Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science

The importance of livestock for food security and nutrition in Sub-Saharan Africa

Boskapsdjurens betydelse för livsmedelsförsörjning och nutrition i Afrika söder om Sahara

Kajsa Bruhn

Independent project • 15 credits
Agriculture programme – Animal Science
Uppsala 2019

The importance of livestock for food security and nutrition in Sub-Saharan Africa

Boskapsdjurens betydelse för livsmedelsförsörjning och nutrition i Afrika söder om Sahara

Kajsa Bruhn

Supervisor: Ewa Wredle, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management

Examiner: Mikaela Lindberg, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management

Credits: 15 credits
Level: Basic G2E
Course title: Självständigt arbete I Husdjursvetenskap
Course code: EX0865
Programme/education: Agronomprogrammet- husdjur
Course coordinating department: Department of Animal Nutrition and Management

Place of publication: Uppsala
Year of publication: 2019
Cover picture: Ewa Wredle
Online publication: https://stud.epsilon.slu.se

Keywords: Undernourishment, stunting, livestock ownership, animal source foods, diarrhea

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Nutrition and Management

Sammanfattning

I Afrika söder om Sahara lider 222 miljoner människor av undernäring och regionen har den högsta förekomsten av undernäring i världen. Förekomsten av hushåll vilka håller boskapsdjur är hög i regionen, vilket gör deras inverkan på undernäring och livsmedelsförsörjning till en intressant aspekt att undersöka. Målet med studien var att undersöka hur livsmedelsförsörjning och nutrition i Afrika söder om Sahara påverkas av tillgången till boskapsdjur och livsmedel av animaliskt ursprung, med fokus på näringsvärden i mat av animaliskt ursprung och hållning av boskapsdjur. Studien är en litteraturgenomgång och resultaten är baserade på vetenskapliga artiklar, böcker och rapporter som är relevanta för ämnet. Det nuvarande läget av malnutrition och livsmedelsförsörjning i regionen presenteras, följt av vilken påverkan mat av animaliskt ursprung har på nutrition, tillväxt och kognitiv utveckling hos barn. Därefter beskrivs positiva och negativa aspekter av att hålla boskapsdjur. Tillgång till livsmedel av animaliskt ursprung kan bidra till förbättrad tillväxt och näringsintag hos barn. Att äga boskap kan öka konsumtionen av livsmedel av animaliskt ursprung och förbättra tillväxten hos barn, men även förvärra nutritionen hos barn på grund av en ökad risk för zoonotiska infektioner och diarré. Slutsatsen är att tillgången till boskapsdjur och livsmedel av animaliskt ursprung kan ha en positiv effekt på nutrition och livsmedelsförsörjning i Afrika söder om Sahara när djurhållningen och förädlingen av animaliska produkter utförs på lämpligt sätt. För att mildra riskerna förenade med att hålla boskapsdjur och konsumera mat av animaliskt ursprung behövs resurser och utbildning inom dessa områden.

Abstract

In Sub- Saharan Africa 222 million people suffer from undernourishment, making it the region with the highest prevalence of undernourishment in the world. The prevalence of household livestock ownership is high in the region, making livestock's influence on undernourishment and food security an interesting aspect to further examine. The aim of this study was to investigate how food security and nutrition in Sub-Saharan Africa is affected by having access to livestock and animal source food, focusing on the nutritional values of animal source food and livestock ownership. This study is a literature review and the results are based on scientific articles, books and reports that are relevant for the subject. The current status of malnutrition and food security in the region is presented, followed by the impact of animal source foods on nutrition, growth and cognitive development in children. Positive and negative aspects of household livestock ownership are then described. The direct access to animal source foods can result in improved child growth and daily nutrient intake. Livestock ownership has been shown to increase consumption of animal source food and improve child growth, but also to worsen child nutrition due to an increased risk of zoonotic infections and diarrhea. In conclusion, having access to livestock and animal source food can have a positive impact on nutrition and food security in Sub-Saharan Africa if livestock keeping practices and processing of animal source foods are executed properly. To mitigate the risks of owning livestock and consuming animal source food, resources for and education on these practices are needed.

Introduction

The second UN Sustainable Development Goal (SDG) *No Hunger* is set to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"(United Nations, 2019). Targets of this SDG include: *2.1* - Ending hunger and ensuring access by all people to safe, nutritious and sufficient food, *2.2* - End all forms of malnutrition and *2.3* - Double the agricultural productivity and incomes of small-scale food producers, all by 2030. It is worth to note that achieving target 2.2 and end all forms of malnutrition will help in achieving several of the other SDGs (FAO, 2018). However, ending all forms of malnutrition poses a challenge as the world population continues to grow and the global demand for food is expected to increase with 50 percent by 2050 (FAO, 2017a).

Africa is the continent with the highest prevalence of undernourishment (PoU) in the world (FAO, 2018). Undernourishment is defined as having insufficient dietary energy intake, and the PoU is expressed as the percentage of the population suffering from undernourishment. The situation is most acute in the region of Sub-Saharan Africa (SSA) where more than one fifth of the population suffered from undernourishment in 2016. This can be compared to Europe and North America where the PoU in 2016 was less than 2.5 percent.

The prevalence of severe food insecurity, expressed as the percentage of the population that are unable to obtain nutritious, safe and sufficient food, was estimated to 33.8 percent in SSA in 2017 (FAO, 2018). Food insecurity is a major contributor to malnutrition, which includes undernutrition, obesity and micronutrient deficiencies (FAO, 2017b). Undernutrition can result in stunting and wasting (FAO, 2017b), and is often described as a number of Z-scores (standard deviations) above or below the reference median or mean value (WHO, 2019a). Stunting (low height-for-age) is a result of undernutrition, repeated infections and insufficient psychosocial stimulation (defined as physical and emotional stimulation through sensory input and an affectionate caregiver-child bond (WHO, 2006)), which will impair the growth and development of children (WHO, 2019b). Stunting before the age of two can result in poor cognition and educational performance, low adult wages and an increased risk of nutrition-related chronic diseases if accompanied by obesity later in life (WHO, 2019b). Wasting (low weight-for-height) is usually caused by acute starvation or severe disease (WHO, 2019c; WHO, 2019d) and can increase child mortality (Caulfield *et al.*, 2004). Overweight in children is defined as high weight-for-height (WHO, 2019e). Micronutrient deficiencies such as iron deficiency, or anemia, and vitamin A deficiency compose a serious threat to the public health (FAO, 2017b).

