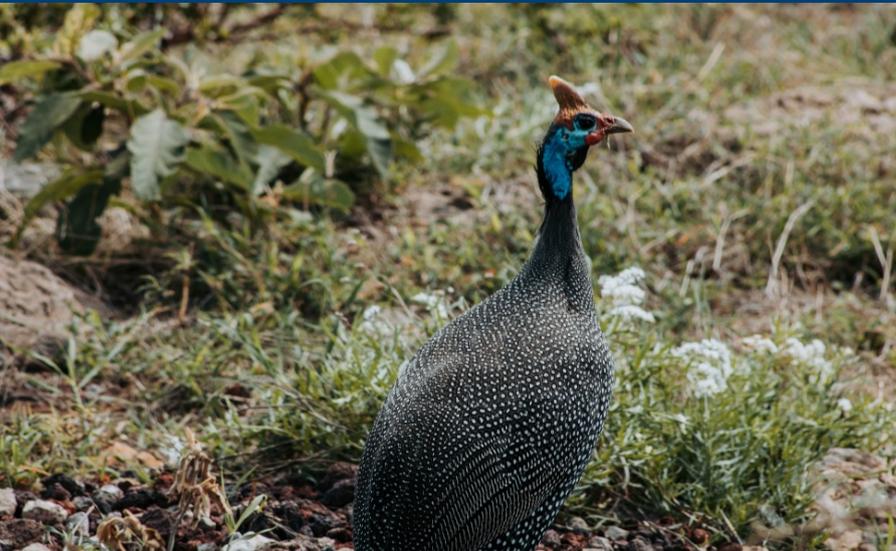




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Is there Unrecognized Potential in Neglected Livestock Species?

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Abstract

Population growth and changing consumption patterns have resulted in an increasing demand for animal protein, especially in Sub-Saharan Africa (SSA). In meeting this demand, efforts have been geared towards intensifying the production of conventional livestock species, namely cattle, sheep, and goats, as well as pigs and poultry. However, trade-offs that negatively impact the environment, human nutrition, gender relations and other socio-economic dimensions are associated with increased conventional livestock production. These negative trade-offs make it expedient to explore the production potentials of other livestock species, which have been neglected. Drawing parallels with neglected or “orphan” crops which have attracted increased research attention in recent years, there are still major knowledge gaps on the role that neglected livestock species could play in improving the sustainability of livestock production in SSA. To address these knowledge gaps, we present a systematic review of the literature on five neglected species, which could play a larger role in SSA: grasscutter, guinea fowl, guinea pig, rabbit, and donkey. Applying the checklist for “Preferred Reporting Items for Systematic Review and Meta-Analysis” (PRISMA) and using Boolean search operators for relevant terms in academic search engines, 128 studies were selected for this review. Criteria used to filter the search items included year of publication, Africa-centric reports, and a specific focus on the selected species. The results show that the opportunities for promoting neglected livestock species include their nutritional importance (high quality protein, low fat, high dressing percentage), high economic gross returns, environmental sustainability, and importance for women’s empowerment. However, the results also show considerable barriers including production challenges such as feed and nutrition as well as diseases and pests; institutional problems, such as exclusion from policies and development strategies, lack of research and extension, unavailability of credit facilities, inadequate markets, and animal welfare issues. We conclude that there are often fewer negative trade-offs in the production of these neglected categories of livestock than in the production of conventional livestock species. This study derives four policy recommendations to promote the improved production of neglected livestock species, namely: (1) institutional and policy inclusion; (2) research, development and genetic improvement; (3) awareness creation; and (4) strengthened value chains. If systematically implemented, these policy instruments could enhance the sustainable adoption of - and benefits from - these livestock for non-farm families, children, men and women farmers. Our review shows that neglected livestock species offer a high and largely unexploited economic and nutritional potential, which could yield considerable benefits in the future if given attention.

Keywords

Neglected livestock; Sub-Saharan Africa; Nutrition; Environmental sustainability

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1. Introduction

Livestock fulfil many of the economic, nutritional, and social needs of households in sub-Saharan Africa (Traoré et al., 2018; Herrero et al., 2013; World Bank, 2009; McDermott et al., 2010). Nationally, livestock also contributes significantly to the Gross Domestic Product (GDP) of African countries and the continent as a whole. For example, in Kenya and Nigeria, the livestock sector accounts for about 4.4% and 1.7% respectively (FAO, 2020). Livestock accounts for about 40% of Africa's agricultural GDP (Balehegn et al., 2021). The exponential population growth currently occurring in Africa is also expected to increase the demand for animal-source foods (ASF), which will drive the intensified production of livestock, famously termed the 'Livestock Revolution' (Delgado et al., 2001). However, as this livestock revolution unfolds, the intensification of livestock production has generated several negative environmental, nutritional, health, and socio-economic trade-offs (Herrero et al., 2009; Salmon et al., 2018; Swanepoel et al., 2010; Mehrabi et al., 2020). For example, due to intensified production, the livestock sector in Africa is responsible for more than 70% of agricultural Greenhouse Gas emissions, specifically due to enteric methane (CH₄), which is produced mostly by ruminants (Balehegn et al., 2021). This paradox – whereby livestock provides and destroys simultaneously – has resulted in increasing efforts to reduce negative trade-offs by developing a broader and deeper understanding of livestock production in Africa. For this reason, we want to provide some further insights into these pressing realities by focusing on some neglected livestock species.

There is a lot of attention on conventional livestock species such as cattle, poultry, sheep, and goat to meet the growing demand for ASF. In contrast, despite their known benefits, some categories of livestock such as poultry (guinea fowl), rodents (grasscutters and guinea pigs), rabbits and donkeys (Assan, 2013; FAO 2014; National Research Council, 1991) continue to be neglected. Long-standing and emerging evidence shows that livestock such as guinea fowl, grasscutter, guinea pig, rabbits, and donkey provide nutritional, economic, environmental, and cultural benefits that also contribute towards women's empowerment (Geiger et al., 2020; Moreki & Seabo, 2012; Lammers et al., 2009; Ibitoye et al., 2019). Collectively, these benefits could minimise the negative trade-offs associated with conventional livestock production and provide food security (Ibitoye et al., 2019; Owen & Dike, 2012; Yeboah, 2009; Benjamin et al., 2009), but have nonetheless been excluded from the mainstream discussions on livestock production. A parallel can be drawn based on the recognised neglect of certain crop species. More recently these 'neglected crops' have received considerable attention which has generated positive outcomes such as the established and unified term of "orphan crops",

increased consumption, and dedicated institutional and financial resources (Hendre et al., 2019; Jamnadass et al., 2020).

Among the reasons for paying less attention to neglected species is the 'small' size of animals, inferring a lack of apparent economic importance. Equating small animal size with low economic potential contrasts considerably with the 'underutilised' narrative applied to crops implying economic importance due to 'unexploited' potential or promise. Other reasons for this apparent exclusion include the lack of a unified name for neglected livestock species and a relatively underfunded animal breeding sector, compared to the crop breeding sector (Assan, 2013). Consequently, arguments are gradually emerging for more attention to be paid to this marginalised section of livestock . An understanding of marginalised livestock species is considered important to evaluate possible socio-economic implications for commercialisation and on the potential transmission and prevention of neglected zoonotic diseases (UNEP & ILRI, 2020; FAO, 2020). In the recent past, the consumption of bushmeat has led to the emergence and re-emergence of zoonoses like Ebola (Ibitoye et al., 2019), and the avian influenza (FAO, 2020). Scaling up the production of neglected species in urban and peri-urban areas to meet the demands of a growing population may increase antimicrobial resistance to diseases such as coccidiosis, pneumonia, or respiratory infection, affecting poultry and wild birds (guinea fowls), rabbits, guinea pigs, rodents (grasscutter) and glanders in donkeys.

