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The Fertility of Agricultural and Non-Agricultural Traditional Societies*

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INTRODUCTION

Since at least the time of Malthus, demographers, economists and anthropologists have considered the impact of technological development, and particularly the effects of agricultural intensification, as a key issue in explaining population change.[1] For most of human prehistory population growth appears to have been close to zero,[2] but a dramatic increase in growth rates occurred following the development of agriculture as a subsistence regime.[3] Rates that have been calculated from the available anthropological and prehistoric data suggest that, during the majority of human existence as subsistence foragers, population growth rates were lower than 0.01 per cent,[4] while following agricultural development these rates leapt to 0.1 per cent.[5] These data should obviously not be taken to suggest that population growth rates were sustainable at such levels for long periods of time. The archaeological record is replete also with evidence for population decline at specific times, in specific areas, and for specific reasons.[6] All that

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[1] E. Boserup, *The Conditions of Agricultural Growth* (London: Allen and Unwin, 1965); *Population and Technological Change: A Study of Long-term Trends* (Chicago: University of Chicago Press, 1981). David E. Coleman and R. Schofield, *The State of Population Theory: Forward from Malthus* (Oxford: Basil Blackwell, 1986); P. Handwerker, 'The first demographic transition: an analysis of subsistence choices and reproductive consequences', *American Anthropologist*, **85** (1983), pp. 5–27; T. R. Malthus, *An Essay on the Principle of Population*. Vols. 1 and 2. P. James (ed.) (Cambridge: Cambridge University Press, 1989); B. E. Spooner, *Population Growth: Anthropological Implications* (Cambridge, Massachusetts: M.I.T. Press, 1972).

[2] G. J. Armelagos, A. H. Goodman and K. H. Jacobs, 'The origins of agriculture: Population growth during a period of declining health', *Population and Environment*, **13** (1991), pp. 9–22; A. J. Coale, 'The history of the human population', *Scientific American*, **231** (1974), pp. 40–51; F. A. Hassan, *Demographic Archaeology* (New York: Academic Press, 1981).

[3] R. L. Carneiro and D. L. Hilse, 'On determining the probable rate of population growth during the Neolithic', *American Anthropologist*, **68** (1966), pp. 177–181; M. N. Cohen and G. J. Armelagos, *Paleopathology at the Origins of Agriculture* (New York: Academic Press, 1984); G. L. Cowgill, 'On causes and consequences of ancient and modern population changes', *American Anthropologist*, **77** (1975), pp. 505–525; M. Harris and E. B. Ross, *Death, Sex and Fertility: Population Regulation in Preindustrial and Developing Societies* (New York: Columbia University Press, 1987); Hassan *op. cit.* in footnote 2; P. E. L. Smith, 'Changes in population pressure in archaeological explanation,' *World Archaeology*, **4** (1972), pp. 5–18; R. W. Sussman, 'Child transport, family size, and increase in human population during the Neolithic', *Current Anthropology*, **13** (1972), pp. 258–259.

[4] Hassan *op. cit.* in footnote 2, pp. 199–200.

[5] Carneiro and Hilse *loc. cit.* in footnote 3; Hassan *op. cit.* in footnote 2, pp. 221–222.

[6] One of the best examples for such trends is Adams's extensive settlement surveys and population reconstructions for periods covering thousands of years in ancient Mesopotamia, now modern Iraq. See R. McC. Adams, *Heartland of Cities: Surveys of Ancient Settlement and Land Use on the Central Floodplain of*

may be said from these data is that agricultural regimes appear, under favourable conditions, to be able to support higher human fertility rates than other subsistence adaptations.

Based on the population reconstructions outlined above and on microdemographic studies of traditional hunting and gathering groups, an anthropological demographic paradigm has developed that views the fertility of foraging groups as relatively low[7] and, by implication, the fertility of agricultural groups as much higher, and more variable.[8] These notions have, however, been contradicted in recent claims by Kenneth Campbell and James Wood that there are no significant differences in the total fertility (the sum of age-specific fertility rates, hereafter referred to as TF) of traditional natural-fertility populations.[9] Evidence from contemporary, acculturated foraging and agricultural populations (particularly the !Kung San) has also lent ethnographic support to the notion of an increase in fertility with the transition to sedentism and food production.[10]

Demographers have customarily been more concerned with documenting the demographic transitions that have occurred with increasing industrialization. Their reconstructions of the fertility and mortality rates of traditional populations have, therefore, tended to ignore specific subsistence distinctions, and referred instead to these groups under more generalized terms, such as 'pre-industrial' 'pre-modern' or 'underdeveloped' Proponents of classic demographic transition theory routinely considered the fertility and mortality of such pre-transition populations as uniformly high, without taking into account ecological forces that may have affected demographic characteristics.[11] With the current critiques of demographic transition theory and the development of alternative hypotheses for changing demographic parameters in traditional societies,[12] microdemographic studies, and the specific input of anthro-

the Euphrates (Chicago: University of Chicago Press, 1981). There are similar, but less extensive data from surveys in other areas of the ancient Near East (e.g. R. Gophna and J. Portugali, 'Settlement and demographic processes in Israel's Coastal Plain from the Chalcolithic to the Middle Bronze Age,' *Bulletin of the American Schools of Oriental Research*, **269** (1988), pp. 11-28.

