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Review Article

Poultry Ecto-, Endo- and Haemoparasites in Tanzania: A Review

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Abstract

Poultry production plays an essential role in food and nutrition security at household level through the provision of eggs and meat and income generation. Ecto-, endo- and haemoparasites occurring in poultry singly or a combination are commonly found in Tanzania and affect poultry sector productivity. At least 27 species of nematodes, one species of trematodes; 13 species of cestodes and seven species of protozoa (only *Eimeria* spp) reported parasitizing commercial, indigenous chicken, ducks, guinea fowls and pigeons in Tanzania. Several ecto-parasites (fleas, mites, lice, soft and hard ticks) identified and reported in indigenous chickens and pigeons whereas eight species of haemoparasites documented in indigenous chickens, pigeons and guineafowls. Most of the studies conducted in Tanzania skewed toward eastern parts of the country, which makes the use of available reports for determination of poultry parasite profiles and distribution difficult or impossible. This paper reviews the ecto-, endo- and heamoparasite profiles of poultry occurring in Tanzania. This review provides available information and gaps in the occurrence and distribution of the ecto-, endo- and haemoparasites in different types of poultry in Tanzania. The study suggests a broader country survey and frequent surveillances establishing the magnitude of the problem, which is an essential tool in designing control strategies.

Keywords: Blood-borne parasites; External parasites; Helminths; Protozoa; Scavenging village chickens

Introduction

Poultry plays a significant role in food, nutrition and financial security, and is the only livestock industry widely and evenly distributed in Tanzania. Among the total number of agricultural households in the country estimated at 4.7 million, more than 78% are keeping chickens. The chicken population in Tanzania is estimated at 69 million, 37 million being indigenous and 32 million commercial breeds, which constitute 24 million broilers and 8 million layers [1]. This data indicates an increase of 29.4%, 94.5% and 11% in a total population of chickens, commercial and indigenous chickens, respectively within seven years from 2008 to 2015 [2].

There are no much works conducted on poultry ecto-, endo- and haemoparasites in Tanzania, and the situation is even worse in the commercial broilers and layers compared to local village chickens. Village poultry is the source of scarce animal protein through meat and eggs production, source of income to meet the household need, active in pest control, provide manure and required for festivals and traditional ceremonies [3]. Indigenous chickens contribute more than 90% of the poultry meat and eggs consumed in the rural areas and 20% consumed in urban areas in Tanzania [1]. However, in rural Tanzania, poultry meat and egg consumptions are very uncommon compared to other types of animal source food, and eggs consumption is not associated with chicken ownership instead with Household Domestic Asset Index (HDAI) [4]. Most households prefer eggs for hatching for flock replacement as the result of high mortality observed in this type of poultry and adult chickens for selling for income generation to cover household expenses [5].

Exposure to a wide range of parasites in scavenging birds accompanied by poor control program results into high infestation/infection and co-infestation from helminths, protozoa, lice, flea and mites [6]. The birds under scavenging system are at high risk of acquiring infestation due to frequent contact with soil, which serves as an important reservoir for the infective larval stages of helminths and arthropods acting as paratenic or intermediate hosts [7,8]. Parasitic infestation results in annoyance, anaemia, decreased feed intake, reduced weight gain, reduced egg production, egg abandonment in brooding hens and chick mortality [6,9,10]. Other ecto-parasites acts as the intermediate hosts of the spirochete, piroplasmosis, rickettsial, bacterial and viral pathogens which cause a wide range of diseases to birds and mammals [11,12]. Also, external and internal poultry parasites infestations can lead to lowered humoral and cellular immune responses [13], which has a negative impact on outcomes of vaccination against other diseases [14,15].

Biotic and abiotic factors influence the rate of ecto-, endo- and haemoparasite infestations/infections, survival and persistence in birds and environment. Altitude from the sea level defines the climatic condition of the areas, which in turn dictate the level of vectors and parasite survival. *Eimeria* infection rate in local chickens in Central Ethiopia found to be higher in highlands as compared to mid and lowlands due to high humidity and low temperature, which favour oocyst sporulation for easy dispersion and transmission [16]. The rate of ectoparasite infestation in chickens including *Argas persicus*

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also follow the same trend whereby the chickens in the humid locality experience more infestation than their counterparts in less humid areas [17].

