conceptions. For further details see text.

conceptions are shown (Index of seasonality) as a function of latitude. The highest values are observed at about Lat. 37°30'S, declining towards the extremes of the country. This seasonality index will be used for further analysis considering conceptions as function of time, temperature, photoperiod and latitude.

To detect possible periodicities in the course of conceptions along time, 5 year-moving means were calculated and plotted in Fig. 4. It was estimated that 5-year means are an

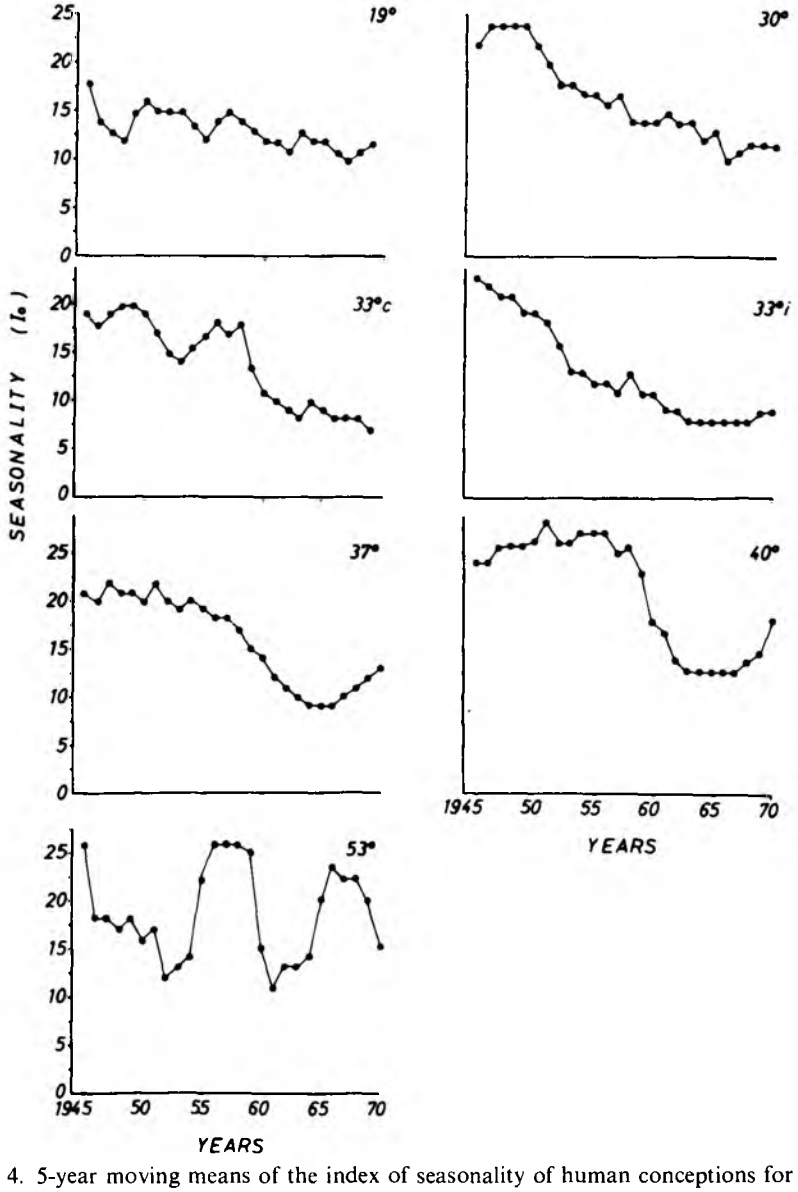

Fig. 4. 5-year moving means of the index of seasonality of human conceptions for the period 1945-1974 in some selected provinces of Chile. These are (Lat.): Tarapacá (19°), Coquimbo (30°), Valparaíso (33°), Santiago (33°), Concepción (37°), Valdivia (40°), Magallanes (53°). c = coastal, i = inland.

