Haroun and Taha
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First record and morphological contributions of *Procyrnea leptoptera* (Rudolphi, 1819) (Nematoda: Habronematidae) in the kestrel *Falco tinnunculus* Linnaeus (Falconiformes: Falconidae) from Egypt

Sahar H. Haroun and Rania G. Taha*

Abstract

Background: The kestrel *Falco tinnunculus*, Linnaeus, 1758 is widely distributed in Europe, Asia, Africa, and East coast of North America. It is a predator species that belongs to family Falconidae. Nematode species of the genus *Procyrnea* infects the proventriculus and gizzard of the birds and may cause serious health hazards including inflammation, erosions, and ulcers for the infected gastric mucosa, general weakness and may lead to death. The present study aimed to improve the limited information regarding the endoparasites of *Falco tinnunculus* in Egypt.

Results: Nine males and twenty-one female nematodes were identified as *Procyrnea leptoptera*, Rudolphi 1819, Chabaud 1958, isolated from the proventriculus of common kestrel; *Falco tinnunculus* gathered from El-Faiyum governorate, Cairo, Egypt, as a new geographical record. The isolated species has been studied morphologically by light and scanning electron microscopy. It was revealed that it is characterized by two lateral pseudolabia with dorsal and ventral labia. The pseudolabium is divided into 2 lobes at the internal side, a number of medium-size teeth (4–6) in the buccal cavity on the interior border of pseudolapia, in addition to the presence of transverse striations. Also, the histopathological effects of the isolated nematode on the liver of the infected host revealed severe damage in the bird's tissues and morphological alterations including infiltration of inflammatory cells, congestion, focal necrosis, and degeneration of hepatic cells.

Conclusions: Raptors like *Falco tinnunculus* are infected with parasites via prey ingestion, so they are serving as intermediate hosts for many species of parasites. Due to the scarcity of studies for the helminth parasites of raptors in Egypt, further studies are needed to get additional precise data on the helminthic infection of raptors and their histopathological effects.

Keywords: Birds of prey, Parasitic nematode, Histopathology, Middle Egypt

Background

Falco tinnunculus, Linnaeus, 1758 known as the common kestrel, European kestrel, Eurasian kestrel, or old-world kestrel is a bird of prey species that belongs to family Falconidae. This species is widely distributed in Europe, Asia, Africa, and East coast of North America. Common kestrels are predators on voles, shrews,

*Correspondence: dr.raniagamal_bio@yahoo.com

Biological and Geological Sciences Department, Faculty of Education, Ain-Shams University, Roxy, Heliopolis, Cairo 11757, Egypt

true mice and sometimes feed on small birds, mainly passerines when mammals are often rare in their diet composition (Mikula et al., 2013). Also, they consume other vertebrates such as bats, swifts, frogs, and rarely lizards. Occasionally, prey items include invertebrates such as earthworms, camel spiders, beetles, and winged termites (Groombridge et al., 2002; Mikula et al., 2013).Genus *Falco* is the highest consumer at the top of food web and is usually infected with parasites by consuming prey items (Komorová et al., 2017). In general, most raptors are protected and are not available for parasitological research. However, several authors studied the helminth fauna of the birds of prey Falconiformes (Oyarzún-Ruiz et al., 2016), Accipitriformes and Falconiformes (Santoro et al., 2010, 2012), Falconiformes and Strigiformes (Sanmartin et al., 2004) and Accipitriformes, Falconiformes, and Strigiformes (Borgsteede et al., 2003; Ebmer et al., 2020; Komorová et al., 2017). The genus *Procyrnea* (Nematoda: Habronematidae) was proposed by Chabaud (1958). At present, 60 nominal species from this genus have been described with a broad world distribution and, all from avian hosts, most signaled in Falconiformes and Strigiformes, and, to a much lesser degree, parasitizing Piciformes, Passeriformes, Tinamiformes, and Rheiformes (Bagnato et al., 2018; Ederli & De Oliveira, 2019; Grandón-Ojeda et al., 2019; Mangas et al., 2020; Pinto et al., 1994; San et al., 2006). *Procyrnea leptoptera* and *P. spinosa* are common spirurid nematodes of raptors. They were isolated from the common kestrel, *Falco tinnunculus* (Ebmer et al., 2020). *Procyrnea* sp. infect the proventriculus and gizzard of the birds and may cause serious health hazards including inflammation, erosions, and ulcers for the infected gastric mucosa, general weakness and may lead to death (Mangas et al., 2020; Niemuth et al., 2013). *Procyrnea* sp. have an indirect life cycle with an orthopteran insect, houseflies, and muscoid flies as an intermediate host (Oyarzún-Ruiz et al., 2016; Santoro et al., 2012; Zhang et al., 2011). There are few studies on the helminth parasites of wild birds in Egypt*; Falco tinnunculus, Upupa epopis, Passer domesticus*, and *Streptopelia senegalensis* (Ahmed, 1994; Haroun, 2005), *Ardeola ibis* (Abou Shafeey, 2019), *Bubulucus ibis*, *Gallinula ch. Choloropus*, *Coturnix c. coturnix, Alcedo atthis* and *Passer domesticus* (Wheeb et al., 2015), and *Pycnonotus barbatus arsinoe* and *Upupa epops major* (Khalifa & El-Naffar, 1983).

