ANNALS OF HUMAN BIOLOGY, 1987, VOL. 14, NO. 3, 249–261

Opportunity for natural selection with special reference to population structural measures among the Vadde

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Received 23 June 1986; revised 31 October 1986

Summary. Crow's indices of opportunity for natural selection have been studied among the Vadde, a fishing community of Kolleru Lake, Andhra Pradesh, India. The sample comes from 15 of the 60 fishing villages. The indices were computed both at the level of village and population units. A village sample of Palle, another fishing group in the area, has also been analysed for the purpose of comparison. An attempt has been made to explain variation in selection indices among the villages using population structural measures.

A wide variation is found in both the fertility and mortality indices between the villages. The values were compatible with those found for other fishing groups studied previously, and in the middle of the range observed for the Indian populations (about 100) studied so far. Population structural measures are found to explain a significant amount of variation in I_m and I_t but not in the fertility index.

1. Introduction

Microevolutionary changes occur primarily from some individuals having more viable offspring than others so that genes from the more successful individuals come to make up a larger proportion of gene pool of the population in the next generation. Crow (1958) devised an index that facilitates quantitative estimation of the selective pressure, given the reproductive pattern of a population. This is a generation analogue of Fisher's (1930) 'Fundamental Theorem of Natural Selection', and measures the proportion by which fitness would increase with specific birth and death rates if they were all selective and the heritability of fitness were complete (Crow 1972). But, in reality, the genetic component in differential fertility and mortality is rather small, as the reproductive outcome of an individual and/or a population is a result of the interaction of a variety of sociocultural factors (Crow 1966, Cruz-Coke, Christofannini, Aspillaga and Biancani 1966, Matsunaga 1966) that greatly affect fertility and mortality. Therefore, the index sets only an upper limit for the potential action of natural selection and is accordingly renamed as opportunity for natural selection (Crow 1966). It can be divided into two components—one due to differential fertility and the other due to differential mortality—and does not reveal more than that which is contained in the vital statistics. It is therefore descriptive and not analytical (Crow 1972). Several investigators have pointed out the difficulties in the use and interpretation of the index (for detailed discussion, see Spuhler 1962, 1976, Morton 1968). Yet, since it is very difficult to measure selection directly in human populations, Crow's index seems the most feasible means of inferring selection, at least indirectly.

In a number of recent papers, attempts were made to explore the relationship between the indices of selection and socioeconomic conditions (Spuhler 1976, Sheets 1979, Terrenato, Ulizzi and San Martini 1979, Ulizzi, San Martini and Terrenato 1979, Rajanikumari, Srikumari and Rao 1985, Padmanabham 1985), and other population structural measures like population size (Reddy and Lakshmanudu 1979, Reddy 1983 a) and inbreeding (Barua 1976, Rao and Murthy 1984). These studies in general confirm the influence of the above factors on the indices. It is, therefore, clear that the indices of selection measure only the amount of opportunity, and working selection can be better envisaged only if the relevance of sociocultural and structural variability of a population is fully understood. Many workers to whom reference has already been made attempted to achieve this by comparing the indices of populations with different sociocultural backgrounds, which may also have different genetic backgrounds. The present paper, however, attempts to explore the interrelationships between indices of selection (I_m, I_f and I_t) and the population structural measures *vis-à-vis* effective population size, village endogamy, mean marriage distance (excluding within village marriages), inbreeding coefficient, surname diversity index, frequency of family planning, and the frequency of more than one marriage for an individual, in different village units of a relatively homogeneous population. This may provide a better theoretical framework for understanding the role of structural variation present within a population in shaping the action of natural selection.

Of the population structural measures, theoretically, inbreeding is expected to increase homozygosity and thus affect fertility, mortality and morbidity. However, this is not always supported by empirical evidence. Village endogamy, mean marriage distance, surname diversity index and population size are to varying degrees found to be related to inbreeding coefficient in general and particularly in the Vadde population (Reddy 1983 b). Therefore, these parameters are expected to exert some degree of influence on the reproductive outcome. The effect of family planning in reducing mean and variability of fertility and marrying several times, either due to death or divorce of the earlier spouse, in terms of interrupting active reproductive life is obvious. Therefore, it would be worthwhile to examine the nature and extent of the influence of these parameters of a population on the indices of selection.

