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ON THE STRUCTURE AND FUNCTION OF THE PROVENTRICULUS OF *GRYLLUS PENNSYLVANICUS* BURM.

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There are two explanations generally given of the function of the proventriculus in insects. The earlier writers regarded this organ as the analogue of the gizzard of birds, an organ for the mastication and comminution of the food in its passage from the crop to the mesenteron, hence the terms "gizzard," "gesier," "Kaumagen."

Another view, and one which perhaps has now the greater number of adherents, is that the teeth of the proventriculus have no triturating function but act as a strainer or grating to exclude solid particles of food from the mesenteron. While some writers deny completely the comminuting function of the proventriculus, others are willing to admit that in addition to its straining action it may sometimes have a triturating action. Still others hold that one of the chief functions of this organ is to thoroughly mix the food from the crop and prepare it for the action of the digestive juices in the mesenteron.

The writer hopes to show from a study of the structure of the proventriculus of *G. pennsylvanicus* and of the condition of the food in the crop, the proventriculus and the mesenteron, that in the Gryllidæ the proventriculus has a definite triturating function. The descriptions are limited to *G. pennsylvanicus* because for his purpose the armature of the proventriculus in all of the Gryllidæ studied by him is essentially similar.

As the proventriculus of other species of the Gryllidæ has already been described the structure will not be given in very great detail.

The anterior division forms a tubular neck leading from the crop. The intima is thrown up into six folds each bearing ten

transverse rows of backward-directed bristles (Pl. V, br.), a few of these bristles, especially in the posterior rows, occasionally develop into small chitinous teeth. The tunic of circular muscles (c. m.) is only two or three layers thick and in each fold there is a band of longitudinal muscles (Pl. V, Fig. 2. r. m.).

The posterior division of the proventriculus is broadly oval and contains a complicated system of strongly chitinized teeth. The tunic of circular muscles is well developed, consisting in some places of ten or twelve layers. Within are six dental folds continuous with the folds in the anterior portion. These folds are separated by means of chitinous partitions (Pl. V, ch. p.). In each dental fold there are normally ten transverse rows of teeth, each row consisting of seven distinct teeth all directed backward towards the mesenteron. In the middle of the fold is the median tooth (m. t.), the only unpaired tooth in the row and the one which projects farthest into the lumen. At its apex it bears four to six sharply pointed, strongly chitinized median denticles (Pl. V, m. d.) and at each of its basal angles a single sharp lateral denticle (l. d.). Immediately in front of the median tooth is a pair of lateral teeth (l. t.); viewed from the inner side (*i. e.*, from the direction of the median tooth) these teeth are narrowly wedge-shaped; from the outer side they present a narrow curved surface around the edge of which are arranged eight small chitinous processes which convert this tooth into a grinder comparable to a molar. Behind the median tooth is a pair of large blunt pad-like processes (i. b. l.) not very highly chitinized as compared with the median and lateral teeth, and covered for the most part with a short yellow pubescence but on the anterior side with rather longer and stiffer hairs. Next the chitinous partition on each side is another brush-like process (o. b. l.) bearing a very sharp backward curving tooth. The two last described processes are termed by Berlese *i lobi a spazzola* so the writer has called them respectively the inner and outer barbated lobes.

The cells of the single epithelial layer of the chitinous partitions are clearly marked off. The epithelial cells of the various processes are not so distinctly marked, the numerous nuclei of the epithelium being very closely packed. Within each row of teeth there is a muscular band (Pl. V, Figs. 4 and 5 r. m.) which pulls the teeth outwards, enlarging the lumen and opposing the action of the circular band.

Examination of the structure of the proventriculus with its complicated system of teeth—the sharp denticles fitted for cutting and tearing, the lateral teeth fitted for crushing and grinding—and its efficient mechanism for powerful compression can hardly fail to convince one that this organ has a definite triturating function; but the evidence does not lie in the structure alone but also in a consideration of the condition of the food in the crop, the proventriculus and the mesenteron.

