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A Search for Operation of Natural Selection in ABO Blood Groups: Evidences from Four Ethnic Groups of Orissa

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ABSTRACT The paper discusses effects of natural selection on four population groups of Orissa in the form of differential fertility and mortality as a consequence of ABO incompaptibity. The negative effect of ABO incompatibility is not fully manifested in terms of significant decrease in the viability of foetus and children. However, incidences of abortion, stillbirth and post-natal mortality are marginally higher among incompatible couples than compatible couples with out revealing significant statistical difference except in Mohato.The prezygotic selection due to antigen-antibody interaction differs between A antigen and B antigen. The hypotheses so far developed by earlier scholars with respect to effect of ABO incompatibility on viability of foetus, children and maintenance of polymorphism have been tested, and the authors have expressed their views logically either in accepting and or rejecting hypotheses.

INTRODUCTION

Natural selection is recognized to be the prime mover in the evolution of organic beings. It may operate at any stage in the life of the organism; be it at the pre-zygotic stage or at post-zygotic or at both. Selection operating at pre-zygotic level includes vitality and meiotic drive of gametes and other genetically programmed hormonal and immunological states of the zygotes. Post-zygotic selection essentially operates through differential fertility and mortality. There is no dearth of examples of pre-zygotic selection in various organisms and is a fairly a common phenomena in natural populations which plays an important role in maintaining the genetic variabilities in populations. Studies on effects of pre-zygotic selection and post-zygotic selections on human populations have been carried out by several scholars and inferences so far drawn have no doubt enriched our understanding of the role of natural selection in maintaining genetic polymorphism in man. This encouraged us to look for such instances in four tribal populations of Orissa with respect to ABO blood group systems, since this system seemed to be maintained in a stable polymorphic state in majority of global populations, signifying selection either pre-or post –zygotic or both was operating on this system.

The effects of ABO antigenic incompatibility have been of much interest to geneticists for its role in sterility, differential fertility, risk of foetal and neonatal deaths and also in maintaining the blood group polymorphism. Reviewing the literatures so far accumulated since reporting by Levin et al. (1941a, 1943) that materno-fetal ABO incompatibility is a cause of foetal wastage through miscarriage, still birth and haemolytic disease. Many scholars have studied the role of ABO incompatibility in pre and post-zygotic selection. Another significant dimension that renewed further interest was the possible role of incompatibility as a cause of infertility since antispermatozoal antibody stimulated by the antigen of sperms in cervical mucus of women some times inactivate a fraction of sperm leading to prevention of conception. Waterhouse et al. (1947), Bruce (1954) demonstrated strong selection effects are well perceptible as an out come of ABO incompatibility between mother and child.. Litwork and Jacobi (1946) found marked hepatic enlargement in case of haemolytic disease of the newborn children born to incompatible couples. Similarly, Nathan, Green and Weise (1947) reported severe jaundice and anaemia in the infants who are born from incompatible parents, especially from marriages between A mothers and B fathers. Matsunaga (1955) and Matsunaga and Itah (1958), Matsunaga and Hirai-Zumi (1962), who conducted large scale studies on human fertility comprising more than 1500 families of two mining towns in Japan, demonstrated that significantly higher frequencies of both infertile couple and spontaneous abortions among ABO incompatible mating groups than among compatible mating groups, indicating very much decreased survivality of ABO incompatible children. Chung