In the light of the above, the objectives of this study are to:

1. Clarify the terminologies used in the literature for neglected animal species, by drawing parallels to the terms used for neglected crops (e.g., yams, millet);
2. Conduct a systematic review of the available literature on the selected neglected livestock species;
3. Carry out an in-depth analysis of the opportunities and barriers to the adoption of neglected species while exploring the consequences of their continued neglect in the face of the livestock revolution.

In the next sections, we review the terminologies (Section 2), provide an overview of the species included (Section 3), and the methodology adopted (Section 4). This is followed by the key findings from the review (Section 5), and the policy implications, which concludes the paper (Section 6).

2. Literature review of terminologies

This section describes three common terms used in the literature to describe neglected crop varieties and livestock species, and begins to explain the challenges for a consensus definition for the latter.

2.1 Neglected and underutilized species (NUS)

Neglected and underutilized species (NUS) as defined by Padulosi et al. (2013), is a term used to describe plants and crops that are paid little attention or are completely overlooked by agricultural researchers, plant breeders, and policymakers. Originally, the term NUS was applied to wild or semi-domesticated crop or forest plant species. NUS are generally not sold as products. According to the FAO (2017), the term NUS can also be substituted with terms such as “forgotten”, “underexploited”, “minor”, “orphan”, “promising” or “little-used”. There is a dearth of literature in which the term NUS has been applied in livestock research.

2.2 Micro-Livestock

Micro-livestock is a term used to describe inherently small species (National Research Council, 1991). Livestock that fall under this category are broadly categorized into two groups. The first group comprises smaller breeds of conventional livestock like goats, sheep, pigs, and cattle, which are called “micro-goats (e.g. American pygmy, west African dwarf)”, “micro-sheep” (e.g. Landim, Berber, Hejazi)”, “micro-pigs (e.g. Chinese dwarfs, Criollo)” and “micro-cattle (e.g. Rodope, N’dama, Zebu)”. The second category of micro-livestock consists of species that are naturally or genetically small (rabbit, grasscutter, guineapig, guineafowl among others) (National Research Council, 1991).

2.3 Minor species

“Minor species” is a term that has been used to describe animal species that are not considered to be one of the major species (defined as those livestock species that are the dominant animal sourced food-producing species) in the animal kingdom such as parrots, ornamental fish, and zoo animals (USFDA, 2020). With respect to livestock research, animal species that are of agricultural importance, and are not among the conventional animal species used as a major source of protein (such as poultry, cattle), are referred to as minor species. This group consists of species such as guinea pigs, goats, sheep, honeybees, catfish, and game birds (USFDA, 2020).

2.4 Challenges on consensus definition for neglected and underutilized animal species in comparison to crop species

Hardly any of the literature applies the terms neglected and underutilised to livestock research. Initially, this was also the case for crop species which were considered minor crops, orphan crops, forgotten crops, neglected crops, and underutilised crops (Chivenge et al., 2015). Some of these crops include roots and tubers (e.g., yam, cassava, cocoyam), cereals and legumes (e.g., finger millet, sesame, sorghum, Bambara groundnut, cowpea), as well as fruits and vegetables (e.g., baobab, wild plum, wild watermelon, marula, wild apricot, monkey orange). However, over the past 50 years, several terms have been mainstreamed to describe these crops, which include neglected, traditional, indigenous, new/future, and orphan crop species (Mabhaudhi et al., 2017).

Traditional crops are those identified to have great cultural importance and that are popular in certain geographic locations (Mabhaudhi et al., 2017). Indigenous crop species are those that were first cultivated within a particular geographical area and are often considered as not having reached their full development potential (Mabhaudhi et al., 2017). New or future crops are crops that have historically held little industrial importance due to their underutilization despite their capability to create additional value chains if given adequate research attention (Hendre et al., 2019). Orphan crops are non-major staple crops that are also termed as 'neglected and underutilized species' (NUS) (Padulosi et al., 2013).

While the definition of terms used in crop research has reached a consensus over the years, the same cannot be said for livestock research. One likely reason for this challenge is the absence of a consortium for neglected livestock research leading to a plethora of definitions applied in different contexts.¹ For instance, village poultry have been referred to as traditional, rural, local, backyard, indigenous, native, scavenging, or family poultry (Moreki et al., 2010). The unification of terminology for neglected livestock species may therefore be among the promising approaches for raising the profile of less researched animal species.

¹ In the case of crops, the African Orphaned Crops Consortium (AOCC) was formed in 2011 with the goal of providing nutritional security by improving locally-adapted nutritious food crops that are neglected, under-researched, and/or orphaned (Hendre et al., 2019). So far the AOCC have named 101 crops as traditionally neglected, under-researched or orphan African food crops. The African Union Development Agency (AUDA-NEPAD, formerly the New Partnership for African Development), World Agroforestry (ICRAF), Mars Inc., the University of California Davis (UCD), and the World Wildlife Fund (WWF) are among the organization's founding partners. The consortium involves participation between public organizations, firms in the private sector, and academic and research institutes as well as non-governmental organizations.

3. Overview of the species included

3.1 Selection criteria for the species

The five species were selected based on the representation of:

1. different animal sizes (micro and macro animals);
2. geographic scope in Africa;
3. diversity of animal groups (e.g. poultry, rodents);
4. differences in the level of domestication (species which are recently domesticated or not domesticated e.g., the grasscutter);
5. availability of literature (e.g. guinea fowl is more represented in the literature compared to other neglected poultry such as quails, pigeon, or doves but it is possible that findings could apply similarly to these species as well).

Table 1 presents an overview on the selected species with information such as their origin, biological attributes, and habitat.

Table 1: Overview of selected species

Species	Scientific name	Description	Picture
Grasscutter	<i>Thryonomys swinderianus</i>	Also known as cane rat, the grasscutter is a hystricomorphic rodent (Akinola et al., 2015) mostly found in many African forests and savannas (National Research Council, 1991). Grasscutters have a round muzzle, short nails, small round ears, stocky bodies, short tail and firm, coarse, bristly fur. Grasscutters thrive in dense grasses close to rivers and swamps, and are common in herbaceous vegetation with access to good cover (Aluko & Salako, 2015).	 <p>Source: Suleman Issifu</p>
Guinea pig	<i>Cavia porcellus</i>	The Guinea pig is a small rodent related to the wild and semi-domesticated caviae (Nuwanyakpa et al., 1997) and is native to the Andes area of South America (Lammers et al., 2009). Guinea pigs have stocky bodies, hind legs that are fairly short, unfurred short ears, no tail and are commonly white, dark brown, grey, or combinations of these colours (Morales, 1994; National Research Council, 1991). These are extremely prolific animals (Morales, 1994) and feed on weeds or vegetation sourced from backyards or roadsides, kitchen	 <p>Source: Unsplash</p>

		scraps, garden waste, barley and alfalfa (National Research Council, 1991).	
Rabbit	<i>Oryctolagus cuniculus</i>	Rabbits have long ears, fluffy tails, and long hind legs with white as the colour for most commercial breeds. Rabbits are best suited to temperate climates (National Research Council, 1991) and feed on crop residues, grasses, legumes, commercially prepared pellets and kitchen scraps (National Research Council, 1991; Proverbs, 1992). Rabbits have high prolificacy, low production cost, early maturity and high feed conversion efficiency (Adedeji et al., 2015; Kale et al., 2016; Serem et al., 2013).	 <p>Source: Unsplash</p>
Guinea fowl	<i>Numida meleagris</i>	Named after the Guinea coast of West Africa, where it was first found (Moreki & Seabo, 2012). Guinea fowl feathers are dark grey with white spots. Guinea fowl have a bony ridge (helmet) on top of their bare heads and their short tail feathers usually slope downwards. These birds have very good eyesight, will shriek at provocation and give a harsh cry (National Research Council, 1991). With a relatively low need for water, these fowls feed on grains, worms, ant eggs, and leaves (Avornyo et al., 2016).	 <p>Source: Unsplash</p>
Donkey	<i>Equus asinus</i>	Donkeys are thought to have originated in North-east Africa before spreading to other parts of the world (Fernando et al., 2002). They have thin, curved in and little hoofs which are flexible, with much larger ears than most animals. Their colours range from grey, brown, to black and have a gestation period of 11 to 14 months (Yilmaz et al., 2012). Donkeys have a tough digestive system (Yilmaz et al., 2012). According to Blench, (1997b), in Africa, donkeys are kept for four reasons: work, breeding, milking, and eating, with work being the most important.	 <p>Source: Juliet Kariuki</p>

