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Morphology of the Intestinal Tract in the White Rhinoceros (*Ceratotherium simum*)

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With 8 figures

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Summary

The intestinal tract of the white rhinoceros (*Ceratotherium simum*) was dissected. We observed a simple structure for the small intestine, duodenum, jejunum and ileum, and a well-developed large intestine, cecum, colon and rectus. The cecum consisted of a small chamber, whereas the colon was much enlarged; notably larger than that of the domesticated horse, which belongs to the same order, Perissodactyla. This suggests that in the white rhinoceros the cecum may be functionally replaced by the well-developed colon which may act as the main fermentation tank in this animal.

Introduction

We have found the various morphological adaptations of the intestine in herbivorous mammals to be of interest. The domestic horse, which belongs to the order Perissodactyla, shows a specific pattern of adaptation in the intestinal tract (Bourdelle and Bressou, 1949; Way and Lee, 1965; Ellenberger and Baum, 1974; Sisson, 1975; Popesko, 1977; Dyce et al., 1987). The enlarged cecum acts as the main fermentation tank in the domestic horse, while the complex colon supports the digestive function of the cecum. It was considered useful to examine the rhinoceros, a member of the same order, Perissodactyla, to compare the morphological adaptation of the intestine in this animal. A white rhinoceros (*Ceratotherium simum*) carcass was donated to us by a zoo, allowing the complete intestine of this species to be examined.

Materials and Methods

We used an adult male carcass of the white rhinoceros (*Ceratotherium simum*). This individual was kept and exhibited by Shonan Animal Production Co., Ltd (Chiba, Japan), died of senility in January 1999, and was donated to the National Science Museum, Tokyo. We excised the whole intestinal tract from the viscera and observed it by the naked eye.

Results

The whole intestinal tract excised from the viscera is shown in Fig. 1.

Small intestine

The duodenum appeared smooth, and was about 70 cm in length from the pylorus to the origin of the jejunum, and 10 15 cm in diameter (Fig. 2). At the end of the duodenum, the wall rapidly thickened, and started to form coils. We considered the first of these coils as the origin of the jejunum. The jejunum curved frequently and sharply, but gradually stopped forming coils near its end (Fig. 3). The ileum had a smooth wall and curved only where it joined the large intestine (Fig. 3). The muscular wall was thickened throughout the ileum. In transverse section, the ileum appeared elliptical, and at the widest point its diameter reached about 20 cm. It increased in diameter near its end, where it connected abruptly to the cecum (Fig. 4).

Large intestine

The Ostium ileocecale was encircled by a well-developed sphincter muscle, the M. sphincter ilei (Fig. 5). The Ostium cecocolicum opened directly into the Ostium ileocecale, and the tract of the colon started in this area. The cecum was a relatively small chamber (Fig. 6). It seemed that the diverticulum protruded from the tract between the end of the ileum and the origin of the colon. It was wide dorso-ventrally and cranio-caudally, and narrow laterally. The chamber, however, was only about 30 cm long dorso-ventrally and cranio-caudally. In the dorsal area near the Ostium ileocecale, the opening to the colon was observed (Fig. 4).

The colon was large and long (Fig. 7). It turned sharply near the cecum chamber, and possessed two bundles of well-developed teniae (Figs 7 and 8). In total it was 230 cm in length and about 20 cm in diameter. The thick mesentery supported the shape of the colon throughout the dorsal area and connected the cecum chamber to the colon. The wall musculature was thick, but thinned rapidly near the rectus.

The rectus was straight and reached to the anus (Fig. 8). It was relatively long; about 120 cm in length.

Discussion

Various types of morphological adaptation have been reported in the intestinal tract. In domestic herbivorous mammals, the horse uses the cecum as the main fermentation tank (Bourdelle and Bressou, 1949; Way and Lee, 1965; Ellenberger and Baum, 1974; Sisson, 1975; Popesko, 1977; Dyce et al., 1987), while the rabbit and the guinea pig also use the colon as an important fermentation chamber (Barone et al., 1973; Cooper and Schiller, 1975). In the domestic horse, we can conclude that the enlarged cecum acts as the main digestive apparatus for plant foods, while the complex colon supports the fermentation of the cecum.

