A Review of the Endoparasites of Mountain Gorillas (31-Jan-2003)

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Introduction

Highly endangered mountain gorillas (\textit{Gorilla beringei beringei}) are found in two distinct non-breeding populations: Bwindi Impenetrable National Park (BINP), a tropical montane rainforest located in the southwest corner of Uganda, and the Virunga Volcanoes located on the mountains bordering Rwanda, Democratic Republic of Congo and Uganda. Both areas are surrounded by some of the most densely populated and intensively cultivated areas in Africa. Approximately 600 mountain gorillas remain, their population split almost equally between the two parks [1]. The mountain gorilla population has enlarged in recent years, but increasing amounts of guerilla activities near the parks, bushmeat consumption, and the expanding human population has made the conservation and protection of these gorillas critical to their survival [2]. Another recently emerging area requiring careful consideration is the human habituation of the gorillas as tourists enter the park [3].

Mountain gorillas have been the focus of several major conservation efforts. Long-term studies on the feeding ecology, ranging patterns, and social behavior of the gorillas in the Virunga Volcanoes have been in place since the early 1960s [4]. Due to ecotourism in both parks and the encroachment of civilization, there is concern that, as gorillas become more intimately associated with their human visitors, human diseases may compromise the gorilla populations. Disease transmission is recognized as an important area of conservation for these species, but to date has been very little studied. The Mountain Gorilla Veterinary Project has assisted in monitoring the health of the mountain gorillas in recent years and their primary objective is to provide emergency care to injured and seriously sick gorillas, and monitor the health of mountain gorilla groups [5].

Here we present a descriptive review of the endoparasites of the mountain gorilla, in hopes that we have provided a resource for primatologists, ecologists, veterinarians, park managers and all others involved in the protection of the gorillas that will assist in providing the tools and background for endoparasite identification in this highly endangered species (Fig. 1).

Figure 1. Silverback mountain gorilla in Bwindi Impenetrable National Park, Uganda. - To view this image in full size go to the IVIS website at www.ivis.org. -

Nematodes

\textit{Order: Strongylidia - Superfamily: Trichostrongyloidea}

\textit{Hyostrongylus kigezienis}

History - This species was described from specimens collected from a necropsied Bwindi mountain gorilla [6], and was later described by Sleeman et al., in the Virunga population [7]. Other hosts of this genus of nematodes include Ethiopian Leporidae, Suidae and a few Bovidae. It is hard to say whether this species represents a true parasite of the gorilla or a worm that typically is maintained in other mammals. The fact that Sleeman et al., found \textit{Hyostrongylus} larvae in cultures of gorilla feces [7] would suggest that this parasite might be a true parasite of gorillas.

Morphology - This worm has the typical structure of trichostrongyloids: an uncoiled body, adorned with continuous longitudinal ridges (Fig. 2).
Living worms are often bright red in color. Females are about 1 cm long, males slightly shorter (Fig. 3). The male has a distinct copulatory bursa and short stout spicules (Fig. 4).

Buccal cavity lacking, the excretory pore lies midway along the esophagus, with the deirids slightly anterior posterior to excretory pore. *Hyostrongylus* can be differentiated from the other stomach worms of gorilla’s, *Paralibyostrongylus kalinae*, because the latter has large medial ridges on the female at level of the vulva. Also, the deirids of *Hyostrongylus* are relatively larger than those of *Paralibyostrongylus kalinae*.

**Diagnosis at Necropsy** - The worms live on the mucosa of the stomach or in small, ulcerated areas on the mucosal surface. Live*Hyostrongylus* tend to be brown or bright red in color.

**Diagnosis in Fecal Examination** - The eggs are typical strongylid eggs (Fig. 5). Based on the drawing by Durette-Desset et al., [6], the eggs are about 70 to 75 µm in length.

**Hosts** - Mountain gorilla; no other hosts are known.

**Mode of Transmission** - Gorillas would be infected by the ingestion of larval contaminated foodstuffs.

**Life Cycle** - The life cycle of *Hyostrongylus kigeziensis* has not been described. The life cycle of a swine parasite, *H. rubidus*, has been reported in detail [8]. The adults live in the stomach. Eggs are passed in the feces. First-stage larvae are about 0.3 mm long. Under optimal conditions, the first molt occurs in about 3 days and the second molt about 2 days later. The first-stage and second-stage larvae have long filamentous tails and tubular buccal cavities. The third-stage infective larvae produced by the second molt are about 0.7 mm long and retain the second-stage larval cuticle as a protective sheath. The infective larvae cannot penetrate the skin, and therefore enter a new host by ingestion. After ingestion, larvae exsheath in the stomach, and penetrate the epithelial folds of the gastric mucosa. The third molt occurs 5 days after infection. The final molt to the adult stage occurs in 13 days. The prepatent period is 17 days [9]. Maximum egg output was observed at 24 days after infection.

**Clinical Signs** - Descriptions based on *H. rubidus* suggest that larvae develop in the gastric mucosa where they destroy the epithelium and cause the formation of lentil-sized nodules. Adult worms induce a chronic catarrhal gastritis leading to the formation of ulcers [10].

*Paralibyostrongylus kalinae*

**History** - This species was first described by Durette-Dusset et al., during a necropsy of the same female mountain gorilla of
the Bwindi Impenetrable Forest in 1989 from which they recovered and described the specimens of *Hyostrongylus kigeziensis* [6]. This species was named after conservation biologist Jan Kalina, who with her husband Tom Butynski, facilitated the creation of the Bwindi Impenetrable National Park. This genus has been reported in, primitive rodents, hyracoids, and porcupines [11-12].

Lane [12] reported the recovery of *Paralibyostrongylus hebrenicutus* from the stomach and duodenum of a necropsied gorilla provided by the College of Surgeons. Dian Fossey recorded *Paralibyostrongylus hebrenicutus* as being recovered during necropsy from the liver of an adult female gorilla of the Rwandan Virungas [13]; the stage of the worm recovered was not given, and the hepatic location seems very unusual for these worms. It seems that both *Paralibyostrongylus kalinae* and *Paralibyostrongylus hebrenicutus* are both rodent or lagomorph parasites that are capable of developing in gorillas. The rodent host of *Paralibyostrongylus hebrenicutus* has been found to be members of the genus *Atherurus*. The rodent or lagomorph host of *Paralibyostrongylus kalinae* has yet to be described.

**Morphology** - This genus has the typical structure of the trichostrongylidae, i.e., body uncoiled and adorned with continuous longitudinal ridges. Living worms are often bright red. There is a large dorsal esophageal tooth present. Females are about 1 cm long, males slightly shorter. The male has a distinct copulatory bursa, and short stout spicules. Buccal cavity lacking, excretory pore lies midway along the esophagus, with deirids slightly anterior posterior to excretory pore. *Paralibyostrongylus kalinae*, has large medial ridges on the female at level of the vulva and deirids that are smaller than those of *Hyostrongylus kigeziensis*. *Paralibyostrongylus kalinae* differs from *Paralibyostrongylus hebrenicutus* in that it has a short dorsal ray on the bursa similar to that on two other species of *Paralibyostrongylus* that have been found in west African lagomorphs.

**Diagnosis at Necropsy** - Worms were identified in stomach contents on one occasion. There was no report of any signs associated with the infection because the gorilla was found dead and the necropsy was performed several days after recovery [6]. At necropsy, it would be expected that the fresh worms would appear red in color.

**Diagnosis in Fecal Examination** - The eggs are typical strongylid eggs, and would be very similar to those of *Hyostrongylus*. The eggs of these two species need to be more carefully described.

**Hosts** - Mountain gorilla.

**Mode of Transmission** - The host is infected by the ingestion or skin penetration of third-stage larvae.

**Life Cycle** - The life cycle of the related species *P. hebrenicutus* is presented because that of *P. kalinae* has not been described. With *P. hebrenicutus*, when the host is infected through the skin, the larvae enter the lymphatic system and reach the lungs and heart within 8 hours of infection. They reach the stomach within 2 days. If they are ingested through contaminated food or soil, they reach the stomach within 24 hours post infection. Larvae localize within the stomach mucosa. The fifth day postinfection, regardless of mode, the larvae become imbedded in the gastric mucosa where they undergo the third molt followed by the fourth molt during the nineteenth day. Eggs appear on the twenty-eighth day after infection [14].

