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Abstract

We described the macroscopic anatomy of the intestines and their peritoneal folds of five adult pampas deer (Ozotoceros bezoarticus), a cervid species considered to ingest a high proportion of grass in its natural diet. The mean (±SD) body weight was 17 (±2) kg. The small intestine and the caecocolon measured 495 (±37) cm and 237 (±24) cm in length, respectively, with an average ratio (small intestine:caecocolon) of 1.9 (±0.1). The ascending colon had two and a half centripetal gyri, a central flexure and two centrifugal gyri. The spiral ansa, which was similar to an ellipse, was fixed to the whole left face of the mesenterium. Apart from the peritoneal folds described in the Nomina Anatomica Veterinaria, three additional, hitherto not described folds were found: a fold that fixed the caecum to the proximal ansa of the ascending colon, one that joined the terminal part of the proximal ansa to the last centrifugal gyrus of the spiral ansa of the ascending colon, and one that linked the ascending duodenum to the proximal ansa of the ascending colon. When compared with published data from other cervids of different feeding niches, it appears that, among cervids, the ratio of small intestine to the caecocolon length does not reflect the natural diet.
Observations on the macroscopic anatomy of the intestinal tract and its mesenteric folds in the pampas deer (*Ozotoceros bezoarticus*, Linnaeus 1758)

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With 4 figures and 2 tables.
Summary
We described the macroscopic anatomy of the intestines and their peritoneal folds of five adult pampas deer (Ozotoceros bezoarticus), a cervid species considered to ingest a high proportion of grass in its natural diet. The mean (±SD) body weight was 17 (±2) kg. The small intestine and the caecocolon measured 495 (±37) cm and 237 (±24) cm in length, respectively, with an average ratio (small intestine:caecocolon) of 2.1 (±0.1). The ascending colon had two and a half centripetal gyri, a central flexure and two centrifugal gyri. The spiral ansa, which was similar to an ellipse, was fixed to the whole left face of the mesenterium. Apart from the peritoneal folds described in the Nomina Anatomica Veterinaria, three additional, hitherto not described folds were found: a fold that fixed the caecum to the proximal ansa of the ascending colon, one that joined the terminal part of the proximal ansa to the last centrifugal gyrus of the spiral ansa of the ascending colon, and one that linked the ascending duodenum to the proximal ansa of the ascending colon. When compared to published data from other cervids of different feeding niches, it appears that, among cervids, the ratio of small intestine to the caecocolon length does not reflect the natural diet.

Key words: cervidae, pampas deer, anatomy, intestine, peritoneum, abdomen, gut, mesenteria
The pampas deer (*Ozotoceros bezoarticus*, Linnaeus, 1758) was a widespread species, originally distributed in the open grasslands (pampas) across eastern South America, from 5° to 41° S (Jackson and Langguth, 1987). However, habitat loss, unregulated hunting, competition with cattle (Jackson and Giullieti, 1988), and transmission of cattle diseases have caused a drastic decrease in pampas deer populations (Jungius, 1976). Although there are small wild populations in Argentina (Merino, 1994; Dellafiore et al., 2003), Brazil (Pinder, 1994) and Uruguay (González, 1993), it is considered to be in extreme danger of extinction (listed in Appendix I of CITES) (Tavares et al., 2002). By cytogenetic, molecular (González et al., 1998) and morphometric (González et al., 2002) approaches, the existence of two subspecies, endemic to Uruguay, *O. b. arerunguaensis* (Salto, 31°65′ S, 56°43′ W) and *O. b. uruguayensis* (Rocha, 33°45′ S, 54°02′ W), different from the *O. b. bezoarticus*, *O. b. leucogaster*, and *O. b. celer* previously described (Jackson and Langguth, 1987), were recently reported.

Although no direct data were presented, it was reported that adult pampas deer individuals weight 30 to 40 kg, and have a shoulder height of 70 to 75 cm (Jackson, 1987). The pampas deer is a peculiarity among the cervids; most cervids are considered either browsers (i.e., the natural diets consist mainly of dicotyledonous forage, like tree foliage, forbs, herbs, or wild fruits) or intermediate feeders (i.e., consuming monocotyledonous forage – grasses – to a certain degree, mostly dependent on seasonal variation in forage availability) (Hofmann 1985). Like only a very few other deer species, such as Père Davids deer (*Elaphurus davidianus*), the pampas deer is assumed to have, for cervids, a comparatively high proportion of grasses in its natural diet (Jackson et al., 1980;
So far, the digestive anatomy of the pampas deer has not been described, to our knowledge. Therefore, we report observations on the intestinal anatomy of pampas deer, including the descriptions of mesenteric structures that have not been previously described in other ruminants.

