REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS
Vol. II. Biology.

J. 1.

Mediterranean Ceratia

By

E. Jörgensen
Biological Station, Bergen, Norway.

Published April 1, 1920.

CONTENTS.

I. INTRODUCTION. EARLIER INVESTIGATIONS ON THE MEDITERRANEAN CERATIA.

The first report of Ceratia from the Mediterranean known to me is to be found in EHRENBERG 1859, (compare the list of literature). Here he describes four species from Trieste: *Peridinium Trichoceros, P. eugrammum, P. Seta* and *P. Candelabrum*. The very short and little characteristic descriptions of that time would scarcely have made them recognizable, had they not fortunately been figured many years later, in EHRENBERG 1873. We have here already three of the commonest Ceratia of the Mediterranean, viz. the southern forms of *C. furca* and *C. fusus*, together with the frequent species *C. candelabrum*. Then, too, EHRENBERG has seen the much rarer *C. trichoceros*. All were very well figured and are easily recognized.

Further communications on Mediterranean Ceratia are not to be found till 1883, when our knowledge was enriched (almost simultaneously) by three important publications, of POUCHET, STEIN and GOURRET. GOURRET's treatise seems to be the first one finished, but as it was delivered to POUCHET — probably for being printed in his Journal — it has lost its priority to the advantage of the other two.

POUCHET's paper contains only three Ceratia really new to the Mediterranean, viz. *C. tripos* var. *dispar, C. tripos* var. *limulus* and *C. tripos* var. *reticulatum*, given by GOURRET as *C. gibberum* var. *sinistrum, C. limulus* and *C. hexacanthum* respectively. Besides, the *C. gibberum* of GOURRET is probably identical with the *C. tripos* var. *megaceras* of POUCHET. This author seems to have adopted some of the new names from GOURRET's treatise — which he mentions as having been delivered to him just before his own paper went to press — as f. i. the specific names *limulus* and *depressum, C. trip.* var. *depressa* Pouch. being synonymous with *C. depressum* Gourr. (*C. candelabrum* Ehrb.). POUCHET's paper is in part very vague and of no great importance (as to the Ceratia).

STEIN's important treatise on the Infusoria vol. III, 2 became the standard work for the Peridineæ, laying the foundation for the system still in use. He mentions several species as Mediterranean, of Ceratia however, only the three common species already detected by EHRENBERG (*C. furca, C. fusus* — he does not mention *C. seta* — and *C. candelabrum*), but figures as a mere form of *C. tripos* the *C. hexacanthum* Gourret. If STEIN has only contributed but little to the knowledge of the species of Ceratia, he has, on the other hand, made wonderful progress in the interpretation of the skeletal construction. This difficult problem was, however, finally solved by KOFOID.

Shortly afterwards, towards the end of the year 1883, that treatise appeared which made the greatest contribution hitherto to our knowledge of the Mediterranean Ceratia, — GOURRET, — sur les Peridiniens du Golfe de Marseille. It is the more remarkable because it shows, only too plainly, traces of unfinished study and of serious errors in the understanding of the real constitution and — (if I may say

so), — the remarkably constant asymmetry of these organisms. In a certain respect this paper supplements STEIN's; while the latter author laid most stress on the study of the construction of the skeleton, GOURRET, on the contrary, chiefly emphasized the investigation of the protoplasmic cell-contents. In this, however, he makes so many mistakes, evidently due to lack of experience, that his conclusions are only misleading and of practically no value at all. That so many of his species may still be accepted, is due first to his discovery of so many conspicuous differences in constitution, — many more than really exist, — in consequence of which he was able to establish a great many species (which are now maintained for other causes), secondly to the circumstance that we are as liberal as possible in maintaining species already established. GOURRET's many figures have therefore attained a decisive importance, while his descriptions are generally either erroneous or useless.

GOURRET established in all 43 species or varieties, 19 of which are still recognizable, viz. the following:

1. *C. euarcuatum*, named *C. tripos* v. *arcuatum* G., 2. *C. candelabrum*, by GOURRET under no less than six different names (*C. dilatatum* with var. *parvum*, *C. globatum*, *C. Allieri*, *C. depressum* and *C. obliquum*), 3. *C. carriense*, 4. *C. contrarium* Pavill. (*C. inflexum* Kof.) under three variety names, *C. tripos* v. *inflexum*, v. *typicum* and v. *contrarium*, 5. *C. extensum*, by GOURRET *C. fusus* v. *ext.* G., 6. *C. furca*, in three badly characterized varieties, v. *singulare* G., v. *tertium* G. and v. *medium* G., 7. *C. fusus*, by G. *C. Berghii* G. and *C. pellucidum* G., 8. *C. longirostrum* G., 9. *C. fusus* v. *concavum* G., which must be *C. inflatum*, 10. *C. gibberum* G. with var. *sinistrum* G., 11. *C. gibberum* v. *contortum* G., compare *C. concilians* nov. nom. below, 12. *C. gracile* G., 13. *C. gravidum* G., 14. *C. hexacanthum* G., including *C. tripos* var. *inaequale* G., 15. *C. limulus* G., 16. *C. macroceros gallicum*, by G. *C. tripos* v. *macroceros*? 17. *C. massiliense*, by GOURRET *C. tripos* var. *mass.*, 18. *C. pentagonum* G., and 19. *C. tripos*.

Of these 19 species only 4 were previously known, so that the number of new species is surprisingly great, the total number for this region being about 33. Beside these species he has, however, several, either quite unacceptable, or not even belonging to the genus *Ceratium*. To the former belong the many different names of one and the same species (compare above, nos. 2, 4 and 13), to the latter *C. globosum* G. (probably *Peridinium oceanicum*), *C. procerum* G. with var. *divergens* G., *C. obtusum* G. and others (compare JÖRGENSEN 1911 b pp. 88, 89).

After GOURRET several authors have occasionally mentioned Ceratia from the Mediterranean and thus gradually increased the number of species known from that region. I will here only mention the more important of them, the more so as further details will be found under the respective species in the next chapter.

DADAY, 1888, establishes four new forms, only one of which is a really new species, *C. "platicornis"*. As no figure is given and the description published in Hungarian his *C. tripos* v. *spinosa* has not yet been solved. To judge from the name this might perhaps be *C. ranipes* with the "hands" wanting (by autotomy). The two other new forms are *C. tripos* v. *curvicornis*, which is *C. gibberum* var. *sinistrum* Gourr., and *C. oviformis*, synonymous with *C. gravidum* Gourr.

SCHRÖDER, 1900, mentions some new varieties of *C. tripos* from Naples, among which is *C. longissimum* (*C. tripos* var. *longiss.* Schröd.). Here for the first time we meet with the peculiar species *C. palmatum* (*C. trip.* var. *p.* Schröd.).

CLEVE, 1900, has *C. contortum* n. sp., founded on *C. gibberum* var. *contortum* Gourr. This is, however, a mistake, similar to the confusion by the same author of the large *C. Karstenii* (*C. arcuatum* Cleve) with the much smaller *C. arcuatum* (Gourr.). *C. contortum* Cleve is a longhorned, characteristic species, related to *C. Karstenii* and widely distributed in warmer seas, but not yet known with certainty from the Mediterranean, while *C. gibberum* var. *contortum* Gourr. has been confounded until now with *C. gibberum* var. *sinistrum* (compare under *C. concilians* nov. nom. below).

CLEVE, 1903 (Mr. Wulff's voyage to and from Bombay) does not mention *C. contortum* from the Mediterranean. The following species, new to this region, are reported by him: *C. Pavillardii* (by CLEVE *C. vultur*), *C. paradoxides* and *C. azoricum*. Besides he has found *C. carriense* var. *volans* and *C. ranipes*.

In ENTZ, 1905, (1902 the Hungarian edition) we find four more species figured, new to the Mediterranean, *C. declinatum* ("*C. tripos gracile*" p. 105 figs. 33—35), *C. Karstenii* ("*C. trip. arcuatum*" p. 107 figs. 31 (?), 32 and p. 109 figs. 44, 45), *C. Kofoidii* ("*C. furca* var. *baltica*" p. 99 fig. 7) and *C. buceros* f. *tenuissimum* (Kof.)? ("*C. patentissimum*" p. 109 fig. 42). ENTZ's interpretation of the notion of species seems to be a singular one and rather out of the ordinary. He considers definite and considerably different species — this word taken in the usual sense — as only different forms of one and the same very variable species, not as more or less badly distinguished species, passing over into each other, but rather — if I understand him rightly — as seasonal forms or similar constantly returning different shapes of the same species. However enticing this conception may be from an evolutional point of view, he has carried it to extremes in establishing the so-called *Phalacroma Ceratocorys*, which was supposed to unite the characters of the two very different genera *Phalacroma* and *Ceratocorys*. His interpretation depends, however, on the false view of the species *Ceratocorys "Jourdani"*, as a species of *Phalacroma* (in accordance with SCHÜTT 1895), which is in reality a genuine *Ceratocorys*. (Compare JÖRGENSEN, 1911 a). Nevertheless, in very rare instances a real metamorphosis most probably does take place among the Ceratia, though in a much lesser degree (compare below under *C. candelabrum* and *C. pulchellum*).

A more thorough examination and discussion of the Mediterranean Ceratia is only attained through PAVILLARD's different papers (1905, 1907, 1916). That of 1905 mentions two new species for the Mediterranean, *C. arietinum* ("*C. heterocamptum*") and *C. symmetricum* Pavill. He also mentions *C. intermedium*, which probably is *C. molle* Kof.

SCHRÖDER 1906 figures two more species, *C. incisum* (by SCHRÖDER *C. belone* Cleve) and *C. Schröteri* n. sp. This latter species must be exceedingly rare, as I never met with it, (except perhaps once, as an uncertain fragment at station 14 in the Southern Adriatic). He also mentions *C. contortum* Cleve (compare above).

ZACHARIAS, 1906, publishes many plankton lists from several seas, also from the Mediterranean. From the great abundance of forms among the Ceratia he has obtained the impression that we cannot here speak of definite species; he seems to believe that one form changes into another and that this is a phenomenon common to these organisms. In this matter he is even more extreme than ENTZ. However, among the species listed by ZACHARIAS we find *C. lunula* Schimp. Yet this cannot be the genuine large species of ZACHARIAS from the Atlantic, as it is described as small, only up to 200 μ long, (perhaps *C. declinatum*). Otherwise, ZACHARIAS' species are for the most part quite undecipherable.

PAVILLARD, 1907, made the Ceratia of the Gulf of Lyons the object of a special, thorough investigation. Here three more new species are found, *C. belone* Cl. (*C. pacificum* Schröd.), *C. digitatum* Schütt and *C. Karstenii* Pavill. In 1909 he adds *C. pennatum*, shortly before described by KOFOID.

1911 (b) I have in my monograph reported *C. geniculatum*, *C. inflatum*, *C. setaceum* and *C. lunula* from the Mediterranean.

In 1916 PAVILLARD gives a new survey of the Ceratia from the Gulf of Lyons, with valuable critical remarks on most of the species.

A more detailed historical report is to be found under the different species in the next chapter.

The cruises of the "Thor" have, however, procured a material, sufficient for a fairly reliable account of the general distribution of Mediterranean species, though some parts of that sea, especially the Southern Adriatic, the Ionian and the Aegean Seas, are still too little known. In a later chapter I shall try to give a general survey of the more important results reaped from the gatherings of the "Thor". Let me, however, mention here the very striking fact that those species which — e. g. by PAVILLARD

— have been stated as exclusively hibernal, are to be found in summer at deeper levels and in even greater numbers than in winter. A second important result is the discovery of a proven metamorphosis of one adopted species into another (compare below under *C. pulchellum*).

II. THE MEDITERRANEAN SPECIES.

Subgenus I. ARCHÆCERATIUM nov. nom.

Epitheca without an apical horn, at the apex rounded or ± acute, usually ± broad and flattened. Apical plates consisting of two, ± large and broad, ventral and dorsal plates and two narrow boat-shaped lateral ones.

Sectio I. DIGITATA Jörg.

Epitheca ± flattened, but never plane and blade-like, usually ± acute at its apex; the ventral and dorsal apical plates without a connecting annulus. The left postical (antapical) horn ± strongly bent in a dorsal direction, spinulate.

1. CERATIUM DIGITATUM Schütt (Figs. 1, 2, p. 8).

Schütt 1895 pl. 12 fig. 42. Jörgensen 1911 b p. 12 pl. II fig. 13.

This peculiar and most characteristic species was first reported from the Mediterranean as found by PAVILLARD (1907 p. 230) in the Gulf of Lyons Nov. 1906, singly in two samples. In 1909 Entz states that it has been found once previously in the Gulf of Naples, Dec. 1902. PAVILLARD 1916 (p. 13) reports it from the Gulf of Lyons (several times, but always in winter, Dec.—Jan.).

On the cruises of the "Thor" it proved surprisingly frequent, being caught at no less than thirteen stations in winter and seven in summer, always, however, a single or very few specimens at a time. It was most frequent in the median part of the Mediterranean in winter, in the Ionian Sea (sts. 10, 11 and 20 east of Sicily, and st. 16 at Corfu), in the Tyrrhenian (at four stations off Naples, sts. 23, 26, 28 and 29, at st. 31 between Corsica and Italy and at st. 39 east of Sardinia) and at the southern border of the Ligurian Sea (sts. 33 and 36). On the winter cruise it was otherwise only found at st. 46 off the African Coast. On the summer cruise it was only found at st. 134 off Tunis, at st. 194 north of the Straits of Messina, and at five stations in the Eastern Mediterranean, everywhere only at deeper levels except at st. 161 near Asia Minor in the Aegean Sea, where there were relatively many (st. 134 at 75—125 m., st. 152 at 250 m. wire, st. 156 at 950 m. wire (only a fragment), st. 163 0—80 m., st. 189 at 945 m. wire, and st. 194 at 1145 m. wire).

A specimen, not quite regenerated after fission, was observed at st. 152, between 11 and 12 o'clock p. m.

Otherwise its known distribution is only within the tropical zone, except at a single locality west of South Africa at 31° S 12° E (German South Pole Expedition 8. VIII. 1903), and just outside that zone, at 25° S 56° E, south-east of Madagascar (the same expedition 15. V. '03). In the Atlantic it has been found in the huge cyclonic movement of the warmer water between South Africa and South America, at many localities in the South Equatorial Current, in the North Equatorial Current off the coast of Guiana, in the Caribbean Sea, and in the Sargasso Sea at 21° N 32½° W (VANHÖFFEN 13. X. '03, (20—200 m.), the most northern locality (outside the Mediterranean) as yet known to me.

The Mediterranean form — at least that from the innermost parts, the Levant and the Aegean Sea — seems to differ considerably from the type of SCHÜTT and from the (similar) forms of the tropical zone (compare Jörgensen l. c. fig. 13). These forms have a short and abruptly pointed apex, at least

in the ventral view of the epitheca (fig. 1), while the Mediterranean form has an evenly rounded epitheca with an inconspicuous apical pore, like *Ceratium gravidum* Gourr. This Mediterranean form is also larger (transdiameter t = about 59 µ as compared to 52 in SCHÜTT's type) and has a less curved antapical horn, only bent at right angle and with its tip far behind the girdle, while Schütt's type and the other forms mentioned have a much stronger curved horn with the tip at the level of the girdle or even nearer to the apex. I don't know if this difference is found in all Mediterranean specimens, as it came to my notice too late; PAVILLARD, 1907, finds his specimens in agreement with SCHÜTT's. I have provisionally designated the form mentioned as var. rotundatum (fig. 2 a, b). I have only seen one other similar form, namely — from the Guinea Current at 6° N 22° W (1. X. 1903, German South Polar Expedition).

I have stated in my monograph (JÖRGENSEN 1911 b p. 90 and 95) that *C. digitatum* seems nearly allied to the subgenus *Poroceratium* and should perhaps be removed from the subgenus *Biceratium*. As I now have found that *C. digitatum* possesses the same two broad ventral and dorsal apical and the same very characteristic boat-shaped lateral plates as *C. gravidum*, I propose to extend the subgenus *Poroceratium* to comprise *C. digitatum* (and *C. Schröderi*). I cannot here give the necessary details, but merely mention that it seems natural to divide this subgenus into two or three sections, one comprising the typical species, the other containing the rest. *C. prælongum* occupies a transitional position between these two sections. As however, this generalized subgenus answers very badly to the original meaning of *Poroceratium* Vanhöffen, I have thought it best to reduce this later denomination to that of a section and to introduce a new name for the new combination.

On account of its rarity one would be apt a priori to consider this species as not indigeneous to the Mediterranean. Nevertheless, we are dealing here with one of those regions where the species is relatively frequent. Also, the fact that the Eastern Mediterranean has a special form differing from the typical one, and the specimen found there in regeneration after fission, suggest that we here really deal with an indigeneous — though rare — species. The much wider distribution of this tropical species in winter shows, however, in my opinion, that it must have emigrated from the Atlantic. An almost decisive proof is its occurrence in samples from deep water. At st. 134 it was found at 75—125 m. (37.34 ‰—.83, 14°.3—13.7), at st. 152 in a net with 250 m. wire out (38.84 ‰, on the surface 38.62, but a distinct intermediate minimum of 38.35 in 75 m., and the net must be supposed to have remained for a relatively long time at a level intermediate between 250 m. and the surface). Both samples may therefore be supposed to come from levels containing water of Atlantic origin, and the same is the case with that from st. 194.

Based on the experiments with drift bottles, carried out on the initiative of JOHS. SCHMIDT (compare this Report vol. III, 1913), we know rather exactly how long time a transport with the Atlantic Current will take in winter from the Straits of Gibraltar to the Gulf of Tunis. Of special importance is the experiment 2 no. 73 (on the accompanying chart 2, by a printer's mistake, no. 71) which for a transport from the eastern part of the Alboran Sea to the Gulf of Tunis required in January—February a maximum of 36 days. We may therefore take it for granted that an organism from the Straits of Gibraltar will in winter be able to reach the median part of the Mediterranean in a month (or sooner). The occurrence of *C. digitatum* at st. 46 very probably answers therefore to a migration through the Straits in the first half of January.

A similar calculation for the other stations is much more uncertain. However, I should think an immigration at Gibraltar in November rather probable for the stations in the Tyrrhenian and Ligurian Seas. This would accord fairly well with the statements of PAVILLARD and ENTZ cited above. That the species occurs in the northern part of the Ionian Sea seems, however, to prove that it is well able to hibernate and may probably keep alive (for years?) in the median and inner parts of the Mediterranean.

To sum up the above statements briefly: *Ceratium digitatum* is chiefly a winter species, at that season spread over the surface of the median parts of the Mediterranean (and probably also over the

inner parts). In summer it is only found at deeper levels in the Eastern Mediterranean and quite exceptionally on the surface. Here in the Eastern Mediterranean it is apparently perennial. It is renewed by immigration from the Atlantic in January (and probably in late autumn, about November).

In a later chapter I shall try to explain how we may account for the occurrence of tropical and subtropical species in the Eastern Mediterranean in summer, chiefly at deeper levels.

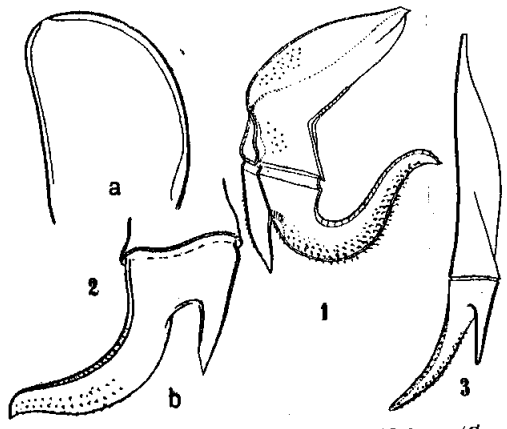


Fig. 1. *C. digitatum* Schütt. Near St. Helena (German South Polar Exp.) 26. VIII. 1903.
Fig. 2. *C. digitatum* v. *rotundatum* nov. v. St. 161 west of Rhodes August 1910; *a* epitheca, *b* hypotheca (of a broken specimen).
Fig. 3. *C. Schroeteri* Schröder (from Kofoid l. c.).

2. CERATIUM SCHROETERI Schröder (Fig. 3, p. 8).

Schröder 1906 fig. 43 p. 368. Jörgensen 1911 b p. 12 pl. II fig. 14 (from Kofoid 1907 pl. 3 figs. 18, 19).

This extremely rare species was observed by SCHRÖDER 1906, who found it singly in a sample from the Ionian Sea, gathered by HUNDHAUSEN in March 1902 (on the route Brindisi—Port Said(?), the geographical position in SCHRÖDER l. c. does not answer to the Ionian Sea). In the gatherings of the "Thor" I did not see it (except perhaps a single, very uncertain, fragment of an apical horn from st. 14 in the Southern Adriatic in winter). Otherwise it is only known from two tropical localities, in the Indian and the Pacific Oceans.

Sectio II. POROCERATIUM (Vanhöffen).

Epitheca ± strongly rounded at the apex; postical horns antapically directed, both almost straight, not spiniferous, at most indistinctly denticulate at their apices.

Subsectio ANNULIFERA nov. nom.

Epitheca most strongly flattened, plane and bladelike, the large ventral and dorsal apical plates firmly united through a skeletal annulus.

3. CERATIUM GRAVIDUM Gourret (Fig. 4, p. 10).

Jörgensen 1911 b p. 10 pl. I fig. 8.

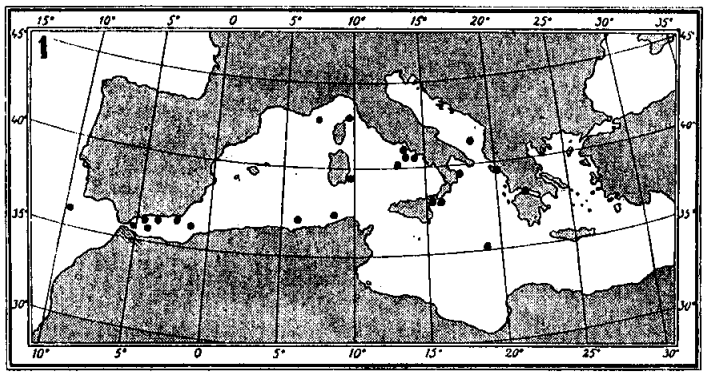
Among several misinterpreted organisms, differing in shape from that of the common Ceratia, we also find this genuine *Ceratium* already described by GOURRET, who has a very good figure of it (pl. I fig. 15). Later on it has been observed at Naples by v. DADAY, who described it as a new species, *C. oviforme* (Daday 1888 pl. 3 figs. 7, 9), by CLEVE (1903) just east of the Straits of Gibraltar in February, and between Barca and Sicily in January, and by PAVILLARD in the Gulf of Lyons (1907: Dec.—April, very rare; 1916: always rare, especially occurring in winter).

On the winter cruise of the "Thor" it proved to be generally distributed all along the route — sbs. Port Alice, 14, 16, Naupaktos, 20, Taormina; 23, 24, 25, 26, 27, 28; 33; 36; 40; 45, 46; 53, 55, 57, 58, 60; 68, 69 — in all gathered at 22 out of 37 stations, everywhere, however, only singly or in very small numbers. It reached its greatest distribution in the Alboran Sea in February, where it was only absent from one out of six stations; otherwise it was present at rather more than half of the stations in different regions, yet wanting at the (single) station (18) in the Gulf of Aegina. Its greatest relative frequency[1] only amounted to between 1 and 2 % (st. 46 off the African Coast).

[1] To obtain a somewhat more reliable base for statements on frequency I have counted all the Ceratia in a smaller part of the sample. By "relative frequency" I mean the number (n) of individuals of the species in question, expressed in percentage of the total number (t) of Ceratia counted, i. e. $\frac{100\,n}{t}$. As the number of individuals under certain circumstances may be extraordinarily small — e. g. in samples from a greater depth — I have tried to exclude those cases in which a high percentage stands in no reasonable proportion to the number of individuals.

On the summer cruise it was apparently much rarer, being only gathered at 21 out of 109 stations (in the Mediterranean) — 91; 98; 126 (100—200 m., 275 m. wire), 128 (0—100 m.), 129 (0—1100 m.); 134 (0—75 m., 75—125 m.); 152 (250 m. wire); 156 (250 m. wire, 950 m. wire), 160 (30—100 m., 100—200 m.); 163 (0—80 m.), 182 (545 m. wire); 184 (945 m. wire), 186 (0 m., 245 m. wire), 187 (100—190 m., 945 m. wire), 189 (945 m. wire); 199 (80—200 m., 945 m. wire); 206 (1945 m. wire); 209 (85—200 m.); 218, 219, 220; 228 (1145 m. wire); 231 (0 m., 1145 m. wire); 234 (95—200 m.) — again singly or in very few specimens. It had its greatest distribution in the Ionian Sea, where it was present at more than half of the stations (5 out of 9). Here again we meet with the same phenomenon as in the case of *C. digitatum*, the species has withdrawn to deeper levels and is very widely distributed, being present in deeper water at all stations where such samples were gathered except four, (sts. 132, 194, 204 and 223, all in the Western Mediterranean).

In winter there is an obvious immigration from the Atlantic with a positive result in January and February — because present at sts. 45 and 46 — perhaps even with a little increase in frequency at the salter and warmer stations (53). Its occurrence at the winter stations in the Tyrrhenian and Ligurian Seas may answer to a late autumn immigration, (perhaps about November, as mentioned above under *C. digitatum*). In June no successful immigration can be traced, the species being only present at st. 91 (in Cadiz Bay) and at st. 98 (in the Straits of Gibraltar), while it was altogether wanting in the Alboran Sea and along the African coast. In September there are traces of a feeble immigration with a positive result. It was then present in the surface at st. 231 (in Cadiz Bay) and at three consecutive stations off the African coast (218—220). This might be the result of a successful immigration in the last half of August.



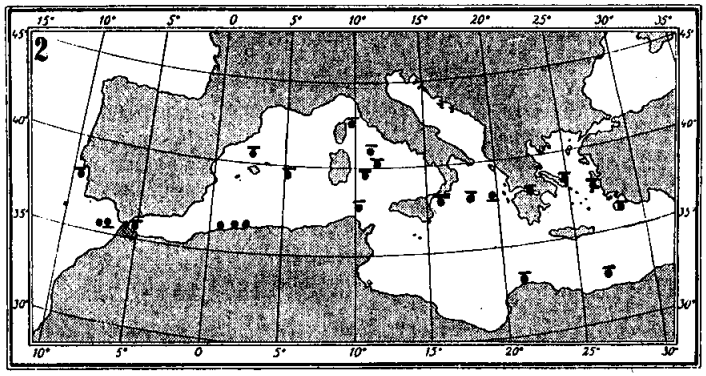


Chart 1. Distribution of *Ceratium gravidum* in winter, from the gatherings of the "Thor" and (two localities) from CLEVE 1903.
Chart 2. Distribution of *Ceratium gravidum* in summer, from the gatherings of the "Thor"; ● both in the surface and deeper, ● only in the surface, ● only in deep water.

Its occurrence in deep water is of special interest. According to the hydrographical data the species in question seems to belong to the layers of the temperature minimum caused by the cooling down of the surface layers in the heart of the winter, and to those lying immediately over. Besides it seems in part to have passed over into those "intermediate" layers below with a (feebly marked) maximum of temperature and salinity (sts. 40, 209, and most of the stations in the Eastern Mediterranean). Its occurrence at st. 228, 1145 m. wire (east of the Straits of Gibraltar) seems to show undoubtedly that here the species was present in the outflowing Mediterranean water. At st. 134 it belongs to the Atlantic water, but only to its deeper layers.

In the Ionian Sea it is present all the year, but in summer only exceptionally in the surface (st. 186). In the innermost parts of the Mediterranean, north of the stations 163 and 182, it is wanting, also to the west, outside the Mediterranean, north of st. 234 (south of Lisbon). At this latter station and likewise at st. 231, where it was somewhat more frequent at 1145 m. wire than in the surface, it also belonged to Atlantic water, chiefly to the deeper layers.

Earlier (1911 b) I have separated three different forms which are generally easily distinguished, — one with a large and broad epitheca, var. *latum*, a second with a long and rather narrow epitheca, var. *angustum*, and finally a smaller form, which I considered the type of the species (see Jörgensen 1911 b pl. I figs. 8, 11 and pl. II fig. 12 and pag. 11, note). In the Mediterranean, var. *latum* as well as my type were frequent, whilst var. *angustum* — which otherwise has a marked tropical distribution — was only seen at st. 182 (in the Aegean Sea), 545 m. wire (a single individual with a shorter epitheca than usual). Beside these three I have met with a fourth form of characteristic shape (see fig. 4). It is large and intermediate between var. *latum* and var. *angustum* in the shape of the epitheca, which here is much broader near the upper end. This forma *obovatum* nov. forma I only saw at the locality just mentioned, where all four forms were present.

Apparently too the development of the postical horns may be used as a distinguishing mark. In my earlier type (var. *elegans*, see below) they are long and slender, the but little broader left one, elegantly curved, in var. *latum* they are shorter, the left one much broader and with a strongly thickened wall, in v. *angustum* as in v. *latum* but with the left horn still more thickened and nearly double the breadth of the right one, and with both horns obviously diverging. In f. *obovatum* these horns are relatively feebly developed, rather short and parallel, or even slightly converging. Perhaps this f. *obovatum* is only an accidental form, caused by special conditions at st. 182, where the deeper layers are covered in the surface by markedly fresher water (from the Dardanelles).

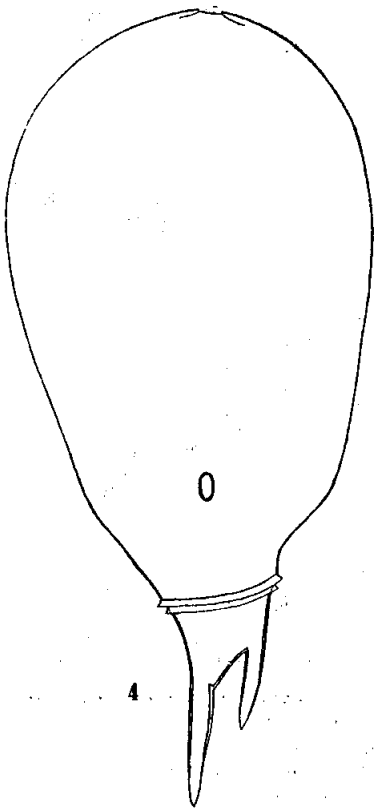


Fig. 4. *C. gravidum* f. *obovatum* nov. f.; dorsal view. St. 182, 545 m. wire, August 1910.

Considering the fact that PAVILLARD found the var. *latum* almost exclusively in the Gulf of Lyons, it seems most correct to consider this form the type of GOURRET's species. My earlier type might then be called var. *elegans* nov. nom. It occurred together with α *latum* at sts. 14, 16, 26, 45; 126, 100—200 m., 182, 545 m., 187, 100—190 m., 945 m. wire, 189, 945 m. wire and 199, 945 m. wire. It was found alone at sts. Naupaktos, 25, 33, 53, 55, 57, 58, 60, 68, 69; 91, 98, 160, 30—100 m., 163,0—80 m., 218, 219, 220, 231, 234, 95—200 m., yet with forms approaching α *latum* at sts. 57 and 58 (in the Alboran Sea). This latter was found alone at sts. Port Alice, 20, Taormina, 23, 24, 27, 28, 36, 40; 126, 275 m. wire; 128,0—100 m., 129, 0—1100 m., 134,0—75 m., 75—125 m., 152, 250 m. wire, 156, 250 m. and 950 m. wire, 160, 100—200 m., 184, 945 m., 186, 0 m. and 245 m. wire, 199, 80—200 m., 206, 1945 m. wire and 209, 85—200 m. In summer α *latum* was more frequent (in deeper water). As a rule the var. *elegans* only prevails in western regions, while α *latum* predominates in the salter parts of the sea and at deeper levels.

Outside the Mediterranean *C. gravidum* is widely distributed in the tropical and subtropical Atlantic — to the north penetrating by exception as far as 57° N between the British Isles and Greenland (VANHÖFFEN) — in the tropical Indian Ocean and near the coasts of southern Japan. At the Azores it is observed from October to June (according to Cleve 1901 a).

Fission stages were seen in the gatherings of the "Thor" in two samples, viz. at st. 26 (off Naples) between 6 and 7 o'clock in the morning, a "*f. antico-juvenile*", incompletely regenerated, presumably belonging to α *latum*, with a still small and ovate epitheca, and at st. 220 (off the coast of Algeria) between 2 and 3 o'clock in the morning, shortly after fission, epitheca still very small. This latter specimen evidently belonged to var. *elegans*.

Summing up: *C. gravidum* is in winter distributed in the surface throughout the Mediterranean

at least as far as Greece and Barca (CLEVE, 1903). It is everywhere rare. In the most western regions it occurs almost exclusively as var. *elegans*, in the others also — in part exclusively — as α *latum*. In summer it is very rare in the surface, again appearing in general as var. *elegans*. In this form it occurs sporadically in the Alboran Sea and along the coast of Africa in the western Balearic. Otherwise it is to be found throughout the Mediterranean at deeper levels, chiefly as α latum.

It is renewed by immigration, — presumably as var. *elegans*, — in January and February, and probably in late autumn, perhaps in all from October—March, (while present f. i. at st. 126 in deep waters). In winter it is (partly) carried into deeper layers where it remains during the summer. The main species, α *latum* seems to be prennial in the greater part of the Mediterranean, (outside the Atlantic Current proper) in deeper layers, apparently to some extent in the intermediate ones. No immigration of this form has been traced).

Subgenus II. **BICERATIUM** (Vanhöffen) Ostf.

Sectio III. **CANDELABRA** Jörgensen 1911.

4. **CERATIUM CANDELABRUM** (Ehrenberg) Stein (Figs. 5, 6, p. 12).

Jörgensen 1911 b (p. 16, pl. I figs. 4, 5, pl. II fig. 21).

This isolated species was at first reported from the Mediterranean (Trieste) by EHRENBERG 1859 who described it as a new species under the name of *Peridinium Candelabrum*.

Later on it was mentioned and figured by POUCHET from the coast of Provence as *C. furca* v. *contorta* (1883 p. 421 fig. *A*), by STEIN, (1883), who recognized it as EHRENBERG's species, from the Quarnero, by GOURRET, (1883), from Marseilles (see below), by IMHOF (1886 and 1891), from Venice, by v. DADAY, (1888), from Naples, by PAVILLARD, (1905) from l'étang du Thau near Cette and (1907 and 1916) from the Gulf of Lyons, by ENTZ jun., (1905), from the Adriatic and from Naples, by SCHRÖDER, (1906), from the Ionian Sea and by ZACHARIAS, (1906), from Naples, the north coast of Sicily, the Algerian coast and the Ligurian Sea.

