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ON A NEW BRAZILIAN FORM OF *FREDERICELLA SULTANA* [BRYOZOA PHYLACTOLAEMATA]

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With my husband, Dr. ERNEST MARCUS, I passed a holiday at Umuarana (Campos de Jordão, State of São Paulo) in January 1946. There we found an abundant material of a new subspecies of *Fredericella sultana* (Blumenbach 1779) in an artificial lake. The lake lies in the hills (Serra da Mantiqueira) at 1750 m. The colonies grow on submerged twigs and decaying leaves of the surrounding trees and Bromelias, as well as on various transient water plants and reeds. In many places the zoaria were exposed to direct sunlight. The accompanying fauna can be summarized as follows: tame ducks, carp, water beetles and various insect larvae, (f. ex. Chironomidae), numerous Cladocera, Ostracoda, Copepoda and Amphipoda, scarce Oligochaeta (chiefly *Dero sawayai* Marc.), some Rotifera, and of Turbellaria many Catenulida, few Rhabdocoela (f. ex. Dalyelliidae), Alloeocoela (*Prorhynchus stagnalis* M. Sch.), and some Ciliata.

Description of *Fredericella sultana crenulata*, subsp. nov.

The colonies are for the most part attached to the substratum with the tips of the zooecia erect (Fig. 1). Only in older central parts single branches grow upright for a short extent, no more than 10-15 mm., and not fused together. The ectocyst is generally rather tender and of light brown colour. The degree of incrustation with living diatoms, their empty skeletons, and debris varies. It is however in all colonies so slight that it is possible to see the polypides as well as the statoblasts.

The diatoms show a distribution (Fig. 3) similar to that described by WESENBERG-LUND in typical *sultana* (1896, pp. 262-263, t. 1, f. 4). They lie principally parallel to the stem in recumbent tubes. In the erect tips and in upright branches they lie in circles around

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the tubes. Tangential sections of such erect parts (Fig. 10) pass first through the layer of diatoms (m), then through the chitinous ectocyst (e), the epithelium of the endocyst (d), the circular (a) and the longitudinal (p) parietal muscles. The longitudinal fibres are much stronger and more numerous than the circular ones. Contraction of the longitudinal muscles produces transverse folds of the epithelium and the still semi-liquid ectocyst in the young growing cones. Such folds will take diatoms with them and dispose them in circles.

The zooecial tubes are keeled and triangular in cross-section (Fig. 6). The keel continues with a slight projection at the zooecial orifice (Fig. 2) that is lower on the opposite side. A furrow in the keel was not observed. The diameter of the cystids ranges from 0,3 to 0,5 mm. with an average of 0,4 mm. Dissepiments, wanting in *F. australis* and its forms (ROGICK 1945, p. 217), occur sometimes in *crenulata* in the main stem after giving off a branch. Large parts of a colony can be without septa. A branch of 2,4 cm. with 3 bifurcations, 31 polypides, and 30 statoblasts did not contain any dissepiment.

The zooecia are up to 7 mm. in length, generally 4-5 mm. They are either recumbent for the whole length, or the distal part, up to 4 mm., is directed upwards (Fig. 4). The polypides are as slender as in *F. sultana*, not stubby as in *F. australiensis* var. *browni* Rogick (1945, p. 218). Full-grown retracted and preserved polypides of *crenulata* measure ca. 2 mm. from the tip of the tentacles to the bottom of the stomach. The length of the tentacles is 0,6-0,8 mm. The polypides of typical *sultana* from Europe (river Bille near Hamburg; KRAEPELIN leg. et det.) measured for comparison were of the same size as *crenulata*; such from the river Yare (H. E. HURRELL leg. et det. 1925) attain 2,5 mm. In typical *australiensis* the tentacles are 1 mm. in length (GODDARD 1909, p. 491); in its var. *browni* the average is 0,451 mm. (ROGICK 1945, p. 225).

The number of tentacles varies between 22 and 28, 24-26 being the most common numbers. Their breadth is 0,02-0,024 mm. and their external-internal diameter 0,024-0,028 mm. A cross-section of a polypide in HURRELL's colony had 20 tentacles measuring 0,017-0,02 mm. and 0,02-0,024 mm.

