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Framing the Quantitative within the Qualitative:
Why Biological Anthropologists do Fieldwork

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Introduction

Biological anthropologists have a biological approach to populations and consequently think in terms of physiological and biological adaptation to environment, lifestyle, and cultural habits in the natural context (Baker 1982; Johnston et al. 1990; Beall et al. 1992; Wood 1994; Brush and Harrison 2001; Vitzthum et al. 2004; Pollard et al. 2006; Steegmann 2006). For example, biological anthropologists have compared the level of physical activity and consequent energy requirements in various populations with different lifestyles, like sedentary farmers, nomadic pastoralists or hunter-gatherers; others interested determining the limits of human adaptation have measured adult or children body composition at various ages, and the change in nutritional status with seasonal variation in food availability. A number of biological characteristics were studied among contrasted group of people sharing a common factor of possible inter-individual variation, either living in the same geographical environment or exposed to the same health hazards. Others have studied the adequacy of the diet for women at various physiological status (Leslie et al. 1993; Gray 1994; Benefice et al. 2001; Dufour et al. 2003; Ferrell et al. 2006), or different aspects of human adaptability to their lifestyle like human fertility (Briebiescas 2001; Campbell et al. 2005a, 2005b, 2006; Campbell and Mbizo 2006).

A number of leading scientists around the world (North America, Europe, Asia, Australasia) contributed to the International Biological Program (IBP 1964–1974). Human biologists and biological anthropologists were particularly involved in two out of nine program areas 'Human Adaptability' and 'Environmental Physiology' (see Harrison 1976; Baker 1996). According to the Archives of the National Academies,

the IBP was originally promoted in the United States by the International Council of Scientific Unions (ISU) and the International Union of Biological Sciences (IUBS). It was later suggested that 'this research contributed to the ongoing transformation of physical anthropology and related fields from a largely descriptive to an analytical science'. The ten year international programme became the base of several multidisciplinary projects in human biology: 'a subfield of demography within human biology has matured; nutrition, infant and child growth, and health studies have proliferated; and molecular genetics and DNA analysis have superseded the earlier population genetics' (Little and Garruto 2000).

For the last twenty years the main objectives of field research in biological anthropology have been:

- To understand the range in variability in one or many major biological characteristics between populations (Harrison 2001).
- To determine the precise limits of human adaptation to environments and to place each of these characteristics in their functional and evolutionary contexts (Garruto et al. 1999).
- To investigate physiological mechanisms likely to explain inter-variability between populations (Beall et al. 2002).

A few biological anthropologists claim that they can do biological anthropology without doing field research. They are involved in analyzing data collected by others (health workers or medical staff running systematic data collection), acquired by several persons (doctors, nurses or midwives) in various wards or health services, possibly using different methods or instruments of measurement, which can introduce a significant variability between measurements. In France in large hospitals, the public health service has recently created 'clinical research units' in which well-trained statistical technicians analyse the vast amount of data collected daily in medical wards and contribute to improving epidemiological data sets useful to medical or public health planners. Thus biological anthropologists will no longer have any justification for using the same medical data for their research and will have to join their counterparts who base their research on data collected during fieldwork. The salience of research findings can be enhanced by combining different approaches but biological anthropologists will never draw complete insights if they ignore the cultural context and characteristics of the population(s) studied.

Old-fashioned human fertility studies in biological anthropology had a descriptive approach to the main characteristics such as age at menarche, age at menopause and reproductive history: number of live births, miscarriages, abortions, stillbirths, duration of interval between marriage and first birth, interbirth interval, duration of menstrual cycle and the characteristics of menses. In contrast, the aims of current fertility studies are:

- To identify the range of variation in fertility between populations.
- To determine precisely the lower limit and upper limit of the normal female reproductive life and its evolution within a population (menarche or menopause).

- To study the determinants of variability in fecundity or fertility for men or women at the population level (duration of post-partum amenorrhea among lactating women or incidence of menstrual troubles among sportswomen).

This chapter will focus on fertility surveys carried out in biological anthropology during the last twenty years in very different settings and various contexts implying totally different logistics and costs for their achievement. As an example, I will relate the context and different steps of my own participation in field research carried out in developing countries. My main research interest was to try to disentangle the role of different characteristics in the lifestyle of women with suppressed reproductive function in order to assess the role of variables like breastfeeding pattern, nutrition, energy expenditure and body composition in the regulation of fertility in human populations without modern contraception.