Plateau, one of the foremost and most authoritative exponents of the theory that the proventriculus is exclusively a strainer, has shown in support of his contention that if a cockroach feeds on food rich in cellulose, which is not digestible in the crop, fragments are found unaltered as to form and size in the mesenteron. If it consumes an abundance of farinaceous food, starch granules which escape digestion in the crop are found uncrushed in the mesenteron. To the writer this evidence does not seem conclusive because if the proventriculus were efficient as a strainer, all large particles should be excluded from the mesenteron no matter what their nature, and we should find much solid food in the crop and only liquid food or finely divided solid food in the mesenteron. On the other hand, if the proventriculus has a masticating action, tough substances such as cellulose would be imperfectly triturated, while bits of food as small as starch grains might easily escape further comminution. The condition of the food in the different sections of the canal would depend on the nature of the food ingested. If the food is soft and easily crushed the contents of the crop and mesenteron will be similar to those described where the straining action is postulated. If the food contains hard or tough particles, not easily crushed, these will be forced through the proventriculus and solid particles of food will be found, not only in the crop, but also in the mesenteron.

An examination of the digestive canal of crickets which had been fed on miscellaneous food, including dead crickets and locusts, revealed the fact that the particles of chitin, quartz and woody tissue found in the proventriculus and mesenteron were fully as large as any found in the crop (Pl. VI, 1, 2, 3).

The crop of crickets which had been fed on dead insects contained large particles of soft animal tissue (Pl. VI, 4). The mesenteron contained only small pieces (Pl. VII). A similar re-

sult was obtained with crickets which had been starved for several days and then fed on grains of wheat. The crop contained large bits both of the hull and of the starchy endosperm. The mesenteron contained several large bits of hull but no pieces of endosperm as large as those in the crop (Pl. VII, 2, 3, 4).

It will be seen from the foregoing that as a grating for the exclusion of large particles from the mesenteron the proventriculus has, in the cricket, little or no efficiency, since it allows even fragments of quartz to pass through it. Indeed a study of the arrangement of the backward directed teeth and the strong muscular coat will make it evident that particles caught in the proventriculus will be forced towards the mesenteron. The action of the proventriculus might be compared with that of the rollers in a mill; anything caught between the rollers is carried onward, if it is strong enough to resist the breaking power of the rollers it will come out unaltered on the other side, if not it will be crushed.

In many insects the teeth of the proventriculus are so poorly developed that they can have little or no triturating action. In others this organ serves some special purpose as in the honey sac of the bee (Cheshire), or the combined pump and valve of the house fly (Hewitt). In the cricket, however, the structure of the proventriculus and the condition of the food after passing through it leave no room for doubt that this organ has a definite triturating function.

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Explanation of Plates.

Plate V. Sections through the proventriculus of *Gryllus pennsylvanicus*. All greatly enlarged.

Fig. 1. Longitudinal section through the median denticles.

Fig. 2. Transverse section passing through two folds of the anterior division of the proventriculus.

Fig. 3. Surface view of a portion of one of the dental folds showing the chitinous partition and four of the transverse rows of teeth.

Fig. 4. Transverse section of proventriculus passing through the median denticles.

Fig. 5. Transverse section of fold cut in the region of the lateral denticles.

Fig. 6. Lateral view of two adjacent inner barbated lobes.

br. = Bristles of anterior division of proventriculus.
ch. p. = Chitinous partition between dental folds.
c. m. = Circular compressing muscles.
c. v. = Cardiac valve.
ep. = Epithelium.
i. b. l. = Inner barbated lobes.
in. = Intima.
l. d. = Lateral denticle.
l. t. = Lateral tooth.
m. d. = Median denticles.

m. t. = Median tooth.
o. b. l. = Outer barbated lobes.
r. m. = Relaxing muscle.

Plate VI. Photomicrographs of the contents of the digestive canal of cricket. Figs. 1, 2, 3 crop, proventriculus and mesenteron of cricket fed on miscellaneous food. Fig. 4, crop of cricket fed on dead insects.

Plate VII. Fig. 1 mesenteron of cricket fed on dead insects. Figs. 2, 3, 4 crop, proventriculus and mesenteron of cricket fed on wheat grains.

NEW POLYDESMOID DIPLOPODS FROM TENNESSEE AND MISSISSIPPI.