This review is describing essential aspects of general epidemiology, occurrence and distribution of important ecto-, endo- and haemoparasites previously identified and reported in poultry production systems in Tanzania. The level of infestation in different types of poultry, economic importance based on the available literature within and beyond the country is also reviewed. The studies reviewed in this paper contribute to the understanding of the magnitude of ecto-, endo- and haemoparasites infestations/ infections in poultry important for assessing existing and formulating new sound preventive and control measures.

Materials and Methods

Review approach

The review conducted using electronic and non-electronic databases describing endo, ecto and blood-borne parasites in poultry in Tanzania. The electronic databases used were CAB Abstract, PubMed, Science Direct and Web of Science. Firstly, titles and abstracts of all retrieved articles searched to identify articles that were missed by the electronic search. Secondly, references of 'all relevant articles' searched to identify articles that were missed by the electronic search. Thirdly, all relevant articles reviewed, and relevant information extracted and compiled in a searchable database. A relevant article defined as the one that contained information describing the subject of interest – meaning ecto, endo, and haemoparasites of poultry. The search conducted for all available years and information extracted included authors and year of publication. The last search took place on 25th April 2018.

Search for articles

All relevant articles included in the search, and there was no restriction on sub-set (journal groups, topics and database). Different search terms deployed to the different search engine. CAB Abstract- ((*indigenous chicken, ducks, guinea fowls, pigeon* or small scale* or large scale**) and (*gastrointestinal* or endo* or ecto* or haemoparasites**) and (Tanzania*)); PubMed – ((*small scale*or large scale*, indigenous chicken* or ducks* or pigeons* or guinea fowls**) and (*gastrointestinal* or gastrointestinal helminths* or ecto* or endo** and (Tanzania*)); Science Direct - ((*small scale* or indigenous chicken* or pigeons* or ducks* or guinea fowls**) or (*gastro-intestinal*, or gastrointestinal helminths* or endo* or ecto** and (Tanzania*)). Other search terms included authors and titles refereed in other articles. An iterative process, which combined different keywords, deployed to arrive at these final search terms. Specific search engines of journals like "Livestock Research for Rural Development" (www.lrrd.org) used to retrieve research information relevant to Tanzania and other similar climatic conditions. Where information was not accessible (unpublished or hard copies), records from the Veterinary department office and dissertations/thesis from Sokoine University of Agriculture (SUA) were retrieved and reviewed for any additional information.

Endo-parasites

The free-range system exposes the birds to the diverse environments, which increase the risk of the birds to acquire eggs, larva and oocysts from the soil during the scavenging process and contribute significantly to a high and diverse endo-parasites infestation in birds [18,19]. However, *Eimeria* spp. infections are more considered as the problem of commercial intensive poultry production than in free-range chickens [20]. Helminths and *Eimeria* spp infestations are the only endo-parasite documented in poultry of all age group in scavenging village chickens, muscovy ducks (*Cairina moschata*) and domestic pigeons (*Columba columba*) in Tanzania [21,22]. Coccidia and helminths co-infections are common in scavenging village chickens, whereby in Tanzania the co-infections rate is 9.9% lower than 22.9% reported in Nigeria [6,23].

Helminth

Helminth infestation is common in Tanzania poultry, mostly in the scavenging system. Reports on the prevalence of helminths in different age groups in Tanzania indicate mixed results. The studies conducted in scavenging chicken and ducks in the eastern part of the country indicate a higher prevalence of helminth infestations in young than adults [18,24], and higher in adults than young pigeons [25]. The higher helminth infestations in adult scavenging chickens is more expected due to extended contact with contaminated environments as compared to other age groups [26].

Variations in temperature and humidity occurring in different seasons of the year affect the prevalence of endo-parasite in poultry. The number of species and the total number of helminths per chicken increase as the rain period advance although other species like *Ascaridia galli* show a reasonably constant count during dry and rainy seasons [22]. Nevertheless, Permin, Magwisha [21] found no significant difference in worm burden between dry and wet season. The study conducted in fowls under semi-intensive system and chickens in scavenging chickens, respectively, in India and semi-arid zone of Kenya, respectively, indicated the helminths and coccidia to be higher during wet season than in dry season, an indication of being the prevailing trend in tropical areas [27,28]. In Germany, which is the temperate country, the prevalence of helminths was significantly higher during the summer than winter in free-range chickens [29]. The records of mixed worm infestations in Tanzania indicates the rate of 38.5%, 14.6% and 10% in scavenging village chickens, ducks and pigeons, respectively [18, 23, 25]. The documented mixed helminth infestation rate in Tanzania in scavenging village chickens is much lower than that observed by Uhuo, Okafor [30] in Nigeria (86.6%) and Phiri, Phiri [31] in Zambia (88.2%). The percentage of worm-infested chickens with low performance as measured by the volume of pectoral muscles during the wet and dry season in Tanzania were 69.9% and 73.0%, respectively, indicating a negative impact of the worm infestation on flock performance [21].