The work of GOURRET (1883) presents special interest. This author is the first who has studied the species in a living state. He did not, however, recognize it as EHRENBERG's species, but described it as a new one under no less than six different names, viz. *C. depressum*, *C. obliquum*, *C. dilatatum* with the var. *parvum*, *C. globatum* and *C. Allieri*. Of these, *C. dilatatum* (l. c. p. 46, pl. 4, fig. 68) with var. *parvum* (fig. 63) certainly belong to this species. They are also quoted by GOURRET as common. *C. globatum* (p. 47, pl. 4, fig. 67) is only a specimen in side view — as already suggested by SCHRÖDER 1900. GOURRET has only seen one single specimen, which under the circumstances is easily understood. *C. depressum* (p. 41, pl. 1, fig. 5) and *C. obliquum* (p. 42, pl. 1, fig. 6) are more doubtful, being very different from the three successful illustrations mentioned. In consideration of the fact that there has been an essential delay in the publication of GOURRET's work — mentioned by himself in a note page 101 — during which he has added the three plates 2, 3, 4 to the single original one 1, it may seem probable that in the meanwhile he had acquired a much more thorough knowledge of the Ceratia and was therefore now able to make more correct drawings. Thus he has not recognized the species which he had already figured as *C. depressum* and *C. obliquum* on pl. 1. Beside the morphological differences of the skeletons, he also states several even more important ones, depending, however, in this and similar cases on accidental circumstances and a false interpretation. The real constitution of the cell remains for the most part concealed from him. The figures of *C. depressum* and *C. obliquum* show f. i. a reversed symmetry, the dorsal view being mistaken for the ventral. He makes this error rather frequently, and it leads of course to the establishing of quite different species.

Also *C. Allieri* (p. 56, pl. 2, fig. 38, 38 *A*) certainly belongs to *C. candelabrum*, the side view (fig. 38 *A*) being exactly the same in both. Very strange is the failing of the right posterior horn, but this is

surely only accidental. Gourret also quotes this form as very rare. I have myself found a similar form — only one specimen — at the station 60 (the Straits of Gibraltar) 21/II 1909.

Hydrographically *C. candelabrum* is a very important species for the Mediterranean, showing very clearly in the superficial layers the influx of Atlantic waters through the Straits of Gibraltar. Besides, this species together with *Ceratium pulchellum* presents points of unusual interest in the manifest proof of the transformation of a relatively well defined variety, (and a generally admitted species), into a very different one.

In the Mediterranean two different main forms of *C. candelabrum* are to be found. At all western stations, in the Bay of Cadiz, the Alboran Sea and the Southern and Western Balearic, a relatively large and robust form (see fig. 5) is the only one met with. It is identical with that which I have described and figured in my monograph of *Ceratium* (JÖRGENSEN 1911 b) as var. *dilatatum* (Gourret) JÖRGENSEN (l. c. p. 16, pl. I figs. 4, 5, pl. II fig. 22), a name which I in what follows propose to exchange for var. *depressum* (Pouchet). In other regions of the Mediterranean another form is present, very rarely accompanied by single cells of the former. Both vary considerably, especially the last mentioned form with the wider distribution, and in certain cases they are not easily distinguished, though generally well defined. Where the area of distribution of one form transgrades into that of the other — which is the case at some few stations in the South-Western Balearic — there might be doubt as to the true var. *dilatatum* Jörg. However, in the proper area of this latter variety, it is well defined and easily recognized (compare fig. 5 which only represents the Mediterranean form).

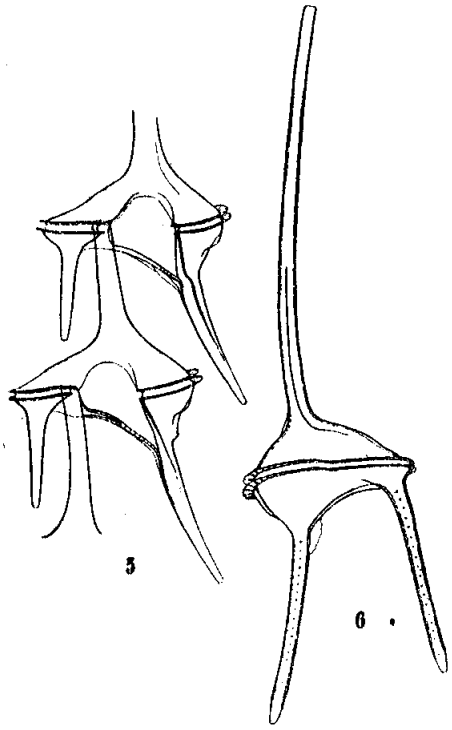


Fig. 5. *C. candelabrum* var. *depressum* (Pouch.); part of a chain. Straits of Gibraltar, Dec. 1908.
Fig. 6. *C. candelabrum* f. *dilatatum* (Gourr.). St. 143 (between Sicily and Barca). July 1910.

The other form, which I have considered the typical form of the species, is usually short-horned. It may, however, be more or less long-horned. The difference from the var. *depressum* depends only in part on the divergence of the posterior horns. As a rule longer posterior horns diverge much more towards their extremities than shorter ones. The main difference is that the "typical" form has a distinctly curved antical horn — with the convexity turning dorsally — whilst the var. *depressum* has a thicker, almost straight or little curved antical horn. The smaller, right, postical horn of the typical form, when long, often curves a little towards the distal end, so that both horns turn their concave sides more or less distinctly in the same direction, (towards the left), whilst the var. *depressum* has a straight right postical horn, or a curved one with the concave side generally opposite to that of the left horn. This different curvature is, however, not equally visible from all views and not always found. Some forms show occasionally a slight degree of curvature in the opposite direction from the usual. When long-horned, the typical form, too, possesses posterior horns showing a very conspicuous divergence at the tips. Besides, the var. *depressum* is somewhat larger and has on the whole a more robust skeleton with more or less numerous prominent lines and winged ribs, while the typical form generally has a much smoother surface.

As to the names, the material dealt with here shows that the var. *dilatatum* Jörg. (1911 b) is most probably not the *C. dilatatum* of GOURRET, which is likely to be identical with the long-horned form of the "typical" *C. candelabrum*. ENTZ 1905 (1902) has already figured this long-horned form (p. 107 pl. V fig. 39); and remarks that "the long slender form which is most frequent in summer is *C. dilatatum*

Gourret". Fig. 6 represents such a long-horned summer form from the Eastern Mediterranean stat. 143 (Sidra Sea). ENTZ also figures the common short-horned forms (l. c. figs. 37, 38).

EHRENBERG's figure of his type of the species (1873 pl., figs. 2, 3) is in accordance with my interpretation of the typical form, but does not show the curvature of the antical horn. GOURRET's and POUCHET's figures are not sufficiently exact to be used as a basis for founding definite varieties, with perhaps the exception of *C. dilatatum* Gourr. Judging from the supposed connection between my (earlier) var. *dilatatum* and the Atlantic current, it seems most probable that none of GOURRET's figures correspond to that variety, while this may be the case with *C. furca* var. *depressa* Pouch. (from Penmarch in Britany). It seems therefore advisable to distinguish the form which I have considered the typical one as α *curvatulum*, while the Atlantic variety — according to the international rules of botanical (and zoological) nomenclature — must be called either var. *dilatatum* Jörgensen (1911) or rather var. *depressum* (Pouchet 1883). Under α *curvatulum* a long-horned forma *dilatatum* (Gourr.) (non var. *dilatatum* Jörg.) might also be placed.

C. dilatatum v. *parvum* Gourr. according to the description (straight antical horn, diverging tips of the postical ones) partly answers to my var. *dilatatum*, but — according to the figure — does not resemble the latter.

C. candelabrum was found quite continually along the routes of the "Thor" in the Mediterranean, both in winter and summer. Only at some shallow coast station or where but scanty material was collected, was it lacking.

Var. **depressum** (Pouch. 1883 under *C. furca*) = var. *dilatatum* Jörg. 1911 (non *C. dilatatum* Gourret 1883) was present at all stations in winter (February 1909) from the Straits of Gibraltar through the Alboran Sea to stat. 46 at the north coast of Africa in the Balearic, except at the (more saline) station 50, from which only α *curvatulum* is noted. Generally the "relative frequency" (the number of individuals in relation to the total number of Ceratia counted see p. 8, note) increases towards the east in the Alboran Sea but from thence decreases along the African coast — where, however, only few and distant samples were taken.

Outside the Straits this variety occurred sparingly at all stations in the Cadiz Bay (mean value of relative frequency only between 1 and 2 % and of salinity 36.29 ‰ with a mean value of 15° Cels). There seems therefore to be only an inconsiderable influx of this variety through the Straits (at that season), followed by a lively propagation in the Alboran Sea, where the optimum (relative frequency 17 %) was found at the most eastern station, 53, with the highest salinity (37.25 ‰) at 13°.9 Cels. (mean values for the Alboran Sea 7 %, 36.75 ‰, 14°.0). Farther to the east along the African coast samples are present only from three, widely separated, stations, stat. 50 with a remarkably high salinity, 37.39 ‰, where only α *curvatulum* was noted, stat. 46 with 36.92 ‰ and only the var. *depressum*, and stat. 45 with 37.0 ‰. With the exception of a single individual at stat. 40 (near the south-eastern corner of Sardinia) 46 is the most eastern station at which var. *depressum* was noted on the winter cruise.

On the summer cruise var. *depressum* was found to be very scarce in Cadiz Bay (in June 1910), being only observed singly at the two western stations 89 and 91. Also on the return (in September) it was very scarce, but present at both stations (231 and 229). In the Alboran Sea it was found everywhere, in June with the mean value of 6 % relative frequency, in September more numerous, — 15 %, with the same mean value of salinity, 36.56 ‰, and almost the same mean value of temperature, 20° in June as compared with 22.6 in September. The optimum in June was at the two stations 108 and 109 near the coast of Africa, (14 %, 36.54 ‰ 20°.8), in September, however, more pronounced and at the western stations 228 (31 %, 36.45 ‰, 18°.4) and 226 (29 %). In the Balearic, where samples were now gathered more continuously, the var. *depressum* was still rather plentiful along the African coast as far as stat. 113, but soon disappeared as the route diverged from the African coast towards the north (st. 114 rr, st. 115 only 5 % empty cells of var. *depressum* as compared with 22 % normal ones of α, the last locality). In

August—September, on the return voyage, the var. *depressum* again suddenly appeared in the same region at stat. 218 (alone; 7 %, 36.74 ‰, 23°.5) and already at the next station, 219, is abundant (optimum; 17 %, 36.76 ‰, 23°.7). Farther to the west it is present at all stations, except 216, which has a remarkably high salinity (37.32 ‰), where only α *curvatulum* was noted. Outside the Atlantic current it was observed in summer only at stat. 186 (west of Greece) in deeper water.

Thus, the circumstances of inflow and distribution of the variety in the Western Mediterranean are essentially the same both in winter (Febr. 1909), and in summer, (June and Sept. 1910). There is only a (quantitatively) inconsiderable immigration through the Straits of Gibraltar, a considerable increase

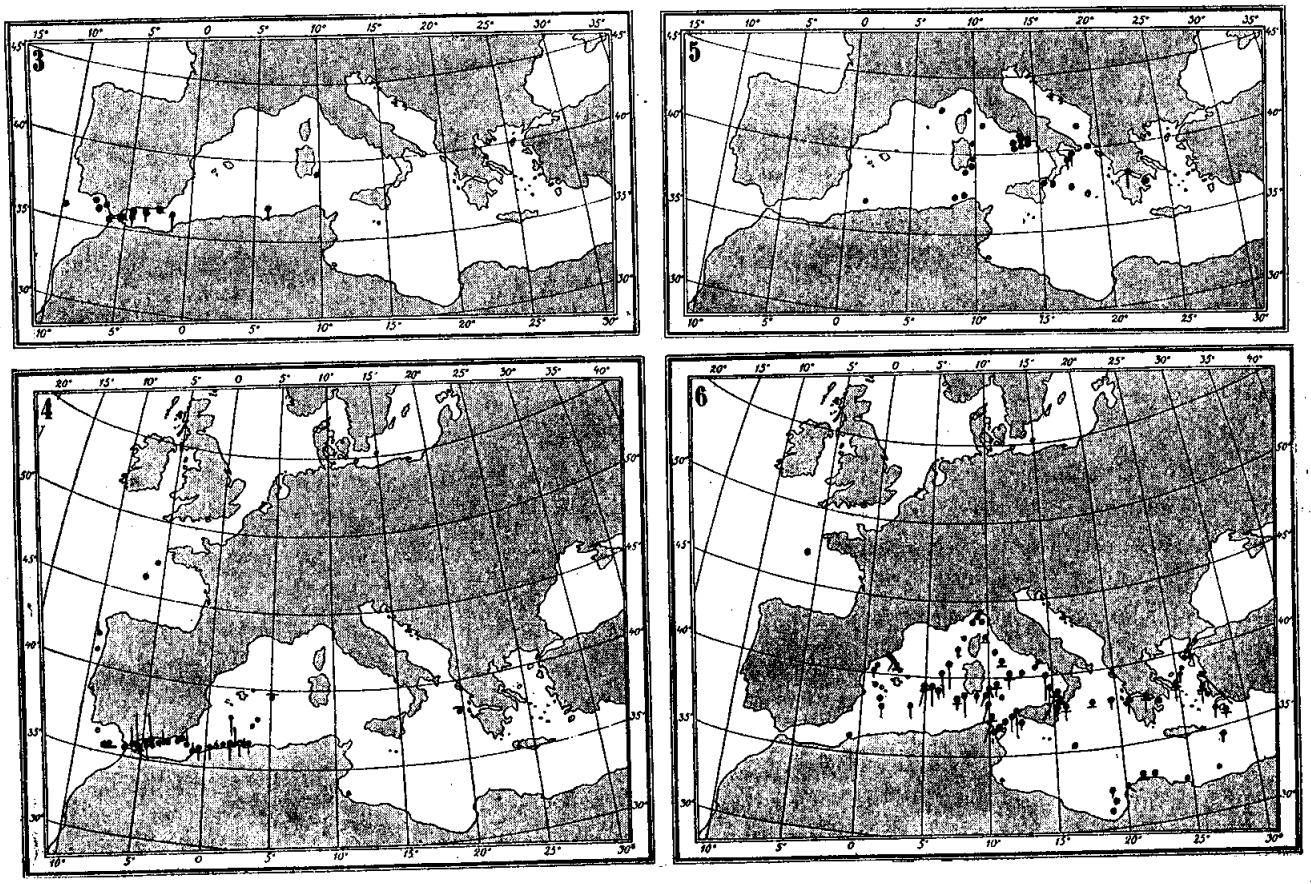


Chart 3. Distribution of *C. candelabrum* var. *depressum* (Pouch.) in winter. A relative frequency greater than 7 % is designated by a short line, 1 mm. long for 10 %, 2 mm. for 20 % a. s. o.

Chart 4. Distribution of *C. candelabrum* var. *depressum* (Pouch.) in summer. The lines in an upward direction designate the relative frequency on the return voyage; otherwise as in Charts 3 and 2.

Chart 5. Distribution of *C. candelabrum* α *curvatulum* in winter.

Chart 6. Distribution of *C. candelabrum* α *curvatulum* in summer. (The same designation as on the preceding charts.)

of frequency in the Alboran Sea — especially late in the summer — also revealed by observations of numerous chains of two or more individuals, exceptionally as many as 11, — and then a rather sudden disappearance in the south-western Balearic on the eastern coast of Algeria. On the summer cruise no samples were taken on this eastern coast (east of stat. 113), and farther to the east, along the Tunisian coast (sts. 134—137), only α *curvatulum* was observed. Considering this fact, and the occurrence of single, most probably dead cells at st. 40 south-east of Sardinia in the winter of 1909, in deep water at st. 186 in the Ionian Sea and at st. 206 east of the Baleares in the summer of 1910, it seems probable that the var. *depressum* does not stand the transmission into the salter water of the inner Mediterranean. The

greater part of the individuals perhaps perish, while a certain number, through a repeated cell-division. transform into the less robust α *curvatulum* which is perennial throughout the Mediterranean, but — as shown below — especially numerous in the southern and western part of the Balearic and the Tyrrhenian Seas. (For further details see below).

α curvatulum.

On the winter cruise this typical form was observed (Dec.—Febr.) at (almost) all stations east of, and at st. 45 (off the border between Algeria and Tunis), farther to the west only at st. 50 (with an unusually high salinity, 37.37 ‰). The relative frequency was on an average in the Balearic 4 % with a salinity of 37.41 ‰ and a temperature of 13°.3 C., while the only station where the var. *depressum* was found (st. 46), had 36.93 ‰ and 14°.2. In the different regions of the Mediterranean this typical form was most numerous at the only station in the (southern) Adriatic (st. 14) in December (5 %, 13°.7) and in the Ionian Sea (mean values 5 %, 38.06 ‰, 15°.4). The optimum was observed at Naupaktos in the Gulf of Corinth (16 %) and at st. 12 in the Gulf of Taranto (11 %, 14°.2). Otherwise the species was only observed in small numbers: Gulf of Aegina 1 %, 38.40 ‰, 15°.2, Tyrrhenian Sea mean values 1 % (maxim. 2 %), 38.02 ‰, 13°.6, Ligurian rr. to 1 %, 38.06 ‰, 12°.9.

On the summer cruise similar relative conditions were found, only the species was far more numerous in the western than in the eastern Mediterranean. The typical form on the outward route appeared 28/VI at st. 115, where the route left the Atlantic current proper. Here both the typical form and the var. *depressum* occurred, the latter, however, in much smaller quantities (5 %), and as empty cells as compared with 22 % normal cells of α *curvatulum*. This answers very well to the mixing of Atlantic and salter Mediterranean waters, extending northwards as a less marked branch of the Atlantic current. On the return voyage in August—September the var. *depressum* again suddenly appeared at st. 217 (sse. of Ibiza), where the typical form was still prevailing, however, a single individual (of var. *depress.*) was observed in deep water at st. 206, where α was numerous, — 21 % in the surface. Farther to the west only the var. *depressum* was found, except at the shallow station 221 on the boundary between the Alboran and the Balearic Seas, where also α was observed, whilst the variety was prevailing.

In the various regions the typical form was present under relatively very different conditions. In the Balearic in June—July the mean values were 20 %, 37.68 ‰, 20°.8 (as compared with 9 %, 37.22 ‰, 21°.5 for the var. *depressum*), in August—September 14 %, 37.70 ‰, 14° (for var. *depressum* 11 %, 36.74 ‰, 22°.4), in August in more easterly regions, towards Tunis, (sts. 133—139) 15 %, 37.36 ‰, 21°.6 with an optimum at st. 134, (29 %, 37.12 ‰, 22.6). In the Catalonian Sea towards the end of August the corresponding figures were 6 %, 37.91 ‰, 24°.8. Here the long-horned form, f. *dilatatum* (Gourret), was present at the stations 212, 213, 215 (and Barcelona), with a lower salinity and a higher temperature (37.71 ‰, 25°.8 as compared with 38.05 ‰, 24°.1) consequently answering to a lower specific gravity. In the Ligurian Sea (July, sts. 122—125) the species was less numerous, the mean values being 5 ‰, 38.12 ‰, 19°.2. In the Tyrrhenian Sea in July there was on an average a frequency of 7 % with the mean values 38.08 ‰ and 20°.8, and an optimum of 15 % (37.95 ‰, 21°.8) at st. 129 in the middle of the sea. In August in the south and south-eastern half of the sea, the corresponding mean values were 18 %, 38.12 ‰ and 24°.2, with an optimum at st. 194 (37 %, 37.92 ‰, 25°.4, the dominating species) and st. 195 (36 %, 38.03, 26°.1). In the Ionian Sea, along the coast of Barca, the species was extremely rare, (sts. 152—153 rr, 38.62 ‰, 24°.2), while in August between northern Greece and Sicily it was plentiful, (mean values 11 %, 38.23 ‰, 24°.1) with an optimum at sts. 184 (in the Gulf of Corinth) and 185 (at the mouth) of 16 % (38.21 ‰, 24°). In the Sidra Sea the corresponding mean values were 6 %, 38.19 ‰ and 24°.5; at the inner stations the species was scarcer. In the Levant there were still (in July—August) a considerable number of individuals (mean values 8 %, 39.01 ‰, 25°.2) with an optimum

at the southern, least saline station, — 154 (18 %, 38.68 ‰, 24°.6). In the Aegean Sea the species was as a rule rather scarce, — here and there, however, numerous (st. 163 18 %, st. 164 48 %, absolute optimum (39.04 ‰, 24°.4), st. 182 in the surface 32 %), mean value 12 %. At st. 168 in the Dardanelles single individuals were encountered, otherwise the species was wholly wanting east of the Aegean Sea, even in the depths of the Sea of Marmora.

On the whole the typical form is perennial in all regions of the Mediterranean except the Alboran Sea and the coast of Algeria, where it is replaced by the var. *depressum* (Pouch.) (= var. *dilatatum* Jörg.). During the winter it seems to decrease greatly in numbers — especially in the western Mediterranean — except in certain enclosed basins like the Gulf of Corinth where its frequency seems to remain rather constant. This decrease may be due to lower winter temperature. However a rise in temperature shows no traceable corresponding increase in numbers. Yet, on the other hand, the fact that this variety is found in relatively greater abundance in winter in the eastern Mediterranean, where the temperature is higher, might lead one to conclude that the effect of the pronounced decrease in temperature in the west was a factor to be considered. Another cause, which is perhaps much more effective, is the vertical movement which may in winter remove most of the individuals from the superficial layers. Unfortunately no deep water samples from the winter cruise are present.

There seems on the whole to be an increase in numbers towards the end of summer — the autumn, and — especially noteworthy — this increase seems to follow the prolongation of the Atlantic current along the north coast of Africa through the Sardinian channel towards Sicily, and farther east up along the west coast of southern Italy, in which region a secondary optimum was found (sts. 194 and 195).

Based on these facts concerning the distribution of the two main forms, α and var. *depressum* (Pouch.) I should be apt to suppose the following connection to exist between them (already suggested above under var. *depressum*): At different seasons, especially during the winter immigration through the Straits of Gibraltar of some individuals of var. *depressum* occurs. These individuals appear to find more favourable conditions for propagation in the Mediterranean and the relative frequency soon becomes considerable. On penetrating farther into the waters of the Mediterranean this form no longer seems able to stand the increased salinity, which at first apparently causes an abnormal increase in the rate of propagation and finally the development of the "typical" form α *curvatulum*, with a more delicate skeleton and a somewhat smaller size. However this transformation takes place only in part, for a considerable portion of the individuals at hand had been unable to adjust themselves in this way to the changed conditions. These will perish and as long as they are in possession of tolerably intact plasma will probably drift with the currents, sinking finally to greater depths or to the bottom.

The crisis being happily overcome — apparently somewhere between Algiers and Tunis, or before, — it is easily understood that the typical form is immediately present in great numbers. This seems still under the influence of the Atlantic Current, for in summer and autumn the relative frequency, which at that time is still on the increase, is greatest in the vicinity of that current. Thus we find a great relative frequency at the stations 115—118 (22—28 %), where a branch of the Atlantic Current curves towards the Gulf of Genoa, and the same is the case from the region of Tunis towards Sicily and from the Straits of Messina up along the west coast of Italy, where a second branch of the current makes its way (sts. 134, 139, 194, 195, 196 show a frequency of 25—37 %).

Quite certain it seems to be that the var. *depressum* (var. *dilatatum* Jörg.) is not indigeneous — though it may be called "perennial" — to the Mediterranean, but emigrates from the Atlantic only to vanish before penetrating very far, while the type, α *curvatulum*, is spread all through the Mediterranean and indigeneous there, in the common sense of the word. Very probably this latter form is also largely independent of the Atlantic Current, being adapted, but to a different degree in different forms (of lower rank), to live under the various more or less high degrees of salinity and temperature. Nor is it necessary to suppose

a continual inflow and transformation in order to understand the present condition of this form; it would be sufficient to admit that inflow has taken place. I think, however, that my hypothesis advanced above explains the facts in question in the most natural way.

Two other facts seem also to support the same explanation, viz. the frequent occurrence of chains in *var. depressum* — see below — while they are almost entirely wanting in α *curvatulum*, and the apparent transition of both forms into each other at the few stations where their areas are contiguous, while otherwise they are easily distinguished.

The var. *depressum* often forms chains (cfr. JÖRGENSEN 1911 b p. 5). These are caused by a repeated self-division without complete separation of the individuals following and may therefore usually be considered a proof that fission has taken place not long before. At all events chains indicate that propagation is going on. Moreover, incompletely regenerated stages after fission were noted for var. *depressum* from 3 stations, chains sometimes relatively numerous, consisting of from 2 to 11 individuals, from 5 stations. Fission also in this species, as usual, most frequently takes place in the night; the greatest number of young stages were found between 3 and 4 o'clock a. m. in July. Also for α *curvatulum* young stages were for the most part observed early in the morning; only one chain (of two individuals) was seen, at st. 120.

In regard to the best hydrographical conditions for the species, the optimum for α *curvatulum* at st. 164 near Asia Minor gives 39.04 ‰ with 24°.4 C., and that at sts. 194 and 195 (between Messina and Naples) seems to suggest a salinity of about 38 ‰ with a temperature in August of 26° as best adapted. For var. *depressum* the optimum at st. 228 (in the western Alboran Sea) gives 36.45 ‰ and 18°.4 in September. At the neighbouring station, 227, several chains (of 3 to 5 individuals) were observed between 5 and 6 o'clock p. m.; at st. 228 only in deep water, but here more than $^1/_4$ of the individuals counted occurred in chains of twos. The disappearance of var. *depressum* between Algiers and Tunis in summer seems to give an upper limit for this variety of somewhat over 37 ‰ with about 22° C. CLEVE (1901 a, p. 213) has the mean values 35.69 ‰ and 22°.4 for *Ceratium candelabrum*.

If the var. *depressum* is really in part killed by the salter Mediterranean water and sinks down to greater depths — as supposed above — it should be found in some quantity in the undercurrent from the Mediterranean to the Atlantic. The material dealt with only contains two samples which might show this, viz. a deep water sample from st. 228 (in the western Alboran Sea, obtained by towing a Nansen-net on the young fish trawl) at 1145 m. wire, and a corresponding one from the eastern, st. 223, 1950 m. wire. Both these samples show indeed a great frequency of var. *depressum* in the depth, st. 228 even 35 % as compared with 31 % in the surface, the eastern st. 223 15 % (the surface sample was in too bad a condition to be regularly treated). On the other hand, α *curvatulum* keeps mainly to the surface and is generally very scarce in deep water.

At all events I hope my hypothesis is worth trying; if it is right in the main, we have here a very interesting example of transformation.

On the way between the Channel and the Bay of Cadiz in June the species was only observed singly at st. 79 (ssw. of Brittany), in September it was somewhat more frequent, at sts. 242 and 245 in the northern part of the Bay of Biscay, scarce, and along the northern coast of Portugal down to Lisbon (sts. 238 (11 %), 237 rr, Lisbon rr).

Sectio IV. **FURCIFORMIA** Jörg. 1911.

5. **CERATIUM FURCA** (Ehrenberg) Claparède et Lachmann (Figs. 7—12, p. 21).

Jörgensen 1911 b (p. 17, pl. II, figs. 23—26).

This cosmopolitan species was noted from the Mediterranean already by EHRENBERG who described it, 1859, from Trieste as a new species, *Peridinium eugrammum*. He was himself aware that it was

closely allied to »*Peridinium*« *furca*, but he considered it distinct because of the conspicuous structure of the theca, not observed by him in *Ceratium furca*. This form from the inner Mediterranean differs from the northern form from the Belt Sea (cfr. JÖRGENSEN 1911 b).

POUCHET, (1883) mentions the species from the Mediterranean by its right name, *C. furca*; his var. *contorta* belongs, however, as above mentioned to *C. candelabrum*. STEIN recognized EHRENBERG's species in the same year as a form of *C. furca*.

GOURRET, (1883) has four figures belonging to this species, pl. 1, fig. 14 and pl. 4, figs. 60—62. The former — like most of his figures on plate 1 — is a bad one, the three latter, however, really good. Fig. 14 is designated as *C. furca*. Fig. 60, *C. furca* var. *singulare* Gourr., resembles my f. *magnipes* (see below). GOURRET founds this variety on a singular notch of the theca, just above the base of the right postical horn; this is, however, only accidental and either owing to a rupture along a suture between two plates of the theca or the "holder" of the posterior individual of a chain. GOURRET tells nothing about the frequency of this variety. His fig. 61, *C. furca* var. *tertium* Gourr., seems to represent a form, nearly allied to that which I have named f. *belonoides* — it is quoted by GOURRET as common —, whilst fig. 62, var. *medium* Gourr., is one of the shorter and broader forms. On the other hand, his *C. furca* var. *mediterraneum* pl. 1 fig. 13 is a (bad) figure of a species belonging to the fusus-group.

Later on, various authors mention *C. furca* as a common species from different parts of the Mediterranean.

It is found almost continually in the plankton samples of the "Thor", but with an astonishing irregularity of frequency, which now and then varies extraordinarily. On the whole the species was most frequent in the western Mediterranean; in the eastern it generally proved very scarce, though as a rule almost everywhere present and exceptionally also in greater numbers (st. 164 near the coast of Asia Minor 27 %). We should, however, remember that this narrow species easily slips through the net.

Outside the Straits of Gibraltar it was still more numerous, especially in June in the Bay of Biscay and along the west coast of Portugal, where as a rule it was by far the dominating species. On an average the relative frequency in the Mediterranean was greatest in the most western part of the Alboran Sea (22 % in February, 22 % in June and 9 % in September).

As to the hydrographical conditions for this species, which on the whole, answering to its cosmopolitan distribution, proves to be amply eurytherm, but probably less euryhaline, the stations where it appeared in greatest numbers show a relatively low mean value of salinity. As such stations the following may be quoted:

st. 246 (63 % relative frequency, 36.09 ‰, 17°.1 Cels.), st. 80 (75 %, 35.57 ‰, 15°.4), st. 242 (72 %, 35.57 ‰, 17°.3), all in the Bay of Biscay, sts. 81 (97 %, 35.43 ‰, 17°.9) and 85 (59 %, 35.95 ‰, 16°.7) west of Portugal, sts. 58 (49 %, 36.80 ‰, 13°.6) and 109 (60 %, 36.55 ‰, 20°.6) in the Alboran Sea, st. 110 (52 %, 36.58 ‰, 20°.8) on the north coast of Africa in the Balearic, Tunis (80 %), Barcelona (72 %), Genoa (19 %), st. 27 off Naples (36 %), outside Naples (63 %).

These stations give the mean values 63 %, 36.09 ‰ and 17°.1. The absolute optimum (st. 81) shows 97 %, 35.43 ‰ (minimum of salinity) and 17°.9.

The high frequency at coast stations is striking. This is especially well marked in the Mediterranean, less so outside the Straits of Gibraltar.

Moreover, the fluctuations of the figures, answering to neighbouring stations are — as mentioned above — very great and apparently without direct connection with the corresponding variations of salinity and temperature. As a rule the species seems to prefer a lower value of these hydrographical elements, which is also in accordance with its scarcity in the eastern Mediterranean; yet it can tolerate a salinity of 39.22 ‰ with a temperature of 26°.3 at Rhodes, st. 160 (6 % relative frequency). In winter and early summer it is relatively numerous and seems to decrease in numbers towards the hot season. PAVILLARD

(1916), also states that it is "sometimes" very numerous, from April to July, in the Gulf of Lyons. This also points to an irregularity of frequency, which only in part may be referred to the defective catching power of the net.

The region of fresher water from the Dardanelles to the Black Sea affords special interest. Here *C. furca* was everywhere present (except in the deepest sample, 195—1000 m., of st. 170 in the Eastern Marmora); in the Dardanelles it was scarce, but otherwise very numerous (relative frequency in the surface of the Sea of Marmora 60 %, of the Bosphorus 85 % and of the Black Sea 70 % and usually by far the predominant species. All four samples taken with the closing net at st. 172 in the Black Sea (0—17 m. 65 %, 17—50 m. 15 % and 51—200 m., in very cold water, 8°.2—7°.3—8°.5, 20 %), show plenty of it. In the eastern part of the Sea of Marmora (st. 170) it is quite predominant in the surface (90 %), plentiful in the still rather fresh water at 0—20 m. (30 %, salinity 21.5 ‰—26.9) and in the mixed water at 20—80 m. (30 %, sal. 26.9 ‰—38.4), but scarce in the almost unmixed salt water from the Aegean Sea at 85—200 m. (4 %, sal. 38.48 ‰—38.46). Here a distinct, though only slight, difference of the forms was observed. In the Aegean Sea the species was represented by a narrow form, very similar to fig. 25 (pl. II) in my monograph, (JÖRGENSEN 1911). This form vanished at st. 167, only to reappear at sts. 179 and 180 (in the Aegean), except a few individuals in the deeper layers of the Sea of Marmora. In the little saline water of the surface of the Marmora and in the water of the Black Sea another, slightly modified, form occurred, which was longer, in ventral view with a more abruptly narrowed epitheca (especially at the right side) and with its right posterior horn half the length of the left one or mostly somewhat longer (fig. 8). In the sample taken from the deepest level (51—200 m.) at st. 172 in the Black Sea, with a low temperature (7°.3—8.5), a short and thick form, similar to fig. 24 of my monograph, occurred. These two forms seem to answer well to those mentioned by MINKIEVICZ 1900 (in Zoolog. Anz. vol. 23 p. 545—46) from the Bay of Sebastopol; he considers the shorter and broader form to be a winter form, the longer one a summer form. According to J. N. NIELSEN, Hydrography of the Mediterranean (1912) p. 117, the intermediate minimum of temperature (at 85 m. of st. 172) is caused by a cooling down of the surface in winter.

The special form of the fresher surface water (fig. 8) was traced all the way from the Dardanelles and back again, otherwise it was only met with by exception in the neighbouring part of the Aegean Sea (st. 167, rr). It, differs however, too little from the Aegean form to serve as a distinct indicator of the water from the Black Sea. Besides, we have already such an indicator in *C. tripos* (see below).

Though of course perennial in the Mediterranean, *C. furca* seems to be constantly reintroduced from the Atlantic. It is undoubtedly an oceanic species, apparently, however, favourably influenced by coastal water. Special forms, adapted to different conditions, have been developed.

In my monograph (JÖRGENSEN 1911 b) I have separated the northern type of the species from the southern form, which is cosmopolitan in all warmer seas and comprises many different forms of lower rank. The material of the summer cruise allows a comparison of these two units — which I have considered as subspecies — in a region where their areas meet each other. From this it is seen that the northern robust form occurs from the Channel to about the southern coast of Portugal, where forms, transitional to the subsp. *engrammum* appear more or less numerous. In this region, north of Cadiz Bay, robust, short, broad and more or less thick forms prevail or appear alone, generally in great numbers.