One asset that has the ability to contribute to food security is livestock, and it can do so in a number of ways (Kariuki *et al*., 2013). Despite the fact that household livestock ownership in SSA is high with an average of 71 percent of households owning livestock across 30 countries (Kaur *et al.*, 2017), the prevalence of food insecurity and undernourishment remains high (FAO, 2018). This makes livestock's contribution to nutrition and food security an interesting topic.

The aim of this study was to investigate the importance of livestock and animal source food (ASF) for food security and nutrition in Sub-Saharan Africa, mainly focusing on livestock ownership and the nutritional values of ASFs. Research question to be answered; How does having access to livestock and animal source foods affect food security and nutrition in Sub-Saharan Africa?

Literature review

Malnutrition in Sub-Saharan Africa

Out of the 804.2 million undernourished people in the world 241.3 million live in Africa, making it the continent with the highest PoU in the world (FAO, 2018). In Africa, SSA is the region with the highest PoU ranging between 8.2 percent in Southern Africa to 31.6 percent in Eastern Africa with an average of 22.3 percent in the entire region in 2016 (FAO, 2018). The situation is most pressing in Zimbabwe and Zambia where the PoU in 2016 was 47 and 45 percent, respectively (World Bank Statistics, 2019). After having decreased since 2005, the number of undernourished people in SSA has increased from 181 million in 2010 to 222 million in 2016 (FAO, 2018). This increase is possibly a result of increased conflict and violence in several parts of the world, as well as droughts and increasing food prices (FAO, 2018).

Stunting is observed in one third of children below the age of five in SSA, with the highest prevalence in Eastern Africa at 44 percent and the lowest in Southern Africa at 3 percent (FAO, 2017b). Sub-Saharan Africa accounts for 23 percent of global wasting, 7 percent of children below the age of five are affected by wasting and 14 percent of children born in the region weigh less than 2500 g. Vitamin A deficiency in pre-school children in SSA is 48 percent which is twice as high as the global prevalence, and 39 percent of women of reproductive age in the region suffer from anemia caused by iron deficiency. Out of all children below the age of five in SSA, 5 percent are overweight. For adolescents and adults, the prevalence of overweight is 14 and 40 percent respectively (FAO, 2017b). Restricted access to healthy foods can increase the risk of low birth-weight and stunting in children, which could be contributing factors to obesity and overweight later in life (FAO, 2018). Ending all forms of malnutrition and achieving target 2.2 is an important step in achieving several of the other SDGs, as described in Figure 1 (FAO, 2018). A cross-sectional study of four rural villages in Ethiopia by Haidar *et al*. (2005) investigated risk factors for child undernutrition. The results indicated that risk factors for undernutrition were low stature of mother, young motherhood, distance from household to water source, lack of health education, inappropriate eating habits (husband/adult served first), food taboos, lack of irrigation and absence of livestock.

Figure 1. How improved nutrition will help achieve several of the other SDGs. Adapted from: FAO (2018).

Food security in Sub-Saharan Africa

Despite the fact that enough food is produced in the world to cover everyone's requirements, more than 800 million do not have access to enough food (Sida, 2018). FAO divides food insecurity into different levels of severity (FAO, 2017b). The most severe level is defined by running out of food and not being able to eat for an entire day and is associated with undernourishment (FAO, 2017b; FAO, 2018). The moderate level is defined by uncertainty about the ability to obtain food, skipping meals and occasionally running out of food as a result of having insufficient resources or money (FAO, 2018). More than one third of people suffer from severe food insecurity in SSA (FAO, 2018)

There are four dimensions to food security that are linked to nutrition: availability (presence of sufficient quantities of food), access (sufficient physical and economic resources to obtain that

food), utilization (food preparation and storage, dietary diversity and feeding practices) and stability (availability, access and utilization are stable at all times) (FAO, 2017b; FAO, 2018). In SSA the agricultural productivity is generally low, forcing the region to rely on imports to achieve food availability (FAO, 2017b). Paying for food imports is a concern in several countries in the region, as it does not resolve food insecurity and takes resources away from other development agendas (FAO, 2017b). Physical and economic access to food can be measured in terms of sufficient road networks to food markets and Gross Domestic Product (GDP) per capita. The average per capita income in SSA is much lower than the world average, which could limit the economic access to food. In 2013, the relative price of food in the region was six times the price of the non-food items in the total household consumption basket of goods. This is twice the world average (FAO, 2017b). In addition, poorer households generally spend a bigger proportion of their income on food than wealthier households (FAO, 2016). Feeding practices such as food taboos, the adults or husband in the family being served first and not exclusively breastfeeding children younger than 6 months has been associated with undernutrition (Haidar *et al*., 2005). The stability in SSA is possibly affected by climate extremes and rising food prices (FAO, 2017b).