A first experience in West Africa

In Africa, the dramatic Sahelian desertification observed between 1968 and 1986 was linked to severe seasonal drought which was highly damaging to both people and the environment. Between 1968 and 1973 successive severe rainfall deficits initiated the whole process. Local people called it the 'Great Drought'. Local authorities in collaboration with Western research institutes and universities decided to set up different research programmes to assess the extent of damage in specific geographic areas and to act to remedy the situation.

As a biological anthropologist, I was involved in a research project in the field of ecology and human biology. The aim of the study was to identify seasonal variation in food availability and food intake in rural agricultural settings and their possible impact on the regulation of human fertility (Rosetta 1986, 1988a, 1988b, 1989; Rosetta and O'Quigley 1990). A survey was conducted between July 1980 and October 1982 among a sample of about 450 people belonging to forty households randomly chosen in the rural community of Ndiaganiao, Senegal, where the national authorities gave me the permission to carry out this research.

Choice of the sample

A preliminary survey had shown the range in family size in this area, according to ethnic groups (Serere people made up a large majority) and the extremely wide range in village size.

The latter required me to stratify in order to allow for a proportional representation of small, medium and large villages. From the official tax records at the regional administration, out of a total of thirty-two villages in the rural community of Ndiaganiao, ten were randomly chosen and four households were then randomly chosen in each village. The randomization was carried out under the supervision of the highest administrator (called a 'sous-prefet'). After the identification of the forty households, the heads of the ten villages were invited to participate in a meeting organized by the administrative authority and the researcher (LR). None of them

were missing. The rationale of the research and how their village were chosen was explained to the villagers. We identified the name of the head of each family randomly chosen in each village and the head of the village was asked to inform the four heads of households in his village. We then organized a second meeting to explain the aim of the study and the extent of involvement of each woman who would participate, and answered any question they and heads of households raised. After their approval we started to visit each compound selected in order to meet the women likely to enter in the survey, to explain the duration and the different aspects of the investigation (questionnaires, anthropometric measurements, food survey) and asked for their informed consent before the beginning of data collection. The study included around 450 people, consisting of approximately 200 women, their husbands (90) and their children aged less than five at the beginning of the survey (160). The newborn infants of these women during the two-year survey were then included.

The design of the survey was indexed on the maximum variation in food resources. In Sahelian countries, there is marked seasonality: the rainy season is followed by a long dry season. Peanut was the staple crop grown by many families in this area, and millet was the staple food. Each family depends on the quality and quantity of a single harvest in late September or early October, the end of the rainy season. In each household, the management of food reserves was under the strict responsibility of the head of family. When the total amount of millet is not enough to reach the next harvest, the manager will regularly decrease the daily amount of the staple food to be shared by all members of the family in order to avoid a sudden scarcity. In some families even the number of meals can decrease at the most difficult times. When there is a food shortage it happens during the wet season, the period of the year when people have to work very hard in the field to prepare for the next harvest. In terms of energy balance, a period of lower energy intake coincides for many adults with a period of higher energy expenditure. This is also the peak season for parasitic diseases like malaria or intestinal parasites, and the total health burden is heavy for deprived people. Data collection took place during two consecutive years twice a year, during the middle of the dry season, the period of relative abundance, and at the end of the rainy season, before the harvest starts. The same data were recorded on each occasion.

Ethical issues

A major concern was to keep the number of investigators to a minimum: most of the time the researcher only, accompanied by a local female interpreter belonging to a well-known and esteemed family in the rural community of NDiaganiao, and the driver. When field assistants had to be recruited, trained and supervised for the food survey for example, they were also chosen from the same community among the young people belonging to the same ethnic group. Both reproductive and food issues are delicate issues requiring particular attention. In field studies about female reproduction it is crucial to avoid any male involvement in questioning women on their reproductive health and history. In field studies requiring investigation on food and nutrition, the ethnic affiliation of the field assistant can introduce a bias. In my

experience, in rural traditional populations, it is recommended to have field assistants from the same ethnic group to get reliable data. They cannot be cheated as they know the cultural habits in terms of food availability and consumption. But they should be discreet and tactful and maintain the strictest confidentiality about the situation observed in the family surveyed. It is the responsibility of the main researcher to make clear to all assistants that in case of any dereliction of duty of discretion, they will be dismissed.

How to get the confidence of the participants in the survey?