**Clinical Signs** - None have been described.

*Impalaia sp.*

**History** - This species was first described by Monnig in 1923 in impalas from South Africa. The species comprising this genus typically parasitize large, herbivorous antelope, such as the impala. Members of this genus have also been found in camels, giraffe, okapi, and sheep. The parasites found in the gorilla were not identified to species. The first report of this genus in the Virunga population of mountain gorillas was from Redmond [15], and the worm was later found during the necropsy of a Virunga gorilla [16].

**Morphology** - The adults recovered from ruminants are about 1 to 2 cm long. The anterior end of both sexes bears a slight inflation with marked transverse striae. The female is readily identified by the monodelphic uterus with the vulva being found just anteriad to the anus. The dorsal ray of the male is very long compared to other members of the family. The synlophe is composed of 16 evenly spaced longitudinal cuticular ridges. The eggs, typical of strongylid nematodes, are around 75 µm by 35 µm.

**Diagnosis at Necropsy** - The worms live in the small intestine or caecum of the host.

**Diagnosis in Fecal Examination** - The worms recovered from the gorilla have not been described as to stage. Adult worms would produce typical strongylid eggs in the feces.

**Hosts** - The reports from mountain gorillas include the collection of *Impalaia* sp. from 1 of 6 necropsied animals [16]. Other hosts of *Impalaia* include herbivores: giraffe, okapi, sheep, impala, reedbuck, Thomson’s gazelle, sable antelope, gerenuk, blesbok, oryx, tsessebe, camels [17-18].

**Mode of Transmission** - The host ingests third-stage larvae that have developed in the soil or on vegetation.

**Life Cycle** - The life cycle for *Impalaia tuberculata* has been described relative to its development in the impala [19-20]. After ingestion of the ensheathed third-stage larvae, the exsheathed third-stage larvae probably do not migrate deeply into the mucosa. The fourth-stage larvae are found in the proximal portion of the small intestine and the young adults are found throughout the intestine. The adult worms tend to be found mainly in the distal small intestine. The female passes numerous
eggs in the feces. The eggs develop to a first stage larva in the feces where they feed off of the microorganisms and fecal matter. They continue to the second stage in a few days and then to the third infective stage. At the third stage they are ensheathed, and migrate from the fecal matter to soil and vegetation using stored food as energy. They can survive for months on their stored food supply until they are consumed by the host.

**Clinical Signs** - Clinical signs would probably be similar to those of an overwhelming infection with *Cooperia*, a related parasite of ruminants that can cause watery diarrhea when present in large numbers.

**Trichostrongylus sp.**

**History** - The genus was first described by Looss in 1905. Over thirty species have been reported in mammals and birds [20]. This genus was first recorded in mountain gorillas, from necropsies of gorillas in the Virunga population [16] and then by identification of *Trichostrongyle*-like eggs in fecal examinations in both the Virunga and Bwindi populations (Fig. 6) [7,21-25].

![Figure 6. Strongylid egg recovered from the feces of Bwindi mountain gorillas. - To view this image in full size go to the IVIS website at www.ivis.org . -](image)

Most species in this genus have been described from birds, ruminants and primitive rodents around the world. Species have also been found in human and non-human primates, camel, pigs and equids. Gorillas are probably not the normal host of these parasites. However, without more careful descriptions, it is not possible to identify the actual host, which is likely a ruminant or a lagomorph.

**Morphology** - These are small worms (less than 1 cm long) without a buccal cavity. The bursa of the male has large lateral lobes with a relatively short dorsal lobe (Fig. 7). The vulva of the female is located slightly posterior to midbody, and the two branches of the uterus are amphidelphic. The uterus is filled with eggs that are thin shelled and of the typical strongylid type (Fig. 8).

![Figure 7. *Trichostrongylus* male. - To view this image in full size go to the IVIS website at www.ivis.org . -](image)

![Figure 8. *Trichostrongylus* female. - To view this image in full size go to the IVIS website at www.ivis.org . -](image)

**Diagnosis at Necropsy** - These small brownish worms are difficult to discern at necropsy without special care to examine the mucosal scrapings of the small intestine. If worms are discovered, care must be taken to recover both males and females if a specific diagnosis is desired.

**Diagnosis in Fecal Examination** - The eggs in feces are typical of other strongylid nematodes, and may be confused with other parasitic nematodes common in the mountain gorilla. There is indication based on measurements made on eggs in feces that the eggs of *Trichostrongylus* may be longer than those of *Oesophagostomum* (Kalema, personal communication). To identify eggs as being those of *Trichostrongylus*, it is necessary to culture the eggs and to examine hatched and developed third-stage larvae. The sheath extending beyond the tip of the tail is shorter than that of most other trichostrongylid parasites.

**Hosts** - Livestock (ruminants, pigs, fowl), humans and other primates, camels, rodents, wild ruminants and equids.

**Mode of Transmission** - The host ingests the infective third stage larvae.

**Life Cycle** - The adult worms produce eggs that are passed in the feces. The eggs hatch under suitable environmental conditions and develop to the first stage larvae in the feces where they feed on the microorganisms and fecal matter in the feces and surrounding soil. They develop to the second stage in a few days and then to the third-stage, ensheathed, infective larva. Migration from the fecal matter to soil and vegetation occurs using stored food as energy. Larvae can survive for months on their stored food supplies until consumed by a host. Larvae can generally withstand harsh temperatures above freezing. When larvae are consumed, they develop in the small intestine and adults inhabit the anterior part of the small intestine. Some species invade and remain in the intestinal mucosa as larvae for some time before re-entering the lumen to mature [20].

**Clinical Signs** - There have been no clinical signs of disease associated with *Trichostrongylus* sp. reported from gorillas,
however, the disease manifestations associated with trichostrongylosis is diarrhea that may sometimes be quite severe. In humans infected with *Trichostrongylus*, slight abdominal discomfort is occasionally reported, but usually patients are asymptomatic [26].

**Order: Strongylidia**  
**Superfamily: Strongyloidea**

**Murshidia devians**  
**History** - This genus of strongyloid nematodes was first described by Lane (1914) and represents species that are typically found to infect elephants and rhinoceros. Campana-Rouget described the species *Murshidia devians* from a lowland gorilla in the Republic of Congo, suggesting that the parasite described was an accidental parasite of the gorilla for three reasons:

1. *Murshidia* was never previously recovered from primates, having been found only in elephants and rhinoceros.
2. The adults of this species are typically found in the large intestine, and in the gorilla, adult worms were found in the large intestine, but they were also found ectopically in the skin and muscles of the back and thorax.
3. The species *Murshidia devians* is very close morphologically to two species commonly infecting elephants [27].

Consequently, it is likely that the elephant is probably the natural host of the parasites found in the gorilla. Hastings et al., report finding *Murshidia devians* in the large intestine of a mountain gorilla at necropsy [16]. Ashford et al., identified the worms during the necropsy of a mountain gorilla in the Bwindi forest [22].

**Morphology** - The genus, as is typical of members of the Strongyloidea, has a large buccal capsule. The buccal capsule is anteriorly directed, has a single external leaf crown, and sometimes bears two or more teeth at its base. In the case of *Murshidia devians*, the oral opening is elongated dorso-ventrally, the external leaf crown has about 80 elements, and there are no teeth figured at the base of the buccal capsule [27]. The recovered worms were about 20 mm long. The vulva of the female is located just anterior to the anus, and leads into a prodelphic uterus with two branches. The bursa of the male has a well-developed dorsal lobe. Males have spicules and a gubernaculum.

**Diagnosis at Necropsy** - The adults would typically be found free within the lumen of the large intestine [16]. Fossey reported finding the worms in the small intestine of a necropsied older female mountain gorilla [13]. The report by Campana-Rouget found that the worms were present in ectopic sites [27]. Thus, it is possible that worms will be found in sites other than the intestine.

**Diagnosis in Fecal Examination** - Eggs of the typical strongylid type may be detected in the feces; the eggs are 60 µm by 30 µm. When third stage larvae are cultured in feces, the larva has a long sheath that extends beyond the tip of the tail [28].

**Hosts** - *Murshidia devians* was described from the lowland gorilla and reported from both populations of mountain gorillas. In all cases, *Murshidia* is probably an accidental parasite [22]. The members of this genus are typically in elephants and rhinoceros.