Health, nutrition and livestock

Nutrition and animal source foods

Livestock have the unique capacity of converting inedible, less palatable and low value protein foods into palatable, nutrient dense and high value protein foods (Smith *et al*., 2012). High value proteins are of particular importance for growth of children and infants, and animal sourced proteins are generally of higher quality, defined by their amino acid composition, than most plant sourced proteins (Willett *et al*., 2019). Compared to plant sourced foods, ASFs are generally richer sources of vitamin A, vitamin B12, Calcium, Zinc, Iron and vitamin B2 (Murphy & Allen, 2003). In addition, the bioavailability of these nutrients is often higher in ASF than in plant source foods. As plant source foods barely contain any vitamin B12, the requirement of vitamin B12 must be met by ASFs. All these nutrients are essential to young children's health and if consumption of these nutrients is too low children will most likely suffer from health issues as a result (Murphy & Allen, 2003). Besides the composition of nutrients in ASF, the high biological value and amino acid composition of animal source proteins complements cereals and vegetable proteins (Bender, 1992). However, the nutritional value of ASF is less important in industrialized countries due to a greater availability of various foods. When there is no informed selection of foods, adding small amounts of ASFs will complement a plant based diet to meet the nutrient requirements (Bender, 1992). Excessive consumption of red meat and hard cheese (high in saturated fat) as well as processed meat can however be associated with coronary heart disease and pancreatic cancer respectively (Bender, 1992; Larsson & Wolk, 2012; Smith *et al*., 2012).

The major sources of energy in SSA are cereals and roots, which represent two thirds of the total energy supply, compared to global figures where starchy food is less than half of the energy supply (FAO, 2017b). The total average supply of protein in SSA is 59 g/capita/day,

compared to the world average at 79 g/capita/day (FAO, 2017b). The average supply of protein of animal origin in the region is low at 13 g/capita/day. This can be compared to North America, Europe and the world average, and varies greatly between countries as shown in Figure 2 (FAO, 2013; FAO, 2017b). The safe level of daily protein intake (defined as two standard deviations above the average daily protein requirement) for children 1-5 years ranges between 13.5-17.5 g. For an adult male at 75 kg and an adult woman at 60 kg, the safe level of daily protein intake is 56 and 45 g respectively. This is calculated for protein of the same quality and digestibility as eggs or milk (WHO, 1985).

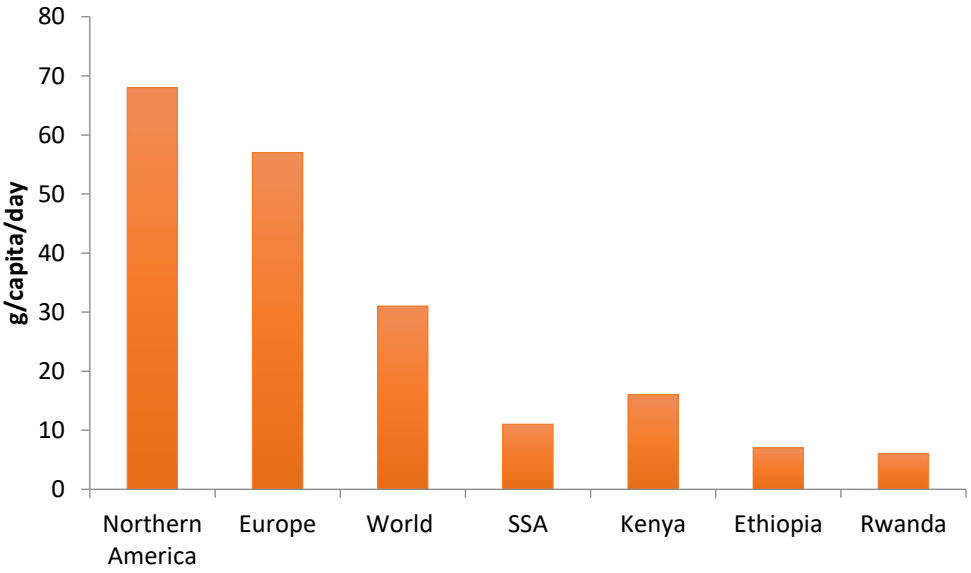

Figure 2. Average supply of protein of animal origin 2011-2013 (g/capita/day) (FAO, 2013).

Heady *et al*. (2018) investigated the linkage between child stunting and consumption of ASF in children between 6-23 months of age through multi-country household survey data from 49 countries in 5 regions: Central, South, Central and South-East Asia; Latin America and Caribbean; Middle East and Northern Africa; West and Central Africa; Eastern and Southern Africa. Children younger than 6 months were not included since growth benefits of complementary foods is not expected to be instantly observed, and these children should be exclusively breastfed. Results from this study show that Latin America and Caribbean was the region with the lowest prevalence of stunting at 22.4 percent, and the highest percentage of children consuming ASF at 82.9 percent. Eastern and Southern Africa had the second highest prevalence of stunting at 37.4 percent (the prevalence in South, Central and South-East Asia was 37.7 percent), and the lowest consumption of ASF at 49.3 percent. Milk, eggs and meat/fish were the three ASFs included in the survey, and fish was the dominating ASF in West and Central Africa. In Latin America and the Caribbean 20.6 percent of children had consumed all three ASFs within the last 24 hours, compared to West and Central Africa and Eastern and Southern Africa where only 4.4 and 3.2 percent respectively had consumed all three ASFs within the last 24 hours. Consumption of multiple ASFs and particularly of dairy seems to have especially beneficial effects on child stunting according to the study.

Murphy *et al*. (2003) utilized data from the Child Nutrition Project feeding intervention to identify the effects of ASF on Kenyan school children's daily nutrient intake. Four types of feedings were assigned to twelve different schools for a total of 21 months. The four feeding interventions were: no feeding (Control group), githeri (a stew made out of beans, maize, vegetable oil and greens) and meat, githeri and milk, and githeri with vegetable oil (Energy group) added to provide the same amount of energy as the milk and meat feedings. After feeding the daily intake of vitamin B12, vitamin B2, vitamin A, available iron and available zinc increased significantly in the Meat group. The Milk group had a higher increase in intake of vitamin B12, vitamin B2, vitamin A and Calcium compared to the Control group. The Energy group had a significant decrease in intake of vitamin B12 and available zinc, and a significant increase in daily intake of vitamin A.