This is a major factor in biological anthropology field surveys. We need a reliable source of information to avoid bias. The population involved in the survey should have every confidence in all the staff who will be in contact with them at every level of responsibility. They also need to understand from the beginning what are for them the advantages or the disadvantages in participation. Food and reproductive issues are private matters which need mutual trust and support between the investigator and the participant in the survey. In developing countries, if we are investigating communities who have recently suffered serious difficulties like natural disaster or major conflict, it seems problematic to ask people to participate fully and honestly if they do not think that their individual participation is beneficial to the community.

The main findings of the study carried out in Senegal were to confirm that there are obvious interactions between nutrition and fertility: long lasting lactational amenorrhea was observed in this population; the composition of the diet was not adequate and resulted in specific nutritional deficiencies likely to impair hormonal metabolism. The long duration of blockade of the reproductive function in this population was explained as a combination of the central suppression of the regulation due to the suckling stimulus, reinforced by the interaction of peripheral factors associated with the composition of the diet. Energy expenditure associated with manual workload was high, particularly during the season of agricultural work and the annual harvest period when the food reserves are at their minimum. Energy balance of these women was found to be low.

The next step of my research was to try to unravel the role of chronic malnutrition (low level of energy intake) from the role of high level of physical activity, and thus to compare the effects of a high level of energy expenditure with the possible function of energy balance in the regulation of fertility. The results of the Senegalese study had also emphasized the nutritional and energetic similarities between amenorrheaic lactating women in developing countries and amenorrheaic female marathon runners in developed countries. I started to carry out parallel investigations on reproductive impairment in Western female endurance runners and to quantify the level of energy balance/ energy expenditure in lactating women living in poor nutritional environments. It was necessary to focus on populations chronically malnourished so that we could compare two groups of women having the same reproductive status. The two categories of women would differ only by one factor supposed to be causal in the regulation of fertility, in this case the level of physical activity.

A survey among chronically malnourished women in Bangladesh

The first challenge was to identify an adequate population of the chronically malnourished, in order to compare two groups of fertile women belonging to the same ethnic group, having the same food habits, and similar resources, but different levels of daily physical activity (Rahman et al. 2002). In Bangladesh in addition to the garment industry in large towns, women are employed as paid workers in the tea industry, a rural activity apparently physically demanding. We choose to focus on female tea workers, as we suspected that women employed as tea pluckers had high levels of daily physical activity and consequently high levels of energy expenditure (Vinoy et al. 2000, 2002). The women who were not employed but lived in the same tea plantation were housewives of male tea workers. From a preliminary survey we had seen that the tea workers in this area in Bangladesh were mainly of Indian origin, had kept over generations their original cultural habits, and were extremely poor.

A longitudinal survey was set up to measure the duration of post-partum amenorrhea in a sample of women recruited in the tea garden, together with the variation of body composition, level of energy intake, energy expenditure, the pattern of breastfeeding and health characteristics (haemoglobin level, detection of parasitic diseases) of the mothers, and the growth and health of their infant.

Data collection started in February 1996 and finished in November 1998, among a sample of women recruited in North East Bangladesh working for the same tea company. We had got permission from one of the major tea companies in Bangladesh to carry out this survey among their employees. We were restricted to investigate only three tea estates in the same geographical area. The socioeconomic situation of the workers was similar in the three plantations. The tea workers and their families lived in villages organized in labour lines inside the tea plantation. They were provided with very simple housing, without electricity or access to schooling and with only rudimentary health care from the tea company. The tea workers were extremely poor and most of them were illiterate. A number of adults and children suffered from chronic malnutrition and parasitic diseases. It was not possible to know a priori if the level of physical activity was quantitatively high (PAL level) among tea pluckers and if their PAL level was significantly different from the group of women living in the same villages but unemployed, i.e., housewives of men working in the tea plantation. Our results showed that the difference was significant, with women employed in the tea plantation having higher levels of physical activity than their unemployed counterparts, although their nutritional status was slightly better since their families probably benefited from a higher income than the families in which only the husband was employed (Rosetta et al. 2005).

To run the protocol, we had the participation of a team composed of researchers, Ph.D. students and research assistants. We recruited a number of local assistants that we had to train and to supervise during the thirty-four months of data collection. Research assistants filled in weekly and monthly questionnaires, recorded anthropometry, and collected biological samples over time. To assess energy intake, energy expenditure and breastfeeding pattern, specialized methods were used, such as heart rate monitoring, doubly-labelled water method, and a minute-by-minute

record of activity (Ghosh et al. 2006). The same female assistants attended the same women throughout the survey; also, their number was kept to a minimum.