and Morton (1961), Chung et al. (1961) concluded that incompatibility was an important selective mechanism operating at the ABO locus. Haga later confirmed these results in 1959. In 1964, again in Japan, Hiraizumi collected an ever-larger body of complete family data from Ohdate with a purpose to test the validity of earlier studies. What is interesting is that Hiraizumi (1964) failed to obtained the evidence of reduced viabilities of ABO incompatible children and the segregation ratio of O gene from AO and BO fathers appeared to be higher than its expected value of 0.50 and a high foetal deaths was the consequence of factors quite unrelated to ABO incompatibility. Maintenance of stable polymorphism in the studied populations of Japan at the ABO, MN, and P blood group loci could have been due to opposite direction of selection pressures operating at two different (pre-zygotic and post-zygotic) stages. Further, no differences were noticed in the proportion of infertile couples as well as childless couples, in the mean number of living children, or in the proportion of prenatal deaths between compatible couples and incompatible couples. Morton et al. (1966) based on their study on a mixed Brazilian population noticed very high fecundity and high mortality, which revealed significance deficiencies of 'A' offspring in incompatible mating, but these were not matched by similar deficiencies in 'A', or 'B' children in compatible mating. While adducing evidence to explain the mechanism of maternal-foetal incompatibility, Clarke (1968) stated that, "there is evidence which suggests that the sperms carrying the A or B blood groups genes tend to be eliminated because they are serologically incompat-ible with the anti-A or anti-B anti-body found in the cervical secretion of mother". Chung et al. (1968) viewed the ABO incompatibility phenomenon from selection point of view and opined that ABO Polymorphism is maintained by heterozygote advantage in compatible mating, compensating for the loss of heterozygotes in incompatible mating Hiraizumi et al. (1973) by analysing large set of family data, reported that segregation frequency differed with birth order and that the frequency of 'AB' type children increased in the second or later births. However, the birth order effect was independent of ABO incompatibility. Kubatova et al. (1984) are of the opinion that children born to incompatible couples likely to have lower level of resistance to diseases. Lucarini et al. (1995) and Han et al. (1993) observed that incompatible experienced habitual abortion of foetus in higher number with A group than other blood groups. Bottini et al. (2001) studied differential effects of ABO incompatibity on fertility through a comparative analysis of couples with recurrent spontaneous abortion and healthy mothers in two populations (Rome and Sassari). While observing differential roles of anti-A and anti-B antibodies in repeated abortion patients and in normal groups. Bakacs et al. (1993, 1995) opined that complement binding capacities between anti-A and anti-B monoclonal IgM immunoglobilins differ considerably resulting in variable protective effect against abortion. Opinions are divided on the issue of the relationship of ABO incompatibility and infertility.

In India, several scholars have investigated the problem of ABO incompatibility and its role in pre-zygotic and post-zygotic selection. Nag and Banerji (1976) suggested that antispermatozoal antibody stimulated by the antigen present in the sperm might have been responsible for higher incidence of infertility among incompatible couples. Chakravartti and Chakravartti (1977) studied 1021couples belonging to Madhya Pradesh and Andhra Pradesh, observed that ABO incompatibility manifests its harmful effects in early pregnancies. They also noticed more prenatal and post-natal death among incompatible couples compared to compatible couples. Banerjee (1983) observed among the hospital patients of Calcutta, that the incidence of prenatal loss was higher than post-natal loss in both the compatible and incompatible mating types. Satyanarayan et al. (1978) based on a study on 183 couples of Visakhapatnam town of Andhra Pradesh concluded that the rate of pre-natal deaths in ABO incompatible couples is higher than ABO compatible couples. Menon and Ranga-nayki (1977), Desamma (1979), Rami Reddy and Chandrasekhar Reddy (1980) and Chengal Reddy and Seshu (1986) also observed similar trends in different ethnic groups of Andhra Pradesh. Srikumari et al. (1987), Chatterjee (2001) in their respective studies failed to observe significant variation in pregnancy outcome, intergenerational change and pattern of allele distribution at ABO/Rh loci. Zindal et al. (1983) demonstrated lower mean fertility and higher pregnancy wastage among incompatible couples than compatible couples. Conversely, Sharma et al. (2004) noticed higher mean live birth and higher post-natal mortality among incompatible rural

Haryana couples. Mohanty (1984) and Deka et al. (2000) were at same variance with those studies to the extent stating that no significant association between infertility and ABO incompatibity-rather the fertility rates were significantly higher of incompatible couples than compatible ones in four tribal communities of Orissa. However, prenatal and neo-natal deaths were higher among incompatible couples. Malekagaskar (2004) obtained clear evidence in favour of ABO incompatibility of the antigens present in the red cell membrane of husband/wife playing some role in abortion.

MATERIALS AND METHOD OF STUDY

1000 (one thousand) couples selected from four ethnic communities (three tribal and one caste), with a sample of 250 couples from each group for the present investigation are mostly endogamous and they differ in terms of their levels of technological and social development and cultural characteristics. For example: One tribe-the Hill Kharia is still in the subsistence stage of economy with marked dependence on forest resources; two tribes such as the Santal and the Bhumij are settled agriculturists and are socially and economically advanced than the Hill Kharia. The Mahato, who were earlier known as a tribe until 1951, is now recognized as a caste community. The socio-economic status of the Mahato is comparatively better than the tribal groups. Since the objective of the present study was to search for evidence in respect of the role selection at ABO locus due to incompatibility, care was taken to eliminate the possible selection effect of Rh incompatibility. This was made possible by eliminating Rh incompatible couples from the couples sampled for investigation. The samples thus consisted of families where both the parents were alive and mothers were above 45 years. ABO blood typing of all sampled parents and their surviving children at the time of survey was made following the standard technique.