2. Materials and methods

Data on marriage, population structural measures, and reproductive histories of 2263 women who had been married at some time, in the Vadde fishing community were collected, between February and June 1982, from interviews mainly with women. Husbands generally confirmed the information given by the wives. Typical of illiterate societies, the fishermen do not keep records, and ages were, therefore, estimated and are approximate. Maximum care was taken in order to obtain the most reliable estimates of age. The 15 villages from which data were collected form the core of the Vadde population distribution. The samples constitute over 80% of the total number of couples available in each of those villages. Although village endogamy ranging from 7 to 43% is observed among the studied villages, no discernible mating isolation is, however, found within the Vadde population (Reddy, Malhotra and Chopra 1986). Data collected on 125 women who had been married at some time from Palle, another fishing community from the only village found in Kolleru Lake, was also used for comparison.

Distances between birth places of spouses were recorded in miles through travel routes. Distance for those born in the same village is scored as zero. Local terms for different degrees of consanguineous relationship are found extremely useful in ascertaining exact relationships between the spouses.

In order to examine the relationship between the indices of selection and the structural pattern in the population, villages are considered as independent units and indices are computed according to Crow (1958). The following formula was used:

$$I_t = I_m + I_f / P_s \tag{1}$$

where $I_m = P_d / P_s$, and $I_f = V_f / \bar{X}^2$. The symbols are: I_m, the index of mortality; I_f, the index of fertility; I_t, the index of total selection; $\bar{X}$, the mean of live births; V_f, the variance of live births; P_d, the proportion of children who died before 15 years of age; and P_s, the proportion surviving to reproductive age (15 years).

Fertility of Indian women is observed to decline relatively early (Mukherjee 1973, Talukdar 1977 a) and no Vadde women aged above 40 years is found pregnant during the field investigation. Therefore, women aged 40 years and above were considered to have completed their active reproductive period and data on such women were used to estimate Crow's indices. Further, women who died during the reproductive period (as suggested by Neel and Chagnon 1968) who would have been at least 40 if living, and the widowed or divorced women aged above 35 years, were also included in the computation because the prospect of their remarriage and further reproduction is found to be rather remote.

In the past, several attempts were made to modify and update the index. For example, Crow (1972) corrected it to include prenatal selection, and Kobayashi (1969), Neel and Weiss (1975) and Hannenberg (1976) presented methods to account for deaths during the reproductive period. Also, methods to adjust for incomplete families (Jacquard 1974, Spuhler 1976) and to estimate fertility index separately for sterile women (Hed 1984) were proposed. These modifications would be particularly important when the incidence of such events is high. In the present paper, data on prenatal deaths have not been used to estimate the indices, for the contribution of such events is rather small (frequency is below 1%) and the information may be relatively less dependable. Other modifications to the index suggested earlier were also not strictly applicable and relevant to the present situation and, therefore, not attempted.

Surname diversity index is defined as a function of number and relative frequency of surnames in a village, i.e.

$$DI = 1 - \sum_{i=1}^{K} pi^2, \tag{2}$$

where p_i values ($i = 1 \ldots , K$) are the relative frequencies of the K surnames existing in the village. This is in analogy with the average heterozygosity measure (Nei 1975) and gives an idea regarding the diversity existing (both in terms of number and their strengths) with reference to surnames in a village. This measure has the property of taking values in the interval 0, 1; it takes the value zero when there is only one surname in a village. Since surnames are exogamous units, the relative magnitudes of these indices may indicate the extent of opportunity of interaction with heterogeneous surnames within any particular village and to some extent with the neighbouring villages.

The effective population size of the villages is calculated using Wright's (1938) formula:

$$N_e = \frac{4N-2}{\sigma^2 k + 2}, \tag{3}$$

where N is the number of parents in a village and $\sigma^2 k$ is the variance in the number of gametes contributed to the next generation.

The indices of selection and as well as measures of population structure are observed to be non-normally distributed. Therefore, to test the interrelationships in a small number of villages, non-parametric Spearman's rank order correlation technique was employed.

3. Population

The Vadde community of Kolleru lake number approximately 30000 individuals and live in about 60 villages scattered in and around the lake (figure 1). Many of these villages, for most of the rainy and winter seasons, are surrounded by water and form isolates. Communication between them is largely by boats. Most of the villages depend primarily on fishing.

Vadde is an endogamous caste. It is stratified into a number of exogamous units called *Intiperus* which act like gotras and guide marital interactions. The marital bond is relatively unstable and their customary laws have a provision for divorce and remarriage. Child marriages are in vogue, a preference for consanguineous marriages is obvious, marriage age is generally low and family planning is gaining popularity.

