Proventricular Glands in Fowl

By

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Summary: Some researchers have already described the fowl proventriculus. However, we believed there was a need for detailed carbohydrate histochemical investigations on the same glands. Moreover, some researchers had erred about the lamina muscularis mucosae. The results of these investigations are as follows.

1. The proventricular glands consist of both superficial and profound gastric glands.
2. The superficial glands are distributed in the lamina propria mucosae while the profound glands exist in the tela submucosa.
3. The superficial glands are simple, branched tubular glands. The columnar glandular cells are arranged in a simple layer and react strongly to PAS, AB (pH 2.5 and 0.5). These appear to be dark purple when they are stained with PAS-AB (pH 2.5). Some other methods have also been tried (Table 1).
4. Judging from the data 3), the superficial gastric glands contain neutral, weak and strong acids, sulfuric and acid mucopolysaccharides, sialomucin, and II and III neutral mucus type.
5. Glandular cells in the body and basal portions of the superficial gastric glands contain a large number of fine pepsinogen granules.
6. Judging from the data 3)–5), we believe that the superficial gastric glands are undifferentiated gastric glands and that they are same kinds of glands that are found in mammals.
7. A large number of profound gastric glands fill the tela submucosa. They are compound tubular glands, and are composed of many glandular alveoli. Their columnar glandular cells are arranged in a simple layer.
8. These glandular cells react moderately to PAS, negatively to AB (pH 2.5 and 0.5) and PAS-AB (pH 2.5). Moreover, we observed some other reactions (Table 1).
9. Judging from the data 8), the profound gastric glands contain a small quantity of neutral polysaccharide; however, sulfuric and acid mucopolysaccharides, and type II and III neutral mucous are found in extremely small quantities and have no sialomucin, or either weak or strong acid mucopolysaccharides.
10. The alveolar cells in the above glands contain a large number of coarse pepsinogen granules.
11. Judging from the data 8)–10), profound gastric glands possess the characteristics of differentiated gastric glands.
12. Our investigations showed that the differentiated gastric glands in many kinds of mammals (including humans) and reptiles are simple, branched tubular glands, which exist in the lamina propria mucosae. At the same time, the glands in birds are compound tubular glands which gather in the tela submucosa. Namely, the construction and region of the same glands in birds are very different from those in mammals and reptiles.
13. Some researchers believe that the profound gastric glands of fowl are in the lamina propria mucosae, while others believe that these glands exist between the two strata of the muscularis mucosae. However, both are mistaken.
14. The gastric glands in mammals (including humans) possess parietal cells, while the above-mentioned glands of birds and reptiles do not have these parietal cells.

The authors carefully investigated the proventricular glands (gastric glands) in fowl. This paper provides the detailed results of those investigations.

Materials and Methods

Two adult fowl were used in this study. They were killed by the injection of air into their veins. Samples were taken in as fresh a state as possible, fixed in buffered formalin, embedded in paraffin, and cut into sections of about 6 μ in thickness. Van-Gieson, PAS, AB (pH 2.5 and 0.5), PAS-AB (pH 2.5), HID, LID, HID treated with HIO₄, LID treated with HIO₄, PA-Con A-HRP, and PA-red-Con A-HRP stains, as well as Bowie’s staining method for pepsinogen granule analysis were used.

Observations

1. Superficial gastric glands.
   These glands were distributed in the lamina pro-
pria mucosae of the proventricular glands, and took
the form of simple branched tubular glands (Figs. 1, 7). The columnar glandular cells were arranged in a
simple layer and reacted strongly to PAS (Figs. 2, 7)
and AB (pH 2.5), while reacting moderately to AB
(pH 0.5) (Fig. 4) and appearing dark purple when
stained with PAS-AB (pH 2.5) (Fig. 5). Table 1
(Figs. 13–18) shows the reactions to the different
mucopolysaccharides.

Glandular cells in the body and in the basal por-
tions of the glands contained a large number of fine
pepsinogen granules (Fig. 5). Parietal cells did not
exist in these glands.

2. Profound gastric glands.

These glands were an aggregation of large com-
pound tubular glands (Fig. 11), and they filled
the tela submucosa of the proven-tricular glands.
Furthermore, they were composed of many alveoli.
The glandular epithelium lining the alveoli was
arranged in a simple layer.

These glandular cells reacted modelately to PAS
(Fig. 7), while reacting negatively to AB (pH 2.5 and
0.5) (Figs. 8, 9) and PAS-AB (pH 2.5) stains (Figs.
10, 11). However, the epithelium lining the excretory
ducts appeared dark purple when stained with PAS-
AB (pH 2.5) (Fig. 11).

Table 1 (Figs. 13–18) show the reactions to
various mucopolysaccharides.

The alveolar cells contain a large number of coarse
pepsinogen granules (Fig. 12). Furthermore, parietal cells are not found in these glands.

Discussion

Some researchers have provided descriptions on
the construction and regions of the fowl gastric glands
(Proventricular glands).1–3, 11, 12) However, these
subjects required supplemental investigations. We,
therefore, observed these regions histologically and
histochemically.

Fowl gastric glands have both superficial and pro-
found regions. The superficial glands are simple,
branched tubular glands which exist in the lamina
propria mucosae. Although Kato11) believes that
these glands penetrate into the tela submucosa, such
an opinion is mistaken. The profound glands aggre-
gate in the tera submucosa. Nevertheless, Kato and
Trautmann11) believe that these glands exist in the
lamina propria mucosae. Accordingly, they are also
mistaken. Hodges3) believes these same glands lie
between the two layers of the mucosal muscles.
However, this muscle has only one layer. Con-
sequently, he is also mistaken.

