Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta Morphologica et Anthropologica, 31 (1-2)
Sofia ● 2024

Trichuriasis in Zoo-Keeping Hamadryas Baboons (*Papio hamadryas*): Case Report and Pathomorphological Findings

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A case of trichuriasis in three zoo-keeping baboons is described. One of the animals had a high degree of infection and marked clinical symptoms, and the other two - low degree of infection and good general condition. The baboons were treated according to two regimens: 1. Albendazole (7.5 mg/kg) orally for three days; 2. Combination of albendazole (7.5 mg/kg) and ivermectin (0.4 mg/kg), both drugs orally for three days. Despite treatment, the condition of the first baboon deteriorated and he was euthanized. The postmortem examination revealed pathomorphological changes in the intestines, liver, kidneys and lungs. Most of the alterations were associated directly or indirectly with the trichurid infection, and another reflected past diseases that have further worsened the animal‘s condition. The combined treatment and the anti-epidemic measures taken led to a complete and long-lasting elimination of trichuriasis in the animals with a low degree of infection.

Key words: trichuriasis; non-human primates; anthelmintic treatment; gross pathology; pathohistology

Introduction

Trichuriasis is a parasitic zoonosis caused by so-called whipworms of the family Trichuridae, phylum Nematoda. Trichurids are located in the digestive tract of their hosts, mainly the cecum and colon, they are geohelminths with a direct life cycle: The infective stage are larvae within the egg, which develop in 1 or 2 months of being passed in the faeces depending on temperature. Under optimal conditions, these larvated eggs may subsequently survive and remain viable for several years. After ingestion, the plugs of the eggs are digested and the released larvae penetrate the glands of the distal ileum, cecal and colonic mucosa. Subsequently, all four moults occur within these glands, the adults emerging to lie on the mucosal surface with their anterior ends embedded in the mucosa [23].

Trichuris trichiura, the causative agent of trichuriasis in humans, is considered the most common pathogenic parasite in non-human primates [5]. Parasitism of mature *T. trichiura* worms leads to chronic inflammation of mucosa of large intestine. Lacerations of mucosa caused by feeding activities of worms may lead to secondary bacterial infections; in heavily infected or young hosts, rectal prolapse is often seen followed by chronic bloody diarrhea associated with rectal bleeding, iron deficiency anemia and growth deficits [10].

Due to the direct faecal-oral route of transmission and ability to persist in the environment, treatment and control of *T. trichiura* is necessary to maintain healthy baboon colonies [17]. The control of trichuriasis is particularly relevant in animals kept in captivity, in view of reducing the threat of its transmission to humans.

In order to succeed in the fight against parasitoses accumulation of basic knowledge regarding all their aspects is needed [15]. In connection with the above, the aim of the present work was set, namely to document a case of trichurid infection in a group of zoo-keeping Hamadryas baboons (*Papio hamadryas*) and to describe accompanying pathomorphological findings.

Materials and Methods

Sample origin and area of the study.

It concerns a group of three male Hamadryas baboons (*Papio hamadryas*) kept at the Sofia Zoo, Bulgaria for more than 20 years. They lived in an enclosure with an inner part (covered with ceramic tiles) and an outer part covered with concrete on which a soft bedding of sawdust was spread.

Coprological study and treatment.

Individual faecal samples of the animals were collected from the ground of the enclosure. They were microscopically investigated by method of direct smear, common flotation (with solution of sodium chloride, gravity = 1.18) and sedimentation technique [2]. The degree of parasite infection was subjectively assessed according to the number of eggs observed per one microscopic field of view, and the following criteria were adopted for documentation: low degree of infection (2-4 eggs per field of view), medium degree of infection (5-10 eggs per field of view), high degree of infection (more than 10 eggs per field of view) and very high degree of infection (eggs too numerous to count).