adequate time period to depict the course of conceptions along the period of observations. In this sense, different patterns of behaviour are present in the selected 7 provinces chosen for this case, which may well represent a summarized situation for the other provinces. Several patterns are recognizable from Fig. 4. In the northern part of the country (approx. Lat. 19°S) a negative slope is evident with some periodical fluctuations of about 8 years, but with a decreasing trend. At 30° latitude a constant and almost regular decrease is observable. An interesting difference may be observed at 33 degrees of latitude between coastal and inland provinces (Valparaíso and Santiago, respectively). The coastal area shows a trend to fluctuate at the beginning of the series with little decrease, but from 1960 on an almost regular decrease is evident. Santiago, at 33°S, the province where the capital of the country is located, shows a regular decrease of seasonality and a stabilization at about 7% from 1960 onwards. At Lat. 37°S a regular decrease is observed until 1965, with an increase again after that year. Further south, at 40°S, a stabilization at about 25% existed for several years and in 1960 a descending wave began, with apparent oscillations starting in 1965. The southernmost province shows a regular oscillating pattern for the 30 years analyzed. It may be concluded that even though there exists a fluctuational pattern in the extremes of the country, this is less noticeable in the northernmost province and is decreasing along time. In the southernmost province at 53°S the oscillations of seasonality of conceptions were between 25% and 10%.

In Fig. 5 climographs relating photoperiod and temperature are shown along a latitudinal gradient. In the northern part of the country, a small range of the photoperiod is observable, with a temperature range at about the mean of 19°C and a difference between the longest and the shortest day of 7.5°C. In the southernmost province of this country, large differences are observed in the length of the photoperiod (between 7.5 and 16.5 h) with a temperature range of 9.5°C at about the mean of 8.5°C.

The relationship between temperature and conceptions for each province are shown in Table 1. In all cases a good adjustment exists between these two variables. As can be seen from the values, the association between this variable and the conceptions is higher in the central part of the country, declining towards the extremes of the country. Values of multiple regressions between conceptions and temperature and photoperiod are also shown in Table 1. In the majority of the provinces, exception made of the northernmost and southernmost provinces, these two climatic variables explain more than 85% of the conception variance.

The relationship between the photoperiod and maximum conception rates (measured through the seasonality index) are shown in Fig. 6. The relationship has been set to length of the day for both the month with the longest and the shortest day. As can be seen from the graph, the maximum and minimum number of conceptions does not coincide exactly with the months of maximum and minimum length of days. The association of the two variables is not so strong in the northern part of the country, but the rest of Chile shows a rather constant relationship with this environmental factor. In all cases, the correlation coefficients for all but the northern part of the country show high and significant values (see Table 1).

Relationship between temperature and maximum and minimum conception flux is shown in Fig. 7. Here, the latitudinal effect is not as clearly evident as before with the photoperiod and some fluctuations exist. Analyzing this figure, we can see that the association is closer with the maximum temperature, that is, the highest conception is very closely associated with the highest temperature, but the lowest conception rates are somewhat more loosely linked to minimum temperature.

DISCUSSION

Analyzing some of the results just stated, it is not possible to relate all the principal and secondary peaks of conceptions to some of the factors usually cited in the literature. It might be speculated at this point that the summer peak might be associated with summer