**Mode of Transmission** - The host ingests the infective third stage larvae.

**Life Cycle** - There is no information on the life cycle of any *Murshidia* sp. It is assumed that this parasite has a direct life cycle like other members of the subfamily Cyathostominae. The female lays eggs in the intestine and the host passes them in its feces. The eggs hatch on the ground to release the first-stage larvae, which feeds on bacteria. The first-stage larvae molt to second-stage larvae that also feed on bacteria. The second stage molts to the third-stage larvae that are ensheathed. The development in the final host has not been studied. The finding of the adults of *Murshidia* in ectopic sites in the gorilla would indicate that there might be some form of extraintestinal development associated with the development of these worms in their normal hosts.

**Clinical Signs** - No information available.

**Oesophagostomum stephanostomum**

**History** - This species was first described from gorillas in 1904 [29]. The worms were from the zoology museum of Cambridge University with the simple designation "from large intestines of gorilla", so there is no indication as to where the host originated. Rouselot and Pellissier reported on the presence of *Oesophagostomum stephanostomum* in western lowland gorillas from the Republic of Congo [30]. Specimens of this genus were later found at necropsy of Virunga gorillas [16], in Bwindi gorillas [22] and in larval cultures [7]. Surveys found eggs in the feces of gorillas from the Bwindi population and identified by them as *Oesophagostomum* [21,22,31].

**Morphology** - Adult females are 18 to 30 mm in length; males are 18 to 24 mm long. The worm has a relative small buccal cavity compared to other members of the strongyloidea and a marked transverse cervical groove at the excretory pore (Fig. 9).
The stoma has both external and internal leaf crowns, with the external crown having 30 to 38 petals. There are two to three times as many petals on the internal leaf crown. The base of the buccal capsule contains six rather large chitinous plates. The male has a prominent bursa and two rather long spicules (Fig. 10). The vulva of the female is near the anus and the vagina connects to the kidney shaped ovejector (Fig. 11) [29].

Diagnosis at Necropsy - Adults are found free within the lumen of the large intestine. Worms of this genus form nodules as larvae in the intestinal wall (Fig. 12).

These are small, raised areas about 1 mm in diameter in the small and large intestine. The lesions can grow into small abscesses and eventually the entire intestine may be inflamed and edematous. Nodules can reach 4 - 5 mm in diameter, and contain eosinophils and leukocytes. There can be a significant number of nodules at necropsy; 40 nodules were found in 1 of 9 gorillas in the Congo [30].

Diagnosis in Fecal Examination - Eggs are 60 - 80 µm by 40 - 55 µm (Fig. 13). When cultured to the infective stage, the third-stage larva is about 1 mm long, has 16 to 24 triangular intestinal cells, and a sheath that extends 150 µm beyond the tip of the larva.

Hosts - Gorillas, chimpanzees, and humans (reported from Uganda, Senegal, and surprisingly, Brazil) [32].

Mode of Transmission - The host ingests infective third-stage larvae.

Life Cycle - There is no information on the life cycle of *O. stephanostomum*. The life cycle is considered to be similar to related species such as *O. bifurcum*, another species found in Old World primates. After larvae are ingested, it takes approximately 3 months until eggs appear in the feces [33]. The molt from third to fourth stage occurs sometime prior to Day
19 to 22 after infection. Some young adult worms were still present in nodules within the bowel wall after almost a year from the time of infection. Animals can shed eggs for almost a year.

**Clinical Signs** - Disease was first associated with gorillas captured for zoological collections in Gabon and the Republic of Congo [30]. The gorillas died within a few months of capture following ill health. Fecal examinations revealed the eggs of strongylid nematodes, and necropsies later revealed that the gorillas were infected with both hookworms and had nodular disease due to oesophagostomins. The clinical signs manifested as anorexia and lack of grooming with an unkempt appearance. There was mucoid diarrhea similar to amebic dysentery in humans. The gorillas remained lying or sitting holding their heads with both hands in an attitude of desperation. In free-ranging mountain gorillas, nodules of oesophagostomiasis have been observed at necropsy by the Mountain Gorilla Veterinary Center (cited in [7]) and Hastings et al., speculate that feces containing blood and mucus may have been caused by *Oesophagostomum* [34].

**Order: Ascaridida**  
**Superfamily: Cosmocercoidea**

**Probstmayria gorillae**

**History** - In 1955, Kreis described *Probstmayria gorillae* based on specimens collected from a gorilla that died in a zoo in Basel, Switzerland [35]. Specimens belonging to the genus *Probstmayria* have been described from mountain gorillas in both the Virunga region [7,15] and in groups of gorillas in Bwindi Impenetrable National Park [22,25,31]. In 1990, Ashford and others found that gorillas had a 100% prevalence [31], while Rothman and others found a 13% prevalence in a single group sampled over 7 weeks [25]. No other surveys of Bwindi gorilla gastro-intestinal parasites found any Cosmocercoidea [21,23]. Specimens collected from the feces of lowland gorillas in Gabon have been described as two species distinct from *Probstmayria gorillae*; these two species were named *Probstmayria goodallae* and *Probstmayria gabonensis* [36].

**Morphology** - These are small worms with an esophagus characteristic of the Cosmocercoidea, i.e., with a large valved bulb at the base and a vestibule between the stoma and the beginning of the muscular esophagus proper (Fig. 14 and Fig. 15).

The female is characterized by giving birth to large larvae that are almost one-third her total length. Waerebeke et al., in their description of *P. gabonensis* [36] stated that because Kreis cited both the gorilla and gibbon as the host of this species [35], it was complicated as to whether this species was originally from a gorilla or a gibbon. The fact that there have been no reports of Probstmayria from gibbons would suggest that the original origin of the species is most likely from the gorilla. *P. gabonensis* is the most similar to *P. gorillae* in that the lips are similar in shape. *P. goodallae* differs form the other two described species from the gorilla in that they have an inverse symmetry (one ventral lip and two latero-dorsal lips). The sizes of all three species are similar, and there have been no careful comparisons of characters that could be used for rapid identification to the species level upon routine examination.

**Diagnosis at Necropsy** - Larvae and adults will be found in the lumen of the cecum and colon. The adults are not large (females are only about 2 mm long), and the larvae that are newly born will be almost half the length of the mother.

**Diagnosis in Fecal Examination** - Fecal examination can reveal both the adults and larvae of *Probstmayria*. The fact that the mother gives birth to highly precocious larvae and that there is no intermediate host required means that very large populations can develop within an infected animal. Eggs will not be seen in the feces.

**Hosts** - Gorillas, other species in chimpanzees, African and Asian pigs and horses, and Central American tapirs.

**Mode of Transmission** - The life cycle is direct (Fig. 16); the host ingests the third stage larvae, usually through infected foodstuffs or by fecal-oral contamination.

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**Mode of Transmission** - The life cycle is direct (Fig. 16); the host ingests the third stage larvae, usually through infected foodstuffs or by fecal-oral contamination.
Life Cycle - The life cycle is direct. Females contain very few (1 to 3) larvae that are quite large compared to her body size. The larvae that are born provide the means for the development of internal autoinfection and for this reason, very large numbers of worms can build up within the intestine of the host. Transmission is probably assisted by the fact that larvae can remain alive in feces for 4 or 5 days.

Clinical Signs - This species has not been found to be pathogenic.

Order: Strongylidia
Superfamily: Ascaridoidea

**Ascaris lumbricoides**

**History** - *Ascaris lumbricoides* was first described by Linnaeus in 1758, as a parasite observed, and recorded by ancient peoples. This is one of the most common parasites of people around the world and is believed to be present in one-sixth of the world’s human population. In 1995, Kalema found *Ascaris lumbricoides* eggs in the Bwindi population of mountain gorillas; she found eggs in the feces of two infants and two adult female gorillas [21]. In 1990, a study of the feces of people living around Bwindi forest revealed high loads of *Ascaris*, but there was no evidence of *Ascaris* in gorilla populations [31].

**Morphology** - *Ascaris lumbricoides* is a large cream-colored or white worm that will reach lengths of up to 30 cm or greater (Fig. 17). The worms have 3 large lips on the anterior end that surround the buccal opening. The tail is relatively short and comes to a rather abruptly pointed tip. The mail tail tends to curl ventrally and has no bursa.

![Figure 17. Adult Ascaris suum recovered at necropsy from pigs. - To view this image in full size go to the IVIS website at www.ivis.org. -](image)

**Diagnosis at Necropsy** - *Ascaris lumbricoides* are quite distinct worms that would be difficult to confuse with any of the other parasites that might be found in the small intestine of gorillas at necropsy. Occasionally, senescent worms will be found in the cecum or colon at necropsy; these worms are dead or dying and in the process of being expelled from the body. There are no reports of necropsied gorillas infected with *Ascaris* sp.