Nematodes: Twenty-seven (27) species of nematodes belonging to 13 genera reported infesting indigenous chickens, ducks and pigeons in Tanzania (Table 1). Reports on the worm infestation in poultry in Tanzania is more in scavenging village chickens, one in ducks and pigeons and none on commercial chickens. The reports on nematodes mostly restricted to few regions where the studies conducted and or based on post-mortem reports at zonal veterinary investigation centres in Arusha, Mtwara and Mwanza [32,33]. The observed prevalence of nematode worms in Tanzania range between 22 - 87% in scavenging village chickens [23, 24], 15.5% in pigeons [25] and 85% in ducks [18]. The most common genera of nematodes

Table 1: Nematodes species reported in free-range poultry in Tanzania.

Type	Parasite species	Host	Geographical area	Reference
Nematodes	*Acuaria hamulosa*	Chicken*	Morogoro	[18,21-25,32,33,37].
	Allodapa suctoria	Chicken	Morogoro	
	Ascaridia galli	Chicken, Ducks*, Pigeon*	Morogoro, Mtwara, Mwanza	
	Ascaridia columbae	Ducks	Morogoro	
	Ascaridia dissimilis	Ducks	Moroogoro	
	Capillaria anatis	Ducks	Morogoro	
	Capillaria annulata	Ducks	Morogoro	
	Capillaria bursata	Chicken	Morogoro	
	Capillaria contorta	Chicken	Morogoro	
	Capillaria caudinflata	Chicken	Morogoro	
	Capillaria obsignata	Chicken	Morogoro	
	Dispharynx nasuta	Chicken	Morogoro	
	Echinuria uncinata	Chicken	Coast & Dar-es-Salaam	
	Gongylonema ingluvicola	Chicken	Morogoro	
	Heterakis brevispiculum	Chicken	Morogoro	
	Heterakis dispar	Ducks, Chicken	Morogoro	
	Heterakis gallinarum	Chicken, Ducks	Morogoro, Mtwara, Arusha	
	Heterakis isolonche	Chicken, Ducks	Morogoro	
	Subulura brumpti	Ducks	Morogoro	
	Subulura sucturia	Ducks	Morogoro	
	Subulura strongyilina	Ducks, Chicken	Morogoro	
	Strongyloides avium	Chicken	Morogoro	
	Syngamus trachea	Chicken	Morogoro	
	Syngamus bronchialis	Chicken	Coast & Dar-es-Salaam	
	Tetrameres americana	Chicken	Morogoro, Arusha, Mtwara	
	Tetrameres fissispina	Chicken	Morogoro	
	Trichostrongylus tenuis	Chicken	Morogoro	

*Chicken - Local scavenging chickens.
*Ducks - Muscovy ducks (Cairina moschata).
*Pigeon - Domestic pigeons (Columba columba).

documented in the country are *Ascaridia, Capillaria, Hetarakis and Tetramere* from the type of poultry mentioned above [18,22,25].

Ascaridia galli and *Heterakis gallinarum* are most prevalent nematodes species found in the scavenging chickens, ducks and pigeons in Morogoro, Arusha and Mtwara regions [23,33]. High prevalence of these two species of helminths has also reported in free-range chickens in India, Nigeria and Poland [30,34,35]. However, other studies reported a high prevalence of *Tetramere americana* than *Ascaridia galli* in scavenging chickens during dry and wet seasons in scavenging village chickens in Tanzania [21]. These studies are in agreement with what documented in Kenya whereby the abundance decrease in the order of *Tetramere americana*, *Ascaridia galli* and *Heterakis gallinarum* in scavenging village chickens [27]. Other species of *Ascaridia* and *Heterakis* are present in the country in chickens, albeit at low prevalence.

