



NOTE

Wildlife Science

Severe whipworm (*Trichuris* spp.) infection in the hamadryas baboon (*Papio hamadryas*)

Kyung-Yeon EO¹), Min-Goo SEO²), Hyun-Ho LEE¹), Yeong-Mok JUNG¹), Dongmi KWAK³) and Oh-Deog KWON³)*

¹)Conservation and Health Center, Seoul Zoo, Gwacheon, Gyonggido 13829, Korea

²)Animal and Plant Quarantine Agency, Gimcheon 39660, Korea

³)College of Veterinary Medicine, Kyungpook National University, Daegu 41566, Korea

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ABSTRACT. A 3-year-old male hamadryas baboon (*Papio hamadryas*) at the Seoul Zoo, Korea, died without any previous symptoms. Necropsy revealed severe whipworm infection in the large intestine. The animal weighed 2.6 kg and had a blood clot at the anus. Numerous whipworms were found attached to the intestinal wall, with their anterior ends embedded in the mucosa. Fecal microscopy revealed typical barrel-shaped, brown eggs of *Trichuris* spp., with hyaline polar plugs at each end. Histopathological examination revealed the thin anterior part of *Trichuris* spp. embedded in the mucosal layer and the thick posterior part at the mucosal surface or hanging freely in the intestinal lumen. This case emphasizes the importance of parasitic infection management in zoo animals.

KEY WORDS: hamadryas baboon, *Papio hamadryas*, trichuriasis, zoo

Trichuris spp. are general parasitic helminths in non-human primates. The prevalence of whipworms in non-human primates is usually high, and the common *Trichuris* sp. that infects non-human primates is *Trichuris trichiura*, which is also known to parasitize humans [1]. The species of non-human primates that can be infected include macaques, African green monkeys, baboons, squirrel monkeys and woolly monkeys. Although light infection is asymptomatic, severe infection produces clinical signs such as severe enteritis, anorexia, gray mucoid diarrhea and sometimes death [2]. Globally, *T. trichiura* is still one of the most important soil-transmitted helminths, in addition to *Ascaris lumbricoides* and hookworms [18].

Hamadryas baboon (*Papio hamadryas*), classified as a least concern species by the International Union for Conservation of Nature Red List, is widespread and abundant, and has no chief range-wide threats believed to result in any important decline in numbers [19]. This species is endemic to northeast Africa and is mainly found in Ethiopia, Sudan, northern Somalia, south-west Arabian Peninsula and Egypt [18]. In January 2016, a 3-year-old male hamadryas baboon weighing 2.6 kg was found dead without any previous symptoms at the Seoul Zoo, Korea. This animal was fed twice per day with a commercial primate biscuit (ZuPreem Primate Dry Biscuit no. 6985, Shawnee Mission, KS, U.S.A.), lettuce, kale, celery, sweet potato, Chinese cabbage, carrot, banana and apple. It was exhibited in a 422 m² outdoor enclosure and 20 m² indoor room as part of a troop.

External observation revealed loose body hair and a blood clot at the anus (Fig. 1A, 1B). Necropsy revealed severe whipworm infection in the large intestine. There was no food in the stomach and small intestine. Numerous whipworms were found attached to the intestinal wall, with their anterior ends embedded in the mucosal layer. Hemorrhage and enteritis with a thickened and ulcerative intestinal wall was observed throughout the tract, including the cecum and rectum (Fig. 1C, 1D). Although bacterial cultures, protozoa detection tests and viral tests were needed to clarify the cause of enteritis in this case, we did not conduct these tests because the lesion caused by *Trichuris* infection was very prominent and severe in the large intestinal wall at necropsy.

For histopathological examination, a piece of the colon containing the whipworms was collected and stored in 10% neutral buffered formalin. Many adult whipworms were found embedded in the colon mucosa, with their thick posterior parts on the mucosal surface (Fig. 2A). Five-micrometer-thick sections of the paraffin-embedded tissue were cut using a microtome and affixed to glass slides. The sections were dewaxed and hydrated by passing them through a xylene-ethanol series. The slides were stained with hematoxylin and eosin for light microscopic examination [6]. The mucosa in the vicinity of the embedded worms was friable and edematous because of inflammation. The stained sections showed the embedded anterior parts of the whipworms surrounded by leucocytes and fibroblasts (Fig. 2B, 2D). Some free-hanging segments of whipworms in the intestinal lumen and slender anterior parts of the *Trichuris* spp. embedded in the mucosa were also observed. The uterus of the whipworms was filled with smooth-walled eggs with unstained bipolar plugs (inset in Fig. 2B). Microscopic examination of the direct smear from the fecal