Therefore, the present study aimed to provide new morphological characters of *Procyrnea leptoptera* (Rudolphi, 1819) Chabaud, 1958 this is not a reference please, delete the highlighting, found in the common kestrel, *Falco tinnunculus* Linnaeus, through optical and scanning electron microscopy in addition to evaluating the histopathological effects of this parasite on liver tissues of the host.

Methods

Study area and sampling

Samples of the kestrel *Falco tinnunculus* were hunted at El-Faiyum Governorate in the middle Egypt 29.31° N 30.8° E by specialist hunters. El-Fayoum is a representative example of the oases of the great North African Sahara Desert in its form, origin, geologic formation, culture, and ecosystem. It is located less than 100 km from Cairo city, Egypt. It is one of the most beautiful regions in Egypt and has rich heritage of flora, fauna, and archeology.

Eight adults of common kestrel, *Falco tinnunculus* (three males and five females), ranged in weight from 180 to 260 gm. were collected at June 2020 (Fig. 1a). They were anesthetized then slaughtered and examined at the biological laboratory, Department of Biological and Geological sciences, Faculty of Education, Ain-Shams University, Cairo, Egypt. Nematodes were isolated from the underlining of proventriculus and gizzard (Fig. 1b). Specimens were washed in physiological saline solution 0.7% NaCl several times under a stereomicroscope and then fixed and preserved in hot 70% ethanol. Some specimens were prepared for light microscopy, and others were ready for scanning electron microscopy.

Light microscopy

The collected nematodes were fixed in hot 70% ethanol, cleared, mounted on slides with lactophenol, and observed under a light microscope. Mounted specimens were photographed using an Olympus C X 31 microscope and an Olympus digital camera E-330-ADU1X Japan. The morphometric studies were based on ten

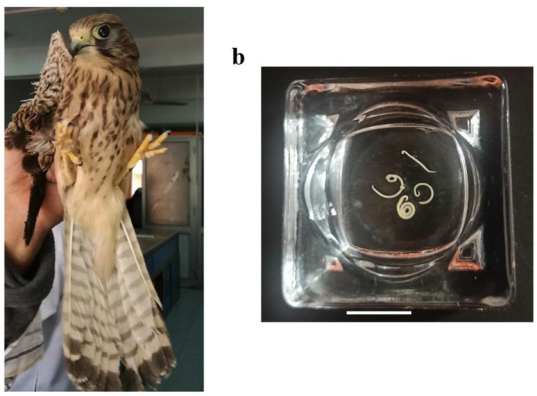

Fig. 1 **a** The kestrel Falco tinnunculus, Linnaeus, 1758; **b** the nematode Procyrnea leptoptera, Rudolphi 1819, Chabaud, 1958 scale = 1 cm

specimens (three males and seven adult females). Measurements were made by 0.01 mm microscope objective micrometer glass scale (Japan) and a calibrated lens. Measurements (range, followed by mean in parentheses) are given in millimeters (mm), unless otherwise stated. The mounted slides were drawn diagrammatically using an Axioplan Zeiss light microscope (Carl Zeiss, Germany) that was outfitted with a camera lucida.

One male and one female voucher specimen were deposited in the helminthes collection in the Biological Department, Faculty of Education, Ain Shams University, Cairo, Egypt.

Scanning electron microscopy

The nematode parasites were deposited for 2 h in 2% glutaraldehyde in 0.1 M sodium cacodylate buffer (PH 7.2) as a fixative and post-fixed in osmium tetroxide (OsO4) for 2 h, then washed in sodium cacodylate buffer, dehydrated in an ascending ethanol series and critical-point-dried with CO2, coated with gold (Nel-S, 2008). The specimens were examined and photographed by scanning electron microscope (Jeol. JSM-5400) at the Atomic Energy Agency, Cairo, Egypt.

Histopathological preparation

Small pieces of liver were collected from infected and uninfected birds, then fixed in alcoholic Bouin's fluid for 24 h, and then preserved in 70% ethyl alcohol. The fixed tissues were dehydrated in ascending series of ethanol, cleared in terpineol, and embedded in the paraplast wax (melting point 58–60). Sections of 5μ thickness were deparaplastinized, hydrated to water, stained with hematoxylin and eosin, and cleared in xylene and mounted in DPX (Bancroft & Gamble, 2002). Finally, the slides were examined and photographed using an Olympus C X 31 microscope and an Olympus digital camera E-330-ADU1X Japan to determine the histopathological effects of *Procyrnea leptoptera* on the liver tissues (Additional file 1).