Cognitive development, educational performance and animal source foods

Whaley *et al*. (2003) studied the effect of ASFs on the cognitive development of Kenyan school children using data from the same project as Murphy *et al*. (2003). Cognitive assessments were made on all children during this period, and they were tested for their ability to organize perceptual details (by completing a matrix arrangement of symbols using a test called the Raven's Progressive Matrices test), as well as their verbal and arithmetic knowledge (addition, subtraction, division and multiplication). Children in the Meat group performed better on the Raven's test than the other groups. There was no significant difference between the groups on the verbal test. Children in the Meat and Energy groups performed better than both the control group and the Milk group on the Arithmetic test. Hulett *et al*. (2014) also used data from the Child Nutrition Project to evaluate the effect of ASF on school performance. Test scores in the Meat group improved significantly compared to the control group in Arts, Arithmetic, English, Geography, Kiembu and Kiswahili. Test scores in the Milk group also improved significantly to the control group in English, Geography, Kiswahili and Science. Neither the energy group nor the control group showed a significant improvement in test scores in any of the subjects. The Meat group had the lowest test scores prior to the start of the feeding intervention, but achieved the highest total test scores and highest test scores in several of the subjects after the feeding intervention. The Milk group did not achieve significantly higher test scores than the Meat group in any of the subjects.

Livestock ownership

Livestock can contribute to food security through deriving income from selling livestock products that can then be used to purchase food (Kariuki *et al*., 2013). An increased supply of livestock products will lower the price and increase access to these products for the poor, and farming productivity can be improved by using livestock for traction and manure. In addition, livestock enables direct access to ASF to households (Kariuki *et al*., 2013). Participants in a study by Dumas *et al*. (2018) described that livestock improved household welfare through food security, financial security, labor and social benefits, such as feeding guest or celebrating

weddings and holidays. The same participants described that livestock cost the household in terms of time and investment capital.

Positive impacts on nutrition and health

Studies have shown that there are positive impacts of owning livestock on nutrition and health. In a study by Choudhury and Headey (2018), the correlation between household dairy production and child growth in Bangladesh was examined. Data from a survey showed that the sample of children was highly undernourished (low mean height-for-age scores) and that 30 percent of the children below the age of two were stunted. Households were divided into three groups; households that did not own dairy cows (control group), households with dairy cows that had not produced milk within the last 12 months (placebo), and households with dairy cows that had produced milk over the last 12 months (treatment). Children in the treatment group consumed more milk, however calorie intake was higher in the placebo group. Owning cattle that produced milk had benefits for child growth especially in children between 6-23 months by increasing height-for-age. A similar study conducted in Ethiopia (Hoddinott *et al*., 2015) found that cow ownership increased consumption of dairy products in children aged 6-24 months. Household cow ownership also raised the height-for-age in children between 12-24 months and stunting was reduced by 10 percent. However, there was no significant difference in dairy consumption or growth in households that owned cows, when there was a sizable market within the village.

In Rwanda, the Heifers international livestock donation programs donated dairy cows or meat goats to different households. Rawlins *et al*. (2014) evaluated the impact from the donation programs, and found that households that received a dairy cow consumed more dairy than the control group (did not receive a dairy cow) and showed a significant increase in height-for-age. In households that received a meat goat no significant effect on height-for-age was shown, however weight-for-height increased. Both the meat goat and dairy cow donations increased weight-for-age. Hetherington *et al*. (2017) utilized data from seven village clusters in seven different countries in rural SSA. Significant positive associations were shown between owning dairy cattle and consuming milk in three of the village clusters, and owning poultry and consuming poultry meat in two of the village clusters. One of the village clusters showed higher height-for-age in households that owned livestock. In two of the village clusters children from households that had consumed ASF within the last 30 days had better anthropometric scores (based on height, weigh and mid-upper arm circumference measurements) than children from households that had not. Weight-for-height was higher from households that consumed poultry meat in one of the village clusters. De Bruyn *et al*. (2018) conducted an observational study of eight rural communities in Tanzania. Results showed that the number of chickens owned by a household was positively associated with chicken consumption by mothers and non-exclusively breastfed children.

Negative impacts on nutrition and health

Owning livestock does not always equal better health and nutrition. Livestock keeping in domestic environments can be associated with an increased risk of diarrhea and zoonotic infections (Zambrano *et al*., 2014). A cross-sectional study of 30 countries in SSA suggested that although livestock ownership had a protective effect on stunting, child mortality in 22 of the 30 countries was negatively impacted by ownership of livestock (Kaur *et al*., 2017). In Egypt, El-Tras *et al*. (2015) found a positive association between keeping backyard poultry that were infected with *Campylobacter*, and *Campylobacter* infection in children. Risk factors of *Campylobacter* infected poultry were wet litter, manure in backyard and inadequate cleaning and sanitation. Symptoms of *Campylobacter* infections are bloody diarrhea, fever, abdominal pain and vomiting, and can in some cases cause the death of young children (WHO, 2018). *Campylobacter* are typically transmitted through contaminated water, raw milk and uncooked meat (WHO, 2018). Consumption of raw milk, which is common in Ethiopia, can be associated with food poisoning caused by toxins produced by *Staphylococcus aureus* (Desissa *et al.*, 2015). Symptoms of the food poisoning includes diarrhea, vomiting and abdominal cramps (Desissa *et al.*, 2015). Repeated diarrhea or intestinal infections of nematodes (transmitted through fecal contamination of soil) is associated with an estimated 50 percent of malnutrition in children (Prüss-Üstün *et al*., 2008). Pathogens from contaminated food, un-safe drinking water and contaminated hands are the major causes of diarrhea, resulting in 1.4 million child deaths every year (Prüss-Üstün *et al*., 2008).

