



Human Biology Review (ISSN 22774424)

www.HumanBiologyJournal.com

International Peer Reviewed Journal of Biological Anthropology

Volume 12, Number 4, October –December 2023 Issue

Original scientific paper

Effects of altitude on the reproductive physiology of the Monpa of Arunachal Pradesh

A. K. Gharami¹, T. Baruah², P. Bharati³ and D. K. Adak^{4*}

Human Biology Review, 12 (4), pp. 302-312.

Revised and accepted on September 24, 2023

¹Social Science Research Unit, Development and Research Services, New Delhi.

e-mail: agharami@gmail.com

²Department of Humanities and Social Sciences, Assam Down Town University, Guwahati, Assam. e-mail: tiluttoma.baruah@rediffmail.com

³Biological Anthropology Unit, Indian Statistical Institute, Kolkata.

e-mail: pbharati@gmail.com

⁴Anthropological Survey of India, Kolkata

e-mail: adakdipak@gmail.com

*Corresponding author

Effects of altitude on the reproductive physiology of the Monpa of Arunachal Pradesh

A. K. Gharami¹, T. Baruah², P. Bharati³ and D. K. Adak^{4*}

Citation: Gharami AK, Baruah T, Bharati P and Adak DK. 2023. Effects of altitude on the reproductive physiology of the Monpa of Arunachal Pradesh. Human Biology Review, 12 (4), 302-312.

ABSTRACT

Background: Reproductive physiology of the peoples living in high altitude is affected by reduction in O₂ supply than their counterparts. High altitude peoples are characterized with reduction of sperm count and elevated number of abnormal spermatozoa in males and delayed menarche among females. This study deals with the effects of altitude on reproductive physiology among the Monpa of Arunachal Pradesh residing in high as well as low altitude.

Design and setting: Dirang and Tawang Monpa were studied. Dirang Monpa residing in Dirang town (1600 m) and its surrounding areas were selected. Side by side, Tawang Monpa residing in Tawang town (3048 m) were selected. Altogether, 134 Tawang and 78 Dirang Monpa mothers, who were aged 45 years and above were studied.

Method: A door-to door survey was undertaken with the help of a structured schedule.

Results: Completed family size among the Dirang Monpa was 4.60 ± 0.06 and the mean number of surviving children was 4.32 ± 0.07 . These values among the Tawang Monpa were 4.16 ± 0.08 and 3.84 ± 0.08 respectively. Mean of live birth among the Dirang Monpa was 3.50 ± 0.07 and among the Tawang Monpa was 3.14 ± 0.06 . Infant and child mortality among the Dirang Monpa were 33.98 and 27.18. Whereas, these were 40.22 and 30.51 respectively among the Tawang Monpa.

Discussion: Both the mortalities (infant and child) were comparatively higher among the Tawang Monpa than that of the Dirang Monpa. In case of average live births a reverse trend is perceptible. In fine, it can be said that low live births among the high altitude Monpa (Tawang Monpa) is indicative of altitudinal stresses on biological traits among them.

KEY WORDS: Reproductive performance. Altitudinal difference. Monpa. Arunachal Pradesh.

INTRODUCTION

Physiological studies on humans involving sojourners to high altitudes suggested reduction of sperm count and elevated number of abnormal spermatozoa in males, and delayed menarche as well as disturbances of the menstrual cycle in females and reduced birth weight. Early human studies on native high altitude populations, especially in the Andes show generally lower fertility, higher neonatal and infant mortality, slower physical growth rate and higher hematological values compared to low altitude populations. It is interesting to note that much less data are available on mortality pattern of high altitude populations (Gupta et al. 1989).

Studies at high altitude have long been of interest for the study of reproduction given the vital nature of O₂ supply for the conceptus and the reduction in O₂ availability at high altitudes (Monge 1948). Monge et al. (1945) observed infertility in couples migrating to high altitudes. Native low altitude women taken to high altitudes may suffer disturbances of the menstrual cycle (Liarena and Coyotupa 1976), dysmenorrhea, and alterations in the duration and intensity of the menstrual flow, although evidence of anovulation in women living at high altitude is yet confirmed (Harris et al. 1966, Donayre 1966, Sobrevilla 1967, Abelson 1972), but contrary evidences have been reported by Harrison et al. (1969) from Ethiopia (cf. Gupta et al. 1989). Delayed menarcheal and advanced menopausal age was found to shorten the reproductive span in some HA populations, whereas in some cases, menstrual cycle was also reported to be irregular. In addition, the completed fertility rate (CFR) was increased when people migrated to lower altitude (Shaw et al. 2018).

