Some Morphological Variations in *Paramecium bursaria* (EHRBG.)[1].

Von

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With 10 figures in the text.

The classification of the Ciliata is necessarily based upon minute characters and is accordingly difficult. Most species show some variations in size and shape, especially the former, among individuals. Variations in shape commonly may be brought about by changes in nutritional and other environmental conditions but such variations are essentially somatic in character and therefore tend to disappear in subsequent generations, especially if the environmental conditions approach more nearly those normal for the species in question. Occasionally variations in structure occur among Protozoa which are hereditary (STOCKING, 1915; JENNINGS, 1916) but such cases are apparently rare (JENNINGS, 1920).

Within the genus *Paramecium*, slight variations in structure and size are of common occurrence. In *P. aurelia* various races are known which differ in size as well as in physiological characteristics and in *P. caudatum* something of the same phenomenon has been shown (JENNINGS, 1910 and others). Variations in body form in other species of *Paramecium* have received relatively little attention.

For studies in protozoan genetics, variations in body form are very valuable as markers of possible biotypic changes. Accordingly, species tending to show such changes in form should be called to the attention of geneticists whenever found and as many data pre-

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sented as possible concerning the environmental conditions under which the animals were found to be living. That the same species may present both constant and inconstant differences under diverse environmental relationships apparently associated with different regions has been shown by GEIMAN (1931) working with *Coleps octospinus* NOLAND. As to the cause of such changes we are still largely ignorant despite the many excellent studies made both in America and Europe on the genetics of the group.

The purpose of this paper is to describe six variations in body form recently found in the widely distributed *Paramecium bursaria* (EHRBG.) and to present data upon the conditions in the environment under which each type is known to have been living. Environmental data are also presented for the typical form of the species in order that comparisons may be made between each variation described and the more typical form. The observations were made incidental to an ecological study of the Protozoa inhabiting Crystal Lake, Norman, Okla., U.S.A. a full report of which will subsequently be published.

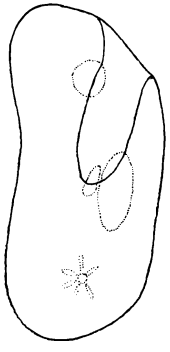

Fig. 1. Typical form of Paramecium bursaria as seen in ventral view. Given for comparison with the variations shown in the other figures.

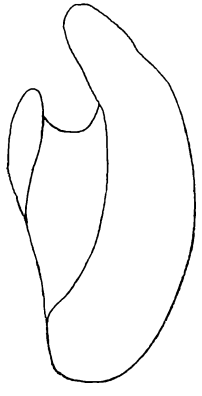

Fig. 2. Variation A, ventral view.

Protozoan collections were made from several types of ecological environments in the lake, approximately weekly between Oct. 5, 1935 and June 1, 1936. From each station the following environmental data were recorded: p_H, dissolved CO_2, bound and half-bound carbonates, dissolved O_2, and water temperature. p_H was taken in the field with a Hellige colorimetric apparatus. Carbon dioxide and the carbonates were determined by the Seyler method and oxygen by the Winkler method as outlined by BIRGE and JUDAY (1911).

The typical form of *P. bursaria* was taken in forty different collections and, in all but a few of these, individuals were abundant. Without exception, the species was found only where filamentous algae were growing in some quantity; often occurring within heavy

mats of *Spirogyra*, *Zygnema*, etc. growing at the surface of the water. Occasionally a few would be found among similar algae growing on the piles of piers projecting into the lake. The ecologic conditions under which the species was found are summarized in Table 1. The data show that it exhibits wide tolerance to changes in the environmental factors studied, a fact also shown by the data of Noland (1925) and of Wang (1928).

Variation A (Figs. 2 and 3) was found among water weeds and algae, Nov. 9, 1935. With it were associated four species of *Difflugia*, *Arcella discoides*, three species of *Euglena*, *Trachelomonas volvocina*, *Peridinium*, sp., *Volvox aureus*, *Vorticella* sp., *Aspidisca lynceus*, and the typical form of *Paramecium bursaria*. The last named form and the various euglenoids and *Difflugia* were especially abundant.

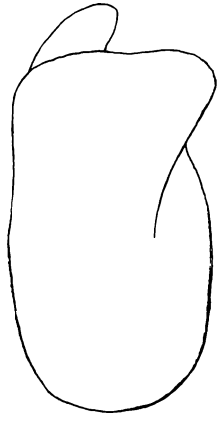

Fig. 3. Variation A, dorsal view.

