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Preliminary Observations on the Influences of Food and Other Factors on the Growth of Bryozoa

With the Description of a New Apparatus for Cultivation of Sessile Plankton Feeders[1])

By DIETHARDT JEBRAM

Abstract: Different food species cause modifications in the growth forms of bryozoan species. Under cultivation conditions a "stolonization of zooids" is possible in *Bowerbankia* spp. In some species, e.g. *Conopeum seurati* and *Alcyonidium* spp., the numbers of tentacles are influenced by external and physiological conditions. Observations on the brackish water Membraniporid *Conopeum seurati* are summarized, which revealed that maturity and growth of the erect form are effected by a complex of interdependent factors (colony size, food, temperature, salinity). It is stressed that greater attentions should br paid to the ecologial conditions by taxononoists and systematists. Numerical inquiries and statistical comparisons which ignore the influences of external factors on the growht forms are questionable. Cultivated Bryozoa may develop forms which under natural conditions will not normally be realized, but which may be of systematic importance.

A new cultivation apparatus for long term rearing of sessile plankton feeders has been developed. The experimental vessel of the apparatus has a U-bottom of perspex to sustain a vertical water rotation. The water movement is produced by water in a container vessel, raised above the level in the experimental vessel by an improved type of a bubble-pump. The experimental animals can be observed with a stereo-microscope or with a photo-apparatus without removal from the experimental vessel.

Erste Beobachtungen über den Einfluß des Futters und anderer Faktoren auf den Wuchs von Bryozoen sowie die Beschreibung eines neuen Apparates für die Kultivierung von sessilen Planktonfressern (Zusammenfassung): Verschiedene Futterarten verursachen Modifikationen in der Wuchsform bei einigen Arten von Bryozoen. Unter Kulturbedingungen ist bei Arten von *Bowerbankia* eine „Stolonisierung von Zooiden" möglich. Die Anzahl der Tentakeln bei einigen Bryozoen-Arten, z. B. *Conopeum seurati* und *Alcyonidium*-Arten, wird durch äußere und physiologische Bedingungen beeinflußt. In einer ersten Zusammenfassung von Beobachtungen an der Brackwasser-Membraniporiden *Conopeum seurati* wird dargestellt, daß sowohl die Geschlechtsreife als auch die Bildung der forma erecta durch einen Komplex von sich gegenseitig beeinflussenden Faktoren (Kolonie-Größe, Futter, Temperatur, Salzgehalt) bedingt werden. Es wird betont, daß die ökologischen Bedingungen bei Arbeiten über Taxonomie und Systematik stärker als bisher berücksichtigt werden müssen. Numerische Erhebungen und statistische Vergleiche haben keinen Nutzen, wenn sie nicht zu genau bekannten Umweltfaktoren korreliert sind. Kultivierte Bryozoen können Formen ausbilden, die unter Freilandbedingungen normalerweise nicht realisiert werden, die aber für die Systematik von Bedeutung sein können.

Eine neue Kultivierungsapparatur für Langzeit-Standard-Hälterung von sessilen Planktonfressern ist entwickelt worden. Das Experimentiergefäß der Apparatur hat einen parabolischen Boden aus Plexiglas, um eine vertikale Rotation des Wassers aufrechtzuerhalten. Die Wasserrotation wird durch Wasser in einem Vorratsgefäß erzeugt, das durch einen verbesserten Typ einer Blasenpumpe über das Niveau des Wassers im Experimentiergefäß gehoben wird. Die Versuchstiere können mit Hilfe eines Stereo-Mikroskopes oder eines Fotoapparates beobachtet bzw. protokolliert werden, ohne daß sie aus dem Versuchsgefäß herausgenommen werden müssen.

Introduction

Bryozoa reared over long periods of time may show morphological details not known from specimens from natural environments (JEBRAM, 1968). This observation encouraged

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[1]) Paper read on Sept. 7, 1971, at the Second International Conference of the International Bryozoology Association in Durham, England.

me to continue the work with cultivated Bryozoa and to search for the influences of external factors on biology and form building.

Results

1. Influences of food on the growth

Firstly, some qualitative observations will be described which must in future be completed by quantitative details:

The size of the zooid varies with quantity and quality of food. Unsuitable nutrition causes the growth of considerable smaller zooids, whilst under optimal food conditions larger cystid buds than normal ones are built. This has been observed in *Conopeum seurati* (Canu), various *Alcyonidium* spp., *Farrella repens* (Farre), and *Triticella korenii* G. O. Sars. The length of the cystid peduncles of the two latter species seems also to depend on the food.

Size and proportions of the gut is also influenced by the nutrient conditions. The gut, especially the caecum, may be expanded passively by large food supply, because Bryozoa are eager feeders and take up food as long as the animals are undisturbed and suitable food is present. On the other hand the gut increases by active growth under good food conditions. This may be observed during some days in the individual development of an evaginating and feeding polypide.

Use of monofood has shown important effects of different food species on the growth and biology of Bryozoa:

Colonies of *Farrella repens* showed a slow vegetative growth by *Monochrysis lutheri* as food, and did not become mature. With *Oxyrrhis marina* as food, *Farrella repens* became mature, but the growth of new zooids was not quick. With *Cryptomonas* sp. as food, *Farrella* quickly built new stolons and zooids, and became regularly mature.

With *Monochrysis* as food, *Bowerbankia gracilis* Leidy became mature and showed a quick growth of long stolons, with comparatively few zooids (fig. 1). The zooids were slender and tall, but they were not much elongated by regenerative growth (maximum height was about three times the primary height). With *Cryptomonas* as food, *Bowerbankia gracilis* and *B. imbricata* (Adams) became mature, but the stolons did not grow quickly; after a longer period of time many zooids were produced along the stolons, which became densely populated (fig. 2). Some of the zooids became longer and longer by regenerative growth.

2. "Stolonization of zooids"

Physiologically exhausted polypides of *Bowerbankia gracilis* and *B. imbricata* are renewed by new polypides in the same cystid in the manner described by Braem (1951) for *Victorella pavida* Kent. When a polypide degenerates, in most cases the vestibulum remains evaginated. So the old collar is situated at the top of the zooid, under which the hidden inner vestibulum opening becomes closed. This closing was also observed in *Alcyonidium gelatinosum* (L.) by Bobin & Prenant (1952). Tentacles and tentacle sheath degenerate at first; during degeneration of the gut the developing brown body is shifted into the proximal part of the cystid.

While the old polypide degenerates, a bud for a new polypide grows in the cystid wall at the oral side, at a small distance from the cystid top, and connected with the old vestibulum opening. The polypide bud forms a gut, tentacles with tentacle sheath, and a new vestibulum with a new collar. When the polypide has attained its full growth, the old vestibulum opening opens and becomes the new aperture. During the first evagination of the new polypide the old collar bursts along its side and becomes situated at the side of the zooid near the aperture, from which position it falls off after some time. Sometimes several old collars may remain at the side of a zooid, as shown in animal A (fig. 3). In some cases the old vestibulum remains invaginated during the change of the polypides, but in each case the old vestibulum develops into an elongation of the cystid, because each new polypide forms its own new vestibulum. In this way the old zooids may become very long, but fig. 4 shows, that not all zooids in a colony will become much elongated.

In *Bowerbankia* as well as in *Alcyonidium*, *Flustrellidra*, and many other ctenostomatous species the brown bodies are not eliminated from the zooid as the first faeces but deposited in the proximal part of the cystid.

In cultivated colonies of *Buskia nitens* Alder, some years ago, I have also seen elongations of cystids by replacement of the polypides. So, tubelike cystids, pointing upwards from the substratum, were produced, which looked atypical for *Buskia nitens*. At first these "abnormal" zooids were considered to be malformations, and therefore I neglected to make drawings of them.

