Can Interventions to Promote Animal Production Ameliorate Undernutrition?1,2

Jef L. Leroy3* and Edward A. Frongillo4

3Center for Evaluation Research and Surveys, National Institute of Public Health, Col. Santa María Ahuacatitlán, CP 62508, Cuernavaca, Morelos, Mexico; and 4Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC 29208

Abstract

The potential of animal-source foods (ASF) to alleviate micronutrient deficiencies is well recognized. How the intake of ASF can be effectively increased is not known, but promoting animal production (AP) is one possible method. We reviewed the impact of interventions promoting AP on nutritional status and on 6 nutrition-related outcomes: production, household income and expenditure, caregiver time and workload, zoonosis, and dietary intake. Information about the effects on each of the possible outcomes is needed to be able to weigh trade-offs in the potential benefits and costs of promoting AP. The majority of the 14 identified studies found a positive effect of the promotion of AP on production. All studies evaluating the impact on household income or expenditure reported a positive effect on these outcomes. Evidence regarding impact on caregiver income and on caregiver time and workload is too limited to draw any conclusions. We found no studies that examined the impact of the promotion of AP on zoonosis. The studies generally reported a positive impact on dietary intake. Only 4 studies evaluated the impact on nutritional status and found a positive effect. It is unclear whether the improvements in dietary intake and nutritional status were a direct effect of increased production or an indirect effect of increased income. Future studies on the AP-nutrition link would benefit from stronger methodological designs. Available evidence is insufficient to answer whether the promotion of AP is an effective means to alleviate undernutrition. J. Nutr. 137: 2311–2316, 2007.

Introduction

Many people in low- and middle-income countries suffer from micronutrient deficiencies. An important factor contributing to these deficiencies is the consumption of mainly plant-based diets that are low in micronutrients and have low micronutrient bioavailability.

Different approaches can be used to combat nutrient deficiencies. Food-based strategies include activities to increase the production and consumption of foods rich in specific nutrients. Food-based strategies are believed to be more sustainable and culturally acceptable than supplementation or fortification. An additional advantage is that several micronutrient deficiencies can be alleviated simultaneously without the risk of antagonistic interactions or nutrient overload (1).

The potential of animal-source foods (ASF) to alleviate micronutrient deficiencies as part of a food-based strategy is well recognized. ASF are energy dense and good sources of protein, minerals (such as Fe, Zn, and Ca), and vitamins (vitamin B-12 and riboflavin). Many minerals and vitamins are better absorbed from ASF than they are from plant-source foods. ASF also tend to be rich in fat, making them more energy dense and a good source of fat-soluble vitamins (2). As a consequence, the consumption of relatively small amounts of ASF can contribute substantially to dietary adequacy. Potential barriers to ASF consumption include their relatively high cost to poor people and intra-household food allocation patterns that may limit the intake of ASF for the most vulnerable groups, such as women and children (3,4).

The promotion of animal production (AP) is perceived as a possible strategy to increase ASF consumption, but its effectiveness is not known. Understanding whether and how AP improves nutrition is essential if potential nutritional benefits are to be realized and potential negative effects mitigated. To fill this knowledge gap, we conducted a literature review that focused on intervention studies evaluating the impact of the promotion of AP on nutritional status and 6 different nutrition-related intermediary outcomes: production, household income and expenditure, caregiver time and workload, caregiver income, zoonosis, and dietary intake. The pathways examined in this document are summarized in Figure 1. Other potential linkages between livestock production and nutritional status are neither included in the figure nor reviewed in this document.

Materials and Methods

We reviewed studies that examined the effects of interventions promoting AP found in the peer-reviewed and gray literature (e.g. institutional reports, discussion papers, and working documents). The following...
The 4 aquaculture studies were conducted in Bangladesh. The primary objective of the interventions in Bouis et al. (6) was income generation through polyculture fish or vegetable production. The intervention was mainly targeted to poor women and entailed credit, agricultural extension, and some nutrition education. Roos et al. (7) studied an intervention in which poor farmers were trained in homestead culture of carp and either mola (rich in vitamin A) or other small indigenous fish species. The 3rd aquaculture intervention promoted 3 different strategies: monoculture of tilapia or silver barb or polyculture of native and exotic carp species (8). Brugere et al. (9) conducted a qualitative study on the gender effects of small-scale, low-input cage aquaculture targeted at the rural resource poor.

