

## Helminth infection of layer and dual-purpose chickens kept under small scale intensive production system, Ethiopia

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### Abstract

Losses due to reduced productivity caused by helminthiasis are economically important to the poultry industry. There are a few research reports in the prevalence of helminth-parasites in the different poultry production systems. A cross sectional study was conducted with the aim of estimating the prevalence of helminth infections in exotic layer and dual-purpose chickens, kept under small scale intensive farms of selected towns, Ethiopia: Addis Ababa (Highlands) and Debre Zeit, Haramaya, Hawassa and Kombolcha (Midlands) climatic zones. Towns and farms were purposively identified while chickens from each farm were randomly selected for fecal sample collection and necropsy examination. A total of 1009 fresh fecal samples and thirty-three chickens were collected from chickens of different breeds. Helminth egg and adult parasite identification was processed through coproscopic and necropsy examination methods, respectively. The overall prevalence of helminth infection was 66%. A statistically significant difference was found in the prevalence of helminthiasis among study sites ( $P < 0.01$ ) and between chicken breeds ( $P < 0.02$ ). Helminthiasis was relatively higher in Addis Ababa (72%), Debre Zeit (71%) and Haramaya (67%) compared to Hawassa (56%) and Kombolcha (34%). Helminth infection in Dominant Sussex was higher, 90%, followed by White Leghorn chicken 80%, Bovans 67%, Koekock 58%, Dominant Red Barred 57%, Lohman Brown 42%, Fayoumi 40% and Lohman Dual 33%. However, the prevalence did not vary ( $P > 0.05$ ) among age groups. Three species of nematodes as *Ascaridia galli* (52%), *Heterakis gallinarum* (57%) and *Capillaria* species (1%) and one species of cestode: *Raillietina* species (3%) were identi-

fied. Regular check up for helminth infection and application of appropriate prevention and control measures are important.

**Key words:** Chicken; Exotic; Intensive; Helminth-infection; Small-scale

## Introduction

There are approximately 25–30 medium to large scale integrated poultry farms in Ethiopia, that keep, process and distribute their products by themselves. Large scale layer farmers rear pullets themselves, mostly from their own or imported day old chicks. However, some medium and most small-scale farmers either choose for pullet rearing or for layer keeping (Boere *et al.*, 2015). There is a gradual increase in commercial small- and medium-scale chicken production in the country (Pagani and Wossene, 2008). In the small-scale intensive system of production in urban and peri-urban areas of the country, small number of exotic breeds of chickens are produced using relatively modern management methods. This activity is being undertaken as a source of income in and around major cities of the country. These farms are involved in the production and supply of table eggs to various supermarkets, kiosks and small roadside restaurants through middlemen (Demeke, 2008). However, most of the poultry (meat and egg) products consumed still come from backyard village poultry systems (Dessie and Ogle, 2001; Udo *et al.*, 2006; Boere *et al.*, 2015). In general, the contribution of the chicken industry to the national economy and per-capita meat and egg consumption is very low. Several factors have been suggested for the low production and productivity of chickens. Poultry diseases continue to play a major role in directly interfering with poultry productivity, which decreases economic returns and may therefore negatively affect the development of the industry. Losses due to reduced productivity (increased feed conversion ratio, poor weight gain, poor egg production, death of young birds) caused by helminthiasis are economically very important to the poultry industry. There are several types of helminths that cause a serious economic problem to poultry industry. Intestinal worms, large roundworm, hairworms, threadworms, but the most common is the large roundworm (*Ascaridia galli*). *Ascaridia galli* is a nematode occurring in the small intestine of chickens. It is a worldwide problem in all poultry production systems, especially in free-ranging birds and is a cause of economic loss in modern poultry. Light to medium infestations may not produce clinical signs; however, heavy infestations may cause diarrhea, intestinal occlusion, intussusceptions, emaciation, anemia, reduced egg production and death. This parasite has been implicated in some cases of egg