In spite of various recent developmental programmes, medical facilities are inadequate. There is no hospital or health centre in the area and emergency medical cases have to be rushed to a nearby town. Lack of proper communication becomes crucial under such circumstances. This community and the Kolleru area in general, which until recently has been largely isolated, is fast becoming affected by urban influences.

4. Results

Mean live births, variance, and Crow's indices of selection along with the population structural measures for each of the 14 villages of the Vadde are presented in table 1. The values of I_t range from 0·311 to 0·810. Most of the villages show a greater mortality component than fertility component. The indices of selection of the Vadde population (table 2) are smaller compared to those in Palle, a neighbouring fisherman caste who are relatively recent migrants in the area. With the exception of Jale of West Bengal, all other fishing groups studied are originally from coastal Andhra Pradesh and show a greater mortality component. However, the indices among the Jalari of Visakapatnam (Rajanikumari *et al.* 1985) are uncharacteristically small, less than one-third of that found for socioeconomically identical Jalari of Puri. Except for this group, the indices among the fishermen are in the middle of the range observed for Indian populations (Reddy and Chopra 1986).

Relationship between indices of selection and population structural measures

Values of Spearman's rank correlation are presented in table 3. It is interesting to note that while I_f and I_t show a significant relationship with N_e and MM, respectively, I_m is significantly related with DI, MMD and α. Association of population structural measures is in general stronger with I_m than with I_f. Indices of mortality and fertility are negatively associated between them ($r_s = -0{\cdot}33$). Simple linear regression and variance analysis was performed with I_m as the dependent variable and DI, MMD, and α each as independent variables on one hand, and I_t as dependent and MM and MMD each as independent variables on the other, to examine how far the variation in I_m and I_t, respectively, are explained by each of the structural variables. The bivariate scatters and fitted regression lines along with the a and b coefficients can be seen from figures 2 and 3.

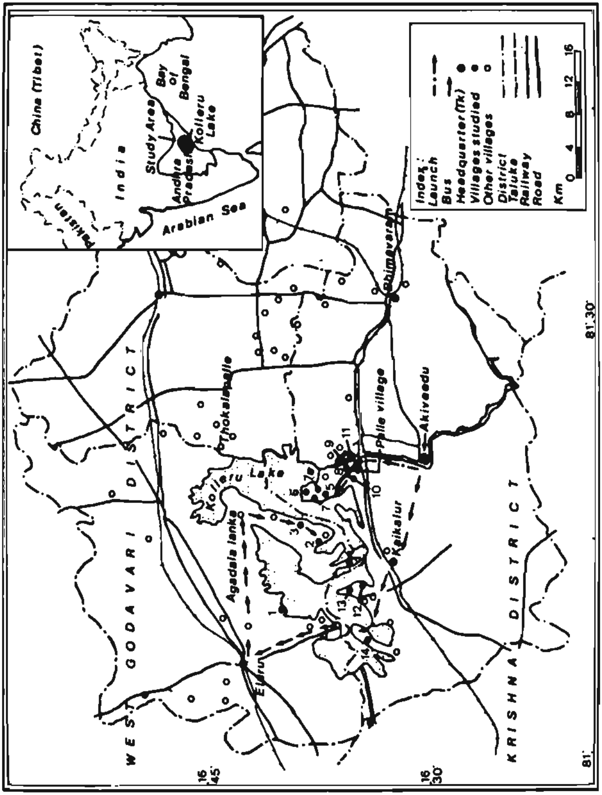

Figure 1. Map showing the geographical location of villages in the region of Kolleru Lake.

Table 1. Crow's indices of fertility, morality and total selection potential, and the population structural measures in different village units of the Vadde population.