The expanded tentacular crown is circular and bell-shaped (Fig. 3). Cross-sections of retracted polypides show a horseshoe-formed lophophore (Fig. 6), also those from the river Yare (typical *sultana*). In January 1946 no reproductive organs were seen in *crenulata*.

Statoblasts were abundant, up to 6 in one zooecium, and 18 to one cm. length of cystidial tube (Fig. 5). So they are much more numerous than the average in the Michigan colonies of typical *sultana* (BROWN 1933, p. 284: 5 statoblasts per square centimeter). Their colour is dark brown, dried they are almost black. Both valves have

nearly the same convexity, the one is slightly more convex in the long axis and the other in the short axis. The length of the statoblasts (20 readings) varies from 0,325 to 0,382 mm. with an average of 0,355, the width between 0,265 and 0,305 mm. with an average of 0,287 mm. The proportion of length to width averages 1,23:1; so the outline is a broad ellipse. The height of the statoblasts measured in the preserving alcohol is approximately 0,2 mm. Dried ones shrink and one of the valves turns concave; the height decreases to 0,1-0,12 mm. (Fig. 8).

The chitinous capsule (Fig. 9, v) is very thick, up to 0,019 mm., generally it is 0,013-0,014 mm. Both valves have a regular pattern of pits (Fig. 7) that stand about 0,007 mm. one from the other. Every pit corresponds to one formative cell. When secretion of the chitinous substance begins, the capsule is smooth and the formative cells are polygonal prisms that are much higher than broad (Fig. 11). As secretion proceeds, the cells become lower and at last quite flat. Corresponding to their borders polygonal ridges appear on the capsule. These grow and finally fuse forming a thick layer of chitinous mass. On its surface the nuclei of the formative cells can still be seen for a time embedded into the cuticular substance in the center of the pits.

I do not know whether the thickness of the chitinous wall in the statoblasts (up to 0,019 mm.) of the present subspecies is of taxonomic value, because I have found only one figure (KRAEPELIN 1892, f. 151) of a section of a statoblast of typical *sultana*. Although KRAEPELIN says that the section belongs to a "nearly complete" statoblast, I cannot consider the diameter of the wall (0,003 mm.) as approximately definitive for the typical form. The formative cells in KRAEPELIN's figure are still so high that they seem to contain much more material for the capsule.

The statoblasts of *crenulata* do not show any traces of a float (annulus) or chitinous material attaching them to the endocyst ("Chitinstreben" KRAEPELIN 1887, p. 101; ROGICK 1945, p. 227, f. 8, 9, CH). They lie free in the cystidial tubes. The border of the statoblasts is slightly extended and forms a flat transparent rim that projects 0,008 mm. (Fig. 9, r) over the surface of the capsule. The rim is crenulate with denticles of 0,001-0,002 mm. in breadth, and is a very conspicuous feature of the subspecies (Fig. 7). This crenulate border is absent in typical *australiensis* (GODDARD 1909, t. 47 f. 8-11), in *australiensis* var. *browni* (ROGICK 1945, f. 8), typical *sultana* (ROGICK 1935, f. 1; BRIEN 1936, f. 24) as well as in all its subspecies and varieties. The crenulation is also missing in *P. sultana indica* (ANNANDALE 1911, f. 41 A), the statoblast of which resembles that of *crenulata* in outline and somewhat in pattern. In *indica* only the dorsal valve is sculptured.

Remarks on the taxonomy and occurrence of *Fredericella*

Adopting the system of the Phylactolaemata proposed by MARY D. ROGICK (1935a, p. 155) and followed by MARCUS (1942, p. 71), I consider the Fredericellidae Hyatt (1866, p. 7) as a separate family characterized by the occurrence of sessoblasts (ROGICK 1943, p. 172) only and a lophophore that is circular or elliptical in adult evaginated polypides. In young ones the lophophore is cordiform (MARCUS 1926, pp. 285-286, fig. 4) and in the buds horseshoe-shaped (BRIEN 1936, p. 576). This transformation of the lophophore was already observed by DUMORTIER & VAN BENEDEN (1850, pp. 58-59). Transverse sections of adult retracted polypides (Fig. 6) show that the lophophore is folded in horseshoe-shape to fit into the tentacular sheath (ANNANDALE 1911, p. 208; ROGICK 1945, fig. 1). Besides the morphological characters of the Fredericellidae there evidently exists a physiological particularity in *Fredericella sultana*, viz. its extraordinary capacity of regeneration (OTTO 1921, pp. 412, 425; BRIEN 1936, pp. 616-621).