Two schemes were used to deworming animals: 1. Albendazole (Zentel® 400 mg tablets) at a dose of 7.5 mg/kg for three consecutive days; 2. Combination of albendazole (Zentel® 400 mg tablets) at a dose of 7.5 mg/kg and ivermectin (Pandex® 1% solution) at a dose of 0.4 mg/kg for three consecutive days. The second treatment was performed 34 days after the end of the first. The drugs were given individually to the animals, orally, mixed with a small amount of their favorite food (boiled rice and dried fruit, sweetened with honey and formed into a ball) after a 12-hour fasting diet. Control examinations of faecal samples were performed on day 7 after treatment according to the first scheme and on days 7, 30 and 90 after treatment according to the second scheme.

Removal of the sawdust litter from the outer enclosure and disinfection of floors (daily) and arrangement (twice a week) with a solution of sodium hypochlorite (1% and 0.05% respectively) were undertaken as anti-epidemic measures.

Pathomorphological study

The carcass of one of the animals was autopsied according to the common way described in the textbooks. Macroscopic changes in the internal organs were described and portions of them (0.5 x 2 x 2 cm) were obtained for histological examination. They were fixed in 10 % phosphate buffered formalin, embedded in paraffin, cut into sections of 5 to 10 μm thick and stained with haematoxylin and eosin according to the routine histological technique. Pictures were taken using a light microscope "Leica DM5000 B", supplied with a camera and software (Leica Application Suite LAS v. 3.1).

Results

Case history

In the summer of 2023, the health condition of one of the baboons deteriorated. Weight loss, malaise and diarrheal stools with traces of blood were observed. The other two animals were in good condition with normal-looking faeces. Examination of faeces using the flotation technique showed the presence of parasitic eggs with morphometric characteristics of *Trichuris* sp. (**Fig. 1**). The degree of infection was subjectively rated as high in the baboon with clinical symptoms and low in the other two animals. All three baboons were treated with albendazole. In their follow-up examination on day 7 after albendazole treatment, trichurid eggs were still found, but they were single, not in all fields of view. Despite the effect of the treatment, the condition of the first baboon continued to deteriorate, became critical and this necessitated his euthanasia. The other two animals were re-treated with a combination of albendazole and ivermectin, and no eggs were found during the all control examinations after this treatment. The euthanized baboon was autopsied.

Fig. 1. Whipworm egg (*Trichuris* sp.) found in faeces of zoo-keeping *Papio hamadryas*.

Gross pathology

External examination: severe cachexia, dehydration and a faeces-stained perianal area. Lungs: small, like pinheads, compacted, gray alterations in the caudal parts of the lung parenchyma (**Fig. 2A**). Liver: adherent with its apical parts to the top of the diaphragm, with colour lighter than normal, covered with tiny dark spots (**Fig. 2B**). Kidneys: different

Fig. 2. Macroscopic view of internal organs, *Papio hamadryas* with *Trichuris* sp. infection: A) lung: small, like pinheads, dark coloured alterations in the caudal parts of the lung parenchyma (arrow), diffuse vessels congestion; B) observation of the abdominal cavity organs: lighter in colour liver, partially adherent to the diaphragm, with subcapsular petechiae; small and large intestines: blood vessels congestion, seen on the serosa, ballooning due to fermentation processes; C) and D) kidneys: different in size and shape, one of them with big perirenal blood coagulum (C), slightly paler in colour cortical part and distinct differences in the renal pelvis sizes (D).

in size and shape, the left one with a big perirenal blood coagulum, slightly paler in colour cortical part and distinct differences in the renal pelvis sizes (**Fig. 2C, D**). Small intestines: strong mucosal hyperemia, blood vessels congestion, seen on the serosa (**Fig. 3A**). Large intestines: pronounced ballooning and blood vessels congestion (**Fig. 3A**); hemorrhages and whitish parasites in the lumen (**Fig. 3B, C**); faeces in the rectum mushy but not diarrheic, of normal colour, without traces of blood.

Pathohistological findings

Lungs: ruptures of the alveolar walls, emphysematous changes, vessels congestion and hemosiderosis (**Fig. 4A**). Liver: space of Disse dilated, sinusoidal dilatation rarely, presence of focal microvesicular fatty changes and parenchymal cells destruction processes as vacuolation, pyknosis, karyorrexis, focal hepatocyte necroses (**Fig. 4B, C**).