Fig. 8 represents such a form from the west coast of Portugal, an especially thick form of singular aspect,

f. **corpulentum** n. f.

Theca short, broad and thick, unevenly angular, with a conspicuous structure of ribs and pores. Outline of theca and dorsal view behind the girdle obviously trapezoidal, with strongly oblique sides. Apical horn more or less conspicuously curved, with its concavity turned ventrally. Posterior horns strong,

only little diverging, the right one more ventrally directed than the left. Transdiameter t up to 64 μ. Is — like *C. pentagonum* var. *turgidum* Jörg. — one of those forms usually occuring singly, which, on account of their greater size, well developed structure and angular theca (?) immediately suggest the idea of being old individuals in contradistinction to the young ones with the opposite characteristics. They are probably due to certain physical conditions; in this case, from the data of st. 87, to the essentially colder water just below the surface.

West coast of Portugal, st. 84, very numerous in 10—25 m. (frequency 38 %, salinity 35.70—.73, scarcely greater than in the surface, temp. 13°.3—12.5, in the surface 17°.0); st. 87 (near Cape S. Vincent) scarce.

Fig. 9 is one of the commoner short and broad (but less thick) forms, evidently transitional between the type of the species and the subspecies *eugrammum*.

In contradistinction to these broader forms I have figured an unusually narrow one in fig. 10 as

f. **belonoides** n. f.

Theca long and slender, without conspicuous structure. Apical horn long and almost straight. Posterior horns nearly parallel. Girdle-region but little or indistinctly prominent. Transdiameter t only up to 37 μ or a little more.

Alboran Sea, sts. 100 and 228. Is essentially the same form as the narrow one, figured in my monograph (Jörgensen 1911 b) pl. II fig. 26, only even longer and narrower. These less extreme forms (as fig. 26) are in fact most common in the Mediterranean, except at shallow coast stations.

While these narrow forms usually agree very well in character with the subsp. *eugrammum* (Ehrb.) Jörg., deviating forms occasionally occur. Such a one is

f. **magnipes** n. f., fig. 11.

Theca, like f. *belonoides*, long and slender, but with relatively very large and robust posterior, horns, which are moreover more or less conspicuously divergent. The right posterior horn more than half the length of the left one (in subsp. *eugrammum* almost always distinctly shorter).

Rare; st. 83 (west coast of Portugal) and sts. 96, 97 (just outside the Straits of Gibraltar), at all three stations much less numerous than the usual forms, but very easily distinguished.

There are many more or less distinctly different or confluent forms of *C. furca* in the Mediterranean (cfr. also PAVILLARD 1916 p. 14); on the whole it might, however, perhaps be possible and practical to distinguish between a narrow variety (JÖRGENSEN 1911 b figs. 26 and 25) and a broad one (fig. 24 l. c.), both with different "forms".

My interpretation of the northern and southern main forms as two subspecies might be justified by the fact that all forms from warmer seas show certain mutual characters, in contradistinction to the northern type of the species. Nevertheless, there exist transitional forms — as f. i. proved by the gatherings from the summer cruise outside the Mediterranean — but apparently only in a small border region. We have here, I think, a case analogous to the geographical species of WETTSTEIN, where nearly allied species show different areas of distribution, in the main mutually exclusive; there is only a great quantitative difference. Here, in the case of *C. furca*, I should think it most natural to consider the widely distributed southern form as the proper "species", the typical form. However, we would then, come into conflict with the adapted international rules of nomenclature, which of course must be folloved as far as possible. According to these rules the northern form must be considered the typical one.

On the other hand one might drop the special denomination for the southern form and substitute a series of "forms", in the usual meaning of the word. This method would have a certain advantage. Nevertheless, I think it generally will be better to group the different units, in so far as it is practicable, according to their different rank, as is always done with the higher units, from "species" upwards. It is not, however, necessary to link these lower group names together — *C. furca eugrammum tertium belono-*

ides — nor is it necessary to write *Peridiniales Peridiniaceæ Ceratium* etc.; *C. furca* f. *belonoides* will do, supposing homonyms being avoided within the species. Besides, every thing that facilitates a general survey should be used, if not serious inconveniences arise.

From this point of view I should recommend trying whether or not the old names, *C. furca* var. *medium* Gourr. and *C. furca* var. *tertium* Gourr. might be used, for the broad and the narrow form of the subsp. *eugrammum* respectively. To support and amplify my figures cited above figs. 24—26 might be used, (fig. 24) for var. *medium* and (figs. 26, 25) for var. *tertium* respectively. Under these varieties a certain number of forms might again be distinguished, as above suggested. Such definite forms should never, however, be founded only on old, vague and incomplete figures or descriptions.

If we drop the denomination subsp. *eugrammum* (as a subspecies) this latter name should only be applied to one of the short and broad coast forms of the Mediterranean.

ENTZ (1905 p. 99) considers the short forms as winter forms, in contradistinction to longer summer forms. This does not agree with my experiences, except in so far as the bigger forms only seem to prevail in colder water.

A very singular form is

f. **nannofurca** n. f., fig. 12; Entz (1905) pl. 1 (p. 99) fig. 1.

Remarkably small and narrow. Apical horn almost passing into the epitheca evenly. Postical horns nearly parallel, the left one diverging a little towards the distal end. — Perhaps only an abnormal and accidental form. Transdiameter *t* only 17 μ; total length about 170 μ (as compared to 236—314 in figs. 3—6).

St. 68 (Cadiz Bay, February), singly. If ENTZ's form is the same, also found in the Quarnero. ENTZ remarks that his form has a flattened horn; I have observed no other flattening than that which is a consequence of the general dorsi-ventral compression of the body and this does not extend to the horn proper.

In deep water samples the species is generally present everywhere, except in the western Mediterranean where as a rule it is more common in the surface; sometimes, however, more numerous (st. 209 11 %, st. 228 in the outflowing Mediterranean water 12 %, st. 231 6 %). In the eastern Mediterranean it is, on the contrary, almost as frequent at deeper levels and sometimes — though seldom — even wanting in the surface (sts. 152 and 156). In many cases an apparent increase in numbers in the deepest layers may naturally be due to the sinking down of dead cells.

It is noticeable that only very few fission stages were observed: between 0 and 1 o'clock a. m. at st. 94, just after fission, between 3 and 4 o'clock a. m. at sts. 113 and 136, and between 5 and 6 o'clock a. m. at sts. 209 and 235 (incompletely regenera-

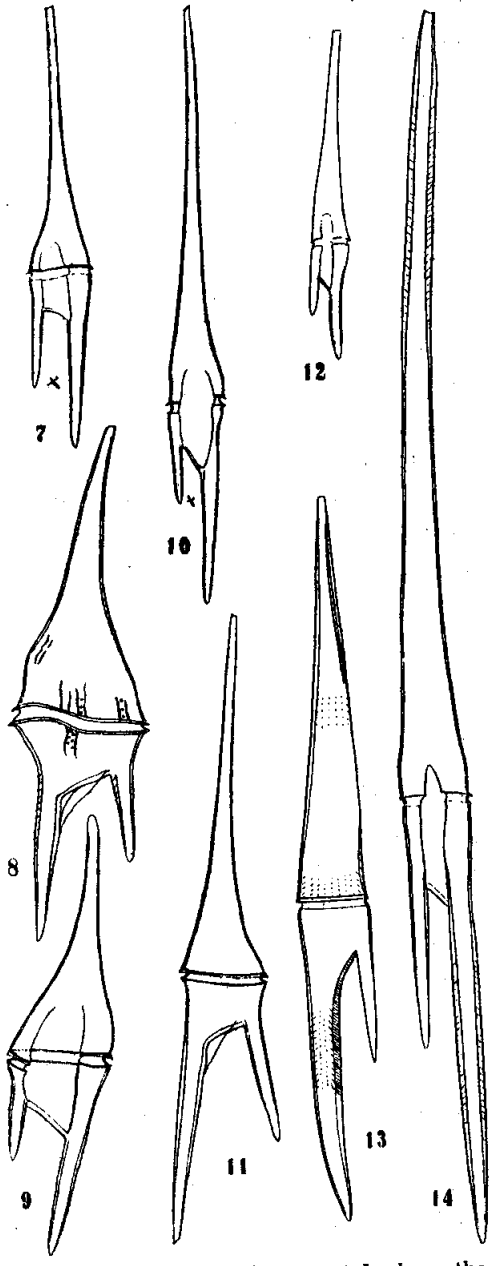


Fig. 7. *C. furca* (Ehrb.) Clap. et Lachm., the form from the fresher water at st. 168 (Marmora) August 1910.
Fig. 8. *C. furca* f. *corpulentum* nov. f. St. 184 (west coast of Portugal) June 1910.
Fig. 9. *C. furca*, a short and broad form, answering tolerably to var. *medium* Gourr. St. 81 (off the north coast of Portugal) June 1910.
Fig. 10. *C. furca* f. *belonoides* nov. f. St. 100 (Alboran Sea) June 1910.
Fig. 11. *C. furca* f. *magnipes* nov. f., dorsal view. St. 83 (west coast of Portugal) June 1910.
Fig. 12. *C. furca* f. *nannofurca* nov. f., ventral view (not oblique). St. 68 (Cadiz Bay), February 1909.
Fig. 13. *C. incisum* (Karst) Jörg. Valdivia-Exp. st. 65 (Gulf of Guinea).
Fig. 14. *C. belone* Cl. St. 55 (south coast of Spain) February 1909.

ted). This shows that in this species too fission (chiefly) takes place at night and that the rate of propagation is low.

6. CERATIUM INCISUM (Karsten) Jörgensen 1911 b (p. 19 pl. II figs. 29, 30). Fig. 13 p. 21.

C. belone Okamura and Nishikawa (1904), Schröder (1906), vix Cleve (1900).

This rare species has only been reported once before from the Mediterranean, viz. by SCHRÖDER (1906) p. 322: "Ionian Sea", March 1902 (see above under *C. Schroeteri*). In the gatherings of the "Thor" I have also only observed it once, at st. 160 (Rhodes) 200—100 m., singly (38.86—38.91 ‰, 14°.4—15°.0, 1/VIII 1910). Till now, this species is only known outside the Mediterranean, from a few localities (only 10 known to me) in the tropical zone, most of them (7) in the Red Sea and the Arabian Seas, and from the south coast of Japan. In the Mediterranean, it is only observed in the salter eastern part; the relatively low temperature which is not favourable for the species, suggests, however, that this occurrence too is only accidental.

It is therefore most probable that this species is only a rare visitor here, and has been carried accidentally through the Straits of Gibraltar by the Atlantic Current. Found where it was it must have passed the Straits several months before, in April or earlier. Like other tropical and subtropical species it is likely to have been transferred to deeper levels by the cooling down of the surface in winter. The layers in question (st. 160, 100—200 m.) show no maximum of temperature and salinity, but are characterised by a very slow decrease of both. Species which by some means or other have got into the real "intermediate" layers are likely to drift a long way and time before they get out again. Like certain other rare tropical species, f. i. *C. digitatum* and *C. prælongum*, *C. incisum* is a relatively heavy species and perhaps only apparently so very rare, because it does not belong to the proper superficial layers. If it passed the Straits below the surface it would require a still longer time to reach the st. 160, so that a migration before winter minimum seems reasonable.

The species is not known from the Azores nor the Florida Current; I have, however, seen it in a sample from the West Indies, between Cuba and Porto Rico, whence it may be carried by the Antilles Current into the Florida Current or the Gulf Stream.

7. CERATIUM BELONE Cleve (non Okamura et Nishikawa 1904, nec Schröder 1906). (Fig. 14, p. 21).

Jörgensen 1911 b p. 19, pl. II figs. 28 *a*, *b*. *C. pacificum* Schröder 1906 p. 368 figs. 42 *a*, *b*.

This rare and isolated species was first noted from the Mediterranean by PAVILLARD 1907 as found in a single sample, Oct. '06 in the Gulf of Lyons. Later, (PAVILLARD, 1916), it was noted as found there in another sample, in January 1909.

In the material of the "Thor" it is usually reported singly, but is found at no less than 22 stations, all in the Western Mediterranean, but as far east as off Naples. It proves to be essentially dependent on the seasons and reaches its greatest distribution during the winter; from Decbr. '08 to Febr. '09 it was found at 19 stations from off Naples towards and past the south-east coast of Sardinia to off the coast of Tunis, and thence to Cadiz Bay. In the early summer, on the contrary, it was almost completely wanting, being only found on the outward route of the summer cruise at st. 93 in Cadiz Bay June '10, north of the entrance to the Straits of Gibraltar. On the return voyage it did not appear till Sept. '10 at st. 218 near the coast of Africa in the Western Balearic, but continued hence at intervals through the Alboran Sea to Cadiz Bay (7 sts. in the Mediterranean as compared to 15 in winter).

On the winter cruise it was caught in the Tyrrhenian Sea at most of the stations off Naples (sts. 24, 25, 26, 28, 29, only wanting at sts. 23 and 27), but did not follow up to the Ligurian Sea. Then it reappeared at st. 39 east of Southern Sardinia, and continued hence to st. 46, off the coast of Eastern

Algeria. Farther to the west it was found at st. 55 (wanting at sts. 53 and 57), and then continually from st. 58 to the most western one in Cadiz Bay, st. 69, where it again was wanting. Its occurrence then in the Tyrrhenian Sea shows a mean value of salinity of 37.94 ‰ with a temperature of 13°.7 C., in the Alboran Sea 36.51 ‰ and 14°.6, and outside the Straits, in Cadiz Bay, 36.30 ‰ with 15°.1. Everywhere it was only found singly except at st. 45 in the Balearic (off the border between Algeria and Tunis) where it made 3 % of the total number of Ceratia counted ("relative frequency" 3 %, 37 ‰, 14°.0), and at st. 60 just east of the Straits where 2 % (36.5 ‰, 14°.6).

On the summer cruise outwards it was only caught at st. 93 (36.04 ‰, 19°.1), but reappeared on the return at sts. 218, 220, 221 and 223 (wanting at 219, 224, 225, 226) and then continually from st. 227 to st. 231, definitely disappearing at the next st. 234 west of Portugal. The corresponding hydrographical data are 36.74 ‰, 23°.5 and 36.56 ‰, 18°.8 in the Balearic, 36.51 ‰, 14°.6 as mean values in the Alboran Sea and 36.42 ‰, 21°.3 in Cadiz Bay. Otherwise the species is only known (to me) from a few (19) localities in the tropical and the northern subtropical zones (Pacific: near the coast of Southern Japan (SCHRÖDER), Humboldt Current (KOFOID); Indian Ocean: nortwest and west of Sumatra (Valdivia-Exp.) and far southwest of Sumatra (9° S 92° E); Atlantic: west of the Benguela Current, 22°—15° S 7° E—14° W, in the Brazilian Current at $14^1/_2$° S $35^1/_2$° W, east of Trinidad in the Northern Equatorial Current, near the northwest coast of Hayti, in the Florida Current at 30° N, in the Sargasso Sea at the same latitude and 57° W, in the Guinea Current, west of the southern coast of Portugal and at CLEVE's localities southwest of the Straits of Gibraltar.

The specimens from the Mediterranean are generally more robust than those figured by SCHRÖDER and myself and correspond somewhat better to CLEVE's original drawing (compare fig. 14, transdiameter $t = 34\,\mu$). On the other hand they also show a closer affinity to *Ceratium incisum* by exhibiting rather strong thickenings of the wall, both of the antical and of the left postical horn; even a slight curvature of the latter is to be found.

The history of this species in the Mediterranean seems to me to be clear. It is introduced from the Atlantic as single individuals in autumn and winter, apparently from about the end of August on to January; it follows the Atlantic Current along the north coast of Africa, farther along the north coast of Sicily and up along the west coast of Italy to Naples. Meanwhile, some individuals may follow the first branch of the current west of Sardinia up to the Gulf of Lyons, which may account for its rare occurrence there in winter. From Naples it does not follow the branch of the current into the Ligurian Sea, probably perishing before reaching so far; it may, however, be traced over to the south east coast of Sardinia, answering to the corresponding branch of the current. Perhaps some individuals reach the western part of the Sidra Sea, from where only early summer samples are at hand. Meanwhile the winter minimum sets in, apparently causing the species to vanish at last.

No fission stages were observed. The robust winter forms answer to the relatively low temperature and the many similar cases in other species.

In the Mediterranean the upper limits of salinity for this species, according to the material of the "Thor", is 37.97 with a temperature of 13°.2 (st. 39). It apparently occurs also in deeper layers, being found in all the three deep water samples within its area, sts. 223, 228 and 231, 1145 m. wire. At the former two stations there is outflowing Mediterranean water; this seems to show that the emigration from the Atlantic through the Straits in early autumn still gives no positive result.

On the contrary, its occurrence in winter at sts. 45, 46 undoubtedly proves a succesful migration in January, and the stations off Naples and off the south east coast of Sardinia probably indicate the same for late autumn (perhaps about November).

Sectio V. **PENTAGONA** (Jörgensen).

8. **CERATIUM PENTAGONUM** Gourret. (Figs. 15—17, p. 28).

Jörgensen 1911 b p. 20, pl. II f. 31, 32.

This species, common in all warmer seas, was already known to GOURRET, (1883), who has given two good figures of it, l. c. pl. IV figs. 58 and 59, the latter as var. *rectum* Gourr. This variety is founded, on the frequent mistake of a reversed symmetry (right in stead of left); in this case it is the main species, fig. 58, which is drawn in ventral, instead of the supposed dorsal view. GOURRET also finds the variety "abundant" at Marseilles, while the supposed main species seems to have been observed but rarely, not surprising under these circumstances.

After GOURRET the species is reported by v. DADAY, 1888, from Naples, by ENTZ, 1902, ('05), from Quarnero, ("*C. furca* var. *baltica* Möbius" p. 101 f. 12, p. 99 f. 9, a chain of two individuals), by SCHRÖDER, 1906, ("*C. lineatum* (Ehrb.) Cl.") from the Northern Adriatic (March and August 1897 a. 1905), from the Ionian Sea (March 1902, rather numerous), by ZACHARIAS, 1906, from the Northern Adriatic (October a. November '05, Febr. '06), from Naples (April a. May '05) and from the coast of Algeria (May '03), and by PAVILLARD, '07, from the Gulf of Lyons (more or less frequent all the year).

On the winter cruise of the "Thor" it was caught at all stations. In the Eastern Mediterranean in the region of the Straits of Otranto and the neighbouring seas, the Gulf of Taranto and the Northern Ionian Sea (sts. 12, 14, 15, 16 about 20 % rel. frequency, temp. 13°.7—15.2, salinity 38.06 ‰ (at st. 11)), it was plentiful, numerous at st. 18 in the Gulf of Aegina (over 20 %, 38.40 ‰, 15°.2); at the other stations more or less scarce (st. 10 and Taormina 4 %, st. 20 and Naupaktos 10 %, st. 11 in the open sea far east of Sicily and at Port Alice singly). In the Tyrrhenian Sea it seems to thrive exceedingly well in winter (latter half of January); it is very numerous at all stations from off the region of Naples northwards through the Ligurian Sea and along the east coast of Sardinia (sts. 23—29 off Naples 15—30 %, 13°.3—14.2, 37.94 ‰ at st. 24; sts. 31, 33, 35 rel. freq. 30 %, sal. 38.04 ‰—.08, temp. 12.8—13.0; at st. 36 even over 60 %, by far the predominating species, temp. 12°.4; st. 38 40 %, st. 39 20 %, st. 40 30 %, st. 42 10 %). At several of these Tyrrhenian stations (the northern sts. 33, 35, 36 a. 38) it was the most numerous species of Ceratia. From now on, though everywhere present, and not at all scarce, it yet becomes much scarcer (Galita 10 %, st. 45 2 %, st. 46 singly, st. 50 not noted; salinity 36.92—37.39 with a temp. of 13°.4—14.2) and continues to be little numerous throughout the Alboran Sea and Cadiz Bay (sts. 53, 55, 57, 58, 59, 60, 64, 68, 69 10 % and somewhat less, only at st. 66 in Cadiz Bay abundant, over 20 %, 36.26 ‰ and 14°.8 C.).

On the summer cruise it did not appear till st. 81 off the west coast of Northern Portugal, the first warmer station, temp. 17°.9, sal. 35.43 ‰, 15. VI, rel. freq. 3 % in the surface and only single individuals at 100 m. wire. Hence it occurs discontinuously (at intervals) and in variable numbers, singly at sts. 86, 89, Cadiz a. 93, wanting at (i. e. not noted) sts. 84, 85, 87, 91, then suddenly plentiful (as to "relative frequency") at sts. 92 (20 %), 94 a. 95 (10 %); at st. 96 just west of the Straits even 40 %. In the Alboran Sea it proved remarkably scarce and discontinuous, only being noted for four stations out of eight (the western sts. 98 and 99 about 5 %, st. 106 singly, st. 109 3 %) and did not reappear till st. 115 in the open sea of the Balearic (2 %). Hence towards the east it is caught at almost all stations (only not noted far sts. 136, 138 a. 139), being still scarce in the Balearic (sts. 115, 116 a. 118 2 %) except to the north (sts. 119 a. 120 far west of Corsica, 10 %). In the adjacent region of the Ligurian Sea still rather numerous (st. 122 10 %) otherwise occurring but sparsely (st. 125 a. Genoa 1 %), but caught everywhere throughout the Tyrrhenian Sea in small numbers or even singly (st. 131), being more numerous at st. 127 (between Southern Corsica and Italy, 30 %) and st. 128 0—100 m. (10 %, in the surface much scarcer, only 1 %). Optimum here corresponds to the highest salinity, 38.37 ‰, and the lowest temperature, 18°.9. In the south-eastern Balearic the species is again discontinuous, mostly scarce and

often wanting, except at st. 134 off Tunis where 10 % at 0—75 m. and 75—125 m., while there is scarcely 1 % in the surface (st. 137 5 %, not noted for sts. 136, 138 a. 139).

On the whole, *C. pentagonum* is generally scarce and discontinuous in the Eastern Mediterranean where it decidedly prefers deeper levels, though not the very deep. In the Sidra Sea it is only noted for three of the six stations (sts. 140, 143 a. 148, singly), in the Southern Ionian Sea noted for one of the two stations (st. 152) at deeper levels (250 and 950 m. wire, 5 %), in the Levant for three out of six and only exceptionally for the surface (singly at st. 158, plentiful at st. 156 250 m. wire: 15 %, 38.84 ‰ (— over 39 ‰ in the surface, with a minimum of 38.5 in intermediate layers), 25°.5, end of July), in the Aegean Sea rather plentiful off the coast of Asia Minor at sts. 161 and 162 (10—20 %), otherwise only scarce or singly except in the only two deep-water samples gathered (st. 163 0—80 m. 20 %, against 3 % in the surface, st. 182 at 545 m. wire 10 %, but wanting in the surface). From the Dardanelles to the Black Sea it was wholly absent except single individuals in the depth of the Marmora (st. 175, at 350 m. wire, rr).

On the cross-section through the Ionian Sea from the Gulf of Corinth to the Straits of Messina the species was found at all stations, but always singly or very scarce at the surface till close to the east coast of Sicily where again it was more plentiful (sts. 190 a. 192 10 %, 38.01 ‰—.30, 21°.9—23.5), in deeper layers, however, all the way decidedly more numerous (st. 184 at 945 m. wire a. st. 186 at 245 m. wire 5 %, st. 187 945 m. wire 10 %, st. 189 945 m. wire over 5 %, st. 192 545 m. w. 10 %). These deep water samples answer to colder water and a higher salinity, down to 12°.8 as compared with 25.9 in the surface and up to 38.76 ‰ as compared with 38.15 in the surface.

On the return voyage through the Tyrrhenian Sea it was found everywhere, but always in the surface only with a low rel. frequency, less than 5 %, except at st. 198 between Naples and Sardinia where 10 % (38.06 ‰, 24°.2); at st. 199 (nearer to Sardinia) there was about 10 % in 0—30 m. as compared to only 1 % in the surface (in 30 m. 38.04 ‰, 19°.2, in the surface 38.24 ‰, 24°.9). Also in the Balearic the species was found continually at all stations except st. 219 at the coast of Africa; at the remarkably little saline (and warm) st. 206 east of the Baleares 15 % in the surface and even somewhat more in deeper water (salinity 38.37 ‰, temp. 13°.0, as compared to 37.39 ‰ and 24°.9 in the surface), otherwise about 5 % except at st. 204, where only singly in the surface. In the Catalonian Sea it was again more numerous and everywhere caught, from 5 % (st. 209 in the surface, st. 211 and at Barcelona) to 10 % (st. 208, st. 209 at 33—80 m. and by 945 m. wire, st. 212) or more (st. 213 15 % a. st. 210 over 20 %, here 37.90 ‰, 24°.0). In the Southern Balearic it was now found singly at st. 217, 5 % at st. 216; 10 % at sts. 218 and 220, but is not noted for the somewhat warmer and salter intermediate st. 219. In the Alboran Sea very scarce, only noted from deep water at st. 223 (1950 m. wire, less than 5 %), the most western st. 228 singly, and at Gibraltar scarce. Outside the Straits only observed in deep water at one of the two stations in Cadiz Bay (st. 231, 1145 m. wire, scarce); on the west coast of Portugal only found singly at st. 234, in and near the surface, and st. 237, more numerous at the most northern st. 238 (10 %, 35.77 ‰, 19°.4, warmer and more saline than the neighbouring stations and the last warm one). Here it suddenly vanishes at about the same place where it at first appeared on the route outwards.

Young regeneration stages were seen between 5 and 6 o'clock a. m. at sts. 95, 209 and 216, cells just after fission between 12 and 1 o'clock a. m. at st. 94 and between 3 and 4 o'clock at st. 200. Accordingly, also here fission takes place in the night.

Like other widely distributed species *C. pentagonum* occurs in several, more or less differentiated forms. Firstly we have variations in the length of the antical horn; the most common forms have a well-developed, but not especially long one. Extreme forms are the var. *longisetum* (Ostenf. and Schmidt) and Gourret's type, his "variety" *rectum* included (cfr. Jörgensen 1911 b l. c.). As to the latter, short-horned

forms I have always received the impression that such forms are merely accidental and do not deserve a special denomination, in any case as varieties. An exception might be made for those short-horned forms which answer to the hinder links of chains; here only the foremost individual possesses a long antical horn (cfr. Jörgensen l. c.). Chains are, however, but rare in this species; it would also be more natural to regard those links of chains as subvarieties or "forms".

Other variations occur in regard to the evolution of the "body" of the cell. In this respect likewise two contrasts are to be found, one form with a large, robust body and stout, well-developed horns (see fig. 15), another much more delicate with little developed posterior horns, but often with a long, yet thin, antical one. That these are to be considered as really different varieties, not merely stages of evolution, is to be seen from the fig. 16 b which, because of its well-developed structure must be considered an old, full-grown form of the smaller variety. The first of these two forms I have figured in my monograph (Jörgensen 1911 b pl. II fig. 32) under the name of var. *robustum* (Cleve). Now, however, I propose to change this name to *subrobustum*, while the genuine var. *robustum* (Cleve) — which possesses a special antarctic area of distribution — most probably must be kept separate in spite of the great resemblance. I have figured two forms of it in fig. 17; *b* is the same as given by Karsten 1907, pl. XXIII fig. 7. The most conspicuous distinctive character of this antarctic form is the better developed long and broad antapical winged list (or lists), which fills up almost all the breadth between the two posterior horns, while in the similar var. *subrobustum* of warmer seas it is small and only keeps to the corner of the left horn. Besides, the var. *robustum* has more strongly diverging posterior horns and an antical one more obliquely directed to the right. Also the posterior horns of the antarctic form are somewhat longer; the right one seems to equal the length of the antapical contour between the horn bases, while in var. *subrobustum* this contour is (relatively) somewhat longer. I do not know, however, if this character will always hold good.

I will name the corresponding small variety var. *tenerum* (fig. 16 *a, b*); while in the var. *subrobustum* the "transdiameter" (Kofoid's) is ± 77 μ, in this smaller variety it is only ± 50 μ (43—58 in the figs. 16 *a, b*). It is characterised — besides by the small size — chiefly by the thin horns and short postical ones. The antapical list is very small, in the corner.

Each of these four varieties again comprise different "forms" or subvarieties which of course — corresponding to their lower systematic rank — are ± difficult or impossible to distinguish from each other, but also seem to be of less or little importance in respect to conclusions as to the connection between different current-systems. Thus the different varieties may include forms with a very different length of the apical horn and with a more or less conspicuous structure of theca. The different length of the antical horn might perhaps be a more important character (for the above mentioned conclusions); apparently, however, no limits in this respect can be drawn, though most specimens of the commonest type of the species for instance either show a long, a short or a middle-sized antical horn. As to structure I think forms with a conspicuous structure of pores and especially of ribs are old or quite full-grown, in distinction to similar unstructured forms which generally have somewhat smaller dimensions. Thus I should think it most correct to consider my var. *turgidum* (Jörg. '11 p. 21 pl. II fig. 33) such a "form" or subvariety — perhaps one might rather apply the term "modification" of the recent theories of heredity — in spite of its striking aspect. Here I am, however, in contradiction to PAVILLARD, who has found this form sometimes abundantly in the winter plankton of the Gulf of Lyons and will rather consider it a distinct species. I myself have always found it but singly or in company with forms transitional to the type, and in all seasons. In the material of the "Thor" I have seen it from five stations of the winter cruise (sts. 12 and 20 near the south and south-east coast of Italy, st. 14 in the Southern Adriatic, st. 55 near the south-east coast of Spain and st. 68 in Cadiz Bay), everywhere singly except at st. 12, where also individuals transitional to the common form were found, and from four stations of the summer

cruise (st. 134 off Tunis, v. *longisetum* f. *turgidum*, st. 206 east of the Baleares, in the surface, and sts. 211 and 215 in the Catalonian Sea, v. *tenerum* f. *turgidum*, everywhere singly). Outside the Straits I can at present only give two localities for it, viz. the Valdivia-station 166 in the southern Indian Ocean, where it occurred together with var. *robustum* (Cleve), and the South-equatorial Current at 0°57′ S 8°42′ W 12. VI. '06 (Chaves).

As mentioned above, several forms with a very long apical horn occur. We may probably, however, distinguish one of them, var. *longisetum* (Ostenf. and Schmidt) as a distinct variety, answering to the figure by Ostenfeld and Schmidt 1901 p. 163 fig. 12 and by Jörgensen 1911 b pl. II f. 31. It is a middle-sized or indeed rather small form, transdiameter about 65 μ, with short posterior horns and usually a very long and thin apical one. Such long-horned forms occur in the material of the "Thor" from very many stations scattered all over the Mediterranean and outside the Straits of Gibraltar, in summer and somewhat more frequent in winter (at 45 % of the stations as compared to 34 % in summer). In summer it is sometimes the only form in the surface (st. 109, the most easterly station of the Alboran Sea, 3 %; sts. 116, 134 and 204 in the Balearic scarce; st. 199 in the Tyrrhenian Sea, st. 185 in the Ionian, all three stations in the Sidra Sea, st. 158 in the Levant and st. 183 in the Aegean Sea, scarce or singly; the most northern station 238 off the northern border of Portugal 18 %, 14. IX. '10). It might therefore be a form which is able to maintain the species in the superficial layers when it would otherwise sink down to the darker and therefore probably less favourable deeper ones.

In the inner, and especially in the eastern, Mediterranean the predominating form seems to be the var. *longisetum* in the above sense. For instance from the Aegean Sea I only saw this variety.

The var. *tenerum* was caught on the winter cruise at the sts. 38, 39, 40 and 42 near the coast of Sardinia, only few individuals, and at sts. 60 and 68, east and west of the Straits of Gibraltar, singly. On the summer cruise it proved more frequent, especially in the Eastern Mediterranean off the coast of Barca (st. 152, $1^1/_2$ %), in the Levant (sts. 156 and 158, at the latter the only form at 0—30 m. and 30—100 m., 3 %) and at st. 187 in the Ionian Sea between Greece and Sicily, at 945 m. wire (2 %); otherwise it was caught at st. 126 (northeast of Corsica, at 275 m. wire, singly), at st. 127 (a forma *longisetum*), at st. 134 off Tunis, 75—125 m. (2 %), at st. 206, 1945 m. wire (2 %), and — as mentioned above — at sts. 206 surface, 211 and 215 as forma *turgidum* (singly). Consequently this form seems specially adapted for warm and salt water, analogous to the smaller forms from warmer seas of the cosmopolitan species *C. furca, C. fusus* and of other Ceratia (cfr. Jörgensen 1911 b pp. 98 and 102). It was nearly always found together with var. *longisetum*, to which it seems closely related; usually, however, this latter variety may be easily distinguished by its larger body, its apical horn as a rule longer and thinner (?) and too by the less narrow and somewhat peculiarly curved posterior horns. Both forms possess short posterior horns and a rather abruptly narrowed hypotheca which in ventral view is ± evidently gibbous just behind the girdle on the right side. The var. *turgidum* generally seems to belong to the var. *longisetum* as a heavy-structured form with an angularly swollen forebody. This change of form might be a simple consequence of the growth (cfr. Schütt '95 p. 27).

At present I am not able to record more than five localities for the var. *subrobustum*. In the material of the "Thor" I have noted its coarse-structured form (see fig. 15) from st. 38, near the north eastern coast of Sardinia, 31. I. '09, and from deeper layers of st. 204 southwest of Sardinia (945 m. wire singly). The specimen figured in my monograph is from the Azores 18. IV. '07, (Chaves); what different authors have reported from warmer seas as *C. lineatum* var. *robusta* Cleve, no doubt refers to my var. *subrobustum*, f. i. the two localities in the Red Sea by Ostenfeld and Schmidt ('01 p. 163) and by Schröder ('06 p. 323).

On the whole, the distribution of *Ceratium pentagonum* in the Mediterranean proves it to be independent of the Atlantic Current (indigeneous, "endogenetic" Aurivillius, "perennial" Pavillard

Moreover, it proves to be essentially a winter-species with its greatest relative frequency in the inner part of the Western Mediterranean, i. e. the Tyrrhenian, the Ligurian and the eastern and northern Balearic Seas. In summer it is more frequent in somewhat deeper layers, about 25—100 m., in the Eastern Mediterranean apparently still deeper; in all deep water samples gathered this was the case, except at very great depths. The best physical conditions afforded in the Mediterranean seem to be a somewhat high salinity and a not too high temperature, the optimum in winter (st. 36) being a little over 38 $^0/_{00}$ with 12°.4 (end of January), and in summer (st. 127) 38.37 $^0/_{00}$ with 18°.9.