4. Methodology

We conducted a systematic review including sources published until December 2020. The following sections explain the selection criteria for the species, how search terms were identified, and the literature search and exclusion conditions (Boolean Search; PRISMA).

4.1 Identification of search terms

The first step in a literature review according to vom Brocke et al. (2009) is to have a broad knowledge and overview of what is already known about the subject, region, or location in question. To this end, we initiated a random Google search of the list of animals designated as neglected livestock species within SSA in the broader context of the aims of this study (see Annex 1 for examples of search words used). This initial search helped to develop a profile of existing terminologies that best describe neglected livestock species, including associated opportunities and barriers to their domestication as well as potential socio-economic, nutritional, and environmental benefits.

4.2 Literature search and exclusion

Adopting key principles from the “Preferred reporting items for systematic review and meta-analysis” (PRISMA) checklist criteria² (Liberati et al., 2009), the following search engines were used to identify literature of interest: Google Scholar, Researchgate, Scopus (Elsevier), Semantic Scholar, World Bank, Springer, PubMed, and FAO. Other organizational databases such as those from Biodiversity International and the World Economic Forum were also used. The Boolean search strings were used with a combination of themes such as “Micro-Livestock” AND (Africa OR Sub-Saharan Africa), food security AND neglected livestock species [grasscutters OR rabbits OR guinea fowls OR guinea pigs OR donkeys] amongst other combinations.

From the search, over 1,262 articles/publications were generated (Figure 1). After excluding non-English publications including duplications, the remaining publications, conference papers, journal articles, journal article abstracts, titles, or executive summaries were subjected to screening based on the inclusion criteria and/ or information based on the themes predefined to guide the review. The literature was selected for inclusion according to the following criteria:

² The PRISMA core concept which includes the checklists, explanation and elaboration, and flow diagram was created to assist systematic reviewers in reporting why the review was conducted, what the authors did, and what they discovered in a transparent manner (Page et al., 2021). It offers reporting guidelines that take into account new approaches for identifying, selecting, evaluating, and synthesizing studies. The flow diagram depicts the report selection process throughout the review and all of the studies that were included based on meeting the eligibility criteria (Liberati et al., 2009).

1. The neglected livestock species of interest (grasscutters, rabbits, guinea fowls, guinea pigs, donkeys), the role of the species in relation to food security and/or other socio-economic, nutritional, and environmental determinants (income generation, gender dimension, nutrition, and environment).
2. The terminology of neglected and underutilized species (crops or animals) was referred to.
3. Continental or country-specific focus on Africa.
4. Year of publication or research between 1990 – 2020.

In order to identify the above-mentioned inclusion criteria, a step-down approach was carried out through a systematic screening of publication title, abstract, keywords, methodology, results, and discussion/conclusions. 128 articles that matched the inclusion criteria were identified as useful for further qualitative synthesis of neglected livestock species. Overall, 70% of the articles (90 articles) focused on at least one of the five neglected livestock species (grasscutters, rabbits, guinea fowls, guinea pigs, donkeys) of primary focus in this study, while 12% (15 articles) focused on NUCS used in establishing a link to neglected livestock species as listed in the study objective. The remaining 18% (23 articles) were termed as “methodology” related articles, which provided fundamental framework concepts in addressing aspects critical to sections of this study such as the introduction, conceptual framework, methodology as well as the discussion. With regards to the species, grasscutter articles had the most hits. Figure 1 is a flow diagram depicting the selection process of the studies used in developing the literature research of neglected livestock species (grasscutters, rabbits, guinea fowls, guinea pigs, donkeys) addressed in this study.

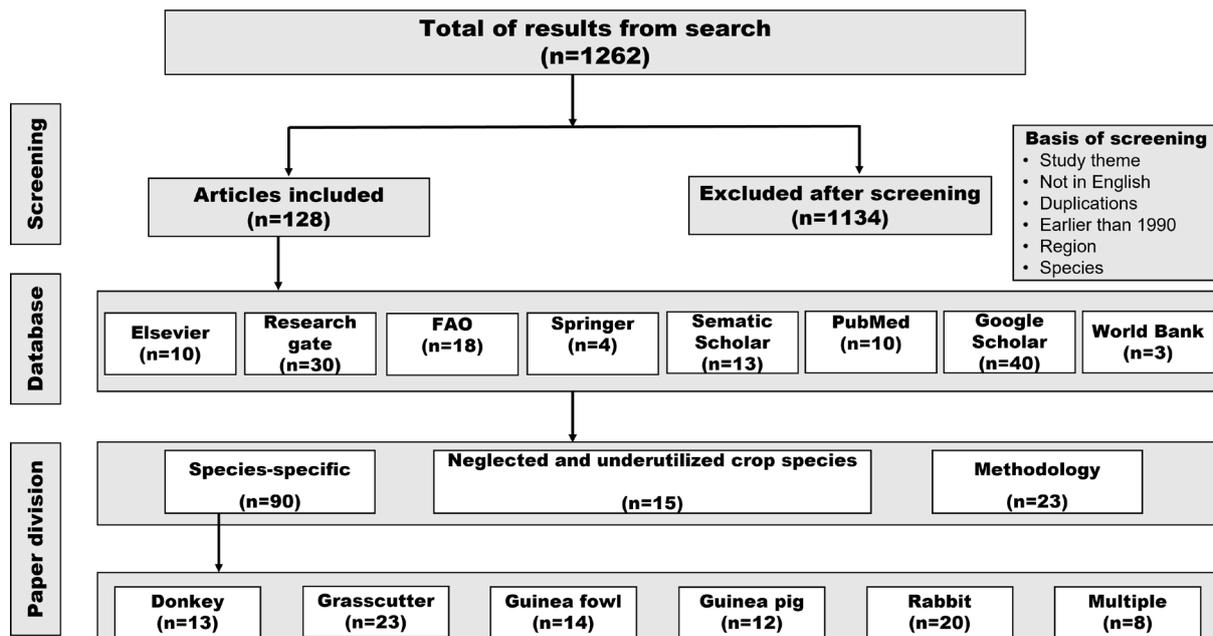


Figure 1: Flow chart showing the distribution of literature

5. Findings

The results - based on the systematic review of the available literature on the selected neglected livestock species - present an in-depth analysis of the opportunities and barriers to their adoption. Specifically, the findings show the numbers and geographic distribution of the literature, study type and methodology of the reviewed articles, and the system of production for the selected neglected species.

5.1 Scope of literature

90 articles and/or publications on the selected species for this study were used in the subsequent analysis and discussion. Figures 2 and 3 below illustrate the number and geographical scope of the literature reviewed.

