

Przewód pokarmowy *Tetrodontophora bielanensis* Waga  
(*Collembola*) i regeneracja nabłonka jelita środkowego  
The alimentary canal of the *Tetrodontophora bielanensis* Waga  
(*Collembola*) and the regeneration of the mid-gut epithelium

napisał

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**Introduction.** *Tetrodontophora bielanensis* Waga a very interesting and primitive species belongs to the elements of an ancient fauna. The studies concerned with its constitution are therefore very interesting from comparative morphology point of view.

**Material and methods.** Material was collected in Las Wolski near Kraków. The alimentary canal were prepared in Ringer's fluid, fixed in Bouin's fixative and then embedded in parafin. Sections 9  $\mu$  in thickness were stained with Delafield's hematoxylin and eosin. Boric carmin was used for staining the whole alimentary canals.

**Anatomy and histology of the alimentary canal.** The alimentary canal of the *Tetrodontophora bielanensis* Waga has a very simple constitution. It is a slightly curved tube, with different lumen, running from the mouth to the anus. (Fig. 1 in text). In the head the alimentary canal is connected to the body wall by the dilator muscles. It consists of three primary divisions: a fore-gut (*stomodaeum*) derived from ectoderm, lined with cuticle continuous with that covering the surface of the body; a hind-gut (*proctodaeum*) also derived from the ectoderm, again with a cuticular lining and a mid-gut (*mesenteron*) uniting these two.

All these parts have muscular coat.

These primary divisions are not differentiated anatomically into parts as in Pterygota, also the Malpighian tubes are absent.

**The fore-gut.** The stomodaeum is a short, narrow tube leading to the mid-gut (Fig. 1 in text). Histologically, the fore-gut is made up of a cuticular intima, laid down by epidermis resting on a basement membrane. Outside these there is a thick muscular coat. The intima in fore part of the stomodaeum is smooth and thicker than in the hind part. The epithelium is flat; the protoplasm is dense and the cell boundaries are often indistincts. The nuclei of the epithelium are large and irregular in shape and dimension. Both the epithelium and the intima in the hind part of the stomodaeum are thrown into longitudinal folds (Table I, fig. 4). The number of the folds is not patent. These folds allow for expansion of the lumen, when the stomodaeum becomes filled with food. A certain number of the folds are definite structures as shown by increased thickness of the intima covering them and of underlying epithelial cells. The muscular coat consists of an outer thick layer of circular fibres. Between this layer and the basement membrane are singly disperse longitudinal muscles. In the fore part of the stomodaeum the dilator muscles penetrate between the fibres of the muscularis and unite with the intima.

The fore-gut is separated from the mid-gut by the cardiac valve. This is a circular fold of the stomodaeal wall projecting into midgut from the posterior end of the stomodaeum. The fold is composed of two cellular lamellae and is covered on each side by the stomodaeal intima. The basal ring of the outer lamella marks boundary between stomodaeum and mesenteron. The cardiac valve have effect as a valve preventing a return movement of the food from the stomach.

**The mid-gut.** The mid-gut is made of columnar cells much higher than the epithelium of the fore-gut. The basement membrane is thick and well visible. The muscular sheat of the mid-gut is less strongly developed than that of the stomodaeum. The epithelial cells are devoid of cuticle, but they are protected from the contents of the gut by a striated bor-

der, made up of rod-like elements organically held together to form a rigid structure.

The appearance of the mid-gut epithelium varies greatly according to the state of the digestive processes. In resting stage most of the cells are columnar with irregular inner ends more or less projecting into the mid-gut lumen. The cytoplasm of the epithelial cells appear granular; the nuclei are oval in shape and generally occupy the middle of the cell bodies, where in sections, they form even rows (Table I, fig. 1). In addition to these columnar cells that form most of the epithelial wall, there are to be seen other smaller cells of a less dense texture occurring singly between the bases of the larger cells. The larger cells, are the digestive cells; the smaller basal cells are the regenerative cells. In many insects there are two quite distinct types of digestive cells. Such is not in *Tetrodontophora bielanensis* Waga, the digestive cells are uniform in structure except in that they may be of different sizes.