Five studies evaluated the impacts of 4 dairy interventions. The Karnataka dairy development program in India (modeled after the Operation Flood Dairy Development Project) aimed at integrating rural households into the market economy (10). Begum (11) compared children in households who joined the Dairy Development Project in Bangalore (India) to children in other families. The objectives of the dairy intervention in Ethiopia were to enable resource-poor smallholder farmers to participate in market-oriented dairying and to test the use of crossbred dairy cows for traction in addition to milk production. With the crossbred cows, the project introduced complementary dairy technologies. Ahmed et al. (12) studied the consumption and income aspects of this intervention and Tangka et al. (13) investigated the gender effects. The other dairy intervention was the Kenyan National Dairy Development Project (14). Intensive dairy technology was promoted through the introduction of crossbred cows and fodder production.

Poultry intervention studies were conducted in Egypt and Bangladesh. In Egypt, a small-scale agricultural project implemented 31 agricultural interventions in 2 villages, covering poultry production and most of the crops. Almost one-half of the poultry farmers were women (15). The Participatory Livestock Development Project in Bangladesh promoted semiscavenging poultry production by rural poor women in small-scale enterprises (16). The Bangladesh Smallholder Livestock Development Project included the establishment of village organizations, awareness education, technical training, and credit programs to increase per capita income and to promote animal protein consumption among the rural poor in Bangladesh. All program beneficiaries were women (17).

The last 3 studies evaluated integrated interventions combining the promotion of different forms of food production with nutrition education. The Dairy Goat Development Project in Ethiopia was targeted at women who were offered training in better dairy goat husbandry. Women received local goats and then crossbred goats. The project included health and nutrition education, training in gardening and food preparation, and the distribution of vegetable seeds (18,19). An intervention in Vietnam promoted the production of fish, eggs, and livestock, as well as home gardening and nutrition education for mothers of preschool children (20). The project in Thailand promoted the production and consumption of vitamin A-rich foods (e.g. eggs and green leafy vegetables) and included a school-based nutrition program (nutrition education, improving school lunches, poultry-raising, and fish ponds) targeted to 10- to 13-year-old schoolgirls. These girls received a weekly iron supplement of 60 mg ferrous sulfate (21).

**Impact on production.** Most studies reporting the impact of the intervention on production found increased AP following the intervention.

**Impact on income and expenditure.** Six studies examined income or expenditure effects. Bouis et al. (6) found a modest, positive income effect in the aquaculture project in Bangladesh. The dairy cooperative project in India increased household income and expenditure (10). The study on market-oriented dairying in Ethiopia reported both increased food and nonfood expenditures. The income of households adopting market-oriented dairying was 72% higher than the income of nonadopters and income was positively associated with food and nonfood expenditures (12). Women in coastal Kenya reported increased household income from dairy production as well as increased food purchases, school fee payments, and book purchases (14). The first poultry intervention project in Bangladesh reported increases in the sales of chickens and eggs (16), and the next project found that economic conditions of households had improved and that food and nonfood expenditure increased (17).

**Impact on caregiver income.** The 4 studies examining the impact of AP on women’s (control over) income reported mixed results. The qualitative study on cage aquaculture in Bangladesh found that the impact on women’s income and control varied greatly among regions, villages, and households, but the study....
did not investigate the determinants of this variation (9). The dairy study in Ethiopia found that men’s incomes benefited significantly more than women’s (13). Women in the dairy project in Kenya reported increased household and women’s income (14). Finally, women in a poultry study in Bangladesh reportedly gained influence in deciding on the use of income (17).

Impact on caregiver time and workload. Only 4 studies reported (limited) information about caregiver time and workload. Bouis et al. (6) found that the demands on women’s time from aquaculture in Bangladesh were relatively small. The qualitative study on cage aquaculture in Bangladesh found that women were responsible for time-consuming activities such as the collection and preparation of feed (9). It is not clear whether the total time burden increased or whether there was any impact on childcare activities. Women in 32 households in an intensive dairy technology project in Kenya reported that the project’s benefits came at the expense of a higher workload (14). In Ethiopia, women’s dairy-related labor was not different between households with crossbred or locally bred cows (13).

Impact on zoonosis. We found no studies that examined the impact of the promotion of AP on zoonosis.

Impact on dietary intake. The polyculture fish production intervention in Bangladesh did not affect overall fish consumption.