In *Bowerbankia gracilis* and *B. imbricata* the elongation of the zooids by replacement of polypides may attain considerable length, as demonstrated by animal C in fiig. 5. In principle this elongation of zooids seems not to be limited by the endogenous constitution, as I found in my cultivated colonies. A break-down of the elongation growth could always be traced back to bad external conditions, for example unsuitable quality or quantity of food, or a defect in the chemical conditions of the cultivation medium. For example the injuries in the animals A^{I}, C^{I}, C^{II}, C^{III} C^{VI}, (C^{VII},) (C^{VIII}), C^{X} and its descendants C$^{(X)}$ and C$^{(X)\prime}$ in fig. 5 were caused by too late a renewal of food and medium; as a result there was uncontrolled propagation of indigestible Ciliates (from spores in the air) in the cultivation vessels.

The elongation of the zooids causes a change in the physiology of growth. Under good nourishment a light yellow yolklike reserve will be deposited in the proximal part of the elongated cystids between the brown bodies (animals C, D, F, H in fig. 3, several animals in fig. 4, B in fig. 5), as well as in the original stolons. When the zooids have attained a length of more than twice their primary size, a septum may sometimes be built, separating the proximal cystid part from the distal part, which includes the polypide or a polypide bud (animal C in fig. 5 and G in fig. 6).

The change in the growth physiology of the elongating zooids of *Bowerbankia gracilis* and *B. imbricata* is confirmed by another speciality: From the primary elongated autozooids new adventive buds grow. These buds may form new, adventive stolons, but also directly may build new, adventive autozooids (fig. 3—6). Normal adventive autozooids may grow from the adventive stolons respectively the adventive autozooids. The number of adventive zooids or stolons at an elongated autozooid may increase very much and will, just as the elongation of the zooids, be limited only by occasional minute decrease of the quality of the cultivation conditions.

Adventive stolons at autozooids of *Bowerbankia "caudata"* (= *gracilis*) in a few finds from natural conditions were mentioned by BRAEM (1951). Adventive autozooids from *Bowerbankia* have not been previously described. In the past such forms may possibly have been considered as malformations, which had no value for morphology or systematics, but these forms are no malformations. The ability to form under special external conditions the elongations of old zooids and of adventive stolons and zooids is included in the genom of these species. In normal cases the conditions in the natural environments do not allow a realization of all potentialities, as demonstrated also in the reticulumzooids of *Conopeum reticulum* (L.) (JEBRAM, 1968). In both these cases the colonies must attain a sufficient age, and the quality and the physiological effect of

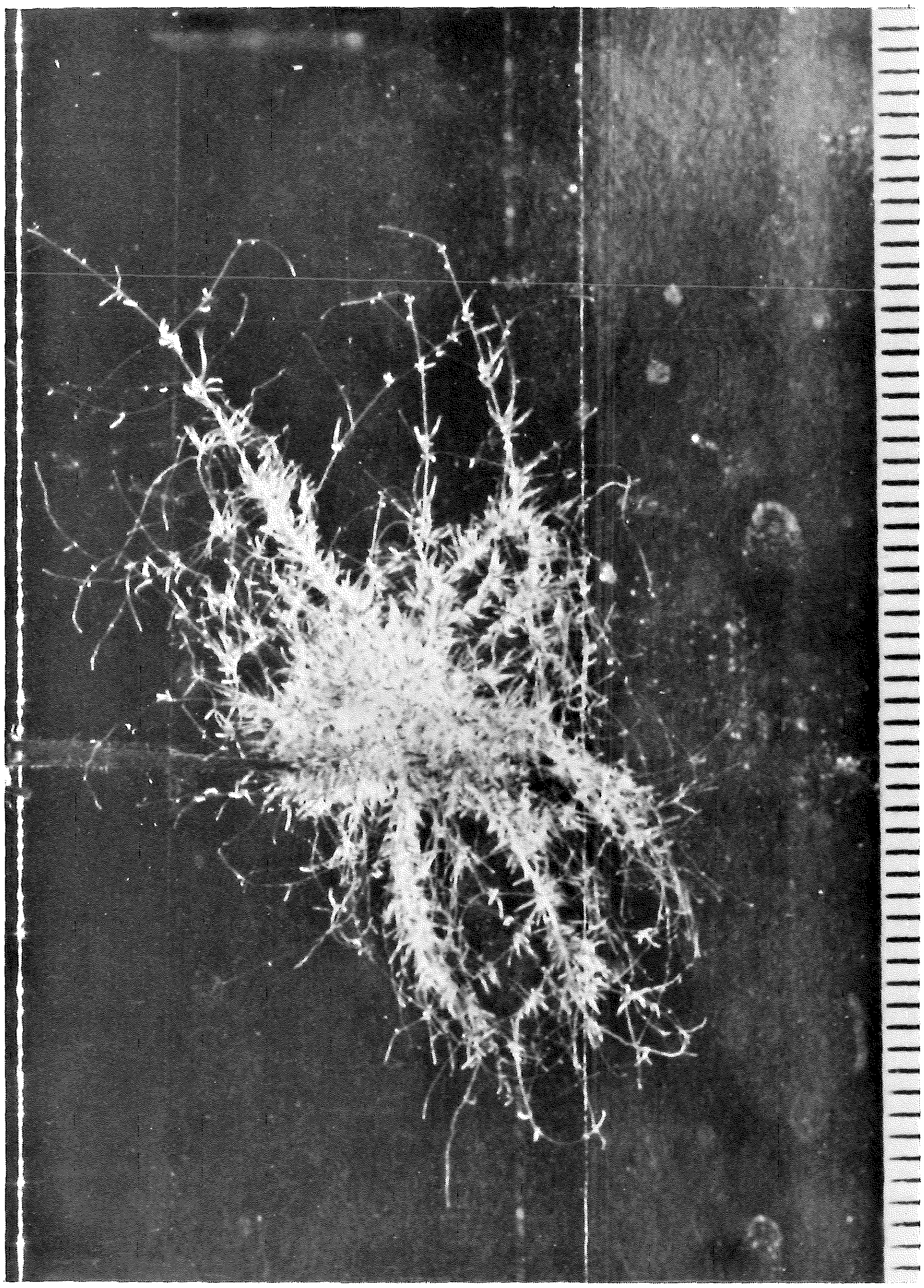

Fig. 1: *Bowerbankia gracilis* Leidy
cultivated colony, food: *Monochrysis lutheri*, age about $^1/_4$ year; quick growth of the stolons (Photograph from a living colony, scale in millimetres)

Tafel 2 (zu D. Jebram)