*Correspondence to: Kwon, O.D.: odkwon@knu.ac.kr

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Fig. 1. External appearance and gross findings at necropsy of a 3-year-old male hamadryas baboon exhibited at a zoo. (A) Loose body hair and light emaciation are observed. (B) A blood clot is seen at the anus. (C) Thickening of the intestinal wall is observed from the cecum to the rectum. (D) Numerous adult whipworms are firmly attached to the intestinal wall of the colon, with their anterior ends embedded in the mucosa.

sample revealed barrel-shaped, brown eggs with hyaline polar plugs at each end (Fig. 2C).

Parasitic infection and disease are the main causes of concern as well as of loss of animal life at zoos. Other infections are usually due to contact with agents such as bacteria, fungi, rickettsiae or viruses. Biohazards should be considered not only among the various animal populations but also among humans, especially those coming in contact with non-human primates [11].

In such cases of infection resulting in gastrointestinal disease, both helminth and protozoan parasites are general causes. Effective parasite treatment regimens, in particular, have enhanced the ability to maintain non-human primates in naturalistic exhibits [2]. Nevertheless, from the perspective of zoonosis, a previous study showed that the fecal samples of four of 54 animal caretakers in charge of non-human primates at five zoos in Belgium tested positive for *T. trichiura* eggs under microscopic examination [13]. The design of exhibits and off-exhibit holding areas should prevent disease transmission between human and non-human primates, such as through the use of glass or other physical separations. Moreover, the management and husbandry protocols should be improved to ensure the health and safety of both human and non-human primates [2].

Various pathogens, such as *Strongyloides* spp., *Enterobius vermicularis*, *T. trichiura*, *Oesophagostomum* sp., *Entamoeba histolytica*, *Balantidium coli*, *Giardia lamblia*, *Shigella flexneri*, *Sh. sonnei*, *Salmonella enteritidis*, *Sa. typhimurium*, adenovirus and hepatitis virus can cause gastrointestinal diseases in non-human primates [10]. Cases of fatal *Trichuris* infection in captive baboons (*Pa. hamadryas*) were reported in Australia and Nigeria [3, 9]. A black-and-white colobus monkey (*Colobus guereza kikuyuensis*) at a zoo in Indiana, U.S.A., died of severe *Trichuris* infection. At necropsy, many *Trichuris* worms were seen protruding from necrotic nodules, having diameters ranging from 0.5 to 2 cm, found in the stomach. However, nematodes were not found in other portions of the gastrointestinal tract [14]. *Trichuris* infection has also been reported in other wild animals. For instance, *Trichuris* spp. were detected in the fecal samples (19.1%, 22/115) of Arabian sacred baboons (*Pa. hamadryas arabicus*) living in human-populated residential and non-residential areas in Asir province, Saudi Arabia, in 1988 [16]. They were also detected in the fecal samples of free-ranging individuals of the three colobus monkey species, including the endangered red colobus (37.8%, 607/1,608, *Piliocolobus tephrosceles*), the eastern black-and-white colobus (79.0%, 376/476, *C. guereza*) and the Angolan black-and-white colobus (100%, 19/19, *C. angolensis*), in Uganda from 1997 to 2003 [7]. In addition, they were detected in the fecal samples (72.9%, 62/85) of free-ranging baboons (*Pa. cynocephalus* and *Pa. anubis*) in Kenya between 1993 and 1995 [8]. Further, *T. trichiura* was detected in the fecal samples of captive and wild-trapped non-human primates such as olive baboons (71.9%, 120/167, *Pa. cynocephalus anubis*), grivets (50%, 25/50, *Cercopithecus aethiops*) and blue monkeys (56.1%, 55/98, *Ce. mitis*) in Kenya in 1998 [15].