In the study by Hetherington *et al*. (2017) households that owned livestock in one of the village clusters showed significantly lower height-for-age than households that did not own any livestock. This indicates that owning livestock could be a risk factor for child stunting. In two of the village clusters anthropometric scores were worse in households that had consumed ASF. In one of the village clusters weight-for-height was lower for households that consumed beef. Heady and Hirvonen (2016) suggested that the nutritional benefits of owning poultry depend on the exposure, particularly of children, to poultry. Their survey on Ethiopian households found that even though owning poultry was positively correlated with child height-for-age, keeping poultry in the main house overnight was negatively correlated with height-for-age, probably because of an increased risk of infection from poultry feces. When analyzing data from two nationally representative surveys from Ghana, Jones et al (2018) found a positive correlation between owning chicken and higher risk of anemia in children aged 6-59 months. However, chicken ownership was not associated with anemia in women of reproductive age, nor was livestock ownership of other species associated with anemia in children or women of reproductive age.

It is recommended to exclusively breastfeed children until 6 months of age, and adding complementary foods after 6 months while continuing to breastfeed (Dewey, 2003). Introducing unpasteurized cow's milk before 12 months of age can be associated with fecal blood loss and low iron status (WHO, 2005) and in the study by de Bruyn *et al*., (2018) consumption of milk was linked to an increased risk of child diarrhea. Studies have shown that

households with milk-producing cows are less likely to exclusively breastfeed children and high producing dairy households introduce cow's milk at a younger age (Cloudhury & Heady 2018; Wyatt *et al*., 2015). Early initiating of breastfeeding (children put to the breast within one hour of birth) as well as exclusive breastfeeding in children less than 5 months has been shown to lower the prevalence of diarrhea in children in Sub-Saharan Africa (Ogbo *et al*., 2017). Children that have been exclusively breastfed are also less likely to suffer from malnutrition (Haidar *et al*., 2005).

Discussion and conclusions

It is obvious that the situation in Sub-Saharan Africa is acute. More than one fifth of the population in SSA has insufficient dietary intake and more than 30 percent of the population experience food insecurity (FAO, 2018). The prevalence of stunting and wasting is high (FAO, 2017b), and due to the current situation the region will most likely be one of the major challenges in achieving SDG 2 as well as several of the other SDGs affected by nutrition. After writing this review, it has become clear that livestock can play a key roll in achieving food security and ending malnutrition in SSA.

The predicted global population growth will lead to changes in consumption patterns with an increased demand for ASFs (FAO, 2009), and livestock's big impact on the environment and climate change (Steinfeld, 2006) should not be forgotten, though it has not been included in this study.

One of the ways through which livestock contribute to improved nutrition in SSA is through the direct access to ASFs. Studies show the connection between consumption of ASFs and lower prevalence of child stunting (Heady *et al*., 2018), an increased intake of important nutrients (Murphy *et al*., 2003) as well as improved cognitive development and educational performance (Whaley *et al*., 2003; Hulett *et al*., 2014). It should however be noted that in the studies mentioned above, children in the Milk and Energy group had a lower intake of energy at home during the feeding intervention compared to the start of the intervention, which may have impacted the results of the studies. The Meat groups higher socioeconomic status and lowest test scores prior to the intervention suggests that the four groups were not homogenous, which poses a challenges when comparing different treatments. The Meat group might have shown a higher increase in test scores, as their scores were lowest prior to the intervention. However the Meat group still achieved the highest total test score out of the four groups. As the studies by Whaley *et al*. (2003) and Hulett *et al*. (2014) utilized the same data, and few other studies on the subject have been published, the linkage between cognitive development and educational performance and consumption of ASFs might not be completely established. However, the link between nutrient intake and cognitive development and school performance (Shariff *et al.,* 2000; WHO, 2019b), may suggest that better nutrition through consumption of ASF would improve cognitive development in school children in SSA. If this is the case, livestock enabling direct access to ASF will not only improve children's nutritional status, but

also improve mental capacity and result in higher adult wages. This could improve these children's economic access to food later in life, which in turn will help in achieving several of the other SDGs. It should however be noted that to further investigate how ASF contribute to nutrition, other animal proteins such as fish, insects and offal need to be included (Hetherington *et al*. (2017).

The benefits of owning livestock include increased consumption of ASF and increased height-for-age, weight-for-height and weight-for-age (Rawlins *et al*., 2014; Hoddinott *et al*., 2015; Hetherington *et al*., 2017; Choudhury & Headey, 2018; de Bruyn *et al*., 2018). These results indicate a linkage between livestock ownership and improved food security and child nutrition. However, in the study by de Bruyn *et al.* (2018) chicken ownership and egg consumption was not significantly associated, and children in milk-producing households in Bangladesh consumed less calories than children from households that owned cows that did not produce milk (Choudhury & Headey, 2018). Perhaps egg-producing households are more likely to sell their eggs or let them develop into a chick than to keep them for household consumption. As livestock provide financial security and serve as a "savings account" to the household (Dumas *et al*., 2018) perhaps they are not routinely slaughtered and therefore do not increase meat consumption. Results from studies on livestock ownership might also be affected by who actually owns the livestock. In the study by Rawlins *et al*. (2014), households had to meet certain criteria in order to qualify for livestock donation (e.g. be able to construct a shed, have access to at least one acre of land), and perhaps the results would be different if the poorest households were the one to receive livestock donation. The linkage between cow ownership and increased milk consumption was shown in several of the studies reviewed, which might indicate an awareness of the nutritional benefits of consuming milk. In the study by Wyatt *et al.* (2015) women were aware of the health benefits of milk, and even if milk was sold some of it was often kept for children's consumption. Women that introduced cow's milk to their children's diets prior to 6 months thought breast milk was inadequate. To maximize the way cow ownership contributes to food security and nutrition in SSA, education on the health benefits and risks of feeding cow's milk to children could be crucial. Improved nutritional status and physical and economic access to milk replacement for those women who are unable to produce sufficient breast milk or do not have time to breastfeed due to work might also be important factors.