yolk peritonitis. *Heterakis gallinarum* found in the lumen of the ceca. Infection with *H. gallinarum* may not show clinical signs but is capable of transferring the protozoa *Histomonas meleagridis* to chickens, a species of protozoan parasite that causes histomoniasis or blackhead disease. *Capillaria* species are located throughout the intestinal tract. Birds are infected when ingesting the earth worms. Infections with *Capillaria* spp. can be highly pathogenic for birds kept in deep-litter systems where big numbers of infective eggs may build up in the litter or in the soil. *Raillietina* is a cestode and located in the small intestine where the scolex is embedded into the mucosa. Chronic infections are characterized by reduced growth, emaciation and weakness (Merck, 2011; PDHA, 2009; Permin and Hansen, 1998). A number of endo-parasites are widely studied and reported in traditional systems of poultry production throughout the world including Ethiopia (Ashenafi and Eshetu, 2004). The prevalence of parasitic diseases in poultry seems to have been reduced significantly in commercial indoor poultry production systems due to improved housing, hygiene and management. However, parasitic diseases continue to be of great importance in deep-litter and free-range commercial systems (Merck, 2011). Besides, there are only a few reports on the prevalence and significance of endo-parasites in the different poultry production systems (Permin and Hansen, 1998). Research in poultry diseases and parasites in the different poultry production systems of the country is limited. Therefore, the study was designed to determine the occurrence of helminthiasis in exotic *layer* and dual-purpose chickens kept under small scale intensive management system of the selected towns of Ethiopia.

## Materials and methods

### Study area and study design

A cross sectional study was conducted between 2015 and 2016 to determine the occurrence of helminthiasis circulating in small scale *layer* and dual-purpose chicken farms, under intensive deep-litter management system of 5 selected towns, Ethiopia: Addis Ababa, Debre Zeit, Kombolcha, Haramaya and Hawassa. Addis Ababa has a subtropical highland climate with an altitude of 2,355 meters above sea level. The average annual rainfall and average maximum and minimum temperature for the area are 1,165mm, and 30.6 °C and 0 °C, respectively. Debre Zeit is located 47.9 km south east of Addis Ababa, the town is located in the east Shewa Zone of the Oromia Region and has a midland climate with an altitude of 1,920 meters above sea

level. The average annual rainfall and average maximum and minimum temperature for the area are 800mm, and 27.7 °C and 12.3 °C respectively. Kombolcha is a city and woreda in north-central Ethiopia, located in the Debu Wollo Zone of the Amhara Region and has a midland climate with an elevation between 1842 and 1915 meters above sea level. Haramaya is a town located in the East Hararghe Zone of the Oromia Region, located in the eastern part of Ethiopia and has a midland climate with an altitude of 2,047 meters above sea level. Hawassa is a city located in the Southern Nations, Nationalities, and Peoples' Region. It is located 273 km south of Addis Ababa and has a midland climate with an altitude of 1708 meters above sea level.

### **Sampling technique**

Because of the selected towns are very well-known for their small scale intensive deep-litter chicken rearing practices and to have relatively high density of chickens, purposive sampling method was been carried out to identify towns while random sampling method was used to identify chickens per farm. A total of 1009 fresh fecal samples from individual layer and dual-purpose chickens and thirty-three apparently healthy chickens were used for fecal sample collection and necropsy examination, respectively. Chickens were selected according to their age groups and breed types. The age was conveniently subdivided into young growers from 2-9 months and into adult chickens to those of 10 and greater than 10 months. Chicken samples were collected from different breeds of layers: Bovans from Addis Ababa (250), Debre Zeit (408) and Kombolcha (93) and White Leghorn (100) chickens and dual purpose: Dominant Red Barred (28), Dominant Sussex (20), Fayoumi (50), Koekock (19), Lohman Brown (26), and Lohman Dual chickens (15).

