Abstract
This study was a preliminary survey for identification of parasites (endoparasites and ectoparasites) and their prevalence in domestic pigeons (Columbia livia) in Tripoli, Libya. One hundred adult domestic pigeons were purchased from different markets of Tripoli. Blood smears were prepared from each bird and examined using light microscopy with oil immersion lens for the presence of blood parasites. Oropharyngeal swab was taken from each pigeon and were processed through direct smear method and staining with Giemsa to identify Trichomonas gallinae. Each pigeon was examined for ectoparasites. Moreover, intestinal parasites were investigated and all helminths were counted before being fixed in 70% ethyl alcohol for further identification. Out of 100 pigeons examined, 76% (76/100) were infected with Haemoproteus spp. and 55% (55/100) with T. gallinae. The overall prevalence of ecto–parasitic infestation was 89% (82% Columbicola columbae, 18% Goniodes gallinae, 3% Menopon gallinae and 1% Pseudolynchia canariensis). The overall prevalence of intestinal helminths in examined pigeons were 56% (56/100). Three species of Cestoda (2% Raillietina tetragona, 32% R. echinobothrida and 4% R. cesticillus) and three species of Nematoda (18% Heterakis gallinarum, 22% Ascaridia galli and 4% Capillaria spp.) were identified. Also, this study revealed that the pigeons examined were found infected with mixed parasites. The study highlights that pigeons are hosts of helminths of veterinary importance and may act as an important source of infection for other avian host, which share the common parasitic fauna.

Keywords: Columbia livia, Ectoparasite, Endoparasite, Libya, Tripoli.

Introduction
Pigeons are live side by side with other animal species in the nature. Also, causes contamination of surroundings with their droppings. In Libya, pigeons are mainly kept for fancy and performing purposes. However, in many parts of the country pigeons are seen daily search for food together with other poultry species. Pigeons may be infected with many organisms, as a reservoir of many parasitic diseases for poultry and the close contact of pigeons with other domestic birds increases risk of parasitic infestation in birds (Piascki, 2006; Sari et al., 2008).

Nematodes are one of the endoparasitic problems of pigeons. According to the studies conducted in different regions of the world, Ascaridia columbae, Capillaria spp., Dispharynx spp., and Tetrameres spp. were commonly identified in pigeons (Harlin, 1994; Dovc et al., 2004). Adang et al. (2008) in Zaria, Nigeria; they found that speckled pigeons were infested with Menopon gallinae, Columbicola columbae, Pseudolynchia canariensis and were infected with cestodes; Raillietina tetragona, Raillietina cesticillus, Amoebotaenia cuneata and Hymenolepis carioca (Magalhaes). In green mountain (El- Jabal Akhtar) region in Libya, Eljadiar et al. (2012) they are found 90% of 30 pigeon (Columbia livia) examined were infected with Elmeria spp., Nematodes (20% for Capillaria spp., 10% for Heterakis spp. and 5% of the fecal samples were infected by multiple parasites and 1% Haemoproteus spp.

The prevalence rate of trichomoniasis in domestic and wild birds maintained at the Zoological Garden, Lahore, Pakistan was found to be 26% and 60%, respectively (Saleem et al., 2008). In Khorasan province, Iran, Borji et al. (2011), found that 156 out of 418 pigeons (Columbia livia) examined were infected with Trichomonas gallinae. The prevalence of trichomoniasis in pigeons in Bursa, Turkey, was 75.78% (Gulegen et al., 2005).

The conception of parasitic diseases of pigeons will help in contemplate the measures to improve health of these birds in Libya. The reason for studying the parasites of domestic pigeons is because they are might transmit their parasites to other domestic birds and wild birds. Several research works have been conducted on parasitic diseases of pigeon in several countries of world but limited works conducted in Libya. Therefore, the aim of this study was performed to identify internal and external parasites and their prevalence in domestic pigeon in Tripoli, Libya.