	Village numbers													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of women	78	91	46	16	88	30	88	25	13	55	38	41	35	53
Total number of live births	457	517	335	115	482	152	515	139	89	259	260	269	183	337
Proportion surviving (P_s)	0·78	0·73	0·66	0·64	0·75	0·75	0·75	0·81	0·87	0·80	0·73	0·73	0·75	0·72
Mean live births ($\bar{X}$)	5·86	5·68	7·28	7·19	5·48	5·07	5·85	5·56	6·85	4·71	6·84	6·56	5·23	6·36
Variance of live births (V_f)	6·17	7·65	7·86	4·03	8·88	7·26	8·87	6·65	6·28	9·52	10·24	8·17	9·98	10·80
Index of mortality (I_m)	0·28	0·38	0·52	0·55	0·33	0·33	0·34	0·23	0·16	0·25	0·38	0·37	0·33	0·40
Index of fertility (I_f)	0·18	0·24	0·15	0·08	0·30	0·28	0·26	0·22	0·13	0·43	0·22	0·19	0·37	0·27
Index of total selection (I_t) = $I_m + I_f/P_s$	0·51	0·71	0·75	0·67	0·72	0·71	0·69	0·50	0·31	0·78	0·68	0·63	0·81	0·77
Effective population size (N_e)	253	228	78	35	283	77	262	84	40	120	63	148	189	131
Village endogamy (%VE)	39·3	19·9	23·3	35·0	24·9	14·7	43·2	6·7	18·6	37·4	24·6	41·4	33·6	12·2
Mean matrimonial distance (MMD)	9·7	9·0	8·6	7·6	12·4	11·4	10·8	16·2	12·3	11·6	11·6	8·6	8·7	11·6
Inbreeding coefficient (α)	0·019	0·022	0·020	0·021	0·017	0·018	0·020	0·017	0·014	0·019	0·013	0·025	0·013	0·024
Surname diversity index (DI)	0·855	0·741	0·792	0·821	0·768	0·779	0·712	0·633	0·678	0·700	0·766	0·741	0·761	0·799
Family planning (%FP)	24·5	42·3	34·1	10·8	12·9	28·6	30·2	6·9	20·3	11·1	5·5	44·7	29·2	25·7
Married more than once (%MM)	9·3	13·4	10·6	8·1	12·7	12·1	10·6	10·5	0·0	9·7	18·5	8·1	15·7	19·0

Table 2. Crow's indices of opportunity for selection among the Vadde and Palle communities of Kolleru Lake compared with other fishing groups.

	Vadde (1)†	Palle (1)†	Vadabalija of Penticotta (2)†	Vadabalija of Vadapeta (2)†	Jalari of Puri (2)†	Jalari of Visakapatnam (3)†	Jele of Bengal (4)†
Number of women	697	39	218	197	55	197	133
Mean live births	5·9	5·4	5·8	5·8	5·7	4·3	5·2
Variance of live births	8·8	10·0	7·2	6·7	6·3	1·9	8·7
Proportion of prereproductive deaths	0·257	0·306	0·256	0·350	0·424	0·158	0·179
Index of mortality	0·346	0·441	0·344	0·539	0·737	0·188	0·218
Index of fertility	0·253	0·347	0·213	0·202	0·197	0·103	0·310
Index of total selection	0·687	0·941	0·631	0·850	1·078	0·310	0·596

†Source: (1) Present study; (2) Reddy (1983); (3) Rajanikumari *et al.* (1985); (4) Talukdar (1977).

Table 3. Values of Spearman's rank order correlation between Crow's indices of selection and the population structural measures in the Vadde.

Population measure	Number of pairs	I_f	I_m	I_t
Effective population size	14	0·556*	−0·138	0·257
Village endogamy	14	0·015	0·042	0·011
Mean matrimonial distance	14	0·213	−0·574*	−0·147
Inbreeding coefficient	14	−0·077	0·600*	0·033
Surname diversity index	14	−0·204	0·582*	0·218
Family planning	14	0·196	0·292	0·231
% Married more than once	14	0·403	0·324	0·630*

*$P<0·05$

ANOVA for goodness of fit on linearity of regressions suggests that while DI ($F=7·4$, d.f. 1 and 12, $P<0·02$) and MMD ($F=8·7$, d.f. 1 and 12, $P<0·01$) individually explain the variation in I_m, only MM is found significantly explaining the variation in I_t ($F=12·9$, d.f. 1 and 12, $P<0·01$). None of these variables significantly explain the variation in I_f.

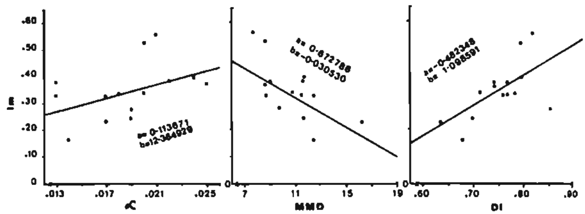

Figure 2. Bivariate scatters and fitted regression line between I_m and α, MMD, and DI, respectively.

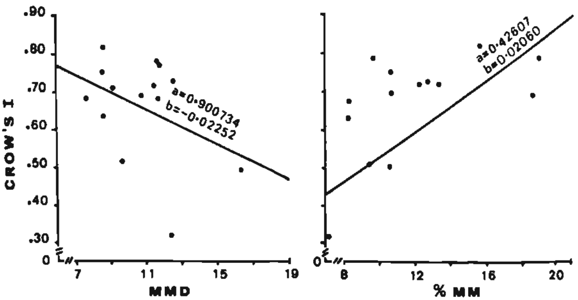

Figure 3. Bivariate scatters and fitted regression line between I_t and MMD, and MM, respectively.