DATA AND ANALYSIS

a) Intergenerational Distribution of ABO Blood Groups in the Studied Populations

As discussed earlier, the primary thrust of the paper is to show variation in reproductive performances of four groups of populations in relation to effects of selection operating at ABO blood locus. The phenotypic frequencies of ABO blood types belonging to parental and filial generation among four ethnic groups are presented in tables 1 and 2. In parental generation, all the three Mundari speaking tribes show comparatively greater incidence of either A or B phenotype followed by slightly lesser incidence of O type. This observation lends support to Sarkar's hypothesis, which states that the ancestral population of Mundari speaking people of India entered in to the sub-continent with greater incidence p and q allele. Mahato stands away from the rest of the three groups with higher incidence of O type individuals followed by A and B phenotypes. All the four ethnic populations are more or less in a state of genetic equilibrium as the chi-square value between observed and expected frequencies is statistically insignificant. Similar state of genetic equilibrium is attained among children of filial generation implying the Mendelian mode of segregation at ABO locus. Intergenerational variation is equally insignificant as far as ABO allele frequencies are concerned.

b) ABO Incompatibility and Pre and Post-Natal Selection

As stated earlier, ABO incompatibility process

Table 1: Distribution ABO blood groups in four ethnic groups (parents)

Group	*O(%)*	*A(%)*	*B(%)*	*AB(%)*
Mahato	32.00	28.60	21.80	17.60
Santal	26.00	27.00	26.40	20.60
Bhumij	26.00	28.80	25.60	17.60
Kharia	26.00	27.00	28.20	18.80

Chi-square = 2.167, d.f. = 9
0.99 > P> 0.98 Insignificant

Table 2: Distribution ABO blood groups among children (in percentile frequencies)

Population	*O*	*A*	*B*	*AB*	χ^2 *value with parental phenotype distribution*	
Mahato	30.36	32.54	27.00	10.7	2.858	Insignificant
Santal	27.78	29.40	38.19	12.61	2.534	Insignificant
Bhumij	27.60	31.24	26.42	14.71	0.832	Insignificant
Kharia	28.30	30.14	30.94	9.54	3.417	Insignificant

is no doubt recognised as one of the agents of selection, which in fact operates both at pre-zygotic and post-zygotic levels. Reproductive performance being an indicator of selection has been studied for four populations. The reproductive performances of couples belonging to ABO compatible and incompatible categories are presented in table 3. Out of 1000 couples chosen for the present study, 550 were compatible and 450 were incompatible; the proportion being 9: 7.All mothers of four groups of population belonging to incompatible mating types are found exhibiting an edge over the mothers of compatible category in respect of average conception implying that prezygotic selection has not been that severe. As is evident from the table 3 the incompatible couples of all four groups of population have on the contrary experienced higher incidence of pre-natal death as well as post-natal deaths than their compatible counterparts. The above observation to some extent demonstrates the expected effect of selection on the fertility and mortality rates. However, attributing all pre-natal and post-natal deaths exclusively as an act of ABO incompaptibity is not viable explanation. The simple reason is that the magnitude of differentiation so observed between incompatible and compatible mating types with respect to mean live births, mean pre-natal and post-natal deaths and surviving children among four population groups is statistically insignificant except in case of Mahato. Nearly 0.8 percent of children belonging to the Santal, the Bhumij, and the Kharia were at risk in the post-natal stage since they developed haemolytic disease. The incidence was 0.7 percent in case of Mohato. In one of our publications Deka et al. (2001), we have already shown that the proportion of childless couples was found marginally higher in compatible couples than in the incompatible couples in all four groups (Table 4). Since the difference so observed is statistically insignificant, no appropriate explanation can be offered at this stage in support of occurrence of higher number of childless couples in compatible couples. Further, one has to look in to the problem of infertile or childless couples not only from the perspective of ABO incompatibility effects alone. Similarly, except the Bhumij, the incidence of infertile couples among the compatible mating category also exceeds marginally over the incompatible mating in all the studied populations, although the magnitude of difference being statistically insignificant. The above observation makes a departure from the findings of some earlier studies, which inferred that greater number of infertile and childless couples are likely to be expected from among the incompatible couples than the compatible one. The problem of infertility is now being analysed and investigated from various angles-hormonal, genetical and biochemical, involving both males and females. On the other hand, in the average number of conception, mean live birth, proportion of pre-