The organism in question was slightly larger than the typical form and of quite different shape. Two lobes extended anteriorly from the sides of the buccal groove as shown in Fig. 2. The left side was markedly more rounded than that of the typical form as seen from the ventral surface and tended toward convexity rather than concavity as seen from the dorsal (Fig. 3). The buccal groove was very deep and was placed more to the right than to the left side. The whole outer surface was ciliated. Internally, the organism showed no marked variation from the typical form of the species. Zoöchlorellae were abundant in the endoplasm and the active cyclosis typical of the species was very evident.

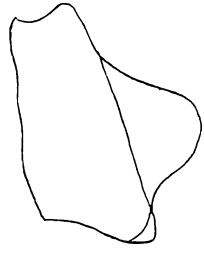

Fig. 4. Variation B, lateral view.

Variation B was found on Jan. 4, 1936 among epiphytic algae. The only Protozoa found with it were *Vorticella* sp. and *Sphaerophyra* sp. neither of which was abundant. The shape of this organism was very peculiar (Fig. 4). It was bilobed posteriorly and one lobe was enlarged laterally to produce a large swelling on one side. The buccal groove extended between the two lobes. This specimen was also green and its internal structures were typical of those of the species.

Variation C was found Jan. 18, 1936 in a culture originally collected from the top of a brownish algal mat on Jan. 11. Asso-

ciated with it were a small species of *Amoeba*, *Chilodon vorax* (?), *Chilodon* sp., *Cyclidium glaucoma* (very numerous), *Paramecium aurelia*, and the typical form of *P. bursaria*. As originally collected, the culture contained *Peridinium tabulatum*, *Chilodon vorax*, *Chilodon* sp., *Aspidisca costata*, *Urostyla grandis*, *Euplotes* sp., and the typical *P. bursaria*. Several unidentified species of Hypotrichida were also present. Individuals of the typical form of *P. bursaria* were very numerous in both cases.

The animal is shown in Fig. 5. The anterior end was markedly curved toward the ventral side and the ventro-lateral border of the buccal groove irregular in outline. The body was depressed anteriorly but was rounded out to an ovoid form toward the posterior region.

Fig. 5. Variation C, lateral view.

Fig. 6. Variation D, ventro-lateral view.

Variation D occurred in two collections from the same pool taken on Mar. 28, 1936. The first of these was taken from a dense mat of filimentous algae; the second by scraping epiphytic algae from the stems of cattails (*Typha* sp.). In the algal collection the following Protozoa also occurred: *Amoeba* sp., *Difflugia lobostoma*, *Peridinium tabulatum* (very numerous), *Coleps bicuspis*, *Coleps uncinatus*, *Chilodon* sp., *Strombidium* sp., *Lionotus wrzesniowskii*, and the typical form of *P. bursaria*. In the second collection, *Peridinium tabulatum*, *Ophryoglena acuminata*, *Trachelomonas volvocina*, *Euglena spirogyra*, *Euglena* sp., *Stylotricha secunda*, *Difflugia lobostoma*, and typical *P. bursaria* occurred.

The body of this animal was almost ovoid and with a blunt process on the anterior end. Otherwise is was similar to the typical form of the species. An outline of the animal is shown in Fig. 6.

Variation E was seen twice, the first time in a collection from among algae on Feb. 29, 1936, the second time in this same collection after it had stood a week in the laboratory. As first seen it was associated with two species of *Euglena*, *Lacrymaria olor*, and typical *P. bursaria*. In the week-old culture occurred *Chilodon* sp., *Chilomonas paramecium* (very numerous), *Euglena gracilis*, *Vorticella campanula*, *Lionotus* sp., *Amphileptus claparedei*, *Aspidisca costata*, and several types of small flagellates which were extremely numerous as individuals.

This animal resembled very closely the one described as variation D as will be apparent from comparison of Figs. 6 and 7. The

Table 1.

Environmental conditions under which *Paramecium bursaria* has been found living in Crystal Lake. Numbers of determinations are in parentheses.