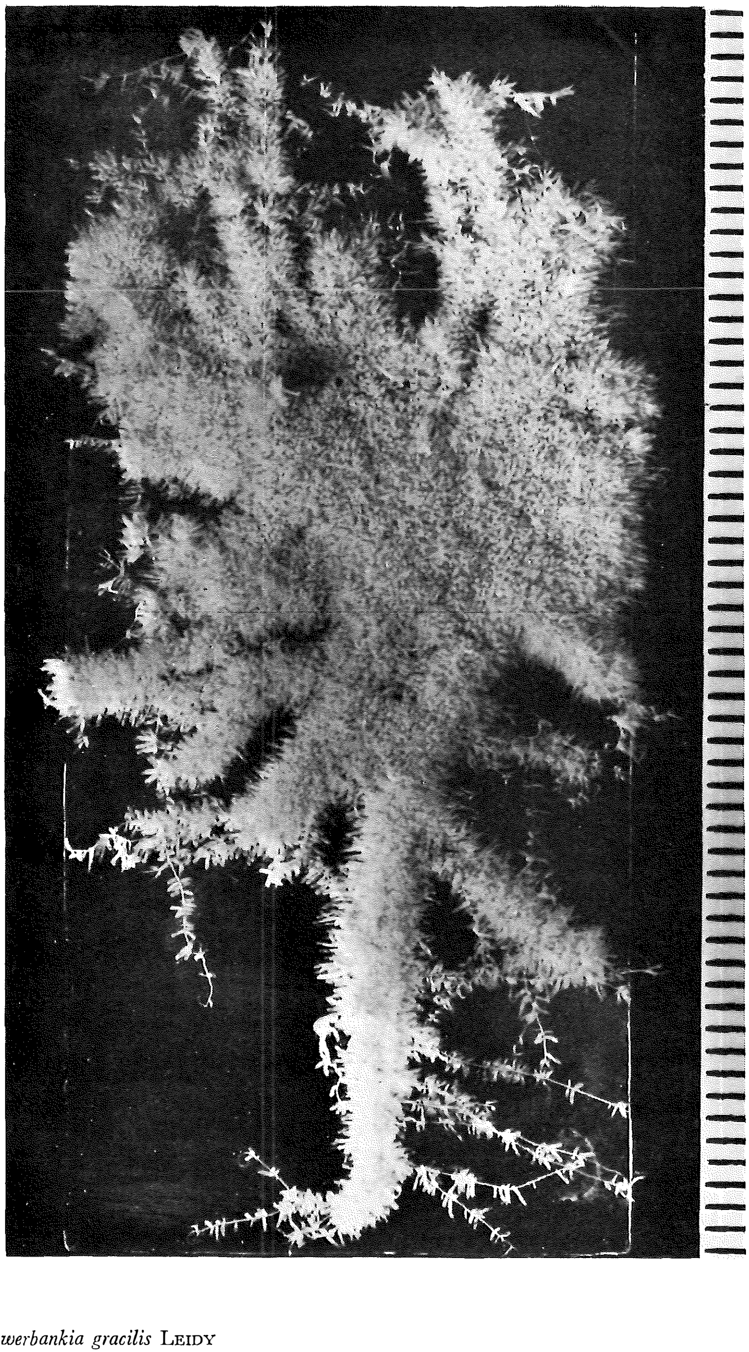

Fig. 2: *Bowerbankia gracilis* LEIDY
cultivated colony, food: *Cryptomonas* sp., age about 1 year, dense population of zooids along slowly growing stolons (Photograph from an alcohol specimen, scale in millimetres)

Tafel 3 (zu D. Jebram)

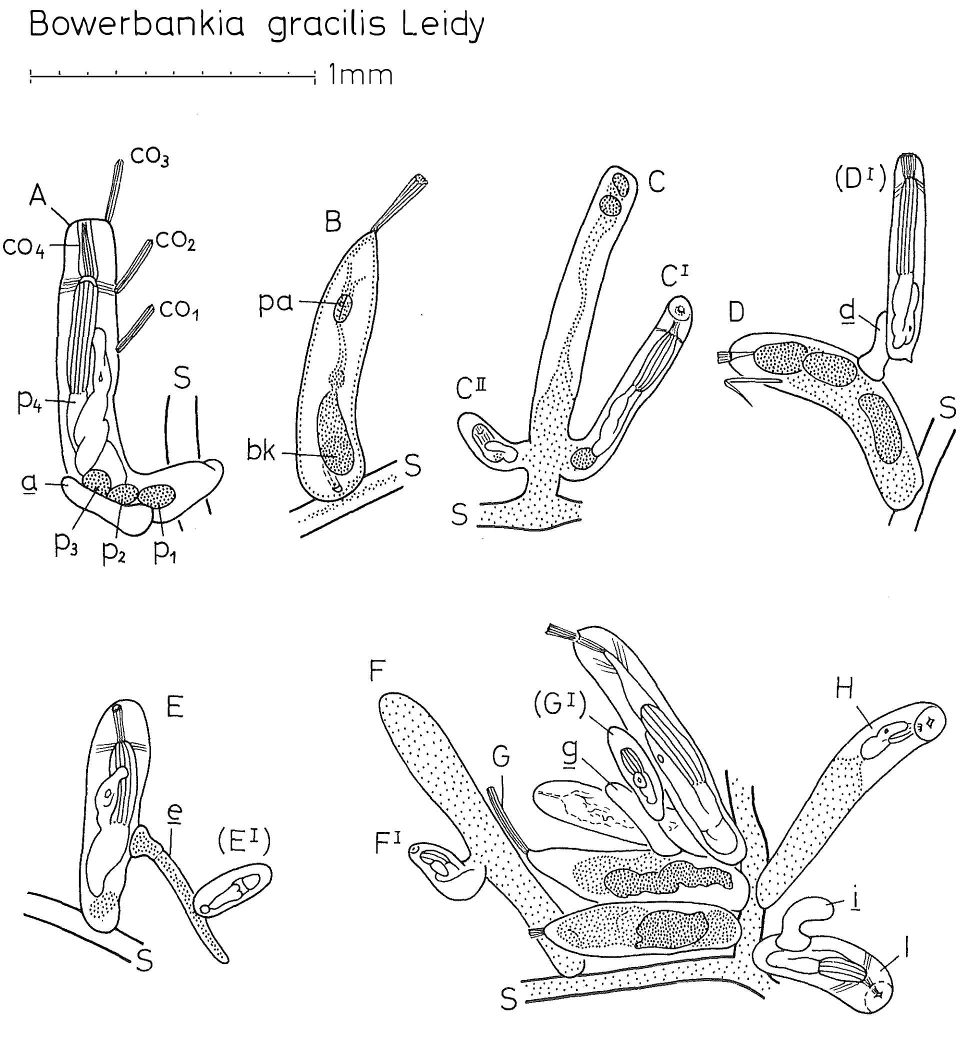

Fig. 3: *Bowerbankia gracilis* LEIDY
cultivated zooids, food: *Cryptomonas* sp.
A: zooid with 3 old and 1 acting collare (co), 3 reduced polypids (p_1, p_2, p_3) and 1 active polypid (p_4), and a developing adventive stolo *a*;
B: zooid during polypid change with a developing brown body (bk) and a polypid bud (pa);
C, D, E, F, G, I: zooids with adventive stolons (small underlined letters) and adventive zooids (capital letters with roman numbers);
C, D, F, H: zooids with light yellow yolklike reserve stuff;
S: in all cases the basal main stolo.

Tafel 4 (zu D. Jebram)

Fig. 4: *Bowerbankia gracilis* LEIDY
part of a cultivated colony, food: *Cryptomonas* sp., the stolonized zooids can easily be seen, because most of them include light yolklike reserve stuff (Photograph from a living colony of an age of about half a year)

Tafel 5 (zu D. Jebram)