However, owning livestock can increase the risk of diarrhea, zoonotic infections (such as *Campylobacter*) and childhood mortality (Zambrano *et al*., 2014; El-*Tras et al*., 2015; Kaur *et al*., 2017). Pathogenic infections might be the cause of up to 50 percent of malnutrition in the world, and the transmission of these pathogens can be mitigated through improved hygiene and sanitation (Prüss-Üstün *et al*., 2008). The linkages shown in studies between livestock ownership and increased risk for stunting, child anemia and lower weigh-for-age and height-for-age (Heady & Hirvonen, 2016; Hetherington *et al*., 2017; Jones *et al*., 2018) could very well be results of diarrhea and zoonotic infections caused by inadequate hygiene and domestic exposure to livestock. Pathogens may also be transmitted through un-safe drinking water,

contaminated food and other household's livestock (El-Tras *et al*., 2015). The linkage between owning poultry and lower height-for-age as well as an increased risk of anemia and *Campylobacter* infection in children (Heady & Hirvonen, 2016; El-Tras *et al*., 2015) could possibly be caused by the economic status of the household. Poultry seem to be of lesser value than other livestock (Dumas *et al.,* 2018), and might be more frequently owned by poorer households that in turn do not have access to a separate shed or clean water and proper sanitation, further exposing them to transmission of pathogens. In addition, since children in milk producing households are less likely to be exclusively breastfed these children might have a higher prevalence of diarrhea and therefore be more likely to suffer from malnutrition. In contrast, results from the study by de Bruyn *et al*. (2018) showed no association between chicken ownership, or keeping chicken inside overnight and an increased risk of child diarrhea, and ownership of cattle was associated with a reduced probability of child diarrhea.

The contrasting results from the studies reviewed indicate that the benefits of owning livestock might be affected by livestock keeping practices and education. Perhaps this is why food insecurity and undernutrition still remains high in the region, despite the high prevalence of livestock ownership and the many intervention studies that have been performed. By improving sanitation and hygiene in households that own livestock, transmission of pathogens can be mitigated (Prüss-Üstün *et al*., 2008) and the risks of diarrhea and zoonotic infections as well as their effects on undernutrition and mortality might be reduced. This improvement would require education on hygiene and processing of ASFs (e.g. boiling or fermenting milk (Desissa *et al.,* 2015) and cooking meat (FAO, 2018)) as well as economic resources, and could enable the full potential of livestock ownership improving child nutrition and food security in SSA.

It is also worth no note that since the impact of cow ownership on milk consumption and growth decreases when the household has access to a market (Hoddinott *et al.*, 2015), developing infrastructure and markets could improve food security and nutrition in SSA without household ownership of livestock. Removing livestock from the domestic environment could decrease the risk of transmission of pathogens, however livestock are an important source of income and financial security for many households in SSA (Dumas *et al.,* 2018), so perhaps this is not a possible solution at present.

Based on the information gathered in this literature study it can be concluded that livestock has the potential to play a key roll in ensuring food security and human nutrition in Sub-Saharan Africa, not only through the direct access of ASFs, but also through deriving income and improving crop productivity. Having access to and consuming ASFs, whether it comes from a village market or the household's own livestock, can improve child nutrition and later on adult wages and food security. This will be an important step towards achieving the other SDGs and ensure a sustainable future for all. However, the risks of household livestock ownership should not be overlooked, and to achieve the full nutritional benefits of owning livestock and consuming ASFs, education and resources for improved hygiene, nutrition and processing of

ASFs may be the way forward. To establish this connection between education on improved management practices and nutrition, further studies and interventions need to be performed on the subject.

References

Bender, A. (1992). *Meat and Meat Products in Human Nutrition in Developing Countries.* Food and Nutrition Paper 53. Rome: FAO. Available at: http://www.fao.org/3/t0562e/T0562E00.htm#Contents [2019-05-02].

Caulfield, L.E., de Onis, M., Blössner, M. & Black, R.E. (2004). Undernutrition as an Underlying Cause of Childhood Deaths Associated with Diarrhea, Pneumonia, Malaria and Measles. *American Journal of Clinical Nutrition,* vol. 80 (1), pp. 193-198. DOI: 10.1093/ajcn/80.1.193.

Choudhury, S. & Headey, D.D. (2018). Household Dairy Production and Child Growth: Evidence from Bangladesh. *Economics & Human Biology,* vol. 30, pp. 150-161. DOI: https://doi.org/10.1016/j.ehb.2018.07.001.

de Bruyn, J., Thomson, P.C., Darnton-Hill, I., Bagnol, B., Maulaga, W. & Alders, R.G. (2018). Does Village Chicken-Keeping Contribute to Young Children's Diets and Growth? A longitudinal Observational Study in Rural Tanzania. *Nutrients,* vol. 10 (11). DOI: https://doi.org/10.3390/nu10111799.

Desissa, F., Roesel, K., Makita, K., Teklu, A., Zewde, G. & Grace, D. (2015). Is Ethiopian Raw Milk Safe For Human Consumption? In: Roesel, K & Grace, D. (eds) *Food Safety and Informal Markets – Animal Products in Sub-Saharan Africa.* Abingdon: Routledge, pp. 135-139. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/42438/Food%20Safety%20and%20Informal%20Markets.pdf?sequence=4 [2019-05-02].

Dewey, K. (2003). *Guiding Principles for Complementary Feeding of the Breastfed Child.* Washington, DC: Pan American Health Organization and World Health Organization. Available at: https://www.who.int/nutrition/publications/guiding_principles_compfeeding_breastfed.pdf [2019-05-07].

