

ANATOMY.

Supraanal opening probably separated from the *anal* by a short mantle-connection, but in all my specimens this is torn by rough handling. Inner lamina of inner gills free from abdominal sac. All four gills marsupial in the female. *Placentae* well developed and *subcylindrical*.

Anal opening with small papillae, branchial opening with well developed papillae. *Palpi* as usual, their posterior margins connected for about one third of their length or less.

As to the color of the soft parts, which is so characteristic in *barnesiana*, not much can be said, since my material has been too long in alcohol. But in most of my specimens the gills are yet distinctly suffused with black. The *placentae* have been rendered whitish, but here and there traces of a dark stain are preserved (which is disappearing gradually). It is quite possible that the color of the *placentae* originally was similar to that of *barnesiana*.

The *glochidia* are subelliptical, slightly higher than long; L. O. 15, B. O. 18, thus agreeing with those of *F. barnesiana*.

NOTE ON THE RELATION OF SNAIL FAUNA TO FLOODS.

BY A. RICHARDS.

During the years 1911 to 1916, while the writer was a member of the faculty of the University of Texas, a series of incidental observations on the snail fauna of Waller Creek was made. These observations have now come to an end due to the change of residence of the observer. It seems not unwise, therefore, to publish a short note on the subject in the hope that the facts recorded, although fragmentary, may have a bearing on the work of some other follower of snail life.

Waller Creek is a small stream near the University of Texas at Austin. It is some four miles in length and empties into the Colorado River at a distance of perhaps two miles below the University. That portion of the stream close to the University between Fifteenth and Twenty-seventh Streets, was most closely observed, but data was also collected from the region below.

During the hot months, from about July 1st to October 1st usually, the stream is dry, or water is to be found only in an occasional pool; during the rest of the year the water flows to a depth of a few inches. The bed is scoured out of limestone (Austin Chalk) and has for much of its length a solid flat rock bottom. The banks of the creek have in general a gradual slope. In time of flood and during heavy rains, this stream rises very rapidly and quickly becomes bank-full, so that the water rushes down in a torrent, the roar of which may at times be heard for a distance of some blocks. The fall of the creek is considerable, being about 75 feet in two miles from Twenty-seventh Street to the Colorado, and this fall in connection with the shape of the bed gives to the current in times of flood a tremendous force.

During the first two years of this observation, 1912-1913, the snail population of the creek in its middle stretches was dense. There were in particular two species very thickly represented, *Planorbis lentus* and *Physa halei*. So numerous were they that one could in a few moments within a very few feet gather a pint of either kind. Wherever a little ripple or a tiny waterfall occurred were many snails oriented in relation to the current, their heads pointing into it. Elsewhere in the more quiet water they were also to be found, but in less numbers. These conditions obtained especially in the early spring; as the breeding season, which in that latitude extends over half the year, passes by, the snails of course become much less numerous.

It is to be noted that previous to the time when the snails had become so abundant, there had been no heavy rains of sufficient importance to be recorded since 1908. Excessive rains occurred in May 1908, November and May 1907, June and March 1905, May and April 1904, July and February 1903, July and November 1902. There was a very severe flood in the creek in April 1900. It will be seen that between the time when my observations began and the last excessive rain considerable time had elapsed and the snails had had the opportunity to reinstate themselves in the creek, assuming that they had suffered in those floods as they have done in the later ones.

In the fall of 1913 there were two floods of unusual propor-

tions in the creek. In October it rose very rapidly, but shortly subsided, and in November, at the time when the entire state was visited by the most severe flood since 1869, it was again subjected to a very thorough scouring. Excessive rains fell on several consecutive days, and streams in the entire Colorado watershed were out of their banks.

After the heavy rains of the earlier part of the month there were several days upon which the rainfall, while comparatively light, was sufficient to keep the creek much higher than its normal level. When the water finally subsided to its normal amount the bed was covered completely with a layer of detritus and soft green humus and algae from a half an inch to an inch in thickness. This deposit and the acids formed from it have been the cause of a much more rapid disintegration of the limestone than had been the case in the immediately preceding years. Loose pieces of limestone which were exposed to the action of the water had in many cases fallen apart by the end of January. Further rises occurred on April 27 and on May 20th, 1914, but were not sufficient to remove all of the accumulated layer of detritus.