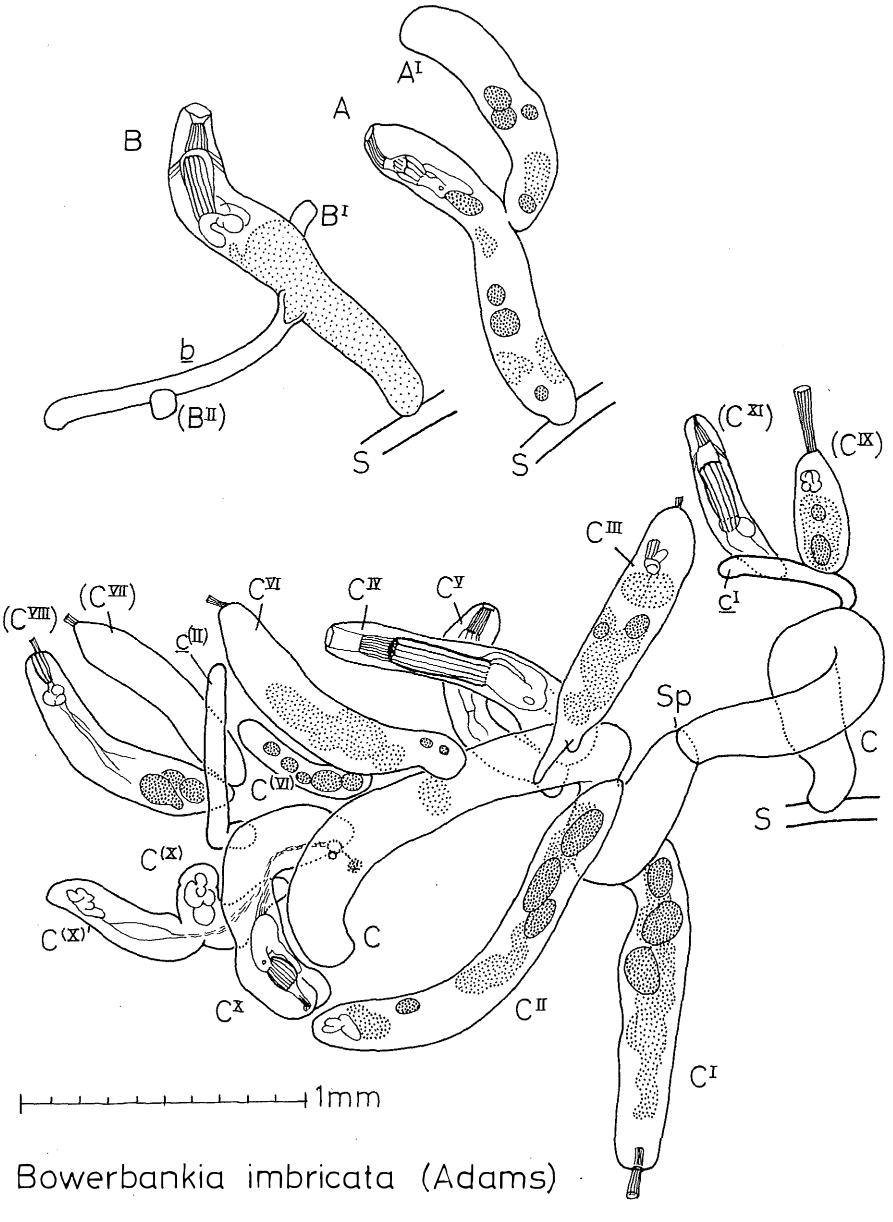

Fig. 5: *Bowerbankia imbricata* (ADAMS)
cultivated zooids, food: *Cryptomonas* sp.
A: zooid with an adventive zooid A^{I};
B: zooid with an adventive stolo *b* and adventive zooids B^{I} and (B^{II});
C: much elongated, stolonized zooid, secondarily devided by a septum (Sp), with many adventive stolons and zooids;
S: in all cases the basal main stolo.

Tafel 6 (zu D. Jebram)

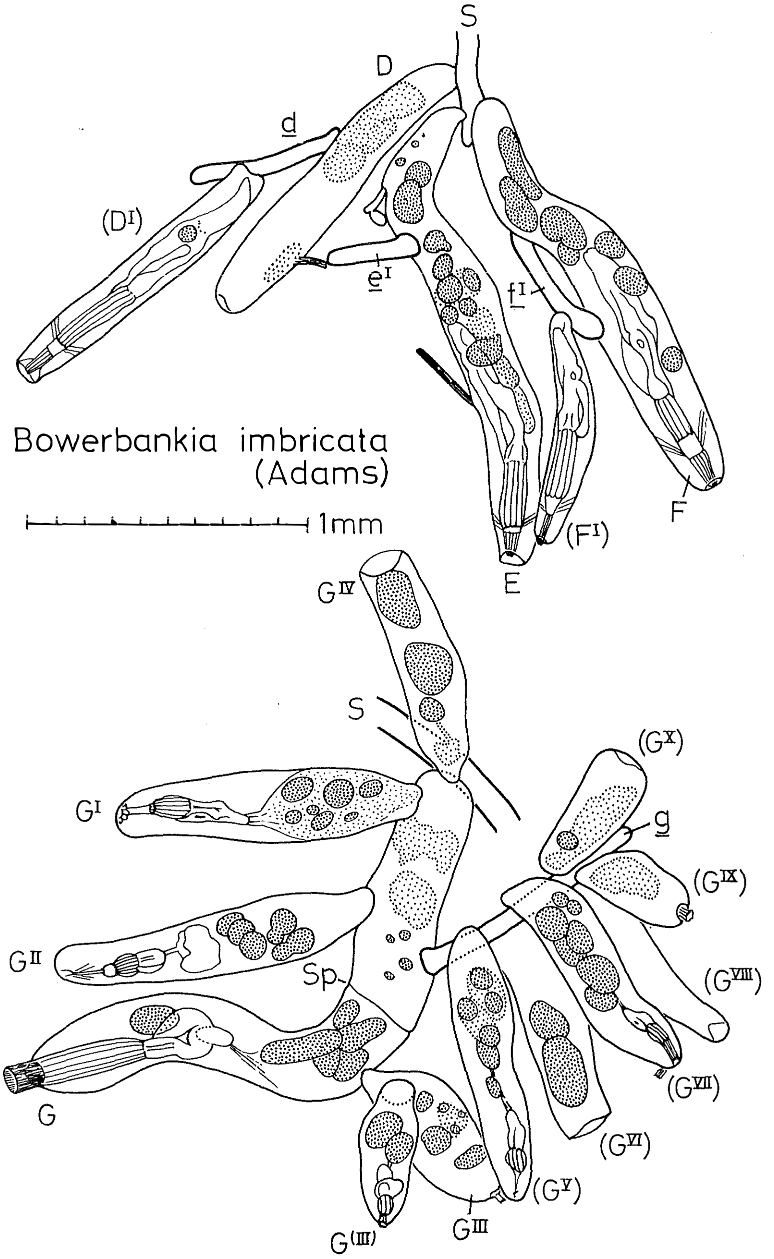

Fig. 6: *Bowerbankia imbricata* (ADAMS)
cultivated zooids, food: *Cryptomonas* sp.
D, E, F: zooids with adventive stolons and adventive zooids;
G: zooid devided secondarily by a septum (Sp), with adventive stolo and adventive zooids;
S: in all cases the basal main stolo.