Since these variables are known to be intercorrelated, stepwise regression analysis was further performed to see which of the variables in linear combination of others that will best explain the variation in selection indices. The equation used for the purpose was

$$Y = a + \sum_{i=1}^{K} b_i X_i, \tag{4}$$

where K is the number of variables in the regression equation. The number K and variables X_i are determined in stepwise manner; the stopping rule for the entry of variables in the regression equation being to stop at any stage when no further significant contribution (as measured by appropriate F-ratio) to the regression sum of squares is obtained. This procedure selects only MMD in the case of I_m (table 4). The a and b coefficients are 0·672786 and −0·030530, respectively, and r^2 suggests that about 42% of the variation in I_m can be explained by MMD alone. Interestingly enough, when log I_m is used in place of I_m, DI instead of MMD is selected, reaffirming the complimentary nature of the association of these two variables with I_m. Although individually both of them contribute significantly, because of colinearity, one of them is always excluded by the stepwise procedure.

Stepwise regression in the case of I_t, however, selects both MM and MMD. The coefficients are $a = 0{\cdot}66966$, $b1 = -0{\cdot}02275$, and $b2 = 0{\cdot}02066$. ANOVA for goodness of fit of linear regression (table 5) yields highly significant F-ratio ($P < 0{\cdot}01$) and R^2 suggests that the linear combination of these two variables explain about 66% of variation in I_t. The stepwise procedure also fails to select any variable to be contributing significantly towards the variation in I_f.

Table 4. Analysis of variance for goodness of fit of stepwise regression of I_m on DI, MMD, α, N_e and VE in which only MMD is entered.

Source of variation	D.f.	Sum of squares	Mean squares	F-ratio	$P<$
Due to regression	1	0·060702	0·060702	8·70	0·012
Error	12	0·083745	0·006979		
Total	13	0·144447			

Table 5. Analysis of variance for goodness of fit of the stepwise regression of I_t on DI, α, MMD, FP, MM, N_e and VE in which only MMD and MM are selected.

Source of variation	D.f.	Sum of squares	Mean squares	F-ratio	$P<$
Due to regression	2	0·15842	0·07921	10·6	0·003
Error	11	0·08221	0·00747		
Total	13	0·24063			
Type 2 SS					
Intercept	$a = 0{\cdot}66966$				
MMD	$\beta_1 = -0{\cdot}02275$		0·033717	4·51	0·057
MM	$\beta_2 = 0{\cdot}02066$		0·125395	16·78	0·002

Discussion

The foregoing analysis of the results brings out certain observations that need further discussion. For example, a large amount of variation is found in the selection indices between different village units of a relatively homogeneous Vadde population. Most of these villages also show a consistently greater value of I_m compared to the fertility component, I_f. However, considering the socioeconomic condition of the villages in general and the Vadde population in particular, this is expected.

Statistically significant heterogeneity is observed between the villages both in mean number of live births ($F = 2{\cdot}79$; $P < 0{\cdot}01$) and prereproductive mortality ($X^2 = 41{\cdot}4$; $P < 0{\cdot}01$). Villages 3, 4 and 9 show comparatively very low values of I_f, as they are characterized by high fertility and less individual variation. Village 10, with low mean fertility and high individual variation, shows the largest value of I_f. The socioeconomic condition of the villages seems fairly uniform except that certain villages have easier access to nearby towns than the others, thereby implying greater access to medical facilities which should reduce mortality. But, such a trend is not apparent. For example, Kovvadalanka (no. 13) and Komatilanka (no. 4) which are in easy access to nearby towns, *Kaikalur* and *Eleru*, show relatively greater values of I_m. Similarly, villages like Prathikudalanka (no. 2), Sringarayathota (no. 5) and Gudakalanka (no. 9) which appear to be apparently a step forward economically do not consistently show lesser mortality rates. This inconsistency may be due to the fact that in these villages only a small fraction is relatively wealthy. However, the villages amongst which the living and sanitary conditions are relatively inferior to the others (nos. 3, 4, 11, 12, 13 and 14) show a large mortality component. This is relevant because most of the infantile deaths are reported to have occurred due to infectious diseases such as diarrhoea, measles etc.