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Materials and Methods

One hundred adult domestic pigeons (Columba livia) were purchased from the different markets of Tripoli (which captured from the city). Blood samples for the preparation of blood smears were obtained from a wing vein of each bird by using 2 ml syringe and needle. Blood was poured into EDTA anticoagulant vacutainer tubes. The air-dried blood smears were subsequently fixed in absolute methanol and stained with Giemsa’s solution for 45 minutes. The smears were later examined using light microscopy with an oil immersion lens for the presence of blood parasites. Or pharyngeal swab was taken from each pigeon. They were processed through direct smear method and staining with Giemsa (Coles, 1980) to identify the T. gallinae. After the decapitation each pigeon, it was immediately placed in a polythene bag and the ectoparasites were collected after leaving the pigeons. Also, each bird was visually inspected and their whole body was fully examined. The external parasites of each were preserved in 70% alcohol for identification. For intestinal parasitic investigation, the postmortem examination was done according to Fowler (1996) and all helminths were collected in dishes and counted under a dissecting microscope. The worm burden per bird was determined then fixed in 70% ethyl alcohol and then cleared in lactophenol (Searle, Essex, England) for 10-15 minutes. The specific identity of collected helminths was determined according to criteria described by Yamaguti (1959, 1961) and Soulsby (1986).

Results

Of one hundred pigeons examined, 76% and 55% were infected with Haemoproteus spp. and T. gallinae respectively. The ectoparasites were found in 89 pigeons (89%). Four different species were identified: Columbicloa columbae (82%), Gonides gallinae (18%), Menopon gallinae (3%) and Pseudolynchia canariensis (1%) (Table 1). Cestodes and nematodes worms were also found in examined pigeon, whereas no trematodes were found. The overall prevalence of intestinal helminths in investigated pigeons was 56% (56/100). Three species of Cestoda were identified (Table 2): Raillietina tetragona (2%), R. echinobothrida (32%) and R.cesticillus (4%). Three species of Nematoda (Table 2): Heterakis gallinarum (18%), Ascaridia galli (22%) and Capillaria spp. (4%) were also identified. The number of cestodes (R. tetragona, R. echinobothrida and R.cesticillus) and nematoda worms (male and female) were numerated (Table 3 and 4). In addition, this study revealed that the pigeons investigated were found infected with mixed parasites. Different species of ectoparasites, endoparasites and type of helminth infections were found in the same examined pigeon (Table 5 - 7).

Table 1. Prevalence of external parasites found in infected pigeons.

| Total samples | Ectoparasites | Prevalence % |
|---------------|---------------|--------------|
| 100           | C. columbae   | 82 (82/100)  |
|               | G. gallinae   | 18 (18/100)  |
|               | M. gallinae   | 3 (3/100)    |
|               | P. canariensis| 1 (1/100)    |
| Over all prevalence |               | 89%          |

Table 2. Prevalence of helminths (Cestodes and Nematodes) found in infected pigeons

| Helminths          | Prevalence % | Prevalence % |
|--------------------|--------------|--------------|
| Cestodes           |              |              |
| R. tetragona       | 2 (2/100)    | 35 (35/100)  |
| R. echinobothrida  | 32 (32/100)  |              |
| R. cesticillus     | 4 (4/100)    |              |
| Nematodes          |              |              |
| A. galli           | 22 (22/100)  | 27 (27/100)  |
| Capillaria spp.    | 4 (4/100)    |              |
| Over all prevalence|              | 57%          |

Table 3. Total and number of nematodes worms found in infected pigeons

| Nematodes          | Positive samples | Male | Female | No. of worms | Total worms |
|--------------------|------------------|------|--------|--------------|-------------|
| H. gallinarum      | 18               | 66   | 81     | 147          | 576         |
| A. galli           | 22               | 113  | 311    | 424          |             |
| Capillaria spp.    | 4                | 5    | 5      |              |             |
| Total samples      |                  |      |        | 100          |             |

Table 4. Total and number of cestodes worms found in infected pigeons

| Cestodes           | Positive samples | No. of worms | Total worms |
|--------------------|------------------|--------------|-------------|
| R. tetragona       | 2                | 2            | 135         |
| R. echinobothrida  | 32               | 95           |             |
| R. cesticillus     | 4                | 38           |             |
| Total samples      |                  | 100          |             |

Table 5. Percentage of pigeons found infected with multiple parasites

| Parasites           | Prevalence % |
|---------------------|--------------|
| C. columbae + G. gallinae | 10           |
| C. columbae + M. gallinae  | 2            |
| Haemoproteus + T. gallinae    | 18           |
| C. columbae + G. gallinae + P. canariensis  | 1            |
| Total samples        | 100          |
Table 6. Type of helminth infections in examined pigeons.