Results

Helminthological examinations of the common kestrel *Falco tinnunculus* Linnaeus (Falconidae) (Linnaeus) (Mullidae) from El-Fayium Governorate in the middle Egypt revealed the presence of nematodes identified as *Procyrnea leptoptera*. Thirty nematodes (9 males and 21 females) of medium size were recovered from five out of eight examined hosts. The morphological description of this nematode species is presented herein.

Family Hapronematidae Chitwood et Wehr, 1932.

Genus *Procyrnea* Chabaud, 1958

Procyrnea leptoptera Rudolphi 1819, Chabaud, 1958

Locality: El-Faiyum, Egypt.

Site in host: Proventriculus and gizzard.

Prevalence and intensity: Five out of eight birds (62.5%), mean intensity is 2, range is (1–3).

Description

Body is small to medium size, sexually dimorphic, females are longer than males, and their length ratio is 1.19–1.45:1. The cuticle is marked by distinctive transverse striations on the whole body (Fig. 4a). The posterior end of male is coiled while it is broad with pointed tip in female (Fig. 3g, h). The cephalic region is consisting of a short buccal capsule which laterally compressed and labial region that is continuous with body contour. Labial region is consisting of two lateral pseudolabia with dorsal and ventral labia; each has two sub-median lobes (Fig. 4c and d). The pseudolabium is the widest and divided into 2 lobes at the internal side. As revealed by scanning electron microscope, there are a number of medium-size teeth (4–6) in the buccal cavity on interior border of pseudolabia and two amphids were located near the distal base of the later (Fig. 4d). Among two prominent cephalic papillae, one is large and the other is small are located on the cephalic region on both sides (Fig. 4d). Cervical papillae were present at the level of nerve ring (Fig. 4a). Two lateral alae were present extending just posterior to the excretory pore (Fig. 4b). Esophagus is long divided into short anterior muscular part and long posterior glandular part (Fig. 2a). Many types of annulations were observed.

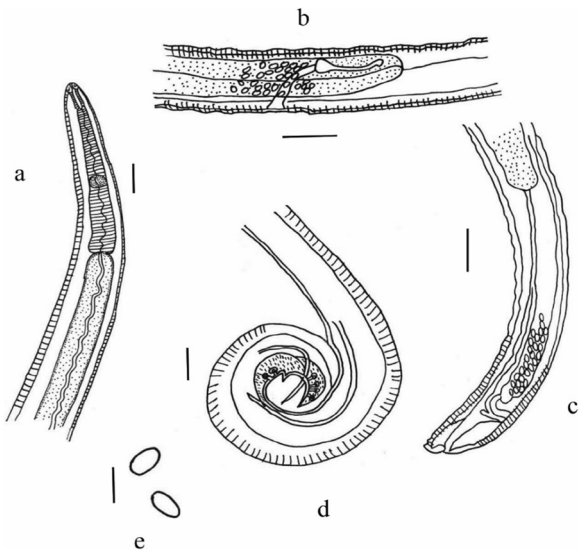

Fig. 2 Drawings of Procyrnea leptoptera Rudolphi 1819, Chabaud 1958 obtained from Falco tinnunculus in Egypt. **a** Ventral view of anterior end of female; **b** pre-equatorial region of female body showing the vulva; **c** posterior end of female; **d** posterior end of male; **e** eggs. Scale bars: **a**, **c** 0.1 μm; **b**, **d** 0.3 μm; **e** 0.05 μm