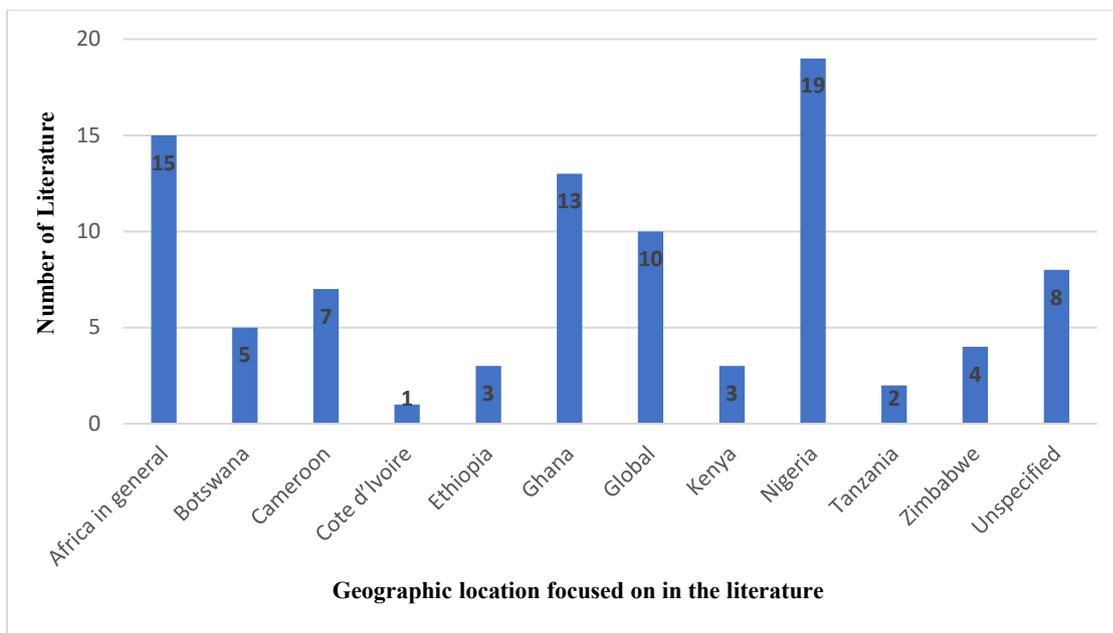


Figure 2: Geographic distribution of species-specific literature

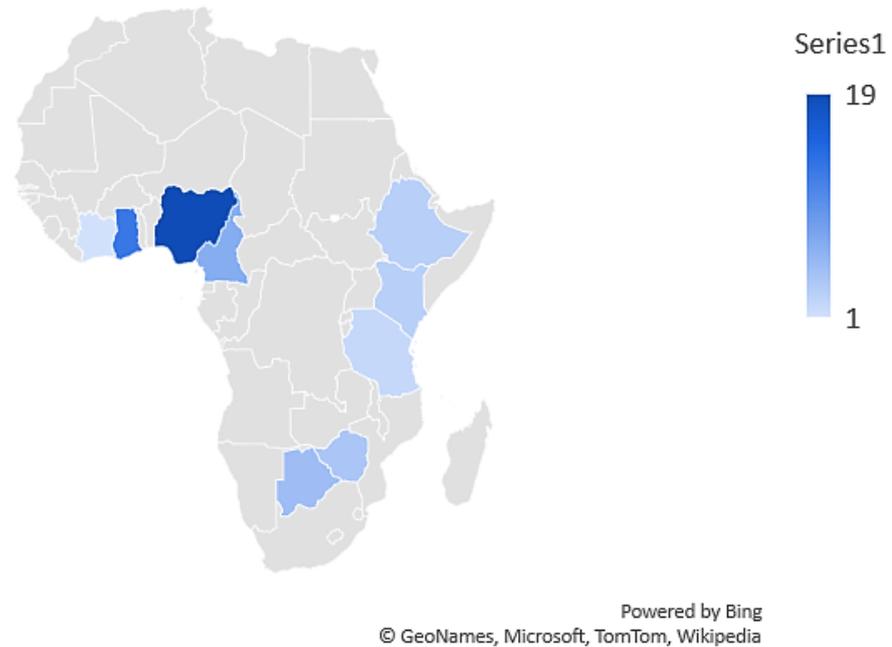


Figure 3: Country mapping of species-specific literature in Africa

Of the 90 reviewed articles focusing on the neglected livestock species, 15 reported findings from Africa, 10 used a global perspective reporting findings across developing regions of the world, 57 were specific to various African countries and 8 did not specify a region but focused on historical dimensions and biological features of the species. Generally, it was observed that the species contributed to this literature’s geographical distribution based on their popularity in various African regions. Donkey-related literature focused on countries mostly from East and Southern Africa, whereas grasscutter literature focused mostly on case studies from Nigeria and Ghana which reflects the fact that the species is native to Western Africa. Literature on guinea pig was dominated by Central African nations such as Cameroon. Guinea fowl and rabbit literature were more widespread continentally, cutting across West, East, and Southern Africa.

5.2 Type of study

The research design, methodologies and study type of the reviewed articles were also examined. The most common studies were observational studies such as case studies (n=49%) and cross-sectional studies (n=4%). Around 36% of the reviewed articles were literature reviews while the remaining 11% were a combination of mixed methodologies.

LITERATURE DISTRIBUTION BASED ON TYPE OF STUDY

■ Case studies ■ Cross-sectional studies ■ Literature review ■ Mixed methods

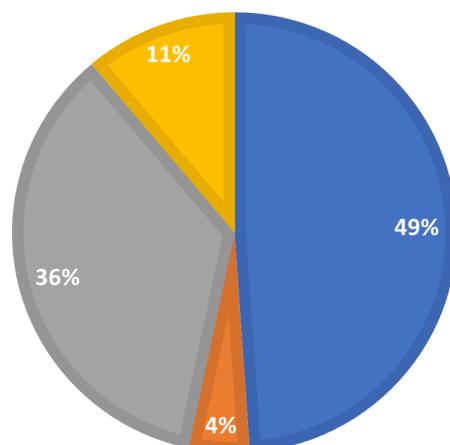


Figure 4: Literature distribution based on the type of study

With regards to the case-controlled (primary research) studies, Table 2 shows the number of species observed as well as the number of species owners, households or respondents interviewed. For donkeys, out of the 13 literature sources, 725 respondents consisting of households, donkey owners, and informants were interviewed to capture information on reasons for keeping donkeys and the roles of donkeys. 639 donkeys from the respondents were studied to ascertain their nutrition, herd structure, contribution to the owners food security, daytime behaviour, and management. 913 grasscutter farmers, 905 guinea pig farmers, and 90 rabbit farmers were also interviewed respectively to identify factors affecting the adoption and farming of these species. 290 grasscutters, 603 guinea pigs, and 90 rabbits were observed for feeding components, housing methods, breeding features, economic potential and reproduction rate. Of the 14 sources of literature associated with guinea fowl 7 reported on interviews with actors across the value chain amounting to a total of 3,189 farmers, retailers, cafeteria employees and consumers ascertaining consumer perceptions, rate of consumption and sale of products. Additionally, 80 guinea fowl were observed based on feed monitoring, conversion efficiency and reactions to disease.

Table 2: Overview of the number of animals and households covered by papers based on primary research.