Table 3: Reproductive performances of compatible and incompatible couples

Population	*Mating type*	*No. of mothers*	*Conception*	*Pre-natal deaths*		*Live-born*	*Pre-natal deaths*	*Post - natal deaths 0-15*	*Mean surviving children*	*Level of statistical significance at 5%*
				Abortion	*Still birth*					
Mahato	Comp	138	637	26	21	590	47	117	452	
			(4.61)			(4.27)	(0.340)	(.847)	(3.26)	Significant
	Incomp	152	636	29	35	572	64	140	417	
			(5.61)			(5.10)	(.571)	(1.25)	(3.67)	
Santal	Comp	143	819	25	29	765	54	148	604	
			(5.72)			(5.34)	(.377)	(1.034)	(4.25)	Insignificant
	Incomp	107	629	29	33	567	62	139	409	
			(5.87)			(5.3)	(.56)	(0.94)	(4.78)	
Bhumij	Comp	131	639	28	32	579	60	115	446	
			(4.87)			(4.41)	(.458)	(.877)	(3.40)	Insignificant
	Incomp	129	655	30	33	592	63	136	439	
			(5.50)			(4.97)	(.53)	(1.142)	(3.73)	
Kharia	Comp	138	776	24	29	723	53	141	564	
			(5.62)			(5.23)	(.38)	(.384)	(4.22)	Insignificant
	Incomp	112	725	37	30	658	67	154	489	
			(6.46)			(5.86)	(.59)	(.598)	(4.37)	

Figures in parentheses indicate average values

Table 4: Distribution of infertile and childless couples and pregnancies among ABO compatible and incompatible couples in four populations

Populations	*Types of mating*	*Total No. of mating*	*Proportion of Infertile couples*	*Prop. of childless couple*	*Total no. of pregnancies*	*Mean ± S.E. of pregnancies*
Kharia	Comp.	118	0.026	0.055	776	5.62±0.240
	Incomp.	112	0.018	0.035	725	6.47±0.319
Bhumij	Comp.	131	0.030	0.055	639	4.87±0.30
	Incomp.	119	0.031	0.053	655	5.50±0.303
Santal	Comp.	143	0.020	0.040	819	5.72±0.25
	Incomp.	107	0.018	0.028	629	5.87±0.321
Mahato	Comp	138	0.027	0.043	637	4.61±0.261
	Incomp.	112	0.020	0.036	636	5.67±0.277

natal deaths and post-natal deaths, the incompatible couples of four ethnic groups demonstrated an edge over the compatible couples. The degree of differences so observed between the compatible groups and incompatible groups with respect to pre-natal and post-natal mortality failed to attain any statistical significance. No marked difference is discernible between the two categories of mating in the average number of surviving children. When the differential pregnancy outcome and pregnancy wastages are put to inter-group comparison, it is seen that the average number of conception, pre-natal and post-natal deaths are higher in 0 mothers of the compatible mating which is a departure from expected result. However, the incidence of abortions is higher in incompatible mating category than the compatible one.

c) Segregation of ABO Alleles among Children

As stated earlier, intergenerational variation with respect to ABO blood group is statistically insignificant. When the segregation of blood groups is analysed according to compatible and incompatible groups**,** (Table 5) the incidences of O children and AB children have declined with a slight rise in the frequency of A and B blood group among the Mohato children born from incompatible parents. The children born to compatible Mohato parents do not show much variation from their parents at ABO locus, except a decrease in the frequency of AB phenotype. Except the Kharia, the incidence of O group is seen decreasing among children born to incompatible parents while the incidence O group is found increasing in children born to compatible couples. Significant intergenerational variation is not observed in the distribution of A children born from both compatible and incompatible couples. Further, there has been a rise in frequencies of B blood group in children's generation of incompatible couples as compared to parental generation. The children of compatible couples are not much differentiated from their parental phenotypes in the distribution of B blood group. What is noteworthy is that there has been appreciable reduction in the incidence of AB children in both compatible and incompatible category in comparison to their parental phenotypes and this phenomenon could have come about possibly due to negative selection effect against AB phenotype at pre-natal and post- natal phase. Incompatibility of maternal and foetal combination is not the sole determinants in this respect. However, the average rate of conception and the rate of pre-

Table 5: Segregation of ABO blood groups in children among four groups of populations