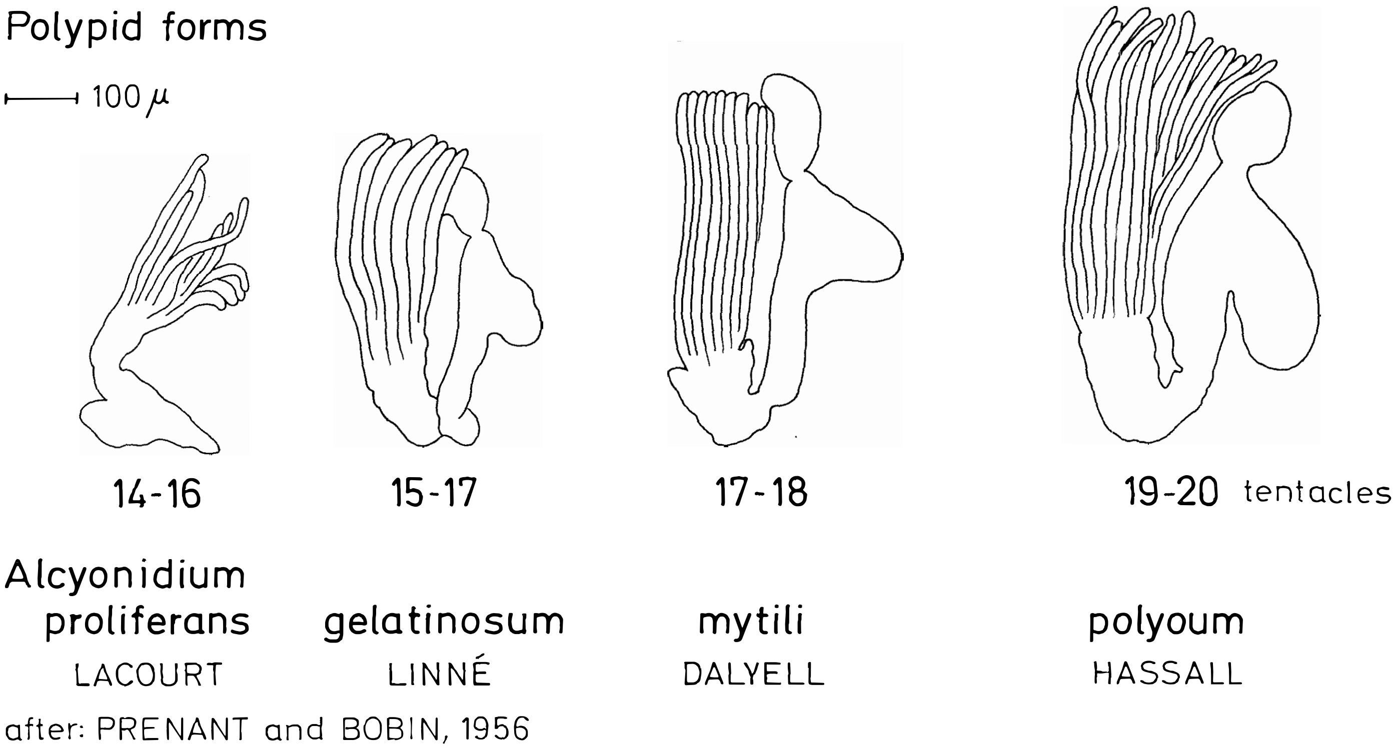

Fig. 7: Polypid forms of *Alcyonidium* "species" with allometric correlation of tentacle numbers to the sizes of the caecum and the whole polypid (after PRENANT & BOBIN, 1956).

Tafel 8 (zu D. Jebram)

Conopeum seurati (Canu)

20‰ S, 13 - 15 °C, food: Cryptomonas sp.

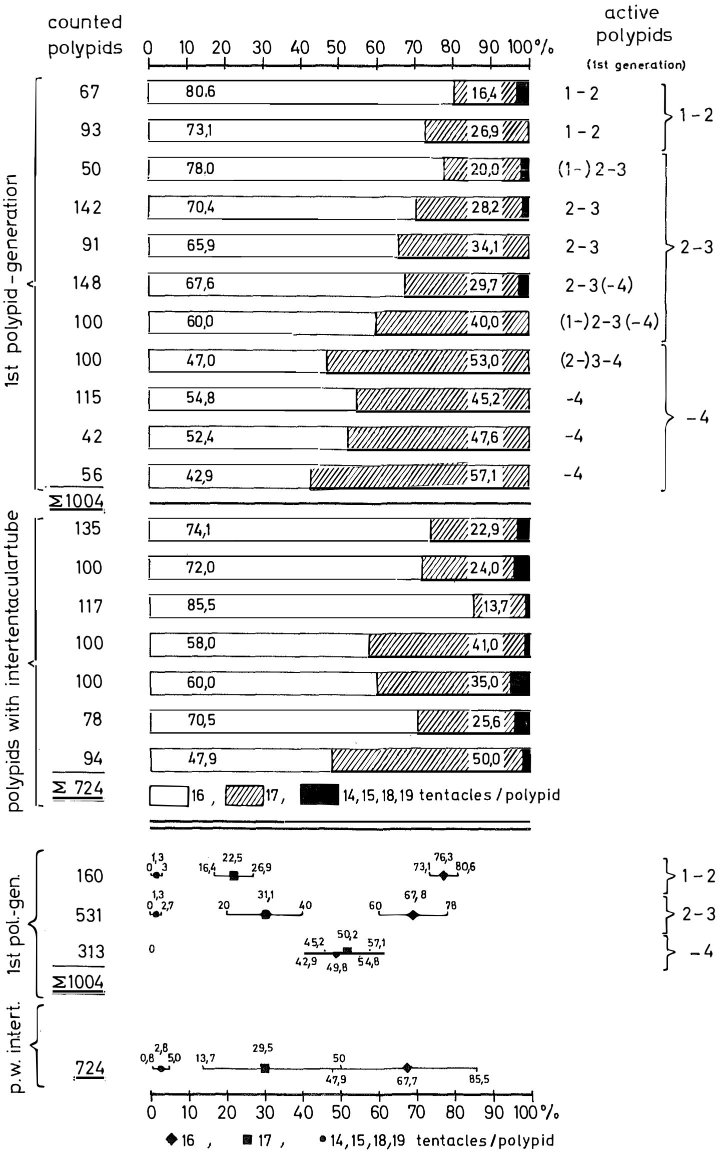

Table I : *Conopeum seurati* (CANU)
variation of the tentacle numbers in relation to the growth rate, which is expressed here in zooid numbers in a distal series with the first polypid generation, and in mature zooids (in cultivated colonies or colony parts, in 20 $^0/_{00}$ S, 13-15^{0}C, food: *Cryptomonas* sp.).

The numbers at the ends of the lines in the lower part of the table show the total range of variation, the numbers at the middle marks are the statistical means in %.

the food organisms (e. g. *Cryptomonas* sp.) is of greatest importance for the maintenance and support of the vitality of the epidermis for increase of cells, for the secretion of the cuticle of the cystid wall, and for the perpetual production of new polypide buds.

The potentiality for the continuous elongation of the zooids is called "terminal dominance". The term "stolonization of zooids" was introduced (JEBRAM, 1970b) for the zooid elongation together with the potentiality for building adventive stolons and adventive autozooids, and for the building of septa in old zooids, and for the deposit of reserves. "Terminal dominance" and "stolonization of zooids" are new concepts in the morphological understanding of the true nature of the stolons in the Bryozoa Ctenostomata and disagree with the old interpretations (cf. EHLERS, 1876; SILÉN, 1944; BRIEN, 1960). The consequence of my observations has led to a revision of the systematics of the Ctenostomata (JEBRAM, 1973).

3. Variations of the tentacle numbers

In the past, the tentacle numbers were used for taxonomical separation of species in some groups of Bryozoa. Therefore, it is necessary to find out, whether external factors might influence the tentacle number.

First observations were made on mature colonies of *Conopeum seurati*, the oldest clone of a cultivated species in my laboratory. Different means of tentacle numbers were found in different colonies and also in different parts of one and the same colony (table I), all grown under the same external conditions. Then I counted tentacles again in the distal parts of the colonies with the first polypide generation, and different means were found likewise, but now I saw that a good correlation exists between the growth rates and the mean numbers: The quicker a colony part grows, the more tentacles per animal will be built. The growth rates are expressed in the table in numbers of zooids, in one distal series, with active feeding polypides in the first generation. The quicker the colony grows, the broader is the zone of zooids with active polypides in the first generation. The growth rates are influenced by all external factors, but in most cases they also vary in different parts of one colony.

In some other species the tentacle number was found to be effected by external factors, especially by food conditions: In *Farrella repens* 8—16 tentacles can occur, as cited by PRENANT & BOBIN (1956). The separate species, "*Farrella elongata*" (VAN BENEDEN, 1844), based on the tentacle number of 16 only, cannot be maintained (as done by OSBURN & SOULE, 1953). Under malnutrition the tentacle number of *Triticella korenii* may decrease to 13, as could be observed in the laboratory; normally this species has 18—21 tentacles (PRENANT & BOBIN, 1956). So, the separate species "*Triticella elongata*" (Osburn) cannot be justified mainly on the tentacle numbers of 16—18.

A more important variation of tentacle number was found in a clone of *Alcyonidium* (clone A, perhaps *A. gelatinosum* (L.)), which had in one colony from 11 to 18 tentacles (at the same time). Comparison with the figured polypide forms and cited tentacle numbers in "Faune de France" (PRENANT & BOBIN, 1956) shows that they can be arranged in a lineage with an allometric correlation (fig. 7). The larger the polypides are, the larger is the caecum comparatively, and the more tentacles are produced. Such allometric correlated lineages can represent different species or races along a phylogenetic lineage as well as modifications of one or few species. The tentacle number of clone A of *Alcyonidium* includes the numbers of more than 3 "species" in "Faune de France". Therefore, I started to cultivate clones of different forms of *Alcyonidium* to find out how species could be distinguished in this genus. Tentacle numbers and sizes of the guts are so variable, that other, new anatomical details must be found, as a result of future work under defined conditions — this is "new systematics" (HUXLEY, 1940).