Dumas, S.E., Maranga, A., Mbullo, P., Collins, S., Wekesa, P., Onono, M. & Young, S.L. (2018). "Men are in Front at Eating Time, but not When it Comes to Rearing the Chicken": Unpacking the Gendered Benefits and Costs of Livestock Ownership in Kenya. *Food and Nutrition Bulletin,* vol. 39 (1), pp. 3-27. DOI: 10.1177/0379572117737428.

El-Tras, W.F., Holt, H.R., Tayel, A.A., El-Kady, N.N. (2015). Campylobacter Infections in Children Exposed to Backyard Poultry in Egypt. *Epidimielogy and Infection,* vol.143 (2), pp. 308-315. DOI: 10.1017/S095026881400096X.

FAO, IFAD, UNICEF, WFP & WHO. (2018). *The State of Food Security and Nutrition in the World 2018. Building Climate Resilience for Food Security and Nutrition*. Rome: FAO. Available at: http://www.fao.org/3/I9553EN/i9553en.pdf#page=21 [2019-04-04].

FAO. (2009). *How to Feed the World in 2050*. Rome: FAO. Available at: http://www.fao.org/3/ak542e/ak542e00.htm [2019-04-18].

FAO. (2013). *Food Security Statistics.* Available at: http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#.XMrWvK3M2u5 [2019-05-02].

FAO. (2016). *Economic Analysis of Food Supply and Demand in Sub-Saharan Africa up to 2022 – Special Focus on Fish and Fishery Products.* Fisheries and Aquaculture Circular No. 1101. Rome: FAO. Available at: http://www.fao.org/3/a-i4455e.pdf [2019-05-02].

FAO. (2017a). *The Future of Food and Agriculture. Trends and Challenges.* Rome: FAO. Available at: http://www.fao.org/3/a-

i6583e.pdf?fbclid=IwAR2P0JEueHMn_Lujt3SMXduPgoFFCwdrI8MmW2Qx84B_rIkIV2bDifCtO9s [2019-05-21].

FAO. (2017b). *Regional Overview of Food Security and Nutrition in Africa 2016. The challenges of building resilience to shocks and stresses*. Accra: FAO. Available at: http://www.fao.org/3/a-i6813e.pdf [2019-04-16].

Haidar, J., Abate, G., Kogi-Makau, W. & Sorensen, P. (2005). Risk Factors for Child Under-Nutrition With a Human Rights Edge in Rural Villages of North Wollo, Ethiopia. *East African Medical Journal*, vol. 82 (12), pp. 625-630. DOI: 10.4314/eamj.v82i12.9367.

Headey, D. & Hirvonen, K. (2016). Is Exposure to Poultry Harmful to Child Nutrition? An observational analysis for Rural Ethiopia. *PLoS ONE*, vol. 11 (8): e0160590. DOI: 10.1371/journal.pone.0160590.

Headey, D., Hirvonen, K. & Hoddinott, J.(2018). Animal Sourced Foods and Child Stunting. *American Journal of Agricultural Economics*, vol. 100 (5), pp. 1302-1319. DOI: https://doi.org/10.1093/ajae/aay053.

Hetherington, J.B., Wiethoelter, A.K., Negin, J. & Siobhan, M.M. (2017). Livestock Ownership, Animal Source Foods and Child Nutritional Outcomes in Seven Rural Village Clusters in Sub-Saharan Africa. *Agriculture & Food Security*, vol. 6 (9). DOI: 10.1186/s40066-016-0079-z.

Hoddinott, J., Headey, D., Dereje, M. (2015). Cows, Missing Milk Markets and Nutrition in Rural Ethiopia. *The Journal of Development Studies*, vol. 51 (8), pp. 958- 975. DOI: 10.1080/00220388.2015.1018903.

Hulett, J.I., Weiss, R.E., Bwibo, N.O., Galal, O.M., Drorbaugh, N. & Neaumann, C.G. (2014). Animal Source Foods Have a Positive Impact on the Primary School Test Scores of Kenyan Schoolchildren in a Cluster-randomised, Controlled Feeding Intervention Trial. *British Journal of Nutrition*, vol. 111 (5), pp. 875-886. DOI: https://doi.org/10.1017/S0007114513003310.

Jones, A.D., Colecraft, E.D., Awuah, R.B., Boatemaa, S., Lambrecht, N.L., Adjorlolo, L.K. & Wilson, M.L. (2018). Livestock Ownership is Associated with Higher Odds of Anemia among Preschool-aged Children, but not Women of Reproductive Age in Ghana. *Maternal and Child nutrition*, vol. 14 (3): e12604. DOI: 10.1111/mcn.12604.

Kariuki, J., Njuki, J., Mburu, S. & Waihanji, E. (2013). Women, Livestock Ownership and Food Security, pp. 95-96. In: Njuki, J. & Sanginga, P.C. (ed.): *Women, Livestock Ownership and Markets – Bridging the gender gap in Eastern and Southern Africa.* Abingdon: Routledge. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/Women%2C%20Livestock%20Ownership%20and%20Markets.pdf [2019-04-17].

Kaur, M., Graham, J.P. & Eisenberg, J.N.s. (2017). Livestock Ownership among Rural Households and Child Morbidity and Mortality: An Analysis of Demographic Health Survey Data from 30 Sub-Saharan African Countries (2005-2015). *The American Society of Tropical Medicine and Hygiene*, vol. 96 (3), pp. 741-748. DOI: 10.4269/ajtmh.16-0664.

Larsson, S. C., & Wolk, A. (2012). Red and Processed Meat Consumption and Risk of Pancreatic Cancer: Meta-Analysis of Prospective Studies. *British Journal of Cancer*, vol. 106 (3), pp. 603–607. DOI: 10.1038/bjc.2011.585.

Murphy, S.P. & Allen, L.H. (2003). Nutritional Importance of Animal Source Foods. *The Journal of Nutrition*, vol. 33 (11), pp. 3932-3935. DOI: https://doi.org/10.1093/jn/133.11.3932S.