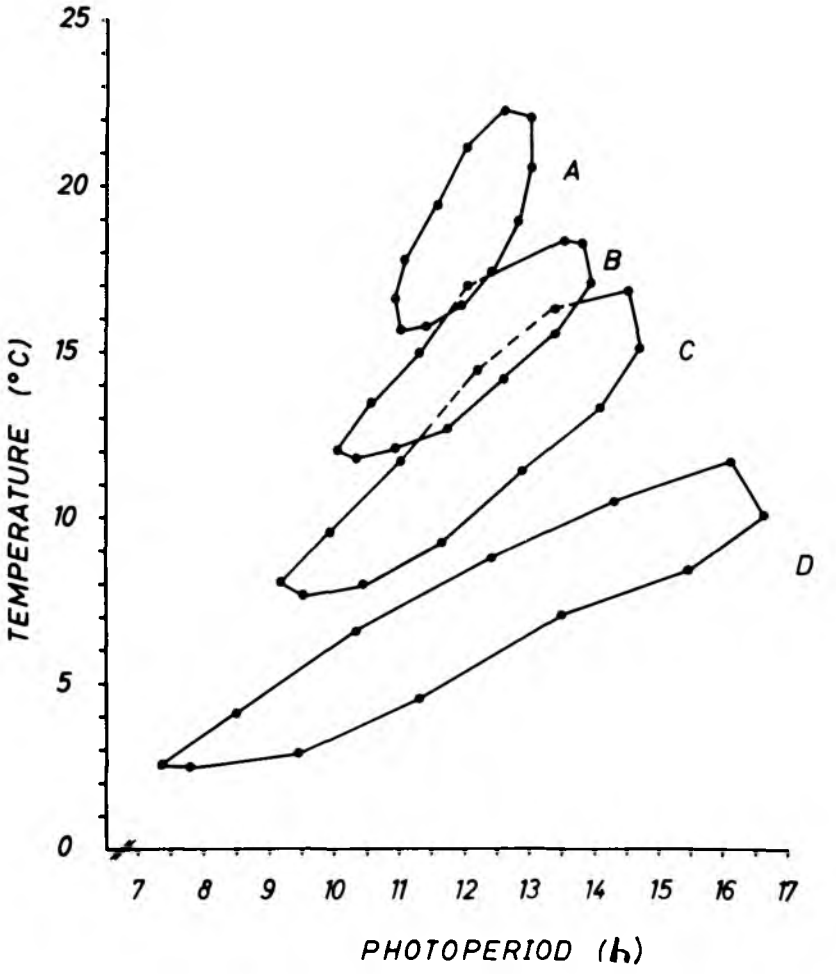

Fig. 5. Climograms of temperature and photoperiod for selected provinces in Chile (Lat.). A = Tarapacá (19°), B = Coquimbo (30°), C = Valdivia (40°), D = Magallanes (53°).

vacations or the higher temperature and longer photoperiod of this part of the year, or with the fact that there might be a "planning" of births to occur in September-October (spring season), where there are more favorable climatic conditions post-winter. In this sense some kind of relationship has been observed with animal populations, whose offspring are usually found to occur in the more favorable portion of the year (Hafez, 1968). On the other hand, Huntington (1938) postulates that a "basic animal rhythm" would exist in man which would cause a greater number of conceptions to occur in spring. Fitt (1941) suggests that there is an internal seasonal biological rhythm, based on endocrine rhythm (Jongbloet, 1975).

April is a transition month between the dry and hot summers and the cooler and wetter winters in most of the country, and these higher conceptions occur after the summer vacations and the re-initiation of labor activities in Chile (mid March).

Easter holidays have fallen in April 80% of the years in the period 1945-1974 and this

Table 1. Correlation coefficients between climatic variables and conceptions of human populations in Chile.

Province, Stations	Temperature and Conceptions		Photoperiod and Conceptions		Multiple Regression	
	r	P	r	P	r^2	P
Tarapacá, Arica	.35		.12		.29	*
Antofagasta, Antofagasta	.41		.62	*	.33	**
Atacama, Copiapó	.75	*	.84	***	.71	***
Coquimbo, La Serena	.81	***	.86	***	.75	***
Aconcagua, Los Andes	.95	***	.95	***	.92	***
Valparaíso, Valparaíso	.86	***	.87	***	.81	***
Santiago, Santiago	.89	***	.84	***	.80	***
O'Higgins, Rancagua	.89	***	.86	***	.80	***
Colchagua, San Fernando	.89	***	.91	***	.85	***
Curicó, Curicó	.93	***	.89	***	.86	***
Talca, Talca	.92	***	.80	***	.85	***
Maule, Cauquenes	.86	***	.81	***	.76	***
Linares, Linares	.85	***	.89	***	.73	***
Ñuble, Chillán	.94	***	.92	***	.91	***
Concepción, Concepción	.90	***	.80	***	.86	***
Arauco, Lebu	.78	**	.94	***	.90	***
Bio-Bio, Los Angeles	.91	***	.95	***	.91	***
Malleco, Angol	.92	***	.94	***	.92	***
Cautín, Temuco	.79	**	.84	***	.73	***
Valdivia, Valdivia	.92	***	.87	***	.86	***
Osorno, Osorno	.92	***	.91	***	.87	***
Llanquihue, Puerto Montt	.83	***	.82	***	.66	*
Chiloé, Castro	.26		.07		.27	*
Aysén, Coyhaique	.64	*	.76	**	.61	*
Magallanes, Punta Arenas	.55	*	.57	*	.32	*

* $P < 0.05$
** $P < 0.005$
*** $P < 0.001$

might be a reason for the increase of conceptions in April. The rest of the time (20%) it has fallen in March, which does not evidence a clear increase of conceptions.

The second increase in June, that is after the minimum conception flux in May, is also difficult to be explained, In June, month of the winter solstice, many saint's days are celebrated as part of the local traditions and usually towards the third week every year a series of clear and sunny days are encountered, with a general temperature increase. This is locally called "Veranito de San Juan" (Little summer of Saint John). We are not able, however, to rationally explain the fact that either or both of these aspects could lead to an improved sexual activity.