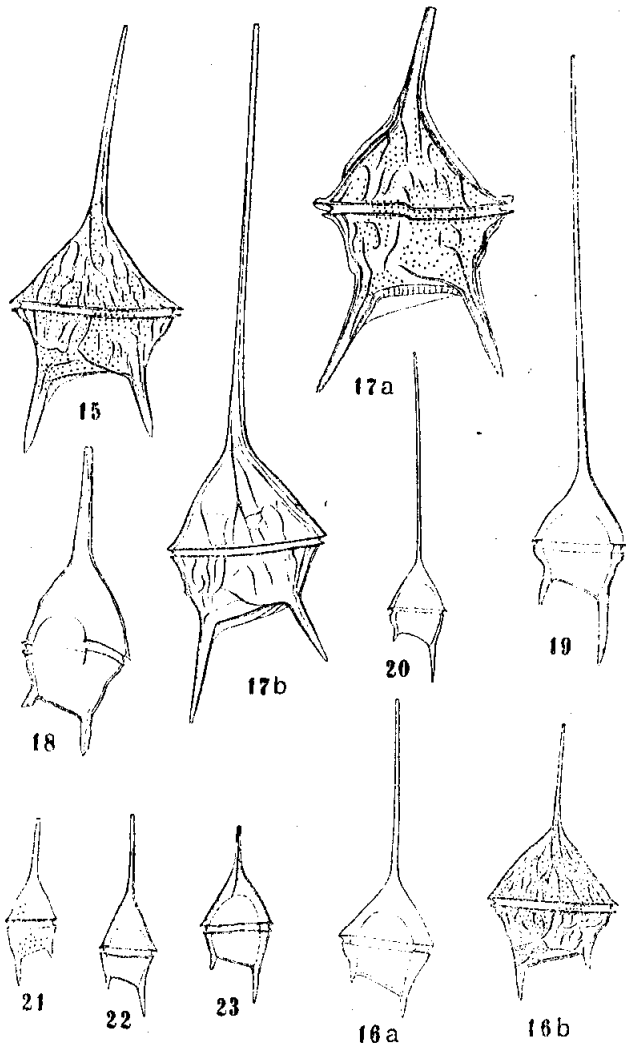


Fig. 15. *C. pentagonum* var. *subrobustum* n. var. St. 38 (east of Sardinia) January.
Fig. 16. *C. pentagonum* var. *tenerum* n. var. a St. 156 (Levant), 250 m. wire, July; *b* a heavily structured and short-horned winter form from st. 38.
Fig. 17. *C. pentagonum* var. *robustum* Cleve. *a* Cape Horn Current, April 1911 (the Fram), *b* Indian Ocean, Valdivia-Exp. st. 166 (37°45′ S 77°34′ E).
Fig. 18. *C. teres* f. *subturgidum* n. f. St. 218 (coast of Africa in the western Balearic), September.
Fig. 19. *C. setaceum* Jörg. St. 126, 275 m. wire (off the north-east coast of Corsica), July.
Fig. 20. *C. Kofoidii* Jörg. St. 152 (off Barca), 950 m. wire, July.
Fig. 21. *C. minutum* nov. nom. St. 79 (west of Brittany), June.
Fig. 22. *C. minutum* n. nom. Cadiz, June.
Fig. 23. *C. minutum* n. nom., a more robust form. St. 246 (west of Brittany), in September.

9. CERATIUM TERES Kofoid (Fig. 18, p. 28).

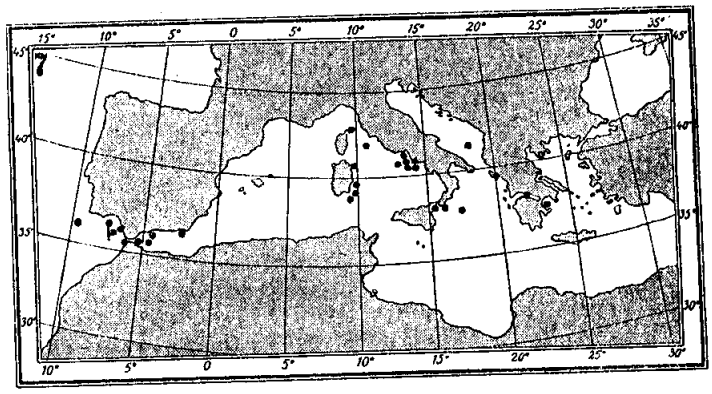
Jörgensen 1911 b pl. II figs. 34, 35.

This nice little species is a very distinct and constant one, never occasioning any trouble or doubt as to its correct determination. Hitherto it is only known from few localities, scattered over the tropical and subtropical zones of all three main oceans, and only extending to the warmest parts of the temperate regions. Most of the known localities — I know at present only 18 certain ones — are situated in the Atlantic, from east of Buenos Ayres in the Brazilian Current and the south point of Africa to the Tortugas in the Mexican Gulf and the Gulf Stream at the Azores. These other Atlantic localities belong to the North African Current, west of Gibraltar, the Guinea Current, west of Liberia, and the huge cyclonic movement of the warmer water between Africa and South America, west of the Benguela Current and north of the Westwind Belt. In the Indian Ocean it occurs in the Arabian Sea, between Ceylon and Sumatra, west of Java and towards the northern limit of the Westwind Belt, at the Valdivia-station 166 Dec. 1898 and near St. Paul (Deutsche Südpol-Expedition, April 1903). In the Pacific it is only known from near the coast of southern Japan (Okamura '06 "*C. lineatum* var. *longiseta*" fig. 7 *a*) and off San Diego, California (Kofoid).

I have first reported it from the Mediterranean as caught in the Straits of Gibraltar (Jörgensen 1911 b, S/S "Sevilla", capt. James Röed, Dec. 1908). Later on it has been found by Schröder (1911) in the northern and middle Adriatic (at Lussin, Sebenico and Lucietta July 1909) and by Pavillard (1916) in the Gulf of Lyons ("several times in winter").

On the winter cruise of the "Thor" it proved rather frequent in the Eastern Mediterranean (Decbr. and first half of January), being noted for 7 of 11 stations (not noted for sts. 11, 12, Port Alice and 15), but occurred only in single specimens, except at st. 16 (Corfu), where it reached a relative frequency of 2 %. In the Tyrrhenian Sea it was caught at all stations except 23 and 24, partly in several specimens, though also here it was but scarce; the greatest number of specimens were found in the region of Naples (off Naples and at sts. 25, 26, 29 and 31 2—3 %, at st. 28 even 5 %).

In the Balearic and the Ligurian Seas it proved entirely wanting except at st. 33 between the latter and the Tyrrhenian Sea (only singly). In the eastern part of the Alboran Sea it was also wanting except at st. 55 (at the south-east coast of Spain, singly); towards the Straits, however, and outside of them, in the Cadiz Bay, it again was present at all stations from st. 58, and relatively plentiful (st. 58 at the south coast of Spain 7 %, at sts. 59—62 4—2 %, at st. 68 even 17 % (optimum) and at st. 69 2 % of relative frequency).



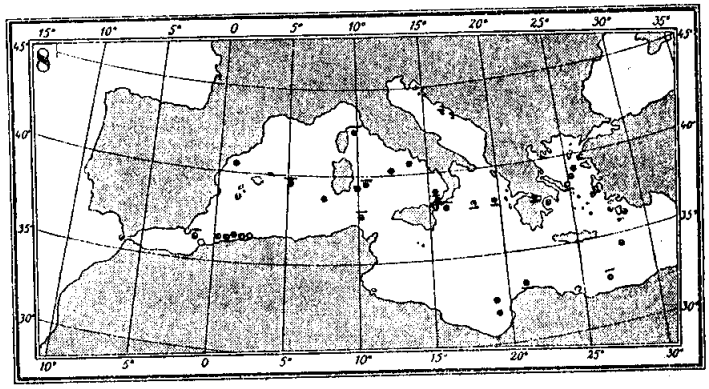


Chart 7. Distribution of *C. teres* in winter. The same designation as in the following chart and in chart 3 (p. 14).
Chart 8. Distribution of *C. teres* in summer. O western localities on the return voyage.

On the summer cruise it did not appear on the route outwards till st. 95, just west of the Straits of Gibraltar (rr, end of June), and then not till sts. 109 and 110, the most eastern ones of the Alboran Sea (rr). Through the whole of the Balearic and the Ligurian Seas it was wanting, not appearing till st. 126 at the border line between the latter and the Tyrrhenian Sea, where it only occurred singly in deeper layers (rr at 275 m. wire, first half of July). From here it was not caught till st. 134 off Tunis, where again single specimens were met with in somewhat deeper layers (0—75 m.). In the Eastern Mediterranean it proved more frequent, being present from st. 147 in Syrtis Major at almost all stations (not noted for sts. 148, 151, 153, 155, 162, 164, 165, 179, 185), nearly always, however, singly in the surface (only st. 184 in the Corinthian Bay, 2—3 %, st. 190 at the east coast of Sicily and st. 163 off the coast of Asia minor, 5 %, excepted), but sometimes more numerous in deeper layers (st. 152 off Barca 3 % at 250 m. wire, st. 156 5 % at 250 m. wire and st. 192 in the Straits of Messina 7 % of rel. freq.). Here it was sometimes only observed in deeper layers (sts. 156 and 189); it might therefore also occur at some of the stations mentioned above, from which it is not noted, only surface samples being taken there.

From the Dardanelles to the Black Sea it was wanting.

On the return voyage it was considerably more frequent in the Western Mediterranean, though as a rule also now only caught in single or very few specimens. In the Tyrrhenian Sea it was now still present at 5 of 8 stations (not noted for sts. 195 and 196 and off Naples), singly except at st. 198 between Naples and Sardinia, where there was 5 %; farther to the west, however, it proved very discontinuous, occurring everywhere only singly. Thus, in the middle Balearic it is noted for only two stations (st. 204 only in the surface, st. 206 only in deeper layers, at 1945 m. wire), in the Catalonian

Sea only for one (st. 212), in the south-western Balearic, however, for four out of five (not noted for st. 217), and in the Alboran Sea for the three most easterly stations (221, 223 and 224) at the African Coast and between Africa and Spain, not for the stations near the south coast of Spain. West of st. 224 it was not observed anywhere, thus now vanishing at a considerable distance east of the Straits.

From this very scarce occurrence we must, of course, take care not to attach too much weight to the absence or presence at the various stations and the different depths; an occurrence in single specimens, rr, may very easily be overlooked. Yet, from the data stated, I think we may conclude that the species takes an intermediate position between the allo- and the indigeneous species, being able to live and thrive and occasionally, though rarely, to propagate in the Mediterranean, yet as a rule it will perish after a longer or shorter time.

Apparently it is rather independent of the Atlantic Current, viz. in February, in September and less decidedly in June, the three seasons at which samples from the Alboran Sea are at hand from the gatherings of the "Thor". In February (1909) the species was present everywhere in Cadiz Bay, even relatively very plentifully at st. 68 (17 %). Correspondingly it occurred at all three stations of the Alboran Sea, next to the Straits (sts. 60, 59 and 58), and reaches even its maximum of relative frequency at the most eastern of them (st. 58, 7 %). Here the species suddenly vanishes (respectively appears). The corresponding hydrographical data show that this latter station is the last (respectively first) one with a low salinity, where consequently a mixing of Atlantic with the Mediterranean waters takes place. The increase of frequency at this end station — here the "relative" frequency is connected with the absolute, the number of individuals being at st. 58 12 *C. teres* of a total number of 172 Ceratia counted, as compared to 8 of 198 at st. 59 and 5 of 153 at st. 60 — might only be a mechanical phenomenon, due to a (supposed) damming up of the current. It may, however, also be possible that a successful immigration into the Mediterranean through the Straits (in the first half of February) is just at its beginning. Farther to the east the species is wanting all along the African coast; we may therefore conclude that no such immigration has taken place in January. The localities in the Tyrrhenian Sea might answer to a migration in late autumn (about November or October).

In June 1910 the species was almost wholly wanting in Cadiz Bay, being only caught singly at st. 95 just outside the Straits. Correspondingly it was also wanting in the Alboran Sea except at the two most easterly situated stations 109 and 110 (rr), again the two last with a lower salinity (36.58 ‰ as compared with 37.19 at st. 112). Moreover, here a chain of two individuals was found (between 10 and 11 o'clock a. m.), the only case of propagation of this species, which I saw. This suggests that an occasional immigration into the Mediterranean through the Straits with a positive result, of single individuals, may take place in early summer, though also this season seems far from favourable, further east in the direction of the current the species being wholly wanting.

In September no specimens were caught west of the middle region of the Alboran Sea, while in the eastern half in the adjacent part of the Balearic along the African coast the species was everywhere present, though only very scarce. Therefore, a previous immigration seems to have taken place, probably in the last half of August. No stations (in the current) east of st. 218 were, however, examined.

In the Eastern Mediterranean the species proves to survive the winter at least till the first days of January (st. 20 at the east coast of Sicily 5. I. '09). Like other species, properly belonging to warmer regions, it is present in somewhat deeper layers of the eastern and median parts of the Sea (present at 14 out of a total number of 17 deep water stations, generally more numerous in the depth, at some of them even wanting in the surface). This seems to suggest that the species has survived the winter, being carried down with vertical currents at this season.

The chain mentioned above was found at st. 110 between 10 and 11 o'clock in the morning, which answers to a fission in the night or early morning, as is common among the Ceratia.

At st. 218 I found a form, analogous to *C. pentagonum* f. *turgidum*, having an angularly convex epitheca. Also here I think we have an old form with a skeleton at the highest stage of development; in any case the cell was unusually large (transdiam. = 49 μ) and had unusually well developed winged lists. (The structure could not be seen for reason of the cell-contents which were not removed). The antical horn only was short. I have called this form f. *subturgidum* n. f. (fig. 18).

In other respects, *C. teres* varies but little except as to the length of the apical horn; in the Mediterranean, forms with a short antical horn were frequent, but also long horned forms occurred.

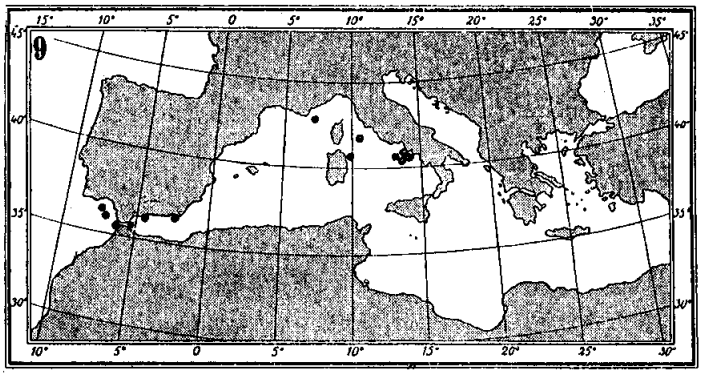
The hydrographical data show an optimum for the species in summer of 38.00 $^0/_{00}$—38.50, and 18°.6—21.9; the optima in winter in Cadiz Bay (36.24 $^0/_{00}$, 14°.8) and the Alboran Sea (36.44 $^0/_{00}$—36.78, 13°.7—14.6) are, I think, of less importance for the occurrence in the Mediterranean.

10. CERATIUM SEACTEUM Jörgensen

(Fig. 19 p. 28).

Jörgensen 1911 p. 23 pl. II figs. 40, 41. *C. furca* v. *baltica* Entz (p. p.) 1902 ('05) p. 99 pl. I fig. 11?

I have found this species nowhere mentioned by other authors, perhaps for reason of a certain superficial similarity with the common *C. pentagonum*. Nevertheless, it has proved to be a very distinct species, easily distinguished from the other Biceratia. It is usually confounded, I suppose, with *C. pentagonum*, but differs from it by lesser size of the "body", more slender shape, less robust posterior horns and especially by the much greater difference in length of the latter, left one being more than double the length of the right.



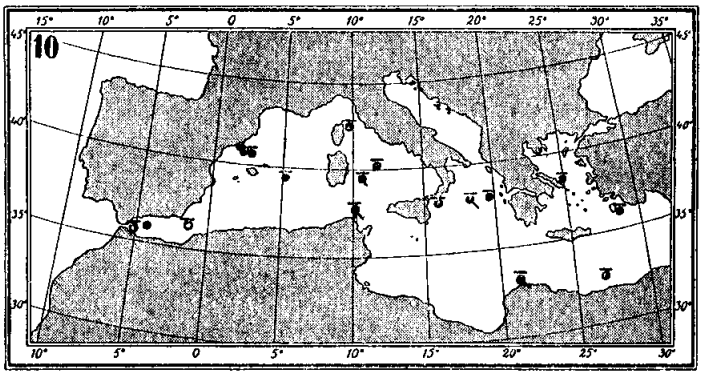


Chart 9. Distribution of *C. setaceum* in winter.

Chart 10. Distribution of *C. setaceum* in summer. (The same designation as in the preceding and the following charts, when not otherwise noted).

On the winter cruise of the "Thor" it was only caught in the Western Mediterranean, at few stations and always in single specimens except at st. 38 at the north-eastern coast of Sardinia, where 5 $^0/_0$ (optimum), and off Naples 2 $^0/_0$. In the Tyrrhenian Sea it was rather frequent, being noted for six out of nine stations (wanting at sts. 24, 26 and 27), wanting in the Ligurian, and in the Balearic only noted for the most northern st. 36. Farther to the west it became somewhat more frequent, being present at sts. 55 and 58 near the south coast of Spain, at st. 60 just east of the Straits of Gibraltar and at three out of five stations in Cadiz Bay (not noted for sts. 64 and 69).

During the summer cruise it proved much more frequent, but was nearly wanting in the surface, being found only at three stations and singly (st. 101 in the Alboran Sea, June, and sts. 210 and 211 off Barcelona, end of August). In deeper water it occurred, however, at many stations, spread all over the Mediterranean, now and then also in somewhat greater numbers (or at least several individuals). Outside the Straits of Gibraltar it was wanting, both in June and in September, and in the Alboran Sea only caught singly, at one station (101, in the surface) on the route outwards in June, and at two stations (228, at 1145 m. wire[1] and 223, at 1950 m. wire) on the return voyage in September. In

[1] As above, this in all cases means the length of wire between the vessel and the net.

the Balearic it was only observed at st. 206, east of the Baleares, on the return voyage (4 % rel. freq., at 1945 m. wire) and at st. 134 off Tunis (8 % at 75—125 m. and 10 % (here only a few individuals) at 125—200 m.). In the Tyrrhenian Sea it was observed at two stations on the route outwards in July, (st. 126, 1 % at 275 m. wire and st. 129 singly at 0—600 m.) and at one station (199, 8 % at 80—200 m. and singly at 945 m. wire) on the return. In the Ionian Sea at st. 152 off Barca (10 % at 950 m. wire) and at three stations between Greece and Italy (st. 186 rr at 1145 m. wire, st. 187 10 % at 945 m. wire and st. 189 singly at 945 m. wire). Finally, in the Levant it is noted for st. 156 (rr at 250 m. wire) and st. 160 (singly at 100—200 m.) and in the Aegean Sea for st. 182 (6 % at 545 m. wire).

On the whole it is noted for 14 out of 20 of the stations where deep water samples were gathered within its area of distribution (only wanting at sts. 128, 132, 184, 192, 194 and 204). As far as I can see from these deep water samples at hand, it generally occurs at a considerable depth, at least about 100 m.; thus the trustworthy results obtained by the closing nets prove an occurrence of several individuals at a depth of 75—200 m. off Tunis (st. 134) and at 80—200 m. east of Sardinia (st. 199).

With such scanty occurrence fission stages are, of course, not likely to be found; at st. 134, 75—125 m., the antical half of a cell, apparently just after fission, was, however, observed, between 12 and 1 o'clock p. m.

The stations 38, 129, 134, 152, 182, 187 and 199, with a higher frequency, give mean values of 14° and 38.33 ‰ for its occurrence in greater numbers, the closing nets (sts. 134 and 199) alone 13°.9 and 38.02 ‰. The optimum in winter (st. 38) gives 38.21 ‰ and 12°.8 (σ = 28.9), in summer (st. 152, 950 m. wire) with some uncertainty 38.7 ‰ and about 14° (σ_t = 29.1).

As above mentioned *C. setaceum* is a remarkably constant species in the Mediterranean, hardly varying in anything but in respect to the length of the apical horn. The size of the transdiameter is 45 μ, postical girdle list very little developed, forebody (epitheca) somewhat elongated; its contour lines in ventral view form a rather acute angle. Hypotheca just behind the girdle somewhat swollen, most conspicuously at the right side. Antical horn thin and usually very long; postical ones slender and a little ventrally directed (apparently slightly curved in ventral view), towards their ends indistinctly denticulated.

Distribution outside the Mediterranean still little known: Atlantic, Azores (CHAVES) and between South Africa and South America (German Southpole-Expedition 27°30′ S 3°7′ E and 28°50′ S 10°28′ E, August 1903, the Fram 30°20′ S 9° W July, and 20°40′ S 25°45′ W August 1911).

A very feeble migration of this species through the Straits of Gibraltar to the south coast of Spain (sts. 58 and 55) seems to take place in February '09. As, however, no trace of it is to be found farther along the African coast, we must suppose, either that the individuals introduced perish or at least vanish from the surface, or that a successful immigration into the Mediterranean is just in its beginning. The only station where the species is somewhat more numerous (st. 38) is remarkable for the uniformity both of salinity and temperature, which may suggest a sinking by vertical currents. In summer, both in June and in September, there are no signs of an immigration, the species being absent from all stations outside the Straits; its occurrence at great depths in the Alboran Sea, (sts. 228 and 223, 1145 and 1950 m. wire), seems to show a very feeble emigration from the Mediterranean. On the other hand, as the Mediterranean is decidedly the region where this species hitherto has been found in greatest numbers, it might preliminarily most naturally be considered an indigeneous deep water species of the Mediterranean. Certainly it may remain alive in the Mediterranean for a rather long time, at least for many months; in the Western Mediterranean it must also be supposed to survive the winter, at least to the end of January (st. 38, 13. I. '09). In the Eastern Mediterranean it seems to be wanting in winter, and is in summer only present in the depth; as, however, deep water samples were not taken during the winter cruise, it is not quite certain whether or not the species is also wanting in deeper layers in winter.

According to the data given *C. setaceum* appears (in the Mediterranean) to be an indigeneous deep

water species, in summer scattered over all the sea but only rare and scarce and but exceptionally met with in the surface, only in western regions. No emigration from the Atlantic is to be traced at that season. In winter there is a suggestion of an immigration into the Mediterranean in the surface in February, apparently, however, with a negative result; at that season it was not caught in the Eastern Mediterranean, where, however, only surface samples were taken.

Considering the fact that only one, and that an uncertain trace of fission has been seen, it might be possible that the species rather is allogeneous, only occasionally introduced from the Atlantic, generally sinking down to a deeper level — for some cause —, drifting about for a relatively long time, but perishing sooner or later for lack of power to propagate.

I shall return to this species, and others of a similar occurrence, in the next chapter. If we suppose it to immigrate only before the winter minimum — the distribution in winter seems to answer to such an immigration in October—November — it will be carried into deeper levels in the heart of winter and remain there during the summer.

11. CERATIUM KOFOIDII Jörgensen (Fig. 20 p. 28).

Jörgensen 1911 b p. 23 pl. II figs. 38, 39.

I have first mentioned this nice little species from the Mediterranean (Monaco) 1911 (Jörgensen l. c.), but it was already previously figured from the Quarnero by Entz jun. 1905 (1902) (p. 99 f. 7) under the name of *C. furca* var. *baltica*, together with a great many other forms belonging to the species *C. furca* (figs. 1—5), *C. pentagonum* (figs. 9—10) and *C. setaceum*? (fig. 11), besides a heteromorphus form of some species or other of *Euceratium* (fig. 8, analogous to *C. tripos* f. *brevicorne* (Lemm.) Jörg. 1911 pl. IV fig. 75 and similar forms belonging to the heteromorphous chains, detected by Lohmann; cfr. Jörgensen l. c. pp. 38, 104). Later it has been reported from Genoa by De Toni and Forti 1916.

In the gatherings of the "Thor" it is very rare, and always found singly or in very small numbers. On the winter cruise it was only taken at two stations, viz. st. 18 in the Bay of Aegina and st. 58 on the south coast of Spain. On the summer cruise it proved but little more frequent, being only noted for two stations in the Western Mediterranean (st. 99 east of the Straits of Gibraltar in June, and st. 198 in the middle of the Tyrrhenian Sea in August) and from two deep water samples in the Eastern (st. 152 off Barca, at 950 m. wire, and st. 156 in the Levant, at 250 m. wire).

Outside the Mediterranean it was (in summer) a little more frequent: sts. 84 and 87 off the west coast of Portugal in June, sts. 234 (here only in the surface) and 235 off Lisbon in September, and sts. 95 and 97 immediately west of the Straits of Gibraltar in June.

The distribution is on the whole still little known. I have seen this species from the Azores, the Florida Current south of Cape Hatteras, the region west of the Benguela Current between 16° and 6° S, the Southern Equatorial Current at 0°15′ N 18° W, the Arabian Sea (Schröder's sample XV, Schröder 1906 p. 325, and at 8° S 61° E), Singapore, the Formosa Channel and the south coast of Nipon.

No fission-stages were seen in the material of the "Thor".

This species follows the nearly related *C. setaceum*, only it is much rarer. It has undoubtedly emigrated from the Atlantic; the distribution points toward a migration in spring or winter. At st. 152 it seems to have passed into the "intermediate" water-layers.

In my monograph 1911 I have considered it as synonymous to *C. eugrammum* Kof. Later I have found that there is another species which answers better to Kofoid's description, and also to the stated distribution (see the following species).

12. CERATIUM MINUTUM n. nom. (Figs. 21—23 p. 28).

C. eugrammum Kofoid (1907 b p. 26 fig. 3), non *Peridinium eugrammum* Ehrb.

By this new name I have designated a little form which I also know from the northern Atlantic. It has been reported (by Ostenfeld and Paulsen 1904) as *C. lineatum* (Ehrb.) Cleve, but seems to be so characteristic that it may be considered a separate species. It is related to both *C. lineatum* and *C. Kofoidii* and perhaps not always easily distinguished from this latter species; I have, however, never seen positively transitional forms.

Description. In ventral view the epitheca is triangular with almost straight side lines and a vertical angle considerably below 60° (about 52°, in *C. eugrammum* Kof. ± 49° (40—58)). The hypotheca obliquely trapezoidal, evenly tapering with almost straight or indistinctly convex sides. Antical horn neither specially feeble nor strong, straight or very slightly curved, usually short, as long as the "body", or shorter, — rarely longer. Postical horns nearly parallel, usually very slightly or indistinctly diverging, the longer one a little shorter than the greatest length of the hypotheca, the other only short, less than half that length; both moderately strong, very acute, towards their ends indistinctly denticulate. The postical rim of the transverse furrow is less developed. Transdiameter usually 25—28 μ (23—35), dorsoventral diameter about half that size; greatest length of hypotheca usually 0.8 times of that of epitheca, rarely only 0.7.

Differs from *C. lineatum* especially in the decidedly smaller dimensions and the less robust theca, the comparatively shorter and broader "body", the shorter postical horns and the relatively shorter right one. *C. Kofoidii* is a more delicate species with longer and narrower horns, in ventral view more distinctly convex side-lines, the hypotheca behind the girdle at the right side distinctly gibbous, and an apical (vertical) angle of about 60° (in the Mediterranean form, however varying considerably in other regions).

In the material of the "Thor" this species vas only seen in samples from st. 79 — far southwest of Brittany in June, where it was plentiful — here and there in small numbers as far as the Straits of Gibraltar, where it was more frequent, though still scarce (st. 80 in the Bay of Biscay, 5 %, scarce off the west coast of Portugal, sts. 84 and 87, at Cadiz and singly at all stations in the immediate vicinity of the Straits, to st. 98). On the return it was only taken at sts. 246 and 248 off Brittany in September. Considering that this small species — as well as the foregoing one — easily slips through the net, we may suppose that it sometimes occurs in no small numbers.

It is consequently no true Mediterranean species, being only observed in the Straits of Gibraltar. The relatively frequent occurrence there in June, having caused no immigration, suggests that the physical conditions are not favourable for it.

13. CERATIUM LINETAUM (Ehrenberg) Cleve.

Jörgensen 1911 p. 22 pl. II figs. 36, 37.

This is certainly no Mediterranean species. In the gatherings of the "Thor" I have only seen it singly at Brest and at st. 80 in the Bay of Biscay.

Subgenus III. AMPHICERATIUM Vanhöffen.

Sectio VI. INFLATA Jörgensen.

14. CERATIUM GENICULATUM (Lemmermann) Cleve (Fig. 24).

Jörgensen 1911 b p. 24 pl. II figs. 42, 43.

This peculiar and rare species has been only reported previously from the Mediterranean by myself (l. c.: Straits of Gibraltar Decbr. 1908). In the material of the "Thor" it was also very rare and

scarce, only found in winter: sts. 42, 46, 55, 59, 66, 68 and 69, and everywhere but singly. Consequently, we may say, that it is only found in the Western Mediterranean, in the southern and western parts of it, in other words in the region of the Atlantic Current proper, st. 42 being the only one which is situated outside its immediate course along the African coast. It is not, however, beyond the realms of probability that this station too lies within the direct influence of the current, f. i. when strong, more or less southerly winds are prevailing.

No doubt this species has emigrated directly from the Atlantic through the Straits of Gibraltar without having been able to gain a firm footing in the Mediterranean. If it had not been so rare, it might have served as an indicator of Atlantic water. Answering to its occurrence at the above mentioned stations an immigration into the Mediterranean through the Straits in February and January is obvious; above a corresponding immigration in December is reported. This is in accordance with the occurrence at st. 42, if the direct connection with the current along the African coast, which was suggested, in reality exists. Otherwise, according to J. N. NIELSEN, who considers this station as situated in a branch of the Atlantic current, passing along the north coast of Sicily and along the west coast of Italy to Naples, and thence across the Tyrrhenian Sea to the south-east corner of Sardinia, the occurrence here will answer to a much earlier migration, — about October — November.

Outside the Mediterranean *C. geniculatum* is known from the tropical regions of the Pacific, Indian and Atlantic oceans; in the latter it is found north of the tropical zone in the Florida Current and at the Azores (in February).

Fig. 24. *C. geniculatum* (Lemm.) Cleve. Straits of Gibraltar, Dec. 1908.

Sectio VII. **FUSIFORMIA** Jörgensen.

15. **CERATIUM INFLATUM** (Kofoid) Jörgensen (Fig. 25 p. 40).

Jörgensen 1911 b p. 25 pl. III figs. 45, 46, 48 a (*"C. pennatum"*, non Kofoid). *C. fusus* v. *concavum* Gourret (1883, pl. IV, fig. 64).

This and the three following species have been confounded, partly also by myself. KOFOID (1907 a) has grouped them as one species, but calls it a very variable one. In my opinion we have here several well distinguished species, each of which is variable, but not to such a degree that it may be confused with the others. Firstly there is a difference in the relative lengths of the epi- and the hypotheca; in *C. inflatum* and *C. falcatiforme* (see below) the transverse furrow divides the theca in two parts of little different lengths, whilst *C. longirostrum* and *C. falcatum* have a longer epitheca. Secondly, the curvature of the two long horns is about the same and is even in *C. longirostrum*, while in the other three species the antapical horn is much stronger and often more or less abruptly curved. Thirdly, the shape of the "body" varies; in *C. longirostrum* and mostly also in *C. falcatiforme* there is no defined apical horn, the broader part of the epitheca passing without any limit over into the hornlike upper part, while both in *C. inflatum* and *C. falcatum* a limit is obvious. Besides, the shape of this broader part ("body") is different.

C. inflatum is the largest species. It is found in the Mediterranean (and elsewhere) under two rather different forms, both figured in my monograph (1911 b), one under the wrong name *C. pennatum* Kof. (see fig. 25). It answers, however, very well to KOFOID's figure of *C. pennatum* f. *inflata* (1907 a pl. 2 fig. B), while his *C. pennatum* f. *propria* is what I called *C. pennatum* f. *scapiforme* (l. c. figs. 47 a—d). This typical *C. inflatum* has a rather long and narrowly triangular epitheca, with an almost straight outline narrowing into the horn, whilst the other form mentioned has a shorter, more swollen body, often above the transverse furrow evidently broader than the hypotheca, and more or less abruptly confined towards the

horn, with a convex outline (JÖRGENSEN 1911 b fig. 46). In the first form mentioned — the genuine *C. inflatum* — the somewhat inflated body of the theca is ± conspicuously trigonal (triangular in cross section), which is most evident in certain positions of the cell. As, however, the development of these ribs — which may be as conspicuous as in *C. geniculatum* — seems to be rather variable, I am not quite sure at present whether the other form — of which I have only seen but few specimens — may always be distinguished with certainty; they seem apparently to be very different.

On examining my slides I have found the following numerical data to be the average for these two forms: *C. inflatum* $\alpha \frac{\text{length of epitheca } 441\ \mu}{\text{length of hypotheca } 384\ \mu}$ and this ratio = 1.15, with the maxima $\frac{548}{476}$ and 1.26 and the minima $\frac{302}{268}$, 1.06; the other form $\frac{501.5\ \mu}{416\ \mu}$, 1.21 with the maxima $\frac{518.5}{429}$, 1.23, and the minima $\frac{484.5}{395}$ and 1.18. Fig. 25 represents a rather small individual.

C. longirostrum Gourret proved to be *C. pennatum* (see below). Therefore I think we may consider it certain that *C. fusus* f. *concavum* Gourr. is synonymous with *C. inflatum*, which it also resembles after GOURRET's figure. In this latter the hypotheca is somewhat too long, the ratio of length being $\frac{249\ \mu\ (?)}{264\ \mu\ (?)}$ = 0.94. In the figure of *C. longirostrum* we find the corresponding values $\frac{234\ \mu}{177\ \mu}$ = 1.32.

Aside from GOURRET's record, *C. inflatum* has only been observed with certainty in the Mediterranean by myself (1911 b, Straits of Gibraltar and a little more easterly, Decbr. 1908), by SCHRÖDER (1911, the Coast of Dalmatia by Selve, Zara Sebenico and Lucietta July 1909, rare and only (?) at a depth of 30 to 200 m.) and by PAVILLARD in the Gulf of Lyons (in winter). In the material of the Thor it was found in winter only at eight stations in the Mediterranean — 14? (a fragment), 18; 23, 26, 31, 45, 58, 60; 62, 64, 66, 69 — everywhere singly or in very small numbers, optimum only 2 % (at st. 60 just east of the Straits of Gibraltar). In February it was, consequently, present at four stations outside the Straits and two (60 and 58) just inside; an immigration into the Mediterranean through the Straits is therefore going on, apparently with only moderate success. The occurrence at st. 45 suggests such an immigration in January, whilst the sts. off Naples and 31 answer to an earlier one, about October—November. Together with the above mentioned record of Decbr. 1908, this points to a migration from late autumn to February (and probably longer).