Species	Number of reviewed papers	Number of papers with primary research	Total number of animals covered by primary research papers	Total Number of households or respondents covered by primary research papers
Donkey	13	6	639	725 households, donkey owners and informants.
Grasscutter	23	14	290	913 farmers
Guinea fowl	14	8	80	3189 farmers, retailers, cafeteria, consumers, focus group participants.
Guinea pig	12	6	603	905 households, farmers
Rabbit	20	8	90	653 farmers, households, housewives

5.3 Production systems

The production systems and associated use of terms are shown in Figure 5. Overall, the literature reported livestock species reared in intensive, semi-intensive, extensive, and free-range systems. 54% of the papers did not refer to a production system. In intensive systems grasscutter, rabbit, and guinea pigs were the main livestock produced. However, with grasscutters, given that they are naturally wild species, literature referred to their intensive system as keeping them in “captivity”. In the semi-intensive system, 7% of the papers reported guinea fowl, guinea pigs and rabbits. In extensive and free-range systems the production of guinea fowl and guinea pigs was reported. 10% of the studies referred to backyard or smallholder systems characterised by donkeys, rabbits and grasscutters. The term “traditional

management systems” was also used in some papers to mean either mixed, backyard or extensive systems.

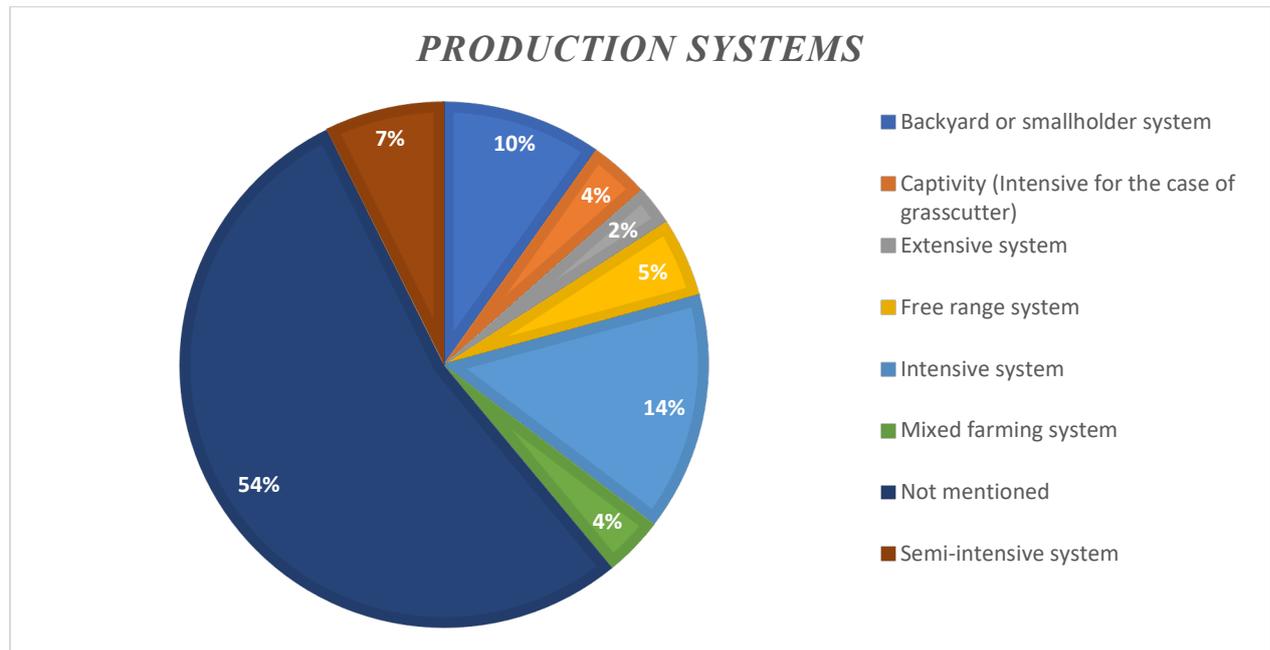


Figure 5: Production systems

Overall, although these species present opportunities for poverty alleviation in Africa or developing countries, their production systems were largely viewed at subsistence levels. It was observed that in most of the papers where the production system was termed intensive, the species were kept for research purposes and not with the aim of commercialization or household consumption. Also, some species cannot be mixed with crops; for example, grasscutter which is considered an agricultural pest for cereals or other crops.

5.4 Opportunities and barriers to production and consumption

From the reviewed literature, the adoption of these species is driven by the variety of opportunities they provide. Common and frequently discussed opportunities among all five species is their economic importance and ease of domestication. This is followed by their nutritional importance which only applies to the micro-livestock as there was no report on such benefits from the consumption of donkey. Their cultural importance, potential for women’s empowerment, and by product potential were the least mentioned. However, the barriers of pest, diseases and mortality, nutrition and feed, lack of public sector support and poor processing/marketing plan were the most frequently discussed as issues preventing higher levels of farming and domestication of these livestock species.

5.4.1 Opportunities

The selected neglected livestock species possess several benefits that promote their production, adoption, and consumption. Of note are economic benefits such as higher per kilo price of meat and eggs in comparison to conventional livestock (Ibitoye et al., 2019; Gono et al., 2013a). Their ‘micro’ size enables easy handling and the ability to improve family nutrition with minimal physical difficulty. The labour-saving ability associated with donkeys in particular can be especially beneficial for women with fewer alternatives (Geiger et al., 2020; FAO, 2014; Adedeji et al., 2015). Neglected livestock species are also socio-culturally significant for purposes such as dowry, funerals, traditional medicine, decoration, and artwork (Akinola et al., 2015; Bello et., 2012; AU, 2012).

Nutritional benefits such as high protein and low cholesterol content suitable for all age groups represent a further key driver to promote the production and consumption of the reviewed species (Lammers et al., 2009; Yiva et al., 2014; Isaac & Chiedu, 2016; Yildirim, 2014). Ease of domestication due to locally sourced feeds, and adaptivity to various climatic conditions was also highlighted in the literature (Houndonougbo et al., 2017; Ebegbulem, 2018; Yiva et al., 2014; Blench, 1997a).

In comparison to conventional livestock, an important characteristic of these neglected livestock is their low contribution to environmental pollution (e.g. droppings have less offensive odour) (Benjamin et al., 2009). Also due to their body size, they have lower land area requirements (Assan, 2013; Kale et al., 2016; Yiva et al., 2014). A related advantage reported in the literature refers to the nutrient-rich by-products such as dung and droppings which are considered a rich source of manure. Other by-products identified in the literature include hides and skin which are used to produce garments, beddings and other household amenities (Lammers et al., 2009; Manjeli et al., 1998; Twerda et al., 1997; Gono et al., 2013). These benefits vary across species and may not necessarily be shared. Table 3 provides a detailed summary of the opportunities that comes with the adoption of these species.