Analyzing the changes in the seasonality of conceptions in Chile during the period of 30 years (in decennials starting 1945) it can be observed that in general there is a decrease in the seasonal flux of conceptions, in almost all the Chilean provinces, this decrease even being noticeable in the provinces located towards the extremes of the country, which show little seasonality in the general pattern. The general pattern is recognizable and apparently there is no change in the peak months along the years of study. Again, the situation of the province of Chiloé may be pointed out, with a somewhat erratic course of conceptions along the years. Evidences exist that insular populations tend to have characteristic behaviour concerning conceptions (Macfarlane, 1970).

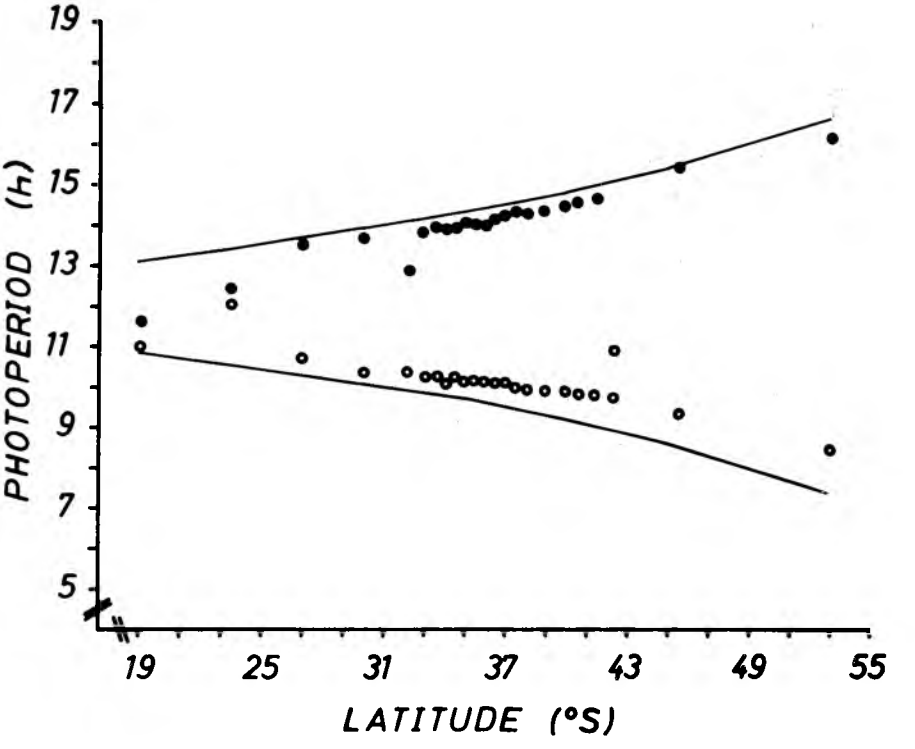

Fig. 6. Photoperiod corresponding to the highest and lowest conception rates along a latitudinal gradient in Chile.

What would be expected concerning seasonality of conceptions along time in a developing country? We could assume that the most likely pattern would be one similar to that of the province of Santiago, i.e. a descending seasonality and afterwards a kind of stabilization. Family planning programs, which were implemented in the 1960's, might be influencing the general decreasing pattern of seasonality.

The provinces south of Santiago show a transition between the central zone (at about 33 degrees of latitude) and the southern extreme of the country, with a fluctuating pattern. Could it be assumed that the decrease in the seasonality of conceptions would be due to the improving of socio-cultural conditions, leading to a better socioeconomic infrastructure and thus tending to make the season of conceptions (and consequent births) almost independent from the season of the year?

Apparently the aforementioned factors seem to be a good reason to explain the decrease of seasonality in most of the Chilean provinces. But what happens actually with those which after a certain period of stabilization, start to oscillate again? Would it mean that living conditions have deteriorated again or are there other factors which in this part of the period of analysis play some more important role? This is hard to account for at this stage of our study.