On the summer cruise it was found at 21 (out of 109) stations, chiefly in the Eastern Mediterranean, where it even enters into the (depth of the) Sea of Marmora: sts. 126, 134, 0—75 m. (? not quite certain), 145, 147, 148, 152 in the surface and at 950 m. wire, 154, 156 in the surface, at 250 and at 950 m. wire, 160 in the surface, 0—30 m. and 20—100 m., 161, 163, 0—80 m., 164, 165, 167, 170, 20—80 m., 181, 182 in the surface and at 545 m. wire, 194, 209, 33—80 m., 228 and 229 here also but singly or very scarce (most numerous at st. 60 2 % relative frequence, at st. 156 in the surface 3 % and at st. 183 5 % (but only a few individuals)).

This distribution corresponds, in my opinion, to an immigration into the Mediterranean through the Straits of Gibraltar in early spring (February to April), while there is no direct migration from June to August, and only a feeble trace (sts. 228 and 229) in September. Such an immigration after the winter minimum may account for the occurrence at the inner stations in the surface. It cannot be exactly determined whether this species is perennial in the Eastern Mediterranean, for want of winter samples, but it seems to be wholly lacking both in the northern Ionian Sea and in the Bay of Aegina. However, it is probably perennial in the Levant and in the Aegean Sea. At st. 156 two cells were found just after fission had taken place, between midnight and 1 in the morning, and at st. 161 at 3 o'clock in the morning; at st. 167 a f. juvenilis, not yet wholly regenerated after fission, was seen between 11 and 12 o'clock a. m.

Otherwise I have seen this species from the West Indies, the Antilles and the Florida Currents, the Azores (in February) and Cadiz Bay (in Decbr. 1908), further from several localities in the tropical regions of the Indian Ocean; it is always scarce. Several authors (f. i. SCHRÖDER, KARSTEN, OKAMURA and NISHIKAWA) mention a *C. fusus* v. *concavum* Gourret, that is most likely to be either *C. inflatum* or *C. longirostrum*.

C. inflatum is rare and scarce in the Western Mediterranean — except in the vicinity of the Straits of Gibraltar — especially in summer, when at several stations it does not occur except below the surface. In the Eastern Mediterranean it is practically only found in summer, when it is rather frequent both in the surface and deeper, though even then scarce. In the innermost regions, the Levant and the Aegean Sea, it is probably perennial, being found to propagate at three stations. It is renewed by emigration from the Atlantic through the Straits of Gibraltar in Decbr. to Febr., probably in all from October—November to April.

16. CERATIUM LONGIROSTRUM Gourret (Figs. 26, 27 p. 40).

Gourret 1883 (p. 55) pl. 4 fig. 65 (side view). *C. pennatum* f. *propria* Kofoid 1907 (a) p. 172, pl. 2 fig. 13. *C. pennatum* v. *scapiforme* Jörgensen 1911 (b) p. 27, pl. III figs. 47 a—d, non *C. scapiforme* Kofoid.

As mentioned above, after a thorough examination of the large forms of *Amphiceratium* I have been convinced that *C. longirostrum* Gourr. is identical with *C. pennatum* Kofoid, or, properly speaking, with that form of this collective species, which — according to my own experience — answers best to Kofoid's f. *propria*, and which I have therefore considered the type of the species. GOURRET's figure is, in itself, quite insufficient for an identification; in working out my material I got, however, a side view which is so strikingly similar to GOURRET's figure already mentioned, that I think there can be no doubt that they both represent the one and the same species (see fig. 26, from the right side, GOURRET's from the left). But GOURRET's description is quite misleading, so that the use of his specific name must be based on the figure mentioned, not on his definition of the species.

C. longirostrum, as I now apprehend this species (and *C. pennatum*), is especially characterized by its long, evenly tapering epitheca, passing insensibly over into the apical horn. On account of this characteristic trait, I have, earlier in my monograph (1911 b), considered it synonymous with *C. scapiforme* Kof., which — also for reason of the different curvature of the upper and lower halves — cannot be correct. In *C. longirostrum* or *pennatum* the antapical horn is curved in much the same way and degree as the apical one, often but slightly and mostly quite evenly. In an oblique side view this species may easily be confounded with *C. inflatum*, which has hitherto usually been the case; we have, however, another distinguishing mark in the different ratio of lengths of epi- and hypotheca in both species. As mean values I have found in *C. longirostrum* $\frac{\text{epitheca } 362\,\mu}{\text{hypoth. } 262\,\mu} = 1.38$ (mean value), with the maxima $\frac{416.5}{302}$, 1.45, and the minima $\frac{310\,\mu}{238\,\mu}$ and 1.26. In comparison with *C. inflatum*, it is consequiently a (usually) smaller species with a relatively longer epitheca.

In GOURRET's figure, the corresponding dimensions are $\frac{234\,\mu\,(?)}{177\,\mu\,(?)} = 1.32$, for a moment loosely estimating his magnification $\frac{2}{5}$ to 333, a value which may later receive an essential rectification.

However, I am not quite sure whether my species is identical with KOFOID's f. *propria*, which, according to his figure cited varies somewhat from mine. The dimensions of his figure are $\frac{\text{epitheca } 500\,\mu}{\text{hypoth. } 435\,\mu} = 1.15$. Especially weighty is the fact that the ratio of lengths answers better to *C. inflatum*; the shape of the broader part of the epitheca, too, is more similar to that of certain forms of *C. inflatum* than to *C. longirostrum*. KOFOID's form is also larger than this latter species (in the Mediterranean) and the cell wall of its antapical horn is exceedingly thick to a degree, which I have never seen in *C. longirostrum*.

Every thing seems to point to a form of *C. inflatum* in a somewhat oblique view (compare the median region of Kofoid's figure). It seems to be the more correct to revive GOURRET's name for the real Mediterranean species.

After GOURRET, *C. longirostrum* has been reported from the Mediterranean by PAVILLARD 1907 (Gulf of Lyons), by myself 1911 (b: east of the Straits of Gibraltar Decbr. 1908 and Monaco) and by PAVILLARD 1916 (little frequent ("peu répandu"), but perennial, together with *C. falcatum*).

On the winter cruise of the "Thor" it was found present all the way to Corfu, in all at 13 out of 37 stations in the Mediterranean, but as a rule singly or very scarce: sts. 12, 16, 40, 42, Galita, 45, 46, 53, 55, 57, 58, 59, 60; 64, 68, 69. It was most frequent from Cadiz Bay to Tunis (sts. Galita to 69), where it was only failing at two stations outside the Straits, and where it also reached its optimum (sts. 64 and 68, relative frequency 4 %); east of this region it only occurred at the two stations 40 and 42 off the south-east coast of Sardinia, and at the stations 12 and 16 in the Ionian Sea.

On the summer cruise, however, it proved to be distributed throughout the Mediterranean, penetrating almost to the Black Sea, but again singly or scarce, with an optimum of 5 % relative frequency at the innermost station (st. 170 in the Marmora Sea, 20—80 m.). In all it was present at 39 out of 102 stations in the Mediterranean, rather evenly distributed along the route except at both ends, where it was rarer in the west and more frequent in the east. It was caught at the following stations: 99, 109 ($Al._1$ = Alboran Sea in June); 110, 111, 112, 120 ($B._1$ = Balearic in June—July); 122, Genoa ($Li.$ = Ligurian Sea); 126 in the surface (? = not quite certain) and at 275 m. wire, 127, 128, 0—100 m., 129 ($T._1$ = Tyrrhenian Sea in July); 134 in the surface (?) and 0—75 m. ($B._2$ = South-Eastern Balearic in July); 145 ($S.$ = Sidra Sea); 152, 250 and 950 m. wire ($I._1$ = Southern Ionian Sea in July); 154 ($Le.$ = Levant); 163, 0—80 m., 164, 165, 167 ($Ae._1$ = Aegean Sea on the route northwards); 169, 170, 20—80 m., 175 in the surface (dead) and at 30, 350 and 1150 m. wire ($M.$ = Marmora Sea); 179, 180, 181, 182, 545 m. wire, 183 ($Ae._2$ = Aegean Sea on the return voyage); 186, 245 m. wire, 187 in the surface, 0—25 m. and at 945 m. wire, 189 in the surface and at 945 m. wire, 192 in the surface and at 545 m. wire, ($I._2$ = Ionian Sea in August); 194, 197 ($T._2$ = Tyrrhenian Sea in August); 208, 209, 33—80 m., 213 ($C.$ = Catalonian Sea); 217 ($B._3$ = Western Balearic in September); 220, 221, 224, 228 in the surface and at 1145 m. wire ($Al._2$ = Alboran Sea in September); 231 (Cadiz Bay). In the Marmora only single dead cells were encountered in the surface.

Consequently, in the Alboran Sea it was more frequent in September (at 4 out of 9 stations) than in June (at 2 of 8). In all it was most frequent in the Aegean Sea, where it only failed at one out of 9 stations, and in the Marmora, where it occurred at 3 of 4, and most rare off Tunis, in the Sidra Sea and the Levant.

As to the occurrence at deeper levels it was present in 12 of the 22 deep water samples gathered, at 7 of these stations even wanting in the surface — sts. 209, 128, 156, 163, 170, 182, 186 — but generally found at no considerable depth, nor in any great numbers. Outside the Mediterranean it was completely wanting on the route outwards in June, and on the return voyage in September was only observed at st. 231 in Cadiz Bay.

A successful emigration from the Atlantic through the Straits of Gibraltar was going on in February, January (sts. Galita to 45), December (1908 see above, then also present outside the Straits) and perhaps in October—November (sts. 40 and 42). In June there was a feeble migration with a positive result (sts. 109 to 112) and also in September and August (sts. 220, 221, 224). To judge from the distribution in summer there seems also to have been a migration in early spring, from about March to May.

Like other long *Amphiceratia C. longirostrum* seems to be injured by being caught or to suffer by preservation, as the specimens are often halved or more or less incomplete, so that it is difficult to determine them with certainty. Similar halved cells, but apparently real fission-stages, occurred at st. 145 be-

tween 3 and 4 o'clock a. m., at st. 134 between 5 and 6 o'clock a. m. and at st. 126 between 11 and 12 o'clock a. m. A quite certain f. *juvenilis*, not yet completely regenerated, was caught between 11 and 12 o'clock a. m. at st. 167 (Aegean Sea). Forms with a pale (i. e. thin) right posterior (postequatorial) horn occurred relatively often, both in the western and in the eastern regions; in most cases they might be young individuals.

Otherwise the species is known from the tropical regions of all three main oceans, in the Indian Ocean also farther to the south, to 36° S, in the Pacific probably also on the coasts of Japan, and in the Atlantic north of the tropical zone in the Canary Current, the Florida Current and at the Azores (in February).

Summing up we see that *C. longirostrum* is frequent in summer in the Mediterranean, penetrating into the depth of the Marmora, but generally very scarce in number. In winter it seems to decrease considerably and is perhaps at last almost restricted to the region of the Atlantic Current proper, from the Straits to Tunis, being rare outside that region. In the Eastern Mediterranean it is able to propagate. The stock seems to be renewed every year by emigration from the Atlantic through the Straits of Gibraltar, apparently going on especially in winter.

17. CERATIUM FALCATUM (Kofoid) (Fig. 28).

C. pennatum f. *falcata* Kofoid 1907 (a, p. 172, pl. 2 fig. 14). *C. pennatum* var. *falcatum* Jörgensen 1911 (b, p. 27, pl. III fig. 48 b).

This is a fairly constant species, easily distinguished from the two preceding ones by its much smaller dimensions. Kofoid (l. c.) already suggested that this form might prove to be a distinct species. There is, however, another still smaller, allied form (see the following species).

The main characteristics of *C. falcatum* are the little curved or almost straight apical horn, which is considerably longer than the antapical, the shape of the body, which is long, to a relatively long distance from the transverse furrow of rather equal breadth and then rapidly narrowed into the apical horn, and finally the strong and more or less abrupt curvature of the antapical horn.

As mean values for the length of epi- and hypotheca in rather a small number of specimens I have found the following: $\frac{\text{ep. } 276\,\mu}{\text{hyp. } 178.5\,\mu} = 1.56$, with the maxima $\frac{289\,\mu}{191\,\mu}$, 1.70 and the minima $\frac{263.5\,\mu}{170\,\mu}$ and 1.38.

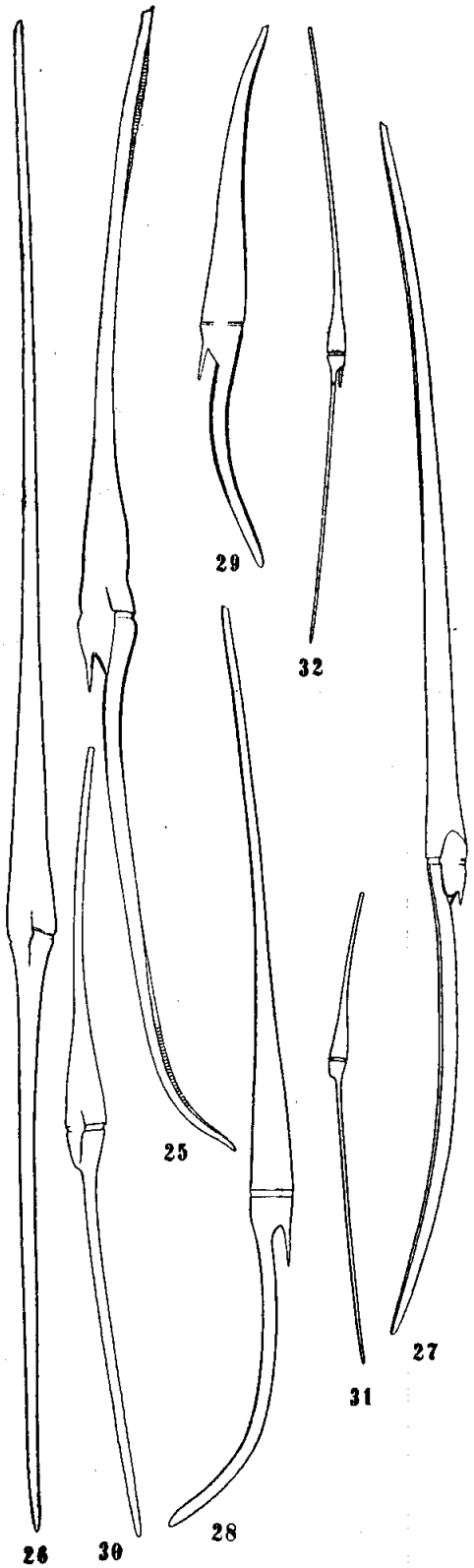
Kofoid's figure shows $\frac{270\,\mu}{190\,\mu} = 1.42$.

This seems to be the most constant one of the four allied species nos. 15 to 18. Only the ratio of lengths of epi- and hypotheca seems to be rather variable; we must, however, remember that just this ratio may be expected to vary with the age of the individual, or, properly speaking, with the degree of regeneration after fission.

This species was first reported by myself from the Mediterranean 1911, (b: outside and inside the Straits of Gibraltar Dec. 1908; Monaco). Later on it is mentioned by Schröder 1911 from the northern Adriatic (Quarnero July 1909, "35 m.") and by Pavillard 1916 from the Gulf of Lyons.

On the winter cruise of the "Thor" it was rare and scarce, being only found in the Mediterranean at 9 stations (out of 37): 14 (*Adr.*); 26, 28, 29, 31, 40 (*T.*); 36 (*B.*); 55, 58 (*Al.*); 68 (Cadiz Bay), always singly or in very small numbers. In contradistinction to *C. longirostrum* it was very rare in the region of the Atlantic Current proper, being noted for only two stations in the Alboran Sea. A feeble immigration into the Mediterranean through the Straits of Gibraltar seems to take place in February, but none is to be traced in January. The occurrence at the stations off Naples may be due to such an immigration in late autumn, October—November.

On the summer cruise it was again very rare to wholly wanting in the region of the Atlantic Cur-



rent, as far as Tunis. Otherwise it was distributed all over the Mediterranean, to the innermost regions, but not penetrating through the Dardanelles. It was in all caught at 35 Mediterranean stations (out of 102), again only singly or very scarce, with an optimum of 3 % relative frequency in the surface of st. 129: sts. 120 ($B._1$); 123, Genoa (*Li.*); 126 in the surface and at 275 m. wire, 128 in the surface and 0—100 m., 129 in the surface, 0—80 and 0—1100 m., 131, 132 ($T._1$); 133, 134, 0—75 m., 135, 137, 138 ($B._2$); 148 (*S.*); 152, 250 and 950 m. wire ($I._1$); 156, 250 m. wire, 158, 160 in the surface and 30—100 m. (*Le.*); 161, 163 in the surface and 0—80 m., 165, 180, 181, 182 in the surface and 545 m. wire, 183 (*Ae.*); 186, 245 m. wire, 187, 945 m. wire, 189, 945 m. wire, 192 ($I._2$); 199 ($T._2$); 206, 1945 m. wire, ($B._3$); 208, 210, 213 (*C.*); 217 ($B._4$); 234 (west coast of Portugal). It was, accordingly, most frequent in the Aegean Sea (at 7 of 11 stations); in the Alboran it was wholly wanting. In deep water samples it occurred at 13 of the 22 Mediterranean stations where such samples were gathered, usually only at a moderate depth; at 7 of these stations —, especially in the Northern Ionian Sea — it failed in the surface.

No direct summer emigration from the Atlantic through the Straits can be traced; however, according to the distribution, there seems, to have been one in early spring, — February to May,

Outside the Straits it was wholly absent in June, and in September only caught at st. 234 off Lisbon (in the surface).

Otherwise the distribution of *C. falcatum* is still almost unknown, the species having been referred to *C. longirostrum* (*C. pennatum*). From the Atlantic I have seen it in a sample from the Canary Current at 25° N 17° W and singly from two localities in the Florida Current.

No fission stages have been encountered with certainty.

Therefore in the Mediterranean *C. falcatum* is apparently rather independent of the Atlantic Current, no direct emigration from the Atlantic being traceable in summer (June and September) and only a feeble incipient one in winter (February). Like the closely related *C. longirostrum* it is more frequent — though always scarce — in summer, when it is distributed over all the Mediterranean except the region of the Atlantic Current proper. This species is not found in the Eastern Mediterranean in winter, except in the southern Adriatic; it is also uncertain, whether propagation can take place there.

18. CERATIUM FALCATIFORME n. sp. (Fig. 29).

Beside the three preceding closely related species *C. inflatum*, *C. longirostrum* and *C. falcatum*, I have met with a few specimens

Fig. 25. *C. inflatum* (Kof.) Jörg., a form with triangular, tapering body. Arabian Sea Nov. 1901 (HUNDHAUSEN, see SCHRÖDER 1906). Fig. 26. *C. longirostrum* Gourr., side view. St. 164 (off the west coast of Asia Minor), August. Fig. 27. *C. longirostrum* Gourr., oblique ventral view. St. 187 (Ionian Sea), in August. Fig. 28. *C. falcatum* (Kof.). St. 156 (Levant), 250 m. wire, in July. Fig. 29. *C. falcatiforme* n. sp. St. 68 (Cadiz Bay), in February. Fig. 30. *C. fusus* subsp. seta (Ehrb.). Monaco. Fig. 31. *C. extensum* (Gourr.) Cleve. Straits of Gibraltar, Dec. 1908. Fig. 32. *C. strictum* (Okam. et Nishik.) Kof. Azores, February 1907. **All figures** (to fig. 77) × 280, except fig. 3 (p. 8) × 150 and figs. 31, 32 (here) × 70.

of a fourth species, belonging to the same group. Though I have as yet only seen some three or four individuals, I will give it a special denomination, as it differs very essentially from each of the three species mentioned.

It resembles both *C. longirostrum* and *C. falcatum*, but is much smaller than either of them, the epitheca being only 144 to 153 μ long and the hypotheca about 128 μ. The epitheca is similar to that of *C. longirostrum*, is distinctly and rather evenly curved and with a long, narrowly triangular "body" which passes insensibly over into the horn. The antapical horn, on the contrary, answers to that of *C. falcatum*, it is, however, more evenly — but less — curved. The ratio of lengths is 1,13 to 1,20, and therefore only corresponds to that of *C. inflatum*. From all these species it differs in having much smaller dimensions.

I have only noted it from st. 68 in Cadiz Bay in February and for st. 161 off Asia Minor in August. Otherwise I have seen it only in a sample from the Valdivia Expedition st. 166, in the Southern Indian Ocean.

19. CERATIUM FUSUS (Ehrb.) Duj. (Fig. 30 p. 40).

Jörgensen 1911 b p. 29 pl. III figs. 51—56.

This cosmopolitan species was already mentioned from the Mediterranean by EHRENBERG 1859 as a new species, *C. seta*, with no accompanying figure; fortunately he figured it later, in 1873. He remarks that it is similar to *C. fusus* (i. e. the northern form), but much more delicate and slender.

POUCHET (1883) mentions *C. fusus* from Marseilles and Carry, where it was abundant in April 1883, and STEIN figures it from the Quarnero without mentioning EHRENBERG's *C. seta*. GOURRET has figured it as *C. pellucidum* n. sp., pl. 1 fig. 20 and pl. 4 fig. 66; a comparison of both figures will show how much better his figures on plates 2—4 are than those on pl. 1. He has also a *C. Berghii* n. sp. which may be the same species, only with a rudimentary right posterior (postequatorial) horn, which is found now and then. DADAY, 1886, has a new variety, *C. fusus* v. *acus*, which is probably a specimen in regeneration (if not injured?) and in my opinion quite indeterminable. SCHRÖDER, 1900, reports from Naples a *C. fusus* var. *inæqualis*, founded on a figure in Schütt 1895 (pl. 9 fig. 35, 1). PAVILLARD 1905 mentions it from l'Étang du Thau (near Cette), as abundant in December and with an optimum in May—June. SCHRÖDER, 1911, found it very frequent in the Northern Adriatic in July (1909), and PAVILLARD, 1916, mentions that it is very frequent in the Gulf of Lyons. It is also mentioned by other authors from different regions of the Mediterranean.

The usual Mediterranean form is what I have called *C. fusus* subsp. *seta* (see Jörgensen l. c.), which is more or less common in almost all warmer seas. This form differs considerably from the much coarser northern one, from the Northern Atlantic and the North Sea to the Baltic, so that it seems well justified, on the part of KOFOID to consider it a distinct species, *C. seta* Kent. Where the northern and southern areas touch each other we find, however, transitional forms which — according to my experience — gradually wipe out the differences. This was f. i. the case on the route of the "Thor" between the North Sea and the S raits of Gibraltar.

On the winter cruise it only failed at sts. 10 and 11 in the Ionian Sea. It was most numerous at st. 16 (Corfu, 25 % relative frequency). In the region of the Atlantic Current proper (Gibraltar to Tunis) it was numerous, with a mean value of 10 % relative frequency, in the Tyrrhenian Sea somewhat less, about 5 %. In the Eastern Mediterranean it was as a rule much scarcer, except at the three stations 14, 16 and Naupaktos, with 12, 25 and 19 % respectively. The optimum at st. 16 answers to a high salinity (between 38.0 and 38.5 ‰) and a temperature of 15° C. In the Alboran Sea it was found in greatest numbers at st. 55 (16 %), where also smaller quantities of a relatively large and thick form were found (besides the usual subspecies *seta*).

On the summer cruise it was remarkably scarce in just the region of the Atlantic Current men-

tioned, (rr to 3 %), and even wanting here at half the number of stations. Farther to the east, along the African Coast, the same was the case (relative frequency only to 2 % and absent at 3 out of 5 stations). Farther on it was generally much more frequent, being present at almost all stations in the Western Balearic (only not noted for sts. 114, 118 in June, st. 202 in August, st. 138 in the south-eastern Balearic in July and st. 195 in the Tyrrhenian Sea in August). The relative frequency in this region varied from under 1 % to 20 % at st. 120 (west of Corsica) and even to 30 % at st. 128 in a sample taken with a fine taffety net. In the eastern Mediterranean the species was again much scarcer except in the Northern Ionian Sea, and was absent at many stations; in the Sidra Sea it was caught at half the number of stations (140, 143, 145), rel. freq. 2—4 %, in the Southern Ionian Sea at one of two stations (152, at 950 m. wire — where it occurred in the greatest numbers — 3 %), in the Levant only at one of 5 stations (156, 250 m. wire, rr), in the Aegean Sea at 5 of 11 (163, 0—80 m., 5 %, otherwise rr: 165, 167, 181, 182, 545 m. wire). In the Northern Ionian Sea it was, on the contrary, present at all stations, and often much more numerous at deeper levels: st. 184 in the surface 10 %, at 945 m. even 30 % (optimum), st. 186 wanting in the surface, rr at 245 and 1145 m. wire, st. 187 also wanting in the surface, 1 % at 250 m. wire and rr at 945 m., at st. 189, on the contrary, 7 % in the surface and rr at 945 m. w., st. 190 5 % (surface), st. 192 5 % in the surface, 7 % at 545 m. w. In the region of the fresher water from the Black Sea it was frequent. In the Dardanelles it was absent in the surface, also in the Sea of Marmora (yet rr at st. 175), but here numerous at somewhat deeper levels (sts. 170, 0—20 m. 13 %, 20—80 m. 7%; 175 at 30 m. wire 9 %); at greater depths again scarce, rr to 1 %. In the Bosporus 6 % (surface), in the Black Sea numerous in the surface and a little below it (sts. 172, 0—17 m. 25 %, but almost as numerous in the surface, 173 (surface) 20 %); here in the surface there was a larger form, occurring singly, whilst a form of subsp. *seta* was the predominating one.

At the stations where deep water samples were taken, the species was present in the depth at 18 out of 22 stations, at four of them wanting in the surface (sts. 170, 182, 186, 187) and at 6 (or 7) more numerous in the depth (st. 128, 0—100 m. 12 % compared with 5 in the surface, st. 129, 0—1100 m. 6 % compared with 3 in the surface, st. 134, 0—75 m. 7 % compared with 3 in the surface, sts. 152, 192 see above, st. 184 30 % at 945 m. w. compared with 9 % in the surface, st. 194 7 % at 1195 m. w. compared with 1 % in the surface).

On the route outwards in June the larger northern type of the species occurred alone and plentiful at Falmouth, but farther to the south only singly or very scarce at the next two stations 79 and 80, southwest of Brest, and at st. 84 on the west coast of Portugal. The subspecies *seta* already appeared at st. 79 singly, and, from st. 80 became more frequent. Its number varied even more greatly than that of *C. furca*; at the shallow coast station 84 and at Cadiz, the relative frequency amounted to 55 % as compared with maximum 6 % at the others. On the return voyage in September the subspecies *seta* was found all the way to st. 245, southwest of Brest, but in very varying amounts, from very little to 10 % rel. freq. at Lisbon and even up to 50 % at st. 237 off the north coast of Portugal (a deep station). Near Cape Finisterre the subsp. *seta* vanished (scarce at st. 245 southwest of Brest), while the northern coarser form takes its place, occurring singly together with the subsp. *seta* at st. 239 (Cape Finisterre) and, farther to the north, alone, from st. 246 near Brest at all the following stations in the Channel, where it was predominating alone and together with *C. tripos*.

Beside the small and slender southern form, the proper subsp. *seta*, larger forms, varying in different respects, are found, for the most part — as is the case with *C. furca* — at more shallow stations. Such a form is f. i. that which is represented in my monograph, fig. 56 (pl. III), with the epi- and the hypotheca of almost equal lengths — while the epitheca is usually considerably shorter — and with a rudimentary right posterior horn. This form answers tolerably well to *C. Berghii* Gourr. (pl. I fig. 19), especially in consideration of the two figures 20 pl. I and 66 pl. IV, both representing *C. pellucidum* Gourr.

Another form is *C. fusus* var. *inaequalis* Schröder, which I have also seen in the transitional zone between Gibraltar and the Channel; however, when SCHRÖDER reports it from Naples, we probably do not mean the same form. I have also seen a coarse form from st. 55 at the south coast of Spain, accompanying the subsp. *seta* (see above). A very striking form, perhaps a separate species, is the var. *Schüttii* Lemmermann (see SCHÜTT l. c. pl. 9 fig. 35, 4 and JÖRGENSEN 1911 b pl. III figs. 54 *a*, *b*), a big, rather short form with a swollen epitheca. I only saw it outside the Mediterranean, at st. 84 on the coast of Portugal, singly.

The form from the Black Sea answered to the subsp. *seta*; however, as mentioned above, a coarser form was seen singly, in the surface of the Marmora.

In this small and narrow species, all the above-mentioned numbers only correspond to a lower limit of frequency, as of course such small narrow cells slip through the net in great numbers. Therefore, where masses of diatoms, f. i., are present, the numbers found have quite another value than in cases where only little plankton or of a coarser consistency is present. The above mentioned sample, taken with a taffety net, shows the same.

In this species fission stages are little conspicuous; I am afraid that I have mostly overlooked them. Halved cells were seen several times in samples from the night and early morning; they may, however, in most or many cases have been mechanically damaged cells. I have noted two certain cases: a cell shortly after fission at st. 135 (Tunis) between 1 and 2 o'clock a. m., and a similar case at st. 92 (just outside the Straits of Gibraltar) between 3 and 4 o'clock a. m.

Consequently, *C. fusus* is generally more numerous in the Mediterranean in winter, when it is increased by emigration from the Atlantic through the Straits in February and probably from late autumn (Octob.—Novbr.) to spring. In summer it is scarcer in the region of the Atlantic Current proper, and especially in the Eastern Mediterranean, except the northern Ionian Sea, where it is partly wanting in the surface. In the median region of the Mediterranean it seems always to be present in greater numbers. An apparently scarcely deviating form occurs in the Black Sea, where there is plenty of it in the upper layers; it passes through the Bosporus into the Marmora, where, however, it vanishes from the surface, but is still present in great numbers in the mixed water a little deeper.

20. CERATIUM EXTENSUM (Gourret) Cleve (Fig. 31 p. 40).

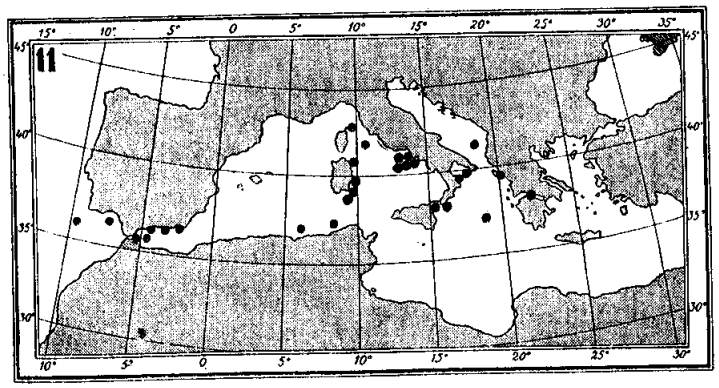
Jörgensen 1911 b p. 28 pl. III figs. 50 *a*, *b*.

This well distinguished species was already known to GOURRET 1883, who has a good figure of it (pl. 4 figs. 56, 56 *a*, as *C. fusus* v. *extensum*). After him it has been reported by CLEVE 1903, who found it occurring in October 1902 from Gibraltar to the vicinity of Crete, and in February 1903 in the Alboran Sea, by PAVILLARD from the Gulf of Lyons, frequent, and by SCHRÖDER and SCHILLER from the Adriatic, where they found it frequent or common in summer.

On the winter cruise of the "Thor" *C. extensum* occurred all along the route to the Bay of Corinth, only wanting at 10 (out of 37 Mediterranean) stations, but generally scarce (rr to 2 % rel. freq.), only a little more numerous in the region of the Atlantic Current proper (sts. 42 and 45 4 %, st. 55 5 %.

On the summer cruise it proved more frequent and especially much more numerous. In the Alboran Sea it was, however, wholly wanting in June, but in September present at all stations and very numerous, at st. 224 being by far the predominating species. In the Balearic it was wanting at 4 of 11 stations in June, and scarce, only with 1 to 3 % rel. freq., except at the salter station 114, where there was 10 %; in July, in the south-eastern region, it was still rather scarce and was absent at one station (138), but in August and September it was everywhere present and reached a mean value of 10 % rel. frequency. In August it was numerous at the two median stations, 205 (with 20 %) and 206 (with 10 %). In the Catalonian Sea it was present in August at all stations and in great numbers,

especially at the somewhat less saline, but warmer stations, in the Ligurian in July likewise everywhere, though scarce. In the Tyrrhenian Sea it occurred in July and August at all stations, but only in small numbers, rr to 4 %, wanting at deeper levels or still more scarce, except in the south-eastern region, where somewhat more numerous. In the Eastern Mediterranean it was only wanting at 5 sts. (151, 153, 154, 162, 167); in the Sidra Sea numerous in the eastern part, where there was 15 %, off Barca and in the Levant plentiful, on an average 15 % rel. freq., also present in deeper layers, though less numerous than in the surface. In the Aegean Sea here and there numerous, especially towards Greece, with a maximum of 25 % in the Bay of Aegina, in the northern Ionian Sea numerous, also at deeper levels, at st. 187 much more numerous at 0—25 m. than in the very surface (10 % as compared with 3).



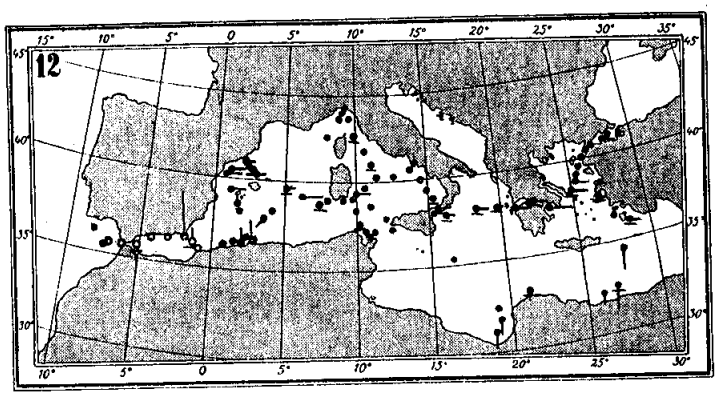


Chart 11. Distribution of *C. extensum* in winter (according to the material of the Thor).

Chart 12. Distribution of *C. extensum* in summer. o designates the September stations, ♂ a relative frequency of 10 % in that month (a line of 1 mm., 20 % 2 mm. a. s. o.; no line less than 7 %), ● the same for August ♀ ,July and ♂ June; ● ♀ both in the surface and deeper).

On the whole it was found almost everywhere in deep water samples (where such were taken), but never only in the depth, sometimes, however, more numerous there (sts. 187, 0—25 m. (see above), 194, 1145 m. w. (3 % as compared with rr in the surface), 209, 1945 m. w. 7 % (as compared with 1 in the surface)).

It penetrates into the Sea of Marmora, where it was more numerous at st. 175, 30 m. wire (7 %); in the surface of the Sea of Marmora and the Dardanelles it occurred singly.

Outside the Mediterranean, between Gibraltar and the Channel, it was only observed in Cadiz Bay, singly or rather scarce (to 3 %) and wanting at most stations in June and February, but present at both stations in September.