Hodges3) and King-McLelland12) microscopically
described the superficial and profound gastric
glands. Although Hodges3) and some other re-
searchers1, 2, 11, 12) did not describe either of the
glands histochemically.

The superficial gastric glands contain weak and
strong acid mucopolysaccharides, sulfuric, acidic
and neutral mucopolysaccharides and type II and
III neutral mucus. Moreover, the pepsinogen
granules in these glands are fine. Accordingly,
we believe that the superficial gastric glands exist in
an undifferentiated stage.

The profound gastric glands contain extremely
small quantities of neutral mucopolysaccharides,
and type II and III neutral mucus, but no weak and
strong mucopolysaccharides. However, the lining
cells of the ducts present a strong color of sialomucin.
Histochemical reactions in the profound gastric
gland ducts are very similar to those in the superficial
gastric glands. Accordingly, they are indistinguish-
able.

The glandular cells in the profound gastric glands
contain a large number of coarse pepsinogen granules.
Consequently, we believe that these glands are in a
differentiated stage.

Although not in birds, undifferentiated gastric
glands of mammals and reptiles exist in the lamina
propria mucosae. In birds, undifferentiated gastric
glands exist in the lamina propria mucosae, while

Table 1. Reactions to complex carbohydrates of the proventricular glands (superficial and profound gastric glands) in fowl.

<table>
<thead>
<tr>
<th>Staining methods</th>
<th>HID</th>
<th>LID</th>
<th>HID (treated with HIO₄)</th>
<th>LID (treated with HIO₄)</th>
<th>PA-Con A-HRP</th>
<th>PA-red-Con A-HRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial gastric glands</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Profound gastric glands</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>+</td>
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</table>
differentiated gastric glands exist in the tela submucosa. This fact is very important and interesting. We investigated mammals (humans, Japanese macaques, crab-eating monkey, horses, cows, swine, cats, dogs, rabbits, mice and rats), bird (fowl and goose) and reptiles (Japanese lizards, geckos, snapping turtle and rock snake). However, we could not recognize the same pattern in birds.

Although not in humans, tubular gastric glands in mammals are distributed in the lamina propria mucosae of the narrow cardiac region and are undifferentiated. However, they become differentiated toward the pyloric region, where they complete their differentiation. Human compound tubular gastric glands are distributed not only in the cardiac region, but also in the lamina propria mucosae of the esophagus. Besides the above-mentioned glands, undifferentiated tubular glands are distributed throughout the cardiac region and are differentiated towards the pyloric region. A more important fact is that the compound tubular glands are distributed only in the lamina propria mucosae of the human esophagus. We have already presented a detailed report on this subject.6

Neither of the gastric glands in fowl possess parietal cells and it is generally believed that the simple glandular alveolar epithelium secretes both hydrochloric acid and pepsinogen.12)

References

Explanation of Figures
(All are related to fowl)

Plate I

Fig. 1. Superficial (A) and profound gastric glands (B). Van Gieson stain. × 15

Fig. 2. Superficial and profound gastric glands (B). PAS stain. The glands react strongly to PAS. × 30

Fig. 3. Superficial gastric glands. AB (pH 2.5) stain. The glands react strongly to this stain. × 76

Fig. 4. Superficial gastric glands. AB (pH 0.5) stain. The glands react moderately to this stain. × 76

Fig. 5. Superficial gastric glands. PAS-AB (pH 2.5) stain. The glands appear dark purple when stained with this chemical. × 76

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Fig. 8. A portion of the profound gastric glands. The alveoli of the glands react negatively to an AB (pH 2.5) stain. ×76

Fig. 9. A portion of the profound gastric glands. The alveoli of the glands react negatively to an AB (pH 0.5) stain. ×76

Fig. 10. A portion of the profound gastric glands. The alveoli of the glands react negatively to a PAS-AB (pH 20.5) stain. ×76

Fig. 11. Epithelium lining the excretory ducts of the profound gastric glands (C) appear dark purple when stained with PAS-AB (pH 2.5). The superficial gastric glands (A) present the same color in C. The profound gastric glands (B) react negatively to this stain. ×30

Fig. 12. Alveolar cells of the profound gastric glands contain a large number of coarse pepsinogen granules. Bowie's staining method for pepsinogen granules. ×760
Plate III

Fig. 13. The superficial gastric glands (A) react moderately to a HID stain, while the profound gastric glands (B) react very weakly to the same stain. × 30

Fig. 14. The superficial gastric glands (A) react weakly to a LID stain, while the profound gastric glands (B) react very weakly to the same stain. × 23

Fig. 15. The superficial gastric glands (A) react moderately to a HID (treated with HI04) stain, while the profound gastric glands (B) react very weakly to the same stain. × 30

Fig. 16. The superficial gastric glands (A) react weakly to a LID (treated with HI04) stain, while the profound gastric glands (B) react weakly to the same stain. × 30

Fig. 17. The superficial gastric glands (A) react moderately to a PA-Con A-HRP stain, while the profound gastric glands (B) react very weakly to the same stain. × 30

Fig. 18. The superficial gastric glands (A) react moderately to a PA-red-Con A-HRP stain, while the profound gastric glands (B) react very weakly to the same stain. × 30