**Materials and Methods**

Five adult female *O. b. arerunguaensis* from a captive breeding station, Estación de Cría de Fauna Autóctona, Pan de Azúcar, Maldonado, Uruguay (ECFA; 34°3’ S, 55°1’ W; altitude: ~ 200 m), were used for this study. The population at the ECFA, which was originated from *O. b. arerunguaensis*, consists of approximately 70 animals. A general description of the population management is published by Ungerfeld et al. (2008). Groups composed by 1 buck and 8-12 does were run together throughout the year in areas of approximately 0.5 ha. Animals grazed over native pastures and received approximately 500 g of dairy cows ration/deer daily.

Five dead adult animals, whose dead cause was not determined, although they were in low body condition status, were used for this study (Table 1). The animals were dissected immediately after being found. The ventral abdominal wall of each animal was removed and the gastrointestinal tract was separated after sectioning the pylorus just prior to the duodenum, and dissecting it away from its attachments to the dorsal abdominal wall. The descending colon was tied off just prior to entering the pelvic cavity and transected. After removal from the abdominal cavity, pictures were taken from each intestinal tract with a Nikon digital camera. After removal of all mesenteric attachments, the lengths of the different sections of the intestinal tract on the anti-mesenteric side were taken with
a standard measuring tape, and the material was fixed with 10 % formalin. The results were recorded and tabulated. Terms are used in agreement with the Nomina Anatomica Veterinaria (2005), and the different intestinal sections were defined according to the Nomina Anatomica Veterinaria (2005) and Barone (1997).

Results

Measurements from the individual intestinal sections are presented in Table 1. The length of the total small intestine was 495.0 ± 37.0 cm (mean ± SD), the length of the caecum and colon was 237.0 ± 24.0 cm. Therefore, the small intestine: caeco-colon ratio was 1.9 ± 0.1. The intestinal tract was mainly situated on the right side (within the supraomentalis recess), and in the caudal left part, of the abdominal cavity.

The cranial part of the duodenum presented a sigmoid flexure, and then continued with a descending portion, situated in the dorsal part of the right flank. The right lobule of the pancreas, which was located within the mesoduodenum, adhered to the cranial portion of the descending duodenum. The major duodenal papilla was slightly salient and was found at the initial part of the descending duodenum. The common bile duct received the pancreatic duct just before it ended (Fig. 1), as a single duct, at the major duodenal papilla. An accessory pancreatic duct was not found in any individual. After a caudal flexure, the ascending part of the duodenum ran in parallel to the descending part, and was accompanied by the first portion of the descending colon (Fig. 2). The mobility of the jejunum was limited by the adherence of the spiral part of the ascending colon to the left sheet of the mesenterium.
The caecum was a smooth, cylindrical sac, without haustrae. Internally, at the border between caecum and the proximal ansa of the ascending colon, the ileal papilla stood out, measuring 7.0 ± 1 mm in height and 15.0 ± 1 mm in length. The colon was externally smooth, without haustrae. The proximal ansa of the ascending colon (Fig. 3) was S-shaped, directed first cranially, then turned over itself caudally, adhering to the cranial part of the caecum, and finally turned medially where it attached to the left sheet of mesentery. The spiral ansa appeared long, and included 2 ½ centripetal gyri, a central flexure and 2 centrifugal gyri situated in the concavity formed by the former. The distal ansa followed the concavity of the proximal ansa.

The intestine was included in its majority within the supraomentalis recess. The greater omentum covered almost all the right side, and almost all the intestine, with the exception of the descending duodenum. The superficial wall of the great omentum originated from the left longitudinal sulcus of the rumen, and the deep wall in the right longitudinal sulcus. Dorsally and to the right, the superficial wall was attached to the descending duodenum, and the deep wall was attached more ventrally, to the distal ansa of the ascending colon.

The free border of the duodenocolic fold was at the level of the caudal flexure (Fig. 2), with a mean length of 1.8 ± 0.3 cm, and was attached to the descending colon. There was another fold that connected the ascending duodenum with the proximal ansa of the ascending colon, the accessory duodenocolic fold (Fig. 2), the length of which was 1.2 ±0.3 cm. In two animals, this fold was attached to the distal ansa of the ascending colon.