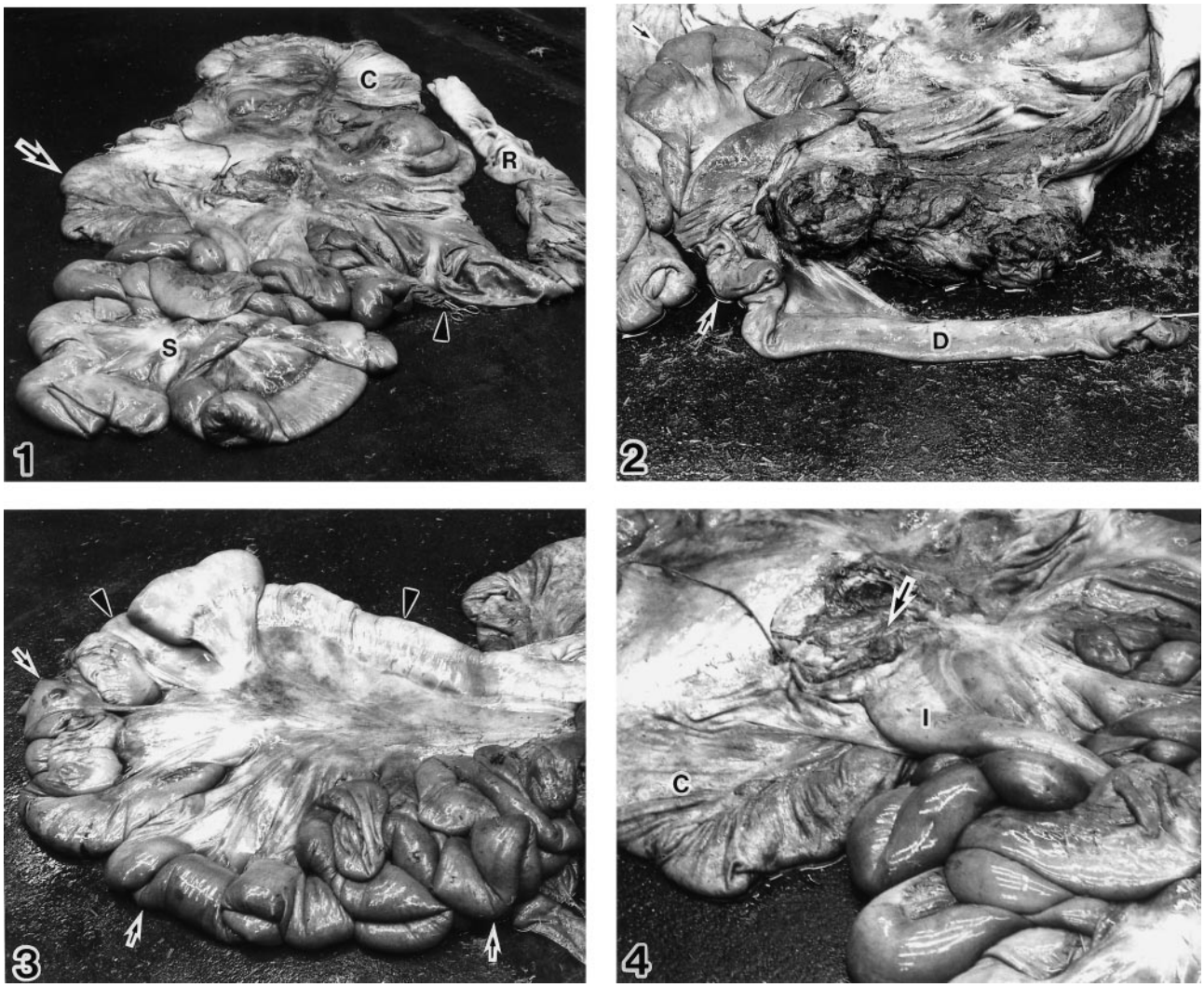

Fig. 1. the complete intestinal tract of the white rhinoceros. The arrowhead indicates the origin of the duodenum from the pylorus. The small intestine including the jejunum and the ileum (S) is shown. The large intestine, the small cecum (arrow), the large colon (C) and the rectus (R) can also be seen.
Fig. 2. The duodenum (D) showing the smooth wall. The arrow indicates the connection of the duodenum and the jejunum.
Fig. 3. The jejunum and the ileum. The jejunum (arrows) has many coils, whereas the ileum (arrowheads) has a straight tract.
Fig. 4. The end of the ileum (I) is large in diameter and opens into the cecum (arrow). The small chamber of the cecum can be seen (C).

In the white rhinoceros, which also belongs to the Perissodactyla, the cecum consists of a small compartment of about 30 cm in length. Although it is a diverticulum-like chamber, its size suggests that the cecum has limited functional significance. Unlike the cecum of the horse, that of the rhinoceros is not used as the main fermentation tank. We have hypothesized that large herbivorous mammals such as horses can separate feeding periods from periods for other behaviours, because the cecum has the ability of continuous fermentation (Stevens and Hume, 1995). The relationships amongst feeding, digestion and other behaviours will be examined in future work.

The large colon found here indicates that the large intestine tract mainly consists of the colon in this species, as mentioned by Garrod (1873) and Stevens and Hume (1995). We suggest that in the white rhinoceros the cecum may be functionally replaced by the well-developed colon, which may act as the main fermentation tank in this animal. The small intestine does not show any morphological characteristics peculiar to the rhinoceros. The smooth duodenum, the coiling jejunum, and the straight ileum of this species are typical of large herbivorous mammals. The small intestine may not contribute to fermentation, but the cecum may function as a plant digestive apparatus.