---

**TABLE 1** Overview of the reviewed intervention studies

| Type of intervention | Country (reference) | Intervention | Production | Income and expenditure | Maternal income | Maternal time and workload | Dietary intake | Nutritional status |
|----------------------|---------------------|--------------|------------|------------------------|----------------|---------------------------|----------------|------------------|
| Aquaculture          | Bangladesh (6)      | Polyculture fish production in household-owned or group-managed ponds to improve income (primary objective) | Yes         | Yes                    | Yes            | Yes                       | Yes            |                  |
|                      | Bangladesh (7)      | Poor farmers trained in carp culture. Household ponds were stocked with carp and either mola or other small indigenous fish species | Yes         |                          |                |                           |                |                  |
|                      | Bangladesh (8)      | Aquaculture extension (pond aquaculture): monoculture of tilapia or silver barb or polyculture of native and exotic carp species using on farm resources | Yes         | Yes                    | Yes            | Yes                       | Yes            |                  |
|                      | Bangladesh (9)      | Cage aquaculture development project in a non-Muslim dominated area in Bangladesh | Yes         | Yes                    |                |                           | Yes            | Yes              |
| Dairy                | India (10)          | Integrating rural households into a market economy; dairy cooperatives were set up in the villages | Yes         | Yes                    |                |                           | Yes            |                  |
|                      | India (11)          | Dairy Development Project of the Indian government; formation of dairy cooperatives | Yes         |                          |                |                           | Yes            |                  |
|                      | Ethiopia (12,13)    | Market oriented dairying for resource-poor smallholder mixed-crop and livestock farmers; use of crossbred dairy cows for milk production and traction | Yes         | Yes                    | Yes            | Yes                       | Yes            | Yes              |
|                      | Kenya (14)          | National Dairy Development Project: intensive dairy technology through introduction of crossbred cows, fodder production | Yes         | Yes                    | Yes            | Yes                       | Yes            | Yes              |
| Poultry              | Egypt (15)          | More and Better Food Project; combined activities promoting plant production with AP (poultry); 47% of poultry farmers were women | Yes         | Yes                    |                |                           | Yes            |                  |
|                      | Bangladesh (16)     | Participatory Livestock Development Project supporting semiscavenging poultry production; loans and technical assistance are provided through women’s groups | Yes         | Yes                    |                |                           | Yes            |                  |
|                      | Bangladesh (17)     | Saving schemes, technical training for poultry rearing and credit programs; project beneficiaries were all women | Yes         | Yes                    | Yes            |                           | Yes            |                  |
| Interventions        | Ethiopia [18,19]    | Women focused goat development project without impact on nutrition expanded: promote vitamin A intake, nutrition and health education, training in gardening, food preparation and distribution of vegetable seeds; school garden clubs | Yes         | Yes                    |                |                           | Yes            |                  |
| including nutrition  | Vietnam (20)        | Fish ponds; livestock; home gardens; nutrition education | Yes         | Yes                    |                |                           | Yes            |                  |
| education            | Thailand (21)       | Promotion of poultry and rabbit raising and home gardens through a community based intervention; nutrition education; school-based nutrition program targeted to 10- to 13-y-old schoolgirls | Yes         | Yes                    |                |                           | Yes            |                  |

1. No studies were found on zoonosis.
but led to a greater consumption of larger fish, which are less nutritious than smaller fish and may thus have decreased dietary quality (6,7). There was no impact on total fish consumption in the Roos et al. (7) study in Bangladesh. Based on the reported total production and the proportion of the harvest consumed by the household, intervention households and their neighbors seem to have consumed more fish in the Thompson et al. study (8), but no statistical tests were provided.

In the Karnataka project, households in villages with cooperatives consumed less milk than households in villages without cooperatives. The nutrient consumption of households with cows in villages with cooperatives rose, whereas that of nonproducing households in those villages fell (10). In the second dairy project in India, only children (1–4 y) in households producing >5 L milk/d had adequate dietary protein intake. Children in households producing less milk were worse off. The same pattern was found for dietary energy intake, but none of the groups met the Recommended Dietary Allowance requirement (no statistical tests provided) (11). Households with crossbred cows in Ethiopia consumed more energy, fat, protein, retinol, and iron than nonadopters (12). In Kenya, women reported increased milk consumption as a consequence of an intensive dairy technology project (14).

The 3 interventions that promoted poultry production had a positive effect on dietary intake. Iron, total protein, and animal protein intake were higher in participating than in nonparticipating households in the agricultural intervention project in Egypt (15). The semiscavenging poultry intervention project in Bangladesh did not increase egg or chicken consumption. The adopting households, however, ate more fish (16). The other poultry production intervention project in Bangladesh resulted in increased consumption of eggs, chicken, fish, meat, milk, and grains (17). The studies in Bangladesh suggest effects on dietary intake operated through increased income.