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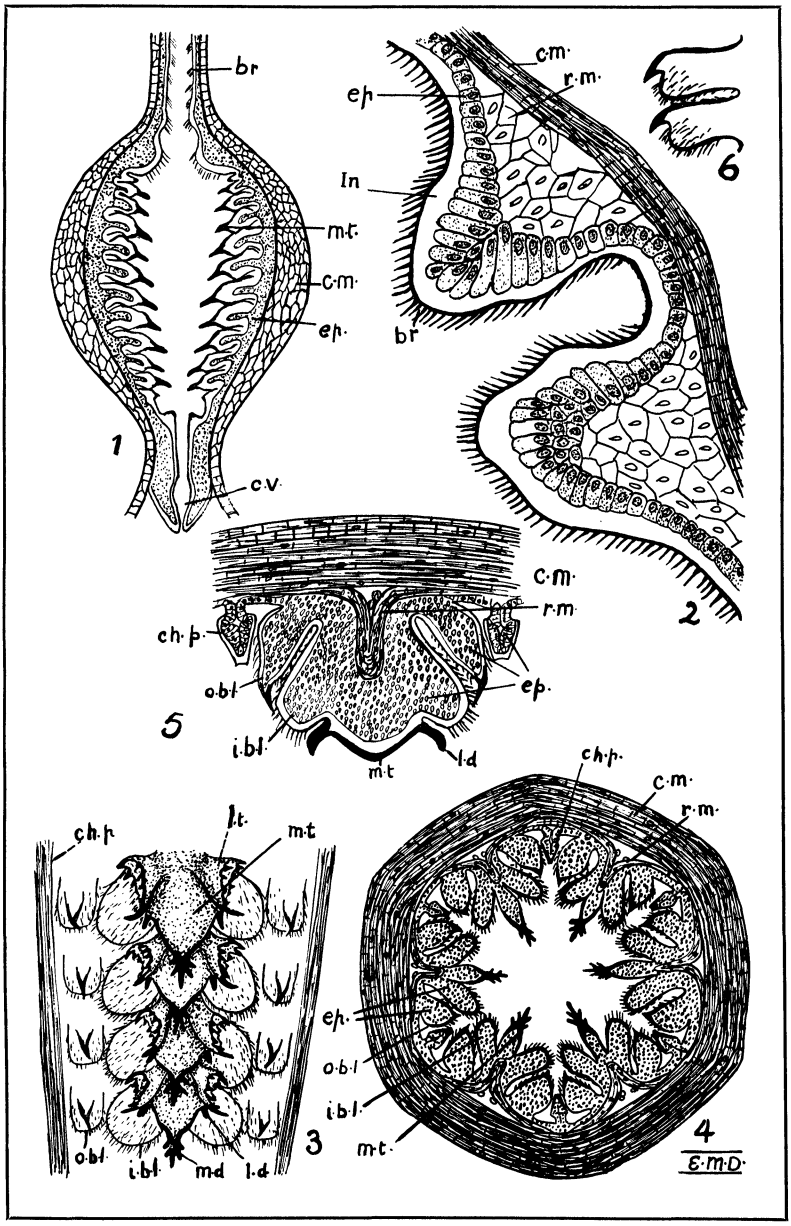
Of the following underscribed species of millipedes one was collected in Mississippi at Agricultural College by Mr. J. W. Bailey, while the other four, three of them pertaining to a new genus, were taken by Professor R. Thaxter at Burbank in eastern Tennessee. The new genus is segregated from *Fontaria* sens. lat.

Fontaria pela sp. nov.

This species when in full color is above deep shining black with the caudal corners of the carinæ and the tip of the last tergite in life apparently bright red, fading in alcohol to brown or orange. There may or may not be a narrow stripe of the same bright color across the anterior border of the first tergite. The lateral region of each somite is in the main reddish or orange brown with a black stripe down the caudal portion from carina to legs, and a less distinct dark stripe in some along the anterior border as well. The antennæ are somewhat chestnut and the legs are brown.

The body is proportionately rather slender. It is parallel-sided excepting at the ends which are narrowed. The lateral carinæ are moderate in size; the caudal margins of the anterior ones are bent forward, those of the middle region less so, and those of the posterior ones first straight and then bent caudad, the posterior angles of the



DUPORTE—Proventriculus of Gryllus.