### **Sample collection and laboratory procedures**

Fecal samples were collected, properly labeled with the necessary information's, placed in clean universal bottle and were kept in portable refrigerator. Then samples were immediately transported to Debre Zeit agricultural research center laboratory, for further laboratory examination. Helminths egg identification was processed by centrifugation flotation method, that involves sodium chloride solution as a floatation fluid. Helminth eggs were identified by their size, shape and the color of the shell wall. Concentration McMaster technique was used for the counting of eggs, that 15 ml of the fecal suspension correspond to 1.0 gram of feces (Permin and Hansen, 1998). The number of eggs per gram of feces (EPG) was calculated by counting eggs in both fields and

by multiplying them by 20 (Permin and Hansen, 1998). The collected chickens were also monitored through necropsy. Incision was made through the cloaca in the midline in cranial direction to inspect the whole abdominal cavity. Gastrointestinal tract: the oesophagus, crop, proventriculus, ventriculus (gizzard) and the whole intestine were placed in the tray and were opened in a longitudinal section and examined. The intestinal contents are carefully washed through a test sieve and the mucosa was carefully scraped and the contents of the sieve transferred to a petri dish and were examined under a stereo microscope through grouping and count of helminths (Kaufmann, 1996; Urquhart *et al.*, 1996; Permin and Hansen, 1998).

### **Data analysis**

Collected data were coded and recorded in Microsoft excel spread sheet. Then analyzed using Statistical Package for Social Sciences (SPSS) version 23. Descriptive statistical analysis (mean and percentage) was used to summarize and present the data. Chi-square test was used to evaluate association of chickens breed and age with the prevalence of helminth infection. P-value <0.05 was considered significant.

### **Results**

Out of one thousand nine examined small scale, layer and dual-purpose chickens, the overall prevalence of gastro-intestinal helminths was found to be 66%. A statistically significant ( $P < 0.01$ ) difference was found in the prevalence of helminth infection among study sites (Table 1).

**Table 1. Overall prevalence of GIT helminth-parasites among chickens of different study sites.**

Study sites	Elevation	Climatic zones	No. sampled	No. positive	Prevalence (%)	95% CI
Addis Ababa	2355	Highlands	250	181	72	0.05
Debre Zeit	1920	Midlands	408	289	71	0.04
Haromaya	1708	Midlands	150	100	67	0.07
Hawassa	2047	Midlands	108	68	56	0.09
Kombolcha	1842	Midlands	93	32	34	0.09
Total			1009	669	66	
F						14.2
P-value						<0.001

There was a statistically significant ( $P < 0.02$ ) difference in the prevalence of helminth infection between chickens of different breeds (Table 2).

**Table 2. Prevalence of GIT helminth infection among chickens of different breed.**

Breed	Study area	No. sampled	No. positive	Prevalence (%)	95% CI
Bovans	Addis Ababa	250	181	72	0.05
Bovans	Debre Zeit	408	289	71	0.04
Bovans	Kombolcha	93	32	34	0.09
	Total	751	501	67	
Dominant Red Barred	Hawassa	28	16	57	1.17
Dominant Sussex	Hawassa	20	18	90	1.13
Fayoumi	Haramaya	50	20	40	0.14
Koekock	Hawassa	19	11	58	4.5
Lohman Brown	Hawassa	26	11	42	3.4
Lohman Dual	Hawassa	15	5	33	0.26
White Leghorn	Haramaya	100	80	80	0.07
	Total	1009	662	66	
F					4.5
P-value					0.002

The prevalence of *A. galli*, *H. gallinarium*, *Capillaria spp* and *Raillietina spp* of layer and dual- purpose intensively managed chickens was 54, 61, 1.2 and 2.9 (%) in Debre Zeit, 68,70, 1.2 and 2 (%) in Addis Ababa, 45, 49, 2 and 1.3 (%) in Haramaya, 37, 47, 0 and 4.6 (%) in Hawassa and 32, 32, 4 and 4 (%) in Kombolcha, respectively. The prevalence of *H. gallinarium* infection among the study sites was statistically ( $P<0.01$ ) significant (Table 3).