A good number of studies are available on altitude and human biology among the populations of Himalayan, Andean, Ethiopian and Tien Shan region (Gupta et al. 1989, Ross 1984, Schull and Rothhammer 1977, Harrison et al. 1969, Mirrakhimov 1978 and many others). Gupta et al. (1989) studied the Sherpa of Nepal and India to examine the effect of altitude on human biological parameters. However, no such study is undertaken so far on this line in any North-East Indian population. It is interesting to note that a good number of Monpa population live in high as well as low altitude in Arunachal Pradesh. This study deals with the effects of altitude on the reproductive physiology of the Monpas of Arunachal Pradesh.

MATERIAL AND METHODS

A door-to-door survey was undertaken using structured schedule among the Tawang Monpa during May-June, 2014 and during May-June, 2015 among the Dirang Monpa. The data were collected from 78 Dirang Monpa and 134 Tawang Monpa mothers, who were aged 45 years and above.

Dirang Monpa: Dirang Monpas are Buddhist by religion, who is one of the sub-groups of Monpa tribe. They inhabit the hilly terrain (1600 m) of West Kameng district of Arunachal Pradesh. The district experiences moderate to heavy rainfall and in the winter, it experiences severe cold. Dirang Monpa residing in Dirang town and its surrounding areas were selected for this study.

Tawang Monpa: Tawang Monpas are also Buddhist. Like Dirang Monpa they are one of the sub-groups of the Monpa tribe, who are high altitude (3048 m) people. They inhabit the hilly terrain of Tawang district of Arunachal Pradesh. This district experiences moderate to heavy rainfall and in the winter it experiences frost and snowfall. For the present study, Tawang Monpas residing in Tawang town and its surrounding areas were selected.

RESULTS

Reproductive performance:

In order to find out the completed family size, the Tawang and Dirang Monpa women, who were aged 45 years and above, married once, and lived continuously in wedlock till attainment of 45 years of age, were taken into consideration. Altogether, 78 Dirang Monpa and 134 Tawang Monpa mothers, who were aged 45 years and above were selected.

Completed family size was shown in Table 1 for the studied population groups. Completed family size among the Tawang Monpa was 4.16 ± 0.08 . It was further seen from Table 1 that the mean number of surviving children to those women was 3.84 ± 0.08 . Side by side, completed family size among the Dirang Monpa was 4.60 ± 0.06 and the mean number of surviving children to those women was 4.32 ± 0.07 .

Table 1: Completed family size

Population	No. of mothers	No. of live births	No. surviving children	Mean no. of live births per mother (\pm S.E.)	Mean no. of surviving children per mother (\pm S.E.)
Tawang Monpa	134	558	514	4.16 \pm 0.08	3.84 \pm 0.08
Dirang Monpa	78	359	337	4.60 \pm 0.06	4.32 \pm 0.07

Mean number of live-births and surviving children of all married women by age groups were furnished in Table 2a and 2b for Tawang and Dirang Monpa respectively. It was found that the mean number of live births per Tawang Monpa mother was 3.14 \pm 0.06. It was also noticed that mean number of live births among the Tawang Monpa increases with advancement of age. Mean number of live births increases from 0.67 \pm 0.21 for the mothers in the age group of 15-19 years to 4.00 \pm 0.12 for the mothers aged 50 years and above. Mean number of surviving children increases from 0.67 \pm 0.21 in the age group of 15-19 years to 3.64 \pm 0.12 for the women aged 50 years and above. Like mean number of live births in case of mean number of surviving children also the mean number increases with advancement of age (Table 2a).