| Infection type | Prevalence % | Total % |
|----------------|--------------|---------|
| Single infection |             |         |
| H. gallinarum   | 2            |         |
| A. galli        | 8            | 37      |
| R. echinobothrida | 26        |         |
| R. tetragona     | 1            |         |
| Double infection |            |         |
| R. tetragona + R. echinobothrida | 1 |         |
| R. echinobothrida + R. cesticillus | 1 |         |
| H. gallinarum + A. galli | 7 | 11       |
| R. cesticillus + H. gallinarum | 1 |         |
| R. echinobothrida + H. gallinarum | 1 |         |
| Triple infection |            |         |
| H. gallinarum + A. galli + Capillaria spp. | 4 |         |
| R. echinobothrida + R. cesticillus + H. gallinarum | 1 | 8        |
| R. echinobothrida + H. gallinarum + A. galli | 2 |         |
| R. cesticillus + H. gallinarum + A. galli | 1 |         |

Table 7. Percentage of pigeons found infected with multiple infection.

| Parasites                        | Total positive samples |
|----------------------------------|------------------------|
| Ectoparasites and endoparasites  | 97%                    |
| Ectoparasites and haemoparasite  | 69%                    |
| Ectoparasites and helminths      | 46%                    |
| Helminths and protozoa           | 54%                    |
| Total samples                    | 100%                   |

Discussion

Prevalence of protozoan Parasitic Infections

Trichomoniasis in pigeons is a disease caused by the flagellated protozoan \( T. gallinae \). It causes a condition known as "canker". Infected birds frequently show no clinical signs of disease. Chickens, Turkeys, and various species of wild birds are parasitized with different degrees of pathogenicity (Levine, 1973). \( T. gallinae \) is a protozoan parasite usually found in the upper digestive tract of cumbolds and avian predators that feed on cumbolds (Conti, 1993). The present study revealed that the prevalence of trichomoniasis in pigeons was 55% (55/100). In comparison Villanua et al. (2006) found the prevalence of trichomoniasis in common wood pigeon in Spain as 34.2%. In south khorasan in Iran, Radfar et al. (2011) recorded 57.84%; in Qualiobia governorate Egypt, Abd El-Rahman et al. (2008) revealed 68.92% and in Colombia, Pérez-García et al. (2015) reported (40%). The differences in the prevalence rate in the various studies is predictable for many factors which affect the occurrence of the disease such as the host resistance, feeding habits, climatic conditions, geographical difference and housing conditions. In the present study, trichomoniasis was reported in apparently healthy pigeons. The reason for the high prevalence may be due to transmission of the parasite when the adults feed their young or through food feeder and water. Adult birds may remain infected for a year or more and are a constant source of infection for their young (Soulsby, 1986). \( Haemoproteus columbae \) and its vector \( P. canarensis \) are widely distributed in the world especially in tropical and subtropical regions (Soulsby, 1986). Out of 100 pigeons examined for blood parasites in the current study, 76% (76/100) were positive only for \( Haemoproteus \) spp. Many studies have determined that the most common blood parasite found in pigeons is \( Haemoproteus \). Our result agreed with the studies done in Uganda by Dranzoa et al. (1999) found \( Haemoproteus \) spp. (76.5%). More-over, In Kirikkale Province, Turkey, Sürsal et al. (2017) recorded that this parasite was detected in 73.9% of pigeons over 1 year old. In Colombia, Pérez-García et al. (2015) reported (73%). In other countries, the studies reported that the prevalence of this blood parasite was lower than that found in this study. Youssefi and Rahimi (2010) found a prevalence of 30% in three different locations in Iran. Also, Samani et al. (2013) in Southwest Iran was 24%. Hussein and Abdelrahim (2016) in different localities of Qena Governorate, Egypt reported a prevalence of (57.2%). No other haemoproteus parasite was observed in the blood smear of examined pigeon. Previous studies reported the prevalence of this haemoparasite in chicken, in Ghana, Poulsen et al. (2000); in Zimbabwe, Permin et al. (2002) was 37 and 35%, respectively. The higher prevalence of haemoparasites in pigeons could be attributed to the unhygienic nature of the environment where these birds are kept.