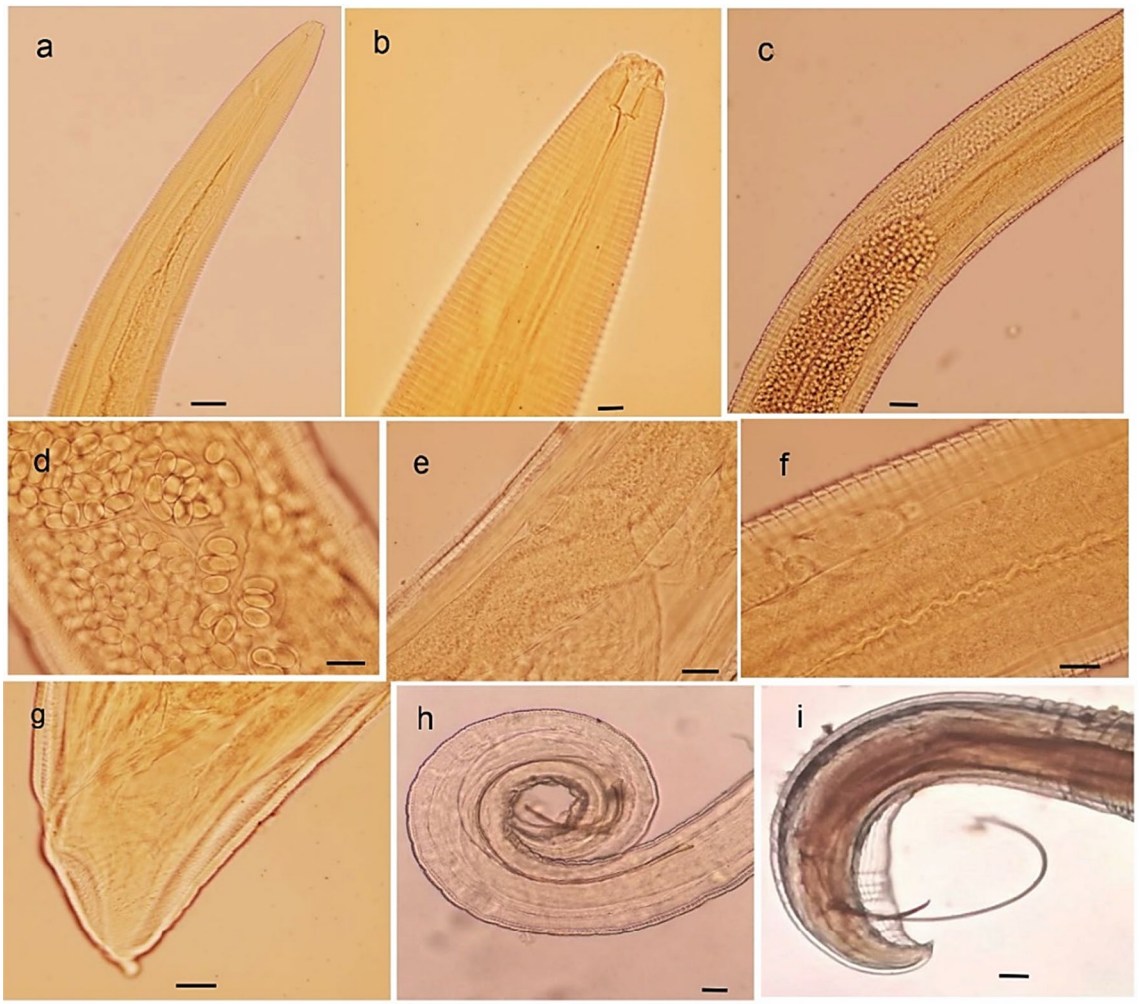

Fig. 3 Photomicrographs of Procyrnea leptoptera Rudolphi 1819, Chabaud 1958 obtained from Falco tinnunculus in Egypt. **a**, **b** Ventral view of anterior end of female worm; **c** anterior third of female showing the uterus. **d** Uterus showing eggs; **e** middle part of female body showing vagina; **f** pre-equatorial part showing the vulva; **g** posterior end of female; **h** posterior coiled end of male; **i** Spicules. Scale bars: **a** 0.1 mm; **b**, **c**, **g**, **h**, **i** 0.03 mm; **d**, **e**, **f** 0.02 mm

The first type is on the dorsal side of the worm characterized by not deep transverse striations with regular pattern (Fig. 4e). The second type is characterized by deeply corrugated annules separated by an equal distance and divided internally by a longitudinal striation located at the middle body of the worm (Fig. 4f). Another type of annulations was observed on the dorso-lateral side of the posterior region of body worm that is represented by a series of imbricated tegumental annulations in a regular pattern with more closed distances (Fig. 4i). The caudal alae are present narrow and covered with slight transverse striations (Fig. 3i). The nerve ring is situated approximately at the middle of muscular esophagus (Fig. 2a). Excretory pore is located just posterior to the nerve ring.

Male

Body is 7.23–7.58 (7.4) length and 0.26–0.28 (0.27) width. Buccal capsule measures (12–18 µm) (15). Dorsal lip measures 14 µm. Pharynx length is 0.02–0.023 (0.021). Esophagus is 2.21–2.72 (2.46) length and 0.09–0.092 (0.091) width. The muscular part is 0.7–0.8 (0.75) length representing 10.13% of (TBL) and the glandular part is 1.5–1.82 (1.64) representing 20% of (TBL). Nerve ring measures 0.32:0.37 (0.35) from the anterior extremity. The excretory pore is 0.38:0.4 (0.39) from the anterior extremity. Caudal alae are asymmetrical with longitudinal striations on ventral surface and transverse striations on dorsal surface (Fig. 3i). Tail measures 0.14–0.19 (0.17); it bears a number of papillae: four pairs precloacal of pedunculated papillae and