Besides accessibility, it is attitudes and awareness of the people towards the effectiveness of the modern medical facilities that will subject them to urban influences. This is evident from the fact that the village Komatilanka, which is only one mile from a town, experiences the highest rate of mortality. A close look at this settlement unfolds the real story. All the families in this settlement are relatively very poor. They live in badly ventilated and congested houses infested with swarms of houseflies and mosquitoes. Families also seem to live in similar conditions in villages 3, 11 and 14. Villages that show relatively large values of I_m are generally associated with high inbreeding, low MMD, and small N_e.

Variation in the fertility component on the other hand seems largely associated with the frequency of women who have never become pregnant (Reddy 1983 b) which would increase variability and decrease mean value of live births. Penchakallamarri (no. 10) and Kovvadalanka (no. 13) with the largest frequency of such women show the largest, and Komatilanka (with no such women), the smallest value of I_f. However, the question that remains is how far this infertility can be attributed to genetic causes?

The problem is to assess how much of the variation in the selection indices among the villages can be accounted for by the structural variability between them. Notwithstanding the trends observed in the indices with respect to average socioeconomic characteristics of the villages, the attempts made to test the interrelationships between the indices of selection and population structural measures yield interesting results. Although none of the 7 population structural measures were selected by the stepwise procedure, the positive correlation obtained between I_f and FP ($r_s = 0{\cdot}20$) and I_f and MM ($r_s = 0{\cdot}40$) are in the anticipated direction.

Family planning in the initial stages is observed to increase the index among American and Italian populations (Crow 1958, Terrenato *et al.* 1979, Jorde and Durbize 1986). This happens due to the relatively faster reduction in mean live births in proportion to the variability during the initial stages of demographic transition.

Although not significant, the multiple R^2 suggests that the seven population structural measures still account together for about 40% of the variation in I_f, most of which is contributed by MMD and N_e. On the other hand, while MMD or DI individually explain about 40% of the variation in I_m, MM and MMD together explain about 66% of the variation in I_t. Multiple regression analysis further suggests that in the case of I_m, the remaining four variables add only 20% to the explained variance of which about 10% is by VE alone. But in I_t, the remaining five variables add only 7% to the variation already explained by MM and MMD.

Excepting FP and MM, it is not hard to comprehend the lack of significant relationship observed between I_f and population structural measures. There are a great many factors that come in between the reproductive potential and its realization. Biological capacity to reproduce is heavily mediated by numerous behavioural and social attitudes associated with any individual or population which are difficult to quantify. Although the frequency of vasectomy and tubectomy which are the only effective means of controlling reproduction in this population is rather high, the impact of family planning is not found to affect I_f significantly. This is because most of the women in 40+ years age group adopted it only after almost completing the active reproductive period and after having 5 or 6 children. On the other hand, it is theoretically expected that the greater MMD and conversely smaller DI and α are associated with greater heterozygosity. However, the extent to which such a phenomenon in this particular population has caused the observed relationship with mortality could not be ascertained empirically. In other words, we do not know whether sufficient inbreeding homozygosity effect exists in this population to be able to detect it in this analysis. Barrai, Barbujani, Beretta and Vullo (1983), for example, found no evidence of increasing heterozygosity with increase in geographical distance between birth places of parents in the limited area, although Wolanski (1980) suggested such a possibility. Nevertheless, the residual amount of prereproductive mortality (mainly perinatal) is believed to be caused by severe conditions which may often be genetically determined (Terrenato *et al.* 1979). Among the Vadde, about 70% of the prereproductive deaths are reported to occur before 1 year of age (most of these are within a week) and therefore the observed relationship between I_m and the population structural measures may be assumed to have some genetic significance. Relatively restricted variability found among small number of villages, however, prevents us from drawing firm conclusions about the correlations or causes.

In the absence of empirical data, as a conjecture, the observed relationship between I_m and MMD can also be attributed to the general socioeconomic trend observed amongst the villages. The higher mortality associated with low MMD may imply that economically poor people, among whom the living and sanitary conditions are expected to be inferior, may tend to choose mates from within the villages and from closer distances; correlated population structural measures serving as markers for socioeconomic level. However, in the absence of clearcut economic differences at the village level and due to the lack of empirical data on individual economic situations this fact can not be further verified. A similar explanation can be used for the MMD to explain a significant amount of variation in I_t but, in the absence of further details, it is not possible to determine the precise nature of the effect of multiple marriages on the I_t. Its Impact is, however, conceivable by way of interrupting the active reproductive carrier.