The study conducted in other types of poultry reported a higher total worm infestation in duckling than in adult ducks, although *Capillaria contorta, Heterakis gallinarum*, and *Subulura brumpti* were more prevalent in adults than in ducklings [18]. *Ascaridia galli* remained as the only nematode isolated in domestic pigeons (*Columba columba*) in Tanzania [25]. Nematode species from other genera, including *Capillaria, Dispharynx, Echinuria, Syngamus, Tetramere* and *Trichostrongylus* are present in Tanzania but not frequently encountered (Table 1). Nematode parasitism alters the gastrointestinal tract of the affected birds structurally and functionally which negatively impact on the performance of the flock and sometimes cause death especially in chicks [26,30,36]. Although there is no information on direct economic losses associated with nematode infestation in Tanzania, this level of prevalence warrant mitigation measures to be instituted to overcome the negative impact on bird productivity, which may be associated with nematode infestations.

Trematodes: Trematodes are not common helminths in poultry in Tanzania (Table 2). All studies conducted in scavenging chickens, ducks and pigeons documented zero prevalence of trematode [18,23,25], except one study conducted in scavenging village chickens

Table 2: Cestodes, trematodes and Eimeria species reported in free-range and commercial poultry in Tanzania.

Type	Parasite species	Host	Geographical area	Reference
Cestodes	*Amoebotaenia cuneata*	Chicken*	Morogoro	[18,21,22,25,37]
	Choanotaenia infundibulum	Chicken	Morogoro	
	Davainea proglottina	Chicken	Morogoro	
	Hymenolepis cantaniana	Chicken	Morogoro	
	Hymenolepis carioca	chicken	Morogoro	
	Metroliasthes lucida	Chicken	Morogoro	
	Polymorphus boschadis	Chicken	Morogoro	
	Raillietina cesticillus	Chicken	Morogoro	
	Raillietina echinobothrida	Chicken, ducks*, pigeon*	Morogoro	
	Raillietina tetragona	Chicken, ducks, Pigeon	Morogoro	
Trematodes	*Ornithobilharzia pricei*	Chicken	Coast & Dar-es-Salaam	[37]
Eimeria	*Eimeria acervulina*	Chicken (commercial)*	Kibaha	[23,46]
	Eimeria brunetti	Chicken (commercial)	Kibaha	
	Eimeria maxima	Chicken (commercial)	Kibaha	
	Eimeria mitis	Chicken (commercial)	Kibaha	
	Eimeria necatrix	Chicken (commercial)	Kibaha	
	Eimeria praecox	Chicken (commercial)	Kibaha	
	Eimeria tenella	Chicken (commercial)	Kibaha	
	Eimeria unclassified	Chicken (commercial and local scavenging)	Kibaha, Morogoro	

*Chicken - Local scavenging chickens.
*Ducks - Muscovy ducks (Cairina moschata).
*Pigeon - Domestic pigeons (Columba columba).
*Chicken (commercial) - Commercial broilers and layers.

[37]. Only one species of trematode, *Ornithobilharzia pricei* was at 1% in the wet season in the study conducted in selected villages of Coast and Dar Es Salaam regions [37]. Zero prevalence of trematodes were also common in local scavenging chickens, commercial broiler chickens and domestic pigeons in Botswana, India, Kenya and Nigeria [10,27,38,39], suggesting unfavorable environment condition for their survival in the areas these studies conducted. In other countries, the prevalence of trematode is as high as 25% (*Echinostoma revolutum*) in domestic pigeons (*Columba livia*) in Bangladeshi and 10.7% (*Prosthogonimus* spp) in scavenging village chickens in Nigeria [8,30]. Birds raised near ponds feeding on snail and fish, the intermediate hosts of trematodes increases the chance of infestations as observed in aquaculture and poultry integrated farms in Vietnam whereby the prevalence were 12% and 30% in chicken and ducks, respectively [40].

Cestodes: Ten (10) species of cestode worm infestations are common in Tanzania reported in scavenging chickens, ducks and pigeons. The species of cestode reported in Tanzania belong to 4 genera including *Choanotaenia, Davainea, Hymenolepsis* and *Raillietina* (Table 2). The overall rate of cestode recovery in Tanzania range between 30.8% - 72.4% in scavenging village chickens [22,23], 66.7% in pigeons [25] and 16.7% in ducks [18]. *Raillietina echinobothridia* and *Raillietina tetragona* are more common cestode species in scavenging village chickens, ducks and domestic pigeons in Tanzania [18,23,25]. The prevalence of *Raillietina echinobothridia* in pigeons is more than 14 and 9 times in nestlings and adults, respectively, as compared to *Raillietina tetragona* [25]. Komba, Mkupasi [23] recounted a prevalence of 34.2% and 38.2% for *Raillietina tetragona* and *Raillietina echinobothridia*, respectively, both having higher recovery rate than other species of helminth in adult scavenging village chickens. The higher prevalence of these two species than other species of helminths in adult scavenging chickens also reported in India, Nigeria, Ethiopia and Zimbabwe [10,41-43].

