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Micro-anatomical Changes Occurring in the Mucosal Epithelium of Gastrointestinal Tract Components of Ostriches Fed Ration Including or Excluding Grit in Botswana

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ABSTRACT

The aim of this study was to compare the micro-anatomical changes occurring in the luminal epithelium of some gastrointestinal tract (GIT) components of ostriches with and without access to grit in Botswana. Fourteen ostrich chicks aged nine weeks and raised on concrete without access to grit were randomly assigned to two feeding groups i.e. with or without access to grit groups. Each feeding group had seven birds raised in a pen 30 meters long by 6 meters wide. All ostriches were fed and watered *ad libitum*. From week 24 an ostrich from each group was slaughtered monthly. The GIT was removed and dissected into its component parts. Specimens of each GIT component were preserved in 10% formalin and histology slides prepared for analysis. Measurements of epithelial features and photography were taken. The data was analyzed using SAS 9.1 2002-2003. The height of the proventricular epithelium for the ostriches exposed to grit (232.68±17.29μm) was significantly ($p<0.05$) shorter than those not exposed to grit (528.93±17.29μm). Likewise the height of the ventricular luminal cornified layer of the ostriches exposed to grit (157.50±6.46μm) was also significantly shorter than those not exposed to grit (408.87±6.46μm). There was also evidence of erosion on the luminal epithelium of the proventriculus and the cornified layer of the gizzard of the ostriches exposed to grit but not in those not exposed to grit. There was no significant difference between the height of the small intestinal luminal epithelium of the grit group of ostriches (587.00±29.90μm) and the no grit group of ostriches (590.56±29.90μm). Further studies should be done on feed utilization by the two groups.

Key words: Botswana, gastrointestinal tract, grit, microanatomy, and ostrich.

INTRODUCTION

Ostriches (*Struthio camelus*) are large, flightless birds and are members of the family of birds known as Ratitae or the running bird. One feeding characteristic of this bird in the wild is the deliberate swallowing of stone and sand or grit believed to assist the gizzard in grinding the food into smaller particles. Kreibich and Sommer, (1995) stated that in domesticated rearing situations where the bird has no access to grit, it must be fed to the ostrich. Although grit assisted gastric grinding is not an absolute essential for digestion it does increase dry matter digestibility and efficiency of digestion (Mackie, 2002). Aganga *et al.* (2000) suggested that grit offered to ostriches could lead to gastric damage if care was not taken to select rounded, non-angular stones. Mushi *et al*, (1997) have reported impaction of the proventriculus and ventriculus (gizzard) of young ostriches associated with excessive engorgement with grit by the birds.

Grit is a useful aid to digestion (Mackie, 2002) especially in situations where the

ostrich gathers its feed from the wild or is fed unprocessed feeds. The present practice to make stones and sand available to ostriches as an aid to digestion (Mushi, et. al. 1997) does seem to mimic the situation in the wild. However, the fact that the domesticated birds are fed highly processed feeds begs the question as to whether the feeding of stones and sand is still necessary.

It has been established that diet type will influence the development of structure and capacity of the gastrointestinal tract of an animal (Chivers and Hladik, 1980). As such animals that eat high fiber diets, such as ruminants, will evolve large capacity stomachs (Starck, 1999). Histological features of an organ such as the epithelium of the ruminant stomach changes as the nature of the contents of the GIT changes along the tract (Dellman and Brown, 1976). Strack (1999) demonstrated rapid and reversible changes in the size of the avian gizzard in response to changes in dietary fiber content. Thus nature provides the gastrointestinal tract most suited to the diet and foraging habits of the animal. The objective of this paper was to examine the micro anatomical changes that occur in the luminal surface of the proventriculus, gizzard, small and large intestines of ostriches exposed to grit and of ostriches not exposed to grit.

MATERIALS AND METHODS

The study was conducted at Botswana College of Agriculture Notwane Farm located in southeastern Botswana. The altitude of the area is 987 meters and the coordinates are S24°34.832 and E025°58.394. Ostrich chicks consisting of males and females aged nine weeks were randomly assigned into two feeding groups using completely randomized experimental design. In each feeding group there were seven young birds raised in a pen. One treatment group was kept in a pen with concrete floor with no access to grit while the other treatment group was kept in a pen with earth floor with access to grit (Waugh *et. al.* (2006).

All the ostrich were fed ostrich grower mash and water ad libitum. One group had access to grit during the study while the other group did not. The ostriches were slaughtered starting from six month old and the gastro intestinal tract carefully dissected out through a midline incision (Waugh et. al. 2006). Cross sectional samples of the proventriculus, gizzard, small and large intestines were taken and fixed in 10% formalin until they were processed.

The micro anatomical features of the epithelium of the GIT components were investigated by first preparing the histological slide for observation with the light microscope. Preparation of samples was according to Dellman and Brown (1976). Digital photographs were taken using the Canon A640 digital camera. The height of epithelial features was measured microscopically in micrometers (µm) using the Axiovision Digital Imaging software Rel 4.6 by Carl Zeiss. Two sets of measurements were taken per microscopic field and a total of 30 measurements were taken for each GIT component.

The data was analyzed using SAS 9.1 2002-2003, the student t-test was used for means comparison at $P<0.05$.