In this situation, though we had gained informed consent from each participant before the beginning of data collection, we knew that the women had little opportunity to choose whether or not to participate in the survey since the tea manager had approved our project. We made clear to each of them that they had the possibility of withdrawing at any time if they were not able to continue. But none of them left the study before reaching an end-point based on defined criteria of exclusion (new pregnancy, confirmed return of menses, use of hormonal contraception, and others), except for one woman who was seriously ill and unable to participate. It turned out that it was even rewarding for the participants to know that people from outside the tea industry were visiting them regularly and they began to consider that we were looking after them and their infants. The whole team was extremely committed to the survey and supportive of mothers who needed health care for themselves or their children.

Local assistants were recruited from families connected to the tea company; this was partly because of a firm request from the tea manager not to employ assistants from outside the company, and also because these assistants lived near the tea plantation in which the women in the survey stayed, and were locally known as honourable people. We employed female and male assistants with various levels of education. Almost all of them worked in a satisfactory manner; with rare exceptions, they all were extremely respectful to the mothers. Those who did not had to leave the project.

Choice of non-invasive methods of data collection

Biological anthropologists combine interviews (questionnaires) with the collection of biological samples and various measurements like body composition, food intake, daily energy expenditure and other physiological tests (Garnier and Bénéfice 2006). Except for human relationships during the actual survey, the choice of methods of investigation adapted to fieldwork can be crucial for the acceptance by the subjects in the long term and the compliance with frequent and regular sampling. To follow the same group of people during two or three years with data collection every week or even every other day for some variables, is quite a different task from occasional visits and the collection of opportunistic biological samples.

In longitudinal fertility studies, biological anthropologists need to have serial sampling from the same subject in order to establish either hormonal profiles or to detect new pregnancies or early miscarriages. A single sample only is generally useless for this purpose, given that hormonal profiles during a full menstrual cycle inform us about various potential causes of subfertility or infertility. Ovulation is a key indicator. In ovulatory cycles, the respective duration of follicular and luteal phase, and the characteristics of the luteal phase are all reliable sources of information on fertility.

In order to select non-invasive methods of sampling and assay procedures, it is usually preferable to use saliva or urine samples instead of blood sampling, to carry out serial hormonal assays in field studies (O'Connor et al. 2003, 2006). When blood samples are necessary, this is often limited to blood spot sampling (Worthman and Stallings 1997; McDade et al. 2000; Campbell and Mbizo 2006; Campbell et al. 2006). The choice of the fluid to be obtained is also a function of cultural habits and taboos in the population studied. Since the first requirement is total acceptance by the subjects, other needs must be linked to those of the convenience of collection, storage, handling and transport of the whole samples collected from the field to the lab. We generally choose to collect very small volumes, preferably on filter paper, without need of freezing before storage in the lab. Otherwise, preservation of biological samples in field conditions may depend on a reliable electric power supply, access to rapid transport, reasonable cost of storage and transport, which are proportional to volume and weight of the whole amount of samples. Once in the lab biological anthropologists can choose between radio-immunoassays used by clinicians, and enzyme immuno-assays, which are often preferred, to carry out the assays. In urinary or saliva samples one can assay sex steroid hormones glucuronide derivates like Estrone-3–glucuronide (E1–G), Pregnanediol-3a-glucuronide (PdG) during menstrual cycles, or gonadotrophin hormones like luteinizing hormone (LH), human chorionic gonadotropin (hCG), prolactin (PRL) during pregnancy. For example, urinary assays for hCG in field studies were carried out during an eleven month prospective study of fetal loss in rural Bangladesh using a modified pregnancy test for hCG (Holman et al. 1998). Urine samples were collected from 494 women: 330 pregnancies and ninety-three fetal losses were detected with this method. Urinary hormonal assays were also used to study intrauterine mortality in nomadic and settled women in Turkana, Kenya. These assays enabled the detection of pregnancies at an early stage, and early miscarriages. Our results suggest an exceptionally high rate of fetal mortality in the settled Turkana of Morulem but a low rate among the nomadic population. A satisfactory explanation is likely to involve environmental stresses associated with settled life in this semi-arid environment (Leslie et al. 1993; Pike 2005).