MaCouple type	*Ethnic group*	*Childless couple*		*Blood groups of living children*				*Total*
		No.	*Prop*	*O*	*A*	*B*	*AB*	
Comp	Mahato	6	.078	148	144	123	37	452
Incomp	-do-	4	.830	116	140	111	50	417
Comp	Santal	6	.107	195	175	166	68	604
Incomp	-do-	3	.081	86	123	140	60	409
Comp	Bhumij	7	.107	152	137	101	56	446
Incomp	-do-	5	.080	92	140	133	74	439
Comp	Kharia	8	.102	170	177	175	42	564
Incomp	-do-	4	.068	128	151	151	59	489

natal and post-natal death are higher in those couples, where at least one of the parents does not possess any type of antigen. In all four populations, higher proportion of pre and post-natal deaths occurred among the incompatible couples. The proportion of abortion and stillbirth is significantly higher among the incompatible mating couples. The mothers of O blood group both in compatible and incompatible groups have shown higher proportions of pre- and post-natal deaths.

In one of our earlier publications, when the incompatible couples were disaggregated in to sub-groups, no significant difference in the proportion of infertile couples was noticed. The proportion of abortions per pregnancy was also approximately the same in both the subgroups. Insignificant differences were noticed in the mean number of pregnancies of the sub-groups of incom-patible mating among the Santal, the Bhumij and the Kharia. However, the two sub-groups of incompatible mating in case of the Mohato showed significant differences in mean number of pregnancies and the proportion of childless couples was approximately the same in the two sub-groups. More or less similar trend was noticed in case of compatible couples.

d) Selection Effects in Terms of Reciprocal Grouping

In order to ascertain net effect of ABO incompatibility on reproductive performances, the reciprocal groupings of five type of incompatible mating have been made and phenotype frequencies of children have calculated (Table 5 and 6). It is observed that in *A* x 0 and its reciprocal mating, the observed frequency of A and 0 children between two reciprocal groups hardly demonstrate marked differences in all the group implying that there is no perceptible deficit of 'A' children on account of deleterious effect of ABO incompatibility. However, in case of ABx B and its reciprocal mating, a significant differences of incompatible children is found in the Mohato and the Kharia populations but not in the Santal and Bhumij. In the ABx O and its reciprocal mating, differences observed in all the groups of people are very negligible.

It is established that the antigen which is absent in the mother's blood group but present in the foetus blood cells, then, there may be a reaction and as a result of which, the foetus may die in gestation stage or may be severely injured or may meet a tragic end in the post-natal stage due to haemolytic disease. Further, antispermatozoal antibody created in women due to antigenic stimulus of sperms some times causes infertility. The result of the present study reveals that, in most of the mating categories, there was no significant deficiency of definite phenotype among incompatible children. Mention may be made here that Matsunaga and Y. Hiraizumi also failed to find any significant deficit of incompatible children in their study on Japanese population. It is nevertheless surprising that the average conception rate is higher when mother do not possess the antibody for the father's antigen. The average pre-natal death is higher in case of BxO, ABxAB and BxO mating types among all the four groups of population. The average post-natal death in the mating types of ABxO, 'ABxB, ABx AB is higher in the Mohato, the Santal, the Bhumij and the Kharia respectively. In these cases, where mother possesses both the antigens, post-natal death is higher. Hence, the role ABO incompatibity in post-natal deaths is a matter of question. When the incompatible mating types are taken into consideration, it is found that the average conception rate, pre-natal death and post-natal death are higher in the 'OX'B, 'Bx'A, 'OxAB, 'Ox AB mating in all four groups of population. Thus, the mothers having both the antibodies but without antigens show an elevation in conception rate, pre-natal and post-natal death rate.Table 7 gives a picture of pregnancy and abortion in two sub-group of incopmtible and compatible couples.It is observed that Kharia have higher mean pregnancies in sub groups of incompatible and compatible couples with higher incidence of mean abortion. Similar situation was noticed neither among the Santal. The Mahato nor the Bhumij

Table 6: χ^2 Values between blood types of children belonging to reciprocal mating

Type of Mating	*Mahato*	*Santal*	*Bhumij*	*Kharia*
AxO				
OxA	.037	2.76	.234	.0467
BxO				
OxB	4.81	.123	2.735	.056
ABxA				
AxAB	3.434	.226	2.074	3.39
ABxB				
BxAB	8.086*	3.379	3.099	8.04*
AxAB				
ABxO	0.616	0.137	0.025	0.018

*Significant at 5% level of significance.