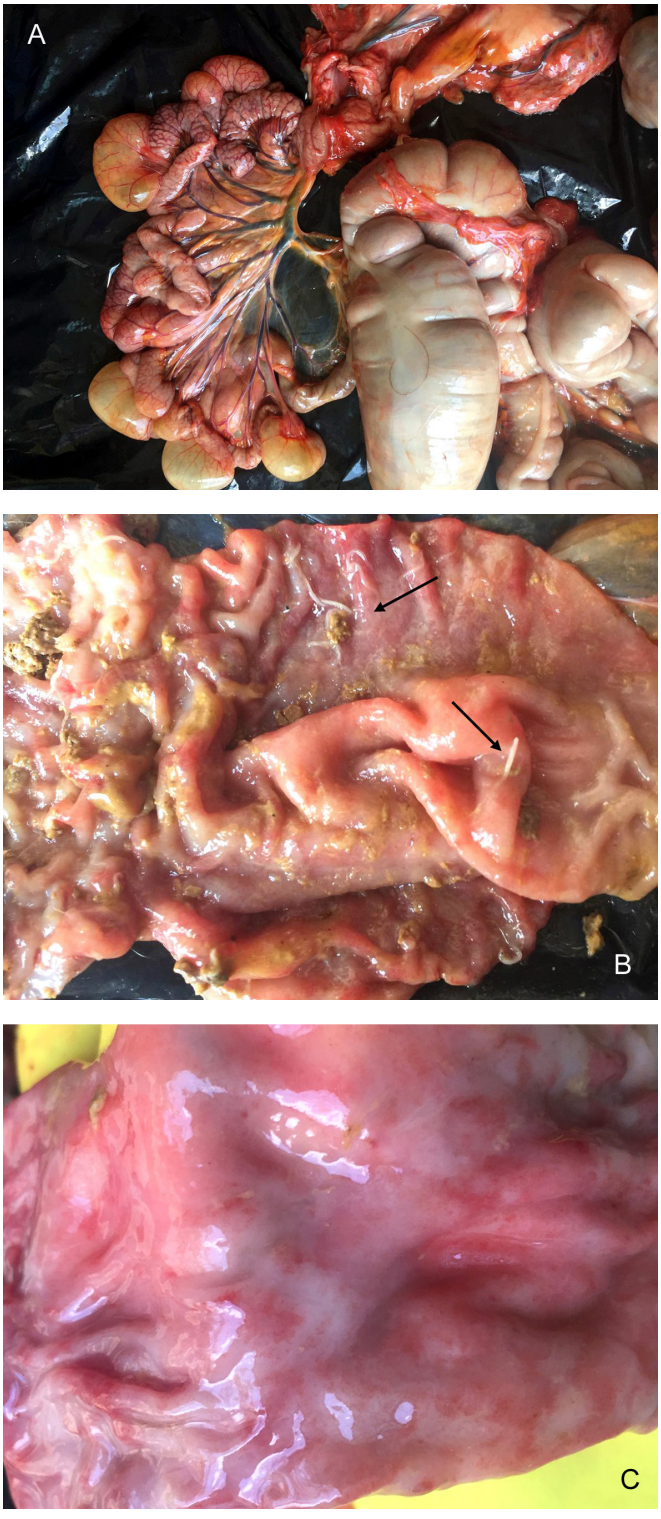

Fig. 3. Macroscopic view of the gut, *Papio hamadryas* with *Trichuris* sp. infection: A) blood vessels congestion and presence of liquid content in the intestinal lumen; B) hemorrhagic colonic mucosa with remnants of intestinal contents and several whipworms (arrows) stuck in it; c) cleaned colonic mucosa with visible diffuse petechial hyperemia.