[7] The !Kung San of Botswana, with a mean total fertility of 4.7 have frequently served as the paradigm of low fertility in foraging groups in many anthropological texts (see N. Howell, *Demography of the Dobe !Kung* (New York: Academic Press, 1979), although there is now some suspicion that their low fertility may in part have been due to sexually transmitted diseases (see R. Pennington and H. Harpending, 'Infertility in Herero pastoralists of Southern Africa', *American Journal of Human Biology*, **3** (1991), pp. 135 153).

[8] C. R. Ember, 'The relative decline in women's contribution to agriculture with intensification', *American Anthropologist*, **83** (1983), pp. 283-304.

[9] K. L. Campbell and J. W. Wood, 'Fertility in traditional societies , in P. Diggory, S. Teper and M. Potts (eds.), *Natural Human Fertility: Social and Biological Mechanisms* (London, 1988), pp. 39-69). For a critique of this position, see G. R. Bentley, G. Jasieńska and T. Goldberg, 'Is the fertility of traditional agriculturalists higher than that of foragers and horticulturalists?', submitted to *Current Anthropology*, 1993.

[10] L. R. Binford and J. W. J. Chasko, 'Nunamiut demographic history: a provocative case', in E. B. W. Zubrow (ed.), *Demographic Anthropology: Quantitative Approaches* (Albuquerque, New Mexico; University of New Mexico Press, 1976), pp. 63-143; Howell *op cit.* in footnote 7; R. B. Lee, *The !Kung San: Men, Women, and Work in a Foraging Society* (Cambridge: Cambridge University Press, 1979); 'Lactation, ovulation, infanticide, and women's work: a study of hunter-gatherer population regulation', in M. N. Cohen, R. S. Malpass and H. G. Klein (eds.), *Biosocial Mechanisms of Population Regulation* (New Haven: Yale University Press, 1980), pp. 321-348; E. A. Roth, 'Sedentism and changing fertility patterns in a Northern Athapascan isolate' *Journal of Human Evolution*, **10** (1981), pp. 413-425; E. A. Roth and A. K. Ray, 'Demographic patterns of sedentary and nomadic Juang of Orissa', *Human Biology*, **57** (1985), pp. 319-325. But cf. H. Harpending and L. Wandsnider, 'Population structures of Ghanzi and Ngamiland !Kung', in: M. H. Crawford and J. H. Mielke (eds.), *Current Developments in Anthropological Genetics*, Vol. 2. *Ecology and Population Structure* (New York: Plenum Press, 1982), pp. 29-50.

[11] For some criticisms of this approach, see S. Greenhalgh, 'Toward a political economy of fertility: anthropological contributions', *Population and Development Review*, **16** (1990), pp. 85-106.

[12] B. Berelson, 'Social science research on population: a review', *Population and Development Review*, **2** (1976), pp. 219-266; J. Blake, 'The fertility transition: continuity or discontinuity with the past', in *International Population Conference, Florence*, Vol. 4 (Liège, 1984), pp. 393-405; J. C. Caldwell, 'Toward a restatement of demographic transition theory'. *Population and Development Review*, 2 (1976), pp. 321-366;

pological perspectives, are attracting increasing notice.[13] The importance of subsistence practices, ecological relationships between populations and their environments, and the influence of these factors on kinship organization are just some of the variables that are being considered by various scholars.

At issue here is whether the generalization discussed earlier – that fertility in foraging groups is low in relation to that of agricultural groups – holds across a large sample of contemporary subsistence-based populations, and whether any predictions can be made about the fertility levels of populations based solely on their subsistence practices. Accordingly, we have constructed two comparative samples of traditional natural-fertility populations to examine these issues in greater depth.[14]

DATA AND METHODS

Any cross-cultural demographic survey is limited by the nature of the data available. The quality and purpose of demographic studies, particularly of traditional societies, is highly variable, ranging from brief surveys and censuses to highly detailed longitudinal demographic, bio-behavioural and ethnographic analyses. In some reports it is not even clear which subsistence techniques are practised by the population studied, which reinforces our criticism that demographic studies have ignored subsistence practices as an important variable. In addition, the accuracy of data derived from traditional societies, where ages of subjects are often unknown even to themselves, are open to question. Early, for example, has pointed out that such data tend to vary with the nature and length of particular studies, as well as with the overall familiarity of the researcher with the population she or he may be investigating.[15] Such variability requires particular care in judging the validity of each source.