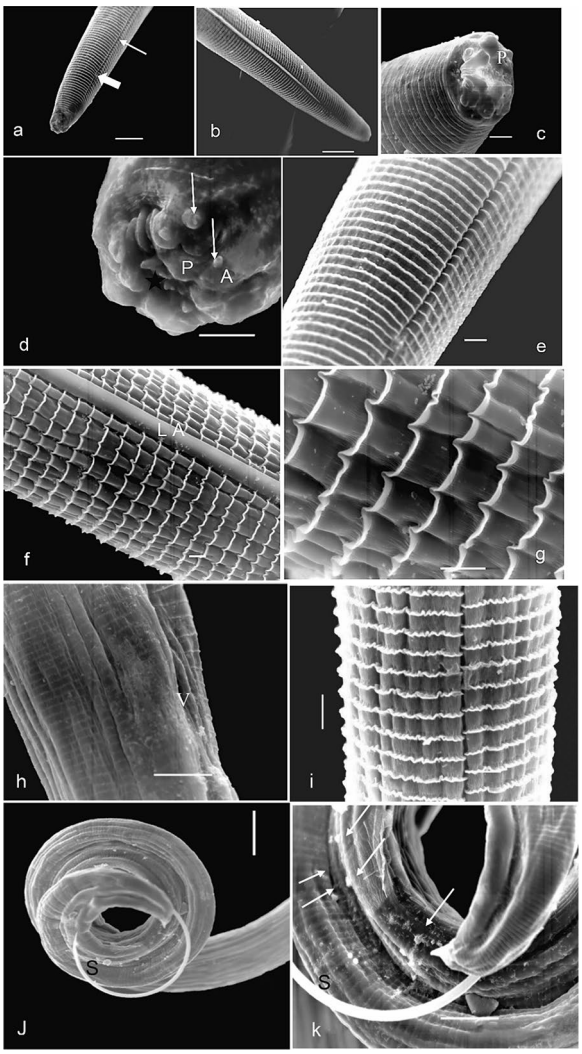

Fig. 4 Scanning electron microscope of Procyrnea leptoptera Rudolphi 1819, Chabaud 1958 from Falco tinnunculus in Egypt. **a** Anterior end of the nematode showing the lateral ala (arrow), cervical papilla (thick arrow); **b** anterior part showing the start of lateral ala (arrow); **c** anterior end of the worm, latero-apical view; **d** cephalic region showing cephalic papillae (arrows); **e** dorsal view of anterior third of the nematode showing cuticular annulations; **f** cuticular annulations of the middle part of the nematode; **g** enlarged view of dorsal middle part of the nematode; **h** anterior third of female body showing vulva; **i** transverse regular striations near the last third of body, dorso-lateral view; **j** Posterior end of male, lateral view; (k) posterior end of male showing papillae (arrows) ventral view. Scale bars: **a**, **b**, **j** 50 µm; **c**, **d**, **e**, **f**, **g**, **h**, **k** 10 µm; **i** 100 µm

two pairs of post-cloacal papillae (Figs. 2d and 4k). Two very unequal, spicules are present; the left spicule is 0.53–0.65 (0.59) length and right spicule is 0.11–0.13 (0.12) length. Spicule's ratio is (1: 4.8–5) (Fig. 3h and i). The spicule sheath of long spicule measures 0.69 and that of short spicule is 0.19. Gubernaculum is present with irregular shape and measures 0.026–0.032 length and 0.016–0.018 width.

Female

Body is 8.62–11.9 (10.17) length by 0.35–0.55 width (0.49). Dorsal lip is 14.3–16 µm (15 µm) length. Buccal capsule (11–15 µm) (13 µm). Pharynx length is 0.022–0.0286 (0.025). Esophagus length is 3.10–3.72 and 0.08–0.092 (0.086) width. Muscular esophagus is 0.39–0.91 (0.65) length representing 6.39% of (TBL) and glandular one is 2.7–2.82 (2.76) representing 27.1% of (TBL). Nerve ring and excretory pore measure 0.19–0.35 (0.27) and 0.25–0.38 (0.32), respectively, from the anterior extremity. Vulva is pre-equatorial, located at the left lateral side of the anterior third of body at 1.82–2.85 (2.33) from the anterior end. Tail is pointed 0.14–0.19 (0.17) length. Eggs are oval, thick shelled 39–52 µm length and 24–32 µm width (Fig. 2e).

Histopathological lesions were noticed in the liver of *Falco tinnunculus* infected with *P. leptoptera* nematode as compared with the uninfected ones. These lesions are demonstrated as accumulation of inflammatory cells, congestion, and dilation of the central vein with erosion of its lining endothelial cells. Some specimens showed infiltration of inflammatory cells. Also, it was seen parenchymal lesions in the hepatic lobules accompanied by the loss of their regular pattern. Focal necrosis and degeneration of hepatic cells were also observed (Fig. 5).