Table 3: Summary of opportunities

<i>Opportunities</i>	<i>Species</i>	<i>Summary of Findings</i>	<i>References</i>
Nutritional importance	Grasscutter, guinea fowl, guinea pig and rabbit.	Their meat has high quality protein, low in fat and cholesterol, high levels of vital amino acids and guinea fowl egg is good for infant growth and bone development. These livestock species are suitable to lessen the	Akinola et al., 2015; Yeboah, 2009; Moreki & Seabo, 2012; Otte & Knips, 2005; Lammers et al., 2009; Yiva et al., 2014; Adedeji et al., 2015; Mailafia et al., 2011.

		vulnerability of households, livelihoods, malnutrition, hunger, and food insecurity.	
Economic importance (source of income)	Grasscutter, guinea fowl, guinea pig, rabbit and donkey.	Their meat and eggs have higher prices than that of other conventional livestock and have high ability to utilize inferior feeds while still producing good quality meat and fur. Also, they are highly prolific and have a short gestation period. Donkeys can be hired out for business. These species have no religious discrimination; therefore, their farming, ownership, and domestication is a lucrative business and has a high potential to improve the financial livelihoods of smallholder farmers.	Ibitoye et al., 2019; National Research Council, 1991; Opara, 2010; Gono et al., 2013a; Lammers et al., 2009; Kale et al., 2016; Serem et al., 2013; Adedeji et al., 2015; FAO, 2014; Geiger et al., 2020.
Ease of domestication	Grasscutter, guinea fowl, guinea pig, rabbit and donkey.	Their feeds can be sourced locally and are less expensive than conventional livestock species. They require less land/space for their housing, less start-up capital, they are friendly and have less odour/smell so they can live with humans. Easily adaptable to various climatic conditions with high disease and drought resistance, high survival rates and low water and feed requirements.	Adu et al., 2017; Owen & Dike, 2012; Benjamin et al., 2009; Houndonougbo et al., 2017; Ebegbulem, 2018; Yiva et al., 2014; Blench, 1997a; National Research Council, 1991; Mailafia et al., 2011; Fernando et al., 2002; FAO, 2014; Smith & Pearson, 2005.
Cultural uses	Grasscutter, guinea fowl, guinea pig and donkey.	Useful for cultural purposes such as bride wealth (dowry), marriages, funerals, gifts, sacrifices and chieftaincy	Akinola et al., 2015; Bello et al., 2012; AU, 2012; National Research Council, 1991; Yiva et al., 2014; Matthola & Chen, 2020;

		installations. Their hair, fur and feathers are used for artwork, decoration and ornamental purposes, as well as the teeth used in place of previously valued cowry shells. They are also useful for medicinal purposes and production of local beauty products.	FAO, 2014; Fernando et al., 2002.
Women empowerment	Guinea fowl, guinea pig, rabbit, and donkey	These species are used as an entry point for women empowerment because of their sizes, easy handling, low land requirements, high proliferation and their proceeds can be used to improve family nutrition. Donkeys also relieve the physical burden of women by assisting with tasks such as firewood collection and carriage, transporting grains, fetching water amongst others.	Geiger et al., 2020; FAO, 2014; Adedeji et al., 2015; Kale et al., 2016; Oseni & Lukefahr, 2014; Moreki & Seabo, 2012; Lammers et al., 2009; Niba et al., 2012; Guèye, 2016.
Useful by-products - manure	Guinea pig, rabbit and donkey	The dung or droppings from these species of livestock are used for manure production. They are an excellent source of plant nutrients and improve soil fertility as well. They are suitable for mixed farming with crops. Also, rabbit urine is useful in preventing respiratory diseases in poultry.	Fon et al., 2014; Hardouin, 1995; Lammers et al., 2009; Manjeli et al., 1998; Yiva et al., 2014; Kale et al., 2016; Finzi, 2000; FAO, 2014.
Useful by-products - Hides and skin	Rabbit and donkey	Garments, beddings and roofing materials and other products are produced from the hides of donkey and rabbit skin. These products command a high price because they are also very attractive.	Twerda et al., 1997; Gono et al., 2013; FAO, 2014.

Transportation	Donkey	Donkeys are used for the transportation of people, possessions, and household supplies such as water, building materials, fodder for other livestock species, sick animals to the veterinary clinic, farm inputs and farm produce.	Beja-Pereira et al., 2004; Avornyo et al., 2015; Matlhola & Chen, 2020; Geiger et al., 2020; FAO, 2014.
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5.4.2 Barriers

The literature identified several barriers that negatively influence the level of farming or domestication of neglected livestock species. These barriers include problems of nutrition and feed, especially during dry seasons when access to fresh grasses and formulated feeds are not readily available (Gono et al., 2012; Fon et al., 2014; Niba et al., 2012). In addition, environmental constraints such as heat stress were considered as barriers to successful adoption (Anang et al., 2011; Akinola et al., 2015). The species reviewed are also considered susceptible to diseases, pests and predators (Akinola et al., 2015; Owen & Dike, 2012) exacerbated by the challenges of health due to their feeding behaviour and weather conditions. Domestication problems such as inadequate finance to acquire inputs, especially the start-up costs, inappropriate cages/housing and thefts were also identified as considerable barriers to effective production.

Overall, the lack of processing opportunities and available markets for the neglected species and their products minimises incentives to farm these species on a commercial level. In particular, various institutional barriers to the sustainable production, adoption and consumption of the species were identified. For example, the lack of public sector support based on the limited recognition of these livestock species in national development agendas, sectorial policies, weak infrastructure, poor information, and low animal welfare standards (Yeboah, 2009; Ebegbulem, 2018; Gono et al., 2013a; Moreki & Seabo, 2012; FAO, 2014; Fernando et al., 2002). A summary of the production barriers concerning the species reviewed is presented in Table 4.

Table 4: Summary of barriers

Barrier	Species	Summary of Findings	References
Domestication challenges	Grasscutter, guinea fowl and rabbit.	Due to their micro nature, the animals and their eggs are often prone to theft due to their system of production. Other domestication problems included inadequate finance to acquire inputs, especially the start-up	Anang et al., 2011; Akinola et al., 2015; Gono et al., 2013a; Mailafia et al., 2011; National Research Council, 1991; Ebegbulem, 2018.

		cost, inappropriate cages, environmental constraint such as heat stress, inadequate fodder during the dry season, increased medical care during raining season.	
Health and reproductive challenges	Grasscutter and guinea fowl	High mortality rate during wet season and hence grasscutter require more care during these times. Due to the scavenging behaviour, guinea fowl are vulnerable to external and internal parasite. Lack of breeding programmes and sexing in guinea fowl is extremely difficult.	Mustafa et al., 2015; Ibitoye et al., 2019; National Research Council, 1991; Ebegbulem, 2018; AU, 2012.
Nutritional constraints or feed problems	Grasscutter, guinea fowl, guinea pig and rabbit	In the dry season, it is difficult to get fresh grasses and succulent ones are not readily available and this leads to high cost of feeds. Also, there are no formulated feed rations for domesticated guinea fowl and guinea pig.	Fayenuwo et al., 2003; Gono et al., 2012; Fon et al., 2014; Niba et al., 2012; Moreki & Seabo, 2012.
Management and housing	Grasscutter and rabbit	High initial capital requirement due to the cost of building appropriate housing for the animals. Inappropriate houses/design increase mortality rates. There is also a lack of land to build livestock houses. High management requirements and skill is also required in which smallholder farmers lack.	Ibitoye et al., 2019; Benjamin et al., 2009; Gono et al., 2013b; Mailafia et al., 2011; Savietto et al., 2012.
Pests, diseases, and resistance	Grasscutter, guinea fowl, guinea pig and rabbit	High prevalence of neonatal disease, mange, external parasites, mites, bugs, lice, trampling, attack by predators such as cat, dogs, and snakes, and pneumonia especially in the raining and harmattan season.	Akinola et al., 2015; Owen & Dike, 2012; Gono et al., 2013a; Manjeli et al., 1998; Mwalukasa, 2009; National Research Council, 1991; Finzi, 2000.
Lack of public sector support and research (institutional problem)	Grasscutter, guinea fowl, rabbit and donkey	In most African countries there is a lack of recognition of these livestock species in national development agendas, sectorial policies, programs, research, and strategies. Absence of policy frameworks that supports backyard production systems, lack of or poor access to extension agents and veterinary services. This neglect has led to a lack of data on these animals,	Yeboah, 2009; Ebegbulem, 2018; Gono et al., 2013a; Moreki & Seabo, 2012; Oseni & Lukefahr, 2014; Serem et al., 2013; (FAO, 2014; Fernando et al., 2002; Matihola & Chen, 2020.