The integrated studies generally found positive effects. In Ethiopia, children in participating households had slightly more diverse diets and were significantly more likely to drink milk >4 times per week. Participating households consumed egg yolk at a low rate of 0.46 per week, but this was significantly higher than in the control households (0.29 times per week). Most produced milk was used in the form of boja, a traditional tea consumed by adults (18,19). In Vietnam, the intervention group had greater intake of vegetables, fruits, energy, protein, vitamin A, and iron (20). In Thailand, vitamin A intake increased in both intervention and control groups, although the increase was greater in the intervention group. Iron intakes increased in lactating women in both the intervention and control groups, in 2–5 y olds in the control group, and in 10- to 13-y-old schoolgirls in the intervention group (21). The authors could not explain these inconsistent findings.

Impact on nutritional status. Only 4 studies evaluated the impact on nutritional status. The prevalence of iron deficiency anaemia dropped in school-aged children during the intervention period in Egypt, which can be plausibly assigned to the reported increase in ASF consumption (15). The goat development project in Ethiopia did not affect child growth but was associated (no statistics provided) with a lower prevalence of night blindness and Bitot’s spots (18). In Thailand, serum retinol and ferritin levels increased significantly in school-age girls. The increase in hemoglobin levels did not reach statistical significance (21). The improved dietary intake in children in Vietnam was accompanied by a positive impact on child growth (20). The composite nature of the last 2 interventions makes it impossible to estimate the contribution of the AP to the effect.

Discussion

Studies with direct measurements of the impact of the promotion of AP on nutritional status are rare. Furthermore, many of the studies identified for this review suffered from important limitations in their design, evaluation, and analysis, a problem previously identified in Ruel’s (1) review of food-based interventions. These limitations included lack of replicated units of intervention and analysis, the inappropriate selection of a control or comparison group, and inappropriate control for confounding factors and intermediary outcomes.

The reviewed studies in general show increased AP resulting from the wide range of interventions. The agreement among studies, despite their shortcomings, leads us to conclude that AP can be successfully promoted.

The interventions associated with clear improvements in dietary intake and nutritional status belong to 2 groups: women either played a critical role in the intervention or the interventions included a nutrition education component. The only well-conducted study forming an exception is Alderman’s (10) evaluation of the dairy cooperatives in India. Although study limitations prevent attributing the effects to the interventions, the findings of the importance of women and nutrition education are consistent with earlier findings in the literature: women tend to be more concerned with the health and well-being of children than men (22) and the inclusion of nutrition education and behavior change components make food-based interventions more effective (1). The positive impact on nutritional status found in the 4 studies reporting this outcome can be plausibly attributed to the intervention, because dietary intake improved in these studies as well. Due to the integrated nature of 2 of the interventions, the contribution of the AP component to the improvement in nutritional status could not be determined. A limitation of many studies was that dietary intake was derived from household-level data, ignoring potential intra-household allocation preferences. Finally, many studies did not report clearly how dietary intake was measured.

All studies reporting household income or expenditure found a positive association between these outcomes and AP. The 2 studies with the strongest methodological design found a modest, positive effect on income and a positive effect on income and expenditure, respectively (6,10). Even though the other 5 studies had limitations, the reported income and expenditure effects are consistent with the best-conducted studies.

The evidence from intervention studies with respect to women’s (control over) income from livestock production activities is limited. Introducing livestock production or intensifying current production systems may lead to an increase in women’s workload, but the small number of studies reporting this outcome shows that this is not a general pattern. This is confirmed by observational studies showing that the specific nature of women’s responsibilities varies widely by region, ethnic group, and production system (23). Several important questions remain. First, more well-conducted studies are needed to strengthen the evidence that nutritional status can be improved through the promotion of AP and how the effectiveness of these interventions can be increased. Whether nutritional status improves as a direct effect of increased production or an indirect effect of increased income needs to be established as well.

Second, livestock may provide a real opportunity for women to increase their income in some situations. In other situations, however, it merely leads to a significant increase in women’s workload without a considerable effect on their control over the
additional resources. A concern of a number of authors is that the market orientation of smallholders may lead to women losing control over income to men (24).