It is true that LEVINSEN (1894, p. 36), BORG (1930, p. 111), WESENBERG-LUND (1937, pp. 404, 407), MARCUS (1940, p. 357), and others, preserve ALLMAN's sub-division of the Phylactolaemata (1856, p. 76) and distinguish only two families: Plumatellidae and Cristatellidae, including *Fredericella* in the first. Probably these authors, as BRAEM (1890, p. 12) and WESENBERG-LUND (1896, p. 265-266) explicitly did, wished to keep at a distance from KRAEPELINS phylogenetic theory (1887, p. 161; 1892, p. 61) on the homologies between the Paludicellidae Allman (1856, p. 113) and the Fredericellidae, the two families that constitute the Polypiarina infundibulata of GERVAIS (1937, p. 80), the fresh-water Bryozoa with tentacles "en entonnoir" (VAN BENEDEN 1847, p. 5). Certainly the resting buds of *Paludicella* and the statoblasts of the Phylactolaemata, particularly those of *Fredericella*, are similar structures and morphologically comparable (HARMER 1913, p. 447). Ontogenetically they are different (BRAEM 1914, p. 544) and therefore only analogous (ANNANDALE 1915, p. 74).

The separation of Fredericellidae and Plumatellidae avoids an excessive enlargement of the latter family that already comprises two subfamilies: the Plumatellinae Annandale (1911, pp. 211, 212) and the Hyalinellinae Marcus (1942, p. 71).

The only genus of the Fredericellidae is *Fredericella*. As a rule the specialists give GERVAIS (1838 or 1839) as the author of the genus, but BASSLER (1934, p. 39) and NEAVE (1939, p. 421) indicate ALLMAN 1844. NEAVE says that GERVAIS wrote *Fredericella* in two papers, one of 1838, and the other of 1839. It is true that the universally adopted form *Fredericella* is used by ALLMAN (1844, pp. 329, 331). I have

found *Frédéricelle* in a report on one of the original communications of GERVAIS (Revue Zoolog. par la Société Cuvierienne, année 1838, p. 311, printed in 1839). The name *Fredericella* is already used by H. MILNE-EDWARDS (1839, p. 184) in an other report on the first publication. Therefore we ought to write *Fredericella* H. Milne-Edwards, 1839. The name for the generic type, *Tubularia sultana*, not the description given in 1774, was published by BLUMENBACH in 1779 (DUMORTIER & VAN BENEDEK 1850, p. 57; ALLMAN 1856, p. 60; BRAEM 1908, p. 1, note 1; ROGICK 1940, p. 195).

The world-wide distribution of *Fredericella sultana* (Blbch.) and its subspecies and varieties was recently detailed in the monograph of the danish Bryozoa (MARCUS 1940, pp. 360-361). In that survey the Australian localities (WHITELEGGE 1889, p. 323; GODDARD 1909, p. 489) must be suppressed because of MARY D. ROGICKS recent specific separation of *F. australiensis* from *sultana*, and Mexico (RIOJA 1940, p. 586) and Japan (TORIUMI 1941) are added. The specimens from New Zealand with 22 tentacles (DENDY 1906) are not *australiensis*; their statoblasts were not seen; they may belong to typical *sultana*. As for the geographical statement of many species of fresh-water Bryozoa also for that of *F. sultana* the opinion of ANNA B. HASTINGS (1938, p. 531) holds true: "the whole question of the status of the various *Fredericella* needs reconsideration after the examination of much more material".