		minimal research and development. Lack of regulation has also led to uncontrolled slaughtering of donkeys and unregulated sale of their hides and skin.	
Poor infrastructural development	Grasscutter and guinea pig	Due to bad road and telecommunication networks, producers/farmers are hindered from market access where they can sell their products (meat, egg, manure, skin) and buy inputs (grains, feed) as well as access to technical knowledge. The coverage of extension service provider is also minimized.	Akinola et al., 2015; Owen & Dike, 2012; Fon et al., 2014; National Research Council, 1991.
Poor information dissemination	Grasscutter, guinea pig and rabbit	Problem of ignorance on the various roles, functions, and importance of these neglected species. Also, poor information availability on how to handle the challenges associated with the domestication of the listed species such as disease outbreaks, and appropriate feeding. In this case, innovations' impacts are limited.	Folitse & Manteaw, 2019; Akinola et al., 2015; Kouakou et al., 2011.
Poor processing and marketing plan	Grasscutter, guinea fowl, guinea pig and rabbit	Unlike the conventional livestock (cattle, chicken, sheep), these micro-livestock suffer from underdeveloped, unorganized, and informal market system, low prices for their meat as well as absence of storage and processing facilities, hence spoilage is prevalent.	Bello Y., 2012; Avornyo et al., 2016; Gono et al., 2013; Nuwanyakpa et al., 1997; Adedeji et al., 2015; Kale et al., 2016.
Welfare issues	Donkey	Little attention is given to the welfare of donkeys, which affects their health and work capacity. Also, donkeys are becoming endangered due to an absence of breeding programmes.	FAO, 2014.
Increased demand for hides	Donkey	The unregulated sale of donkey hides has led to increased slaughtering of donkeys rather than keeping them for household and agricultural uses.	Matihola & Chen, 2020.
Myths	Donkey	Traditional and religious myths associated with donkeys sometimes prevent their use and led to increased	Fernando et al., 2002; Yilmaz et al., 2012; Blench, 1997b.

Changes in agriculture	Donkey	prices for donkeys. Other religious restrictions apply. Traditional agricultural functions of donkey have become less attractive and lucrative due to mechanization and industrialization.	Fernando et al., 2002.
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6. Discussion and Policy Recommendations

This study systematically reviewed the literature on neglected livestock species to understand the underlying reasons for the challenges facing their sustainable production within the context of the African 'livestock revolution'. The findings reveal the lack of a universal terminology for the categories of livestock reviewed, in contrast to neglected crops. For example, while the institution African Orphaned Crops Consortium (AOCC), was formed to leverage underutilized crops as a solution to food insecurity caused by the effects of climate change on staple crops (Hendre et al., 2019), no such institution exists for neglected livestock species. These efforts have resulted in the coining of universal terms for underutilized crop species while universal terms for neglected livestock continue to be indeterminate. To the extent that neglected livestock species promise more than just nutritional benefits unlike in the case of underutilized crops, arguably, they deserve more attention.

The benefits associated with the adoption of neglected livestock species as identified in this study, compliment several Sustainable Development Goals, namely 1, 2, 3, 5, and 13 – another justification for why these species deserve serious consideration. Insights from the literature on underutilised crops indicate that a universal term may be an impactful first step towards the promotion and adoption of neglected livestock. For this, we propose “Neglected Livestock Species” as an appropriate term that encompasses the multidimensionality of the species including biology, functionality, and production systems. According to the Oxford and Merriam-Webster dictionaries, the word/verb "neglected" means "not receiving proper attention; disregarded; suffering a lack of proper care" which adequately defines the situation of this category of livestock. In comparison to existing terms such as “micro-livestock” and “minor-species”, there are livestock species that are often excluded from these terms, for instance donkey due to its size and functionality for draught power is not categorised as a micro-livestock. Therefore drawing parallels to the definition given by Padulosi et al., (2013) for crops, “Neglected Livestock Species” best fits in describing the situation of neglect faced by the category of livestock being discussed.

The results also bring to attention the reduction of detrimental environmental trade-offs associated with the production of neglected livestock species. For instance, indigenous poultry such as guinea fowl are reported to have low carbon and water footprints (Rota and Urbani, 2021). Also due to the micro body size and weight of grasscutter, guinea fowl, guinea pig and rabbit, they are believed to cause minimal impact on the environment such as soil compaction and have lesser requirement for land area (Assan, 2013; Kale et al., 2016; Yiva et al., 2014). Furthermore, the neglected livestock species in question can be reared on grass without the methane production associated with ruminants. In addition to a lower environmental footprint

compared to conventional livestock species, the production of these neglected species overcomes many of the problems in modern human societies such as malnutrition, food insecurity, and gender inequality. The intensified production of conventional livestock has created an array of negative environmental interactions (GHG emissions, ground water use, pollution), antimicrobial resistance, health issues such as coronary heart diseases, cancer, and stroke caused by red meat consumption amongst other implications (Mehrabi et al., 2020).

Collectively, the literature reports on an array of opportunities for the adoption of neglected livestock, positioning the intensive production potential of these species in contemporary discussions on megatrends. Megatrends, namely, population growth, urbanization, climate change, and technology development have a direct effect on livestock production (FAO, 2019). The effects of these megatrends have led to increased discussions about paradigm shifts in livestock production. Population growth and urbanization have led to an increased demand for animal proteins (Delgado et al., 2001). This increased demand, is leading to a reconfiguration of the livestock production system through the use of technology in order to meet the demand (Villarejo, 2020). Simultaneously, the associated negative trade-offs such as climate change, gender inequality, amongst others, are on the rise. To this end, a conversation on how to meet the growing demand for animal protein while mitigating the trade-offs is imminent.

Insect production is frequently discussed as an alternative to conventional livestock production (Guiné et al., 2021). Insects promise low trade-offs in terms of climate change, the spread of zoonotic diseases, and efficient use of scarce resources while achieving nutritional goals (Guiné et al., 2021; Mattiello et al., 2018). These benefits from insects, in addition to reducing the gender gap, are found in neglected livestock species too. In this context, the neglected livestock species discussed in this paper, share similar traits with insects. This paper, therefore, brings to the fore the possibility of discussing insects side by side with neglected livestock species as a composite solution to the problems of livestock production in the context of megatrends.

Despite the positive outcomes of resorting to neglected livestock species as an alternative animal protein source, it was found that factors such as a lack of market, policies, weak institutions, diseases, unavailability of feed, amongst others militate against their adoption (Ibitoye et al., 2019; Moreki & Seabo, 2012; Yiva et al., 2014). While it is clear from the literature that adoption could be successful in low-income communities in sub-Saharan Africa, the lack of resources committed to research and policies minimises adoption (Kosgey & Okeyo, 2007). In comparison to neglected livestock species, more research has been conducted for insects because they are more promising in terms of less spread of zoonotic diseases (Mattiello et al., 2018). However, the issue of neglected tropical livestock diseases is still an area where further research is required if neglected species are to be intensified.

Since these livestock are consumed in some communities, research is needed to unearth the health risks and other threats that come with their consumption (Mehrabi et al., 2020; UNEP & ILRI, 2020). This is particularly important in light of the recent history of zoonotic diseases, like Ebola, that have been attributed to some neglected livestock species such as grasscutter consumed as bush meat (Ibitoye et al., 2019; Folitse & Manteaw, 2019).

Thus, a holistic approach (such as One Health) that integrates the health of humans, animals, and the environment (Lebov et al., 2017) ought to be given attention in discussing these neglected livestock as an alternative. Looking away from these neglected livestock due to issues associated with them leads to losing a golden opportunity to cut down the negative trade-offs associated with increased conventional livestock production and risks a potential outbreak of zoonotic diseases especially within communities that consume them. In order to address this, strategies such as institutional attention and commitment of resources, such as those put in place to push underutilized crops into prominence (Hendre et al., 2019), could be adopted for neglected livestock species.