Murphy, S.P., Gewa, C., Liang, L-J., Grillenberger, M., Bwibo, N.O. & Neumann, C.G. (2003). School Snacks Containing Animal Source Foods Improve Dietary Quality for Children in Rural Kenya. *The Journal of Nutrition*, vol. 122 (11), pp. 3950-3956. DOI: https://doi.org/10.1093/jn/133.11.3950S.

Ogbo, F.A., Agho, K., Ogeleka, P., Woolfenden, S., Page, A., Eastwood, J. & Global Child Health Research Interest Group. (2017). Infant Feeding Practices and Diarrhoea in Sub-Saharan African Countries with High Diarrhoea Mortality. *PLoS ONE*, vol. 12 (2): e0171792. DOI: 10.1371/journal.pone.0171792.

Prüss-Üstün, A., Bos, R., Gore, F. & Bartram, J. (2008). *Safe Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. Geneva: WHO. Available at: https://apps.who.int/iris/bitstream/handle/10665/43840/9789241596435_eng.pdf [2019-05-14].

Rawlins, R., Pimkina, S., Barrett, C.B., Pedersen, S. & Wydick, B. (2014). Got milk? The impact of Heifer International's livestock donation programs in Rwanda on nutritional outcomes. *Food Policy*, vol. 44, pp. 202-213. DOI: https://doi.org/10.1016/j.foodpol.2013.12.003.

Shariff, Z.M., Bond, J.T. & Johnson, N.E. (2000). Nutrition and Educational Achievement of Urban Primary School Children in Malaysia. *Asia Pacific Journal of Clinical Nutrition*, vol. 9 (4), pp. 264-273. DOI: 10.1046/j.1440-6047.2000.00191.x.

Sida (2018). *Agriculture and Food Security.* Available at: https://www.sida.se/English/how-we-work/our-fields-of-work/agriculture-and-food-security/ [2019-05-03].

Smith, J., Sones, K., Grace, D., McMillan, S., Tarawali, S. & Herrero, M. (2012). Beyond Milk, Meat and Eggs: Role of Livestock in Food and Nutrition Security. *Animal Frontiers*, vol. 3 (1), pp. 6-13. DOI: 10.2527/af.2013-0002.

Steinfeld, H. (2006). *Livestock's Long Shadow: Environmental Issues and Options*. Rome: FAO. Available at: http://www.fao.org/3/a-a0701e.pdf [2019-05-15].

United Nations. (2019). *Sustainable Development Goals Knowledge Platform – Sustainable Development Goal 2*. Available at: https://sustainabledevelopment.un.org/sdg2 [2019-04-27].

Whaley, S.E., Sigman, M., Neumann, C., Bwibo, N., Guthrie, D., Weiss, R.E., Alber, S. & Murphy, S.P. (2003). The Impact of Dietary Intervention on the Cognitive Development of Kenyan School Children. *The Journal of Nutrition*, vol. 133 (11), pp. 3965-3971. DOI: https://doi.org/10.1093/jn/133.11.3965S.

WHO. (1985). *Energy and Protein Requirements*. Geneva: WHO. Available at: http://www.fao.org/3/aa040e/AA040E00.htm#TOC [2019-06-04].

WHO. (2005). *Guiding Priciples for Feeding Non-Breastfed Children 6-24 months of age*. Geneva: WHO. Available at: https://apps.who.int/iris/bitstream/handle/10665/43281/9241593431.pdf?sequence=1 [2019-05-14].

WHO. (2006). *Mental Health and Psychosocial Well-Being among Children in Severe Food Shortage Situation*. Geneva: WHO. Available at: https://www.who.int/mental_health/mental_health_food_shortage_children2.pdf [2019-05-10].

WHO. (2018). *Campylobacter*. Available at: https://www.who.int/news-room/fact-sheets/detail/campylobacter [2019-05-14].

WHO. (2019a). *The Z-score or Standard Deviation Classification System.* Available at: https://www.who.int/nutgrowthdb/about/introduction/en/index4.html [2019-04-28].

WHO. (2019b). *Stunting in a Nutshell.* Available at: https://www.who.int/nutrition/healthygrowthproj_stunted_videos/en/ [2019-04-16].

WHO. (2019c). *Child Growth Indicators and their Interpretation.* Available at: https://www.who.int/nutgrowthdb/about/introduction/en/index2.html [2019-04-16].

WHO. (2019d). *Moderate Malnutrition.* Available at: https://www.who.int/nutrition/topics/moderate_malnutrition/en/ [2019-04-29].

WHO. (2019e). *Cut-off points and summary statistics*. Available at: https://www.who.int/nutgrowthdb/about/introduction/en/index5.html [2019-04-29].

Willett, W., Rockström, J., Loken, B, Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A., De Vries, W., Sibande, L.M., Afshin, A., Chaudhary, A., Herrero, M., Augustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S & Murray, C.J.L. (2019). Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. DOI: https://doi.org/10.1016/S0140-6736(18)31788-4.

World Bank Statistics. (2019). Available at: https://data.worldbank.org/indicator/sn.itk.defc.zs?year_high_desc=true [2019-04-17].

Wyatt, A.J., Yount, K.M., Null, C., Ramakrishnan, U. & Webb Gerard, A. (2015). Dairy Intensification, Mothers and Children: an Exploration of Intfant and Young Child Feeding Practices among Rural Dairy Farmers in Kenya. *Maternal and Child Nutrition,* vol. 11 (1), pp. 88-103. DOI: 10.1111/mcn.12074.

Zambrano, L.D., Levy, K., Menezes, N.P. & Freeman, M.C. (2014). Human Diarrhea Infections Associated with Domestic Animal Husbandry: A Systematic Review and Meta-Analysis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, vol. 188, pp. 313-325. DOI: 10.1093/trstmh/tru056.