Fertility data were thus obtained from the published demographic and anthropological literature and were included in our sample only if they met the following criteria: that they conformed to the definition of a natural-fertility population;[16] that

R. Freedman, 'Theories of fertility decline: a reappraisal', *Social Forces*, 58 (1979), pp. 1–17; W. P. Handwerker (ed.), *Culture and Reproduction* (Boulder, Co.: Westview Press, 1986); G. McNicoll, 'Institutional determinants of fertility change', *Population and Development Review*, 6 (1980), pp. 441–462.

[13] J. C. Caldwell, A. G. Hill and V. J. Hull, *Micro-Approaches to Demographic Research* (London, 1988); Greenhalgh *loc. cit.* in footnote 11.

[14] We have approached the data using many of the same methods as Campbell and Wood (*loc. cit.* in footnote 9), who, to a great extent, inspired the following analyses.

[15] J. D. Early, 'Low forager fertility: demographic characteristic or methodological artifact?', *Human Biology*, 57 (1985), pp. 387–399.

[16] L. Henry, 'Some data on natural fertility', *Eugenics Quarterly*, 8 (1961), pp. 81–91. Although Henry's original definition excluded any populations in which intentional family limitation is practised, he refined his terminology to exclude only those groups that modified their fertility in relation to achieved parity. This qualification is somewhat problematic as pointed out by Blake, *loc. cit.* in footnote 12; C. Wilson, J. Oeppen and M. Pardoe, 'What is natural fertility? The modelling of a concept', *Population Index*, 54 (1988), pp. 4–20; and J. W. Wood, 'Fertility and reproductive biology', in R. Attenborough and M. Alpers (eds.), *The Small Cosmos: Studies of Human Biology in Papua New Guinea* (Oxford, in press). For example, those groups that modify behaviour to increase birth intervals, such as post partum sex taboos, or terminal abstinence, conform to Henry's definition of natural-fertility populations even though such practices can effectively lower total fertility. (For data on post partum sex taboos, see W. K. A. Agyei, 'Breast-feeding and sexual abstinence in Papua New Guinea', *Journal of Biosocial Science*, 16 (1984), pp. 451–461; J. C. Caldwell and P. Caldwell, 'The role of marital sexual abstinence in determining fertility: a study of the Yoruba in Nigeria', *Population Studies*, 31 (1977), pp. 193–217; and M. Singarimbun and C. Manning, 'Breastfeeding, amenorrhea, and abstinence in a Javanese village: a case study of Mojolama', *Studies in Family Planning*, 7 (1976), pp. 175–179). For data on terminal abstinence, see H. Ware, 'Social influences on fertility at later ages of reproduction', *Journal of Biosocial Science, Supplement* 6 (1979), pp. 75–96). Since an increase in birth intervals may reduce the potential number of children that a woman bears during her reproductive lifespan, these behavioural mechanisms may have an indirect contraceptive effect. We have, therefore, avoided including groups where post partum taboos last longer than six months, and where terminal abstinence is known to occur when women are still potentially fertile.

there had been no recent, or major drop or increase in fertility rates that might indicate social and economic upheaval that frequently accompanies the processes of acculturation in traditional groups;[17] and that there should be a certain minimum number of women sampled to ascertain total fertility.

To address this issue, we constructed two samples, called the *Base* and *Augmented Sample*, respectively (Appendix 1). The Base Sample contains groups where, for greater statistical reliability, at least 50 women contributed to the fertility histories that were compiled, and consists of 47 populations (5 foragers, 12 horticulturalists and 30 agriculturalists). The Augmented Sample, however, also includes groups with sample size below 50, to provide an increased total of 57 populations (12 forager, 14 horticulturalist, and 31 agriculturalist groups).

We excluded any data where there was a suspicion of unreliability, or where we could not verify from primary sources the validity of methods used to obtain the demographic data.

We excluded populations in which the rate of primary sterility exceeded 0.1. Since rates of primary sterility in most natural-fertility populations are very low (rarely more than 0.05)[18] we took a rate of 0.1 or higher to be indicative of exposure to sexually transmitted diseases.

The published sources or other related references had to specify the subsistence base of the specific population studied.

We employ the term 'foragers' (hunters and gatherers) to refer to groups that either collect, hunt, or scavenge their required resources from the immediate environment. We have also defined some groups that practise a combined foraging-horticultural strategy as foragers for the statistical comparisons that follow.[19] The term 'horticulturalist' is used to define cultivators who engage in shifting (extensive) cultivation, generally using hoes, where the cultivated produce provides most of their nutritional resources. Intensive agriculturalists are distinguished by their repeated cultivation of the same land plots, often involving crop rotation and, generally, the use of the plough. In most cases, we were able to derive subsistence information from the original demographic sources, but sometimes found it necessary to refer to additional literature. These additional sources are listed in Appendix. 1.[20]

Attention also needs to be paid to the potential sample bias and the artificial inflation of sample size in these cross-cultural analyses by the inclusion of non-independent cases, referred to as *Galton's Problem*.[21] Non-independence can be a function of ethnic, regional, or chronological relatedness between populations. For example, some fertility data are given in the literature for several towns from one region,[22] or for more than one

[17] Examples of such populations include the Nunamiut Eskimos (see Binford and Chasko, *loc. cit.* in footnote 10); and Ontong Java (see T. P. Bayliss-Smith, 'Ontong-Java: depopulation and repopulation', in V. Carroll (ed.), *Pacific Atoll Populations* (Honolulu, 1975), pp. 417–484. Further examples are given in Bentley *et al.*, *loc. cit.* in footnote 9.