Table 7: Distribution of incidence of pregnancy and abortion in two sub –groups of compatible and incompatible couples among four ethnic groups

Population	*Sub-groups of couples*	*No. of couples*	*No of infertile couples*	*Total pregnancies*	*Mean Preg.*	*No of Abortion*	*Proportion of abortion*
Mahato	Comp -.I	73	2	349	4.78	16	0.045
	Comp-.II	65	-	288	4.43	10	0.034
	Incomp-I	62	1	385	6.2	16	0.041
	Incomp- II	50	2	251	3.13	13	0.051
Santal	Comp-.I	61	1	374	6.13	11	0.029
	Comp-.II	82	2	445	5.42	14	0.031
	Incomp.-I	49	1	290	5.91	14	0.048
	Incomp.-II	58	1	339	5.84	16	0.048
Bhumij	Comp. -I	65	1	309	4.75	16	0.051
	Comp-.II	66	3	330	5.00	13	0.031
	Incomp-I	46	1	271	5.89	15	0.055
	Incompa-II	73	3	384	5.26	15	0.256
Kharia	Comp-.I	62	-	321	5.17	13	0.04
	Comp.-II	76	2	455	5.98	11	0.024
	Incomp.-I	55	1	376	6.83	16	0.042
	Incomp.II	57	1	349	6.12	14	0.04

experienced significant trend of mean pregnancy followed by abortion.

e) Sex-ratio of Children According to Blood Group of Mothers

Sex-ratio is viewed as an important indicator of viability of children according to sex and it is measured as number of females per thousand males. When the sex ratio pattern of children is analysed according to ABO compatible and incompatible category (Table 8 and 9), we observe that the sex ratio is more favourable to males than to females in the incompatible couples. Except the Mahato, rest of the tribal groups have more number of female children born to compatible couple. This implies that the compatible couples have experienced higher incidence of death of male children at postnatal stage. When sex-ratio of children is viewed according to blood groups of mothers (Table 8), it is seen that children born to A mother among the Mahato and the Bhumij have higher sex ratio where as same is the case with children born to AB and B mothers of the Sanatal and the Bhumij populations respectively. Lowest sex-ratio was observed in children born to O Bhumij mothers. In case of the Kharia and the Mahato, the sex ratio is more favourable to males. We may state here that in tribal society girl child is never considered as a social burden on them, rather, the tribal communities welcome the birth of a girl child as a blessings since she bring in with her wealth to parents in the form of bride-price.

Table 9: Sex-ratio of children in two types of Couples among four ethnic groups

Couples	*Sex-ratio of Live born + Stillborn*	*Sex-ratio of Live born*	*Sex ratio of surviving at The time of Investigation*
Mahato Comp	1054.79	1069.09	1073.39
Incomp	1059.54	1273.46	1329.6
Santal Comp	1017	1003.57	947.59
Incomp	1059	1106.22	1100.47
Bhumij Comp	1017	1003.57	947.59
Incomp	1059	1106.22	1100.47
Kharia Comp	1005.4	997.16	958.33
Incomp	1151.89	1150.5	1173.33

DISCUSSION

The effect of selection at ABO locus has been subject of inquiry since the publication of

Table 8: Sex–ratio and fertility record by blood group of Mothers

Blood groups of mother	*Mahato*			*Santal*			*Bhumij*			*Kharia*		
	No.	*Avcon*	*Sex ratio*	*No*	*Avconc*	*Sex-Ratio*	*No*	*Avcon*	*Sex-ratio*	*No*	*Avcon*	*Sex-ratio*
O	77	6.0	1200	69	5.84	992.90	65	5.33	967.7	68	6.35	1191.1
A	67	4.47	1253.96	65	5.67	1083.91	72	5.18	1051.8	62	6.37	1050.0
B	61	4.54	1089.2	63	5.47	1067.56	67	4.79	1108.1	71	5.66	1050.3
AB	45	5.20	1230.76	53	6.24	1098.36	46	5.50	911.7	49	5.55	741.3

landmark paper by Levin in 1943, which identified ABO incompatibility as a cause of early abortion and stillbirth. Since three decades down the time, results of numerous studies have been accumulated out of which some scholars either rendered support to the role of selection in the form of ABO incompatibility in causing loss of viability of foetus or rejected the negative role of selection and some partially supported the effect. The authors here make an endeavour to test the validity of following hypotheses/generalisations that have been developed over the years with respect to effects of ABO incompatibility on reproductive performances of couples.