Davainea proglottina, Choanotaenia infundibulum and *Raillietina tetragona* prevalence in Tanzania was higher in grower than in adult scavenging village chickens compared to other species of cestodes [21]. *Raillietina cesticillus* and *Davainea proglottina* prevalences are significantly higher in the wet season whereas that of *Raillietina echinobothridia*, *Choanotaenia infundibulum* and *Hymenolepis carioca* is higher in dry than in wet season in scavenging village chickens in Tanzania [21]. The high prevalence of the cestodes is more expected during wet/rain period as observed in Kenya due to increase in the population of beetles, ants and oribatid mites that acts as transport hosts for most of the cestodes [27]. Species-specific variations in the prevalence of cestodes between dry and rainy seasons in Tanzania need further investigations. Cestode parasitism in poultry results in lowered growth rate, enteritis, diarrhoea and haemorrhages, which cause the death of young birds and reduced egg production in adult [30].

Protozoa

Coccidia: Coccidia infestation is common in local and commercial poultry and causes losses through lowered productivity and deaths [6,44,45]. The prevalence of coccidia infestation in scavenging village

Table 3: Ecto-parasites and their predilection sites in free-range poultry in Tanzania.

Type	Host	Parasite species	Predilection sites	Geographical area	References
Fleas	Chickens*	*Echidnophaga gallinacea*	Head, eyes, comb and wattles	Northern coastal and northern high lands, Lake zone, southern coastal Mtwara	[17,32,33]
Mites	Chickens	*Cnemidocoptes mutans, Dermanyssus gallinae*	Fetlock joint and planter /distal surface of the foot, on the skin	Northern coastal and northern high lands, Lake zone,	[17,32]
Soft ticks	Chickens	*Argas persicus*	Under the wing base	North coastal (Mkinga)	[17]
Hard ticks	Chickens	*Rhipicephalus* spp nymph	On the skin	Lake zone	[32]
Lice	Chickens and Pigeons*	*Menopon gallinae*	On the skin and feathers	Northern coastal and northern high lands	[17]
	Chickens and Pigeons	*Menacanthus stramineus*	On the skin and feathers of chicken and pigeon	Eastern Morogoro region and Lake zone	[25,32]
Flies	Pigeons	*Pseudolynchia canariensis*	On the skin and feathers (pigeons)	Eastern Morogoro regions	[25]

*Chicken - Local scavenging chickens.
*Pigeon - Domestic pigeons (Columba columba).

chickens in Tanzania ranges between 11.1% - 13.9% [23,37], and the prevalence in scavenging village chickens was seven times lower than that reported in commercial broilers and layers [46]. The high stocking density and genetically homogenous breeds typically found in intensive commercially produced flocks may be a reason for high prevalence in commercial poultry than in scavenging village chickens [46]. Despite a few poultry coccidiosis studies conducted in Tanzania, the similarities of climate and husbandry system between Tanzania and other countries with high prevalence suggest a similar trend in the country.

The mixed *Eimeria* species infestation in commercial broiler and layer flocks in Tanzania is at 63% which is comparable to 65% observed in broilers in Romania, compared to 23.4% and 26.5% documented in scavenging village chickens in Kenya and Tunisia, respectively [27,44-46]. The number of *Eimeria* species recovered in flocks of layers and broilers in Tanzania, Ghana and Zambia (7) is higher than that documented in broilers in Iran (4) and Romania (4) and in scavenging village chickens in Tunisia (3) and Kenya (2) [44,46,47]. There is no documentation on coccidia infestation in other poultry types in Tanzania other than indigenous and commercial chickens. However, the report from Turkey shows the coccidia oocyst prevalence of about 60% in domestic pigeons (*Columba livia domestica*) [48]. *Eimeria* is the only gastrointestinal protozoan parasite isolated in poultry in Tanzania, however, other species including *Tyzzeria* spp. and *Cryptosporidia* spp. have been reported in ducks in Nigeria [19].