**Table 3. Prevalence of GIT helminth species on the basis of study site.**

Study sites	A. galli				H. gallinarium			Capillaria spp			Raillietina spp		
	No. sampled	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI
AA	250	170	68	0.05	175	70	0.05	3	1	0.01	5	2	0.01
DZ	408	222	54	0.04	250	61	0.04	5	1	0.01	12	3	0.01
HAR	150	67	45	0.08	73	49	0.08	3	2	0.02	2	1	0.01
HAW	108	40	37	0.09	51	47	0.09	0	0	0.00	5	5	0.04
KOM	93	30	32	0.09	30	32	0.09	4	4	0.04	4	4	0.04
Total	1009	529	52		579	57			1			3	
F		14.1			13			1.8			0.9		
P-value		2.8			0.000			0.1			0.4		

AA=Addis Ababa, DZ=Debre Zeit, HAR=Haramaya, HAW=Hawassa, KOM=Kombolcha

Three species of nematodes were identified. The overall prevalence of *A. galli*, *H. gallinarium*, *Capillaria spp* and *Raillietina spp* was 52, 57, 1 and 3 (%), respectively. A statistically significant ( $P<0.01$ ) difference was found in the prevalence of *H. gallinarium* infection among the study breeds (Table 4).

The overall mean EPG count of gastro-intestinal helminthes: *A. galli* ranges from 7 to 364, *H. gallinarium* from 31 to 538, *Capillaria spp* from 0 to 3 and *Raillietina spp* from 0 to 7. Except the *Raillietina spp*, the mean EPG prevalence of nematodes did not vary ( $P>0.05$ ) among study sites (Table 5).

**Table 4. Prevalence of GIT helminth-parasite species on the basis of breed.**

Study sites	A. galli				H. gallinarium			Capillaria spp			Raillietina spp		
	No. sampled	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI	No. positive	Prevalence (%)	95%CI
BOV	751	415	55	0.06	455	61	0.06	12	2	0.2	21	3	0.2
DRB	28	12	43	0.19	15	54	0.2	0	00	0.0	0	00	0.0
DS	20	11	55	0.2	17	85	0.2	0	00	0.0	2	10	0.02
FAY	50	17	34	0.1	12	24	0.1	2	4	0.2	2	4	0.01
KK	19	3	16	0.2	5	26	0.2	0	00	0.0	3	16	0.02
LB	26	10	38	0.2	9	35	0.2	0	00	0.0	0	00	00
LD	15	4	27	0.3	5	33	0.3	0	00	0.0	0	00	00
WLH	100	50	50	0.09	.61	61	0.09	1	1	0.2	0	00	00
F		0.1			5.1			1.8			0.9		
P-value		1.9			0.000			0.1			0.4		

**Table 5. Mean EPG count SE of helminth-parasites on the basis of study sites.**

Study sites	A. galli			H. gallinarium			Capillaria spp			Raillietina spp		
	Mean	Standard Error	95%CI	Mean	Standard Error	95%CI	Mean	Standard Error	95%CI	Mean	Standard Error	95%CI
AA	125	8.9	17.5	538	44.1	86.9	2.60	1.5	2.9	0.02	0.0	0.01
DZ	364	14.9	29.3	484	19.1	37.5	0.00	0.0	0.0	10.6	3.4	6.7
HAR	84	10.4	20.7	363	37.2	73.6	0.54	0.3	0.7	0.01	0.0	0.01
HAW	65	13	25.7	126	14.7	29.3	1.78	0.6	1.2	0.03	0.02	0.03
KOM	7	1.1	2.36	31	5.8	11.5	3.10	1.6	3.1	2.4	1.2	2.4
F	106			33			2.2			3.2		
P-value	6.3			4.4			0.06			0.01		

EPG=egg count per gram of feces; SE= Standard Error

AA=Addis Ababa, DZ=Debre Zeit, HAR=Haramaya, HAW=Hawassa, KOM=Kombolcha



Bovans chicken, collected from around Debre Zeit and Addis Ababa showed a sever *A. galli* infection (Figure 1).