[18] J. Bongaarts and R. G. Potter, *Fertility, Biology, and Behavior: An Analysis of the Proximate Determinants* (New York, 1983).

[19] See Appendix 1 for the relevant subsistence categories. This procedure was followed partly to increase the sample size for the foraging category.

[20] Since we could find reliable data for only a few pastoralist societies, these are also excluded from the comparisons in the Base and Augmented Samples, although total fertility for them is listed at the bottom of Appendix 1.

[21] For a discussion of Galton's Problem, see M. M. Dow, M. L. Burton, D. R. White and K. P. Reitz, 'Galton's problem as network autocorrelation', *American Ethnologist*, **11** (1984), pp. 754–770; R. Naroll, 'Galton's problem', in R. Naroll and R. Cohen (eds.), *Handbook of Methods in Cultural Anthropology* (New York, 1973), pp. 974–989; D. R. White, M. L. Burton and M. M. Dow, 'Sexual division of labor in African agriculture: a network autocorrelation analysis', *American Anthropologist*, **83** (1981), pp. 824–849.

[22] Examples of this are the Genevan groups from Switzerland, and the various German villages (see Appendix 1 for data and sources).

time period for the same population.[23] This can be a serious problem and affect statistical results. There are two possible approaches to this issue: the first would be to aggregate populations from the same region and time-period where the ethnic identity of each group is considered highly similar. The second would be to disaggregate sub-populations and to control statistically for the overrepresentation of particular geographical regions and time periods. The latter approach has the advantage of maintaining population heterogeneity and variability, which can exist even in historical demographic groups from similar areas.[24] The disadvantage of this approach, however, is that it is not possible to treat all aggregated cases consistently. For example, data for individual villages are available for some groups, but the data from Yunlin in Taiwan, for example, and Matlab Thana in Bangladesh are also regional, and the published sources are not presented in a way which could permit disaggregation.[25]

Given this situation, and the general variability inherent in these collective data that we have already pointed out in the Base and Augmented Samples, we have taken the first alternative, and sacrificed heterogeneity for consistency. We have thus combined time-periods for single populations where these are reported separately in the original publications (e.g. the Hutterites and Mormons). We have also amalgamated data for certain regions (e.g. the French villages) which relate to the same time periods, where it seems clear that the groups in question are highly similar in their ethnicity, mode of subsistence, and historical experiences. Appendix 1 gives details of these procedures.

We also need to clarify whether cohort or period rates were used to calculate total fertility. In most cases, only cohort fertility rates could be obtained for the groups we have examined. For the sake of consistency, we have therefore used cohort rates where both period and cohort rates were available. However, in 11 cases (the combined French villages, Crulai, rural Canadians, British parishes, Martinique, Estonian Swedes, Chinese from the Northern Region, Haitians, Bangladeshis from Matlab Thana, Mucajai Yanomamo, and the Maring) only period rates were given, and these are used in our analysis (see Appendix 1).

Since none of the samples (when divided according to subsistence categories) approximates a normal distribution, we have used non-parametric statistics (Mann–Whitney's *U* for two-sample comparisons, and Kruskal–Wallis for three-sample comparisons).

ANALYSES OF THE DATA

Results from the statistical analyses did not differ significantly between the Base and Augmented Samples (Table 1). The following results, using means and standard errors, are therefore reported from the Augmented Sample. The mean total fertility for all the natural-fertility populations is 6.1 ± 0.2. The distribution of total fertility for the Augmented Sample is shown in Figure 1. The mean for foragers is 5.6 ± 0.4, 5.4 ± 0.2 for horticulturalists, while average total fertility for agriculturalists is 6.6 ± 0.3. In Figure 2 we compare the distributions of total fertility for all three subsistence categories for the Augmented Sample.

There are significant differences within the samples when all three subsistence

[23] For example, the Hutterites and Mormons (see Appendix 1 for data and sources).

[24] See P. R. A. Hinde, 'Resources and the fertility transition in the countryside of England and Wales', in John Landers and Vernon Reynolds (eds), *Fertility and Resources* Symposium Volume of the Society for the Study of Human Biology **31** (Cambridge, 1990), pp. 76–91; P. G. Spagnoli, 'Population history from parish monographs: the problem of demographic variation' *Journal of Interdisciplinary History*, **8** (1977), pp. 427–452.