An emigration from the Atlantic through the Straits is obvious in February and January; judging by samples in my possession a migration took place also in December 1908, when it was found both in the Alboran Sea and outside the Straits. The rare occurrence outside the Straits in winter, compared with the relatively frequent one inside them, prove that the immigration into the Mediterranean has been successful. The other distribution in winter makes it probable that also such an immigration has taken place in late autumn (October—November). In June, on the contrary, no emigration from the Atlantic through the Straits is to be traced, except a very feeble one (sts. 111, 112), but in September a most successful one is going on, leading to an enormous increase in frequency in the Alboran Sea and the Western Balearic.

This, the longest of all Amphiceratia, is easily damaged by being caught in nets, and very often or even usually appears in the samples as broken cells or fragments. In many cases this may be partly due to a recent fission, the young stages generally being more fragile. Sometimes in the samples, taken at night, only such fragments were found. Quite certain fission stages were also frequent, most of the individuals in regeneration seen in samples from the early morning, especially in samples taken between 5 and 6 o'clock.

The many stations where the relative frequency was over 10 %, give as mean value for the salinity 37.92 ‰, with a maximum of 39.18 and a minimum of 36.64, which latter also answers to the optimum (at st. 224), and for the temperature 24°.2, maximum 25.8, minimum 22.3, optimum 23.9. Therefore the species seems to be rather euryhaline, but stenotherm (and thermophilous).

Otherwise *C. extensum* has a wide distribution in all three warmer main oceans, in the tropical, the subtropical and the warmer temperate zones. In the Atlantic it occurs at the Azores in different seasons, perhaps especially from summer to February (according to CLEVE 1901 a and my own observations); to the north, according to CLEVE l. c., it extends even to the sea southwest of Ireland.

Therefore, in late summer *C. extensum* is very frequent throughout the Mediterranean. In winter it seems to decrease considerably in numbers, but very probably survives in most regions of the sea (apparently not in the Ligurian Sea). It is again increased by a successful immigration into the Mediterranean through the Straits of Gibraltar, especially in autumn and winter, together with a lively propagation in late summer, both in the region of the Atlantic Current proper and elsewhere.

21. CERATIUM STRICTUM (Okamura et Nishikawa) Kofoid (Fig. 32 p. 40).

Jörgensen 1911 b p. 27, pl. III figs. 49 a, b.

I have already earlier (l. c. p. 28) emphasized the great similarity existing between *C. extensum* and *C. strictum*, and have mentioned the remarkable correlation which seems to exist between the development of the little, right posterior horn and the recent fission of the cell. Afterwards I have met with a great many cases, which seem to support my supposition, that forms with a young posterior region ("forma *postico-juvenile*") often or generally possess a more developed — though pale and thin — posterior right horn, than older, fullgrown individuals. I have also, however, in some cases seen a well developed right posterior horn without any trace of a recent regeneration, but such cases are apparently only exceptional. My observations apply especially to *C. fusus*, which, however, occurs in several, more or less different forms.

In *C. extensum* the same phenomenon is only more evident. Among the usual forms with a transversely cut body at the right posterior side, individuals with a distinct little right horn now and then appear, a horn which may be quite normally developed and with a length as great as in other Amphiceratia, f. i. *C. longirostrum*, *C. inflatum* and *C. falcatum*. There is perhaps a difference in the development of the cell wall, which, in the forms of *C. extensum* is almost always thin and pale, and perhaps therefore has not reached the final stage in its chemical evolution, usual in the Ceratia. I have revised my notes of this "*C. strictum*" in the gatherings of the "Thor", and found that all cases in summer, and almost all in winter, refer to individuals of the "f. *postico-juvenile*". On the whole I know only one or two cases from the Mediterranean where "*C. strictum*" seemed to be a species, really different from *C. extensum*, viz. one at st. 45 (off the African Coast in the Atlantic Current), where an exceedingly long (to 1.8 mm.) and very coarse form occurred, which had a well developed and relatively robust right posterior horn of 42 μ length — see fig. 32 — (transdiameter of cell 36 μ, in *C. extensum* usually not exceeding 30 μ), the other at st. 69 (in Cadiz Bay), a form with a long, fully developed left posterior horn, simultaneously with a well developed right one.

It therefore seems to me now evident that *C. extensum* f. *postico-juvenile* — probably for the most part only — differs from the older, full-grown form in having a more or less well developed, but thin and pale posterior right horn. It seems to me further probable that this horn may, in some cases, be persistent and by this circumstance give rise to a *C. strictum*, very little different from *C. extensum*. Whether there exists another (larger (?) and very rare) *C. strictum* I do not know with certainty.

The above mentioned form, *C. extensum* f. *strictum* (Okam. a. Nishikawa) was observed at the following stations: Port Alice, st. 14, Naupaktos, Taormina, sts. 24, 25, 26, 28, 38, 40, 42, 45, 55, 59, 60,

69; 120, 134, 0—75 m., 184, 945 m. wire, 185, 189 in the surface and at 945 m. wire, 209, 33—80 m. It occurred consequently at no less than 14 out of 27 Mediterranean stations in winter, but only at 6 stations in summer, partly below the surface. The fact, that the form in question is most rare in the season when the main species is most numerous, might favour the interpretation of this form as a separate species; the abnormally increased rate of propagation in *C. candelabrum* var. *depressum*, stated above (under that species), and f. i. of *C. tripos* giving rise to the heteromorphous chains of LOHMANN (compare JÖRGENSEN 1911 b pp. 37—39, 103) show, however, that fission is not bound to the best conditions of life.

A *C. strictum* is previously reported by me (l. c.) from Monaco, Cadiz Bay in Decbr. 1908, the Azores (in February), the Benguela and the Guinea Currents and from the Indian and the Pacific Oceans. SCHRÖDER, (1911), reports it from several localities in the northern Adriatic, mostly rare, at Lucietta, the most southern one, frequent, PAVILLARD (1916) from the Gulf of Lyons (rather distributed in winter).

Subgenus IV. **EUCERATIUM** (Gran) Ostf.

Sectio VIII. **TRIPOS** Ostf.

CERATIUM TRIPOS AND CERATIUM PULCHELLUM.

One of the most important results, gained by the investigations of the "Thor" as regards the *Ceratia*, is the detection of a true connection between the widely distributed warm water species, *C. pulchellum*, and the northern, *C. tripos*.

In my monograph (1911 b) I have united SCHRÖDER's type of *C. pulchellum* (the very peculiar form with a tiny right posterior horn, see fig. 46) with the normally developed similar, but larger form, which is so frequent in warmer seas. Though I mainly considered this form as a fission-stage, a "*f. postico-juvenile*", I also suggested — because this form is relatively frequent — that we perhaps here deal with a case of fission, sisting at an early stage. On the same occasion I mentioned that this form had been recorded by most authors as *C. tripos*, but that it was obviously different from the northern species, which is chiefly confined to colder seas.

Through the gatherings of the "Thor" I have obtained ample proofs that the extension of SCHRÖDER's species to comprehend the forms with a normally developed right posterior (postequatorial) horn was quite correct. On the other hand it has proved less correct to consider that type a mere *f. postico-juvenile*. In some few cases I was fortunate enough to meet with fission-stages of this form, and these show that we are here dealing with a separate form, dividing like the usual species. In my opinion this form has come up through a sisting regeneration (for further details see below under *C. pulchellum*).

PAVILLARD, 1907, mentions that he has been convinced that *C. tripos* v. *atlanticum* Ostf. occurs in the Gulf of Lyons in a scarcely different form, yet a little deviating and therefore perhaps deserving a special name as a geographical race. His supposition of a near relationship between the Mediterranean and the North Atlantic forms has been partly justified by the gatherings of the "Thor" in the intermediate region, between the Channel and the Straits of Gibraltar. Though the proper var. *atlanticum* has proved very rare in the Mediterranean, occurring there only by exception, it has nevertheless been found, and in the intermediate region just mentioned forms occur, which on the one hand must be reckoned to *C. tripos* in the vicinity of var. *atlanticum*, and on the other seem undoutedly to be transitional forms, passing without limit into the Mediterranean species *C. pulchellum* "sensu latu".

This fact may, however, allow of interpretation in two especially different ways: either it is the *C. tripos* which in the Mediterranean transforms into *C. pulchellum*, or these two species exist simultaneously, together with many intermediate forms. Which of these views is the right one, I am unable to prove definitely by the material at hand at the moment, but I am most inclined to adopt the first — that forms

of *C. tripos* for the greater part, in fact almost always, by transmission into the Mediterranean undergo a gradual transformation into more or less extreme forms of *C. pulchellum*, in a different degree in different seasons (compare below under that species). If this is correct, we have here a most interesting proof of a sort of plasticity of the living *Ceratium* cell, which enables it to adapt itself to changed conditions of life chiefly on account of and by means of a repeated fission. Another instance is the supposed transformation of *C. candelabrum* after migration through the Straits of Gibraltar, as stated in detail above under that species.

By the by I may mention that this is the most excessive instance of anything like a metamorphosis of species, which I have encountered among the Peridinea (Dinoflagellates). Such cases do not interfere with our usual conception of species, except in so far as the definition of this notion is no easy one, and constantly capable of modification, as our knowledge increases. No serious naturalist of experience, dealing with geographic-biological subjects, will consider the notion of species as merely artificial or arbitrary as regards a shorter duration of time, f. i. the lifetime of man; however, the limits between the different species are often concealed by variations (modifications) and more or less difficult to extricate.

22. CERATIUM TRIPOS (O. F. Müller) Nitzsch (Figs. 33—39 p. 48).

Jörgensen 1911 (b, p. 35).

MÜLLER's type of *C. tripos* from the Danish waters (Western Baltic or Belt Sea, see Jörgensen l. c. pl. IV figs. 65, 66) does not occur in the gatherings of the "Thor" (except some few empty cells in a bad condition, appearing at intervals in samples taken with the net P. 30, certainly remnants from an earlier use of the nets). Forms, more or less agreeing accurately with the var. *atlanticum* Ostenfeld (1903 p. 583 figs. 132, 133, *C. neglectum* Ostenfeld l. c. p. 584, fig. 135 included) were, however, more or less plentiful in the Bay of Biscay and along the coast of Portugal into the Bay of Cadiz, especially on the return voyage. Besides, at three stations in the Mediterranean a form, at least very near to var. *atlanticum*, was caught (see figs. 33, 34): at st. 226 on the south coast of Spain in September, rather copious, 10 %, together with *C. pulchellum* and about as numerous, off Naples in August, but singly, and at st. 14 (in the southern Adriatic) in December. These specimens agree with var. *atlanticum* in the long posterior horns and their directions, but are also reminiscent of *C. pulchellum* in the shape of (the left side of) the hypotheca.

A more exact examination of forms may however give rise to some doubt as to the correct interpretation of the var. *atlanticum* Ostenfeld. This author has given two figures of it, which are rather different, though both very well characterise this form in comparison to his f. *subsalsa* fig. 134, which was his proper purpose. According to the accepted rules of nomenclature I consider his first figure, 132, as the type of this var. *atlanticum*. According to this interpretation it agrees very well with my figures 69, 70, cited above. His other figure, 133, represents a nearly related form with a shorter right posterior and a shorter apical horn, and especially deviating by a remarkably short hypotheca, *h* and a very small distance (*y*, see JÖRGENSEN l. c. pl. VII fig. 132 a) from the body to the right posterior horn at the level of the girdle.

Forms, which correspond better to this second figure — and to *C. neglectum*, which is scarcely anything other than a more robust form of the same, with a strange appearance on account of its large crests and coarse structure — proved to be more or less common and numerous on the outward summer journey of the "Thor", from the Bay of Biscay about to Cadiz (see figs. 35, 36). They were present everywhere, in general moderately numerous, seldom rare (at the shallow coast station 84 rr), now and then abundant (st. 85 10 % rel. frequency, st. 89 20 %, Cadiz 10 %), and sometimes even greatly predominating (st. 87 80 %, st. 93 70 %). Forms, more obviously transitional to *C. pulchellum*, appeared on the south coast of Portugal and became gradually more frequent at the sacrifice of those, better agreeing with *C. tripos*, though still somewhat different from the forms of *C. pulchellum* farther east.

Inside the Straits generally only *C. pulchellum* was present, a few rare cases excepted. In the inner Mediterranean I only saw the *Ceratium tripos* var. *atlanticum* off Naples, as mentioned above (see fig. 34), and at st. 14 in the Southern Adriatic.

On the return voyage of the "Thor" the forms, distinctly transitional to *C. tripos* (var. *atlanticum*), appeared already on the south coast of Spain, from about st. 225. At st. 226 (Malaga) they were present

Fig. 33. *C. tripos* var. *atlanticum* Ostf. Malaga; September. Fig. 34. *C. tripos* var. *atlanticum* Ostf., a form, slightly deviating towards *C. pulchellum* f. *tripodioides*. Naples; August. Fig. 35. *C. tripos* var. *atlanticum* Ostf., forma. St. 246 (west of Brittany); September. Fig. 36. *C. tripos* var. *atlanticum* Ostf., forma. St. 80 (Bay of Biscay); June. Fig. 37. *C. tripos* var. *ponticum* n. var. St. 170 (Sea of Marmora), 0—20 m.; August. Fig. 38. *C. tripos* var. *ponticum* n. var. St. 172 (Black Sea), 0—17 m.; August. Fig. 39. *C. tripos* (var. *ponticum*) f. *pachysomum* n. f. Constantinople; August.

in somewhat greater numbers than the genuine *C. pulchellum* (s. l. or forma *tripodioides*, see below under *C. pulchellum*), and here also the true *C. tripos* var. *atlanticum* was observed (see fig. 33). Hence forms, partly similar to *C. pulchellum*, partly to *C. tripos* var. *atlanticum* (see figs. 35, 36) followed up to st. 243 in the Bay of Biscay, mostly abundant or predominating (st. 235 50 % rel. freq., st. 239 near Cape Finis-

terre even 90 %, here both a large form near *C. pulchellum* and others, more similar to *C. tripos*, st. 243 70 %). Farther to the north only the forms of *C. tripos* seem to occur.

In the innermost regions of the Mediterranean, influenced by the fresher water from the Black Sea, *C. tripos* again appears and in very great numbers or by far predominating (together with *C. furca*). The form occurring here has nothing to do with *C. pulchellum*; it keeps always separate from this latter species. It is sufficiently constant and distinguished to deserve a special name, var. *ponticum* n. var. (see figs. 37, 38). Its chief characteristics are the squarrose right postical horn, which recalls *C. massiliense* var. *protuberans* and is often strongly bent in a ventral direction, and the widely spread posterior horns (i. e. great values of x and y, see JÖRGENSEN l. c. fig. 132 a pl. VII and fig. 57 pl. III). Transdiameter usually about 70 μ, $\angle \alpha_l$, between the direction of the apical horn and the left posterior one at its basis about 60° or a little greater; the corresponding $\angle \alpha_r$ for the right horn about 90°; the distance x between the body and the left posterior horn at the level of the girdle but little less than the length of the transdiameter (usually 0.8 to 0.9 t), the posterior horns moderately long, a little diverging at their tips, both in relation to each other and to the apical horn, which is usually rather long and often nearly parallel to the right posterior one.

In this innermost region *C. tripos* proved to be a sharp indicator of the water from the Black Sea. It appeared suddenly at st. 165 (south of the Dardanelles, the first station with less saline water, 35.53 ‰, 24°.5 C.) with a relative frequency of 70 %, while *C. pulchellum* here only occurred singly, and continued hence as the predominating plankton species in the surface to the eastern part of the Marmora Sea (st. 170), where it was replaced by *C. furca*, though *C. tripos* still remained abundant. Now *C. furca* became the predominating species in the surface through the Bosporus to the Black Sea and back again, till the same region was reached on the return voyage, when *C. tripos* again took the lead (from st. 175). At three of these stations, deep water samples were taken, (sts. 170, 172, 175), and they show that at the two eastern stations (170 and 172) *C. tripos* was more numerous below the surface (at st. 170, 0—20 m., 20 % as compared with 10 % in the surface, at st. 172, 17—50 m. and 50—200 m. even 80 %) but at st. 175, on the contrary, in the very surface (70 %), though also here abundant at lower levels (at 30 m. and 1150 m. wire 40 %, at 350 m. w. 45 % rel. freq.).

At Constantinople this variety of *C. tripos* occurred in a special form of a very striking appearance, forma *pachysomum* n. f. (see fig. 39). This is one of those supposedly old forms — f. i. analogous to *C. pentagonum* var. *turgidum* — which are distinguished by a larger "body" (t here = 80 μ or more) and a much coarser structure, especially with a copious development of conspicuous fin-like crests. It also occurred in the depth of the station 172 in the Black Sea where — in a less extreme form — it made the bulk of the plankton (80 %) at 50 to 200 m. and was also present in small numbers just above this level, at 17 to 50 m. At the other station in the Black Sea (173), where only surface samples were taken, it occurred singly in the surface, and at st. 171 in the Bosporus it was present (in the surface) in small numbers among the usual form (*v. ponticum*).

Farther to the west *C. tripos* v. *ponticum* predominated (from st. 175) to st. 180 (included), west of Lesbos, where still 70 % (38.64 ‰, 24°.3), but became suddenly very scarce at the neighbouring station 181, where the subtropical plankton prevailed in spite of the slightly lower salinity (38.03 ‰, 24°.6). Farther on it was present in somewhat greater numbers (10 %, but only empty cells) at st. 182 (near the southern end of Euboea) in the surface, where fresher water was present (36.64 ‰, 25°.5), but otherwise singly, at st. 182, 545 m. wire, and at st. 183 in the Bay of Aegina.

About the "heteromorphous" and degenerated forms, see below under *C. pulchellum*.

I have noted large forms of *C. pulchellum*, similar to *C. tripos*, occurring from the winter cruise, at st. 27 (off Naples) and at st. 16 (Corfu). Outside the Straits of Gibraltar *C. tripos* was present singly among *C. pulchellum* at st. 69 in Cadiz Bay, and a similar, intermediate form at st. 66.

SCHRÖDER, 1911, mentions *C. tripos* (var. *atlanticum*) as rare from Lucietta and Sebenico on the coast of Dalmatia (independent of *C. pulchellum*, which was frequent). The latter locality is brackish.

Fission stages of the var. *atlanticum* were observed between 12 and 1 o'clock a. m., at st. 94 one cell just after fission, and between 3 and 4 o'clock a. m. at st. 89, shortly after fission. (Both stations outside the Straits). In the Black Sea region only two cases were observed: at st. 79 between 2 and 3 o'clock a. m., single cells just after fission, and at st. 169 between 4 and 5 o'clock a. m., when 25 % of the observed *C. tripos* were seen in regeneration and two cells (of 151) just after fission. Here, in the western part of the Sea of Marmora, the species was especially numerous.

23. C. PULCHELLUM Schröder, Jörgensen (Figs. 40—53, p. 54).

Jörgensen, 1911, (b p. 33, pl. III figs. 59—62).

In the Mediterranean this species was undoubtedly already known by GOURRET, who reports it under the name of *C. tripos* as frequent in the Gulf of Marseilles. He does not figure it, but finds it accurately agreeing with the fig. 2 in CLAPARÈDE and LACHMANN (1859, pl. XIX). This figure, though representing the *C. tripos* α *balticum* Schütt, so common on the coasts of Norway, really recalls to mind the *C. pulchellum*, on account of its short posterior horns and much longe rapical one. SCHRÖDER, (1900), figures from Naples as *C. tripos* var. *gracile* several species, among which most probably the *C. pulchellum* (fig. 17 e) also is found. PAVILLARD, (1907), who finds it perennial in the Gulf of Lyons, refers it to *C. tripos* var. *atlanticum* Ostenfeld — which is undoubtedly its nearest ally — but remarks that it ought perhaps to be considered a special geographical race (see above under "*C. tripos* and *C. pulchellum*" p. 46). SCHRÖDER, 1911, reports it as frequent, but generally scarce in the northern Adriatic (July, 1909). It was only wanting at the brackish stations (Sebenico-region), but was here replaced by *C. dalmaticum*, which in my opinion is likely to be a singular variety of *C. pulchellum*, produced by the influence of the brackish water and analogous to the individuals of LOHMANN's heteromorphous chains of *C. tripos* (see below).

It is mentioned by PAVILLARD, (1916), as the most frequent species of *Ceratium* in the Gulf of Lyons. In my monograph I have called SCHRÖDER's type of the species *C. pulchellum* "*sensu strictu*", and the form with a well developed right horn *C. p.* "*sensu latu*". Now, when the *C. pulchellum s. str.* has proved to be a separate form, it seems most natural to avoid these inconvenient terms and to use common variety-names. I therefore propose calling SCHRÖDER's type, α *eupulchellum* (fig. 46), and the *C. p. s. l.* forma *tripodioides* (figs. 41, 42). The many intermediate forms with a more or less reduced right posterior horn might perhaps be included under the mutual designation f. *semipulchellum* (figs. 43, 44), if they cannot be referred (without doubt) to one or other of the two main forms. For more accurate statements one must for the sake of surety add some further words about the length of the shorter horn, limits being wholly wanting. The consequence of my supposition stated above, that *C. pulchellum* merges into *C. tripos* without any limit, and develops from the latter species on transmission into warmer and salter water, should properly be that *C. pulchellum* is only to be considered a variety of *C. tripos*. For practical reasons I shall at present maintain it as a separate species, the more so as my hypothesis cannot yet be considered as quite certain.

The behaviour of the species in the Mediterranean — as far as it can be seen from the material of the "Thor" — is very interesting. In winter it was present throughout the route and at all stations (only not noted for st. 64 in Cadiz Bay), but while f. *tripodioides* was present everywhere, f. *eupulchellum* was rare in the Western Mediterranean. Intermediate forms occurred all the way, but were rare in the region of the Atlantic Current proper (west of Sardinia). In this region they are only noted for sts. 68, 69 in Cadiz Bay (f. *semipulchellum* with the shorter posterior horn about half the length of the left one, which may be considered the type of the f. *semipulchellum* in a stricter sense), and for st. 46 off the African Coast, where they were more numerous than f. *tripodioides*. The latter form became considerably

more frequent inside the Straits in the Alboran Sea, especially on the south coast of Spain (st. 55 10 % rel. freq.). Off the south-east coast of Sardinia (sts. 42, 40 and 39) the f. *tripodioides* was plentiful (about 10 %), together with f. *semipulchellum* which at st. 39 — where a vivacious fission was taking place — even by far surpassed the f. *tripodioides* in numbers. Farther on this latter form, accompanied by more or less numerous individuals of f. *semipulchellum*, was throughout present in great numbers, especially off Naples, where on an average about 15 %; optimum 23 % at st. 27, but nearly as numerous at sts. 29, 25, 23, 10 and Port Alice. The f. *eupulchellum* was only observed in the Western Mediterranean at sts. 23, 25, 26, 33, singly or scarce, whilst it was present at all stations in the Eastern, here and there also numerous (sts. 15, 16, 20 about 5 % rel. freq., optimum at the two warmest, 15 %, sts. 10, 11). Intermediate forms (f. *semipulchellum*) were almost everywhere present and often as numerous or even more.

In summer the behaviour of both main forms was very interesting and characteristic.

On the journey outwards in June the true f. *tripodioides* was not met with until Cadiz Bay. Already at Cape San Vincent a large form, similar to *C. tripos* occurred, forming the bulk of the plankton (80 % rel. freq.). From the station 89 sure forms of *C. pulchellum* appeared, viz. the f. *semipulchellum*, in small numbers (3 %) among numerous specimens intermediate to *C. tripos* (20 %). At Cadiz the latter forms, mostly with a shorter apical horn (see fig. 40), were still numerous, and likewise at st. 93, where yet a large form (fig. 41) of f. *tripodioides*, together with similar others, was by far the prevailing species (70 %). At the next station, 94, there were only a few forms similar to *C. tripos*, as compared with very many of the proper *C. pulchellum* f. *tripodioides*, together with obviously intermediate ones (in all 45 % rel. freq.). Hence f. *tripodioides*, recalling *C. tripos*, was continually present in great numbers till st. 108, where optimum (30 % rel. freq., 21°, 36.53 ‰). At the next station, 109, most specimens were the true f. *tripodioides*, which continued hence all along the African Coast, (mean value of rel. freq. about 10 %, at the last, less saline, station 15 %).

In this region of the Atlantic Current a remarkable reduction of the dimensions has taken place. A revision of my slides gave the following values of the transdiameter t (length of girdle in ventral or dorsal view): at st. 87, a large f. *tripodioides*, but somewhat similar to *C. tripos*, $t = 77\,\mu$, at Cadiz (fig. 40) $t = 72\,\mu$, at st. 93 (fig. 41) $t = 74\,\mu$, at st. 94, a similar large f. *tripodioides*, $t = 68\,\mu$, at st. 101, less reminding of *C. tripos*, $t = 64\,\mu$. I will here add the values for the rest of my slides: st. 129 (Tyrrh. Sea), f. *tripodioides* $t = 62\,\mu$, st. 163 (Aegean Sea), 0—80 m., $t = 68\,\mu$, Barcelona, a f. *tripodioides* recalling in much *C. tripos*, $t = 68\,\mu$, st. 229 (western entrance to the Straits of Gibraltar) f. *tripodioides* (fig. 42) $t = 72\,\mu$, f. *semipulchellum* (fig. 43) $60\,\mu$ and (fig. 44) $52\,\mu$, st. 234 (south of Lisbon), a form similar to fig. 40, $t = 70\,\mu$, st. 239 (Cape Finisterre), a large f. *tripodioides*, $t = 77\,\mu$, and a form nearer to *C. tripos* var. *atlanticum* $t = 81\,\mu$. We see from this that when we go from the Atlantic into the Mediterranean, the size of the cell body, especially that of the transdiameter, suffers a most remarkable and continual diminution. I wish to add that the slides in question have not been specially selected; they are all that I possess, and are only preserved for sake of control.

After station 113, where the route of the "Thor" leaves the coast of Africa, the state of things as regards *C. pulchellum* is suddenly changed. At st. 114 f. *eupulchellum* appears for the first time, singly, while f. *tripodioides* has vanished. This latter form still appears once in great numbers (10 %) at the next station, 115, but only as empty cells, and is wanting farther on till sts. 120 and 122, where it only appears singly. Hence it is generally only present singly or scarce in the surface and wanting at many stations, but occurs at deeper levels at all stations where such samples were gathered (except at st. 132), and is there as a rule the most numerous form of *C. pulchellum*.

In the Balearic, outside the Atlantic Current proper, the f. *tripodioides* was wanting at 4 out of 11 stations in June—July (sts. 116—119), and in the region off Tunis at 5 out of 8 stations; the samples from st. 134, where it was wanting in the surface, show, however, that it occurs at deeper levels (0—75 m.,

75—125 m., 125—200 m., everywhere but singly). In the Ligurian Sea it was wanting at one (st. 123) out of four stations, but was there represented by f. *semipulchellum*, in the Tyrrhenian Sea in July (wanting) at two of six (sts. 131, 132). Here, (at sts. 126, 128, 129) it was more numerous below the surface (st. 126, 100 to 200 m. 5 %, as compared to only 1 % in the surface), or in the surface only represented by f. *semipulchellum* (sts. 128, 129 here the most numerous form of *C. pulchellum* at 0—80 m., 0—600 m. and 0—1100 m., 6 to 8 % rel. freq.). In the Sidra Sea and the southern Ionian both the f. *tripodioides* and the f. *semipulchellum* were entirely wanting, except below the surface (st. 152, 950 and 250 m. wire, 1 to 3 % and f. *semipulchellum* singly at 950 m. wire, st. 156 only rr at 250 m. and st. 160 only singly at 100 to 200 m.). In the Aegean Sea it only occurred in the surface at three stations, (sts. 164 and 183 about 5 %, st. 179, singly in a larger form, more similar to *C. tripos*), but was again present below the surface

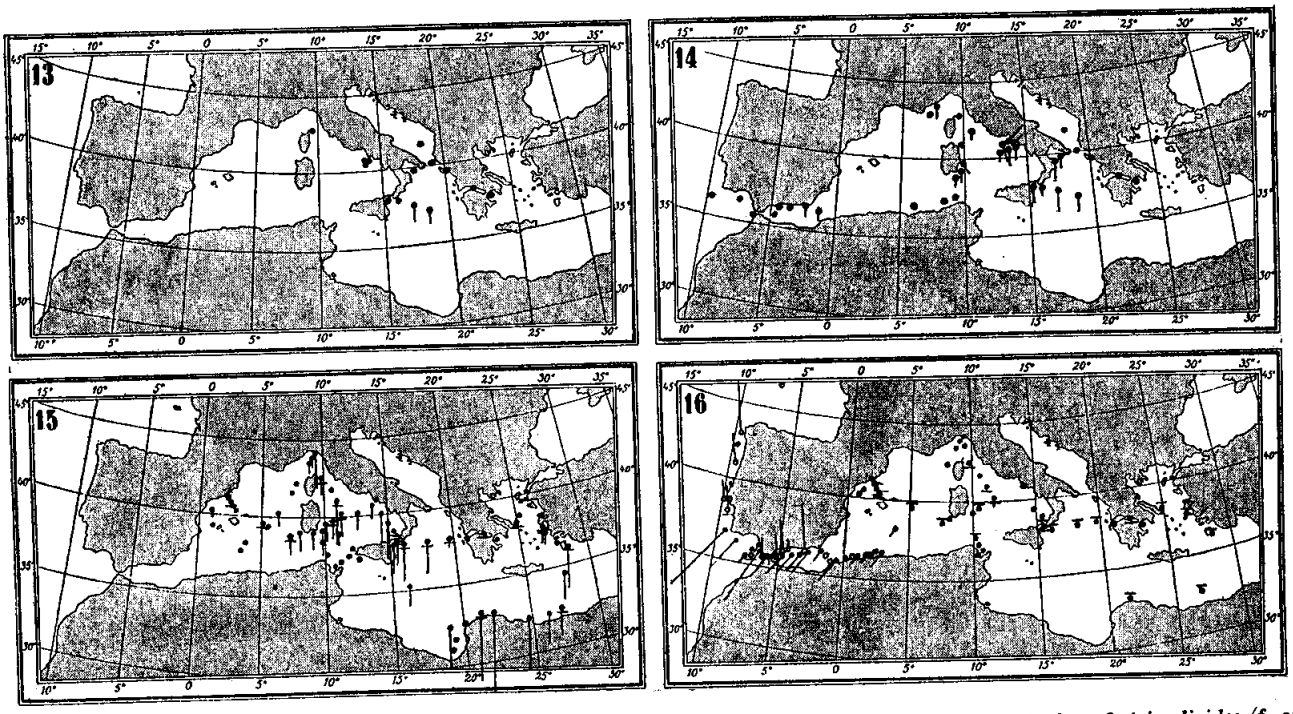


Chart 13. Distribution of *C. pulchellum* α *eupulchellum* in winter. Chart 14. Distribution of *C. pulchellum* f. *tripodioides* (f. *semipulchellum* included) in winter. Chart 15. Distribution of *C. pulchellum*, *eupulchellum* in summer. Chart 16. Distribution of *C. pulchellum* f. *tripodioides* (f. *semipulchellum* included) in summer. ♂ Western stations in September.

(sts. 163, 0—80 m. 1 %, st. 182, 545 m. wire 4 %). In the region, influenced by the fresher water from the Black Sea, it was entirely wanting.

On the return voyage it was present everywhere in the northern Ionian Sea, but partly only at deeper levels, where less scarce than in the surface (sts. 186, 187); f. *semipulchellum* was seen at sts. 190, 192 (surface, 2 %). In the Tyrrhenian Sea (August) it was again rarer, wanting in the surface at five out of eight stations (sts. 196—199, singly, except at st. 194, 1145 m. wire, where 8 %), but off Naples represented by f. *semipulchellum*. Across the Balearic it was present in the surface only at st. 203 (empty cells, 2 % rel. freq.), but was relatively numerous at deeper levels (st. 204, 945 m. wire, 6 %). In the Catalonian Sea it was relatively copious, though wanting at two (of the eight) stations, again more numerous below the surface (st. 209, 33—80 m. 10 %), otherwise from very scarce to 8 % (st. 211). In the Western Baleric, in September it was wanting at the two stations in the open sea south-west of the Baleares, but reappeared on the African coast at st. 219 and was hence continually present at all stations (yet not noted for st. 224), at first singly (st. 219), but soon increasing rapidly in numbers and generally abun-

dant; optimum already at st. 225, where it was the predominant species (50 % rel. freq., 22°.6), accompanied by a few specimens of f. *semipulchellum*. Generally the forms of f. *tripodioides* in this region have a right posterior horn which is somewhat smaller than the left one; an obvious f. *semipulchellum* with a considerably shorter right horn was still present outside the Straits in very small numbers at sts. 229 and 231, but wanting farther on.

The f. *tripodioides* and similar, more or less deviating, forms were encountered more or less numerously up to sts. 242, 243 in the Bay of Biscay, at the latter stations with more spreading posterior horns than usual. The larger forms with a less, or not reduced right posterior horn, were found at st. 229 but singly, becoming, however, generally more and more numerous at the sacrifice of the forms nearer to f. *semipulchellum*, except at deeper levels (sts. 228, 231, 234) where, on the contrary, these latter forms prevailed, partly as empty cells. At st. 239 (Cape Finisterre), where the species was abundant, the f. *tripodioides* could be seen to pass insensibly, through different intermediate forms, into the *C. tripos* var. *atlanticum*, which generally has a shorter apical, but longer and more spreading postical, horns.

The f. *eupulchellum* shows in summer a wholly different distribution. It is entirely wanting in the Alboran Sea and along the African Coast as far as Tunis. It appeared at first singly at st. 114 in the Balearic, as mentioned above, and was continually present from here at almost every station to the most southern station (215) in the Catalonian Sea (included). On this long distance it is only wanting at six stations (118, 135, Tunis, 180, 205 and 212), but at two of these the intermediate f. *semipulchellum* is present. Its (relative) frequency at the different stations varied remarkably, suggesting the great influence of different local conditions. In the Balearic in June—July it was scarce except at st. 117, where 10 %; in the Ligurian Sea it was more numerous, especially at Genoa, where nearly 40 %. In the Tyrrhenian Sea in July it was generally abundant, its frequency yet varying from 5 % (sts. 127, 134) to 45 % (st. 128). In the south-eastern Balearic it was rather scarce except at st. 133 (15 %) and st. 138 (5 %), in the Sidra Sea, however, abundant (at the warmest stations: st. 143 20 %, sts. 145, 147 45 %, st. 148 40°, but sts. 140, 151 only singly), and likewise very abundant farther on through the Southern Ionian Sea (optimum 90 % at st. 153, 24°.3, 38.64 ‰) and the Levant (30 to 55 % rel. freq.). In the Aegean Sea it was considerably less numerous (most at st. 163, 15 %) and proved very sensitive to the fresher water from the Dardanelles (sts. 165, 167, 179, 182 but singly, also at the much more saline station 181). In the northern Ionian Sea it was again abundant, especially towards the west, (st. 187 35 %, st. 189 40 %, st. 190 30 %, st. 192 25 %, at the two latter stations accompanied by several specimens of the f. *semipulchellum*, which is otherwise usually wanting where f. *eupulchellum* is abundant). In the Tyrrhenian Sea (in August) it was about as numerous as in July, with a relative frequency varying from 10 to 35 % (st. 195); off Naples it occurred but singly, accompanied, however, by some specimens of the f. *semipulchellum*. South-west of Sardinia in the Balearic (sts. 202 to 204) it was also abundant, but very scarce (at st. 206 in the surface) or wanting (at st. 205) in the median part of the sea. In the Catalonian Sea it was generally but little numerous (2 to 8 %) and vanished — as mentioned above — at st. 215. The f. *eupulchellum* was present in almost all deep water samples, but generally much scarcer there than in the surface. The only exceptions are the stations in the northern Ionian Sea, sts. 186 to 192, where it was nearly as numerous below the surface (at st. 187, where reliable vertical samples were taken, 0—25 m.), st. 199, at 945 m. wire as great relative frequency as in the surface, though at 0—30 m. only 2 %, and st. 206, where there was 2 % at 1945 m. w., but only single cells in the surface.