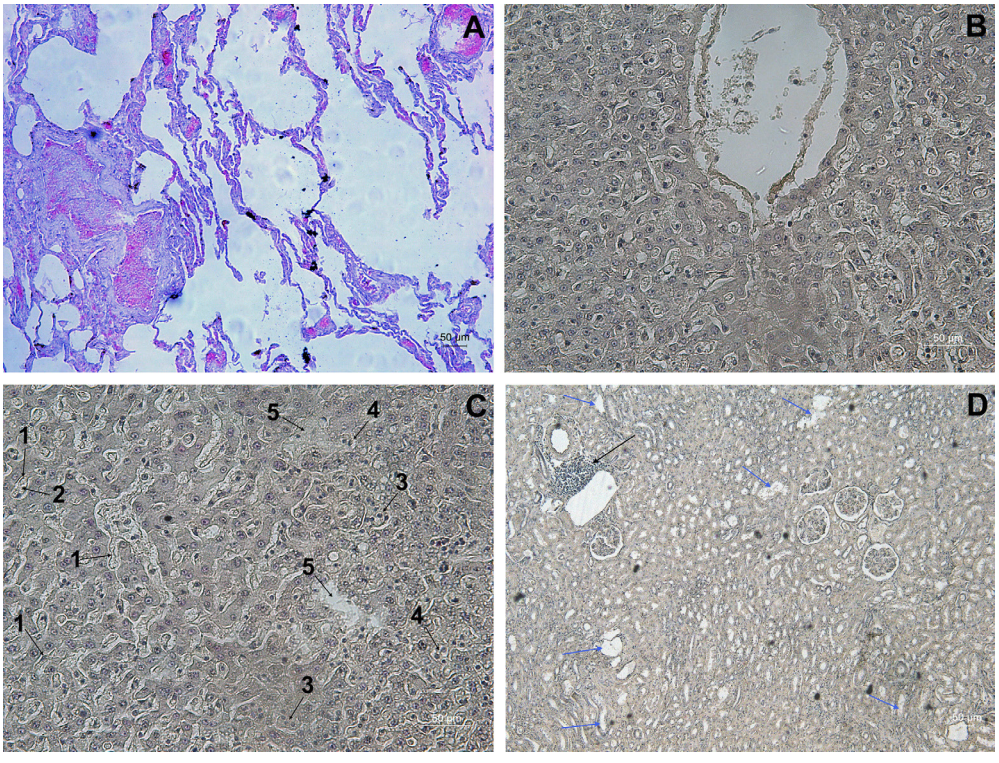

Fig. 4. Parenchymal organs, *Papio hamadryas*: A) lungs: ruptures of the alveolar septum progressing to emphysematous changes, vessels congestion and focal hemosiderosis; B) and C) liver: B) vena centralis in lobulus hepaticus and hepatocytes arranged in irregular cords, C) visible dilated space of Disse (1), sinusoidal lumen (2), karyopyknosis (3), hydropic degeneration of hepatocytes (4), focal islets of cell necrosis and detritus (5), rarely microvesicular fatty changes; D) kidney: blue arrows - cystic tubule dilation and changes in tubular epithelium; black arrow-focal perivascular inflammatory infiltrates; H&E.

Kidney: presence of nonproliferative degenerative lesions like tubular epithelial changes, cystic tubule dilation and focal perivascular inflammatory infiltrates (**Fig. 4D**). Small intestines: lymphoplasmacytic inflammation of lamina propria of the villi, desquamation of the epithelium of the villi and crypts of Lieberkühn (**Fig. 5A**). Large intestines: presence of adult parasite worms in the mucosa, mucosal destruction and cell detritus, neutrophil and lymphoplasmacytic infiltrates in propria mucosae (**Fig. 5B, C, D**).