[25] Disaggregated data exist for groups such as the 14 British parishes, and regions like NW France (see Appendix 1 for data and sources).

Table 1. *Statistical analyses of total fertility between subsistence groups in the Base and Augmented Samples*

	Base Sample			Augmented Sample		
	Mean	S.E.	*n*	Mean	S.E.	*n*
Foragers	5.4	0.7	(5)	5.6	0.4	(12)
Horticulturalists	5.5	0.3	(12)	5.4	0.2	(14)
Agriculturalists	6.6	0.3	(30)	6.6	0.3	(31)
All groups	6.2	0.2	(47)	6.1	0.2	(57)
P-value (two groups)* Mann–Whitney *U*		0.007			0.004	
P-value (three groups)† Kruskal-Wallas		0.04			0.02	

* Combines foragers and horticulturalists as open group (non-agriculturalists) and compares to agriculturalists.
† Compares the three subsistence groups (foragers, horticulturalists and agriculturalists) separately.

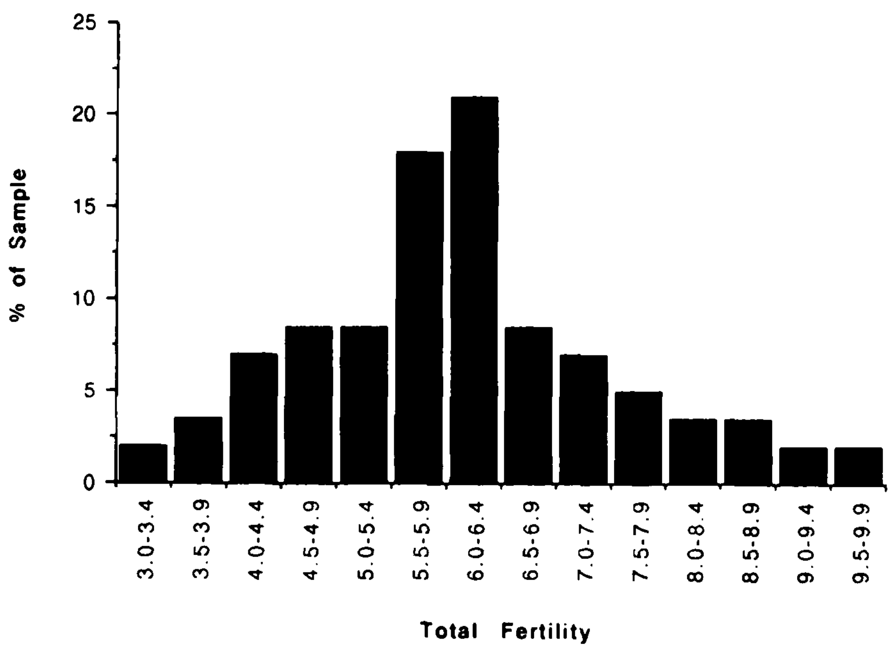

Figure 1. Percentage distribution of total fertility from the Augmented Sample.

categories are compared (Table 1: Kruskal–Wallis for the Augmented Sample, $p = 0.01$). When these comparisons are further broken down, we find that there are no significant differences between foragers and horticulturalists (Mann–Whitney's *U*, $p = 0.8$), but there are marginally significant differences between foragers and agriculturalists ($p = 0.06$), and significant differences between horticulturalists and agriculturalists ($p = 0.007$). We have, therefore, combined the results for foragers and horticulturalists into one category called *non-agriculturalists*, and compared this group to agriculturalists. When the total fertility of non-agriculturalists and agriculturalists is compared there are obviously significant differences ($p = 0.004$). The mean for non-agriculturalists is 5.5 ± 0.2 (compared to 6.6 ± 0.3 for agriculturalists). The comparative distributions for these indices are shown in Figure 3 for the Augmented Sample.