4. General remarks about maturity

I have found that bryozoan colonies attain maturity only after they have increased to a minimum number of zooids, which differ in different species and under different external conditions. (I am searching now for the influences of food, salinity, and temperature on the maturity of some bryozoan species from both brackish and marine waters.)

Beside the minimum size of the colony, suitable quality and quantity of food is necessary. When the nutrient conditions are unsuitable, even large colonies will not become mature. When mature colonies do not get food enough, they will quickly reduce maturity. Ovaries and testicles will be reduced in a few days, and full grown ova in the coelom will be absorbed. When one mature zooid from a mature colony is isolated by cutting it off, it quickly loses its maturity, even when the other external conditions remain suitable.

5. Influences on the building of the erect form of *Conopeum seurati*

During experimental work on brackish water Bryozoa erect parts of colonies were often found growing upwards from the slides (fig. 8). For some kinds of statistical inquiries it is necessary that the colonies grow flat on the slides. It was therefore also necessary to discover why the colonies grow in two forms (fig. 9).

Schneider (1959) found a positive phototropical growth reaction of *Bugula*. Therefore some light physiological experiments were made. Colonies were reared in light and in darkness, but the results were inconsistent. It was found after some time that the growth direction in the Membraniporidae is independent from light, light direction, or gravity (cf. Marcus, 1926). Then experiments were made with different temperatures, water currents, and food, but the results continued inconsistent. It was then found that the variation of one factor has an influence on the effects of other factors. This complex action of all external factors seems to be a general rule in ecological relationships. The main factors for the growth of the erect form of *Conopeum seurati* are as follows (fig. 10):

Firstly, the colony must attain a minimum size, expressed as a minimum number of zooids, which is nearly related to the minimum zooid number for maturity. If a colony with erect growing parts is reduced below the minimum zooid number, the erect growing parts will then grow in the basal direction towards the substratum. Secondly, a sufficient quality and quantity of food is necessary. If nutrition becomes unsuitable, the erect colony parts will turn towards the basal direction. Thirdly, temperature must have a sufficient range; there is a minimum temperature for the upwards growth, for example about 15°C in $20^0/_{00}$ S. Salinity seems to have influence on the minimum zooid number and on the minimum temperature (I am making researches now about these details).

Salinity itself does not appear to modify the forms of bryozoan species significantly, but influences modifications of forms by interaction with other factors. Salinity influences the distribution of species, even of species of the planktonic food organisms. By this way salinity may have important indirect influences on the modifications of forms.

In general, the building of the erect form seems to depend on the growth rate, which is influenced by colony size, food, temperature, salinity, and perhaps other factors. A minimum growth rate is necessary for the start of the growth upwards in a frontal direction. The growth rate is an indicator for expressing the kind of vitality, which influences the building of zooids and colonies of the Bryozoa, as shown in the tentacle number and the growth of erect forms.

Tafel 9 (zu D. Jebram)

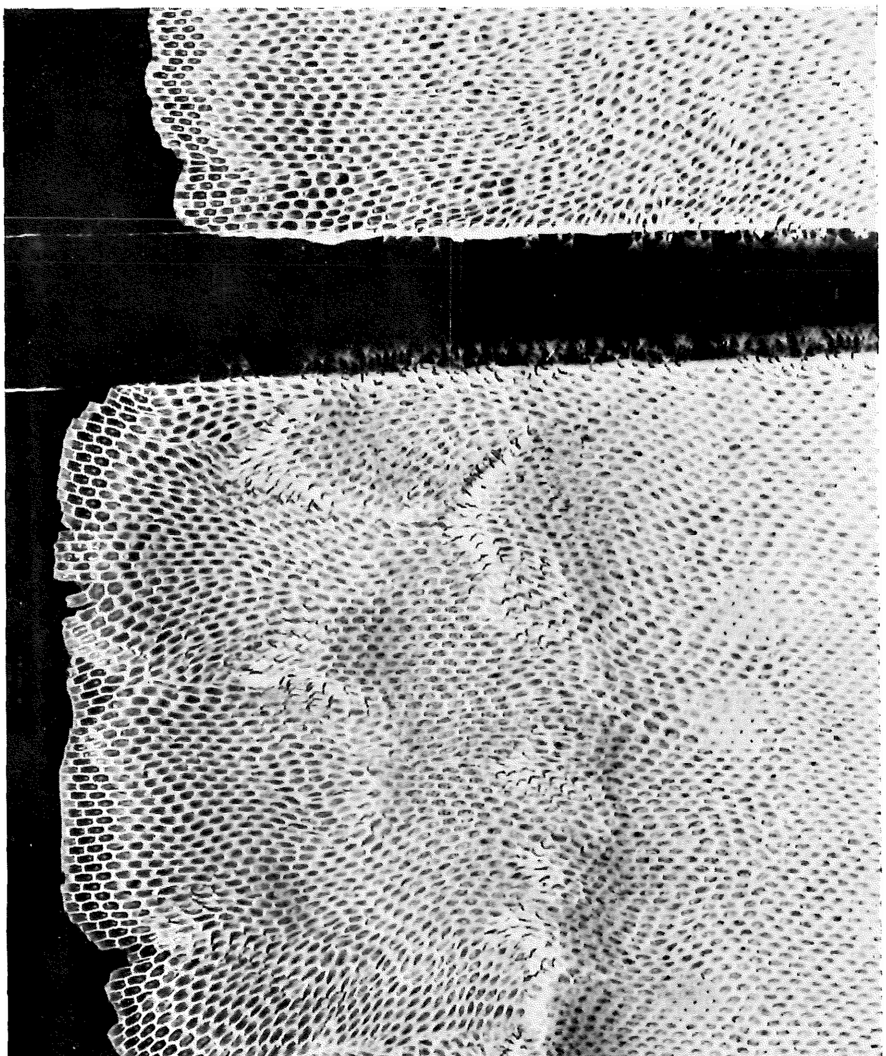

Fig. 9: *Conopeum seurati* (Canu)
cultivated colonies, food: *Cryptomonas* sp., $20^0/_{00}$ S, different temperatures, the lower colony shows changes between the encrusting and growth waves of the forma erecta (frontal view from above on the colonies, scale in millimetres).

Tafel 10 (zu D. Jebram)

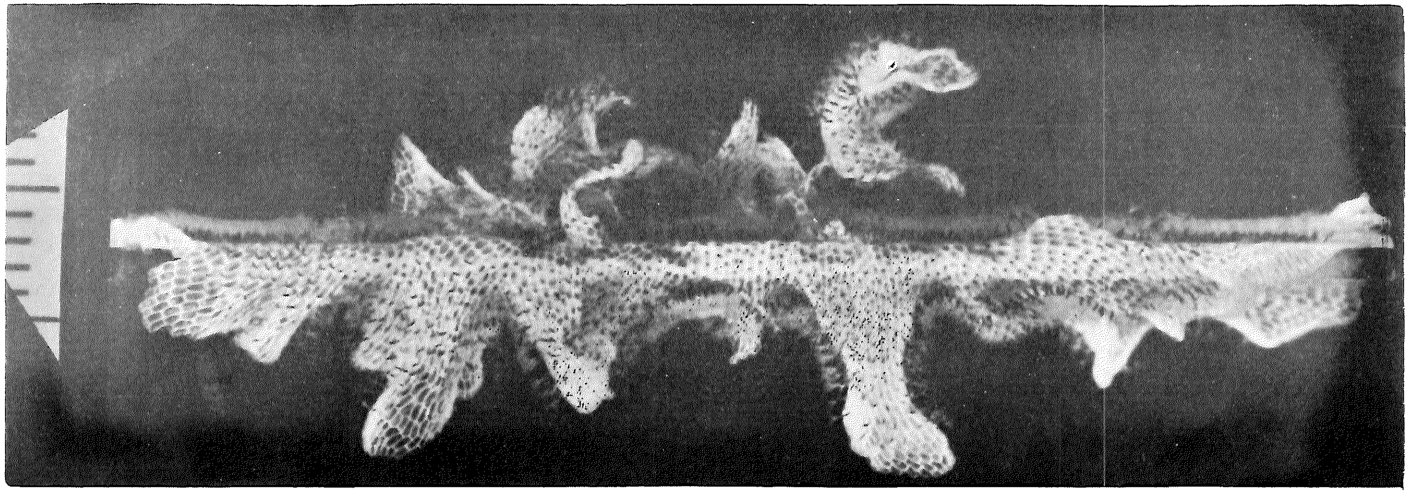

Fig. 8: *Conopeum seurati* (Canu) with forma erecta growth
(cultivated colony: $20^0/_{00}$ S, food: *Cryptomonas* sp.) (view from the side parallel to the plane incrusting colony parts / scale in millimetres)