**Diagnosis in Fecal Examination** - *Ascaris lumbricoides* eggs are ovoid and about 60 µm long. The eggs have a thick shell and a dark-brown external coat that appear to have a rough outer coat typically stained by bile to a golden brown color (Fig. 18). When passed in feces, the eggs usually contain a single undivided cell.

![Figure 18. Ascaris egg. - To view this image in full size go to the IVIS website at www.ivis.org. -](image)

**Hosts** - Humans and other primates.

**Mode of Transmission** - Infected soil/foodstuff is ingested by the host (Fig. 19). The eggs persist in the soil for long periods and can remain infectious in soil for years. It takes about two weeks under optimal conditions for eggs to become infectious through the embryonation of the larval to the infective stage.
Life Cycle - After ingestion of an infective egg, larvae hatch. Recent work has suggested that the eggs hatch in the large intestine and that the larvae actually enter the circulation through the wall of the large bowel (at least, with the closely related parasite of swine, *Ascaris suum*). The hatched larvae will migrate into the intestinal wall, and travel through the portal circulation to the liver, heart and through the pulmonary vessels to their destination, the interalveolar tissues of the lung. The larvae then make their way up the respiratory escalator, and they are then swallowed. The remainder of the development takes place in the lumen of the small intestine. The prepatent period is about 2 months, and the worms live about 1 year. The females produce prodigious amounts of eggs, having been shown to produce about 200,000 eggs per day.

Clinical Signs - There are no clinical signs reported in mountain gorillas. In humans, light infections usually produce little in the way of signs or symptoms. Heavy infections can cause intestinal obstruction and related signs. It has been shown in people that *Ascaris lumbricoides* infections do have some effect on the nutrition of their human hosts.

**Figure 19. Life cycle of Ascaris:** Direct life cycle. These large nematodes live in the small intestine. Eggs are passed in the feces, and after several weeks in the soil, the eggs are embryonated and infectious. The gorillas become infected by ingesting infectious soil, or soil contaminated vegetation. In the gorilla, the larval *Ascaris* make a liver-lung migration before returning to the small intestine where they complete their development. The prepatent period is about 6 weeks. Light infections are typically without pathology, although the large adult worm can occasionally cause intestinal perforation or migration into and blockage of the bile duct. Very heavy infections that might occur in young animals could cause significant disease. - To view this image in full size go to the IVIS website at www.ivis.org.

**Order: Spirurida**  
**Superfamily: Physalopteroidea**

*Chitwoodspirura* sp.  
**History** - In 1956, Chabaud and Rousselot described *Chitwoodspirura wehri* from a lowland gorilla from Congo (Braizeville) [37]. Only immature specimens were found. It was further described from specimens collected from a gorilla at the Hirakata Zoological Park soon after its arrival from the Congo [38]. A nematode found during the necropsy of mountain gorillas in Rwanda was identified as *Chitwoodspirura* sp., but a specific determination was not made [16].  
**Morphology** - The worms are large: males are 5 cm and females are 10 cm, in length. The esophagus is typical of spirurids (divided into a muscular and glandular portion). There is a large buccal cavity, and the anterior end possesses a pair of lateral pseudolabia that close over mouth. Each of the two pseudolabia possesses approximately nine large denticles. The vulva is about one-third of the body length behind the anterior extremity. In the male, the right spicule is about 1 mm long; the left is about 5 mm long. The tails of both the males and females come together in a relatively rounded tip. The egg is small (23 x 45 µm), larvated, thick shelled, and bears what appear to be seated opercula on each end.  
**Diagnosis at Necropsy** - The worm is found in the stomach [16,37].  
**Diagnosis in Fecal Examination** - Characteristic small, thick-shelled, larvated spirurid eggs would be found in the feces.  
**Hosts** - Lowland gorilla, possibly a mountain gorilla.  
**Mode of Transmission** - Based on other spirurid life cycles, it is expected that the gorilla would become infected by the accidental ingestion of a coprophagous arthropod on vegetation.  
**Life Cycle** - There is no known information about the life cycle of *Chitwoodspirura* sp. Spirurid nematodes go through an arthropod intermediate host. The thick-shelled nature of the egg passed in the feces would suggest that the intermediate host is likely to be a coprophagous arthropod of some type that becomes infected by ingesting the embryonated egg.  
**Clinical Signs** - No information available.

**Order: Rhabditida**  
**Superfamily: Rhabditioidea**

*Strongyloides fulleborni*  
**History** - This species was described in 1905 by von Linstow using specimens collected from *Anthropithecus troglodytes* and *Cynocephalus babuin*. Man was first recorded as a host of this parasite in Zimbabwe [39]. *Strongyloides fulleborni* eggs have been reported in the feces of mountain gorillas in both Bwindi and the Virungas [7,21-24,31].  
**Morphology** - The parasitic parthenogenetic female is about 3.5 to 4.5 mm long. Like other *Strongyloides* spp., she is very slender and has an esophagus that is very long, one-fourth to one-fifth of the total body length. The ovary of *Strongyloides fulleborni*, like other species that produce eggs in the feces rather than larvae, spirals around the intestine. These eggs produced by the parthenogenetic female appear clear, contain a larva, and measure 50 to 60 µm x 25 to 35 µm.  
**Diagnosis at Necropsy** - These worms are very small and very easy to overlook at necropsy unless techniques are used that
are designed specifically for their collection. It is best to take a small portion of fresh bowel (proximal small intestine) and suspend it with weights in a graduated cylinder of saline at 37°C overnight. The very small worms will migrate out of the tissue and drop to the bottom of the cylinder. The next morning, the intestine can be removed from the cylinder, and the sediment examined for the presence of the small *Strongyloides*.

**Diagnosis in Fecal Examination** - The eggs of *Strongyloides fulleborni* are ovoid, clear, and embryonated when passed in the feces with a relatively thin shell (Fig. 20).

![Figure 20. Strongyloides egg. - To view this image in full size go to the IVIS website at www.ivis.org. -](image)

The eggs measure 50 to 60 µm x 25 to 35 µm. It is easy to miss the eggs in fecal samples because they are transparent. If the feces sit for any length of time at room temperature, the larvae are liable to hatch. The larvae of *Strongyloides* can be identified by their possession of a short esophagus (rhabditiform with a distinct corpus, isthmus, and bulbus) and a genital primordium that is quite large, being longer than the body is wide.

**Hosts** - Humans and other primates. The species *Strongyloides fulleborni* is much more common in non-human primates than in humans even where the ranges overlap; it is believed that typically non-human primates are the major host of this parasite.

**Mode of Transmission** - The most common mode of infection is penetration of the skin by infective third-stage larvae. In people of the Democratic Republic of Congo, 26 of 76 infants less than 200 days of age were infected with this parasite [40]. Examination of milk from nursing mothers revealed three *Strongyloides* larvae; in one 2 ml sample of milk from a nursing mother 2 weeks post-partum [40]. It is expected that *Strongyloides fulleborni* would also be transmitted in non-human primates in the milk of nursing mothers.

**Life Cycle** - The infective larvae that develop in soil are 575 - 640 µm and penetrate the skin. When larvae penetrate the skin, they enter the blood stream and are carried to the lungs. From the lungs, the larvae make their way to the intestinal tract by entering the respiratory openings, being coughed up, and swallowed. It takes 3.5 days for the larvae to reach the small intestine and 9 days before eggs are passed in the feces. Larvae that penetrate the skin may also enter into muscle and other parts of the body where they are capable of persisting as larvae for extended periods. These larvae form the reservoir of larvae that cause transmammary transmission, which accounts for infection in newborn animals.

The life cycle of *S. fulleborni* includes a free-living portion that has been termed the "heterogenic cycle". The heterogenic cycle is one wherein the stages that develop from the egg passed in the feces develop in the soil to free-living male and female worms. The eggs produced by the free-living female then go onto produce larvae that are the same as the infective third-stage larvae that penetrate the skin. This is in contrast to the "homogenic cycle", wherein the larvae develop directly from the stage passed in the feces into the stage that penetrates the skin. This relatively academic point surrounding the life cycle of this parasite is important because it provides a means of the worm increasing its genetic diversity and the number of potentially infective stages when conditions are appropriate for heterogenic development.

**Clinical Signs** - The clinical sign of most significance in humans is the "swollen belly" syndrome that has been reported in neonate humans in New Guinea. It appears that the infection is well tolerated by adult humans. In the case of primates, there appear to be no reports dealing with the presentation of disease in infected animals.