Discussion

The present study is the first record of the nematode *Procyrnea leptoptera* Chabaud 1958, (Habronematidae) from the kestrel *Falco tinnunculus* (Falconidae) in Egypt. Chabaud (1958) established the genus *Procyrnea* as a subgenus of *Cyrnea*. (Chabaud) in 1975 raised it to generic level. Sixty valid species of *Procyrnea* have been described from avian hosts, especially Falconiformes and Strigiformes. Also, this genus is rarely recorded from Piciformes, Passeriformes, Tinamiformes, and Rheiformes (Bagnato et al., 2018).

Species of the genus *Procyrnea* parasitized proventriculus of *Rhea pennata* and *Buteogallus schistaceus* (Bagnato et al., 2018; Mangas et al., 2020), and this is in accordance with the present finding. On the other hand, *P. spinosa* is isolated from the intestine of *Milvago chimango temucoensis*; this is may be due to the post-mortem migration of this parasite (Oyarzún-Ruiz et al., 2016). Bagnato et al., (2018) created a key for 60 species of *Procyrnea*; only *P. cameroni*, Gupta & Kazim, 1978 was not integrated in this key. This key was designated according to the presence or absence of lateral alae and their number (single or two), length of left spicule and if the latter has pointed end without barbs or has one or two barbs, the position

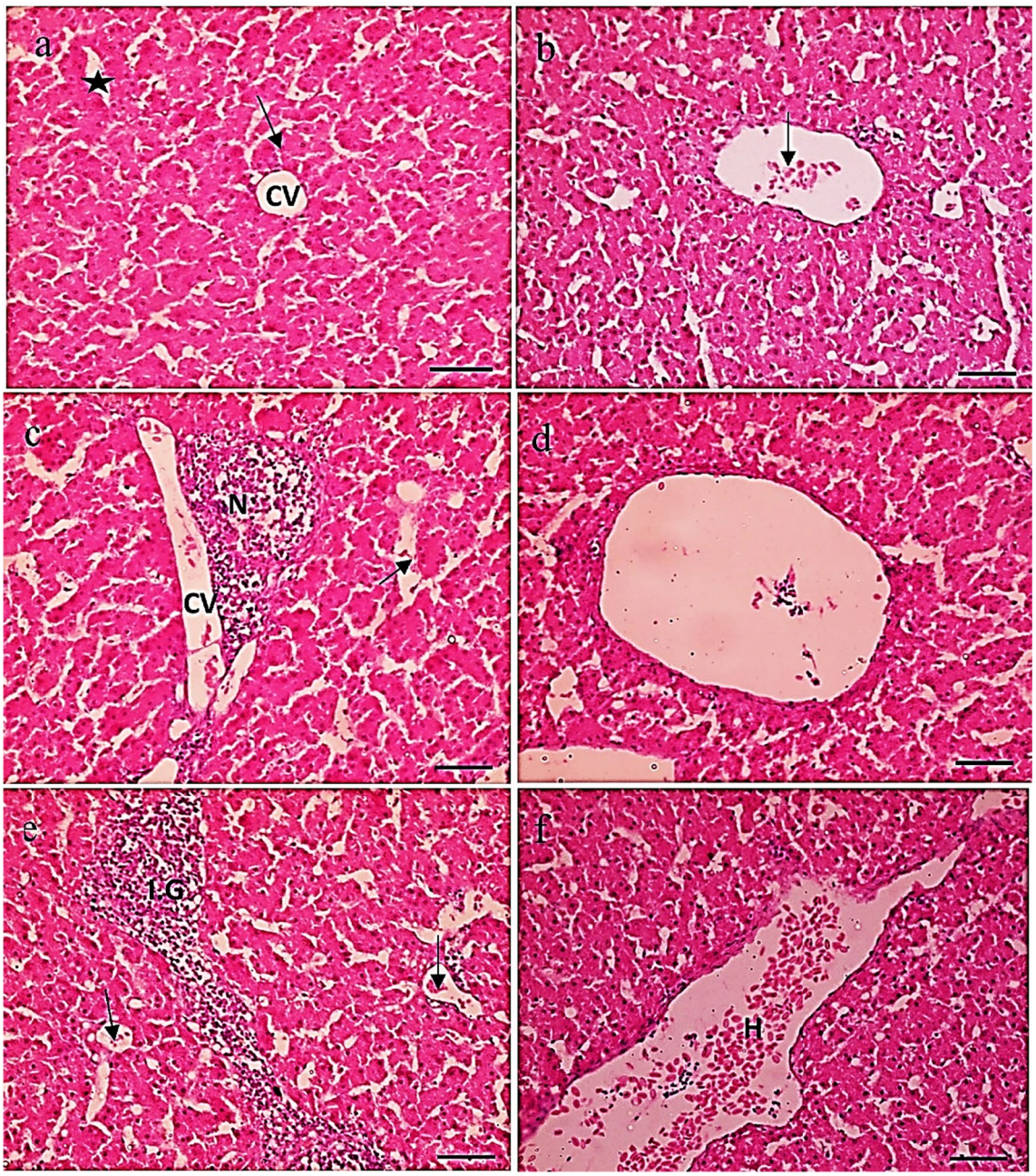

Fig. 5 Photomicrograph of sections of the liver of Falco tinnunculus from Egypt. **a** Uninfected liver showing hepatocytes (arrow), blood sinusoids (star); **b** liver of infected bird showing dilation of central vein with blood congestion (arrow); **c** irregular central vein, dilated sinusoids (arrow); **d** severe destruction of hepatic lobules with highly devasted central vein; **e** inflammatory cells infiltration (arrows); **f** infected liver showing hemorrhage. Scale bar: 0.20 mm

of vulva; pre-equatorial or post-equatorial, shape of caudal alae, and male length.