Prevalence of Ecto-Parasitic Infestations

External parasites are living on the skin or feathers, using the host as a shelter and source of food. Ectoparasites have significant impacts on health and productivity of animal. The overall prevalence of ectoparasites found in this study was 89% (89/100) of pigeon examined. Four different species were identified: \( C. columbae \) (82%), \( G. gallinae \) (18%), \( M. gallinae \) (3%) and \( P. canarensis \) (1%). In addition, the current investigation observed a mixed infestation. Radfar et al. (2011) mentioned that double infestation of pigeon could be due to that ectoparasites can live together without causing any hurtful effects on each other. Higher prevalence of \( C. columbae \) in pigeons also reported by many authors, Dranzoa et al. (1999) and Foronda et al. (2004) found 94.1 and 100% in
Uganda and Tneriffe respectively. In south khorasan in Iran, Radfar et al. (2011) reported higher prevalence of ectoparasites in pigeon, C. columbae (79.41%), M. gallinae (44.11%) and P. canariensis (63.72%). Jahantigh et al. (2016) in Zabol, southeast of Iran, 78.40% of pigeons were infected with C. columbae. Pérez-García et al. (2015) in Colombia, recorded that C. columbae (64%), P. canariensis (52%), M. gallinae (24%). In the other study in Mashhad city Iran, Borji et al. (2012) found that C. columbae (42.8%), P. canariensis (16.1%) and M. gallinae (7.1%). These ectoparasites were also reported in the free-range chicken. Radfar et al. (2012b) observed that M. gallinae had the highest prevalence (55.93%) in free range backyard chickens and followed by C. columbae (41.30%) in domestic pigeons. The infestation with C. columbae in this study agreed with Harlin (1994) who recorded that C. columbae is the most common malphagian parasite of pigeons. The infestation of pigeons is probably quite like that of chickens and other birds (Hamad-Ameen and Al-Iraqi, 2007). So, the pigeon management programs should be taken place to reduce the risk of the transmission of parasites in the country.

Prevalence of Intestinal Parasitic Infections

All the cestodes identified in the pigeons of this study belonged to the genus Raillietina. This agree with similar studies in other parts of the world, reporting that the most common internal parasites of the rock pigeon are the tape worms of the genus Raillietina (Dede and Richards, 1998; Dehlawi, 2006). In the current study, the overall prevalence of intestinal helminths in pigeons was 56% (56/100). However, in Egypt, Nagwa et al. (2013) reported prevalence rate of 51.7% in Gharbia provinces. Furthermore, 23.18% in Urmia, Iran (Khezerpour and Naem, 2013) and 74% in Bursa Province, Turkey (Senlik et al., 2005). The prevalence of cestodes was 35% (35/100). However, Nagwa et al. (2013) found prevalence rates of 30.9% in domestic pigeons in Gharbia provinces, Egypt. In our study the prevalence of R. tetrarogna, R. echinobothrida and R. cesticillus were 2%, 32% and 4% respectively. In comparison with Ashrafihelan et al. (2010) recorded that the prevalence of tapeworms was 28.13% in domestic pigeons in Iran. The prevalence of R. echinobothrida in the current study was similar to that reported by Radfar et al. (2011) 32.35% in South Khorasan, Iran but higher than found by Nagwa et al. (2013) 17.7% in domestic pigeons, Gharbia, Egypt, Natala et al. (2009) in Nigeria 7.6% and lower than those recorded by Sam-Wobo and Mafiama (2003) in Nigeria and Ashenafi and Eshetu (2004) in Central Ethiopia with prevalence of 35.9 and 65.3% respectively. This Variation might be related to the presence of intermediate hosts, decreased host immunity and bad control and management in either birds or the surrounding environment. A higher number of the infected pigeons had single infection were 27% (27/100) compared to those that had a mixed infection with R. echinobothrida and R. cesticillus 1 pigeon (1%) and R. echinobothrida and R. tetrarogna also 1 pigeons (1%) while no triple infection was recorded. Adang et al. (2008) and Borji et al. (2012) recorded in a similar study that single infection was higher than mixed ones. Therefore, the higher prevalence of single species infection depends on the initiation of infection in the host which may acquire higher habitat and less suitable for late infection.