Ecto-parasites

Ecto-parasites are pests carrying and transmitting diseases and negatively impacting the production potential and well-being of the poultry [9,49]. Ecto-parasite infestations result in production losses in poultry by causing a nuisance, skin damage, irritation, skin allergy and anaemia [50-53]. Climatic condition is essential determinants of ecto-parasite infestation in chickens in Tanzania whereby high humid is associated with a high infestation rate [17]. This association is in agreement with the study conducted in Nigeria in which the high prevalence recorded in rainy than in dry season [54]. Variations in temperature and humidity in different seasons of the year determine the survival and perpetuation of ecto-parasites with subsequent increase in bird infestations. Also, poultry infestation by different species of lice, flea, soft and hard ticks, mites and flies is mostly associated with poor management and lack of parasite control programs [27].

Ecto-parasite infestations are common in East African countries due to tropic and subtropics nature, which favours their survival [55]. The published reports on ecto-parasite fauna in domestic poultry in Tanzania are limited to a few geographical locations; hence, they do not reflect the actual countrywide occurrence and distribution. The documented species of ecto-parasites infest poultry in Tanzania belong to orders Acarina (mites, two species; and ticks, two species), Siphonaptera (fleas, one specie) and Phthiraptera (lice, two species) (Table 3). The prevalence of ecto-parasite infestation in Tanzania was 83.9% and 62% in scavenging village and domestic pigeons (*Columba columba*), respectively [17, 25]. The reported prevalence of ecto-parasite infestation in scavenging village chickens in Tanzania (62%) is lower than 100% and 95.8% reported during the wet and dry period, respectively, in Kenya [56]. The infestation rate of ecto-parasites in domestic pigeons (*Columba columba*) (62%) is lower compared to 91.7% reported in Bangladeshi in different species of domestic pigeons (*Columba livia*) [8]. The mixed infestation in scavenging chickens in Tanzania is common and reported at 81.7% [17], higher than 70.3% reported in Iran [57]. Ecto-parasite infestations in scavenging chickens and domestic pigeons are the only available literature on poultry ecto-parasite infestations in Tanzania.

Fleas

Fleas are annoying biters leading to discomfort, secondary infection and skin allergy (Wall and Shearer 1997; Dieme et al., 2015). Studies conducted in different parts of the country reported *Echidnophaga gallinacea* or "sticktight" as the only available flea and most common prevalent ecto-parasite in scavenging village chickens in Tanzania. The study conducted on ecto-parasites show the prevalence of 71.9% and 97.7% of *Echidnophaga gallinacea* in village chickens in northern areas and around Lake Victoria shore, respectively [17,32]. Apart from northern areas and Lake Victoria shore, *Echidnophaga gallinacea* also reported in Southern Zone in Mtwara region [33]. The prevalence of "sticktight" fleas in scavenging village chickens in the south-east area of Kenya bordering Tanzania range between 29.2% - 76.7%, which is an indication of the region rather than the individual country problem [27,56].

Lice

Chewing and blood-feeding behaviours of lice result into anaemia, skin irritation, decrease in egg production, decreased weight gain and feed intake in poultry, hence negatively affects the general

performance of the flock [9,58]. The currently available records in Tanzania show the presence of body lice (*Menacanthus stramineus*) and feather shaft lice (*Menopon gallinae*) both observed in scavenging village chickens and domestic pigeons (*Columba columba*) [17,25,33]. *Menopon gallinae* prevalence was found at 28% in scavenging village chickens in Mkinga (northeastern) and northern highlands of Babati and Ngorongoro and was the only species of louse recovered in these areas [17]. *Menacanthus stramineus* documented in Lake Victoria shore at the prevalence of 66.4% is the only louse species reported in scavenging village chickens in these areas [32]. Both *Menacanthus stramineus* and *Menopon gallinae* have also identified in the Southern zone (Mtwara region) and Eastern zone (Morogoro region) in scavenging village chickens and domestic pigeons, respectively [25,33]. The overall lice infestation in scavenging village chickens in Kenya was higher (89.6%) than other ecto-parasites, furthermore, In addition to two species occurring in Tanzania, large chicken lice (*Goniodes gigas*) and wing lice (*Lipeurus caponis*) have also recorded in this country [56].