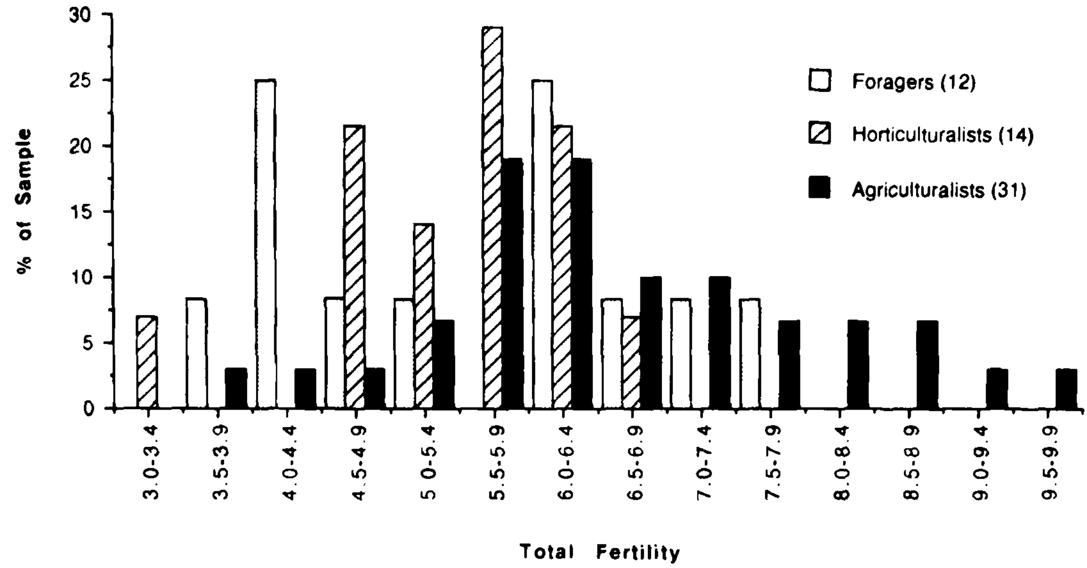

Figure 2. Comparison of the percentage distributions of total fertility between foragers, horticulturalists, and agriculturalists in the Augmented Sample.

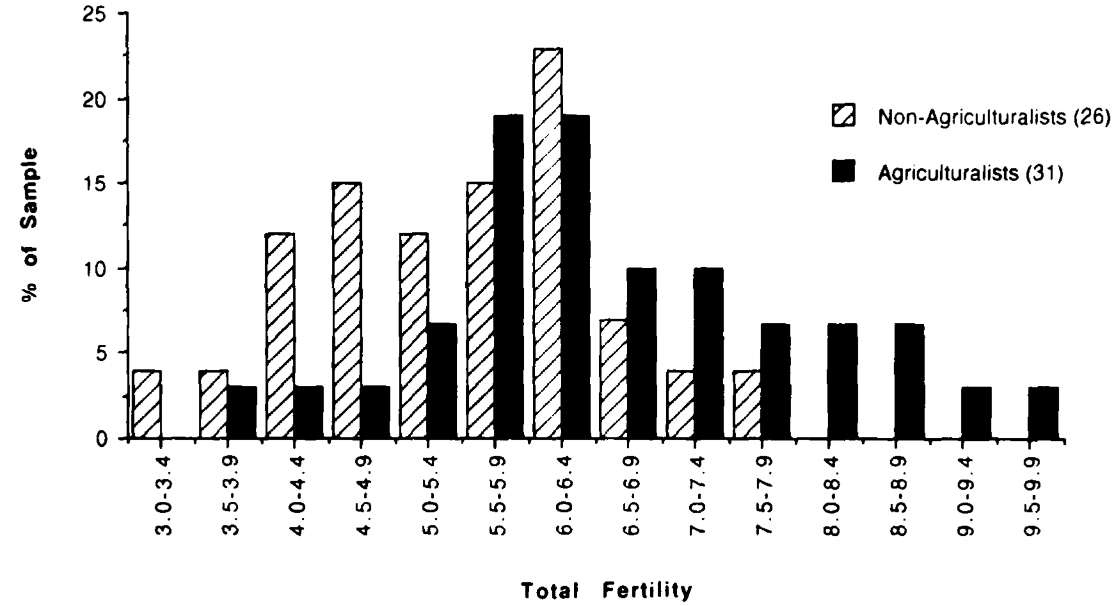

Figure 3. Comparison of the percentage distributions of total fertility between non-agriculturalists and agriculturalists in the Augmented Sample.

DISCUSSION

Our study demonstrates that there are significant differences in the fertility of traditional societies characterized by different subsistence regimes. What is particularly intriguing is that fertility differences exist between intensive agriculturalists and all other non-agricultural groups, rather than between foragers and all cultivators.[26] The explanation

[26] Barry Hewlett (B. S. Hewlett, 'Demography and childcare in preindustrial societies' *Journal of Anthropological Research*, 47 (1991), pp. 1–39) has also recently provided an analysis of demographic variables between forager and horticultural populations, in the context of comparing child-care practices and demographic structures. Although his sample includes groups that do not need the same rigid criteria that we have adopted here, he also notes that the difference between mean total fertility for foraging and horticulturalist groups is not significant.

for this is probably related to the socio-economic and cultural changes that frequently occur with the technological transition to intensive agriculture. Intensive agriculture can increase the quantity of available nutrition, and, perhaps more importantly, provides surpluses that mitigate against seasonal shortages often experienced by peoples with less intensive cultivating regimes. It has generally been documented, for example, that the introduction of the plough significantly raises land productivity.[27] Accompanying the agricultural changes may be a shift to more permanent dwellings and better food storage facilities.