Mean number of live births per Dirang Monpa mother was 3.50 \pm 0.07. It was also found that among the Dirang Monpa, mean number of live births increases with advancement of age. Mean number of live births increases from 0.75 \pm 0.25 for the mothers in the age group of 15-19 years to 4.72 \pm 0.08 for the mothers aged 50 years and above. Mean number of surviving children increases from 0.75 \pm 0.25 in the age group of 15-19 years to 4.41 \pm 0.10 for the women aged 50 years and above. Like mean number of live births in case of mean number of surviving children also the mean number increases with advancement of age (Table 2b). Thus, both the average live births and surviving children were higher among the low altitude Monpa (Dirang Monpa) than that of the high altitude Monpa (Tawang Monpa).

Table 2a: Number of live births and surviving children to all married women by age groups:

Tawang Monpa

Age groups (in years) of mothers	No. of married women	No. of live births	No. of surviving children	Mean no. of live births \pm S.E.	Mean no. of surviving children \pm S.E.
15-19	6	4	4	0.67 \pm 0.21	0.67 \pm 0.21
20-24	51	64	62	1.25 \pm 0.15	1.22 \pm 0.14
25-29	81	175	168	2.36 \pm 0.16	2.27 \pm 0.15
30-34	54	147	135	2.72 \pm 0.08	2.50 \pm 0.08
35-39	77	282	260	3.66 \pm 0.11	3.38 \pm 0.10
40-44	56	212	197	3.78 \pm 0.10	3.52 \pm 0.10
45-49	78	334	310	4.28 \pm 0.11	3.97 \pm 0.10
50+	56	224	204	4.00 \pm 0.12	3.64 \pm 0.12
Total	459	1442	1340	3.14 \pm 0.06	2.91 \pm 0.06

Table 2b: Number of live births and surviving children to all married women by age groups:

Dirang Monpa

Age groups (in years) of mothers	No. of married women	No. of live births	No. of surviving children	Mean no. of live births \pm S.E.	Mean no. of surviving children \pm S.E.
15-19	4	3	3	0.75 \pm 0.25	0.75 \pm 0.25
20-24	20	35	32	1.75 \pm 0.10	1.60 \pm 0.11
25-29	35	76	70	2.17 \pm 0.08	2.00 \pm 0.04
30-34	60	179	174	2.98 \pm 0.09	2.90 \pm 0.07
35-39	50	188	179	3.76 \pm 0.13	3.58 \pm 0.12
40-44	47	190	179	4.04 \pm 0.13	3.81 \pm 0.13
45-49	32	142	134	4.43 \pm 0.09	4.19 \pm 0.11
50+	46	217	203	4.72 \pm 0.08	4.41 \pm 0.10
Total	294	1030	974	3.50 \pm 0.07	3.31 \pm 0.06

Mortalities

Mortality plays an important role in determining the age-sex structure of a population. Reduction in mortality in infancy and early childhood results in the prolongation of life span, which in turn results in a 'young' age distribution. Different mortalities occurred among the Tawang and Dirang Monpa were dealt in this section. The measure of infant mortality used in this study was calculated following the method suggested by Khan (1987). To calculate the index of the infant mortality all births, which took place during 12 months prior to interview, were excluded from the analysis, as they did not have one full year of experience. The index thus obtained is similar to infant mortality rate (IMR) estimated from a cohort but is different from a period (one year) rate. It averages the period IMRs over the entire reproductive period of women included in the sample. In this study index of infant mortality, index of child mortality and index of reproductive wastage were calculated according to Garma (1983).

Table 3: Record of conception, pregnancy wastage and fertility

Population	No. of mothers	No. of conception	No. of reproductive wastage	Mean reproductive wastage	No. of live births	Average live births
Tawang Monpa	459	1469	32	0.02	1442*	3.14
Dirang Monpa	294	1043	15	0.01	1030**	3.50

*Inclusive of 5 twin births **Inclusive of 2 twin births

Average live births among the Tawang and Dirang Monpa was 3.14 and 3.50 per mother respectively (Table 3). It can be mentioned that to calculate this value mothers of all ages were considered. However, mean of reproductive wastage was found to be 0.02 among the Tawang Monpa and 0.01 among the Dirang Monpa.

Table 4: infant and child mortality (1-4 years)

Population	No. of live births	No. of infant died (0-1 year)	No. child died (1-4 years)	Index of infant mortality	Index of child mortality
Tawang Monpa	1442	58	44	40.22	30.51
Dirang Monpa	1030	35	28	33.98	27.18

Infant and child mortality (Table 4) among the Tawang Monpa were 40.22 and 30.51 respectively. Whereas, these were 33.98 and 27.18 among the Dirang Monpa. Thus, both the mortalities were comparatively higher among the Tawang Monpa than their counterpart.

