

**The Neolithic Revolution Did Not Increase the Adaptive Value of Pregnancy  
Sickness<sup>1</sup>**

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Holland and O'Brien (2003) present a thought-provoking extension of the idea that pregnancy sickness<sup>2</sup> serves a prophylactic function, protecting both the mother and the developing organism<sup>3</sup> from ingestible pathogens and toxins during a period of enhanced vulnerability (Fessler 2002, Flaxman and Sherman 2000, Profet 1988, Profet 1992). Their position can be summarized as follows: 1) pregnancy sickness offers prophylactic protection, but does so at the cost of dietary constriction; 2) the domestication of plants provided an abundant source of food, reducing the nutritional costs of pregnancy sickness; 3) the domestication of plants also allowed for sedentism, decreasing the energetic demands placed on pregnant women, and thereby reducing the costs of dietary constriction; 4) by decreasing the costs of pregnancy sickness, the domestication of plants curtailed stabilizing selection that had previously limited the extent and/or prevalence of this trait; the fitness benefits provided by prophylaxis then favored the evolution of more extensive and more widespread pregnancy sickness in human populations.<sup>4</sup> Although this is an interesting hypothesis, Holland and O'Brien's argument suffers from a number of important difficulties.

Holland and O'Brien's position is premised on the assumption that the dietary constriction entailed by pregnancy sickness constituted a significant cost to ancestral foragers -- the authors begin by stating "Since it is axiomatic that a pregnant woman must 'eat for two,' why should a condition that restricts food intake occur at the same time as this dramatic rise in nutritional and caloric requirements?" However, axioms aside, as I have reviewed elsewhere (Fessler 2002:26), the first trimester of pregnancy, the period during which pregnancy sickness is most marked, is characterized by notably low caloric demands -- scaled for body size, humans exhibit the lowest daily increases in energy demands of any pregnant mammal, we seem to undergo metabolic changes in early pregnancy allowing for more efficient use of available resources, and, most important of all, because tissue growth through cell division is an exponential process, the mass of embryonic and supporting tissues initially increases only slowly, progressively accelerating over the course of successive trimesters. Meat is the principal target of gestational food aversions (Flaxman and Sherman 2000). Because game animals are lean, meat is often primarily valuable to foragers as a source of protein rather than a source of calories. While adequate protein intake is important during pregnancy, this is principally true of the second and third trimesters -- studies reveal that decreased protein intake during the first trimester may be minimally harmful, harmless, or even beneficial (see Fessler 2002:28). Hence, although it is unquestionably true that any mechanism that results in dietary constriction entails some costs, it is important not to overestimate the impact of enhanced first trimester dietary selectivity if we are to realistically assess the strength of the stabilizing selection that limited the extent and/or prevalence of pregnancy sickness in ancestral forager populations. That said, however, even if we entertain their

premise in this regard, the facts simply do not support Holland and O'Brien's conclusion that the Neolithic Revolution reduced the costs of pregnancy sickness.

Holland and O'Brien argue that changes in the relative nutritional and caloric costs of pregnancy sickness created by the domestication of plants partly explains, in their words, the "frequency and geographic distribution" of the trait.<sup>5</sup> Their reasoning can be explicated as follows: The more that domesticated plant foods can be substituted for the game animals and wild plant foods on which foragers rely, the less costly it is to avoid pathogen- and toxin-bearing wild foods. The less costly it is to avoid hazardous wild foods, the more advantageous such avoidance becomes. Pregnancy sickness is the means whereby avoidance of foods hazardous to the mother and developing organism is realized. It therefore follows that pregnancy sickness should be most evident in populations with the greatest reliance on domesticated plants.<sup>6</sup> However, the very evidence adduced by Holland and O'Brien suggests that exactly the opposite is true. Citing Flaxman and Sherman (2000), the authors note that a) societies in which pregnancy sickness is apparently *absent* rely on plant staples, typically corn, and b) corn can be processed in a way which enhances the availability of essential amino acids AND IT ALSO CAN BE COMBINED WITH LYSINE RICH PLANTS, SUCH AS BEANS, AS PART OF A DIET PACKAGE TO FURTHER ENHANCE AMINO-ACID CONSUMPTION. If, as the authors argue, cultural innovations such as the domestication of corn and the development of corn processing techniques involving alkali changed the selective forces acting on women so that "a reproductive advantage associated with the maternal propensity for [pregnancy sickness] could be realized," then why is pregnancy sickness both a) quite evident in foragers with no known history of agriculture (e.g.,