**Order: Enoplida**
**Superfamily: Trichinelloidea**

**Trichuris trichiura**

**History** - Linnaeus was the first to describe this worm. Ashford et al., reported that the game guards at Bwindi Impenetrable National Park were infected with *Trichuris trichiura* and that it did not appear to be infecting the gorillas at that time [31]. However, a later report [21] found that the gorillas in the same area where Ashford et al., conducted their study were infected. In Nkurunungi’s study conducted between 1993 and 1994, Bwindi gorillas were found to have an 80% prevalence of *Trichuris* [23]. Nkurunungi claimed that the eggs found were morphologically dissimilar to *Trichuris trichuria* [23]. Rothman et al., did not find any *Trichuris* sp. in the research group of gorillas located in the same area of Bwindi forest in 2000 [25]. Mudakikawa et al., and Sleeman et al., found 1 out of 74 fecal samples from the Virunga population of mountain gorillas positive for *Trichuris* eggs [7,24]. They were of the opinion that it was the same as *Trichuris trichiura* found in man, and were concerned that it was a case of transfer from humans to habituated gorillas [7,24].

**Morphology** - The adult parasites live with their anterior ends threaded through the mucosa of the large bowel. The worms are about 2 to 3 cm long and have a very thin anterior end that encloses the stichosome esophagus characteristic of this group of worms (Fig. 21). The eggs contain a single cell when passed in the feces and are brown, lemon shaped, with polar pugs; the
eggs are about 50 µm long and 22 µm in widest diameter.

Figure 21. Male *Trichuris*. - To view this image in full size go to the IVIS website at www.ivis.org. -

**Diagnosis at Necropsy** - These worms will be found as small cream-colored worms attached to the wall of the cecum. Uncommonly, worms in humans are found in the wall of the appendix and in the colon, probably when present in large numbers. The exact location of the worms in gorillas at necropsy has not been described.

**Diagnosis in Fecal Examination** - The eggs of *Trichuris trichiura* are characteristic and would be difficult to confuse with other eggs passed in the feces of gorillas (Fig. 22). The eggs contain a single cell when passed in the feaces and are brown, lemon shaped, with polar pugs; the eggs are about 50 µm long and 22 µm in widest diameter.

Figure 22. *Trichuris* egg. - To view this image in full size go to the IVIS website at www.ivis.org. -

**Hosts** - Humans and other primates. *Trichuris trichiura* is a common parasite of people, and there is a good chance that it could move into the gorilla population if the gorillas were to become infected and if the soils were of an appropriate type to support the transmission of this parasite.

**Mode of Transmission** - Transmission is by the ingestion of eggs containing an infective-stage larva (Fig. 23). Eggs can persist in the soil for many years.

Figure 23. Life Cycle of *Trichuris*: Direct life cycle through the ingestion of soil or soil contaminated vegetation containing eggs. Adults live with their anterior ends threaded through the mucosa of the colon and rectum. Eggs are passed in the feces and require several weeks to become infectious. All stages of maturation occur within the mucosa of the posterior bowel. The prepatent period is 3 months. Light infections typically cause no disease. Heavy infections can cause diarrhea, anemia and in people, stunted growth. - To view this image in full size go to the IVIS website at www.ivis.org. -

**Life Cycle** - Eggs passed in the feces enter the soil environment where they embryonate and become infectious, under appropriate conditions and temperatures, it will take the eggs several weeks to embryonate. Infection is obtained by the ingestion of an egg either in soil or soil-contaminated foodstuffs. Once ingested, the eggs hatch within the large intestine, and the larvae penetrate the wall where they develop (there is some controversy as to whether any development takes place in the wall of the small intestine [41]). The adult worms will lay eggs 2 to 3 months after eggs are ingested. Worms probably live somewhere between 1 to 4 years.

**Clinical Signs** - Clinical signs have not been reported in gorillas. Signs in people include anemia, growth stunting, and in massive infections, prolapse of the rectum.

**Calodium hepaticum**

**History** - This worm is often described under the synonym, *Capillaria hepatica*; the accepted designation at this time is *Calodium hepaticum*. This species was first described by Bancroft in 1893 in the rat. This worm was described in the Virunga mountain gorilla during necropsies [16,42].

**Morphology** - *Calodium hepaticum* is a small worm, several mm long, which is threaded through the liver parenchyma. The female, like most other members of this superfamily, are characterized by having an esophagus composed of a change of glandular cells, i.e., a stichosome esophagus. Males have a terminal anus and a single spicule within a protrucible membranous sheath. The eggs are typical of the group, being brown with polar plugs. The eggs have discrete small pits over their surface.

**Diagnosis at Necropsy** - *Calodium hepaticum* is found in the liver parenchyma, therefore diagnosis is made at necropsy or via biopsy (Fig. 24 and Fig. 25). The lesions tend to be small and discrete. In massive infections there may be hepatitis with
Eosinophilia.

Figure 24. *Callodium* eggs in an infected liver. - To view this image in full size go to the IVIS website at www.ivis.org.

Figure 25. Section of a *Callodium* female worm in the liver. - To view this image in full size go to the IVIS website at www.ivis.org.

**Diagnosis in Fecal Examination** - Eggs are not found in the feces of infected individuals. Sometimes eggs are seen in the feces of primates or other animals that have ingested the liver of a host containing adult forms (Fig. 26).

Figure 26. *Callodium* egg that was passed in the feces. - To view this image in full size go to the IVIS website at www.ivis.org.

**Hosts** - Typically found in rodents, but also found in dogs, cats, hyraxes, humans and other primates.

**Mode of Transmission** - Rodents are the main transmitters of the parasite while cats and dogs are the principle hosts releasing the eggs into the soil where they undergo embryonation to the infective stage (Fig. 27). Ingesting embryonated eggs infects the final host. After ingestion, the larva from the embryonated egg hatches, penetrates the intestinal mucosa, and makes its way to the liver where it develops to the adult stage.

Figure 27. Life cycle of *Callodium*: Normal parasite of rats and other small rodents. Unusual life cycle in that female lives and lays eggs within the liver parenchyma. For eggs to become infectious, they require a period of incubation in aerated soil. Thus the eggs are free to the environment when a rat dies and decomposes, or when ingested by a predator such as a cat. The eggs in the soil from a decomposed rat or passed unharmed in cat feces will embryonate, and become infectious to most mammalian hosts. The host becomes infected when they accidentally ingest eggs. The pathology is minimum to nil. - To view this image in full size go to the IVIS website at www.ivis.org.

**Life Cycle** - The female worm moves into the liver and deposits small groups of uncleaved eggs that become encapsulated by host tissue. The eggs become encapsulated and are not released from the original host, so the next host or a disseminator species must consume the host either by cannibalism, predation or scavenging. If a disseminator species ingests the original host, the eggs pass through the gastrointestinal tract and are dispersed into the environment with the feces. The eggs develop at 25°C in moist soil conditions to become infective in about a month. After ingestion, first stage larvae (140 - 190 µm) are found in the liver two days post infection and it is suggested that they follow the portal system from the intestine to the liver. Third-stage larvae appear on the 5th day and fourth-stage larvae appear on the 9th day. By day 13, lesions are found on the liver. Males reach the adult stage in 18 days and females reached the adult stage in 20 days. Males die by day 40 and females remain alive for 59 days after depositing several groups of eggs [20,43].

**Clinical Signs** - Acute or subacute hepatitis with hypereosinophilia, probably only in very heavy infections [41].
Cestodes
Family: Anoplocephalidae

**Anoplocephala gorillae**

**History** - Nybelin described *Anoplocephala gorillae* from a mountain gorilla inhabiting Mount Sabinio, Kivu Volcano (Virunga Region) [44]. Ashford et al., found that Bwindi gorillas had an 85% prevalence of these cestodes in the populations sampled [31]. This finding was confirmed through fecal examination of Bwindi gorilla groups in later surveys [21-23]. Gorillas in the Virunga region were infected as well, and that prevalence between age-sex classes differed, with infants containing the lowest prevalence (57%) compared with adults (77% – 100%) [7,24]. In a study in 1992-1993, Nkurunungi found that all Bwindi gorillas sampled were infected with *Anoplocephala gorillae*, with the exception of a lactating infant [22]. Recently, in the research group of mountain gorillas in Bwindi forest, no Anoplocephalidae were found [25].

**Morphology** - These are relative large cestodes with the typical appearance of an anoplocephalid, being thick-bodied with very wide segments and a scolex with large muscular suckers and no rostellum. The tapeworms that have been described are about 10 cm long and about 1.5 cm wide.