Such investigations become very informative and allow one to go deeply into the physiological understanding of human adaptation to environment according to lifestyle. Many large projects have been carried out over years in remote areas (Bailey et al. 1992; Rosetta et al. 2005; Ferrell et al. 2006; Vitzthum et al. 2006). Most of them have combined questionnaires with collection of series of biological samples necessary to run hormonal assays.

How is it possible to introduce biases during fieldwork studies?

In human populations for ethical reasons, studies carried out by biological anthropologists in natural settings are mainly observational, either descriptive or etiological and may have the same bias as epidemiologic surveys. The definition of the sample should comprise criteria for inclusion and exclusion. During fieldwork, loss of follow-up, withdrawal, and censored data are all potential sources of bias. It is then crucial to avoid selection bias during the phase of recruitment by using proper designs. Bias of sampling can be indirect or linked to external factors. They can result from various circumstances: remote place of residence can lead to missing subjects difficult to reach for the investigators. In fertility studies we may have difficulties in recruiting women shortly after delivery, when young women leave their husband's house to stay at their mother's house for a little while: in this case, the short absence of women from home at the time of recruitment can create bias. Medical or psychological factors may also bias recruitment; these factors can also introduce a further bias during follow-up. In addition since young women are more likely to visit their mother's house after delivery than older women, this tradition may introduce a selection bias in age. When we study two groups, the loss in follow-up may be greater in one group compared to the other one and we should suspect a confounding factor which was not clearly understood at the beginning.

Whatever the source of error in the information obtained, a study subject may be misclassified. A selection bias can severely interfere with the conclusions of the study. A variable that potentially affects an outcome variable should be carefully controlled and a pilot survey held to detect potential bias of auto-selection. An example of bias we had to face was as follows: a multinational study of breast-feeding and lactational amenorrhea was carried out in seven different countries by the World Health Organization Task Force on Methods for the Natural Regulation of Fertility (1998a, b). The Bangladeshi study refered to earlier in this chapter (Vinoy et al. 2002; Rosetta et al. 2005; Ghosh et al. 2006) was based on the same protocol with permission of the WHO. Out of the seven centres selected to participate in the multinational study, five were in developing countries (China, Guatemala, India, Nigeria, Chile), and two were in developed countries (Sweden and Australia). Although we applied the same protocol, major differences appear in our results (Table 10.1): in the multinational study, the median duration of lactational amenorrhea ranged between 122 and 282 days (WHO Task force 1998a, 1998b) while in the Bangladeshi survey it was 491 days (Rosetta and Mascie-Taylor 2009). Since another major difference was in the nutritional status of the women included in both studies, we can suspect this factor to have a significant and causal effect on the duration of blockage of ovarian function in women with similar patterns of breastfeeding. Mean Basal Metabolic Index (BMI) ranged between 21.4 to 24.8 in the WHO multinational study, that for the Bangladeshi women was 17.8 ± 1.6 (chronic malnutrition, level III), at three and a half months post-partum. The nutritional status was significantly different between the two studies. If we hypothesize that breastfeeding pattern and duration are not the only determinants of the duration of lactational amenorrhea, nutritional status becomes a key (or confounding) factor.

Table 10.1. Duration of lactational amenorrhea by place and nutritional status of lactating women (WHO multinational study and Bangladeshi study with the same protocol).

	Duration of Lactational Amenorrhea (days)	BMI of the Mother at 6 weeks post-partum (kg/m2)
	Median (95% CI)	Mean ± sd
• CHENGDU	282 (266-304)	21,5 ± 0,08
• GUATEMALA CITY	209 (196-228)	24,8 ± 0,12
• MELBOURNE/SYDNEY	272 (258-285)	24,8 ± 0,14
• NEW DELHI	122 (111-134)	21,4 ± 0,13
• SAGAMU	234 (215-255)	24,5 ± 0,12
• SANTIAGO	171 (156-183)	24,8 ± 0,06
• UPPSALA	230 (221-241)	24,0 ± 0,12
• BANGLADESH STUDY	491 (418-564)	17.8 ± 1,6 (1)

(1) at 15 weeks post-partum

What was the source of bias in this particular example? A single criteria of inclusion was able to modify the composition of the sample population: for practical reasons, WHO choose to include only women able to read and write, so that the women could themselves fill in the forms, whilst in Bangladesh we did not make this requirement but selected women solely by occupation. The tea workers employed in the tea garden were extremely poor, having almost daily, very heavy sessions of work during the plucking season, were illiterate in 99 per cent of cases and unable to fill in forms. We recruited a number of female field assistants to visit the women every week and fill in the questionnaires translated in the language of the tea workers (in this case Hindi). Otherwise all other criteria of inclusion and discontinuation were similar in both studies. The results show that our sample was significantly different from the whole sample of the WHO Multinational Study and highlight the fact that breastfeeding alone cannot explain the variability in duration of post-partum amenorrhea among populations.