Fission stages were frequent. In f. *tripodioides* they were most numerous between 3 and 4 o'clock a. m. (at st. 136, single cells in regeneration, at st. 225, nearly half the number of cells in regeneration, a few just divided, at st. 200, a few recently divided) and between 4 and 5 o'clock a. m. (at st. 235 one third of all cells in regeneration, st. 209); between 7 and 8 o'clock a. m. at st. 39 many cells were in regeneration. Single cells in regeneration were seen at st. 234, between 7 and 8 o'clock p. m. at 0—25 m.,

and between 9 and 10 o'clock at 200—700 m., just after fission. In f. *eupulchellum* fission stages were much rarer: between 5 and 6 o'clock a. m. at sts. 209, 211 single cells in regeneration, between 7 and 8 o'clock a. m. at st. 198 two cells in regeneration, between 4 and 5 o'clock a. m. at st. 204 a cell recently

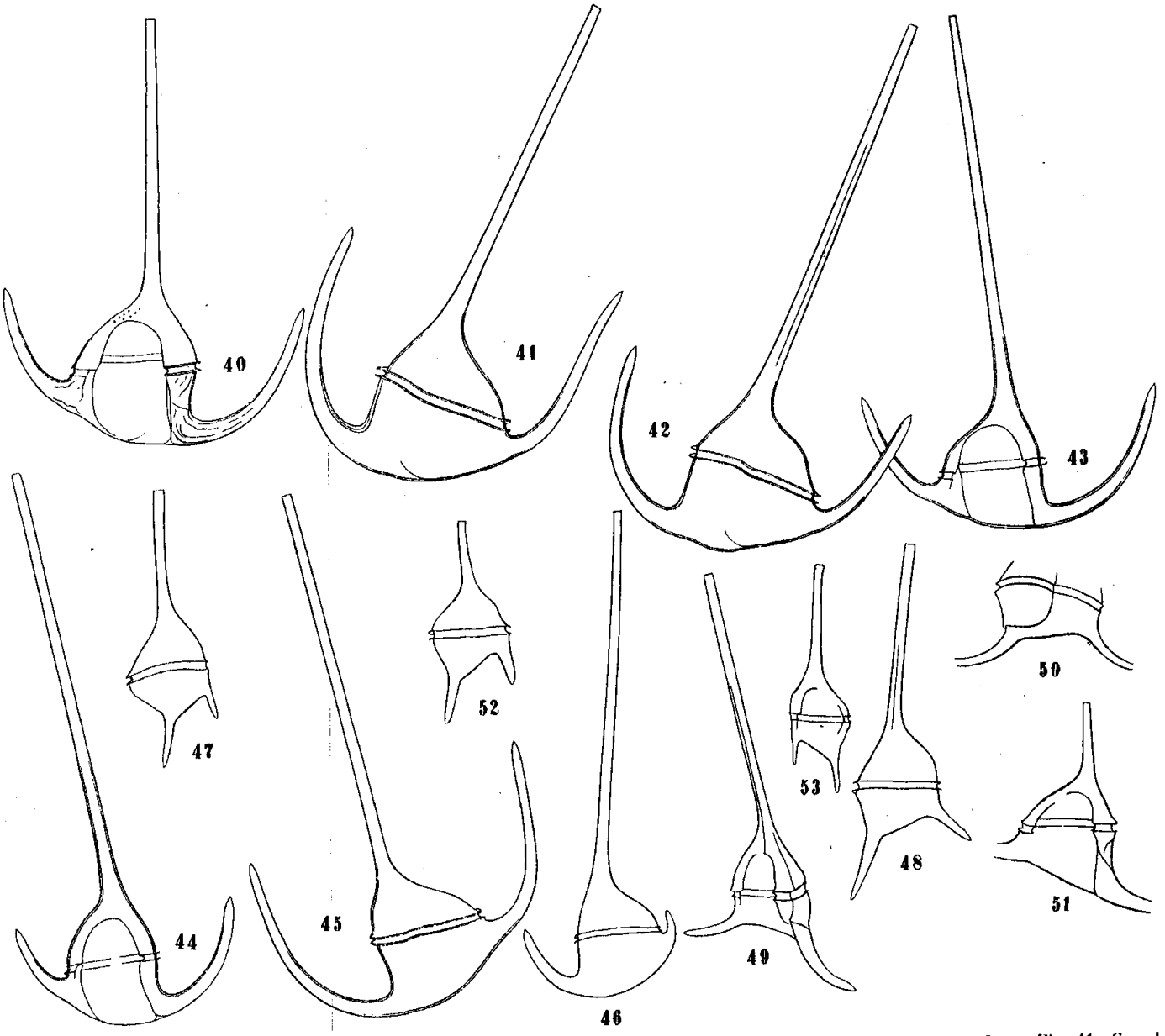


Fig. 40. Intermediate form between *C. tripos* var. *atlanticum* and *C. pulchellum* f. *tripodioides* n. nom. Cadiz; June. Fig. 41. *C. pulchellum* f. *tripodioides*, a large (sub-)form, transitional to *C. tripos* var. *atlanticum*. St. 93 (Cadiz Bay); June. Fig. 42. *C. pulchellum* f. *tripodioides*. St. 229 (just west of the Straits of Gibraltar); September. Fig. 43. *C. pulchellum* f. *semipulchellum* n. f., a (sub-)form with a rather long right posterior horn. St. 229. Fig. 44. *C. pulchellum* f. *semipulchellum*, a (sub-)form with a rather short right posterior horn. St. 229. Fig. 45. *C. pulchellum* f. *tripodioides*. St. 129 (Tyrrhenian Sea); July. Fig. 46. *C. pulchellum* α *eupulchellum* n. nom. St. 152; July. Fig. 47. *C. tripos* (var. *ponticum*), a form near to f. *brevicorne* (Lemm.). St. 174 (Sea of Marmora); August. Fig. 48. *C. tripos* (var. *ponticum*), a form near to f. *divaricatum* (Lemm.). St. 175 (Sea of Marmora); August. Fig. 50. *C. tripos* var. *ponticum*, a form, intermediate between f. *divaricatum* and the fully developed, normal form. St. 175. Fig. 51. *C. tripos* var. *ponticum*, a form, almost normally developed. St. 175. Fig. 52. A form, analogous to *C. tripos* f. *brevicorne* (Lemm.), but perhaps belonging to *C. pulchellum* (f. *tripodioides*). St. 26 (off Naples); January. Fig. 53. A form, answering to *C. tripos* f. *brevicorne* (Lemm.), but probably belonging to *C. pulchellum*.

divided, likewise between 3 and 4 o'clock a. m. at st. 129, and at st. 156 a forma juvenile between 12 and 1 o'clock a. m.

A cell of the f. *semipulchellum* was also found just after fission at st. 39, (between 7 and 8 o'clock a. m.), which definitely shows that its shorter right posterior horn is not due to an unfinished regeneration.

In a few rare cases I saw single individuals which obviously belonged to the peculiar heteromorphous chains of LOHMANN (see Jörgensen l. c. pp. 37, 38). They were relatively frequent in the region of the fresher water from the Black Sea: st. 168 (in the Dardanelles), st. 170, 0—20 m., sts. 174 (fig. 47) and 175 (figs. 48—51) in the surface of the Marmora Sea, everywhere singly or very scarce. It seems to me that there can be no doubt but that these forms are due to a degeneration, caused by certain hydrographical conditions. In the Baltic these are most probably the great variation of salinity, alone or in combination with other factors, and the same is undoubtedly the case here. The chief reason for considering them forms of degeneration is the smaller dimensions, forming a continual series of decreasing values from the normal forms to the most extreme heteromorphous ones. The transdiameter of the specimen, fig. 47, the most extreme form, answering tolerably to f. *brevicorne* (Lemmermann), is only 45 μ, in fig. 48, f. *divaricatum* (Lemm.), 48 μ, in fig. 50 62 μ and in fig. 51 64 μ (fig. 49 is excluded, because it is an oblique view). The normally developed form of the Marmora, see fig. 37, has a transdiameter of 72 μ.

In this case these forms belong to *C. tripos* var. *ponticum* and seem to have developed during the passage through the Marmora and the Dardanelles. They seem, as usual, to have some connection with the fission process. Perhaps they may be supposed to be the result of a rapidly repeated fission in the waters between the station 173 in the Black Sea and the sts. 174, 175 in the Marmora, as the number of individuals seems to have increased during this stretch. These stations in the Marmora have a higher salinity. Unfortunately, the samples are taken late in the afternoon so that formae *juveniles* are likely to be rare. The only station in this region, where such forms, and thereby the rate of fission, might be expected to be found, is st. 169, (sample taken at 4^{40} a. m.), but this station has a slightly lower salinity than the two preceding ones. Here fission stages were really present in single instances, 3 %, but among them no heteromorphous forms.

Outside this region such forms were exceedingly rare: st. 109 (coast of Africa in the eastern Alboran Sea, June, fig. 53, $t = 34$ μ), st. 26 (off Naples in January, fig. 52, $t = 43$ μ), st. 126 (in the northern Tyrrhenian Sea in July, a larger form, perhaps belonging to *C. carriense* or *C. massiliense*, $t = 57$ μ) and st. 134, 0—75 m. (off Tunis in July, "*C. Ehrenbergii*" Kofoid or at least very similar to it, see Jörgensen l. c. pl. IV fig. 80). Only that from st. 109 seems to belong with certainty to *C. pulchellum* or to *C. tripos*; perhaps this is also the case with those from st. 26 and 134, in spite of their strikingly short apicals. The former station, (109), is remarkable for being the first one in the Atlantic Current, where the larger f. *tripodioides*, still recalling *C. tripos*, has become less numerous than the smaller one with the shorter right posterior horn, and at st. 26 a relatively lively propagation was going on (6^{40} a. m.), visible through many incompletely regenerated cells belonging to different species, — among them also *C. pulchellum*.

These heteromorphous individuals, lacking in normal development, occurred at all these stations sparsely or singly — as also usually in other regions, except in the Baltic (?). In the brackish water on the coast of Dalmatia, however, a special form of a similar origin seems to have developed from *C. pulchellum* and there, in the Sebenico-region, to be abundant. As I have not seen this form, I must refer to SCHRÖDER, (1911, pp. 43, 44 fig. 10 *a—d*); it seems to me to be a short-horned degenerated form of *C. pulchellum* f. *semipulchellum* (?).

According to the data stated above the two principal forms of *C. pulchellum* behave almost inversely in the Mediterranean. In summer — both in June and in September — the f. *tripodioides* is abundant in Cadiz Bay, whence it migrates into the Mediterranean with a good result. This is the case with several forms, answering more or less to both *C. tripos* v. *atlanticum* and to *C. pulchellum*, the latter partly

answering to a *C. pulchellum* with a larger cell body, partly to the true Mediterranean form and (a few) to f. *semipulchellum*. In the Alboran Sea this larger *C. pulchellum* — very probably also the forms intermediate to *C. tripos* — undergo by repeated fission a gradual metamorphosis, the final result being the true Mediterranean form of *C. pulchellum f. tripodioides*, the *f. semipulchellum* and — in the warmest and saltest regions — the *f. eupulchellum*. In winter, (February), the *f. tripodioides* is present in Cadiz Bay, but only in small numbers; it migrates into the Mediterranean in January and February and probably also in late autumn (October—November). At this season (in winter) it is more numerous in the Tyrrhenian and the northern Ionian Seas, than in the region of the Atlantic Current proper. In the heart of the winter it will be carried into deeper layers and appear there in summer in the different regions of the sea. Meanwhile in summer a continual immigration into the Mediterranean through the Straits of Gibraltar goes on, which should spread the *f. tripodioides* over the surface of the sea in different regions, especially in the Sidra Sea, the Southern Ionian and the Levant. Here, however, in the surface, this form is almost wanting. This, I suppose, is due to the supposed metamorphosis into the *f. eupulchellum*, which in these inner regions is especially numerous.

In sharp contradistinction to f. *tripodioides*, f. *eupulchellum* is wanting in the region of the Atlantic Current proper and in Cadiz Bay, and is in summer much more distributed and much more numerous than in winter. During this latter season it is restricted to the Eastern Mediterranean and a relatively small area in the northern and eastern Tyrrhenian Sea, and is mostly scarce, or present in rather small numbers. Though apparently independent of the Atlantic Current it would not be likely to regain its huge area and distribution in summer if it was not renewed through the immigration into the Mediterranean of f. *tripodioides* and the metamorphosis mentioned. In winter this metamorphosis is obviously much feebler than in summer, and at deeper levels, with their much more uniform hydrographical conditions, there seems to be no metamorphosis at all.

Otherwise this species is widely distributed in the tropical and subtropical regions of the Atlantic and the Indian Oceans; in the Pacific Ocean it is known from the coasts of Japan. With the Florida Current east of America it spreads to north of Cape Hatteras and thence across the Atlantic to the Azores (at least in April and July). It is also present in the Canary and the Guinea Currents.

The hydrographical conditions at the stations where the species is abundant give for the f. *tripodioides* a probable optimum of about 36.6 ‰ at about 23° (st. 255: 22°.6, September) and for α *eupulchellum* (st. 153) 24°.3, about 38.63 ‰ in July.

24. CERATIUM EUARCUATUM nov. nom. (Fig. 54 p. 63).

C. arcuatum (Gourr.) Pavill., Jörgensen 1911 (b p. 43, pl. IV fig. 90, pl. V fig. 91). Not *C. arcuatum* Cleve 1900 (p. 13 pl. VII fig. 11).

This characteristic species was already detected by Gourret 1883 (pl. 2 fig. 42, *C. tripos* var. *arcuatum*), but was not re-discovered till 1907. Gourret reports it as rare from Marseilles and justly remarks that it is very near to *C.* (*tripos* var.) *gracile*. This relationship is indeed so close that certain short-horned forms are sometimes likely to be mistaken for *C. gracile* var. *symmetricum*.

Schröder, 1900, figured it from Naples, together with other species, as *C. tripos* v. *gracilis* (fig. 17 *d*). Pavillard, 1905, mentions that there is a noticeable difference between the figures of Cleve and of Gourret, and that Gourret's species occurs in l'Étang du Thau (near Cette) from November to June, rare, except in November—December.

In 1907 he further clears up this difference, establishing the new species *C. Karstenii*, a larger species which is founded on Cleve's *C. arcuatum*, but is wholly different from Gourret's. Pavillard finds the latter abundant in winter in the Gulf of Lyons; in 1916 he says that it is "very common" there and perennial, but especially abundant and "well developed" in winter. Schröder, 1911, finds it at all his

stations in the northern Adriatic except in the brackish region, usually r or rr, at Lucietta frequent (+), in July 1909. His samples were taken down to a certain depth.

I am sorry to say that I think we must let CLEVE's specific name *C. arcuatum* stand for the larger species, *C. Karstenii* Pavill., as it is the first specific name of this latter, and no other serious objection can be made to it than that it was founded on a false interpretation of GOURRET's varietal name. It is the first *C. arcuatum*, established as a species. To avoid more confusion than necessary I propose to change PAVILLARD's specific name to *euarcuatum*; but I am fully aware, that such prefixes may be misleading, when used in a similar manner. In this case, however, there is no doubt left about the true meaning of these names; only, the name *euarcuatum* cannot be used for definite forms of *C. Karstenii*.

C. euarcuatum usually occurs in two rather different forms, one with a very long, slightly curved apical horn, a short left posterior and a thin right posterior horn of different length, usually narrowing to a long, acute and almost straight tip (see fig. 54), the other with a shorter apical horn, but longer and stouter posterior ones, of which the left horn is less spread out from the body (distance x smaller, see Jörgensen l. c. pl. VII fig. 132 *a*). Both forms are frequent in the Mediterranean, the former perhaps especially towards the west, where, however, the second form also occurs. PAVILLARD figures the latter from l'Étang du Thau.

On the winter cruise the species was present continually all the way until the coast of Africa, except at the two northern stations 33 and 35 in the Ligurian Sea. It was only moderately numerous, optimum only 7 % rel. freq. (in the Bay of Aegina), here and there but singly (Naupaktos, Port Alice, apparently thus at shallow stations). In the region of the Atlantic Current proper it was much rarer: sts. 45, 55, 60, singly or very scarce, and in Cadiz Bay present at four (out of five) stations, singly to 2 % (not noted for st. 64).

On the summer cruise it was generally only found at stations where deep water samples were taken, and here, as a rule, only below the surface and at every station, except Naupaktos and the two western ones, in the Alboran Sea (sts. 223, 228). In the surface it was only caught at ten stations: sts. 161 and 167 in the Aegean Sea, st. 183 in the Bay of Aegina, sts. 187, 190, 192 in the northern Ionian Sea, st. 194, off Naples and st. 200 in the Tyrrhenian Sea, at Barcelona and at st. 218 on the African coast in the western Balearic, everywhere singly or very scarce. At deeper levels, however, it is not only, as has been said, generally distributed, but also much more numerous: st. 126, 275 m. wire, 10 %, st. 128, 0—100 m. 3 %, st. 129, 0—80 m. 15 %, 0—600 m. 40 %. 0—1100 m, 15 %, st. 132, 195—600 m. rr, st. 134, 0—75 m. 3 %, 185—350 m. singly, st. 152, 250 m. w. and 950 m. w. 3 %, st. 156, 250 m. w. and 950 m. w. singly, st. 160, 0—30 m. and 30—100 m. singly, st. 163, 0—80 m. 4 %, st. 182, 545 m. w. 10 %, st. 186, 245 and 1145 m. w. rr, st. 187 in the surface, at 100—190 m. and at 945 m. w. singly, st. 189, 945 m. w. singly, st. 192 in the surface and at 545 m. wire singly, st. 194 in the surface 1 %, at 1145 m. w. 8 %, st. 199, 0—30 m. 10 %, 80—200 m. singly, 945 m. w. only 2 individuals, sts. 204, 945 m., 206, 1945 m. and 209, 33—80 m. and 1945 m. w. very scarce. Consequently, it is rather numerous at deeper levels in the Tyrrhenian Sea, but otherwise, except at st. 182 in the Aegean Sea, scarce. In the region of the Black Sea water it is wholly wanting, likewise in summer (June and September) between the Straits of Gibraltar and the Channel.

No emigration from the Atlantic (in the surface) is going on in June, and in September there is only a slight trace, (st. 218). In winter, on the contrary, the species was present in February at almost every station in Cadiz Bay, but an immigration into the Mediterranean through the Straits seems only to have had a moderate success in that month and in January, the species being only present at two (out of six) stations in the Alboran Sea and at one (of three) on the coast of Africa, where (everywhere) it is also as scarce as west of the Straits. No emigration from the Mediterranean is to be traced (absent at sts. 223, 228).

Taking its distribution in winter as a starting point there seem to me to be two or three ways of explaining the main features of its occurrence. After the winter minimum has set in, the species must be supposed to occur from the surface to a more or less considerable depth, (on account of the vertical winter-movement). During the summer the species will chiefly remain at the level in question, but will drift with the water to other regions of the sea. Some few specimens seem to have reached the "intermediate" layers (with the west-going drift: sts. 134, 185—350 m., 186, 1145 m. w., 156, 950 m. w., 182, 545 m. w., 199, 945 m. w.) and may drift about with them for a longer or shorter time, the bulk seems, however, to belong to Atlantic water (sts. 134, 0—75 m. 3 %, 129, 0—80 m., 15 %, 199, 0—30 m. 10 %, 152, 250 m. w. 3 %) and therefore to partake of its circulation. In this way the species may attain a distribution answering to the real state of affairs.

At the different stations of the "Thor" — which are chiefly situated along the branches of the Atlantic Current — the surface layers drift with a greater velocity than those lying deeper, so that the species will generally be wanting in the surface, when these deeper layers have reached a certain other station. This will account for the almost total absence of the species in the surface of the Tyrrhenian Sea and, too, in the Western Mediterranean in summer, while there will be a certain possibility of finding remains of these surface layers more easterly, in the Aegean and the northern Ionian Seas. In late autumn, and during the winter, the species would be likely to reach the surface again — on account of the mixing of the upper layers, caused by the cooling down of the surface — even if, in the meanwhile, no immigration into the Mediterranean had taken place.

The distribution in winter might also be explained as the result of a direct immigration into the Mediterranean through the Straits of Gibraltar in late autumn, October—November. During the winter the species would (partly) be carried into deeper layers, and would drift with them, as above mentioned, into the different regions, to appear there chiefly as a deep water species.

Which of these theories is the more correct, can hardly be decided; the scanty migration observed, makes it probable, however, that both causes play their part, the former perhaps the greater.

It may also be possible that the species has immigrated into the Mediterranean somewhat below the surface after the winter minimum, and in this way has directly reached the lower levels, where it was found in summer. As these deeper layers must be supposed to move more slowly, they must have passed the Straits relatively early, in order to reach the stations where deep water samples were gathered. F. i., to reach st. 199, east of Sardinia, or st. 152 off Barca, a long time must have elapsed, so that we again fall back upon a supposed migration before the winter minimum (for most of the stations). Its occurrence at st. 134, 0—75 m. (layer of Atlantic water) seems to show definitely, that there has been a migration through the Straits in about May or April, but this occurrence may perhaps also be due to the large cyclonic movement of the water in the Western Mediterranean. After all, this possibility too seems to play a part.

I have seen specimens of *C. euarcuatum* from the Straits of Gibraltar and from Cadiz Bay in December, 1908. An immigration into the Mediterranean through the Straits of Gibraltar was, consequently, going on at that time, but I am not able to judge, whether it has been successful or not.

The only station (129 in the Tyrrhenian Sea), where the species was numerous according to the material of the "Thor", gives a probable value for the optimum of about 38.3 ‰ at somewhat less than 14°. This low rate of temperature seems to prove that it does not live in the Mediterranean under normal conditions. Neither were fission stages encountered.

Outside the Mediterranean and Cadiz Bay it is widely distributed in the tropical and the subtropical regions of the Atlantic and the Indian Oceans. East of America it is found in the Florida Current as far as north of Cape Hatteras, and is otherwise present in the Antilles Current and the Gulf Stream west of the Azores.

Summing up the data stated we find that only in winter is *C. arcuatum* in the Mediterranean chiefly distributed in the surface, but then everywhere frequent, except in the Atlantic Current proper. In summer it has almost exclusively withdrawn to deeper levels, where it (apparently) occurs throughout the sea at a moderate depth, abundant in the middle of the Tyrrhenian Sea, but otherwise — as well as in winter — in rather small numbers. It is only in part renewed through a feeble immigration into the Mediterranean through the Straits of Gibraltar, probably from late autumn to spring. A fission has not been observed (by me), but is likely to take place occasionally (and to cause the sporadically greater frequency).

25. CERATIUM GRACILE (Gourret) Jörgensen (Figs. 55 to 59 p. 63).

Jörgensen 1911 (b p. 44, pl. V figs. 92—95).

This species was discovered by GOURRET (1883) at Marseilles; however, he says nothing about its occurrence there. His figure of it, "*C. tripos* var. *gracile*" pl. 1 fig. 1, is — as most of his figures on pl. 1, — no happy one and has caused much confusion, having been the object of different interpretations by different authors (see Jörgensen l. c.). Strictly speaking, the name *C. tripos* v. *gracile*, according to the international rules of nomenclature, should yield to *C. tripos* v. *gracile* Pouchet — most probably synonymous to *C. inflexum* (*C. contrarium*) — but this must again, in its turn, give way to the specific name, *C. gracile*, (see below).

SCHRÖDER (1900 pl. 1) figures from Naples as "*C. tripos* v. *gracilis* Gourret" several species, viz. *C. declinatum* (fig. 17 *b*), the species in question *C. gracile* Jörg. (fig. 17 *c*), *C. euarcuatum* (fig. 17 *d*) and *C. pulchellum* f. *tripodioides* (fig. 17 *e*). ENTZ, 1905, (1902), has a figure of the present species from the northern Adriatic (Quarnero), on p. 105, pl. IV, fig. 30; he considers it a winter form of "*C. tripos arcuatum*".

The specific name *C. gracile* is first used by PAVILLARD, 1905, founded on *C. tripos* var. *gracilis* Schröd., 1900, pl. 1 figs. 17 *b, d, e*. This name would have the priority as name for a species, if it had been accompanied by a figure or a description; now it must be abandoned, because the figures cited represent, as I have said, three different species. It is also impossible to apply this name to the first one of these figures, as the species in question, *C. declinatum*, just on the preceding page (50) was listed by PAVILLARD as the true *C. tripos* and figured as such pl. I (figs. 5, 7). According to the text and the other figure cited, PAVILLARD's species is undoubtedly the *C. pulchellum* f. *tripodioides*, answering to the last one of the three figures cited. However, this result appears chiefly as a negative one, from the fact that the species in question can be none of the others. To substitute this name for *C. pulchellum* f. *tripodioides* should therefore be avoided, the more so as PAVILLARD, himself, 1907, uses the same name in another meaning. He now includes his *C. tripos*, from 1905, under *C. gracile* and cites another figure with SCHRÖDER (fig. 17 *a*), really representing the same species as *C. tripos* Pavillard 1907, viz. *C. declinatum*. He excludes SCHRÖDER's figures 17 *b—e*, mentioning that they represent other species ("*C. arcuatum*, *C. coarctatum*, etc."), which is quite correct, except that fig. 17 *b*, — in my opinion — really is *C. gracile* Pavill. 1907. This name has hereby attained a definite sense, but how is it with its priority?

In my monograph I have used the oldest names as specific, even if they were established as names for varieties. I consider this most just in the majority of cases — also in the present — but, according to the rules of nomenclature now adopted, the oldest specific name is to have the priority. Moreover, according to the rules mentioned, a name, which (later on) is found to designate more than one species, may be used for one of them. In this case, the first author to separate the species in question and to use the name for one of them, is to be followed. PAVILLARD, 1907, has corrected the name *C. gracile*, used by him in 1905, and should have the right to determine definitely its true meaning in the future. The only grave objection to be found is — in my opinion — the fact that the real sense of *C. gracile* Pavill. 1905 can scarcely have included that of *C. gracile* Pavill. 1907, as the latter species was

separately listed by him 1905, (under the name of *C. tripos*) as well as *C. gracile* (1905), and also *C. coarctatum*, *C. symmetricum* and *C. arcuatum*. Accordingly, the question seems to me to be whether *C. gracile* Pavill. 1907 is not in contradiction to *C. gracile* Pavill. 1905?

In my opinion it is, nor is it conceivable that an author with PAVILLARD's profound knowledge of the Peridineae could refer two so different forms as *C. pulchellum* (f. *tripodioides*) and *C. declinatum* to one and the same species. It is therefore most probable that it is the wish to be in the best accordance possible with the earlier citation of *C. tripos* var. *gracilis* Schröd., which has caused the change in the real sense of this name, *C. gracile* Pavill., at the moment when he had reached a clear comprehension of the species in question.

In short, *C. gracile* Pavill. 1907 is — in my opinion — in contradiction to *C. gracile* Pavill. 1905, in spite of the apparent accordance in a formal sense. The latter name can only be used for *C. pulchellum* f. *tripodioides* (above), the former has lost its priority. If PAVILLARD had modified this former name a little, it should have had a priority before *C. declinatum* Karst.

I might use this name *gracilis* now for *C. pulchellum* f. *tripodioides*, calling it *C. pulchellum* f. *gracile* (Pavill. 1905). I think, however, that this too should be avoided, as long as *C. pulchellum* f. *tripodioides* is not distinctly or with certainty separated from *C. tripos* (in all its forms), so that it might be listed by others as a variety of the latter species. We should then fall back again upon one more *C. tripos* var. *gracile* (Pavill. 1905), and there are already too many of them.

I shall therefore retain my above name for the present species, the more so as it is in accordance with GOURRET's original one.

I hope that this detailed clearing up of the names will not be useless; the closer we keep to the adopted rules of nomenclature, the sooner these troubling questions of priority will be definitely settled.

The present species was described by PAVILLARD 1905 as a new one under the name of *C. coarctatum*, with the nearly allied form *C. symmetricum*, by PAVILLARD also considered as a separate new species. He found them both in l'Étang du Thau near Cette in winter, the former from November to January, the latter more frequent and from November to May. He reports them both (1907), from the Gulf of Lyons: *C. symmetricum*, very common there in winter, *C. coarctatum* accompanying it, but rarer.

C. gracile is present in the Mediterranean in different forms, which are generally rather constant and tolerably well defined. The two main forms are the two species mentioned by PAVILLARD, *C. coarctatum*, answering to GOURRET's type, and *C. symmetricum*, which I still consider a variety (see below), though a very well defined one. The main species is in its typical form of very characteristic shape (see fig. 55), owing to the long and convergent horns and the abruptly rounded posterior outline; besides, the right posterior horn is displaced ventrally out of the plane of the two others, which is much less obvious in var. *symmetricum*. The latter variety has also somewhat smaller dimensions, especially of the cell body, and has generally the three horns almost parallel at their tips (see fig. 57).

Beside these two forms I have described a third in my monograph, the f. *orthoceras* (see fig. 56), which in part only seems to be a young form of α *coarctatum*, but in part to be an intermediate form (between α and var. *symmetricum*). Another transitional form, especially found at deeper levels, is represented in the figures 58 and 59. It is nearer to var. *symmetricum* in habitus — though with a longer apical horn — but has a larger cell-body and a more concave shape, like α *coarctatum*. At st. 228 in the Alboran Sea this form occurred together with the usual var. *symmetricum* and forms, obviously belonging to α *coarctatum*.

On the winter cruise of the "Thor", *C. gracile* was present at all stations in some form or other. Generally the var. *symmetricum* was the most numerous form, sometimes superseded by f. *orthoceras*, never by α *coarctatum*. Usually all three forms were present together (at 19 of the 37 Mediterranean stations), especially in the Eastern Mediterranean, where the species was in all most numerous (on an average

10 % of relative frequency). The main species, α *coarctatum*, was always scarce, at most reaching 3 % of rel. freq. and often only occurring singly; the f. *orthoceras* — which, as mentioned above, in part may only be a younger form of α *coarctatum* — was sometimes plentiful, with an optimum of 10 % at st. 20. The var. *symmetricum* was generally present in somewhat greater numbers and at all stations, with a mean value of relative frequency somewhat below 5 %, (at sts. 11 and 39 10 %). In Cadiz Bay the species was also present at all stations, very scarce to nearly 10 % (at st. 66), α *coarctatum* only singly, and f. *orthoceras* more numerous than var. *symmetricum*.

An immigration from the Atlantic into the Mediterranean has certainly taken place in February and January, but was apparently only followed by a little increased frequency in the var. *symmetricum*. In the region of the Atlantic Current proper the species was on the whole least frequent, the mean value of relative frequency there being only 2 %.

On the summer cruise it appeared first suddenly (as var. *symmetricum*) in greater numbers at st. 81 (off the north coast of Portugal) at 100 m. wire (23 % rel. freq.), was, however, in the surface only met with at intervals and as very scarce (v. *symmetricum* at sts. 87, 92, 96, α *coarctatum* at sts. 92, 95, 96 and f. *orthoceras* at sts. 92, 94, 95, 96). In the Alboran Sea it was still caught singly at st. 98 (f. *orthoceras*) and st. 99 (α *coarctatum*), but was otherwise almost entirely wanting in the surface, whilst everywhere present in deep water samples, where such were taken. After st. 99 it was only caught singly in the surface at five stations, where no deep water samples were taken, (α *coarctatum* at sts. 167, 200, 210 and var. *symmetricum* at sts. 185, 195, 1 % rel. freq.) and in the surface at five other stations, where deep water samples were gathered and where, accordingly, the species was present in the depth, (sts. 128, 156 and 204 α *coarctatum*, st. 186 all three forms, and st. 194 α *coarctatum* with var. *symmetricum*). In the deep water samples α *coarctatum* was as a rule the most numerous form, (st. 134, 75—125 m. 15 %, st. 152, 250 m. w. 10 %, st. 163, 0—80 m. 6 %, st. 182, 545 m. 5 %, st. 194, 1145 m. 5 %, st. 199, 80—200 m. 25 % (optimum), st. 206, 1945 m. 4 %, st. 209, 33—80 m. 4 %), at a few others the var. *symmetricum* (st. 126, 100—200 m. and 275 m. w. 15 % (optimum), st. 129, 0—80 m. 2 %, 0—1100 m. 8 %), sometimes also the f. *orthoceras* (st. 152, 950 m. w. 3 %, st. 156, 950 m. w., st. 186, 245 m. w. 15 % (optimum)). Generally the species, (all forms included), seemed to be most frequent at a level of about 100 m. (st. 126, 100—200 m., 25 %, and 275 m. wire — these "wire-samples" must be supposed to have run for the longest time at some intermediate level — 15 %, st. 134, 75—125 m. 20 %, st. 186, 245 m. w. 25 %, st. 199, 80—200 m. 30 % (optimum)). It was very scarce in the region of the Atlantic Current proper in June, and in September even entirely wanting, except at stations 223 and 228, in deep water samples with outflowing Mediterranean water. Outside the Straits it was in September only found below the surface at st. 231 in Cadiz Bay (α *coarctatum* 2 % rel. freq., var. *symmetricum* 4 %).

A feeble immigration into the Mediterranean through the Straits of Gibraltar is to be traced in June, but seems to have failed, the species being only encountered at sts. 98, 99, in the Straits and immediately east of them. In September there was no such immigration at all.