Shostak 1981), and b) least evident in exactly those agricultural societies in which it is ostensibly least costly, and therefore most advantageous? Such a seemingly perverse outcome is understandable if it is the case that Holland and O'Brien have misconstrued the nature of the changes brought on by the Neolithic Revolution.

Holland and O'Brien claim that the domestication of plants decreased the costs of pregnancy sickness by improving the nutritional status of women. However, the available evidence indicates that the rise of agriculture often taxed pregnant women by causing a net decline in nutritional status, in part because the adoption of agriculture ultimately led to a decrease in dietary breadth due to a heavy reliance on a few staple crops (Kiple and Tarver 1992, Sciulli 1977). The decline in women's nutritional status was likely further exacerbated by the increased patriarchy facilitated by sedentism and agriculture (Whyte 1978), as this enhanced men's ability to monopolize the most desirable foodstuffs (cf. O'Laughlin 1974).

Holland and O'Brien propose that the domestication of plants diminished the costs of pregnancy sickness via reductions in energy expenditure achieved through sedentism. However, plant domestication probably exacerbated, rather than relaxed, the exogenous energetic demands placed on women during the first trimester of pregnancy. While the shift from foraging to non-transhumant agriculture does eliminate the need for periodic relocation of a woman's home base, this energy savings is likely vastly overshadowed by the increased demands on female labor associated with both the aforementioned rise of patriarchy and the dramatically increasing returns obtainable from intensification that agriculture, unlike foraging, supports (see Boserup 1990). To quote one of the very same sources cited by Holland and O'Brien, "[I]t is clear that female

work-related pathology changed significantly . . . in a way that would be consistent with a model of increased labor for women with the acquisition of maize agriculture," (Buikstra et al. 1986:531).

While it is true that, as Holland and O'Brien remark, the heightened fertility associated with the adoption of agriculture allows women to delegate some chores to older children, any resulting energy savings are probably greatly outweighed by the elevated rates of maternal depletion caused by decreased birth intervals (see King 2003 for review). Indeed, contrary to the impression given by Holland and O'Brien, the increases in fertility associated with agriculture likely usually derive not from enhanced prosperity, but rather from regionally variable combinations of a) the greater value of children's labor, b) the role of family size in the acquisition and defense of fertile land, c) elevated infant and child mortality due to diseases associated with increased population density, and d) the availability of weaning foods that shorten lactational amenorrhea (Armelagos et al. 1991, Boserup 1990, Buikstra et al. 1986, Cowgill 1975, Kiple and Tarver 1992).

Holland and O'Brien argue that sedentism reduces the costs of dietary constriction accompanying pregnancy sickness by allowing for food storage, a practice that buffers consumers against fluctuations in resource availability.

THIS IS AN ARGUMENT DERIVED FROM NEW WORLD DATA WHERE HE PRINCIPAL CROP, MAIZE, NECESSITATED MILLENNIA OF MANIPULATION BEFORE IT COULD PROVIDE A USABLE SURPLUS DEMANDING STORAGE FACILITIES. IN THAT CASE SEDENTISM AND STORAGE DEVELOPED IN TANDEM (AND VERY LATE AFTER AGRICULTURE). IN THE OLD WORLD,

HOWEVER, WHERE THE PRINCIPAL STAPLE IS GRAIN, WILD GRAIN IS MORE NUTRITIOUS THAN DOMESTIC AND A SHORT MATURATION SEASON FOR WILD GRAIN MEANT THAT STORAGE NEEDS CAME FIRST AND IT IS THESE THAT FORCED SEDENTISM -- LONG BEFORE AGRICULTURE.

However, rather than reducing exposure to episodic food shortages, the shift from foraging to agriculture may have often increased the severity of such events.