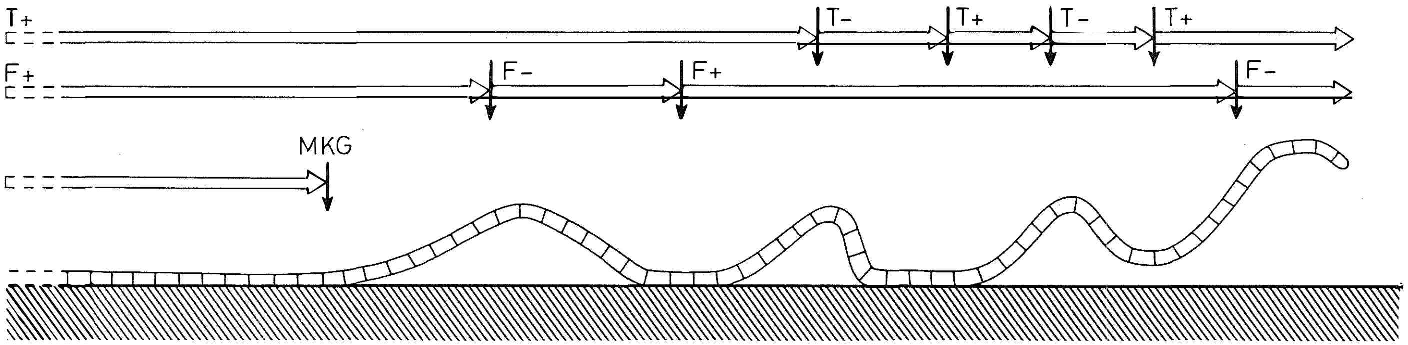

Fig. 10: *Conopeum seurati* (Canu)
influences on the building of the forma erecta (schematical sketch in sagital view) by several factors in suitable (+) or unsuitable (—) conditions, MKG minimum colony size (in zooid number), F food, T temperature; growth direction is independent from gravity or direction of light.

Tafel 11 (zu D. Jebram)

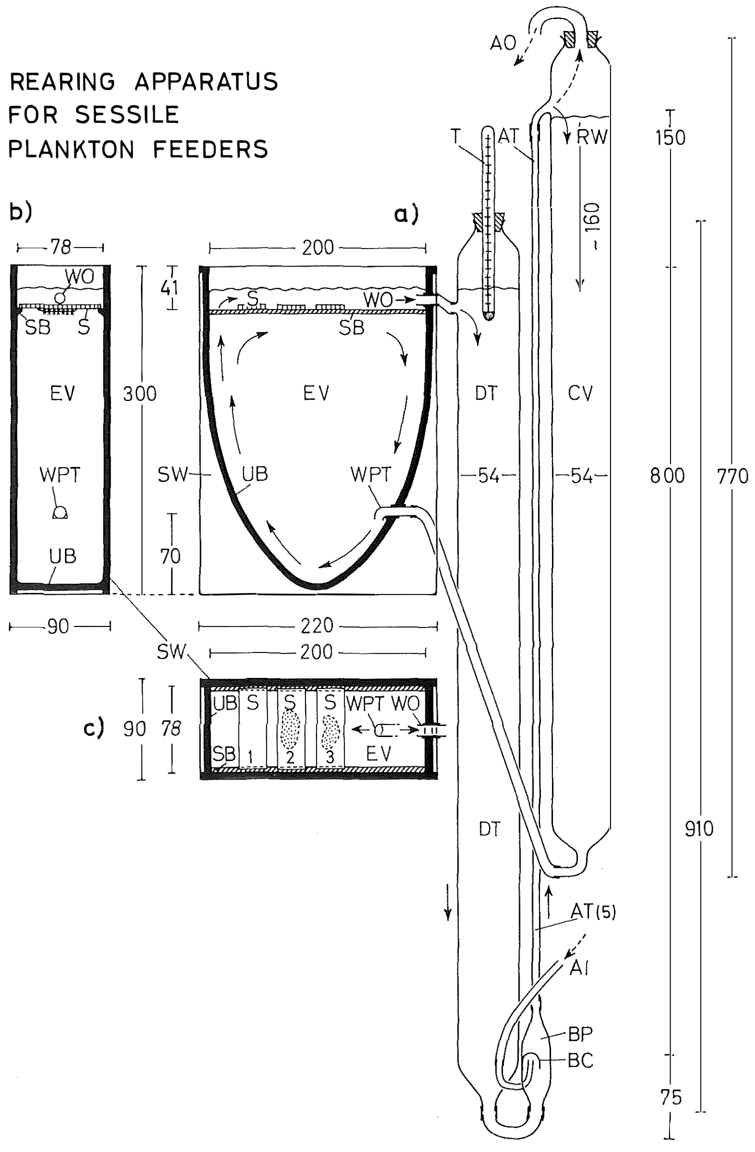

Fig. 11: Rearing apparatus for sessile plankton feeders:
a) the apparatus in side view, b) cross section of and c) view from above on the experimental vessel;
AI air inlet tube, AO air outlet tube, AT ascending tube, BC bubblecup, BP bubble-pump, CV container vessel, DT descending tube, EV experimental vessel, RW raised water level in CV, slides with the experimental animals, SB side boards for S, SW side walls of EV, T thermometer, UB u-formed bottom of EV, WO water outlet tube, WPT water-propelling-tube; numbers (exept on the slides) represent millimetres, arrows indicate the movement of water and air in the apparatus.

Tafel 12 (zu D. Jebram)