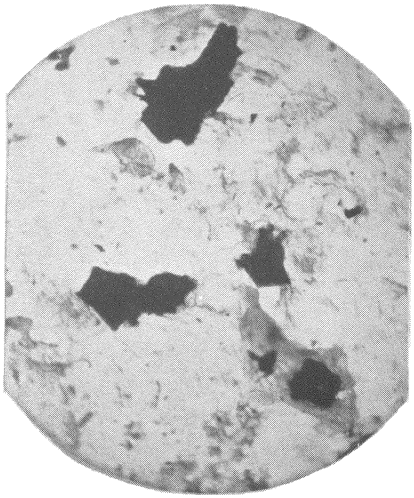


Fig. 1

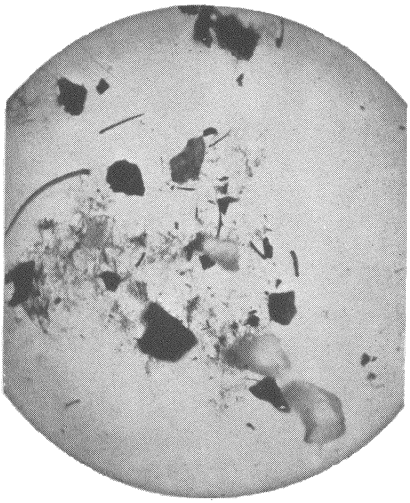


Fig. 2

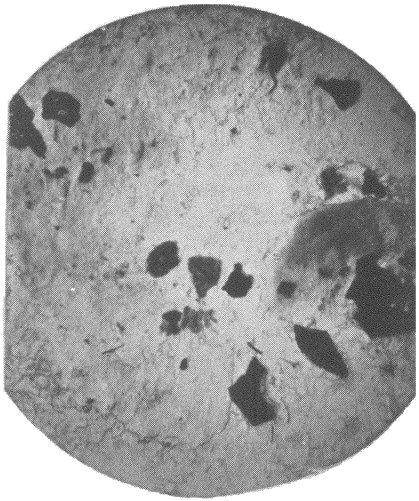


Fig. 3

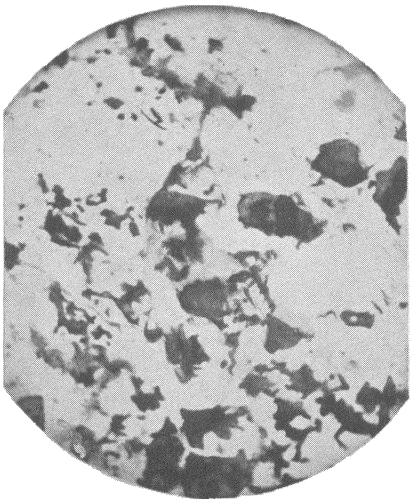


Fig. 4

DUPORTE—Proventriculus of Gryllus.

Fig. 1

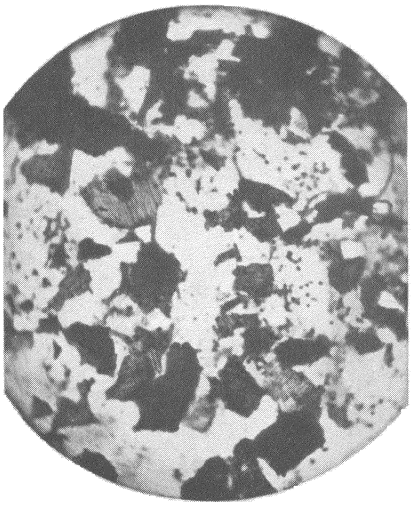


Fig. 2

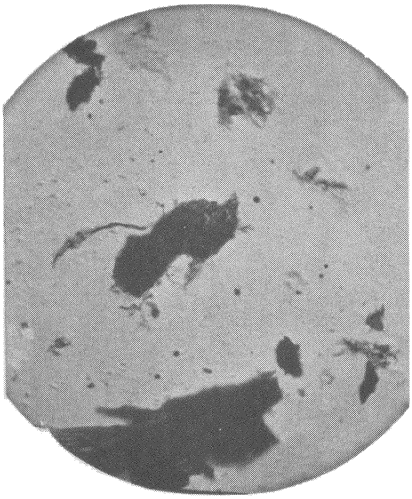


Fig. 3

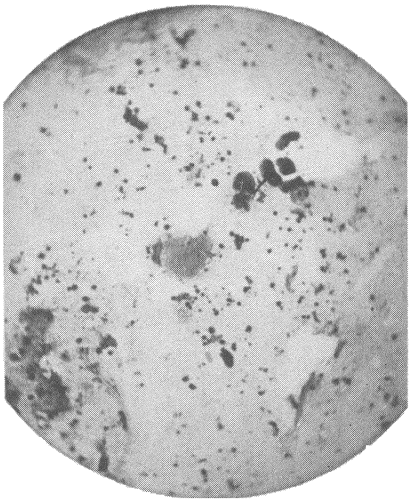


Fig. 4

DUPORTE—Proventriculus of Gryllus.