7. Policy Recommendations

To reduce this neglect and sustainably enhance the production, adoption and consumption of this category of livestock, the following policy recommendations are suggested as steps to propel the benefits of these neglected livestock species to a more recognized position.

7.1. Institutional and policy inclusions

The exclusion of these species in policies and development strategies contributes significantly to the level of neglect these species have received. If an enabling institutional and policy environment is made available (Otte & Knips, 2005), the interest and willingness of rural farmers to adopt the farming and domestication of these neglected species (grasscutter, guinea fowl, guinea pig, rabbit, and donkey) might be encouraged.

As an institutional agenda, households can be supported with these neglected species, or with provision of formulated feeds, since feed problems were identified as prevalent in the farming of these species. With adequate policy inclusions, extension staff can be better equipped and trained to enhance the benefits which these species provide farmers which could be coupled with the provision of better veterinary services at subsidized rates. With a well-established policy that includes these neglected livestock species, public, and private sector investment will be enhanced. This collaboration will further improve the availability and/or accessibility of loans and credit to enable farmers to acquire breeding stock, good housing, and feeds, all of which represent the huge start-up cost in the farming of these species (Anang et al., 2011). This may also improve the value chain of these livestock species (Yeboah, 2009). More recently, there is an increasing interest by formal and informal bodies on non-conventional livestock production in which grasscutter, guinea fowl, guinea pig, rabbit and donkey are part of (Niba et al., 2012) and they are being integrated into some countries policies. For instance, in the case of donkey in Ethiopia, the Ministry of Agriculture has set up an animal welfare working group that allows groups and the government to coordinate actions on animal welfare, policy, research, and strategy development. (FAO 2014). Also in the policies and strategies for livestock development in Ghana, households are being encouraged to keep and produce these micro/non-conventional livestock particularly, grasscutters, rabbits and snails. The Kenya's draft Livestock Policy (2019) also accommodates the utilization of products from 'Non-conventional Livestock' such as guinea fowl, quails and donkeys that have high potential to enhance income and livelihoods of the farming community by promoting their production through research, licensing and improved capacity.

7.2. Research, development, and genetic improvement

In most African countries, research and extension are still lacking on neglected livestock species, especially the micro livestock, and this research neglect has been attributed to the attention given only to conventional livestock as well as lack of training and education (Assan, 2014). Since industrial production started, there has been less research aimed at the development of rural breeding systems, which has led to a lack of specific know-how for these species (Anang et al., 2011; Niba et al., 2012; Serem et al., 2013). Funding for research on genetic improvement of conventional livestock is substantially more available than for genetic improvement programs for neglected livestock species under smallholder production systems such as those focused on in this study (Kosgey & Okeyo, 2007). But overall there has been limited government expenditure on research and development in Africa. Also, production systems such as the extensive or peri-urban systems in which these livestock thrive and are being produced do not receive sufficient attention as compared to the extensive systems used for mainstream livestock.

For these neglected species, more research is needed to understand the environmental trade offs of neglected livestock species vis a vis other livestock species. Research ranging from the measurement of greenhouse gases emitted, the energy cost of maintenance and work, nutrient requirements, quality feed, diseases that affect them, their optimum environment, genetic breeding and improvement, production characteristics, egg production, commercialization to better management practice is needed (Assan, 2013; Ibitoye et al., 2019; Mattiello et al., 2018; Saina, 2005; Smith & Pearson, 2005; Yeboah, 2009). There is also a need for system-specific attention to accommodate the needs of these neglected species and put in place mechanisms that can minimise negative outcomes on human and animal health.

Therefore, state or private-funded research institutions should increase their attention on the production of these NULS (Assan, 2014). Furthermore, with increased research, genetic improvement can be achieved, increasing output and profitability for smallholders (Kosgey & Okeyo, 2007).

7.3. Awareness creation

The vast role and benefits of these neglected livestock species are not widely known or popular in Africa, a continent characterised by high cases of malnutrition, hunger, drought, and nutrient deficiencies. This lack of awareness has also contributed to the neglect of these species. Therefore, more awareness of these species needs to be raised so that they can be incorporated into programs such as animal research or economic development programs (National Research Council, 1991). Awareness can be created through extension services, awareness creation programs on the nutritional and economic importance of NULS to farmers

and households, informal education, training on how to farm these species and information dissemination through seminars and workshops (Assan, 2014; Ibitoye et al., 2019; Kale et al., 2016; Lammers et al., 2009). Awareness creation can be handled by both government and non-government organizations (Ume & Ezeano, 2017). Research and development programs can also create awareness on smallholder livestock production which increases the chances of poverty alleviation, household food security and empowerment of women (Oseni & Lukefahr, 2014).

7.4. Strengthened value chain

In every production value chain, especially livestock production, marketing is a critical factor. Although with NULS, the absence of ready or formal markets is reported (Avornyo et al., 2016; Marshall et al., 2019). It is therefore important that government institutions, private organizations, non governmental institutions and research organizations help to develop the value chains for NULS in order to enhance their supply and marketing (Assan, 2014; Gono et al., 2013a, 2013b; Mutsami et al., 2019). Also, other problems that affect the marketing of these species and their products such as processing, storage and transportation should be given attention as well. Furthermore, the promotion of livestock specific technologies by most livestock programs have been focused on conventional livestock and not on species such as grasscutter, rabbit and other neglected species (Assan, 2014). It is essential to train farmers of these neglected species in the use of new technologies that can help improve the handling and management of these species. Such training will be beneficial to both educated and uneducated farmers and women as well (Folitse & Manteaw, 2019).

8. Conclusion

The study faced some limitations such as not being able to account for the exact number of articles excluded by the various themes for exclusion because the collection of literature started before the decision on the type of review to be conducted. Overall, the term “neglected livestock species” is suggested by this study as the most appropriate term for these categories of livestock that are given less attention. The review also suggests that due to the lesser trade-offs associated with the production of these livestock species, and the high and largely unexploited economic and nutritional potential they offer, which could yield large benefits in the future, greater attention may minimize the barriers that currently affect their production. Due to the knowledge gaps that exist regarding the balance between increased production and the sustainability implications in comparison to conventional livestock, additional studies on the health, economic, nutritional, and environmental impact, technical feasibility, gross margins, etc., can considerably unravel the potentials of these livestock in addressing food and nutritional insecurity in Africa and other developing regions.

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Annex

Annex 1: Example of search words used

Examples of search words used.
Neglected livestock species in Africa.
Neglected species In Africa.
Underutilized /unutilized animal species in Africa.
Neglected livestock species and food security.
Grasscutters OR rabbits OR guinea fowls OR guinea pigs OR donkeys AND neglected livestock species
Role of traditional and non-traditional meat animals.
Role of wildlife for food security in Africa.
Ungulates, primates and rodents useful for households.
Animal species in Africa useful for income and food but are neglected.
Micro-livestock.
Backyard system.
Non-commercial livestock in agriculture.
Unpopular livestock species.
Potential reasons why micro-livestock are neglected.
Role of livestock for developing countries.
Livestock development for Sub-Saharan Africa.
Grasscutters OR rabbits OR guinea fowls OR guinea pigs OR donkeys AND food security.
Grasscutters OR rabbits OR guinea fowls OR guinea pigs OR donkeys AND gender.
Malnutrition AND micro-livestock production in Africa.
Minor and unpopular livestock.

Social and Institutional Change in Agricultural Development

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