According to the present state of the bibliography *F. sultana* includes as synonyms the three North American species (DAVENPORT 1904, p. 216; ROGICK 1940, p. 196): *regina* Leidy 1851, *walcottii* Hyatt 1868 (should be *walcottae*; see *ibid* p. 91), and *pulcherrima* Hyatt 1868. ABRICOSSOFF (1925, pp. 51, 56) thought at first that *regina* might be a subspecies, but later on (1927, pp. 85, 91) he considers it a synonym. The same author described material from Karelia (1926, p. 45; 1933, p. 385) as intermediate between typical *sultana* and *dupl. ssisi* Forel, known from the depths of subalpine and alpine lakes and from Greenland (WESENBERG-LUND 1907). The latter can therefore only be counted as a growth-form of *sultana* ("saeregen Vaekstform" WESENBERG-LUND 1937, p. 407). As ANNA B. HASTINGS (1938, pp. 530-531) has shown, *F. sultana jordanaica* Annandale (1913, p. 223), described as a subspecies, cannot be separated specifically from *F. sultana* as ABRICOSSOFF did (1927a, p. 308). Also *F. cunningtoni* Rousset (1907, p. 254) and *F. indica* Annandale 1909 (*id.* 1911, pp. 209-211; the specimens mentioned on p. 245 are typical *sultana*, see *id.* 1913, p. 224) are not independent species. The statoblasts of *cunningtoni* are unknown; LOPPENS (1908, p. 158) held it for a variety, and other workers on African material adopted this

opinion (ULMER 1912, p. 286; KRAEPELIN 1914, p. 58). BORG (1936, pp. 23-24) is inclined to go farther, taking *cunningtoni* as a local form (he says "modification"), but as long as *cunningtoni* has not been re-examined, and intermediate colonies have not been found, I think that *cunningtoni* must preserve subspecific rank (ABRICOSSOFF 1925, pp. 51, 56). CUNNINGTON (1920, p. 539) maintains *cunningtoni* separated from *sultana*. In their observations on the Polyzoa of the Kumaon Lakes ANNANDALE & KEMP (1912, pp. 130, etc., 140) still took *F. indica* for a species; later on, when ANNANDALE (1913, p. 224) identified the material from the Western Himalayas with the typical *sultana*, he called *indica* a race, and continued so (1919, p. 91). As *indica* seems to be restricted to the plains of India, and the differences between it and the European *sultana*, although unimportant, are constant, it may be considered as a subspecies. The great number of tentacles (28-32) makes it probable that also the North Swedish form *major* Borg (1936a, p. 275) is a subspecies. *F. sultana* var. *grandigemmis* with "very big statoblasts" (ABRICOSSOFF 1927a, p. 308) cannot be judged until it is fully described and illustrated. Of *F. lepnevae* (ibid.) from the Altai I have not found any description (see Zool. Rec. v. 73, p. VII, 38).

The South American specimens from the Magellanic region (KRAEPELIN 1893, p. 14; CALVERT 1904, p. 39) and from Brazil (KRAEPELIN 1914 p. 58) belong most probably to typical *sultana*; otherwise KRAEPELIN would have noted whichever particularities.

Fredericella sultana transcucasica Abricossoff (1927, p. 87, 91) is regarded as a variety of *F. australiensis* Goddard 1909 by MARY D. ROGICK (1945, p. 216, etc.).

The highest altitude in which *F. sultana* was collected is 3480 m. in the Uintah Mountains, Utah. The greatest depth is 214 m. in Lake Lucerne (ZSCHOKKE 1906; MARCUS 1930, p. 326), where the temperature remains between 4 and 5° C. (BROWN 1933, p. 278). The indication of 1825 m. (HEDDING 1938, p. 1) is certainly a typographical error.

I cannot repeat here the manifold excellent observations of BROWN (1933) with regard to the conditions of life of *Fredericella* and other fresh-water Bryozoa. I only wish to emphasize his experiments on the means of distribution of the statoblasts. There are only few records of Arthropods and birds (ducks and herons; HARMER 1913, p. 435) that retained statoblasts on the surface of their bodies (MARCUS 1925, p. 44). BROWN fed vertebrate carriers of all classes with statoblasts, and established that at least a few of them pass through the digestive tract of Vertebrates unharmed. Of *Fredericella* some statoblast germinated after having been retained during 5-14 days in turtles and 14-26 hours in ducks.