The present nematode species disagrees with the following species where they have one lateral ala; *Procyrnea rauschi*,, *P. vinodi* and *P. fotedari*, Gupta & Kumar, 1980, *P. tulostoma* Hemprich & Ehrenberg, 1866, *P. suraiyae, P.daleri, P. chabaudi* and *P. singhi*, Ali, 1961, *P. urophasiana* Wher, 1931, *P. magnilabiata* and *P. asymmetrica*, Maplestone, 1932, *P. pileata*, Walton, 1927, *P. unilateralis*, Molin, 1860, *P. skrjabini*, Vuylsteke, 1953, *P. imbricate*, Maplestone, 1930, *P. waltoni* Freitas & Lent, 1947, *P. falco*, Mawson, 1968, *P. spinosa*, Gendre, 1923, *P.*

monoptera, Gendre, 1922 and *P. sinica*, Zhang et al. (2011). Moreover, the Present specimen differs from; *Procyrnea ruschii* Freitas, 1967, *P. aptera* Wang, 1976, *P. choique* Bagnato et al., (2018), *P. spiralis*, Mawson, 1968, *P. aegotheles* Johnston & Mawson, 1941, *P. ornate*, Cheng & Ye, 2000, *P. ameerae*, Ali, 1961, *P. javaensis*, Zhang et al., 2009, *P. uncinipenis* Molin, 1860, *P. brevicaudata*, Zhang et al., (2004), *P. graculae*, Eduardo & Villa, 2011, *P. anterovulvata*, Pinto et al., 1996, *P. haliasturi*, Gupta & Kumar, 1980, *P. dollfusi*, Mawson, 1968, *P. murrayi* Ortlepp, 1934, *P. excisiformis* Yamaguti, 1935 and *P. ficheuri* Seurat, 1916 where they lack lateral alae (Bagnato et al., 2018). The present specimen characterized by the presence of two lateral alae and this is in harmony with *P. leptoptera* Rudolphi, 1819, *P. zorillae* Seurat, 1919, *P. paraleptoptera* Johnston & Mawson, 1941, *P. mawsonae*, Zhang et al., (2004), *P. seurati* Skrjabini, 1917, *P. longispiculata* Walton, 1927, *P. mclennanae*, Zhang et al., (2004), *P. kea* Clark, 1978, *P. colaptes* Walton, 1927, *P. strialata*, Zhang, 1991, *P. diesingi* Maplestone, 1932, *P. longistriata* Molin,1859, *P. hyderabadensis*, Ali, 1961, *P. hrishii* Agrawal, 1965, *P. mansioni* Seurat, 1914, *P. dolichocolpos* Chabaud & Brygoo, 1958, *P. beveridgei*, Zhang et al., (2011), *P. incerta* Smith, 1908, *P. buckleyi* Bisseru, 1955, *P. americana* Chandler, 1941, *P. magnipapillata* and *P. waheedae*, Ali, 1961, *P. longialatus* Cid del Prado, Maggenti & van Riper, 1985. The left spicule in the present nematode has pointed end without barbs and this disagrees with *P. mawsonae* and *P. mclennanae*, Zhang et al., (2004) and *P. kea* Clark, 1978 whose their left spicule has double barbed tip and also, it disagrees with *P. seurati* Skrjabini, 1917 and *P. longispiculata* Walton, 1927 in the left spicule with single barbed tip (Bagnato et al., 2018). Also, the present material differs from *Procyrnea zorillae* Seurat, 1919 and *P. colaptes* Walton, 1927 in the length of male (17.4–19.1 & 10–15 mm) versus 7.4 mm for the present nematode. The sessile caudal papillae are absent in the present nematode while, *Procyrnea zorillae* and *P. colaptes* have 11 & 10 sessile caudal papillae, respectively. Also, *P. diesingi, P. hyderabadensis, P. hrishii, P. dolichocolpos, P. waheedae and P. longialatus* have larger size of left spicule (1.7, 1.2–1.6, 1.43–1.82, 6.3, 0.91–0.98, 0.87–1.00 mm, respectively, vs. 0.59 mm). On the other hand, *Procyrnea colaptes*, *P. longistriata*, *P. strialata*, *P. hyderabadensis*, *P. hrishii*, *P. waheedae*, *P. longialatus*, *P. magnipapillata* disagree with the present parasite in the presence of sessile caudal papillae. Also, the present nematode disagrees with *P. paraleptoptera* in the position of vulva which is post-equatorial vs pre-equatorial in the present specimen.