DISCUSSION

The Tawang and Dirang Monpa are the sub-groups of the Monpa tribe. The Tawang Monpa inhabit at high altitude, the hilly terrain of the Tawang district of Arunachal Pradesh, whereas the Dirang Monpa inhabit at a low altitude of West Kameng district of Arunachal Pradesh.

Physiological studies on humans to high altitude suggested reduction of sperm count and elevated number of abnormal spermatozoa in males, and delayed menarche as well as disturbances of the menstrual cycle in females and reduced birth weight. Early human studies on native high altitude populations, especially in the Andes, tend to correspond to the above-mentioned observations by showing reduced fertility, higher neonatal and infant mortality, slower physical growth rate and higher haematological values compared to low altitude populations (Gupta et al. 1989).

The age of first birth is somewhat delayed in rural or urban Bolivians in comparison with low altitude populations (Crognier et al. 2002). However, completed fertilities in Andean as well as Himalayan populations are either similar or greater than those of comparable low altitude groups (Vitzthum 2013). A large study of 22662 consecutive births in Peru found higher rates of stillbirths at high compared to low altitudes (Gonzales et al. 2008), but another report, based on a literature review of nine studies in indigenous Andean or Himalayan residents, showed lower levels of pregnancy loss than in United States of America sea-level populations (Vitzthum 2013).

The mean live births were lower among the Tawang Monpa (3.14) than their counterpart, the Dirang Monpa (3.50). It is interesting to note that mean live births among the Tawang Monpa was lower than the high altitude Sherpa (3.91) residing in Nepal (Table 5). The Tawang Monpa show lower fertility than the Sherpas of low altitude too. However, the low altitude Sherpa of Mungpoo show more or less similar mean live births with present population.

But the Sherpa of Rongoo and Lava, both in Kalimpong show higher mean live births than that of the Tawang Monpa. Though the mean live births of the Tawang Monpa was lower than high altitude Sherpa, mean surviving children was higher (2.91) than that of

the said population (2.49). Like high altitude Sherpa the low altitude Sherpa of Mungpoo also showed lower mean surviving children (2.69) than that of the Tawang Monpa. The Sherpa of Lava (4.22) showed the highest mean of surviving children among all the population groups. Physiological studies on humans to high altitude suggested reduction of sperm count and elevated number of abnormal spermatozoa in males. Low live births among the high altitude Monpa is indicative of altitudinal stresses on biological traits in highlander Tawang Monpa.

Table 5: Fertility measures: comparative data

Population	Area	Altitude (m)	Mean no. of live births per women	Mean no. of surviving children per women	Source
Sherpa, Nepal	Upper Khumbu	3500-4050	3.91±2.09	2.49±1.82	Gupta et al., 1989
Sherpa	Kalimpong, India	1000-1050	4.74±3.15	3.88±2.59	-do-
Sherpa, Rangoo	Kalimpong, India	-do-	5.16±3.33	3.90±2.41	-do-
Sherpa, Echhay	Kalimpong, India	-do-	3.67±2.76	3.14±2.34	-do-
Sherpa, Munsong	Kalimpong, India	-do-	4.53±3.15	3.60±2.60	-do-
Sherpa, Lava	Kalimpong, India	-do-	5.16±3.19	4.22±2.60	-do-
Sherpa, Labdah	Darjeeling, India	-do-	4.43±2.98	3.74±2.44	-do-
Sherpa, Mungpoo	Darjeeling, India	-do-	3.17±2.10	2.69±1.88	-do-
Lepcha	Kalimpong, India	-do-	4.12±2.70	3.63±2.51	-do-
Tawang Monpa	Tawang, Arunachal Pradesh	3048	3.14±0.06	2.91±0.06	Present study
Dirang Monpa	Dirang, Arunachal Pradesh	1600	3.50±0.07	3.31±0.06	Present study

NOTE: Original version of this paper was presented in XXI Bhopal Seminar 2023 – Contemporary Issues in Demography and Development in India” during 22-24 February, 2023.