AGRICULTURE AT THE SAME TIME WOULD HAVE REDUCED THE NUMBER OF EPISODES OF FOOD SHORTAGE BUT INCREASED THE SEVERITY OF THOSE THAT DID TAKE PLACE

Domestication involves a reduction in plant defenses and an increase in the within-species simultaneity of ripening (Schwanitz 1966), changes that make plants more vulnerable to pests. Agriculturalists rely on a small number of staple crops, degrading or displacing alternative resources in the process. In contrast, foragers exploit a wide range of well-adapted food sources that exist in a complex, heterogeneous ecosystem. As a consequence, foragers are generally markedly less vulnerable to famines caused by pests and climatic variation (Armelagos et al. 1991).

Perhaps the domestication of plants did indeed change the distribution and frequency of pregnancy sickness. However, if it occurred, any such change was probably in the opposite direction than that claimed by Holland and O'Brien. Whether via changes in allele frequencies or a reduction in facultative trait expression, because the adoption of agriculture increases the costs of pregnancy sickness, it may decrease, rather than increase, rates of pregnancy sickness. This conclusion is supported by the very study cited by Holland and O'Brien, as Flaxman and Sherman's survey of the Human Relations Area Files reveals that 86% of the societies in which pregnancy sickness reportedly does not occur rely exclusively upon plant staples (2000: Table 3).

## Notes

1. I thank Guillermo Algaze (helpful source of information) and Jennifer Fessler (muse).
2. Although the authors follow Flaxman and Sherman (2000) in referring to the syndrome at issue as *nausea and vomiting of pregnancy (NVP)*, the postulated adaptation is actually quite complex, and the term *pregnancy sickness* more accurately captures the suite of physiological, subjective, and behavioral changes characteristic of the first trimester of pregnancy.
3. Holland and O'Brien state that, during pregnancy, "...toxins and pathogens put two humans at risk." Describing an embryo or first trimester fetus as a human being is a political claim rather than a scientific portrayal. Using such language obscures the delimited nature of the fitness value to the mother of an organism in which maternal investment to date is still relatively low.

4. I have phrased Holland and O'Brien's argument in selectionist terms consistent with those that they employ in their penultimate paragraph and elsewhere. Although examples such as the contemporary distributions of adult lactase production (Hollox et al. 2001) suggest that natural selection can indeed conceivably act within the 10,000 year time frame postulated by the authors, skeptics may question the feasibility of such rapid evolutionary change. However, Holland and O'Brien can meet such a challenge merely by phrasing their position in terms of facultative trait expression in response to environmental contingencies, rather than changes in allele frequency over time -- their basic argument about the consequences of plant domestication need not be a selectionist one.

5. Consistent with their proposal that the adaptive value of pregnancy sickness is contingent on cultural practices, Holland and O'Brien describe pregnancy food taboos in a manner that implies that they view such proscriptions as either potentially or actively functional in nature. However, most such taboos apply only to select species, or even to particular parts of particular animals. Piecemeal proscriptions against specific types of meat fail to provide any meaningful protection to reproductively immunosuppressed women (Fessler 2002:26), making the cultural functionalist account untenable. Rather, the prominence of meat as a target of both pregnancy and non-pregnancy food taboos is best explained as an accidental consequence of the interaction of a) evolved psychological mechanisms that single out meat as the target of adaptive conditioned aversions, and b) interpersonal processes that give rise to cultural beliefs (Fessler 2002:24 n.5, Fessler and Navarrete 2003).

6. Holland and O'Brien repeatedly make statements that can only be interpreted as arguing that between-population differences in the prevalence and/or severity of pregnancy sickness are the product of differing selection pressures stemming from the respective means of subsistence. While this position is vulnerable to the criticism that gene flow may have disrupted any such culturally-generated differences in allele frequency, the authors' basic argument can be rescued simply by positing that between-population differences in pregnancy sickness reflect facultative adjustment of trait expression in response to environmental contingencies. However, even this watered-down version of their position is contradicted by the facts that Holland and O'Brien themselves adduce.

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