Ticks

Ticks can cause significant production losses in poultry and a threat to public health by transmitting zoonotic bacteria, viruses and protozoa [59]. Two species of ticks have recovered in poultry in Tanzania; soft ticks- *Argas persicus* and hard ticks - *Rhipicephalus* spp nymph, the former being more common (Table 3). Based on the tick distribution map of Eastern Africa, *Argas persicus* was previously recorded only in the eastern shore of Lake Victoria and around Lake Natron on the Rift Valley basin in Ngorongoro district in Tanzania, and in south-central of Kenya [60]. The latest survey indicates the presence of the *Argas persicus* at a prevalence of 23.9% in local scavenging chickens along the northeastern coast of Tanzania, where it was previously unrecorded [17]. The extension of its distribution may be explained by transportation of live birds through trade along the northern east coast border of Tanzania and Kenya.

The occurrence of *Argas persicus* predisposes poultry to chicken fever caused by *Aegyptianella pullorum*. More than 23% of chickens in the northeast coastal and northern highlands of Tanzania infested by *Argas persicus* and prevalence of avian aegyptianellosis was 15.3% [17]. The intensive tick survey did not report the presence of *Argas persicus* on the northeastern coast of the country [61]. However, soft ticks have demonstrated in human, and poultry houses in Dodoma in central Tanzania and no investigation on poultry infestation has been conducted in these areas [62]. Although there is no seasonal prevalence recorded on *Argas persicus* distribution in Tanzania, the study conducted in Kenya shows a prevalence of 25.0% and 37.5% during dry and wet seasons, respectively, which is more likely to be the same trend in Tanzania [56].

Mites

Mite infestation in chickens cause listlessness, scratching and blood loss, which may result in birds to abandon eggs in their brooding nests [63]. *Dermanyssus gallinae* (red poultry mites) and *Cnemidocoptes mutans* are two species of mites prevalent in the northern coastal areas and Lake Victoria shores in Tanzania [32]. The northern coast and northern highlands areas including Pangani, Mkinga and northern districts of Same, Meru, Babati, Monduli and Ngorongoro also found to be infested by *Cnemidocoptes mutans* [17].

The prevalence of *Cnemidocoptes mutans* is 19.6% and 83.2% in the northern part and Lake Victoria shore areas, respectively, in smallholder village chicken keepers in Tanzania [17,32]. The prevalence reported in these two areas of the country is higher than that documented in the semi-arid zone of Eastern Kenya (13.3%) in local scavenging chickens. There is no age difference in *C. mutans* infestation in Tanzania, but in southern Ethiopia and Zimbabwe, the infestation was found significantly higher in adults than in growers and chicks [41,64]. The prevalence of poultry red mite in village chickens in urban and peri-urban areas of Lake Victoria shore in Tanzania was 63.4% and is the only report available of this specie of mites in the country [32]. The reported prevalence of red mites in Lake Victoria shore of Tanzania is comparable to that of the semi-arid zone of Eastern Kenya (60%) [27].

Flies

Some species of the hippoboscides that infest poultry cause annoyance, suck blood and act as the vectors of the pathogens. *Pseudolynchia canariensis* or pigeon louse fly or pigeon fly is the only fly of poultry documented in domestic pigeons in Tanzania. *P. canariensis* transmits *Haemoproteus columbae* which cause pigeon malaria. The only study conducted in domestic pigeons (*Columba columba*) in Tanzania established 61.1 % pigeon louse fly infestation in adult and nestling domestic pigeons [25]. A prevalence of 50% *Pseudolynchia canariensis* infestation also recorded in the domestic pigeon (*Columba livia domesticus*) in Zimbabwe, indicating a wide geographical distribution of the fly in this type of poultry.

Haemoparasites

Prevalence of the haemoparasites in local chickens observed to be more common in scavenging group than in their counterparts fed by feeders indicating a high exposure and contact rates of the birds to vectors in scavenging group [65]. Weather condition is the crucial determinant of Haemoparasite infections in poultry, more observed in warmer than in colder period mostly likely due to increases in arthropods vector activities during this period [66]. High infection is more reported in female local chickens in pigeons and quail [65,67,68], the trend associated with high progesterone and prolactin hormones in females which tend to lower the host immunity [69]. Haemoparasites are frequently detected in the blood of clinically healthy chickens, pigeons, ducks and quails [68,70], however, reports of 20–30% mortality associated with *Haemoproteus* spp. outbreak in bobwhite quails in captives are available [71].