ACKNOWLEDGEMENTS

This study was undertaken as a part of ICMR funded project (IRIS ID: 2010-07150). The willing co-operation of the subjects is highly appreciated.

REFERENCES

Abelson AE. 1972. *Altitude, migration and fertility*. M.Sc. Thesis (unpublished). The Pennsylvania State University, Pennsylvania, USA. (cited by Gupta et al.1989).

Crognier E, Villena M, Vargas E. 2002. Reproduction in high altitude Aymara: physiological stress and fertility planning? *Journal of Biosocial Science*, 34 463–473. (<https://doi.org/10.1017/s0021932002004637>).

Donayre J. 1966. *Population growth and fertility at high altitude*. In: Life at high altitude. Ed. A. Hurtado. Scientific Publication no. 140. Washington D.C.: Pan American Health Organization.

Garma, I.O.G.Y. 1983. *Some factors associated with infant mortality in Mexico*. In: Infant and Child Mortality in the Third World. Inter-Centre Cooperative Research Programme. Project no. 1: Final Report. CICRED, WHO/OMS, Paris.

Gonzales GF, Steenland K, Tapia V. 2009. Maternal hemoglobin level and fetal outcome at low and high altitudes. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology*, 297 R1477–R1485(<https://doi.org/10.1152/ajpregu.00275.2009>).

Gupta R, Basu A, Pawson IG, Bharati P, Mukhopadhyay B, Mukhopadhyay S, Roy SK, Majumder PP, Bhattacharya SK, Bhattacharya KK, Das SK. 1989. *Altitude and Human Biology: A comparative Study of Himalayan, Andean and Ethiopian Data*. In: Human Biology of Asian Highland Populations in the Global Context, Eds. A. Basu and R. Gupta. Calcutta, 9 Indian Anthropological Society Occasional Papers.

Harris CW, Shields JL, Hannon JP. 1966. Acute altitude sickness in females. *Aerospace Medicine*, 37: 1163-67.

Harrison GA et al. 1969. *The effects of altitudinal variation in Ethiopian populations*. Philosophical Transactions of the Royal Society, London, B 256:147-25.

Khan ME. 1987. Infant mortality in Uttar Pradesh. *Social Change*, 17(3):52-64.

Lierena Paz LA, Coyotupa J. 1976. *Radio-immunoassay in endocrine studies at high altitude: The endocrine profile during puberty*. International Atomic Energy Authority Research Coordination Meeting on In-vitro Procedures and Techniques. London (cited by Gupta et al.1989).

Mirrakhimov MM. 1978. *Biological and physiological characteristics of the high altitude natives of Tien Shan and Pamirs*. In: The biology of high altitude peoples, Ed. P.T. Baker. Cambridge: Cambridge University Press.

Monge MC. 1948. *Acclimatization in the Andes: Historical Confirmations of 'Climatic Aggression' in the Development of Andean Man*. Baltimore, MD: Johns Hopkins University Press.

Monge MC, Martin MS, Atkins J, Castanon J. 1945. *Aclimatacion del gonado Ovino en las grandes Alturas: Fertilidad reversible en la fasa adaptive*. Anales de la Facultad de Medicine de Lima, 28:15-31. (cited by Gupta et al.1989).

Ross JL. 1984. Culture and fertility in the Nepal Himalayas: A test of hypothesis. *Human Ecology*, 12:163-81.

Schull WJ, Rothhammer F. 1977. *A multinational Andean genetic and health programme: A study of adaptation to the hypoxia of altitude*. In: Physiological variation and its genetic basis. Ed. J.S. Weiner. London: Taylor and Francis.

Shaw S, Ghosh D, Kumar U, Panjwani U, Kumar B. 2018. Impact of high altitude on key determinants of female reproductive health: a review. *Int J Biometeorol*, 62(11):2045-2055.

Sobrevilla L. 1967. *Fertility at high altitudes*. WHO/PAHO/IBP Meeting of Investigators on population Biology of Altitude, Washington D. C.: Pan American Health Organization.

Vitzthum VJ. 2013. Fifty fertile years: anthropologists' studies of reproduction in high altitude natives. *American Journal of Human Biology*, 25 179–189 (<https://doi.org/10.1002/ajhb.2235>)