Intensification can also lead to the demand for and/or desire for greater numbers of children to provide extra labour,[28] encouraging practices that raise fertility, such as the earlier introduction of supplementary feeding for infants and young children, shortened periods of weaning, and a reduction in post partum amenorrhoea and birth intervals. In addition, these practices may lead to higher rates of infant and child mortality that also increase fertility by further reducing birth intervals.[29] Separating such factors as causal agents will require the collection of high-quality micro-demographic data from a variety of natural-fertility, traditional societies, as well as the determination of the relevant proximate determinants. We have already collected some of the requisite published information that exists for the populations represented in our samples, but the numbers are too small as yet for any meaningful statistical analyses.

It is clear, however, that forager, horticultural, and agricultural groups are all characterized by a high degree of heterogeneity in their fertility rates, and that it is not possible to predict fertility rates on the basis of subsistence technology alone.[30] Agricultural groups are, however, able to achieve higher total fertility than non-agricultural societies, and the variance in these rates is larger. The most we can state from these findings is that, over a long period of time, it is possible that in agricultural societies population growth rates would be increased, provided mortality remained similar to, or less than, that of non-agriculturalists. In order to assess more rigorously, however, the impact that a mean increase of 1.1 offspring (the difference in average total fertility between non-agriculturalists and agriculturalists) might have on population growth rates, we require further comparative data on the mortality rates in different traditional subsistence groups.[31]

CONCLUSION

Our comparative analysis of the total fertility of traditional natural-fertility societies has illustrated that there are significant mean differences between non-agriculturalists and intensive agriculturalists. This finding supports the longstanding claim by a variety of

[27] E. Boserup, *op. cit.* in footnote 1; J. Goody, *Production and Reproduction* (Cambridge, England: Cambridge University Press, 1976).

[28] J. C. Caldwell, *loc. cit.* in footnote 12.

[29] This has been eloquently attested recently by Brainard's comparison of fertility rates of nomadic and settled Turkana women, J. M. Brainard, *Health and Development in a Rural Kenyan Community* (New York: Peter Lang, 1991). Completed fertility of nomadic Turkana women was 7.2, compared to 5.7 for settled women. The higher fertility of the former was largely explained by higher infant and early childhood mortality rates that shortened birth intervals for nomadic women. Both settled and nomadic women ended up with a similar mean number (4.4) of surviving offspring. Nomadic women also introduced to their young infants very early food supplements in the form of milk from their herds.

[30] This was initially pointed out by Campbell and Wood, *loc. cit.* in footnote 9, p. 43. Hewlett, *loc. cit.* in footnote 26, also noted the tremendous variability in fertility rates in his sample of foragers and horticulturalists.

[31] Hewlett, *loc. cit.* in footnote 26, also collected mortality data for the same populations for which he examined fertility rates. There were no differences in mortality between foragers and horticulturalists in his sample. Hewlett did not have statistics for populations in which intensive agriculture was practised.

scholars that the intensification of subsistence technology is associated with increases in fertility. However, it appears from our data that levels of fertility in populations characterized by horticulture, or extensive modes of cultivation, are similar to those in foraging groups. Higher fertility is primarily associated with the intensification of agriculture. We have not yet collected sufficient data to compare the mortality rates between subsistence groups, that would shed further light on the potential growth rates of non-agriculturalists and agriculturalists.

Despite the fact that the mean and maximum total fertility among intensive agriculturalists is higher than among non-agriculturalists, we cannot use these data to make predictions about the fertility levels of this subsistence group. There is a large variance among and between the subsistence categories, and several ecological and behavioural factors are likely to impinge on the determinants of fertility for individual societies. These data demonstrate, however, the continuing need for micro-demographic studies which incorporate anthropological perspectives in order to assess the wide range of factors that affect fertility in societies with different subsistence practices.