Third, little is known about the impact on caregivers’ time and workload. Reasonable workloads and adequate time availability are factors determining the ability of mothers or caregivers to provide adequate childcare (25). The potential benefits of AP may be offset by a decrease in time spent on childcare (26).

Fourth, current understanding does not allow us to predict the impact of promoting animal husbandry on the spread of zoonotic infections. In malaria-endemic areas, for example, the introduction of livestock could range from a zoonoprophylactic to a potentiating effect on malaria transmission. The potential negative impact likely varies depending on disease virulence, number of animals at risk, dependency on AP for livelihood, and method of control (27). Current research efforts are insufficient, with fewer than 300 U.S. researchers focusing on emerging diseases from animals (28). More research thus needs to be conducted to advance our understanding, because for those taking up AP on a small scale to improve nutrition, it is possible that more harm than good could be done if zoonotic infections increase, leading to illness of children and adults and consequent lost production and livelihood.

Fifth, ASF tend to be rich in energy, saturated fat, and cholesterol, all of which have been associated with increased risk of chronic disease in well-nourished populations (29). Little is known about the trade-off between the health benefits of animal products as a rich source of micronutrients and the risk of chronic disease. In 2 recent studies, the authors pointed out that in healthy diets, the beneficial role of meat outweighs the uncertain association with cancer (30,31).

In summary, with only 4 studies looking at nutritional status, the evidence is insufficient to answer whether the promotion of AP is an effective means to alleviate undernutrition. Notwithstanding the positive impact on 3 intermediary outcomes (production, dietary intake, and household income), little is known about potential negative effects on maternal time and workload, maternal income, and the risk of concomitantly promoting zoonosis. The possible risk of chronic diseases is not well understood either. Well-designed studies using rigorous analytic strategies are urgently needed to evaluate the true potential of the interventions promoting AP. Studies focusing on whether AP interventions work will contribute little to our understanding if they do not simultaneously evaluate why the interventions work (or do not work). To fully judge the net impact and trade-offs of AP on health, these studies need to evaluate the impact of AP both on nutritional status and on the intermediary outcomes shown in Figure 1.

Acknowledgments
Thomas Randolph and Charles Nicholson provided leadership for the overall project. The International Food Policy Research Institute (IFPRI) provided additional logistical support for discussion meetings. IFPRI staff Marie Ruel, Mary Arimond, and Ken Simler and International Livestock Research Institute staff Shirley Tarawali and Jitske Brouwer provided numerous helpful suggestions on previous versions of this document.