Discussion

Trichuriasis is a widespread parasitosis caused by more than 70 species of *Trichuris*, each with their own host species [4]. It is a soil-transmitted infection [10]. Factors related with this, such as direct infestation by swallowing eggs from the contaminated environment and the high persistence of eggs and larvae in the soil (infective larvae in egg shell may survive up to 6 years [10]) rank this helminthosis among the persistent

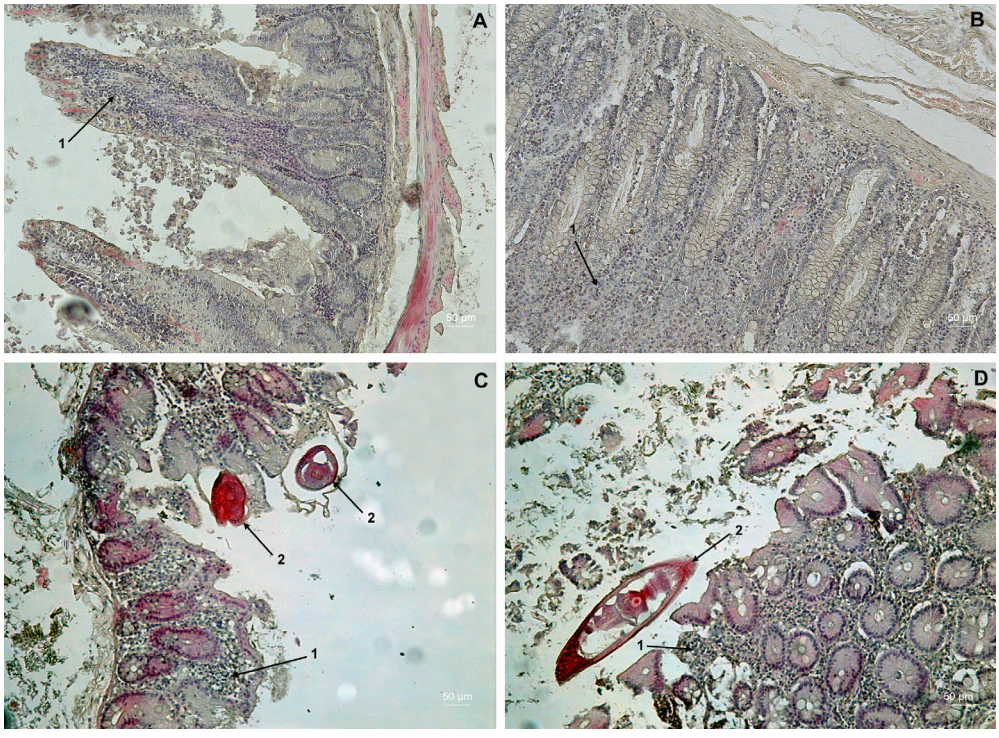

Fig. 5. Tubular organs, *Papio hamadryas*: A) small intestine; B), C), D) colon. Arrows 1- lymphoplasmacytic inflammation of the villus propria and the crypts of Lieberkühn; Arrows 2 – transverse and oblique sections of *Trichuris* sp. adult worms located in the intestinal mucosal tissues; destruction of the columnar epithelium; H&E.

parasitic infections in animals and humans. The nature of the causative agents and the epidemic conditions for their spread, further favored in a zoo environment [14], contribute to the frequent occurrence of the disease in animals kept in captivity. Trichurid infections have been found in a variety of mammal species, including primates, from zoos around the world [1, 3, 7-9, 11, 12, 14,16, 18, 21].

Trichuriasis can be asymptomatic or manifest clinically depending on the degree of infection [10]. We observed this in the present case as well – the two animals in which the infection was in a low degree were in good health status, while the third one, with a high degree of infection, was in a severe condition. The clinical symptoms manifested in this case, such as weight loss, dehydration and diarrhea with possible impurities of blood, are characteristic of the disease and are observed in the various host species of trichurids [10, 23].