Despite the small sample size, the present study brings out a significant aspect in that the population structural measures do explain an important part of variation in the indices of selection. Therefore, inclusion of such variables in the study of selection opportunities at the population level may probably help in understanding the variation observed in the opportunity for selection among different populations.

Acknowledgements

Acknowledgement is due to the authorities of the Anthropological Survey of India, the Indian Statistical Institute and the Alexander-von-Humboldt Foundation, for providing the necessary facilities and financial support to BMR, at different stages of this work. We thank Mr Hermann Mueller for computational assistance.

References

BARRAI, I., BARBUJANI, G., BERETTA, M., and VULLO, C., 1983, Heterozygosity and geographic distances in a limited area. *Journal of Human Evolution*, **42**, 403–408.

BARUA, S., 1976, Selection intensity among the consanguineous and non-consanguineous groups of Muslim population of 24 Paraganas. *Man in India*, **56**, 359–363.

CROW, J. F., 1958, Some possibilities for measuring selection intensities in man. *Human Biology*, **30**, 1–13.

CROW, J. F., 1966, The quality of people: Human evolutionary changes. *Bioscience*, **16**, 863–867.

CROW, J. F., 1972, Some effects of relaxed selection and mutation. In *Proceedings of the 4th International Congress of Human Genetics*, edited by J. De Grouchy, F. J. G. Ebling and I. W. Henderson (Amsterdam: Excerpta Medica), pp. 155–166.

CRUZ-COKE, R., CHRISTOFANNINI, A. P., ASPILLAGA, M., and BIANCANI, F., 1966, Evolutionary forces in human populations in an environmental gradient in Arica, Chile. *Human Biology*, **38**, 421–438.

FISHER, R. A., 1930, *The Genetical Theory of Natural Selection* (London: Oxford University Press).

HANNENBERG, M., 1976, Reproductive possibilities and estimations of the biological dynamics of earlier human populations. *Journal of Human Evolution*, **5**, 41–48.

HED, H., 1984, Opportunity for natural selection during the 17th–19th centuries in the Diocese of Linköping as estimated with Crow's index in a population of clergymen's wives. *Human Heredity*, **34**, 378–387.

JACQUARD, A., 1974, *The Genetic Structure of Populations* (New York: Springer-Verlag).

JORDE, L. B., and DURBIZE, P., 1986, Opportunity for natural selection in the Utah Mormons. *Human Biology*, **58**, 97–114.

KOBAYASHI, K., 1969, Changing patterns of differential fertility in the population of Japan. In *Proceedings of the Eighth International Congress of Anthropological and Ethnological Sciences* (Tokyo: Science Council of Japan), pp. 345–347.

MATSUNAGA, E., 1966, Possible genetic consequences of family planning. *Journal of the American Medical Association*, **198**, 533–540.

MORTON, N. E., 1968, Problems and methods in the genetics of primitive groups. *American Journal of Physical Anthropology*, **28**, 191–202.

MUKHERJEE, D. P., 1973, Patterns of marriage and family formation in rural India and genetic implications of family planning. *Journal of the Indian Anthropological Society*, **8**, 131–145.

NEEL, J. V., and CHAGNON, N. A., 1968, The demography of two tribes of primitive relatively unacculturated American Indians. *Proceedings of the National Academy of Sciences*, **59**, 680–689.

NEEL, J. V., and WEISS, K. M., 1975, The genetic structure of a tribal population, the Yanomama Indians. XII. Biodemographic studies. *American Journal of Physical Anthropology*, **42**, 25–52.

NEI, M., 1975, *Molecular Population Genetics and Evolution* (New York: American Elsevier).

PADMANABHAM, P. B. S. V., 1985, Selection intensity among the rural and urban Naika of Gujarat, India. *Anthropologie*, **23**, 101–103.

RAJANIKUMARI, J., SRIKUMARI, C. R., and RAO, T. V., 1985, Variability of selection opportunities with changing socio-cultural environments. *Human Heredity*, **35**, 218–222.

RAO, V. V., and MURTHY, J. S., 1984, Selection intensities and inbreeding among some caste groups of Andhra Pradesh, India. *Social Biology*, **31**, 114–119.

REDDY, B. M., 1983 a, Opportunity for natural selection among the three migrant groups of fishermen of Puri, India. *Social Biology*, **30**, 335–338.

REDDY, B. M., 1983 b, *Mating Patterns and Reproductive Behaviour of the Vadde, a Fishing Community of Kolleru Lake, Andhra Pradesh, India.* (Technical Report No. Anthrop./04/1983).