**Diagnosis at Necropsy** - Large white to cream colored worms recovered from the small intestine (Fig. 28).

Fossey recovered these worms from the large intestine in one necropsied gorilla, and recovered worms from the small intestine in another necropsied gorilla. Six of eight gorillas necropsied in the Virunga mountain gorillas were found to harbor this parasite [45].

**Diagnosis in Fecal Examination** - The egg of this species was presented as a drawing by Ian Redmond [15]. In sedimentations or direct smears, the eggs of anoplocephalid tapeworms appear rather dark with a clear central area containing the hexacanth embryo. The shape tends to be that of an irregular spheroid. In sugar flotations, the eggs appear clearer, but the hexacanth embryo will be more evident (Fig. 29).

**Hosts** - Gorillas

**Mode of Transmission** - The gorilla is probably infected by the accidental ingestion of infected orabatid mites present in vegetation or soil (Fig. 30).

**Life Cycle** - The life cycle of this species has not been studied, and the details for other species have not been worked out [46]. In *Anoplocephala perfoliata*, a very similar parasite that uses the horse as a final host, soil-dwelling oribatid mites are the intermediate hosts. The mite ingests the egg passed in the feces, and a procercoid larval tapeworm matures and grows within the body cavity of the mite. The horse is infected by the accidental ingestion of these mites on soil or on foodstuffs. All development within the gorillas occurs within the intestinal tract. (Fig. 30).

**Clinical Signs** - None described, and based on related species, no significant pathology would be expected.
Protozoa
Phylum: Sarcodina

Entamoeba histolytica

History - This species is mainly a cosmopolitan parasite of humans and is found in all populations around the world, especially in unsanitary communities. The first description of this species in wild mountain gorillas was by Hastings et al., in 1992 [16]. E. histolytica was later described in the feces of Rwandan Virunga gorillas [7,24]. Amoebae identified as E. histolytica have been found in the Virunga population of mountain gorillas; but to date, Entamoeba histolytica has not been found in the Bwindi population [21-25].

Morphology - There are two stages in the life history of this parasitic amoeba, the trophozoite and the cyst. The trophozoite is a nonflagellate form that moves by the protrusion of blunt pseudopods that extend out from the surface of the cell. Trophozoites are uninucleate and have a nuclear structure that is characteristic, i.e., a large endosome (central dot) and clumped nuclear material in a relatively regular pattern along the inner surface of the nuclear membrane (Fig. 31).

Figure 31. Trophozoite of E. histolytica. - To view this image in full size go to the IVIS website at www.ivis.org . -

Amoebae feed by encircling bits of food or tissue with their protoplasm that are then endocytosed and digested. Invasive forms of Entamoeba histolytica are the only intestinal amoeba trophozoites that will be seen to contain red blood cells. The stage that is transmitted between hosts is the cyst stage. Mature cysts contain 4 nuclei (Fig. 32).

Figure 32. Cyst of E. histolytica. - To view this image in full size go to the IVIS website at www.ivis.org . -

It has been recognized that there are two distinct species of Entamoeba in humans, Entamoeba histolytica and Entamoeba dispar [47]. The two species are identical, although they can be distinguished by various molecular markers that have been incorporated in various diagnostic test kits for humans. It is believed that Entamoeba histolytica is the invasive species while Entamoeba dispar lives as a commensal. The species in gorillas have been identified as E. histolytica, but there has not been any attempt to distinguish the parasite in the gorillas from E. dispar.

Diagnosis at Necropsy - In the wild gorillas, all findings have been either in healthy animals in which case cysts have been found in fecal samples, or where organisms have been found in the feces at necropsy. There do not seem to be any signs of large bowel ulceration or ectopic abscesses in wild gorillas that are attributable to infection with this parasite. If gorillas were to develop disease due to E. histolytica, it is expected that it would mimic that seen in humans with erosive ulceration of the large intestine [41].

Diagnosis in Fecal Examination - The cysts are observed in formed stools. The trophozoites are seen in diarrheic stool. The trophozoites measure from 8 to 30 µm and can be highly active in saline preparations made with fresh feces. Cysts measure from 10 to 20 µm, mature cysts contain 4 nuclei and may contain chromatoidal bodies with blunt ends. E. histolytica can be differentiated from E. hartmanni by the size of its cysts. E. histolytica has larger cysts compared to E. hartmanni.

Hosts - Humans and other primates.

Mode of Transmission - The host ingests cysts in contaminated water or food.

Life Cycle - The trophozoites (motile, feeding stage) are located in the large intestine and reproduce by binary fission. They vary in size according to their degree of activity and conditions within the host but are normally about 8 to 30 µm in diameter. The trophozoites exhibit significant movement, using their pseudopodia to propel them in different directions. Trophozoites can cause ulcers in the intestinal wall through the secretion of enzymes that disrupt the mucosa. Trophozoites feed on sloughed cells and intestinal material, but when of the invasive variety, can destroy living tissue and will ingest red blood cells. If the wall of the cecum and colon become ulcerated, invasive trophozoites can be carried to other tissues, most typically the liver, where they can establish abscesses that can become quite large.

In the lumen of the colon, the amoebae go through a process of encystation, where the trophozoite expels all of its undigested food and condenses into a precyst. Then, a thin cell wall is secreted so that the premature cyst is formed. The maturation of the cyst consists of 2 consecutive mitotic divisions of the nucleus. The cysts are then infective and pass out with the hosts’
feces. Cysts may survive in the external environment for at least 12 days and can tolerate temperatures up to 50°C. After being ingested, the cysts reach the digestive tract and excystation occurs to initiate the next infection. **Clinical Signs** - There have been no clinical signs reported from gorillas. In humans, we would not expect clinical signs with *E. dispar*, and cysts would be present in the stools. When diarrhea occurs for other reasons, trophozoites may be passed in the more fluid feces due to the increased motility of the intestine. With tissue invasive *E. histolytica*, the infected individual has intermittent diarrhea which progresses to dysentery with fever and abdominal discomfort. Trophozoites and blood cells in mucoid feces are often passed.

*Entamoeba hartmanni*

**History** - This amoeba is cosmopolitan in distribution and for a long time was considered to be a smaller type of *E. histolytica*. In 1959, Burrows redescribed it, noting several important morphological differences that warranted a separate species [41]. It was first reported in the mountain gorilla in 1989 by Hastings et al., in 1992 and later by Mudakikwa et al., 1998 and Sleeman et al., in 1995-1997. It has only been found in the Virunga population.

**Morphology** - Very similar in all aspects to *E. histolytica*. The trophozoites measure 4 to 12 µm and the cysts measure 5 to 10 µm.

**Diagnosis at Necropsy** - No signs of pathogenicity. The presence of cysts and/or trophozoites in the intestinal tract indicates infection.

**Diagnosis in Fecal Examination** - See *E. histolytica*. The smaller distinguishes this species from *E. histolytica*. Vacuoles do not contain erythrocytes because this species is not pathogenic.

**Hosts** - Humans and other primates.

**Mode of Transmission** - The cyst is the transmission stage that moves between hosts either by direct fecal oral contact or through contaminated food or water.

**Life Cycle** - This species feeds on bacteria in the intestinal tract and does not invade the intestinal wall of the host.

**Clinical Signs** - non-pathogenic

*Entamoeba coli*

**History** - This is a worldwide non-pathogenic parasite of man. It was first discovered by Grassi in 1879 [41]. It was first described in mountain gorillas by Hastings et al., in 1992 in the Virunga population [16] but has not yet been found in the Bwindi population.

**Morphology** - The trophozoites of *Entamoeba coli* are the largest amoeboid trophozoites (15 to 50 µm) that will be found in the gorilla. The trophozoites have a nucleus that is similar to that of *Entamoeba histolytica*, but the karyosome is larger (Fig. 33).

![Figure 33. Trophozoite of *E. coli*.](www.ivis.org)

Trophozoites of *E. coli* will never be seen to contain red blood cells. The mature cysts of *Entamoeba coli* will contain 8 nuclei (Fig. 34). Cysts may also contain chromatoidal bodies that will have jagged, splinter-like ends.