1. Deleterious Effects of ABO Antigenic Incompatibility Have Been Reflected in the Form Higher Infertility, Lower Rate of Pregnancy, Spontaneous Abortion and Stillbirths, Post-Natal Death (Hypothesis-1)

The findings of the present study are not in agreement with the above hypothesis for the simple reason is that all four studied tribal communities are characterized by the occurrence of higher incidence of infertile couples among the compatible couples than the incompatible couples. Grubb and Sjostedt (1954-55) and Bennett and Walker (1955-56) failed to lend support to the above hypothesis. Behrmana et al. (1960) on the other hand found a significant excess of ABO incompatible couple in 102 persistently sterile mating as to compare with 71 fertile couples. They suggested that ABO related infertility is due to the action of antibodies that are formed in the secretions of the mother's genital tract nullifying the activity of spermatozoa due to incompatibility. However, it is still not clear how total sterility could be explained only on only the evidence of ABO incompatibility since there could be other factors intervening and interacting in the process. In view of this, more data are needed on blood groups of aborted foetuses and of the partners in total sterile mating. The present study had no scope to investigate the blood groups of aborted foetuses particularly at an earlier stage of pregnancy.

Further, all four ethnic communities have shown higher mean pregnancies followed by high proportions of pre-natal deaths (includes abortion and still births) in case of incompatible couples. This is in full agreement with the original hypothesis espoused by Levine (1943, 1958). and Matsunaga et al. (1958), which states that the selection effect of ABO incompatible mating is conspicuously well visible in the form of pre-natal loss of genotype as compared to compatible mating and the differential loss of genotype was statistically significant. When one takes the average figure for pre-natal death and post-natal death per mother in incompatible mating groups and compatible groups in to consideration, it is observed that a substantial portion of total deaths is accounted for by the post-natal death rather than by pre-natal deaths in the present circumstances. What is even more interesting to observe is that notwithstanding occurrence of higher proportion of pre-natal and post-natal deaths in incompatible couple, no significant variation is noticed between the compatible group and incompatible group with respect to incidence of surviving children. We would like to make a point worth mentioning that except Santal, the trend of occurrence of post-natal deaths parallels the trend of pre-natal deaths. Therefore, logically we may infer that the negative effect of ABO incompatibility leading to occurrence of post-natal death among incompatible couple has been to some extent well perceptible, which, nevertheless does not rule out the possibility of intervention of other mortality causing factors such as malnutrition, disease and infections etc.

The existence of cervical hostility due to ABO incompatibity resulting in a lower mean number of pregnancies was reported by Matusnaga and Itoh (1962). The data of the present investigation demonstrate a lower mean pregnancy among incompatible couples in all four ethnic groups, and all the studied groups are further characterised by the occurrence of marginally higher mean value of conception and pregnancy as compared to compatible couples. However, the differences so observed between compatible and incompatible groups are not statistically significant.

Reproductive performances between sub-types of reciprocal matings both in case of incompatible as well as compatible couples have been compared to ascertain differential effect of selection operating against the incompatible genotype. As compared to other studies, the two sub-groups of incompatible mating hardly demonstrated any remarkable variation with respect to incidence of infertile couples, proportion of abortion, incidence of childless couples. Only significant difference is noticed between sub-groups of incompatible mating among the

Mahato in mean number of pregnancies and between sub-groups of compatible mating among the Mahato and the Bhunya in mean number surviving children and between the sub-group of compatible matings, in the mean number of living children among the Santal and Bhumij. Cohen (1970) while analysing larger CDS (Child health and Development Studies) data, clearly indicated an elevation of early foetal wastage associated with ABO - incompatibility, but, he was unable to confirm with certainty the ABO selection effect accounting for late foetal wastage, pregnancy wastage as a consequence of ABO incompatibility. In addition to this, a possible increase in ABO - associated neonatal mortality was suggested by Cohen. An increase in the rate of pre-natal deaths (include abortions and still births) and post-natal deaths with ABO incompatibility is confirmed from the findings of the present study, although the magnitude of increase over the rate of pre-natal and post-natal mortality of compatible mating is statistically insignificant.

2. Significant Difference is More Discernible between Sub-Groups of Incompatible Couples (Hypotheseis –II)

Matsunaga and Itoh (1958) based on their study on Japanese population and Satyanarayan and Vijaylaxmi (1978) based on their study on people of Andhra Pradesh have shown that a significant difference was noticed in the mean number of surviving children in the four sub-groups of ABO compatible and incompatible mating. In the present context, our findings do not lend support to the above hypothesis since no marked difference is noticed in respect of mean number of surviving children between sub-groups. As a sequel to this paradoxical observation, an attempt is made to look at the relative loss of specific type of blood group phenotype. The segregation of blood groups of the children of two reciprocal matings both in compatible and incompatible groups has been compared.