Literature Cited
1. Ruel MT. Can food-based strategies help reduce vitamin A and iron deficiencies? A review of recent evidence. Washington, D.C.: International Food Policy Research Institute; 2001.
2. Allen L, Gillespie S. United Nations. Administrative Committee on Coordination. Sub-committee on Nutrition, Asian Development Bank. What works? a review of the efficacy and effectiveness of nutrition interventions. Geneva: United Nations Administrative Committee on Coordination Sub-Committee on Nutrition in collaboration with the Asian Development Bank; 2001.
3. Smitasiri S. A comment on how the nutritional impact of agricultural innovations can be enhanced. Food Nutr Bull. 2000;21:503–6.
4. Gittelsohn J, Vastine AE. Sociocultural and household factors impacting on the selection, allocation and consumption of animal source foods: current knowledge and application. J Nutr. 2003;133:S4036–41.
5. Berti PR, Krasevec J, FitzGerald S. A review of the effectiveness of agriculture interventions in improving nutrition outcomes. Public Health Nutr. 2004;7:599–609.
6. Bouis H, de la Briere B, Gutierrez I, Hallman K, Hassan N, Hels O, Quabili W, Quisumbing A, Thilsted S, et al. Commercial vegetable and polyculture fish production in Bangladesh: their impacts on income, household resource allocation, and nutrition. Washington, DC: International Food Policy Research Institute; 1998.
7. Roos N, Islam MM, Thilsted SH. Small indigenous fish species in Bangladesh: contribution to vitamin A, calcium and iron intakes. J Nutr. 2003;133:S4021–6.
8. Thompson PM, Sultana P, Nuruzzaman M, Firoz Khan A. Impacts of aquaculture extension on pond operators and the rural community. Tenth Biennial Conference of the International Institute of Fisheries Economies and Trade; 2000 June 10–14; Oregon. Corvalis (OR): IFIET; 2000.
9. Brugere C, McAndrew K, Bulcock P. Does cage aquaculture address gender goals in development? Results of a case study in Bangladesh. Aquac Econ Manag. 2001;5:79–89.
10. Alderman H. Cooperative dairy development in Karnataka, India: an assessment. Washington, DC: International Food Policy Research Institute; 1987. Research Report Series No.: 64.
11. Begum JM. The impact of dairy development on protein and calorie intake of pre-school children. Indian J Med Sci. 1994;48:61–4.
12. Ahmed MM, Jabbar M, Ehu S. Household-level economic and nutritional impacts of market-oriented dairy production in the Ethiopia highlands. Food Nutr Bull. 2000;21:460–5.
13. Tangka F, Ouma EA, Staal SJ. Women and the sustainable development of market-oriented dairying: evidence from the highlands of East Africa. International Sustainable Development Research Conference; 1999 Mar 25–6; Leeds, UK. University of Leeds; 1999.
14. Mullings G, Wahome L, Tsangari P, Maarse L. Impacts of intensive dairy production on smallholder farm women in coastal Kenya. Hum Ecol. 1996;24:231–53.
15. Galal OM, Harrison GG, Abdoul AI, Zein el Abedin A. The impact of a small-scale agricultural intervention on socio-economic and health status. Food Nutr (Roma). 1987;13:35–43.
16. Nielsen H, Roos N, Thilsted SH. The impact of semi-savaging poultry production on the consumption of animal source foods by women and girls in Bangladesh. J Nutr. 2003;133:S4027–30.
17. Nielsen H. The socio-economic impact of a smallholder livestock development project, Bangladesh. Integrated Farming in Human Development (workshop), Tune Landboskole (Denmark): Danish Agricultural and Rural Development Advisers Forum; 1996.
18. Ayalew W, Gabriel ZW, Habtemariam K. Reducing vitamin A deficiency in Ethiopia: linkages with a women-focused dairy goat farming project. Research Report. Washington, DC: International Center for Research on Women (ICRWW)/Opportunities for Micronutrients Interventions (OMNI); 1999. Report No.: 4.
19. Habtemariam K, Ayalew W, Habte GZ, Gebre MT. Enhancing the role of livestock production in improving nutritional status of farming families: lessons from a dairy goat development project in Eastern Ethiopia. Livestock Research for Rural Development. 2003;15.
20. English RM, Badcock JC, Giay T, Ngu T, Waters AM, Bennett SA. Effect of nutrition improvement project on morbidity from infectious diseases in preschool children in Vietnam: comparison with control commune. BMJ. 1997;315:1122–5.
21. Smitasiri S, Dhanamitta S. Sustaining behavior change to enhance micronutrient status: community-and women-based interventions in Thailand. Research Report. Washington, DC: International Center for Research on Women (ICRWW)/Opportunities for Micronutrients Interventions (OMNI); 1999. Report No.: 2.
22. Quisumbing AR, Brown LR, Feldstein HS, Haddad L, Pena C. Women: the key to food security. Food Policy Report. Washington DC: The International Food Policy Research Institute; 1995.

23. Niamir-Fuller M. Women livestock managers in the third world: a focus on technical issues related to gender roles in livestock production. Technical issues in rural poverty alleviation staff working paper. Rome: International Fund for Agricultural Development; 1994. Report No.: 18.

24. Huss-Ashmore R. Livestock, nutrition, and intrahousehold resource control in Uasin Gishu district, Kenya. Hum Ecol. 1996;24:191–213.

25. Engle PL, Menon P, Haddad L. Care and nutrition: concepts and measurement. World Dev. 1999;27:1309–37.

26. Quisumbing AR. Women, livestock, and family food security. Symposium on human nutrition and livestock in the developing world; October 14, 1998; Little Rock (AR): Heifer Project International; 1998.

27. Domenech J, Lubroth J, Eddi C, Martin V, Roger F. Regional and international approaches on prevention and control of animal transboundary and emerging diseases. Ann N Y Acad Sci. 2006;1081:90–107.

28. Guterman L. They came in the night. Chronicle of Higher Education. July 6, 2007;53:A11.

29. Hu FB, Willett WC. The relationship between consumption of animal products (beef, pork, poultry, eggs, fish and dairy products) and risk of chronic diseases: a critical review. Boston: Harvard School of Public Health; 1998.

30. Hill M. Meat, cancer and dietary advice to the public. Eur J Clin Nutr. 2002;56 Suppl 1:S36–41.

31. Biesalski HK. Meat and cancer: meat as a component of a healthy diet. Eur J Clin Nutr. 2002;56: Suppl 1:S2–11.