Two peritoneal folds inserted at the caecum, and two at the proximal ansa of the ascending colon (Fig. 3). The caecum was connected to the ileum by the ileocecal...
fold (Fig. 2), the mean length of which, at its free border, was 5.6 ±0.5 cm. The other peritoneal fold, which we named ‘caecocolic’, covered the terminal portion of the ileum and attached at the caecum and the proximal ansa of the ascending colon (Fig. 3). The mean length of the free border of this fold was 2.7 ±0.8 cm. A last fold originated from the terminal part of the proximal ansa and inserted at the last centrifugal gyrus of the spiral ansa of the ascending colon (‘colo-colic’ fold) (Fig. 3). Its free border measured 2.6 ±0.5 cm.

Discussion

According to our knowledge, this is the first anatomical description the intestinal tract and the mesenteric folds of the pampas deer, an emblematic species; therefore, even this information derived from a small number of animals is important.

The ascending colon of the *Ozotoceros bezoarticus* had three ansae (proximal, spiral and distal) as it is described for bovines, ovines and caprine (Smith, 1955a; 1955 b; Smith and Meadows, 1956; Smith, 1959; Barone, 1997; Nomina Anatomica Veterinaria, 2005) and for other deer (Westerling, 1975). Also in agreement with the literature, the spiral ansa was constituted by centripetal gyri, a central flexure and centrifugal gyri. The arrangement and number of gyri was consistent in the five animals studied, in contrast to what has been reported in domestic ruminants and other deer species, where irregularities can occur (Smith, 1955a; Smith and Meadows, 1956; Westerling, 1975); most likely, this is an effect of the small number of individuals dissected for this study.

The omentum of *Ozotoceros bezoarticus* is similar to what is observed in bovines, ovines and caprines (Barone, 1997).
We observed three additional folds that were not previously observed in other ruminants, such as bovines, ovines (Fig. 4), caprines (Barone, 1997; Nomina Anatomica Veterinaria, 2005), and other deer species (Westerling, 1975): the ‘caecocolic’ fold connecting the caecum and the proximal ansa of the ascending colon, the ‘colo-colic’ fold connecting the terminal part of the proximal ansa and the last centrifugal gyrus of the spiral ansa of the ascending colon, and the ‘accessory duodenal’ fold connecting the ascending duodenum and the proximal ansa (the distal ansa, in two of the animals, respectively) of the ascending colon.

In relation to other ruminants, the presence of these folds may impose a further restriction on the mobility of the intestinal sections. Whether these fold represent a particularity of all cervids, or of certain sub-groups, remains to be determined.

Between the different ruminant families, other fundamental differences in soft tissue parameters, such as the presence or absence of the gall bladder, have been described (Janis and Scott, 1987), and therefore, differences in mesenteric folds would not be surprising.

With respect to ecological niche partitioning among ruminants, the comparative ratio of the small intestine to the large intestine, in terms of length measurements, is of interest. In this respect, Hofmann (1989) suggested that this ratio was 1.9-2.7 in browsing and 4.0-4.5 in grazing ruminants, respectively. A qualitative test of this hypothesis can be made by using the data for pampas deer generated in this study and that of other studies on the length of the intestinal tract of several cervid species, and comparing this to the reported percentage of grass in the natural diet of these species (Table 2). As is evident from Table 2, the ratio appears to remain comparatively constant, and within the ‘browser range’ as suggested by Hofmann (1989), regardless of a high percentage of grass in the natural diet. Possibly, at
least within cervids, this ratio is not directly related to feeding niche. Similarly, Clauss et al. (2005) found, in Himalayan tahr (*Hemitragus jemlahicus*), a species with a high proportion of grass in its natural diet, a small intestine:large intestine ratio within the range postulated by Hofmann (1989) for browsers. Actually, Hofmann (2000) already stated that his prediction regarding this ratio could not be confirmed in all species investigated.

One of the determinants of this ratio – the length of the large intestine – is particularly related to the water metabolism of a species. In effect, Woodall and Skinner (1993) showed in African ruminants that those species with particularly low faecal water losses had longer large intestines. According to their habitat, ruminants differ in the amount of water they lose in their faeces (Clauss et al., 2004). However, cervids do not show the same variation in the parameter of faecal dry matter as bovids do: in the dataset of Clauss et al. (2004), the range of dry matter contents in cervids (25-52%) is smaller than that for bovids (16-62%).