Although the name *lucifuga* appears in the older synonymy of *F. sultana*, and the species as well as *F. australiensis* (GODDARD 1909, p. 487) belongs to the fauna of tanks and pipes of water-works (HARMER 1913; ANNANDALE 1921), the "Lady polyzoon" (HURRELL 1916, p. 33) does not avoid the light (JULLIEN 1885, p. 127; BROWN 1933, p. 277; BORG 1941, p. 485). The species is eurythermic; it lives in eutrophic, oligotrophic, and dystrophic habitats (BORG 1941, pp. 484-485) and in still and slow-flowing waters as well as in swift-running ones (OTTO 1921, p. 400). It occurs also in brackish water (HYATT 1868, p. 93), but there the colonies are small. Recent observations (ROGICK 1940a, p. 164) however have shown that the animals died after a hurricane that suddenly turned a fresh-water pond brackish (salinity 3.57 per thousand). A possible attempt of the statoblasts to germinate had not advanced very far (ROGICK 1941, p. 454). *F. sultana* settles on stones, roots, living and dead water-plants; on twigs and decaying leaves, but in some regions, f. ex. in Sweden, it rarely occurs on living plants (BORG 1941, l. c.), on which it is common in Denmark (WESENBERG-LUND 1896, p. 260). The colonies can also grow sticking in mud or lumps of filamentous algae and on colonies of Protozoa (OTTO 1921, l. c.).

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PLATES I-II

PLATE I

Fredericella sultana crenulata, subsp. nov.

1. Colony growing on a dead leaf.
2. Zoocelial tubes belonging to several branches growing on a reed.
3. A branch with four tentacular crowns expanded, showing the distribution of the diatoms in the ectocyst.
4. Various aspects of recumbent and erect zoocelia.
5. Some zoocelial tubes with a total length of 14 mm. containing 22 statoblasts.
6. Part of a cross-section of a zoocidium with retracted polypide on the level of the membrane (e) that unites the tentacles (t) at their base. The keel (k) of the ectocyst (c) and the horseshoe-shape of the lophophore are visible. d, endocyst. s, tentacular sheath.