APPENDIX 1. POPULATION DATA FOR THE BASE AND AUGMENTED SAMPLES WITH SOME SUPPLEMENTARY PASTORALIST CASES

Population name	Locality	Country	TF (Cohort)	TF (Period)	Date	Population size	Subsistence mode
			Base Sample				
East Hadza[1]	East Rift Valley	Tanzania	6.2	—	1967; 77; 85	61	1
Ngbaka[2]	Bobua Village	Central African Rep.	4.2	—	1948–57	100	2
Gainj[3]	Madang Province	Papua New Guinea	4.3	—	1977–78; 82–83	91	2
Moejoe[4]	—	Irian-Jaya	4.36	4.7	1959–64	827	2
Mucajai Yanomamo[5]	—	Brazil	—	7.9	1958–87	104	2
Terena[6]	Cachoeirinha	Brazil	5.5	—	1955–60	81	3
Black Carib[7]	Belize	Honduras/Guatemala	5.8	—	1946 & 56	164	3
Semai Senoi[8]	East Penang	Malaysia	5.69	6.3	1968–69	111	3
Irian-Jayans[9]	Various villages	Irian-Jaya	6.1	7.2	1959–64	4923	3
Maring[10]	Simbai Valley	New Guinea	—	4.7	1966–1976	> 50	3
Murapin-Enga[11]	Tukisenta	New Guinea	5.9	—	1966	119	4
Kiunga[12]	—	Papua New Guinea	3.24	—	1969–72	108	4
Madang[13]	—	Papua New Guinea	6.5	—	1969–72	106	4
Serer[14]	Sine-Saloum	Senegal	6.7	6.7	1963–65	1000	5
Yao[15]	Liwonde	Malawi	5.4	—	1946–47	52	5
Lufa[16]	EC Highlands	Papua New Guinea	4.6	—	1968–9	742	5
Juang[17]	Central Orissa	India	6.1	—	1954	68	5
Kipsigis[18]	Kericho Province	Kenya	6.9	—	1982–3	102	6
Chinese[19]	Yunlin	Taiwan	7.1	—	1952	> 50	7
Chinese[20]	Northern Region	China	—	5.5	1929–31	> 50	7
Swiss[21]	Torbel	Switzerland	4.6	—	1700–1900	572	7
Bambara[22]	Mali	West Africa	7.6	8.1	1981–2	5000	7
Canadians[23]	Rural	Canada	—	8	1700–1730	623	8
Hutterites[24]	—	USA	9.7	10	1950	209	8
Sundanese[25]	West Java Province	Indonesia	6.1	7.3	1979–83	361	8
Mandinka[26]	Kenebar and Manduar	The Gambia	7	—	1951–75	> 50	8
Tonga[27]	Mazabuka District	Zimbabwe	6.6	—	1946–50	61	8
French[28]	Combined	France	—	6.3	1665–1780	> 50	9
Normans[29]	Crulai	Normandy	—	5.6	1674–1742	113	9
Mormons[30]	Utah	USA	7.9	8.5	1800–1869	17000	9
Amish[31]	Holmes, Ohio	USA	6.3	7.4	1964	793	9
British[32]	14 parishes	United Kingdom	—	5.5	1600–1799	2445	9
Germans[33]	Rural villages	Germany	5.5	6.6	1750–1850	6424	9
Indian[34]	Nasik	India	6.1	—	1952–53	100	9

Indians[35]	Bombay	India	6.8	6.1	1954 55	1000	9
Swedes[36]	Baltic	Estonia	—	5	1841–1900	318	9
Indians[37]	Matlab Thana	Bangladesh	—	6.3	1969–71	193	9
Dule Bagdi[38]	West Bengal	India	4.2	—	1967–69	215	9
Haitians[39]	Artibonite Vall	Haiti	—	5.9	1968 72	424	9
Mayan Indian[40]	Santiago Atitlán	Guatemala	9.2	8.2	1964–66	> 50	9
Tamang[41]	Timling	Nepal	5.3	—	1981	56	10
French[42]	Martinique	French Antilles	—	8.5	1914–1928	> 50	11
Peruvians[43]	Tambo Valley	Peru	8.3	8.4	1974	63	11
Malays[44]	Cocos-Keeling	Indian Ocean	8.8	8.2	1888–1947	107	11
Europeans[45]	Geneva	Switzerland	7.4	6.4	1550–1649	637	12
European[46]	Tunis	Tunisia	5.92	7	1840–59	147	12
Kota[47]	Kerala	India	3.7	—	1963–68	134	12
		Additions for the Augmented Sample					
Pahira[48]	Nr. Bengal	India	6.3	—	1963–64	36	1
Aka[49]	Ndele & Bagandu	Central African Republic	6.2	—	1974–84	34	1
Hiwi[50]	Cinaruco	Venezuela	5.1	—	1985–88	16	1
Agta[51]	NE Luzon	Philippines	6.5	—	1980–82	15	1
Macá[52]	Asunción	Paraguay	3.6	—	1965	48	2
Ache[53]	Chupa Pou	Paraguay	7.2	—	1980–85	32	2
Kanikkar[54]	Travancore	India	4.7	—	1952	31	2
Cashinahua[55]	Amazon Basin	Peru	5.2	—	—	24	2
Kapauku[56]	Kamu Valley	Irian-Jaya	4.9	4.7	1955	14	3
Bhoksa[57]	Tiperpur	India	6.4	—	1975	30	7
		Pastoralists					
Fulani[58]	—	Mali	6.8	6.9	1981–2	6000	13
Tamasheq[59]	—	Mali	5.2	5.9	1981–2	6000	14
Datoga[60]	—	Tanzania	6.6	—	1989	116	14
Fulani[61]	Nakwamoru	Kenya	7.2	—	1977 79	22	14

NOTES

* Subsistence codes are: 1 = foragers; 2 = forager-horticulturalists; 3 = subsistence horticulturalists; 4 = horticulturalists with cash crops; 5 = horticulturalists with wage labour; 6 = horticulturalists with herds; 7 = subsistence agriculturalists; 8 = agriculturalists with cash crops; 9 = agriculturalists with wage labour; 10 = agro-pastoralists; 11 = wage labourers; 12 = merchants and wage labourers; 13 = semi-sedentary pastoralists; 14 = mobile pastoralists.

APPENDIX 1. *cont.*

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