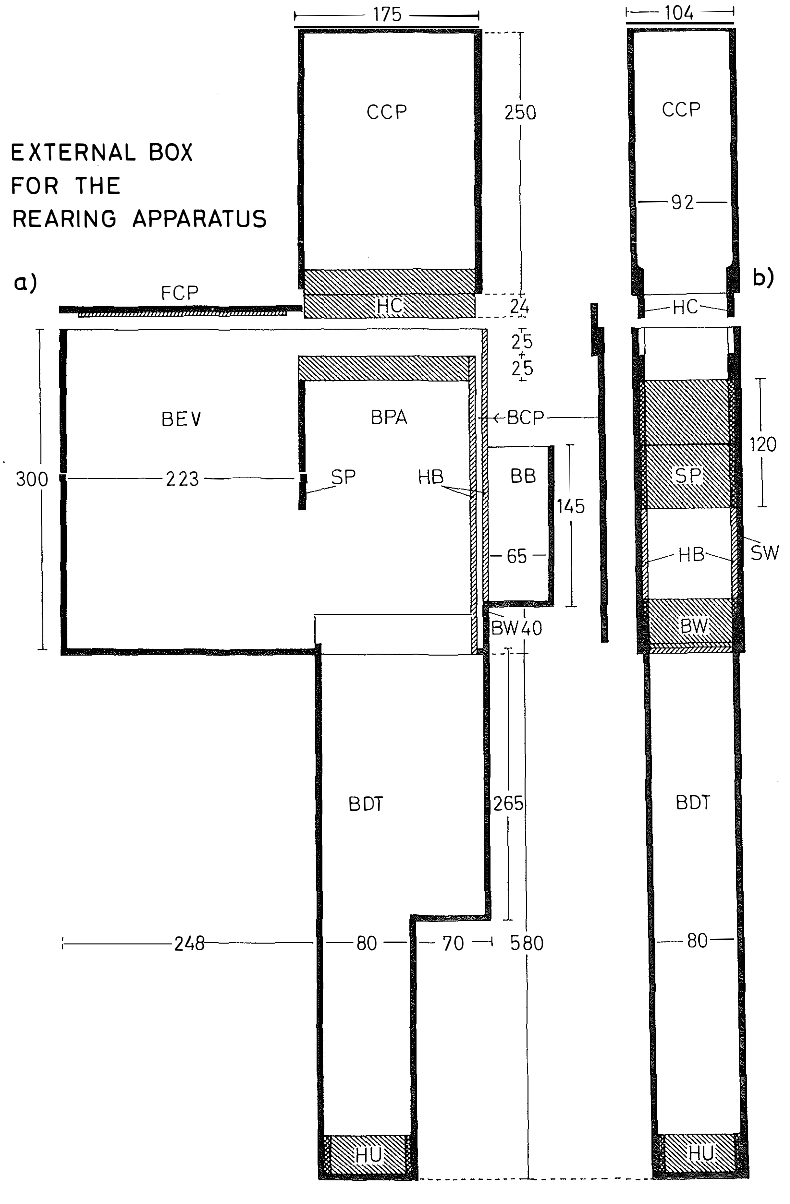

Fig. 12: External box for the rearing apparatus:
a) side view of the box, b) cross section through the back pan
BCP back coverplate, BDT box for the descending tube and the bubblepump, BEV box for the experimental vessel, BPA box for (a part of) the pumping apparatus, BW back wall, CCP covercup for the pumping apparatus, FCP frontal coverplate (glass), HB holding device boards for BCP, HC holding device boards for CCP, HU holding device for the u-tube connecting the descending tube and the bubble-pump, SP separating wall, SW side wall of the external box; numbers represent millimetres

Interpretation of specimens and ecological factors

The few qualitative observations described above demonstrate the difficulties which appear in explaining ecological relationships and interpreting the growth forms and the anatomy of specimens from natural environments systematically. For example, the elongation of the zooids by polypide replacement in *Bowerbankia* and related forms demonstrates the necessity that measurements of zooid sizes for numerical comparison must be related not only to the external factors but also to the age. The absolute age (hours, days) is not important in all cases, because the growth/time relation can vary according to different conditions. The physiological age and the stage of ontogenetical development are often much more important, which may in some cases be indicated by the numbers of polypide generations. (As a standard, the size at the end of the first polypide generation should be measured.)

Counting, measuring, and statistics about "phens" have utility only, when they stand in relation to well known ecological factors, but in most cases, these factors are not, or only poorly known for collections from natural environments or from geological deposits. In nature we find always complexes of interactions and overlapping effects of different factors. Beside this, a simple numerical comparison may present pretentious or netlike similarities when in primitive phyla, like Bryozoa, only a small amount of different anatomical details is available and convergences are also possible. Therefore, too much stress on the use of numbers and an uncritical use of the methods of the "numerical taxonomy" (SOKAL & SNEATH, 1963) on today's level of knowledge may lead to unjustified systematical derivations in Bryozoa.

Statistics can be only a help and is one method besides many others. A presentation of numbers, statistical means, and ratios cannot render unnecessary the necessity of their interpretation. On the other hand, the action of ecological factors can be recognized from experimental research under defined conditions. Observations of living colonies over long periods of time in the laboratory may help find new anatomical details, which are of great importance for comparative morphology and systematics of the Bryozoa. According to the "modern synthesis" (HUXLEY, 1945) we have to use all possible methods for research on systematics and anatomy.

An apparatus for cultivation of sessile plankton feeders

The first results in my research about experimental ecology of Bryozoa were carried out under simple laboratory conditions. For a long time I have searched for methods to overcome most of the difficulties in rearing Bryozoa, which have resulted in the construction of a new cultivation apparatus.

The new apparatus (fig. 11) consists of the experimental vessel and the pumping devices. The experimental vessel has a parabolic bottom made of perspex. This form sustains a vertical water rotation and hinders planktonic organisms from sedimentation. A related form of rearing vessel was developed by GREVE (1970). GREVE's "double-kuvette" has a curved bottom of sand to filter the water, but I don't want to filter the medium; sand is not good for clean work and is not sufficient from the point of view of current technique. Food species with poor swimming activity, like *Cryptomonas* species, will quickly settle into the pores between the sand grains.

The pumping device consists of a descending tube, bubble-pump, ascending-tube, container vessel, water-propelling-tube, air inlet tube, air outlet tube, and connecting tubes. The different parts of the apparatus are stored in an external box (of perspex) (fig. 12). In this external box the apparatus can be lodged in a constant temperature bath. The frontal coverplate over the experimental vessel is made of glass. The other walls and the covercup are made of perspex. The pumping apparatus and the tubes connecting it with the experimental vessel are made of glass and silicon-rubber. Experimental vessels can also be built with side walls of glass and a parabolic bottom of perspex. Such vessels can be dry sterilized at 110°C. With these experimental vessels in the apparatus sterile work is possible.

The cultivation apparatus has a total content of about 7 litres of water. The water amount is large enough to maintain the stability of the chemical conditions for some weeks, when only few bryozoan colonies will live in it. The water in this apparatus circulates in a closed system constantly for some weeks. Any type of mechanical pump would damage the planktonic food organisms during longer periods of time. For this reason the water rotation is produced by the hydrostatic pressure of a raised water level in a container vessel above the level in the experimental vessel. The water is raised by an improved bubble-pump (JEBRAM, 1970a) with a diameter of 22 millimetres, bubble-cup 10 millimetres.

The water level in the experimental vessel is near the water outlet. This arrangement supports a water current parallel to the water surface. The current has a high speed on the parabolic bottom of the experimental vessel, while at the surface it is of few centimetres per second only.

Bryozoa are grown on glass slides which lie on small boards in the experimental vessel, at a small distance from the water surface. This distance allows the observation of the animals through a LEITZ-stereo-microscope (x 4 objective magnification), and photography, without removing the colonies. Colonies are placed in the apparatus with the evaginating polypides downwards to prevent them from sedimentation of faeces. One can look through the slide and the thin basal wall into the body cavity. Thus the physiological conditions of the animals can easily be controlled by observing the colour of the gut and the development of polypides and ovaries.

The food for the experimental animals is separated by centrifugation from its cultivation medium and washed with sterilized seawater into the experimental vessel. Therefore, Bryozoa can be cultivated in seawater of a required salinity, without an eutrophication by the nutrient solution, which is necessary for the propagation of the autotrophic food organisms. This allows the cultivation of delicate euhaline species which, in most cases, dislike an eutrophication of the medium (JEBRAM, 1968).

Sedimented food cells soon die and support an increase of Bacteria. The great current speed along the parabolic bottom hinders a sedimentation of food organisms and the faeces of the Bryozoa there. Faeces and some food cells can settle on the top sides of the slides, especially on the first slide. For this reason Bryozoa were not cultivated on the first slide.

A strong increase of Bacteria is in general the most negative factor during cultivation of Bryozoa. The lack of eutrophication and of sedimentation hinders a strong increase of Bacteria, and a cleaning of the colonies from Bacteria by brushing appears to be necessary only at longer periods.

The new cultivation apparatus is suitable for standard-rearing of and experiments with many bryozoan species and other sessile plankton feeders.

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