Trichuris infection has also been detected in zoo animals. For example, *Trichuris* spp. were detected in the fecal samples of baboons (100%, 6/6, *Pa. cynocephalus*), ring-tailed lemurs (100%, 6/6, *Lemur catta*) and Bactrian camels (100%, 6/6, *Camelus*

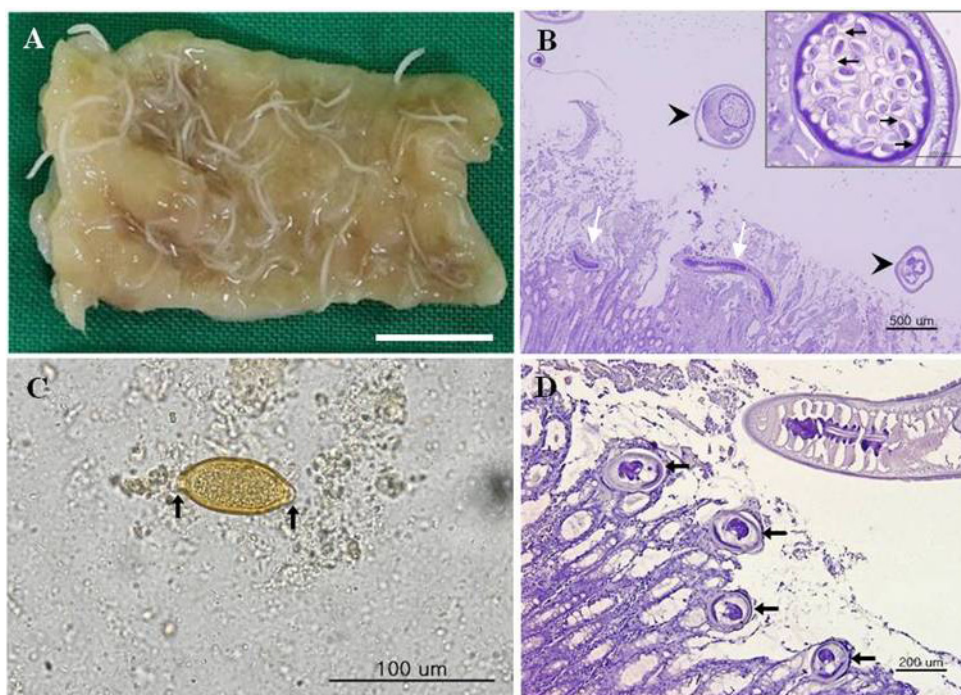


Fig. 2. Histopathological study of the colon after staining with hematoxylin and eosin. (A) A part of the dissected colon after formalin fixation. Whipworms are found embedded in the intestinal mucosa. The bar represents 1 cm. (B) Microscopic observation of the intestinal tissue embedded with whipworms. Free-hanging segments of worms in the intestinal lumen (arrowheads) and the slender anterior parts of *Trichuris* spp. embedded in the colon mucosa (white arrows). Inset: Note the eggs within the uterus of the whipworms, showing smooth walls and bipolar plugs (black arrows). (C) Fecal microscopy shows a barrel-shaped egg with hyaline plugs at each end (arrows). (D) The anterior parts (arrows) of the whipworms invade into the large intestinal wall.

bactrianus) at two Italian zoological gardens in 2007 [5]. Further, they were detected in the fecal samples of baboons (75.0%, 3/4) and peacocks (100%, 2/2) at the zoological garden in Nekede, Nigeria, in 2010 [17]. They were also detected in the fecal samples of Celebes crested macaques (20.0%, 2/10, *Macaca nigra*), hamadryas baboons (15.7%, 16/102, *Pa. hamadryas*), Hamlyn's monkey (2.9%, 1/35, *Ce. hamlyni*) and black-crested gibbon (33.3%, 1/3, *Hylobates concolor*) at four zoological gardens in Belgium between 2004 and 2006 [12]. *Trichuris* spp. were also the cause of infection in three dromedary camels (*Ca. dromedarius*) at the Seoul Zoo, Korea, in 2013 [4].

We monitor gastrointestinal parasitic infection in hamadryas baboon troops twice a year by using a typical microscopic fecal test. On the basis of the findings of the fecal test, we prescribe anthelmintics to treat parasitic infection. However, in the case of baboons, individual administration is difficult because of the large troop size, and oral administration of drugs is challenging because of the baboon's ability to detect medicated food or drink. Hence, it is uncertain whether the anthelmintics were consumed by infected animals. Therefore, to eradicate whipworm infection in the whole troop, long-term monitoring, regular fecal examination and individual drug administration are important and necessary. This case of severe whipworm infection in a captive hamadryas baboon serves as an example of pathological trichurid infection and emphasizes the importance of parasitic infection management in zoo animals.

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