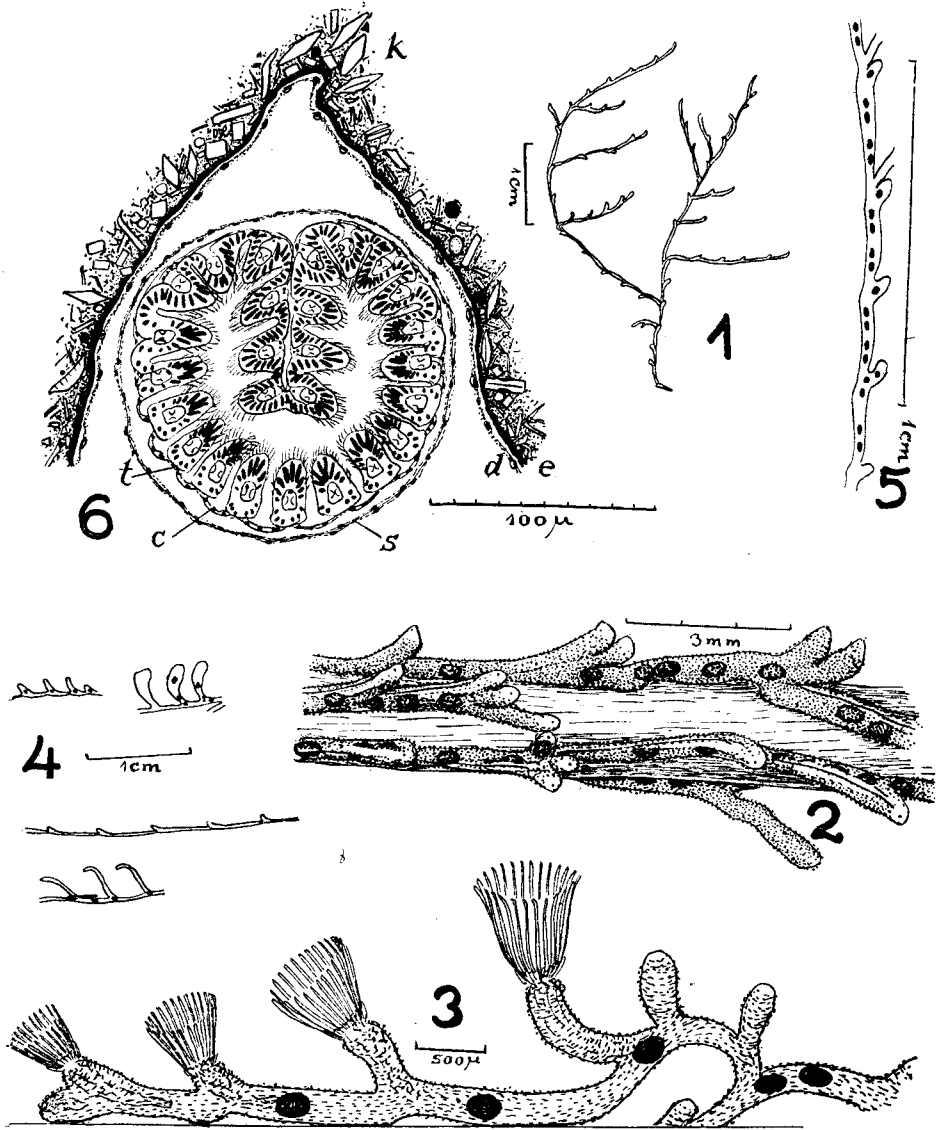
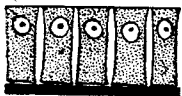
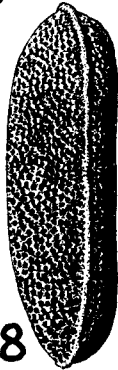
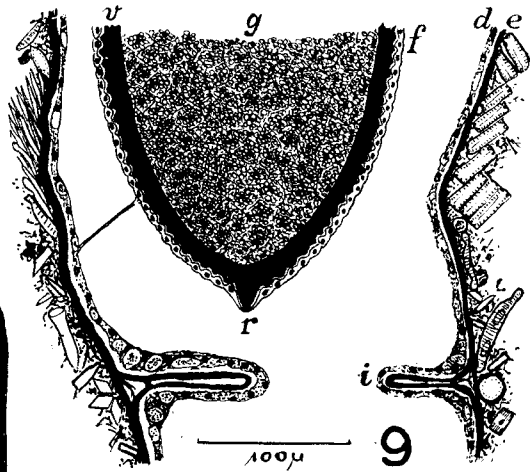
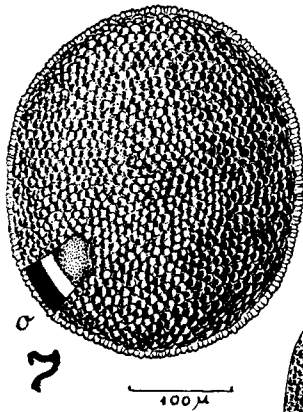


PLATE II

Fredericella saltana crenulata, subsp. nov.

7. Statoblast in water seen from above; o, a part showing the crenulated rim, the thick capsule and the germinative material.
8. Dry statoblast seen from the side.
9. Longitudinal section of a zooecial tube with ectocyst (e), endocyst (d) and septum (i), and of a nearly complete statoblast that shows the formative cells (f) of the capsule, the rim (r), and the wall of the latter, and the germinative material (g).
10. Tangential section through the erect part of a zooecium, passing through the diatoms (m), the ectocyst (e), the epithelium of the endocyst (d), and the layer of circular (a) and longitudinal (p) parietal muscles, showing the mostly annular disposition of the incrusting diatoms.
11. Five successive stages of the secretion of the chitinous capsule of the statoblast; simplified.



11