![Figure 34. Cyst of *E. coli*.](www.ivis.org)

**Diagnosis at Necropsy** - Trophozoites and cysts may be found in the fecal matter.

**Diagnosis in Fecal Examination** - The cysts of *E. coli* have 1 to 8 nuclei while those of *E. histolytica* have only 1 to 4 nuclei. There are numerous textbooks on human parasitology that can be used to distinguish the different species of amoebae found in the stools of gorillas. There are various immunodiagnostic tests that are specific for *E. histolytica* that can be used to distinguish the antigens in the feces and species on slide by immunofluorescence.
Hosts - Humans and other primates.
Mode of Transmission - Direct fecal oral transmission of the cyst stage.
Life Cycle - The cyst is ingested and trophozoites are released within the large bowel. This organism is a commensal and the trophozoites live on the intestinal mucosa. Some trophozoites encyst and are passed in the feces.
Clinical Signs - non-pathogenic

**Iodamoeba buetschlii**

History - This parasite is widespread all over the world, but is less prevalent compared with *E. coli* or *E. histolytica*. This species was first described in mountain gorillas by Hastings et al., [16] in the Virunga population but has not yet been described for the Bwindi population. It was later found in a survey of the Virunga gorillas in 1995-1997 [7,24].

Morphology - The trophozoites and cysts both contain a single nucleus. The nucleus is distinctive in that it has a very large central karyosome that almost fills the entire nucleus except for a small halo. The cyst and trophozoites may contain a large glycogen granule that will stain dark brown with Lugol’s iodine. The mature trophozoites are 6-25 µm in diameter (Fig. 35).

![Figure 35. Trophozoite of Iodamoeba.](www.ivis.org)

Diagnosis at Necropsy - Trophozoites and cysts can be found in the fecal matter.
Diagnosis in Fecal Examination - The glycogen vacuole can be seen in an iodine preparation from fresh stool; in iron-hematoxylin-stained and trichrome-stained preparations, the glycogen reserve will appear as an empty vacuole.
Hosts - The host ingests the trophozoites or cysts in contaminated water or food.
Mode of Transmission - Humans, non-human primates, domesticated animals.
Life Cycle - *I. butschlii* is transmitted by a cyst that can be differentiated from other cysts because it contains a large, easily visible glycogen reserve. The amoeba escapes through a pore in the cyst wall and moves rapidly in the host.
Clinical Signs - non-pathogenic

**Endolimax nana**

History - This is a worldwide non-pathogenic parasite of man. It was first described as a separate species in 1917. Mudakikawa et al., and Sleeman et al., found 31 out of 70 fecal samples from the Virunga population of mountain gorillas positive for *Endolimax nana* cysts, and 63 of 73 samples were positive for trophozoites that were identified as either *Endolimax nana* or *Iodamoeba buetschlii* [7,24].

Morphology - The trophozoites of Entalimax nana are small (6 to 15 µm). The nucleus is distinctive in that it has a very large central karyosome that almost fills the entire nucleus except for a small halo (Fig. 36). The cysts have four nuclei when mature.

![Figure 36. Trophozoite of Endolimax nana.](www.ivis.org)

Diagnosis at Necropsy - Trophozoites and cysts may be found in the fecal matter.
Diagnosis in Fecal Examination - The cysts of *Endolimax nana* have 1 to 4 nuclei and can therefore be readily distinguished from those of *Iodamoeba butschlii* that have only 1 nucleus. There are numerous textbooks on human parasitology that can be used to distinguish the different species of amoebae found in the stools of gorillas.
Hosts - Humans and other primates.
Mode of Transmission - Direct fecal oral transmission of the cyst stage.
Life Cycle - The cyst is ingested and trophozoites are released within the large bowel. This organism is a commensal and the trophozoites live on the intestinal mucosa. Some trophozoites encyst, and are passed in the feces.
Clinical Signs - non-pathogenic

**Giardia lamblia**

History - *Giardia lamblia* is a common temperate and tropical parasite. Hastings et al., (1992) first described *Giardia* in the
feces of necropsied Virunga gorillas. Mudadikwa et al., and Sleeman et al., found that 270 Virunga gorillas had *Giardia* cysts in their feces [7,24]. Nizeyi et al., found *Giardia* in two fecal samples, with an overall prevalence in the population being 2% from non-habituated Bwindi gorillas [48]. The prevalence of *Giardia* in cattle living outside park boundaries in Bwindi can reach 35%, and may be a significant means of transmission to the gorillas [49].

**Morphology** - The trophozoite is a 12 to 15 µm bilaterally symmetrical pear-shaped flagellate (Fig. 37).

There are two nuclei with central karyosomes, two axonemes, two blepharoplasts, two parabasal bodies, and four pairs of flagella. An ovoid sucking disc occupies approximately 3/4 of the surface of the ventral surface. This luminal flagellate’s trophozoite is sometimes considered to resemble a "tennis racket with eyes" [50]. The cyst is ellipsoidal, 9 to 12 µm, and contains 2 to 4 nuclei with several of the structures of the trophozoite (Fig. 38). The flagellate inhabits the small intestine (duodenum and upper jejunum) and at times the bile duct and gall bladder.

**Diagram at Necropsy** - At necropsy, fecal samples can be assessed for presence of trophozoites and cysts.

**Diagnosis in Fecal Examination** - Trophozoites may be detected in direct smears of diarrheal feces. Cysts may be found through fecal flotation in zinc sulfate.

**Hosts** - Humans and other primates, domesticated pets and livestock.

**Mode of Transmission** - It is probable that mountain gorillas are infected by ingesting contaminated food, water or through accidental contact with infected feces of man and/or other gorillas (Fig. 39).

**Life Cycle** - Like other protozoa described above, *Giardia* has a direct life cycle with a cystic and trophozoite stage. After the infective cyst is ingested, *Giardia* excysts and trophozoites attach to the epithelial cells of the small intestine by the use of its sucking disc. Trophozoites probably feed by absorbing nutrients through the surface opposite to the disc. Trophozoites divide by longitudinal binary fission. Encystation occurs as trophozoites move into the colon. Recently formed cysts have two nuclei, but the trophozoite inside will divide so that the mature cyst contains two trophozoites. Cysts are the infective stage passed in the feces. The prepatent period is 6 - 7 days. Often infections are without signs. There may be intermittent loose stools, and on occasion it is associated with diarrhea that can become severe. - To view this image in full size go to the IVIS website at www.ivis.org. -

*Chilomastix mesnili*

**History** - *Chilomastix mesnili* is a cosmopolitan, world-wide non-pathogenic protozoan commensal of man, first seen by
Davaine in 1854 who called it *Cercomonas hominis*. It was later renamed in 1912. In a survey in 1995-1997, it was found that 31/70 Virunga mountain gorillas contained either trophozoites or cysts in their feces [7,24]. It has been suggested that this commensal could have been introduced into the Virunga population from humans, or may not have been detected in other surveys because of differential technique [7]. Monkeys harbor a species of *Chilomastix* that is morphologically indistinguishable from *C. mesnili*, and this species has been found in surveys of primates.

**Morphology** - The trophozoite is asymmetrically pear shaped with a spiral groove extending through the middle half of the body, measuring 6 - 20 µm in length and 3 to 10 µm in breadth. Iron hematoxylin staining will show a nucleus near the anterior pole, a small central karyosome, and a well-defined cytosome situated near the nucleus. The colorless cysts are lemon shaped, measuring 7 to 10 µm in length and 4 to 6 µm in breadth (Fig. 40). A cytosome, and 1 - 2 nuclei are visible.

**Diagnosis at Necropsy** - *Chilomastix mesnili* lives commensally in the cecal region of the large intestine. Fecal examination will indicate infection.

**Diagnosis in Fecal Examination** - Iron hematoxylin staining of a fecal film will demonstrate the trophozoites and/ or cysts. It is hard to see flagella in iron-hematoxylin stained preparations and diagnosis is most easily made in fresh feces where the trophozoites can be observed to move.

**Hosts** - Humans and other primates.

**Mode of Transmission** - *Chilomastix mesnili* has a direct life cycle; infection results through fecal-oral contamination, or through infected food/water supplies.

**Life Cycle** - *Chilomastix mesnili* is considered to be a normal commensal protozoon of humans. The trophozoites live on enteric bacteria in the lumen of the cecal region of the large intestine, and multiply by binary fission. Both the cysts and trophozoites are passed in the feces.

**Clinical Signs** - None, *Chilomastix* is a harmless commensal.

**Phylum: Apicomplexa**

**Cryptosporidium parvum**

**History** - Nizeyi et al., were the first to describe the presence of *Cryptosporidium* oocysts in the feces of wild gorillas [48]. Using immunofluorescence staining, 11/100 Bwindi gorilla fecal samples were positive for cysts [48]. Molecular analysis revealed that these samples contained *Cryptosporidium parvum*, Genotype 2, which can be transmitted zoonotically between animals and humans [51]. Captive populations of lowland gorillas are also known to rarely harbor *Cryptosporidium* [52]. Cattle and people living outside park boundaries in Bwindi may be a reservoir of *Cryptosporidium* [49].