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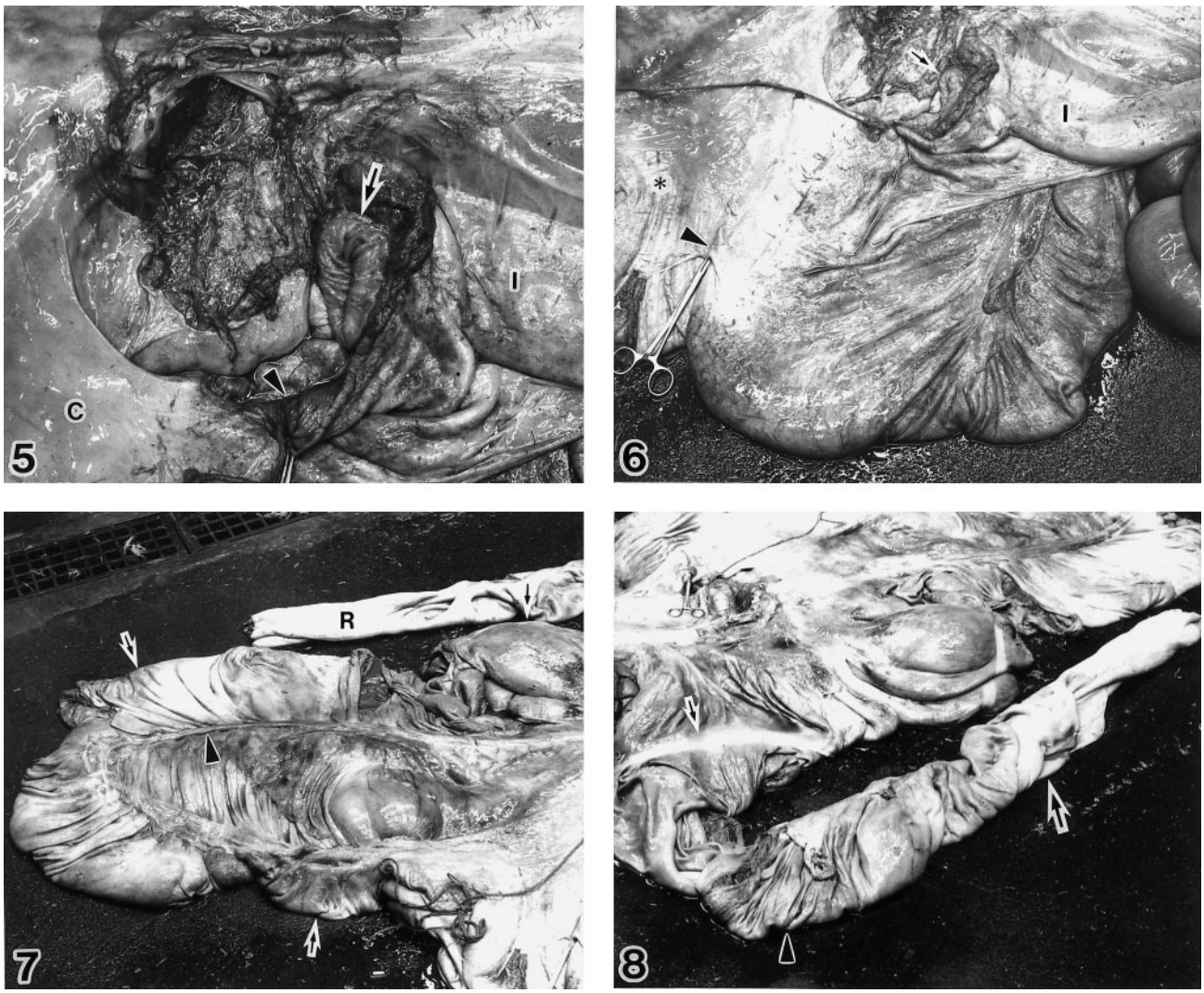

Fig. 5. The Ostium ileocecale is encircled by the well-developed M. sphincter ilei (arrow). The Ostium cecocolicum is located near the Ostium ileocecale. I, ileum; C, cecum.
Fig. 6. Lateral view of the cecum. The cecum consists of a small chamber. It is the diverticulum protruded from the tract between the end of the ileum (I) and the origin of the colon (asterisk). The arrowhead indicates the connection between the cecum and the colon.
Fig. 7. The colon, which has a U-shape (arrows). It turns sharply and has a bundle of well-developed teniae (arrowhead). R, rectus.
Fig. 8. The simple structure of the rectus (large arrow) caudally to the end of the large colon (arrowhead). The rectus is straight and reached to the anus. The bundle of teniae (small arrow) can be observed in the colon.

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