Students doing fieldwork: what we teach them about field techniques and what they learn in the field

When we are carrying out fieldwork in countries with different cultures and different socioeconomic levels than in our own, which happens very often, it can be a real experience for students. Since it is for them often their first experience in a developing country, together with their first experience of research in the field, it becomes a new environment added to a personal adventure, which we cannot do in their place, as well as a research experience, and they have to learn. We should pass on our knowledge and help them to avoid difficulties. We also have to train them in field methodology. In biological anthropology we commonly use anthropometry, questionnaires, heart rate monitoring, and many other techniques of record to assess nutritional and energetic variables together with reproductive variables. We often

need to set up a pilot survey to test the possible methods of recording and adjust or select the most adapted to the situation.

This preliminary phase is run with voluntary subjects who will never be included in the survey itself and is designed to train research assistants and students to acquire the skills necessary to insure the success of data collection. The process should be closely supervised by researchers since the quality of data (repeatability and precision of the measurements, reliability and accuracy of the measurement) determine the full success of the project. Although the reverse is rare, but may happen, most of the students who embark on field research for an M.Phil or a Ph.D. have an interest in understanding different cultures and how to handle delicate topics with people who are not scientists and who require explanation of what we are doing and how they will contribute.

Another aspect is the relationship between students, research assistants and other collaborators, like computer technicians or other health staff. When students have the role of supervising part of the data collection or part of the project, particularly in developing countries, they must be unpretentious and certainly not arrogant with local staff.

Conclusion

Biological anthropologists do fieldwork to try to disentangle the role of different variables in various aspects of physiological constraints imposed on human beings by their lifestyle. Another aim of fieldwork in biological anthropology is to question the limits of adaptation to the environment in functional and evolutionary contexts. It is then appropriate to test hypotheses among a representative sample of populations, or to examine sub-samples of a population chosen with particular characteristics, in order to control a causal factor and then draw a comparison between other factors. For practical reasons, it is not always possible to select large and representative samples of populations. Subsequent statistical analysis requires careful handling.

Many pilot surveys have led to modification of an original protocol, since one of the permanent challenges during fieldwork is to balance the acceptability to participate for the subjects involved with the number of measurements needed. In addition we have to keep to a minimum the intra- and inter-investigators' variability in measurements. Although fieldwork in difficult settings, in terms of distance, transport facilities, climate, or even accommodation, can be a proper test for the researcher, most biological anthropologists consider that it is also a rewarding and valuable step in their research and they would never change over to analyzing data whose reliability they cannot control.

The greatest chance of bias creeping in is likely to happen when participants are not confident with the investigators, when they are not really willing to participate or when they find the study too demanding. In biological anthropology, during fieldwork, human relationships are crucial to the success of the project, as in other disciplines, but the quality of data collection depends largely on this factor. In field research, all human beings, either voluntary participants, technical collaborators, or local authorities are equally important and should be approached with caring consideration.

References

Bailey, R.C., M.R. Jenike, P.T. Ellison, G.R. Bentley, A.M. Harrigan, and N.R. Peacock. 1992. 'The ecology of birth seasonality among agriculturalists in central Africa', *Journal of Biosocial Science* 24: 393–412.

Baker, P.T. 1996. 'Adventures in human population biology', *Annual Review of Anthropology* 25: 1–18.

Beall, C.M., C.M. Worthman, J. Stallings, K.P. Strohl, G.M. Brittenham, and M. Barragan. 1992. 'Salivary testosterone concentration of Aymara men native to 3600 m', *Annals of Human Biology* 19: 67–78.

Beall, C.M., M.J. Decker, G.M. Brittenham, I. Kushner, A. Gebremedhin, and K.P. Strohl. 2002. 'An Ethiopian pattern of human adaptation to high-altitude hypoxia', *Proceedings of the National Academy of Sciences of the USA*, 99: 17215–8.