In the secretory stage visible changes occur: the nuclei stain deeply, the cytoplasm becomes much spongy and vacuolised. Secretion consists of the accumulation of granular material in the apical ends of the cells, succeeded by a rupture of the cell wall and the discharge of the material into the mid-gut lumen. The cell wall then closed, the striated border is reestablished, and the cell continues its digestive functions.

In the *Tetrodontophora bielanensis* Waga may be seen simple functional subdivision of the mid-gut into two parts: in its hind part secretion is much intensive than in the fore.

The food content, in many insects, is separated from the mid-gut epithelium by a peritrophic membrane. In the *Tetrodontophora bielanensis* Waga such membrane is absent.

**The hind-gut.** The entrance to the hind-gut from the mesenteron is constricted, and the opening is guarded by a regulatory apparatus-pyloric valve. It is a single internal circular fold, projects from the posterior margin of the mid-gut epithelium (Fig. 1 in text, Table I, fig. 2). Behind the mesenteron,

in the anterior part of the proctodaeum is located sphincter with powerful circular muscles (Fig. 1 in text, Table I, fig. 2).

The walls of the proctodaeum resemble in structure those of the stomodaeum. But the cells of the epithelium are larger, the cuticular intima is much thicker and the muscular coat is strongly developed.

Toward the hind end the epithelial cells tend to decrease in size and to be arranged in longitudinal folds.

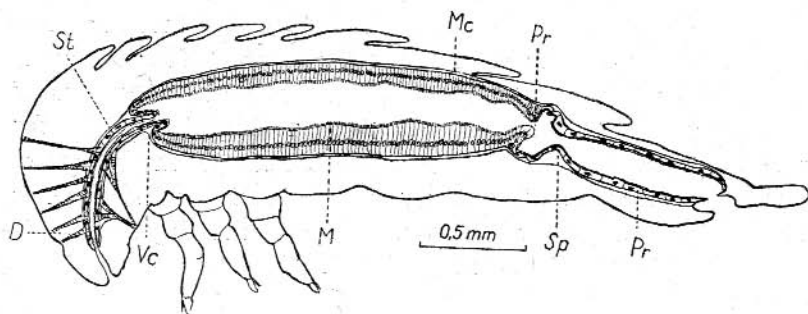


Fig. 1. Diagram of the alimentary canal of the *Tetrodontophora bielensis* Waga. D — dilator muscle, M — mesenteron, Mc — muscular coat, Pv — pyloric valve, Sp — sphincter, St — stomodaeum, Vc — cardiac valve.

**The regeneration of the mid-gut epithelium.** Throughout the active life of most insects, there takes place in the mid-gut epithelium a partial or complete degeneration of the digestive cells. The reconstructive processes, varying in degree, are undertaken by the regenerative cells. This may be a gradual process, or it may occur rhythmically as in those insects showing holocrine secretion. In some insects the epithelium of the mid-gut may be renewed completely at each moult (Folsom and Welles (1906), Boelitz (1933), Möbusz (1897), Braun (1912), Yung-Tay (1929), Hase man (1910). Similar process takes place in the case of the *Tetrodontophora bielensis* Waga which moult throughout whole life.

The renewal of the mid-gut epithelium is preceded by an evacuation of the gut and starts with mitotic divisions in the regenerative cells. The regenerative cells multiply and form