Recently, three nematode species have been recorded from the kestrel *Falco tinnunculus*: *Procyrnea monoptera*, *P. leptoptera* and *P. spinosa* (Ebmer et al., 2020; Oyarzún-Ruiz et al., 2016; Zhang et al., 2011). But the species found in this work is not correspond to either of *P. monoptera* or *P. spinosa*. It was found that the present nematode differs from *P. monoptera* that has body with one lateral ala, left spicule with single barbed tip and the length of left spicule 1.86–1.90 mm. Also, the present finding disagrees with *P. spinosa* in the presence of one lateral ala, left spicule with double barbed tip, length of left spicule is 1.22–1.37 mm and length of right one is 340–410 µm.

However, the present nematode species is morphologically similar with *Procyrnea leptoptera* in the presence of two symmetrical lateral alae, left spicule with pointed tip, without barbs and absence of median precloacal papillae (Barus et al., 1978). Moreover, our specimens show very close metrical data to that of *Procyrnea leptoptera* regarding the length of male (7.23–7.58 vs 7.1 mm), the length of left spicule (0.53–0.65 vs 0.64 mm) and the length of gubernaculum (0.026–0.032 vs 0.03 mm). *Procyrnea leptoptera* as well as the material described here are characterized by the presence of four pairs of preanal papillae and two pairs of postanal papillae.

However, *P. leptoptera* has a group of eight sessile papillae near tail end that was not observed in the present specimens. Regarding to the female of the present species, it is approximately similar to that of *P. leptoptera* in the total length (8.62–11.9 vs. 11.7–14.0), the length of muscular esophagus (0.39–0.91 (0.65) vs. 0.36–0.38 mm), the length of glandular esophagus (2.7–2.82 vs. 2.55–2.71 mm), the position of nerve ring and excretory pore in relation to anterior extremity (0.19–0.35 and 0.25–0.38, respectively, vs. 0.23–0.25 mm and 0.30–0.32 mm) and the egg size (39–52 X 24–32 µm vs. 0.032–0.041 X 0.019–0.024 mm). Therefore, based on the present data this is the first record of the nematode *Procyrnea leptoptera* in Egypt.

The histopathological effects of *Procyrnea leptoptera* on the liver of *Falco tinnunculus* showed the appearance of some lesions such as accumulation and infiltration of inflammatory cells, congestion, and dilation of the central vein with erosion of its lining endothelial cells, necrosis, and degeneration of hepatic cells. The circulating antigen toxins and immune complex produced as a result of parasitic infection are responsible for the degenerative changes and necrosis that were observed in the present study (Peter & Robert, 1989). These lesions are coincident with the results of (Yen-Li et al., 2017) who found vasodilation, necrotic cell, and slight chronic inflammation in the infected liver of eclectus parrots (*Eclectus roratus*) with Filarial nematode.

Moreover, the present lesions are very similar to the finding of (Brener et al., 2006) in their study of the effect of *nematode Heterakis gallinarum* on the liver of turkey,

Meleagris gallopavo. They observed extensive granulomatous and necrotic areas that agree with the results of (Movsesyan et al., 2008) as they recorded some alternations like dilation of sinusoids and necrosis in the liver of infected rats with *Hymenolepis diminuta*. Also, the present results are similar to (Mahmoud et al., 2000) on the see-see partridge infected with *Hartertia gallinarum* and (Adang et al., 2010) on the domestic pigeons infected with *Ascaridia galli.* On the other hand, the hemorrhage reported in the present study was in accordance with the result of Haroun (2005) who found this lesion in the kidney of *Falco tinnunculus* infected with the trematode of *Renicola* sp. It was due to the direct irritation produced by the parasite on the endothelium or by indirect way through the action of various parasitic toxins.

Conclusions

Due to the scarcity of studies for the helminth parasites of raptors in Egypt, further studies are needed as molecular studies to get additional precise data on the helminth parasites of raptors in Egypt and their effects on host's tissues.

Abbreviations

µm: Micrometer; cm: Centimeter; A: Amphid; LA: Lateral ala; S: Spicule; T: Teeth; P: Pseudolabia; V: Vulva; TBL: Total body length; C.V: Central vein; N: Necrosis; I.G: Interstitial granulomas; H: Hemorrhage.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41936-022-00295-6.

Additional file 1. Arrival Guidelines.

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Author contributions

HS and TR carried out together all the practical procedures, recorded the results, wrote, and revised the manuscript. Both authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The technique in the present study was approved in compliance with international standards for animal by the local institutional animals Ethics Committee of Ain Shams University.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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