RESULTS AND DISCUSSION

Proventricular luminal epithelium

The results presented on table I show that the height of the proventricular luminal epithelium of the ostriches not exposed to grit (528.93± 17.29µm) was significantly greater than that of the ostriches with exposure to grit (232.68± 17.29µm). This reduction in height of the proventricular epithelium in the grit group of ostriches is

evidence of the erosive influence of grit on the luminal epithelium of this organ (Waugh *et al.*, 2007) effectively reducing the luminal epithelial surface area in contact with ingester and should therefore negatively affect the digestive and absorptive capacity of this organ

Table 1: Means of gastrointestinal tract tissues taken from ostriches without access to grit and with access to grit in Botswana

Variable	No access to grit group	Access to grit group
Proventhiculus Epithelium (µm)	528.93±17.29a	232.68±17.29b
Gizzard Epithelium (µm)	408.87± 6.46a	157.50± 6.46b
Small intestinal Epithelium (µm)	590.56±29.90a	587.00±29.90a
Large intestinal Epithelium (µm)	57.75± 2.63a	51.37± 2.63a

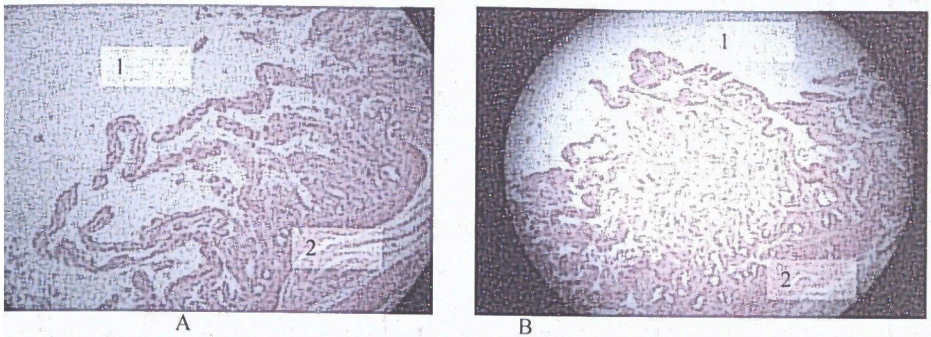
[a, b] Means within rows with different superscripts differ significantly (P<0.05)

Ventricular Luminal Cornified Layer

The results on table 1 also indicate that the height of the cornified layer of the gizzard luminal epithelium of the ostriches exposed to grit (157.50 ±6.46µm) was significantly lower than that of ostriches not exposed to grits (408.87±6.46 µm). The gizzard is the organ that provides the power for the feed grinding process that occurs in gastrointestinal tract of the bird (Mackie, 2002). Given the contents of the gizzard (Mushi et. al., 1997) and the potential abrasive power of the grit involved the significant erosion of the epithelium of the ostriches exposed to grits is not surprising. The erosion of the cornified layer of the gizzard epithelium of the grit group however should not negatively affect the contribution to the digestion process of this organ as the digestive function of the gizzard seems to resides in the power of the muscles of this organ to grinding the ingester. The gizzard muscles undergo significant hypertrophy in the grit group of ostriches an occurrence that would enhance digestion in this group. (Waugh et. al., 2007). Aganga et. al., (2000) suggested that grit offered to ostriches could lead to gastric damage if care was not taken to select rounded non-angular stones. No such selection was made in this experiment, which could be a factor in the significant erosion of the luminal surfaces of the proventriculus and the gizzard.

Small Intestinal Epithelium

The results (table 1) show no significant difference between the height (587.00± 29.90µm) of the small intestinal epithelium of the ostriches exposed to grit and the height (590.56± 29.90 µm) of small intestinal epithelium of ostriches not exposed to grit. Unlike the proventricular and gizzard epithelia, the small intestinal epithelium was apparently spared the erosive influence of the course grit material. The reason for this effect is most likely vested in the valvular and convoluted anatomical arrangement of the ventricular duodenal portal (Getty, 1975) which effectively retains the coarse and granular grit material in the lumen of the gizzard allowing only finely ground particles to escape into the duodenal lumen. The texture of small intestinal ingester for the grit group as determined by palpation was of an agranular smooth nature and quite similar to that of the ostriches not exposed to grit. Therefore even in the ostriches exposed to grit it is unlikely that the ingester would exert any significant erosive effects on the small intestinal epithelium. The digestive and adsorptive functions of the epithelium should therefore be unaffected.



A B

Figure 1: Pictures of elongated small intestinal villi in both the ostriches not exposed to grit 'A' and the ostriches exposed to grits 'B', areas labeled '1' and '2' indicate the small intestinal lumen and muscularis mucosa respectively

Large Intestinal Epithelium

As shown in table one there is no significant difference between the height of the large intestinal luminal epithelium of the ostriches exposed to grit (51.37±2.63μm) and that of ostriches not exposed to grit (57.75±2.63μm). As in the case of the small intestines, the retention of the granular grit material in the gizzard of the ostriches exposed to grit resulted in the large intestinal luminal epithelium being protected from the erosive effects of the grit material.

CONCLUSIONS

It can be concluded that the luminal epithelial microstructures of the gastrointestinal tract components anterior to the ventricular duodenal portal i.e. the proventriculus and the ventriculus in the ostriches exposed to grit was subjected to erosion by the abrasive grit particles. By contrast, the luminal epithelium of the post ventricular gastrointestinal tract components, for example the small and large intestines was not affected by the grit material in the ostriches exposed to grit. This is due to the fact that the course and granular grit material cannot pass from the gizzard to the duodenum due to the anatomical nature i.e. the intricate folding of the ventricular duodenal portal, which causes the retention of the grit material in the lumen of the ventriculus. Based on all information available in this and previous works, these birds should have access to grit, as is the case in the wild as inclusion of grit in the diet seems to have a net positive influence on digestion and feed utilization.

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