**Figure 1.** Small intestine of layer chickens is showing a large number of adult and larva *A. galli* worms

## Discussion

In the current study the overall prevalence of GIT helminth infections in small scale chicken farms under intensive deep-litter management system was 66%. This was lower compared to that of 79.9%, reported in small scale commercial chickens of Bahir Dar town by Belete and Addis (2015) and 98.9%, reported in broiler breeders of the United States by Yazwinski *et al* (2013). The prevalence of helminthiasis was relatively higher in Central Ethiopia: Addis Ababa (highlands) and Debre Zeit (midlands) and Haramaya (midlands) than those of Kombolcha and Hawassa (midlands) climatic zones. According to the findings reported by Ashenafi and Eshetu (2004), there was a significant difference in the prevalence rate of helminth parasites between the different agro-climatic zones. However, the difference found among the prevalence's of the current study areas couldn't be related to the different climatic zones. Most probably it could be due to the management practices of those areas. The increased intestinal helminth infections reported in Central Ethiopia, could be resulted due to the poor management, health care practices and bio-security status of some small-scale chicken farms. Management problems in general, were common in Central Ethiopia: Debre Zeit and Addis Ababa. (Wossene, 2006). This was confirmed through our direct observation while we were collecting samples, we observed a large number of chicken houses, with poor construction systems, close to each other, with chickens of different production type; either

broiler or layer and with chickens of different age and breeds. The presence of old build up used litters, droppings, extensively reared endogenous chickens, domestic animals and family houses also observed, very close to the majority of chicken houses. This was in line with the report of Wossene (2006), Ayele and Rich (2010) and Adamu (2015), who have also reported that the management, health care practices and bio-security status in many of the small-scale intensive poultry farms in Ethiopia are generally poor. The high prevalence of GI helminth infections among the small scale intensively managed chickens reported in the current study was in consistent with those previously reported from different parts of the world for instance: Yazwinski *et al* (2013) from United States and Wokem and Obiyor (2018) from Nigeria. This was supported with the discussion reported by Permin and Hansen (1998) and Merck (2011), who described that modern confinement rearing of poultry has significantly reduced the incidence and diversity of endoparasite infections, which are common in ranged birds and in backyard flocks. However, severe parasitism still may be seen in floor-reared chickens where management problems may exist. The 34% of prevalence reported from Kombolcha is consistent with that of Ngongeh *et al* (2014), who reported the prevalence of 34.4% of GI helminths in slaughtered layer chickens reared in Enugu State, Nigeria. According to an informal discussion done with some *layer* chicken farm owners whose chickens were diagnosed with widespread *A. galli* and *H. gallinarium* infection, reported that their chicken flocks were never treated against helminth infection. However, they were properly vaccinated and supplemented with balanced feed but the egg production was reduced up to about 30 percent. This could be due to the chronic and un-treated helminth infections. This was in line with the report of Shane (2005), who discussed that extensive *A. galli* infection may reduce egg production in floor housed breeders and commercial layers. Some poultry farmers also reported that they have no idea about the occurrence of helminth infection in the intensive deep-litter management system. However, whenever management problems exist such as poor biosecurity practices and accumulation of used litter and droppings around chicken house, they may serve as shelter and breeding places for intermediate hosts of helminths like, earthworms, insects, other invertebrates and for the accumulation of infective eggs. As a result, confined chickens can be easily affected by eating the intermediate and/or paratenic hosts which move to the chicken houses containing infective eggs of helminths.

A significant variation was found in the *A. galli* and *H. gallinarium* infection among different chicken breeds of the study areas. The variation of helminth

infection among chicken breeds of the same management system could be due to the genetic resistance variation of the chickens. Helminth infection in layer (White Leghorn and Bovans) and Dominant Sussex (dual- purpose) chickens was higher than the other dual-purpose chickens. This was in line with the report of Kaufmann (2011), who found the higher resistance to *A. galli* infection of Lohmann Tradition and Lohmann Brown hens than that of Lohmann LSL classic and ISA Brown hens when exposed to an experimental *A. galli* infection. Abdelqader *et al* (2007), also reported the higher resistance of local chickens than Lohmann LSL white chickens. Local chickens of Jordan infected with *A. galli* revealed significantly fewer worms and excreted less *A. galli* eggs than those of Lohmann LSL white chickens.