	p_H		Temp. C		O_2 c. c. per l		CO_2 p. p. m.		Carbonates		Bicarbonates	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
Typical Form (Fig. 1)	6.0 8.8	7.8— (37)	0.0 26.0	15.8+ (38)	2.02+ 8.51+	5.63— (38)	0.0+ 23.5	6.78— (38)	7.5 81.5	49.7+ (34)	29.5 81.5	49.3+ (34)
Variation A (Fig. 2 and 3)	8.0 (1)		18.0 (1)		6.70+ (1)		5.5 (1)		47.0 (1)		47.0 (1)	
Variation B (Fig. 4)	7.6 (1)		8.0 (1)									
Variation C [1] (Fig. 5)	7.6 (1)		11.0 (1)		8.38— (1)		5.0 (1)		32.0 (1)		32.0 (1)	
Variation D (Fig. 6)	8.8 (1)		16.0 (1)		3.72— (1)		3.0 (1)		50.5 (1)		50.5 (1)	
Variation E (Fig. 7 and 8)	7.4 (1)		12.0 (1)		8.17— (1)		5.0 (1)		63.0 (1)		63.0 (1)	
Variation F (Fig. 9 and 10)	8.0 (1)		18.0 (1)		2.37+ (1)		11.5 (1)		56.0 (1)		56.0 (1)	

principal difference between them was that this animal had an acute rather than a rounded point at the anterior end. Fig. 8 shows approximately how a section of the body through XY, Fig. 7 appears. It is to be noted that the body approaches ovoid in general shape.

Variation F appeared in a collection taken from filamentous algae on Mar. 21, 1936. The following Protozoa were also found in this collection: *Trachelomonas hispida* (common), *Euglena* sp., *Peridinium tabulatum*, *Pandorina morum*, *Difflugia lobostoma* (common), *Pseudodifflugia gracilis*, *Dileptus* sp., *Lembadion bullium*, and typical *P. bursaria*.

This animal when seen from dorsal or ventral view appeared much like variations D and E. When seen laterally, however, it proved to be much more flattened. The animal is shown in Fig. 10. Fig. 9 gives approximately the sections of the body at the levels indicated by the letters A, B, etc. on Fig. 10.

Discussion.

From the data presented it would seem that the variations described probably were not caused by the reactions of the animals to conditions of p_H, temperature, dissolved O_2- or CO_2- content, nor

[1]) Data based upon the conditions found at the time of the collection of the sample. The variation appeared a week later in a culture in the laboratory. The environmental conditions had undoubtedly changed in the interval.

the concentrations of the carbonates or bicarbonates in the waters of the lake. The typical form of the species was found in both acid and alkaline conditions of p_H (p_H 6.0—8.8) although acid conditions in this small soft-water lake occur only locally at protected shore stations and are usually transitory. All of the variations were found in alkaline water (p_H 7.4—8.8) and in most cases the typical form of the species occurred abundantly on the same microscopic slide as the variation. Table 1 shows that other environmental factors studied also probably had no effect in the production of the variations. One can only suppose that they were caused by environmental factors which were not studied or that they were genetic in origin. I am inclined to think the latter possibility the more probable.

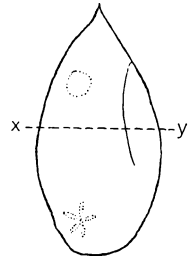

Fig. 7. Variation E, ventro-lateral view.

Fig. 8. Approximate X-section, taken through XY, Fig. 7.

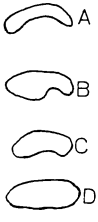

Fig. 9. Approximate X-sections of variation F, taken respectively at levels shown at A, B, C, and D of Fig. 10.

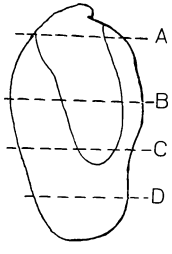

Fig. 10. Variation F, ventral view.

About 150 species of Protozoa have been collected in the lake, many of them several times, yet none of these have shown as marked variations in form as those here described in *P. bursaria.* For example, *Cyclidium glaucoma* has been taken 13 times; *Vorticella campanula,* 15; *Trachelomonas volvocina,* 46; *T. hispida,* 57; *Volvox aureus,* 50; and *Difflugia lobostoma,* 55 times. Of these *Trachelomonas hispida* and *Difflugia lobostoma,* especially the latter, were the most variable forms. Both belong to genera whose species are known to vary considerably, yet neither of these species showed as wide variations from the form typical of the species as some of those described here in *P. bursaria.* On the other hand, both *Trachelomonas* and *Difflugia* were much more consistant in their variations both as to the number and as to the types of them.

From the above, the following conclusions may be drawn:

1. *Paramecium bursaria* (EHRBG.) is a more variable species than is commonly supposed.

2. The variations are of less frequent occurrence than in some other Protozoa known to vary (e. g., *Difflugia lobostoma*, *Trachelomonas hispida*).

3. Variations which occur are likely to depart widely from the form characteristic of the species.

4. Nothing positive was learned as to what may have caused the variations observed.

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