Treatment of primates with trichuriasis in previous cases was performed with benzimidazoles and macrocyclic lactones [5, 17]. Reichard et al. [17] found that fenbendazole administered to baboons at a dose of 50 mg/kg orally, once daily for 3 consecutive days was 100% effective (stopped shedding *T. trichiura* eggs within 6 days of treatment, and faecal egg counts remained negative at 65 day after treatment), while the administration of milbemycin oxime in a dose of 1 mg/kg orally at 30-days

intervals for 3 months never totally eliminated eggs of *T. trichiura*. The administration of albendazole in a dosage of 7.5 mg/kg, orally for three consecutive days was completely effective in olive baboons (*Papio anubis*) (faecal egg count reduction was 100% at 28 day post treatment), but with less success (75% reduction of faecal egg count) in vervet monkeys (*Chlorocebus aethiops*), while its application together with ivermectin in a dose of 300µg/kg subcutaneously, each drug for three consecutive days, gave 100% effectiveness in both species of primates [5]. It is interesting to note that the trials of Kagira et al. [5] to treat trichurid infection in these two species of primates with ivermectin alone were completely ineffective (0% faecal egg count reduction at 28 day post treatment). In the present case, the initial treatment of the baboons with albendazole at a dose of 7.5 mg/kg for three consecutive days did not give a completely satisfactory result. However, a long-term 100% elimination of infection in both baboons was achieved after the treatment with albendazole and ivermectin (7.5 mg/kg and 0.4 mg/kg respectively) which confirmed the positive results of combined treatment in a similar situation [5].

Unfortunately, in the present case the condition of the baboon with a high degree of infection worsened regardless of the treatment undertaken and he was euthanized. Obviously, the animal had other health problems in addition to severe infestation. We found evidence of this in the post-mortem examination. Pathological changes were found both in the intestines and in other internal organs - liver, kidneys and lungs.

The cecal and colonic mucosa were inflamed, hemorrhagic with ulceration and formation of diphtheritic membranes. Such kind of alterations are characteristic of the sever cases of trichuriasis [23] and due to the embedding of the adult trichurids with the whiplike anterior portion in the intestinal mucosa [10]. Inflammatory changes in the small intestine can also be associated with trichuriasis, as this is where the larvae hatch and penetrate the intestinal glands remaining there for 2-10 days [3, 23]. It is very likely that the whipworm infection was among the causes that led to the partial liver adhesion to the diaphragm. Supporting this assumption is a study revealed that chronic trichuriasis causes not only a decrease in body weight, but also changes in the abdominal organs and greater visceral adhesion [20].

The mechanisms of internal organ damage in trichuriasis can be associated with general intoxication of the body as a result of resorption of toxins released by trichurid worms and damaged intestinal mucosa [6], intestinal microbiota imbalance and bacterial invasion promoted by the infection [20]. The alterations we observed in the liver, expressed in vacuolization, karyopyknosis and karyorrhexis in the hepatocytes, dilation of the sinusoids and visualization of the perivascular spaces, were not a consequence of autolysis, as we assumed due to the slight delay in performing the autopsy. They had occurred before death and were most likely provoked by chronic exposure to toxins and inflammatory processes associated with the parasitosis [13, 22]. The dilated spaces of Disse, which are a reservoir for stem cells, indicate damage to the liver parenchyma and activation of regenerative processes [19], which testifies to the chronic course in the development of the disease. The emphysematous changes and hemosiderosis in the lungs and the non-proliferative cystic changes in the kidneys cannot be directly related to trichurosis, but they reflect other past diseases that further have worsened the animal‘s condition.

The treatment combined and anti-epidemic measures undertaken apparently led to the overcoming of the infection in the two less infested baboons. This was evident from

the negative coprological tests performed on the 7th and 30th day after treatment. Data on a long prepatent period of 60-90 days in *Trichuris* infection [10, 17] were the reason to the control parasitological examinations performed 90 days after the treatment, which also gave a negative result.

Conclusion

The presented case of trichuriasis in baboons revealed a different course of the infection, related to the degree of infestation and overall health status of the individuals. The combined treatment and anti-epidemic measures taken led to a positive result in the control of trichurid infection in the low infested animals.

Acknowledgements: This research was performed on a voluntary basis, according to an agreement for collaboration between the Institute of Experimental Morphology, Pathology and Anthropology with Museum-Bulgarian Academy of Sciences and the Sofia Zoo.

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