**Morphology** - The oocysts are one of the smallest protozoan stages present in the feces of animals. The typical oocyst is round and approximately 5 µm in diameter. The oocysts when passed in the feces contain 4 sporozoites and a residual body (Fig. 41). The wall of oocysts will become red on acid-fast staining. Nizeyi et al., gave the dimensions of oocysts reported from gorillas as being 4.3 to 5.6 µm with a mean of 5.1 µm [48].

**Diagnosis at Necropsy** - Oocysts can be found in the feces of animals at necropsy. The life-cycle stages of *Cryptosporidium parvum* are found just under the surface of enterocytes. These very small stages can be observed with routine histopathology of the intestinal mucosa, although the probability of sectioning the appropriate area within the intestine is small.

**Diagnosis in Fecal Examination** - The detection of *Cryptosporidium* oocysts in the feces is difficult because of their small size. In sugar flotations, the oocysts will often appear somewhat pink due to chromatic aberration that occurs with more
inexpensive lenses, on research grade microscopes the oocysts will often appear colorless and be harder to detect. Various fluorescent antibody test kits have been developed for the detection of this parasite in human feces, and there are also ELISA kits that can be used to detect free antigen in the fecal matter of infected hosts. More recently, PCR techniques have been used to distinguish genotypes of oocysts present in fecal matter using extracted DNA or RNA. Immunoflourescent antigen assays and staining techniques have been developed that cause fecal preparations containing cysts to be easily detected by use of an flourescent light microscope.

**Hosts** - Humans and other primates, other mammals including livestock, and a wide range of other vertebrates

**Mode of Transmission** - Direct fecal-oral transmission of the oocyst stage.

**Life Cycle** - Infection is acquired by the ingestion of infective oocysts that contain 4 sporozoites. Excystation occurs in the upper gastrointestinal tract, and the developmental stages are found in the brush border of the mucosal epithelium of the intestine. Sporozoites develop into trophozoites, which undergo schizogony to produce Type I schizonts (containing 8 merozoites each) and then TypeII schizonts (containing 4 merozoites each). Trophozoites and schizonts are found within the cells just underneath the cell membrane and bulge into the intestinal lumen. The Type II schizonts initiate a gametogenerative cycle, which, by forming micro and macro gametocytes, form mature gametes. Fusion of the gametes occurs, and 80% of the progeny become thick walled infective oocysts, and the remaining 20% become thin walled oocysts that autoinflect the host’s intestine by opening and starting the asexual reproductive cycle again.

**Clinical Signs** - Nyzei et al., report that 3/11 mountain gorillas found to be infected with *Cryptosporidium* had blood and mucous in their stool, neither sign of which is typically associated with cryptosporidiosis [48]. In humans, acute diarrhea is often a clinical sign of cryptosporidiosis, and in some cases, nausea, vomiting, abdominal cramps, and fever. In infants and young children, dehydration from diarrhea and vomiting can have a fatal outcome. Fortunately, there have been no reports of infant gorillas dying of signs associated with cryptosporidiosis.

**Summary**

This review of the literature identified 13 helminths and 8 protozoa (Table 1). A diagnostic chart for examining fecal samples for protozoa is present in Table 2a and Table 2b.

<table>
<thead>
<tr>
<th>Table 1. The endoparasites identified in mountain gorillas.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parasite</strong></td>
</tr>
<tr>
<td><strong>Helminths</strong></td>
</tr>
<tr>
<td><em>Hyostrongylus kigeziensis</em></td>
</tr>
<tr>
<td><em>Paralibyostrongylus kalinae</em></td>
</tr>
<tr>
<td><em>Impalaia sp.</em></td>
</tr>
<tr>
<td><em>Trichostrongylus sp.</em></td>
</tr>
<tr>
<td><em>Murshidia devians</em></td>
</tr>
<tr>
<td><em>Oesophagostomum stephanostomum</em></td>
</tr>
<tr>
<td><em>Probstmayria gorillae</em></td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
</tr>
<tr>
<td><em>Chitwoodspirura sp.</em></td>
</tr>
<tr>
<td><em>Strongyloides fuelleborni</em></td>
</tr>
<tr>
<td><em>Trichurus sp.</em></td>
</tr>
<tr>
<td><em>Capillaria hepatica</em></td>
</tr>
<tr>
<td><em>Anoplocephala gorillae</em></td>
</tr>
</tbody>
</table>
Entamoeba coli and Entamoeba histolytica may be differentiated by nuclear morphology when stained. In Entamoeba coli, the peripheral chromatin is irregular in size and arrangement, and is more abundant. The karyosome is large and is surrounded by a halo of unstaining material. In Entamoeba coli, chromatoidal bodies that have jagged, splinter-like edges are observed.

(* only references relating specifically to the subspecies of mountain gorillas are reported, for a full list refer to text)
Entamoeba coli and Entamoeba histolytica may be differentiated by nuclear morphology when stained. In Entamoeba coli, the peripheral chromatin is irregular in size and arrangement, and is more abundant. The karyosome is large and is surrounded by a halo of unstaining material. In Entamoeba coli, chromatoidal bodies that have jagged, splinter-like edges are observed.

Table 2b. Characteristics of the trophozoites (unstained) of intestinal amoebas and flagellates found in mountain gorillas.

<table>
<thead>
<tr>
<th>Protozoa</th>
<th>Trophozoites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amoeba</strong></td>
<td></td>
</tr>
<tr>
<td>Endolimax nana</td>
<td>Size (µm) 6 - 15</td>
</tr>
<tr>
<td></td>
<td>Nucleus: rarely visible</td>
</tr>
<tr>
<td></td>
<td>Inclusions: bacteria</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: large; central or eccentric</td>
</tr>
<tr>
<td>Entamoeba coli **</td>
<td>Size (µm) 15 - 50</td>
</tr>
<tr>
<td></td>
<td>Nucleus: rarely visible</td>
</tr>
<tr>
<td></td>
<td>Inclusions: bacteria and other material</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: usually large; variable location</td>
</tr>
<tr>
<td>Entamoeba hartmanni</td>
<td>Size (µm) 4 - 12</td>
</tr>
<tr>
<td></td>
<td>Nucleus: invisible</td>
</tr>
<tr>
<td></td>
<td>Inclusions: bacteria and other material</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: usually large; variable location</td>
</tr>
<tr>
<td>Entamoeba histolytica **</td>
<td>Size (µm) 8 - 30</td>
</tr>
<tr>
<td></td>
<td>Nucleus: usually invisible</td>
</tr>
<tr>
<td></td>
<td>Inclusions: red blood cells</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: minute; location is central</td>
</tr>
<tr>
<td>Iodamoeba buetschelli</td>
<td>Size (µm) 8 - 20</td>
</tr>
<tr>
<td></td>
<td>Nucleus: invisible</td>
</tr>
<tr>
<td></td>
<td>Inclusions: bacteria</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: large and granular; location is central</td>
</tr>
<tr>
<td><strong>Flagellates</strong></td>
<td></td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>Size (µm) 9 - 12 length x 5 - 15 width</td>
</tr>
<tr>
<td></td>
<td>Nucleus: pair of nuclei, one on each side of the midline</td>
</tr>
<tr>
<td></td>
<td>Inclusions: organelles, sucking disc, four flagella</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: central</td>
</tr>
<tr>
<td>Chilomastix mesnili</td>
<td>Size (µm) 6 - 20 length x 3 - 10 width (pear shaped)</td>
</tr>
<tr>
<td></td>
<td>Nucleus: one, medial, near the anterior pole</td>
</tr>
<tr>
<td></td>
<td>Inclusions: organelles, three flagella, cystome</td>
</tr>
<tr>
<td></td>
<td>Karyosomes: small but distinct, central</td>
</tr>
</tbody>
</table>

* adapted from Beaver et al., [41]
** Entamoeba coli and Entamoeba histolytica may be differentiated by nuclear morphology when stained. In Entamoeba coli, the peripheral chromatin is irregular in size and arrangement, and is more abundant. The karyosome is large and is surrounded by a halo of unstaining material. In Entamoeba coli, chromatoidal bodies that have jagged, splinter-like edges are observed.

References


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