Therefore, little differentiation in the relative length of the large intestine need not be considered surprising among cervid species.

In summary, we provided a whole anatomical description of the intestinal tract and its mesenteric folds in the pampas deer: we described three mesenteric folds that have, to our knowledge, hitherto not been described; and we conclude that the relative length of the small and the large intestine appears to be rather constant among cervids and not indicative of their ecological feeding niche.

**References**


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Jiang, Z., S. Hamasaki, H. Ueda, M. Kitahara, S. Takatsuki and M. Kishimoto, 2006: Sexual variations in food quality and gastrointestinal features of sika deer


Table 1. Body weights (BW, kg) and length measurements (cm) of the different sections of the intestinal tract (DD duodenum, JJ Jejunum, IL ileum, CC Caecum, ApC Ansa proximalis coli, AsC Ansa spiralis coli, AdC Ansa distalis coli, CTD Colon transversum and descendens) in the pampas deer (*Ozotoceros bezoarticus*) studied.

<table>
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<th>Animal</th>
<th>BW</th>
<th>DD</th>
<th>JJ</th>
<th>IL</th>
<th>CC</th>
<th>ApC</th>
<th>AsC</th>
<th>AdC</th>
<th>CTD</th>
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<td>20.0</td>
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<td>11</td>
<td>20.0</td>
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<td>9.6</td>
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<td>18.7</td>
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<td>35.7</td>
<td>0.4</td>
<td>1.9</td>
<td>2.1</td>
<td>16.2</td>
<td>1.0</td>
<td>4.9</td>
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</tbody>
</table>

Table 2. The ratio of the length of the small intestine:large intestine (SI:LI) and the percentage of grass in the natural diet of various cervid species.

<table>
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<th>Species</th>
<th>%grass*</th>
<th>SI:LI</th>
<th>Source</th>
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<tr>
<td>Moose <em>Alces alces</em></td>
<td>2</td>
<td>1.8</td>
<td>Westerling (1975)</td>
</tr>
<tr>
<td>White-tailed deer <em>Odocoileus virginianus</em></td>
<td>9</td>
<td>1.8</td>
<td>Westerling (1975)</td>
</tr>
<tr>
<td>Reindeer <em>Rangifer tarandus</em></td>
<td>36</td>
<td>1.9</td>
<td>Westerling (1975)</td>
</tr>
<tr>
<td>Fallow deer <em>Dama dama</em></td>
<td>46</td>
<td>1.8</td>
<td>Westerling (1975)</td>
</tr>
<tr>
<td>Sika deer <em>Cervus nippon</em></td>
<td>50</td>
<td>2.0</td>
<td>Jiang et al. (2006)</td>
</tr>
<tr>
<td>Pampas deer <em>Ozotoceros bezoarticus</em></td>
<td>70</td>
<td>1.9</td>
<td>this study</td>
</tr>
<tr>
<td>Père Davids deer <em>Elaphurus davidianus</em></td>
<td>75</td>
<td>2.0</td>
<td>Hofmann et al. (2006)</td>
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</tbody>
</table>

*data on %grass from Van Wieren (1996) and *estimated* for Père David’s deer according to Geist (1999) and for pampas deer according to Jackson and Giullieti (1988)
Figure legends

**Figure 1.** Ventral view of the liver, Ductus choledochus and Ductus pancreaticus.

**Figure 2.** Parts of the colon related to the duodenum. APC: Ansa proximalis coli; AD: Ascending duodenum; CD: colon descendens; Black arrows: duodenocolic fold; ADCF: accessory duodenocolic fold.

**Figure 3.** Ventral view of some parts of the large intestine of Ozotoceros. APC: Ansa proximalis coli; IL: ileum; GCAS: last centrifugal coil of the spiral ansa; PI: ileocecal fold; **: colic-colic fold; CCF: cecolic fold.

**Figure 4.** Same view of figure 3 in the sheep (*Ovis aries*) showing the only peritoneal fold described: Plica ileocecalis (PI).

GCAS: last centrifugal coil of the spiral ansa; APC: Ansa proximalis coli.
| Roe deer | *Capreolus capreolus* | Hofmann? |