The overall prevalence of GI nematodes *A. galli* and *H. gallinarum* was 52% and 57%, respectively. This was higher compared to those reported by Belete and Addis (2015) who reported the prevalence of 20.9 and 17(%), respectively in small scale commercial chickens of the Bahir Dar town. The reason for the higher nematodes infection is similar to those previously indicated for the higher prevalence of helminthiasis. The most prevalent nematode species identified were *A. galli* and *H. gallinarum*. This result is in agreement with those previously reported in laying hens kept in organic production systems in Germany by Kaufmann (2011), who reported the prevalence of *H. gallinarum* (98 %) and *A. galli* (88 %) as the most prevalent nematode species. The prevalence of *Capillaria* and *Raillietina* species reported in the current study is lower. This is closely related to those reported by Beyene *et al* (2014), Ngongeh *et al* (2014) and Belete and Addis (2015).

The mean egg count per gram of feces (EPG) are important for monitoring helminth infections at individual as well as population level (Permin and Hansen, 1998). The mean EPG count of Addis Ababa, Debre Zeit and Haramaya showed more severe *H. gallinarium* infection ( $EPG=538, 484$  and  $363$ ), respectively while chickens of Debre Zeit and Addis Ababa showed more severe *A. galli* infection ( $EPG=364$  and  $125$ ), respectively compared to the mean egg count of others studied chickens. This was in agreement to those previously reported by Bachaya *et al.*, 2015, who reported that *White leghorn (layer) chickens, reared in deep litter had more severe infection of A. galli (EPG=1920) compared with those of battery cages birds (EPG=500)*. The mean EPG count of *Raillietina* species was significantly ( $P<0.01$ ) different among the study sites. However, mean EPG count of *A. galli*, *H. gallinarium* and *Capillaria* did not vary ( $P>0.05$ ) among the study site.

## Conclusion

The prevalence of helminth infection among the study chickens was higher. A significant difference was found in the prevalence of helminth infection among study sites and chicken breeds. However, the prevalence did not vary among different age groups. Three species of nematodes as *A. galli*, *H. gallinarum* and *Capillaria* species and one species of cestode: *Raillietina* were identified. *H. gallinarum* and *A. galli* are the most prevalent nematode species found. The mean egg count of Addis Ababa, Debre Zeit and Haramaya showed more severe *H. gallinarum* infection while chickens of Debre Zeit and Addis Ababa showed more severe *A. galli* infection. Proper control and prevention measures through awareness creation, proper sanitation, disposal of droppings and removal of used litters, regular checkup for helminth infection, timely deworming, rearing of chickens separately by their breed management system and age groups, would help to improve egg and poultry meat production.

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## Conflict of interest

There is no conflict of interest to declare.

## References

- Abdelqader, A., Gaily, M. and Wollny, C.B.A., 2007. Response of two breeds of chickens to *Ascaridia galli* infections from two geographic sources. *Vet. Parasitol.*, 145(1-2), 176–180. <https://doi.org/10.1016/j.vetpar.2006.11.004>.
- Adamu, M., 2015. Evaluation of risk factors associated with coccidiosis in broiler farms of selected towns of Ethiopia. *African J. Basic & Appl. Sci.*, 7(1), 34-40.
- Ashenafi, H. and Eshetu, Y., 2004. Study on gastrointestinal helminthes of local chickens in central Ethiopia. *Rev. Med. Vet.*, 155, 504-507.
- Ayele, G. and Rich, K.M., 2010. Poultry Value Chains and HPAI in Ethiopia, Africa/ Indonesia team working paper, [Available from: <http://www.hpai-research.net>].