In January 1914, a search for snails where they had before been numerous failed to reveal a single specimen of *Planorbis* and less than half a dozen *Physa*. Even in the deeper pools they could scarcely be found. Later in the spring in the lowest part of the stream a number of very small *Physa*, as well as some clusters of eggs were found. The force of the current had been so great as to wash the snails down to the river, and it is possible that the condition of the water due to the decomposing humus may have affected those which were able to escape the flood danger. That some of the *Physa* were left after the flood may be attributed to their pointed shape which decreases the amount of force that the water was able to exert on them as compared with that on the flat *Planorbis* shells. Except as noted above in April and May 1914, the conditions in the creek remained as normal.

In January 1915, *Physa* has again made its appearance in the middle parts of the stream, although in small numbers only. Diligent search, however, failed to reveal a single *Planorbis*.

The snails which were present were found only under fair-sized rocks where they were well protected; they did not occur out in the open stream as had been the case when the creek was more densely populated with snails.

In April 1915, on the 22d and 24th, Waller Creek was swept by three scouring floods which devastated the entire bottoms. The water rose higher during the night than it had at any time since 1886; bridges were washed away and much damage done. The bottom of the creek was again washed clean except under the larger stones and in deep holes in the bed. Snails were not observed in any numbers following this flood during the rest of that year. Early in January 1916, however, *Physa* had again appeared fairly abundantly where they had formerly been very thick, in the region just above the University; later in the spring they became quite numerous here. In January of this year the first *Planorbis* were found that had been seen in the creek since the autumn floods of 1913. Between Fifteenth and Sixteenth Streets in a pocket containing good-sized stones over which the water flows rather swiftly a number of specimens were taken, although none were found above or below this locality. It is noted that below this region the creek is frequently covered with oily scum and that it receives the refuse from the adjoining properties. Except after high water which would clean it out, the creek in this region would hardly be expected to support much snail life. It must be supposed either that the *Planorbis* had made their way up to Sixteenth Street during the short time following the floods before the water became badly contaminated, or else that in this particular place a few specimens from the previous years had withstood the floods and reproduced themselves in sufficient numbers to be noticeable in January. Of these two suppositions the latter seems much the more rational.

After the flood of 1915 the water subsided very quickly so that a new layer of humus and algae was not deposited, but that the bed was again restored to its former condition of a clean smooth rock bottom. Upon the return to this condition the snail population increased very rapidly, and at the time when the last observation was made in the early summer of 1916, seemed in a fair way to return to the condition of 1912.

It seems to the writer that the slow return of the snails during the year 1914 was due not only to the repeated rains of the fall and winter of 1913-14, but also to the condition of the creek bed at this time. Although the heavy rains of 1915 were more severe, they were confined to one month, and the creek bed was left in a very much cleaner condition than during the preceding year.

The conditions of life which obtain now in Waller Creek are those of a new life region. This must of necessity be so in an intermittent stream to a certain extent, but owing to the flood conditions here they are doubly so.

The chief facts of interest in regard to the habits of snails as shown by these observations, are these: 1, The snails of both species are to be found commonly in uncontaminated water which is running at a fairly rapid rate, and the most common orientation is with the heads pointing up stream; 2, The snail population in any stream is subject to wide fluctuations depending upon flood conditions; 3, *Physa* because of its shape is less affected by floods than *Planorbis*; 4, The return of the snail population to a given stream is determined not only by the frequency and severity of the floods, but also by the condition of the bottom of the stream after the subsidence of the high water; 5, The snails thrive best where there is a constantly renewed supply of clean water which contains little decaying vegetation.

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WILLIAM BULLOCK CLARK.

Dr. William Bullock Clark, professor of geology in the Johns Hopkins University, eminent for his contributions to geology, died suddenly from apoplexy on July 27, at his summer home at North Haven, Maine.

Wm. Bullock Clark was born at Brattleboro, Vermont, December 15, 1860. Since 1894 he was professor of geology in Johns Hopkins University. In 1896 Professor Clark organized the Maryland Geological Society, and has been State Geologist since that time. The admirable volumes on paleontology of



Richards, A. 1917. "Note on the relation of snail fauna to floods." *The Nautilus* 31, 64–68.

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