The current study revealed that the overall prevalence of nematodes was 27% (27/100) which was higher than that reported by Nagwa et al. (2013) in Egypt, 14.3% and lower than that recorded by Tanveer et al. (2011) in Pakistan, 40.5%. The prevalence of Ascaridia galli (22%) in our investigation was higher than those determined by Radfar et al. (2012a) in Iran, Nagwa et al. (2013) in Egypt, Natala et al. (2009) in Nigeria and Djelmoudi et al. (2014) in Algeria, 16.66%, 12%, 1.2% and 4.2% respectively but was lower than those reported by Permin et al. (2002) in Zimbabwe, Sam-Wobo and Mafiama (2003) in Nigeria and Abed et al. (2014) in Al-Dewaniya city, Iraq which had 69, 73.4% and 38.94% respectively. A. columbae is one of the common nematodes of pigeons which have been reported in different parts of the world (Mushi et al., 2000; Senlik et al., 2005; Msoffe et al., 2010). The prevalence of Capillaria spp. (4%) was like that recorded by Baris et al. (2008) in Turkey, (4.3%). It was higher than that recorded by Khezerpour and Naem (2013) in domestic pigeons in Iran (0.72%) but lower than those reported by Ghosh et al. (2014) in Bangladesh and Eljadar et al. (2012) in Green Mountain Region, Libya, 22 and 20% respectively. The prevalence of Heterakis spp. was 18% which was found to be lower than done by Ashenafi and Eshetu (2004) in Central Ethiopia 32.6 in chickens but higher than those reported by Eljadar et al. (2012) in domestic pigeon in Green Mountain Region, Libya 10%; Borji et al. (2012) in Mashhad Iran 1.85% and Baris et al. (2008) in Turkey 3.7%. The nematode, H. gallinarum is non-pathogenic, but a vector for Histomonas meleagridis which is highly pathogenic causing Blackhead disease which lethal to chickens, turkeys, pheasants and other fowls. The overall mixed infection of nematodes 14% (10% with H. gallinarum and A. galli; 4% with H. gallinarum, A. galli and Capillaria spp.).

Our study revealed mixed infection with helminths which agree with El-Dakhly et al. (2016) in Benti-Suef, Egypt, found that R. echinobothrida was shown to be an important cestode of pigeons and one harbour a single nematode and a single cestode. Msoffe et al. (2010) in Tanzania; Abed et al. (2014) in Iraq, they
reported multiple parasites infection in pigeons. However, in the present study none of the pigeon harboured trematode parasites. This our result agrees with many studies done by Abed et al. (2014) in Iraq; Borji et al. (2012) in Mashhad city. This might be due to absence of lakes and non-accessibility of intermediate hosts in these areas.

The worm burden in pigeons in this study (worms/bird) ranged from (1-119) for A. galli, (1-42) for H. gallinarum and (1-2) for Capillaria spp. For cestodes; (1) for R. tetragona, (1-14) for R. echnobothrida and (1-30) for R. cesticillus. Msoffe et al. (2010) reported that worms/bird was ranged from (2-160) for A. galli, while cestode; (1-6) for R. tetragona and (1-18) for R. echnobothrida. El-Dakhly et al. (2016) who recorded (1-170) for Ascaridia spp., (1-5) for R. tetragona, (2-41) for R. echnobothrida, (2-7) for R. cesticillus and (1) for Capillaria spp. Based on the authors’ knowledge, infective dose, availability of intermediate hosts may be indicative to the variability of the worm burdens.

**Conclusion**

In conclusion, our study indicated that more studies are required for different parts of Libya in pigeon and other birds particularly chickens, turkey and ducks. Almost all the birds were found to be infected with different types of endoparasites and ectoparasites. Mixed infections were also seen in pigeons. Therefore; it was concluded that pigeon management programs and public education should be implemented to reduce the risk of a pigeon to livestock transmission of pathogenic agents and parasites in the country. However, this study will make the way to take further extensive study related to these infections which will help to take necessary preventive and control measures against them.

**Conflict of interest**

The authors declare that there is no conflict of interest.

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