- Bachaya, H.A., Raza, M.A., Anjum, M.A., Khan, I.A., Aziz, A., Manzoor, Z. and Munawar, S.H., 2015. Prevalence of *Ascaridia galli* in white leghorn layers and Fayoumi-Rhode Island red crossbred flock at government poultry farm Dina, Punjab, Pakistan. *Trop. Biomed.*, 32(1), 11–16.
- Belete, A. and Addis, M., 2015. A survey of gastrointestinal helminthes among chickens in Bahir Dar town, Ethiopia. *Euro. J. Applied Sci.*, 7(2), 64-71.
- Beyene, K., Bogale, B. and Chanie, M., 2014. Study on effects and occurrence of nematodes in local and exotic chickens in and around Bahir Dar, Northwest Ethiopia. *America-Euroasian J.r Scientific Res.*, 9(3), 62-66
- Boere, A., Duns, H., Kidane, D., Vernooij, A. and Legesse, M., 2015. Business opportunities report poultry #3 in the series written for the “Ethiopian Netherlands business event 5–6 November.”, 19 pages, Rijswijk, The Netherlands”.
- Demeke, S., 2008. Poultry Sector Country Review: an analysis of the poultry sector in Ethiopia, Animal production and health division, emergency center for transboundary animal diseases, socio economics, production and biodiversity unit: FAO, 48 pages, Rom, Italy.
- Dessie, T., and Ogle, B., 2001. Village poultry production systems in the central highlands of Ethiopia. *Trop. Anim. Health Prod.*, 33(6), 521-537.
- Kaufmann, F., 2011. Helminth infections in laying hens kept in alternative production systems in Germany, Prevalence, worm burden and genetic resistance. Georg-August-University Göttingen, PhD Dissertation.
- Kaufmann, J., 1996. Detection of helminth eggs, larvae, oocysts, and sporocysts of protozoa in feces. 5–7 pages. In: J. Kaufmann, (ed.). *Parasitic Infections of Domestic Animals (A diagnostic manual)*. Birkhauser Verlag, Basel, Switzerland.
- Merck., 2011. Merck Veterinary manual, Overview of helminthiasis in poultry. (Nematode and cestode infections). In: M.K. Cynthia (Ed.), *MVM*. 10th ed, online version, Merck Sharp & Dohme Carp, a subsidiary of Merck & Co., Inc, Whitehouse Station, NJ, USA.
- Ngongeh, L.A., Chiejina, S.N. and Lawal, A.I., 2014. Prevalence of gastrointestinal helminth infections in slaughtered chickens reared in the Nsukka area of Enugu State, Nigeria. *IOSR-JAVS.*, 7(11),51-54
- Pagani, P., Wossene, A., 2008. Review of the New Features of the Ethiopian Poultry sector, Biosecurity Implications. Consultative Mission, March, FAO, pp. 1-29.
- PDHA., 2009. Poultry disease hand book for Africa, Global livestock collaborative research support program, Msoffe, P.L., Cardona, C.J.:(Ed.), pp. 91.

- Permin, A. and Hansen, J.W., 1998. Epidemiology, diagnosis and control of poultry parasites, Animal Health Manual, Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 169.
- Shane, S.M., 2005. Hand book on poultry diseases. 2<sup>nd</sup> ed, American Soybean Association (ASA), St. Louis, USA, pp. 191.
- Udo, H.M.J., Asgedom, A.H. and Viets T.C., 2006. Modeling the impact of interventions in village poultry systems. *Agri. System*, 88 (2-3), 255-269.
- Urquhart, G.M., Armour, J., Duncan, J.L., Dunn, A.M. and Jennings, F.W., 1996. Veterinary Parasitology. 2<sup>nd</sup> ed. Blackwell Science, Scotland, pp. 307.
- Wokem, G.N. and Obiyor, E.T., 2018. Assessment of intestinal parasites of commercial layers in selected local government areas of Rivers State, Nigeria and their public health implications. *Curr. Trends in Biom. Eng & Biosci.*, 11(5), 1-5
- Wossene A., 2006. Poultry Bio-security Study in Ethiopia. A consultancy report. Ministry of Agriculture and Rural Development Animal Health Department and Food and Agriculture Organization of The United Nations, April, Addis Ababa, Ethiopia, pp. 35.
- Yazwinski, T., Tucker, C., Wray, E., Jones, L., Johnson, Z., Steinlage, S. and Bridges, J., 2013. A survey on the incidence and magnitude of intestinal helminthiasis in broiler breeders originating from the southeastern United States. *J. Appl. Poult. Res.*, 22, 942-947