REDDY, B. M., and CHOPRA, V. P., 1986, Opportunity for natural selection among the Indian populations: Social and occupational variation. *7th International Congress of Human Genetics*, Berlin, September (Abstract).

REDDY, B. M., MALHOTRA, K. C., and CHOPRA, V. P., 1987, Mating structure of the Vadde, a fishing community of Kolleru Lake in Andhra Pradesh, India. *Biology and Society*, **4**, 29–39.

REDDY, P. C., and LAKSHMANUDU, M., 1979, Indices of opportunity of selection in Mala, Madiga and other Indian Populations. *Journal of the Indian Anthropological Society*, **14**, 245–252.

SHEETS, J., 1979, Selection intensities on Colonsay and Jura, the Inner Hebrides. *Current Anthropology*, **20**, 455–456.

SPUHLER, J. N., 1962, Empirical studies on quantitative human genetics. In *Proceedings of the UN/WHO Seminar on the Use of Vital and Health Statistics for Genetic and Radiation Studies* (New York: United Nations).

SPUHLER, J. N., 1976, The maximum opportunity for natural selection in some human populations. In *Demographic Anthropology: Quantitative Approaches*, edited by E. Zubro (Albuquerque: New Mexico Press), pp. 185–226.

TALUKDAR, S., 1977, Selection intensity among diabetics and in natural populations. *Journal of the Indian Anthropological Society*, **12**, 247–252.

TALUKDAR, S., 1977a, On age at menarchy in India. *Man in India*, **57**, 345–350.

TERRENATO, L., ULIZZI, L., and SAN MARTINI, A., 1979, The effect of demographic transition on the opportunity for selection: Changes during the last century in Italy. *Annals of Human Genetics*, **42**, 391–399.

ULIZZI, L., SAN MARTINI, A., and TERRENATO, L., 1979, Changes of selection opportunities with a changing environment: Regional heterogeneity in Italy. *Annals of Human Genetics*, **43**, 137–141.

WOLANSKI, N., 1980, Heterosis and homosis in man. In *Physical Anthropology of European Populations*, edited by I. Swidetzky, B. Chiarelli and Olga Necrasor (New York: Mouton), pp. 213–234.

WRIGHT, S., 1938, Size of population and breeding structure in relation to evolution. *Science*, **87**, 430–431.

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Zusammenfassung. Crows Indices der Gelegenheit für natürliche Selektion wurden angewandt bei den Vadde, einer Fischergemeinshaft am Kolleru-See in Andhra Pradesh, Indien. Die Stichprobe kommt aus 15 der 60 Fischerdörfer. Die Indices wurden sowohl für das Niveau des Forfes als auch der Bevölkerungseinheit berechnet. Eine Dorfstichprobe der Palle, einer anderen Fischergruppe der Region, wurde ebenfalls untersucht, für Zweck des Vergleichs. Es wurde versucht, die Variation der Selektions-Indices zwischen den Dörfern durch Maße der Populationsstruktur zu erklären.

Sowohl bei den Fertilitäts- als auch bei den Mortalitäts-Indices fand sich eine breite Variation zwischen den Dörfern. Die Werte entsprachen jenen für andere, früher untersuchte Fischergruppen und der Mitte der Spannbreite bisher untersuchter indischer Bevölkerungen (etwa 100). Es wurde gefunden, daß Maße der Bevölkerungsstruktur einen signifikanten Variationsanteil von I_m und I_t erklären, aber nicht vom Fertilitätsindex.

Resumé. Les indices d'opportunité de la sélection naturelle de J. Crow, ont été étudiés chez les Vadde, une communauté de pêcheurs de lac de Kolleru dans l'Andhra Pradesh en Inde. L'èchantillon est formé à partir de 15 des 60 villages de pêcheurs. Les indices ont été calculés à la fois au niveau du village et à celui des unités de population. Un échantillon villageois de Palle, un autre groupe de pêcheurs de la région, a également été analysé aux fins de comparaison. Un essai d'explication de la variation des indices de sélection dans les villages, a été réalisé à l'aide de mesures structurelles des populations. Il apparait une large variation entre villages pour les indices de fécondité et de mortalité. Leurs valeurs sont compatibles avec celles trouvées dans les autres groupes de pêcheurs étudiés auparavant et sont au cente de la gamme des valeurs observées sur la centaine des populations indiennes étudiées jusqu'à présent. Les mesures structurelles des populations expliquent une part significative de la variation d'I_m et d'I_t mais non d'indice de fécondité.