Bénéfice, E., D. Garnier, and G. Ndiaye. 2001. 'High levels of habitual physical activity in West African adolescent girls and relationship to maturation, growth, and nutritional status: results from a 3–year prospective study', *American Journal of Human Biology* 13: 808–20.

Bribiescas, R.G. 2001. 'Reproductive ecology and life history of the human male', *American Journal of Physical Anthropology* Suppl 33: 148–76.

Brush, G., and G.A. Harrison. 2001. 'Components of length growth variation in infants from the same population but different environments', *American Journal of Human Biology* 13: 197–203.

Campbell, B., P.B. Gray and P. Leslie. 2005. 'Age-related changes in body composition among Turkana males of Kenya', *American Journal of Human Biology* 17: 601–10.

Campbell, B.C., P.W. Leslie, M.A. Little, and K.L. Campbell. 2005. 'Pubertal timing, hormones, and body composition among adolescent Turkana males', *American Journal of Physical Anthropology* 128: 896–905.

Campbell, B., P. Leslie, and K. Campbell. 2006. 'Age-related changes in testosterone and SHBG among Turkana males', *American Journal of Human Biology* 18: 71–82.

Campbell, B. and M. Mbizo. 2006. 'Reproductive maturation, somatic growth and testosterone among Zimbabwean boys', *Annals of Human Biology* 33: 17–25.

Dufour, D.L., J.C. Reina and G.B. Spurr. 2003. 'Physical activity of poor urban women in Cali, Colombia: a comparison of working and not working women', *American Journal of Human Biology* 15: 490–7.

Ferrell, R.J., K.A. O'Connor, D.J. Holman, E. Brindle, R.C. Miller, G. Rodriguez, J.A. Simon, P.K. Mansfield, J.W. Wood, and M. Weinstein. 2007. 'Monitoring reproductive aging in a 5–year prospective study: aggregate and individual changes in luteinizing hormone and follicle-stimulating hormone with age', *Menopause* 14: 29–37.

Garnier, D. and E. Bénéfice. 2006. 'Reliable method to estimate characteristics of sleep and physical inactivity in free-living conditions using accelerometry', *Annals of Epidemiology* 16: 364–9.

Garruto, R.M., M.A. Little, G.D. James, and D.E. Brown. 1999. 'Natural experimental models: the global search for biomedical paradigms among traditional, modernizing,

and modern populations', *Proceedings of the National Academy of Sciences of the USA* 96: 10536–43.

Ghosh, R., C.G.N. Mascie-Taylor and L. Rosetta. 2006. 'Longitudinal study of the frequency and duration of breastfeeding in rural Bangladeshi women', *American Journal of Human Biology* 18: 630–8.

Gray, S.J. 1994. 'Comparison of effects of breast-feeding practices on birth-spacing in three societies: nomadic Turkana, Gainj, and Quechua', *Journal of Biosocial Science* 26: 69–90.

Harrison, G.A. 1976. 'Genetic and anthropological studies in the human adaptability section of the International Biological Programme', *Philosophical Transactions of the Royal Society of Biological Sciences* 274: 437–45.

—— 2001. 'Comparative stress in human societies', *Journal of Physiological Anthropology and Applied Human Science* 20: 49–53.

Holman, D.J., F.N. Rasheed, C.M. Stroud, E. Brindle, K.A. O'Connor and K.L. Campbell. 1998. 'A commercial pregnancy test modified for field studies of fetal loss', *Clinica Chimica Acta* 271: 25–44.

Johnson, P.L., J.W. Wood, and M. Weinstein. 1990. 'Female fecundity in highland Papua New Guinea', *Social Biology* 37: 26–43.

Leslie, P.W., K.L. Campbell and M.A. Little. 1993. 'Pregnancy loss in Nomadic and settled women in Turkana, Kenya: a prospective study', *Human Biology* 65: 237–54.

Little, M.A., and R.M. Garruto. 2000. 'Human adaptability research into the beginning of the third millennium', *Human Biology* 72: 179–99.

McDade, T.W., J.F. Stallings and C.M. Worthman. 2000. 'Culture change and stress in Western Samoan youth: Methodological issues in the cross-cultural study of stress and immune function', *American Journal of Human Biology* 12: 792–802.

O'Connor, K.A., E. Brindle, D.J. Holman, N.A. Klein, M.R. Soules, K.L. Campbell, F. Kohen, C.J. Munro, J.B. Shofer, B.L. Lasley and J.W. Wood. 2003. 'Urinary estrone conjugate and pregnanediol 3–glucuronide enzyme immunoassays for population research', *Clinical Chemistry* 49: 1139–48.