Haemoparasite infections in poultry in Tanzania are common, and there is no study on the economic significance conducted in the country to-date. The haemoparasites documented in scavenging village chickens in Tanzania are *Aegyptianella pullorum, Haemoproteus columbae, Leucocytozoon schoutedeni, Leucocytozoon simondi* and *Trypanosoma numidae* [17,37,72]. *Leucocytozoon neavei, Leucocytozoon caulleryi* and *Trypanosoma numidae* detected in guinea fowl [72], and *Haemoproteus columbae* in domestic pigeons (*Columba columba*) [25]. The latest report indicates *Aegyptianella pullorum* as the only available and prevalent haemoparasite in northern Tanzania in scavenging indigenous chickens. The documented prevalence of *A. Pullorum* in Tanzania (15.3%) is almost the same as that of Zimbabwe (14%) and three times higher than the one reported in Kenya [17,41,56]. Leucocytozoonosis is also accounted haemoparasitic

disease in scavenging village chickens in Tanzania, *Leucocytozoon schoutedeni* and *Leucocytozoon simondi* being responsible species causing infections at the rate of 50% and 2.9% respectively [37, 72]. The infection rate of *Leucocytozoon schoutedeni* in scavenging village chickens in Tanzania is close to that observed in Kenya (52.1%) [73].

Haemoproteus columbae is the only blood parasite reported in the country in domestic pigeons (*Columba columba*) at an infection rate of 37%, more common in adults than in nestlings [25] and similar age prevalence trend as observed in Bangladeshi in another type of domestic pigeons (*Columba livia*) [68]. The prevalence of *Haemoproteus columbae* reported in Tanzania in domestic pigeons is lower than reported in Botswana (79.2%) [25,38]. Although the *Haemoproteus columbae* is non-pathogenic, infection in young and stressed pigeons may result in clinical disease and deaths [68,74]. Also, leucocytozoonosis associated with some histopathological changes in ducks had documented in Bangladeshi [70]. Mixed infections with double (*Plasmodium* spp. and *Haemoproteus* spp.) or triple (*Plasmodium* spp., *Haemoproteus* spp. and *Leucocytozoon* spp.) haemoparasites in scavenging village chickens are common and have reported in Iraq and Nigeria [67,75]. *Aegyptianella pullorum* infections result into anaemia, lowered growth and production, emaciation, diarrhoea, fever and paralysis in chickens [55,76]. *Aegyptianella pullorum* and other haemoparasites might be prevalent in poultry in Tanzania, which call for more investigation on their impacts on the poultry production in the country.

Limitations of the Study

Our review was not 'systematic and meta-analysis' and therefore it was limited to surveys carried out in Tanzania mostly targeting few available international journals, local journal and dissertations. Survey methods, sample size and study regions or districts varied between studies limiting direct comparability between analyses. Not all regions, let alone districts had studies reporting ecto-, endo- and haemoparasites prevalence in poultry. More than 90% of the studies conducted in one region making the results of these studies biased in estimating the occurrence and distribution of the ecto-, endo- and haemoparasites in the country. Despite many studies concontracting in the eastern part of the country, it is suggestive that poultry is in contact with parasites across the country, taking into account the absence of a specific country control program.

Conclusion

There is the numerous and high prevalence of ecto-, endo- and haemoparasites occurring in poultry production systems in Tanzania. Multiple ecto-, endo- and haemoparasite infestations/infections are more common than a single parasite in all types of poultry studied in Tanzania. Heavy ecto-, endo- and blood parasite infestation/infection reported by different studies are likely to be one of the main contributors for the low productivity of the extensively raised poultry in rural, urban and peri-urban settings in Tanzania. There is no sound poultry parasites survey in the country, which makes the estimation of the country poultry parasites burden difficult. More structured surveys covering more extensive geographical areas and poultry species are necessary in order to provide a broader understanding of the impact of poultry endo-, ecto and blood-borne parasites in Tanzania.

Although chickens are the type of poultry mostly kept in Tanzania, other types of poultry including ducks, turkeys, pigeons and guinea fowls are also available. In order to improve poultry parasites control in Tanzania, the intensive surveys required to determine the spatial and temporal distribution, type, significance and economic importance of poultry parasites that will contribute to the development of technically feasible and economically viable control strategies rather than depending on poultry keeper's efforts only.

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