3. Selection for or against Genotypes as a Consequence of ABO Incompatibility (Hypothesis-III)

Matusnaga et al. (1962) introduced a method of family size equivalent to ascertain the role of pre-zygotic selection in ABO blood groups which they applied on Japanese family data. They demonstrated that there is pre-zygotic selection for O gene and against A gene indicating that O-carrying sperms from AO and AB fathers were more than fifty percent. When the study was extended to larger couples with wife's age ranging from 30 to 40 years, they failed to demonstrate pre-zygotic selection for *O* gene in males and no significant deficit of incompatible children was noticed on comparison between two reciprocals in AXO and BXO mating. As is evident from the results of present study, no indication of reduced viability of incompatible heterozygous children is noticed in majority of mating types of four ethnic groups. The only exception being the Mahato and the Kharia, who have shown significant difference between blood types of children belonging to reciprocals of ABXB and BXAB mating with reduced number of 'B' children. Contrary to our expectation, the compatible couples revealed higher incidence of pregnancy wastage where mothers belonged to B or AB blood group and fathers belonged to 'A' group and where as among incompatible couples the pregnancy wastage is higher where mothers belong to blood group 'A' and fathers belong to either 'B' or 'AB'. Thus, it would be appropriate here to suggest that possibly there exists difference in terms of severity of antigen-antibody reaction between 'B' antigen and 'A' antigen resulting in the haemolysis of foetus. Our findings are not in full agreement with results of Matusnaga and Itoh (1958) and Haga (1959) who have indicated reduced viability of ABO incompatible children. Vogel (1961) was more in favour of accepting the hypothesis that substantiates comparatively higher loss of genotype because of intra-uterine selection due to ABO incompatibity. Lending support to this, Chakravartii and Chakravartii (1977) demonstrated a deficiency of 21.6 percent deficiency of 'A' children in ' Ox A mating as compared to AXO mating 16 percent loss of 'B' children in OX B mating as compared to BXO mating, the difference being statistically significant in both the cases. Reddy and Seshu (1986) also observed the similar trend demonstrating the action of selection against blood group 'A' and 'B' when comparison is made between two types of reciprocal matings. Reed (1956) brought home the point that the differential vitality of homozygotes and heterozyotes after birth have to considered while making plausible assertion on the role of

selection with respect to ABO blood group. Peritz (1967) failed to obtain a discernible OXA incompatibility effect on live birth progenies, however, he could not rule out the possibility of selection effect at the early stage of pregnancy.

CONCLUSION

The forgoing discussion in the form testing the hypotheses in fact brought home certain issues with respect to operation of natural selection in human populations. In the present context, three tribal groups and one caste group have been subjected to a close analysis of differential fertility and mortality as well as maintenance of genetic polymorphism with in the ambit of ABO incompatibility- an agent of selection. We may state here that effect of ABO incompatibility leading to reduction in the viability of children is not a full proof inference despite the fact that the incidence abortion, still birth and post natal mortality is marginally higher in incompatible couples. The negative role of ABO incompatibility phenomena is partially reflected in certain demographic features. Although significant fluctuation in the allele frequencies is not reckoned with in the studied groups as whole, significant variation in the distribution of ABO allele in reciprocal mating of incompatible category is witnessed in one of the groups ie the Mahato. What is again interesting to observe is that the intensity of antigen-antibody reaction differs between A antigen and B antigen. We are at loss to offer appropriate explanation to substantiate such variation in terms of property of the antigen. The role of improved environmental and other biological factors in masking the negative effect of selection has to be given due emphasis before firm conclusion is arrived at. In this context Cohen's view seems more appealing which states, …. "rather than selection directly specifically against ABO incompatible foetuses, embryos, zygotes or gametes and in favour of compatible couples, there appears to be selection directed against the overall "biological fitness" of mating - possibly against the gametes of the father whose ABO type is incompatible with their spouses, or possibly against the products of conception of these incompatible fathers and the spouses but, in any case, independent of the genotype of the conception it follows, therefore, that the term "ABO incompatibility" should be given a broader connotation - "maternal-paternal incompatibility" or "paternal incompatibility" rather than saying that the biological mechanism leading to early pregnancy wastage as a consequence of ABO incompatibility, must be different from that erythroblastosis which is recognized as a haemolytic disease of late pregnancy.

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