CLIMATIC FACTORS AND CONCEPTIONS IN CHILE

Temperature and photoperiod have been postulated as having a significant effect on the reproductive behaviour in different animal species (Hafez, 1968) and also could be thought of playing some role on human behaviour in relation to this aspect (Macfarlane, 1970;

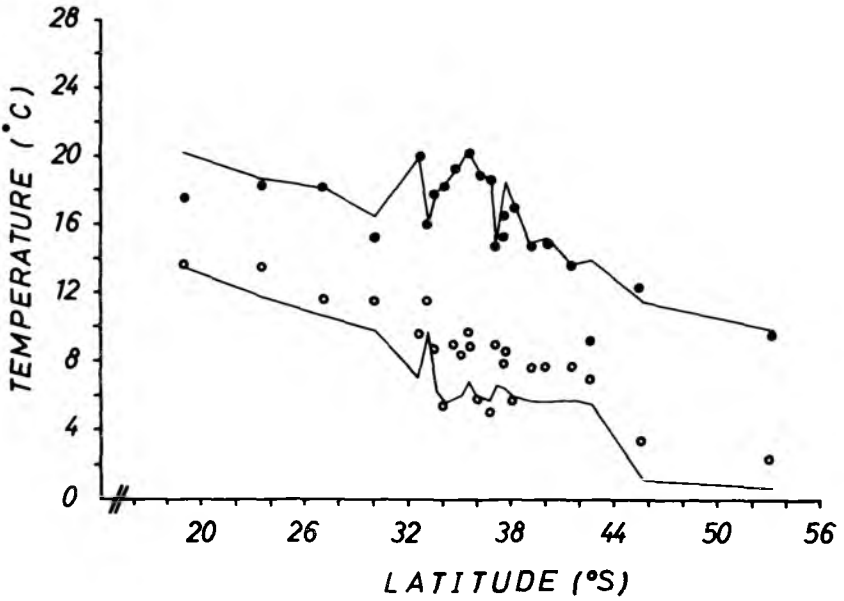

Fig. 7. Temperatures corresponding to the month with the lowest and highest conception rates in Chile as related to latitude.

Weihe, 1979). In fact, we have shown in this research that the relations between these two variables and the conceptions are highly significant.

In the Central part of Chile, the temperature seems to be more important than the photoperiod, the opposite occurring in the southern provinces. Our results are in concordance with the experiences made in birds and some mammals (review in Hafez, 1968). According to that, in the tropics the photoperiod does not influence the sexual behaviour of animals and therefore there is no seasonality. In the north of Chile the photoperiod, as well as the temperature, is constant all year and no seasonality exists in the conceptions.

Temperature and photoperiod account in a great part for the latitudinal variation observed in the conceptions. This suggests to us that the human populations would be responding similarly to animal populations, i.e. temperature and photoperiod might be acting on the nervous system either increasing the sexual activities or improving the quality of gametes (Macfarlane, 1970). Somebody might argument that this relation is coincidental, since the summer, when the maximum of conception occurs, coincides with the vacations, Christmas and New Year feasts, these being probably the most important factors. However, in the northern part of Chile, where the vacations are also in summer, seasonality of conceptions does not exist.

As final concluding remarks we may state that the conceptions show clear seasonal courses in Chile in almost all the provinces, exception made at the extremes of the country, where this seasonal course is less evident. These conception rates are closely associated with temperature (highest temperature showing the highest peaks of conception) and with the photoperiod. There has been a somehow regular decrease of seasonality of conceptions in Chile along the studied 30 years, with a fluctuating aspect in the southernmost part of the country. Up to now, the different causes that may lead to this clear seasonal course, specially in those months where secondary peaks exist, like April and June, are not clear.

It seems to be clear, from a climatic viewpoint, however, that the stronger seasonal course of the conceptions in the central part of Chile could be attributed to a more fluctuating climatic condition along the year. We exclude the fact that the higher concentration of

population in the central zone of the country might be giving a more fluctuating general pattern in this part of Chile. In the central zone of the country, we find the province of Santiago, with the capital and which we may define as an "urban" province, opposed for example to Ñuble, which is also in the central zone and is, on the other hand, what may well be called a "rural" province.

The extremes of the country show a regular pattern of conceptions with no marked seasons. This may be thought of being associated with constant climates. In the northern part it is most probably an adequate macroclimate all year around, surpassing a minimum threshold temperature and photoperiod for conceptions and in the southernmost province it might be the microclimate in the home.

Heating degree-days (HDD) may well be used as an index of cold and climatic regularity. In the extreme south a high proportion (4411) of heating degree-days (base 18°C) are found, with a heating season of 52 weeks, whereas in the northernmost province, coastal area, HDD are only 375, with a brief heating season, because of the higher temperatures (Hajek et al., unpublished data).

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