O'Connor, K.A., E. Brindle, R.C. Miller, J.B. Shofer, R.J. Ferrell, N.A. Klein, M.R. Soules, D.J. Holman, P.K. Mansfield and J.W. Wood. 2006. 'Ovulation detection methods for urinary hormones: precision, daily and intermittent sampling and a combined hierarchical method', *Human Reproduction* 21: 1442–52.

Pike, I.L. 2005. 'Maternal stress and fetal responses: evolutionary perspectives on preterm delivery', *American Journal of Human Biology* 17: 55–65.

Pollard, T.M., N.C. Unwin, C.M. Fischbacher and J.K. Chamley. 2006. 'Sex hormone-binding globulin and androgen levels in immigrant and British-born premenopausal British Pakistani women: evidence of early life influences?' *American Journal of Human Biology* 18: 741–7.

Rahman, M., C.G.N. Mascie-Taylor and L. Rosetta. 2002. 'The duration of lactational amenorrhea in urban Bangladeshi women', *Journal of Biosocial Science* 34: 75–89.

Rosetta, L. 1986. 'Sex differences in seasonal variations of the nutritional status of Serere adults in Senegal', *Ecology of Food and Nutrition* 18: 231–44.

—— 1988a. 'Seasonal variations in food consumption by Serere families in Senegal', *Ecology of Food and Nutrition* 20: 275–86.

—— 1988b. 'Seasonal changes and the physical development of young Serere children in Senegal', *Annals of Human Biology* 15: 179–89.

—— 1989. 'Breast feeding and post-partum amenorrhea in Serere women in Senegal', *Annals of Human Biology* 16: 311–20.

Rosetta, L., and J. O'Quigley, 1990. 'Mortality among Serere children in Senegal', *American Journal of Human Biology* 2: 719–26.

Rosetta, L., A. Kurpad, C.G.N. Mascie–Taylor and P.S. Shetty. 2005. 'Total energy expenditure $H_2\,{}^{18}O$, physical activity level and milk output of lactating rural Bangladeshi tea workers and non tea workers', *European Journal of Clinical Nutrition* 59: 623–31.

Rosetta, L. and C.G.N. Mascie-Taylor. 2009. 'Factors in the regulation of fertility in deprived populations', *Annals of Human Biology* 36: 642–52.

Steegmann, A.T. Jr. 2006. 'Physiological Anthropology: Past and Future', *Journal of Physiological Anthropology* 25: 67–73.

Vinoy, S., L. Rosetta and C.G.N. Mascie-Taylor. 2000. 'Repeated measurements of energy intake, energy expenditure and energy balance in lactating Bangladeshi mothers', *European Journal of Clinical Nutrition* 54: 579–85.

Vinoy, S., C.G.N. Mascie-Taylor and L. Rosetta. 2002. 'The relationship between areca nut usage and heart rate in lactating Bangladeshis', *Annals of Human Biology* 29: 488–94.

Vitzthum, V.J., H. Spielvogel and J. Thornburg. 2004. 'Interpopulational differences in progesterone levels during conception and implantation in humans', *Proceedings of the National Academy of Sciences of the USA* 101: 1443–8.

Vitzthum, V.J., H. Spielvogel, J. Thornburg and B. West 2006. 'A prospective study of early pregnancy loss in humans', *Fertility and Sterility* 86: 373–9.

Wood, J.W. 1994. 'Maternal nutrition and reproduction: why demographers and physiologists disagree about a fundamental relationship', *Annals of the New York Academy of Sciences* 709: 101–16.

World Health Organization Task Force on Methods for the Natural Regulation of Fertility. 1998a. 'The World Health Organization Multinational Study of Breast-feeding and Lactational Amenorrhea: I. Description of infant feeding patterns and of the return of menses', *Fertility and Sterility* 70: 448–60.

World Health Organization Task Force on Methods for the Natural Regulation of Fertility. 1998b. 'The World Health Organization Multinational Study of Breast-feeding and Lactational Amenorrhea: II. Factors associated with the length of amenorrhea', *Fertility and Sterility* 70: 461–71.

Worthman, C.M. and J.F. Stallings. 1997. 'Hormone measures in finger-prick blood spot samples: new field methods for reproductive endocrinology', *American Journal of Physical Anthropology* 101: 1–23.