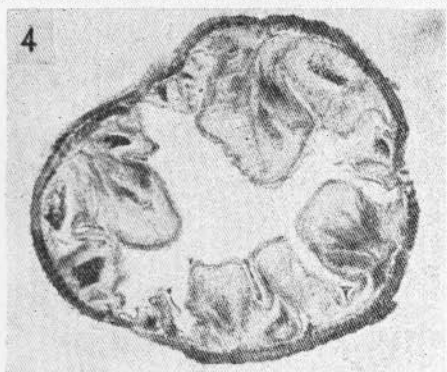
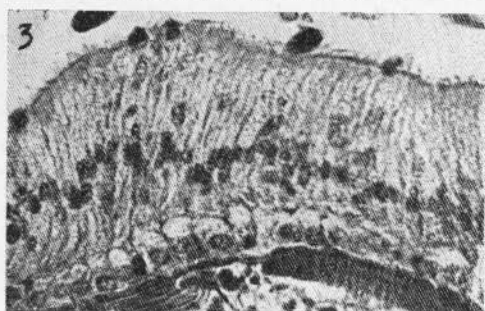
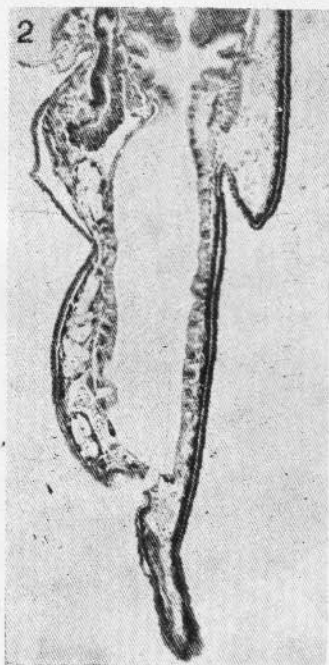
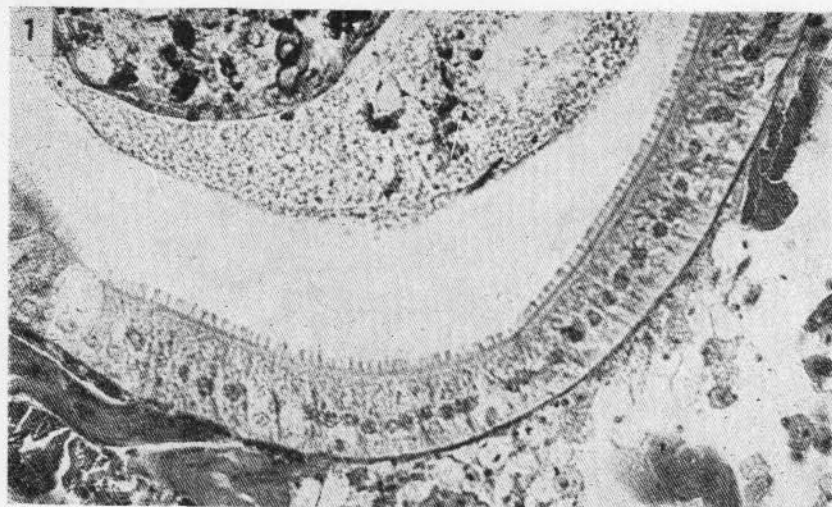
a layer (Table I, fig. 3). As new cells multiply, the old epithelium is separated from basement membrane which remains intact and is pushed toward the mid-gut lumen, finally to be thrown off into the latter, where it is digested and absorbed by the new epithelium.

### STRESZCZENIE

Przewód pokarmowy *Tetrodontophora bielanensis* Waga, zbudowany jest bardzo prosto. Można go podzielić na trzy odcinki: *stomodaeum*, *mesenteron*, *proctodaeum*. Wymienione odcinki nie są zróżnicowane na odcinki mniejsze, tak jak to ma miejsce u *Pterygota*. *Stomodaeum* i *proctodaeum* zbudowane są podobnie. W skład ich ścian wchodzi nabłonek pokryty intymą, oparty na błonie podstawowej oraz mięśnie podłużne i okrężne. *Mesenteron* różni się od *procto-* i *stomodaeum* kształtem komórek nabłonka oraz przede wszystkim brakiem intymy; miejsce jej zajmuje brzeżek szczoteczkowy. Cewki Malpighiego nie występują. Nabłonek środkowego jelita jest odrzucany po każdym linieniu. Proces odnowy podejmują komórki regeneracyjne, które są rozrzucone pojedynczo pomiędzy komórkami trawiącymi.

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Tablica I — Table I

- Fig. 1. The epithelium of the mesenteron when resting.  
Fig. 2. The sagittal section through the proctodaeum.  
Fig. 3. Mid-gut epithelium in the regeneration stage.  
Fig. 4. The transversal section through the stomodaeum.

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