The species was sometimes wanting in the upper layers of the deep water samples, a little below the surface (sts. 160, 0—30 m., 187, 0—25 m. and 199, 0—30 m.) or was very scarce there (st. 129, 0—80 m., and st. 134, 0—75 m., singly); at some stations it seemed to have sunk into the intermediate layers, (sts. 186, 1145 m. w., 156, 950 m. w., 160, 100—200 m., 182, 545 m. w., 199, 945 m. w.), which also answers to its occurrence in the outflowing water in the Alboran Sea. Otherwise it seems to be most numerous in the layers near the (winter) minimum of temperature (f. i. at st. 199, 80—200 m., 30 %); in the layers with Atlantic water (f. i. st. 134, 0—75 m. and st. 199, 0—30 m.) it was very scarce or wanting.

A propagation undoubtedly takes place in the Mediterranean. I saw a recently divided cell of α *coarctatum* from st. 95 (in Cadiz Bay), between 5 and 6 o'clock a. m., and incompletely regenerated cells at st. 182, 545 m. w., between 11 and 12 o'clock p. m. Apparently young forms were seen at several

stations, mostly — as is usually the case — where the samples were taken early in the morning, they had feebly developed girdle lists, which were sometimes indistinct towards the right side. By the near relationship to *C. euarcuatum* with its incompletely developed girdle region, it is perhaps possible that the f. *orthoceras* — which has often more or less indistinct girdle lists — is rather a finished form than a young one, and that α *coarctatum* is only a rarer, more robust form, adapted to the special physical conditions of winter, and of deeper levels. In some respects, (the posterior outline, the divergence of the left posterior horn and the more or less robust development of the right) there is a relative accordance between the two principal forms of *C. euarcuatum* (see Jörgensen l. c. figs. 90 and 91) on one side and the α *coarctatum* and var. *symmetricum* on the other. This latter variety is, however, for the most part well distinguished and easily recognizable; its more robust form (see fig. 59) was often — as above mentioned — the only one occurring at deeper levels (f. i. at sts. 132, 57—1090 m., 134, 75—125 m., 187, 100—190 m. and 945 m. w., 189, 945 m. w. and 228, 1145 m. w.).

To judge from the cases where the different forms of the species were most numerous, the α *coarctatum* answers to a greater salinity. Like *C. euarcuatum* this species also occurs at temperatures which are relatively low for the species; this may in some degree account for the irregularity and usually low value of its frequency.

C. gracile is widely distributed, especially as var. *symmetricum*, in the tropical and subtropical regions of the Indian and Atlantic Oceans. It is found in the latter in the Antilles Current, in the Gulf Stream as far as the Azores (in February) and in the Canary Current, both α *coarctatum* and var. *symmetricum*.

C. gracile is therefore undoubtedly indigeneous in the Mediterranean, where it appears in the surface in winter, frequent all over this sea, but generally only moderately numerous. In summer it has almost wholly vanished from the surface, but is everywhere present at deeper levels, especially near the (upper) intermediate (winter) minimum. While in winter the var. *symmetricum* is generally the predominating form, in summer α *coarctatum* is relatively numerous and sometimes more frequent than the var. *symmetricum*. The species is only renewed to a very slight extent by an emigration from the Atlantic, which takes place in winter and perhaps in spring.

26. CERATIUM ARIETINUM Cleve (Figs. 60 to 62, p. 63).

Cleve 1900 (p. 13, pl. VII fig. 3). Jörgensen 1911 (b p. 48, pl. V, figs. 102—105).

This species, easily recognized, as a rule, was first recorded under the name of *C. heterocamptum* (Jörg.) from the Mediterranean by Pavillard, 1905, who found it in l'Étang du Thau near Cette, rare, from November to April. Schröder, (1906) reports it as rare from the northern Adriatic in March, August and September, and as frequent from the Ionian Sea in March, (1902). Pavillard, 1907, finds it rather widely distributed in the Gulf of Lyons in winter, always delicate and of small dimensions; in 1916 he reports it to be rare there, a little in excess in winter. There are several forms, which in their extreme shapes differ rather considerably from each other (see Jörgensen l. c. and the figures 60—62).

We have first a robust form, (Jörgensen l. c. fig. 102), which I have seen from the Azores and from Brest, and in the material of the "Thor" from the Bay of Biscay in June, (st. 79) and off the coast of Portugal, (st. 81, 100 m. 30 % rel. freq., st. 84 singly, in June, st. 239 singly in September). It is chiefly characterized by a stout and nearly straight apical horn, a relatively great transdiameter (60—66 μ), a broadly convex or somewhat gibbous antapical outline and a strong right posterior horn, which is stouter than the left one, except at its tip. The apical horn is often provided with more or less conspicuous, bladelike lists. This form may be Cleve's type, which, however, is more similar to fig. 61, except in the shape of the apical horn. At any rate my form is much more robust, so that it will be best to designate it with a special name, f. *valens* n. f.

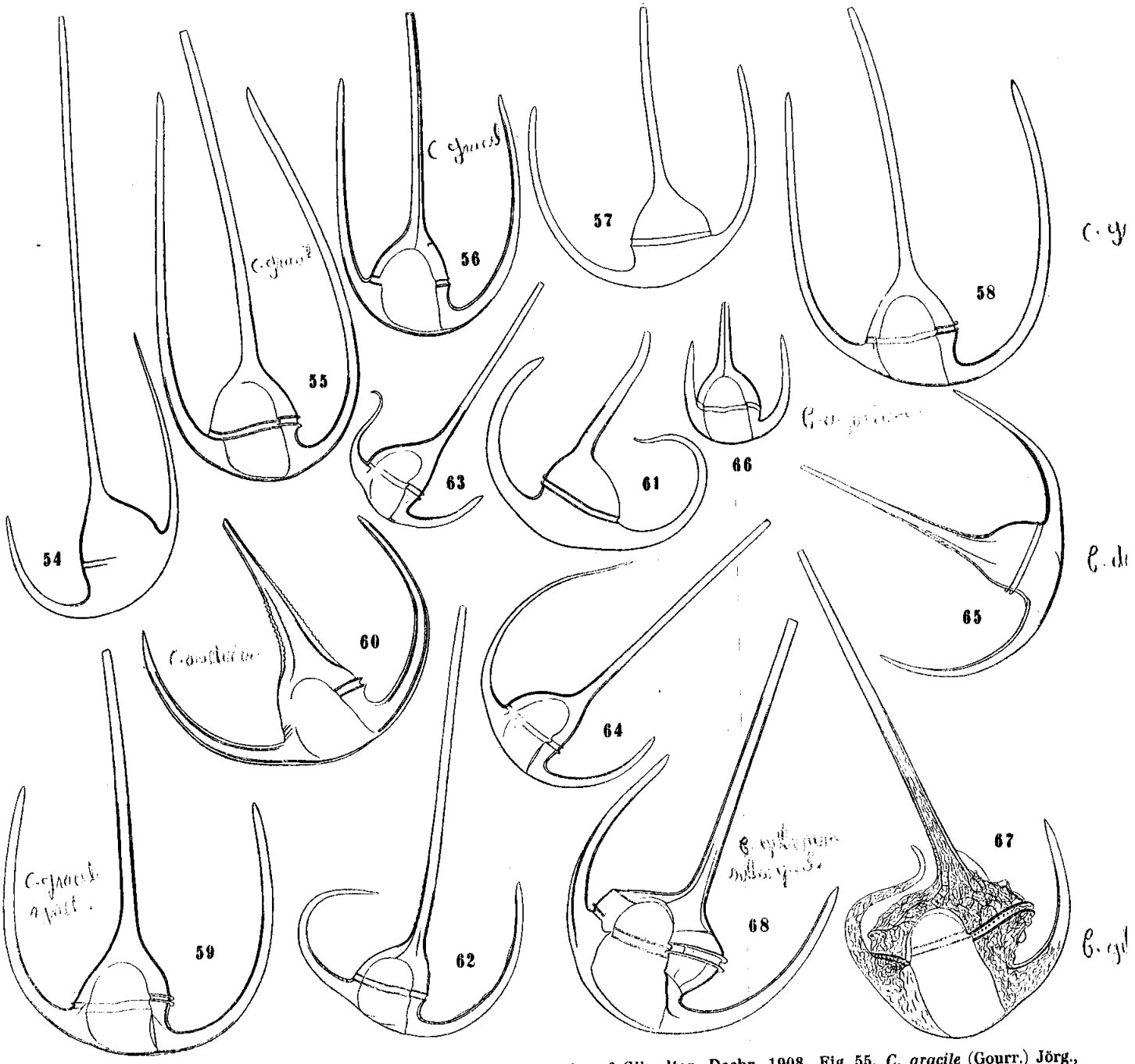


Fig. 54. *C. arcuatum* (Gourr.) Pavill. = *C. euarcuatum* n. nom. Straits of Gibraltar, Decbr. 1908. Fig. 55. *C. gracile* (Gourr.) Jörg., *α coarctatum* (Pavill.). Taormina (Sicily); January. Fig. 56. *C. gracile* (Gourr.) Jörg., f. *orthoceras* Jörg., probably a young form of *α coarctatum*. Taormina. Fig. 57. *C. gracile* (Gourr.) Jörg., var. *symmetricum* (Pavill.). Straits of Gibraltar, Decbr. 1908. Fig. 58. *C. gracile* (Gourr.) Jörg., var. *symmetricum*, a form approaching *α coarctatum*. St. 128 (Tyrrhenian Sea), 0—100 m.; July. Fig. 59. *C. gracile* (Gourr.) Jörg., var. *symmetricum* (Pavill.), a beautiful form from deeper water, different from the usual ones. St. 228 (east of the Straits of Gibraltar), 1145 m. wire; September. Fig. 60. *C. arietinum* Cleve, f. *regulare* n. f. St. 79 (south-west of Brittany); June. Fig. 61. *C. arietinum* Cleve, f. *detortum* (Stüwe). Straits of Gibraltar, Decbr. 1908. Fig. 62. *C. arietinum* Cleve, f. *gracilentum* n. f. Monaco. Fig. 63. *C. declinatum* Karst., *α debile* nov. nom. Naupaktos; December. Fig. 64. *C. declinatum* f. *brachiatum* n. f. St. 91 (Cadiz Bay); June. Fig. 65. *C. declinatum* var. *majus* n. var. St. 204 (south-west of Sardinia); August. Fig. 66. *C. azoricum* Cleve. Straits of Gibraltar, Decbr. 1908. Fig. 67. *C. gibberum* Gourr., f. *dispar* Pouch. South-east coast of Spain, Decbr. 1908. Fig. 68. *C. gibberum* Gourr., f. *subaequale* nov. nom. Naupaktos; Decbr.

A very interesting modification of this robust form is f. *regulare* n. f. (fig. 60). It agrees with f. *valens* except in the development of the right posterior horn, which is here quite normally developed and similar to the left horn, without the delicate curved tip which is otherwise so distinctive for this species. This is a very interesting case, probably representing an atavistic return to the original and ordinary type, from which this deviating species is undoubtedly derived. I only saw this form from two localities in the material of the "Thor", from st. 79 in the Bay of Biscay, in June (1910), and from the same region in a sample (in my possession) from May 1909. In both cases f. *regulare* was accompanied by the normal f. *valens*.

Another form is f. *detortum* (Stüwe) (fig. 61), chiefly distinguished by its (usually) short apical horn, which near to the apex is rather abruptly bent to the left. Its antapical outline is more conspicuously gibbous than in the other forms, and its right posterior horn is about as stout as its left. In the material of the "Thor" it was only present near the Straits of Gibraltar. This form is smaller than the preceding (t = 50—55 μ), and the tip of the right posterior horn is — as in f. *valens* — mostly flexuose (S-shaped) at its tip. Stüwe 1909 (p. 274, pl. II fig. 14) calls it *C. tripos heterocamptum* f. *detorta* and reports it from two localities in the Atlantic, (Gulf Stream west of the Bay of Biscay and Canary Current, south of the Azores).

In the inner Mediterranean a fourth form (see fig. 62) is present, f. *gracilentum* n. f., a slender form with a generally long and almost straight, thin apical horn — though all forms of *C. arietinum* show a feebly flexuose (indistinctly S-shaped) apical horn — a more feebly developed right posterior horn, which usually lacks flexuosity at its tip and is directed nearly perpendicularly to the apical, and an antapical outline which is, as a rule, without any trace of gibbosity. This form has the smallest cell body (t = 43—45 μ).

It is somewhat doubtful which of these forms is closest to Cleve's type. His figure (l. c.) is most similar to f. *detortum*, but lacks the characteristic abrupt flexion at the apex; the size too corresponds to this form, (t in Cleve's figure 56 μ). It seems provisionally best to list the f. *detortum* as a special form of the main species. F. *valens* and the f. *gracilentum* are, however, probably forms of a higher systematic rank (varieties), while the apparently more deviating f. *regulare* is, — in my opinion — only a special rare form of the first variety, *valens*. As I still have an insufficient knowledge of the constancy of these varieties, I shall, for the present, list them as mere forms.

F. *regulare* is analogous to the so-called *C. gibberum* α, which is in reality a very rare form of the frequent *C. gibberum* f. *sinistrum* (f. *dispar*). The same connection exists between *C. bucephalum* and its variety *heterocamptum*, but here the former is just the main type in the usual sense of the word, var. *heterocamptum* being the least common variety (or modification).

In winter, *C. arietinum* was found almost continuously distributed along the route of the "Thor", except in the region of the Atlantic Current proper, where it was only observed at the three stations 58, 59, 60, singly to 1 %, just east of the Straits of Gibraltar. Here it occurred in a coarse form, resembling f. *valens*, which was also seen singly at st. 68 in Cadiz Bay, together with f. *gracilentum*, the only station in winter outside the Straits, where the species was encountered. Otherwise it was only wanting at seven stations in the Mediterranean, (sts. 10, Port Alice, 12 and Naupaktos in the northern Ionian Sea, st. 18 in the Gulf of Aegina, the shallow station 27 off Naples — but frequent there at the other stations — and st. 42 south-east of Sardinia). The species only occurred in small numbers, from single individuals to 4 % (at st. 28 off Naples).

On the summer cruise it already appeared in small numbers at st. 79 in the Bay of Biscay in June (f. *regulare* and f. *detortum*) and farther on was observed at sts. 81, 100 m. wire (30 %), 84, 0—5 m. (singly), 95 and 96 (f. *detortum*, 2 % of rel. freq.). Inside the Straits it proved to be almost completely wanting in the surface (only noted for sts. 135, 136 off Tunis, 158 in the Levant, 183 in the Gulf of

Aegina, 194 north of the Straits of Messina and 228 in the Alboran Sea, everywhere singly), while it was present at almost all stations, where samples from deeper water were gathered. Only at four (out of 22) of these stations was it wanting (sts. 189, 192, 194, on both sides of the Straits of Messina, and st. 223 in the Alboran Sea). In these deep water samples it was — like *C. gracile* — often wanting in the upper layers (sts. 129, 0—80 m., 160, 0—30 m. and 30—100 m., 187, 0—25 m., 199, 0—30 m. and 209, 33—80 m.), while it was most frequent at a greater depth, about 100—200 m. (sts. 126, 100—200 m. 10 % rel. freq., 275 m. w. 2 %, 134, 125—200 m. 10 %, 160, 100—200 m. 20 %, 182, 545 m. w. 25 % and 187, 100—190 m. 50 %, optimum); only in two cases was it present in considerable numbers at another level (sts. 152, 950 m. w. over 5 %, 187, 945 m. w. 25 %). At other levels the species was only scarce, from less than 1 to 2 % rel. freq. The hydrographical data show that it generally belongs to layers with the winter minimum of temperature; in some cases it seems to have passed into the intermediate layers with the undercurrents (sts. 182, 545 m. wire, 25 %, 186, 1145 m. w. rr, 187, 945 m. w. 25 %).

The occurrence of single specimens at st. 134 off the coast of Tunis, 0—75 m., presents special interest. While the two separated areas of the species, the region of the Straits of Gibraltar and the inner Mediterranean, contained the very different forms, f. *detortum* and f. *gracilentum*, the layer mentioned had an intermediate form, nearer to f. *detortum*, but slightly approaching f. *gracilentum*. This is a proof that the layer mentioned, which contains Atlantic water, can at intervals bring about the successful immigration into the Mediterranean of living specimens, and may suggest than such an occasional immigration of f. *detortum* has given rise to the Mediterranean stock of f. *gracilentum* through a metamorphosis. We must note in this connection that the dimensions of the cell body of this latter form are smaller.

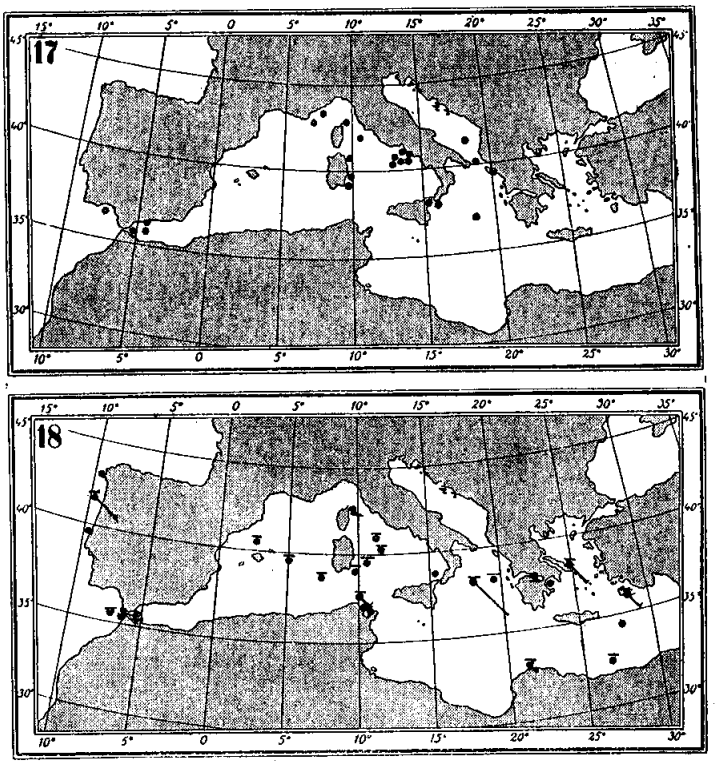


Chart 17. Distribution of *C. arietinum* in winter.
Chart 18. Distribution of *C. arietinum* in summer.

On the return voyage in the region of the Atlantic Current proper the species was only observed at st. 228 in the Alboran Sea, and outside the Straits only at st. 231, 1145 m. w. in Cadiz Bay and at st. 239 near Cape Finisterre, everywhere singly and as f. *detortum* except at st. 231, where f. *gracilentum*. In the Black Sea region it was entirely wanting.

Fission stages were seen at st. 239, incompletely regenerated specimens between 5 and 6 o'clock a. m., and in the Mediterranean at st. 26 (off Naples), in January, about half-grown individuals in regeneration, between 6 and 7 o'clock a. m.

The optimum at st. 187, 100—190 m. gives a salinity and a temperature of 38.4 ‰ and 14°.6.

Otherwise the species is widely distributed in the warmer regions of the Indian and Atlantic Oceans; in the latter it occurs in the northern Equatorial Current, the Florida Current to 37° on the coast of North America, and thence in the Gulf Stream to the Azores, where it is present from autumn to spring. It is also found in the Canary Current.

C. arietinum is, consequently, distributed in the Mediterranean in winter in the surface of the

median part of the sea, the Northern Balearic, the Ligurian, the Tyrrhenian, the Ionian and the Adriatic Seas, only moderately numerous. In summer it is present in the same regions, but almost entirely wanting in the surface, here and there abundant at a depth of about 100 to 200 m. The species is present in these inner regions of the Mediterranean under a special, slender form, f. *gracilentum*. There is only a feeble emigration from the Atlantic, in winter and probably in spring, perhaps also in autumn, but it is generally a failure. The migrating form is (as a rule?) different from the one indigeneous to the Mediterranean, and is but exceptionally found at a larger distance from the Straits of Gibraltar, where it is generally present in small numbers throughout the year.

27. CERATIUM DECLINATUM Karsten (Figs. 63—65, p. 63).

Jörgensen 1911, (b p. 42, pl. IV, figs. 87—89). Karsten 1907, (p. (229) 406, pl. 48 fig. 2 *a*, *b*).

This nice little species was first figured by Schröder, (1900), from Naples, under the name of *C. tripos* var. *gracilis* "Gourret", (l. c. pl. 1 figs. 17 a, b, not c—e), together with three other species (see above p. 59). It was next figured under the same name from the northern Adriatic by Entz, 1905, (1902), (p. 105 figs. 33—35, not 36). Pavillard, (1905), was the first author to mention it as a separate species, but he mistook it for the northern *C. tripos* because of a certain similarity in shape. He hereby overlooked, however, the considerable difference in dimensions, *C. declinatum* being one of the smallest species among the Ceratia. Pavillard found it in l'Étang du Thau near Cette from September to June, with a maximum in Novbr.—Decbr. He describes *C. pulchellum* f. *tripodioides* simultaneously under the name of *C. gracile* nov. nom., remarking that *C. tripos* var. *atlantica* Ostf. and var. *subsalsa* Ostf. seem to belong to this species. He exchanges these names in 1907, calling the *C. declinatum*, *C. gracile* and the *C. pulchellum*, *C. tripos* (see above pp. 59, 60). In 1916 he reports it from the Gulf of Lyons as perennial, and sometimes abundant, especially in winter.

Zacharias, (1906), mentions a "*C. lunula*" as a small species, up to 200 μ in length; this is most probably the present species. Schröder, 1911, says that it is rare and scarce in the northern Adriatic.

This species, too, appears in different forms. The type of Karsten is a small one, (*t* about 40 μ in his figures) with short posterior horns, the right one curved outwards at its tip. I know this form from several regions and should consider it a special form, not the main type, but for the adopted rules of nomenclature, which require that the first form described be considered the typical form of the species. I should, however, think that it will be most practical to designate it by a special name, f. i. α *debile* (nov. nom.). The characteristic feature is properly that the right posterior horn is thin and flexible in its distant half (see fig. 63). This is on the whole rare among the Ceratia, but is also found in a few other species, f. i. *C. Karstenii* f. *caudata* and f. *Okamurai* (Schröd.) (see Jörgensen l. c. p. 55), where the distant part of the right posterior horn has remained incompletely developed, perhaps especially in a chemical sense. It appears pale and thin in the samples, but is by no means always directed as shown in fig. 63 (and by Karsten l. c.). This striking irregularity is — according to my experience, though I have not seen the species in question in a living state — only produced artificially by being preserved in alcohol.

Another, much more common, form is figured in my monograph, (Jörgensen l. c. figs. 87—89). It agrees in the main with α *debile*, but lacks the irregular development of the distal region of the right posterior horn, which, too, is generally longer than the left one, while in α they are of about equal length. In my opinion this is the natural main type of the species (from which the others are derived as deviating forms); it may be called f. *normale* (nov. f.).

A third, rarer, form is represented in fig. 64, f. *brachiatum* (nov. f.). It differs from α in having a much longer right posterior horn, and from f. *normale* in the development of this horn, which again possesses a long, narrow and flexible distal part.

Both these forms are closely related to the typical form. Much more deviating is var. *majus* n. var. (see fig. 65), which is so different from the type that it might be considered a separate species, if there were not intermediate forms. It is larger and generally more robust, with a shorter apical horn but longer posterior ones, which are much more spread than in the type. It is this variety which PAVILLARD figured in 1905 (pl. 1 figs. 5, 7) as *C. tripos*; 1916 he justly mentions its difference from KARSTEN's type. By using the designations in my monograph, (see Jörgensen l. c. pl. VII fig. 132 *a* and pl. III fig. 57) this difference may be expressed numerically by the different values of the distance x and the angle α_l: while x in α *debile* is about 25 μ, in the var. *majus* it is about 42, and the angle α_l in the first form is somewhat greater than 90°, as compared with only 75° in the latter, while α_r is about the same in both (about 105—110°). Therefore in var. *majus* the posterior horns are directed almost exactly opposite to each other at their bases, while in α *debile* they are distinctly diverging.

On the winter cruise of the "Thor" it was present at all stations, (only not noted for st. 53 in the eastern Alboran Sea and the two shallow coast stations Galita and st. 64 (Cadiz Bay)). In the region of the Atlantic Current proper it was scarce, (mean value of relative frequency in the Alboran Sea less than 1 %, on the African Coast 2 %). In the Tyrrhenian Sea it was plentiful, (10 %), in the Ligurian abundant, (20 %). There was also plenty of it in the southern Adriatic (st. 14 10 %); more easterly, however, it was much scarcer, in the Ionian Sea only on an average of 3 %, and in the Gulf of Aegina (st. 18) but 1 %.

Outside the Straits of Gibraltar it was present, (in February), in Cadiz Bay in small numbers or singly. A migration into the Mediterranean through the Straits of Gibraltar obviously takes place in January and February, but without any distinct increase in frequency.

On the voyage outwards in June it did not appear before Cadiz Bay, where it was abundant at the two outer stations 89 (25 %), and 91, (15 %), but scarce at the others. In the Alboran Sea and on the coast of Africa it only occurred singly and was wanting at several stations (100, 102, 103, 109, 110 and 111). The same was the case here and in Cadiz Bay in September, which shows that a very inconsiderable migration from the Atlantic takes place in summer and early autumn.

Outside the Atlantic Current proper *C. declinatum* was generally abundant and present everywhere, (in all only wanting at the two shallow coast stations 151 and 153 off Barca, st. 155 in the Levant, sts. 180 and 183 in the Aegean Sea and st. 183 in the Gulf of Aegina). In the Balearic in June—July on the route outwards there was a mean value of 10 % relative frequency, the greatest at the stations west of Corsica, but on the return in August across the sea from Sardinia to the Baleares it had increased to between 15 and 40 %. In the Ligurian Sea in July the species was abundant (20 to 80 %, optimum at st. 125), at Genoa less (10 %). In the Tyrrhenian Sea in July it was very abundant (20 to 50 %), and no less so in August on the return voyage, but was somewhat scarcer at Naples (10 %). Also in the Catalonian Sea in August it was present in very great numbers (20 to 45 %).

Off Tunis and in the adjacent part of the Sidra Sea it was the predominating species at several stations and on the whole very numerous, farther to the east, however, it was generally much scarcer and sometimes even wanting, (at sts. 151, 153 and 156 in the surface, and at sts. 180 and 183) or present in single specimens (sts. 154, 156, 160, 161, 164, 165, 179, 181, 182), except in the northern Ionian Sea, where again it was present at all stations and in greater numbers (3 to 20 %). On the return voyage it became considerably scarcer south-west of the Baleares, and in the Atlantic Current and in the Bay of Cadiz, was, as mentioned, scarce, (1 to 2 %), or as a rule only present in single specimens and sometimes wanting (at the two eastern stations 219 and 220). After Cadiz Bay it was only observed in single and empty specimens below the surface at st. 234 south of Lisbon (25—200 m.).

Where deep water samples were gathered the species was also present (almost) everywhere below the surface (only wanting at st. 160 and at the two stations 81 and 84 off the coast of Portugal in June.

As a rule it was much scarcer below the surface, yet at several stations it was still abundant at a relatively deep level, (st. 128, 0—100 m., st. 129, 0—600 m. and 0—1100 m. 10 %, st. 134, 0—75 m. 20 %, st. 204, 945 m. wire 55 % and st. 206, 1945 m. w. 10 %).

Striking is the scarcity in the southern part of the Eastern Mediterranean, where the species at st. 152 was less scarce at a greater depth (950 m. wire 5 %, α debile, as compared to only 1 % in the surface) and at st. 156 it was even wanting in the surface.

Below the surface the form α *debile* was generally relatively more numerous; otherwise this form only occurs in small numbers, but is present both in winter and in summer. I cannot at this time give sufficient details concerning the distribution of the other forms, but shall only mention that var. *majus* and f. *brachiatum* seem to be less rare in summer and in the northern Balearic and the Ligurian Seas, and too that all forms are at times present in Cadiz Bay or more westerly.

In the innermost part of the Mediterranean, the species penetrates towards the entrance to the Dardanelles; at station 167, the prevaling form was α *debile.*

At shallow coast stations the species was generally much scarcer. It was the predominant species at about 25 % of all the stations on the summer cruise, most of them being situated in the Tyrrhenian Sea.

The hydrographical conditions at the (six) stations, where the species had a relative frequency of more than 50 %, give as mean values 37.7 ‰ and 22°, the optimum alone 38.35 ‰ and 19° (in the first half of July).

Fission stages were seen, once in winter (at st. 39 east of Sardinia, a cell in regeneration between 7 and 8 o'clock a. m.) and at six stations in summer. Most of these latter cases were observed between 5 and 6 o'clock a. m. (at st. 209, where the species was very numerous, both in and below the surface, one cell in regeneration was seen in the surface and two at 945 m. wire; at sts. 211 and 216, too), the others at different hours (at st. 123 var. *majus* shortly after fission, between 1 and 2 o'clock a. m.; at st. 136 many halved cells, apparently in fission between 3 and 4 o'clock a. m., at st. 186 a chain of two individuals, between 8 and 9 in the evening, and at st. 217 cells shortly after fission, between 1 and 2 o'clock p. m.). Chains of *C. declinatum* are on the whole very rare; the hinder individual had a very short apical horn.

Otherwise this species is distributed in the tropical and subtropical regions of the Indian Ocean and the Atlantic, where it is also found in the Florida Current and the Gulf Stream to the Azores (here in February and July) and west of the Straits of Gibraltar.

C. declinatum is undoubtedly indigeneous to the Mediterranean (perennial) and present in the surface everywhere all through the year. In summer it is the predominant species at very many stations, occurring in big numbers, especially in the height of summer in the Tyrrhenian Sea and the adjacent regions of the median part of the Mediterranean. During the winter its numbers decrease greatly, yet very many individuals survive in the region mentioned. It is only renewed to a slight degree by a migration from the Atlantic, which apparently takes place mainly in winter.

28. CERATIUM BUCEPHALUM (Cleve) Cleve.

Jörgensen 1911 (b p. 47, pl. V figs. 99—101).

This northern species does not occur in the Mediterranean. SCHRÖDER, 1906, reports it from the "Ionian Sea", (March 1902, r); it is, however, most probable that the species in question is either *C. gracile* v. *symmetricum* (Pavill.) or *C. declinatum* v. *majus.*

In the material of the "Thor", I have only seen specimens from the shallow station 84 on the coast of Portugal. It occurred here as single specimens at 10—25 m., accompanied by the var. *heterocamptum* Jörg. I am not quite sure whether even this locality is a certain one, as on some occasions single empty and dirty specimens were found in the other samples of the "Thor", (sts. 102, 109, 180

(v. heterocamptum), 198 and 203). All these samples were taken with the net "P 30" (see this Report vol. I p. 25), and the cells observed were no doubt remnants from an earlier use of the nets in northern waters.

29. CERATIUM AZORICUM Cleve (Fig. 66 p. 63).

Jörgensen 1911, (b p. 47, pl. V figs. 97, 98).

This peculiar tight little species was first reported from the Mediterranean by CLEVE, 1903, who found it in samples from that sea between Sardinia and Algeria in October, 1902, and in the Alboran Sea in February, 1903.

PAVILLARD, 1905, mentions it as occurring in l'Étang du Thau near Cette in December, and 1907 from the Gulf of Lyons: regularly occurring in winter, but always in small numbers. In 1916 he reports it from the same gulf as rare at all seasons, but more abundant in winter. SCHRÖDER, 1906, finds it in the northern Adriatic, rare in March 1905 and August 1897; in 1911, he reports it from three stations on the coast of Dalmatia, (in the region of Lussin), as rare, in July, 1909, in samples from the surface and from deeper levels.

On the winter cruise of the "Thor" it proved very rare in the Ionian Sea (sts. 12, 16, singly), but from st. 23 off Naples was continually present at all stations, (only wanting at st. 36 in the Northern Balearic and at st. 66 in Cadiz Bay). To st. 39 included it was only scarce (single specimens to 3 %), from the south-east coast of Sardinia (st. 40), however, it became more numerous (to 5 %), though still at intervals scarce, especially at the shallow coast stations. In the Alboran Sea the relative frequency increased towards the Straits of Gibraltar to nearly 10 % at st. 60 (optimum). In Cadiz Bay the species was still present in somewhat greater numbers at the warmer inner stations, but was rather scarce at the outer (68, 69, 3 and 2 %).

On the summer cruise it already appeared in the northern part of the Bay of Biscay in June, and was thence at intervals present as far as the Straits of Gibraltar: sts. 79, 81, 100 m. wire, 84, 10—25 m., 85, 92, Cadiz, 95, 96, 98, everywhere singly except at st. 96, where 3 % (and several specimens). Within the Straits it was only observed at st. 134, 0—75 and 75—125 m. (Atlantic water), at st. 206 in the median Balearic, at 1945 m. wire, and at st. 228 in the Alboran Sea, near to the Straits, in the surface and at 1145 m. wire (in the outflowing Mediterranean water). Outside the Straits on the return voyage it was caught at the only two stations where deep water samples were gathered in this region, st. 231, 1145 m. wire, in Cadiz Bay, and st. 234 south of Lisbon, 0—25 and 25—100 m., and besides in the surface at Lisbon, everywhere singly. As it occurred at deeper levels on the coast of Portugal and in Cadiz Bay both in June and September at all stations where deep water samples were gathered, it is probably present all the summer below the surface in this region. At the st. 134 off Tunis it occurred in layers with Atlantic water, and at st. 228 in the Alboran Sea in the outflowing Mediterranean water; at st. 206 in the Balearic, where it also was found, Atlantic water is present to some considerable depth, but it cannot be exactly decided in which depth these "wire samples" have been taken.

Fission stages were not seen.

Otherwise this species is distributed in the tropical, subtropical and warmer northern temperate Atlantic, and in the Indian Ocean at least in the Arabian Sea. At the Azores it is found from February to April and (from Cleve 1901 a) in June.

According to the gatherings of the "Thor", *C. azoricum* may not be considered an indigeneous Mediterranean species, being almost wholly absent in summer, when it was only caught at deeper levels in the Western Mediterranean, except just east of the Straits of Gibraltar. In winter, on the contrary, it is widely distributed in the surface of the Western Mediterranean, but more or less scarce except in the region of the Atlantic Current proper and off the south coast of Sardinia. Every year it re-migrates from the Atlantic into the Mediterranean in January and February, or probably from late autumn to spring.

The occurrence at deeper levels off Tunis in July might be due to a migration below the surface through the Straits of Gibraltar in April or May.

In the Eastern Mediterranean it was very rare in winter and wholly wanting in summer.

30. CERATIUM GIBBERUM Gourret (Figs. 67, 68, p. 63).

Jörgensen, 1911, (b p. 49, pl. V figs. 106—109).

This large and easily recognizable species was first with certainty found by GOURRET, 1883, who has three figures of it. POUCHET, whose treatise was published in 1883, some months before GOURRET's, has, to be sure, a *C. tripos* var. *megaceras* (l. c. p. 421 fig. *C*) and a *C. tripos* var. *dispar* (p. 423 fig. *D*) which may be this species; however, both figures are so bad that they would be quite useless for identification, had we not those of GOURRET for comparison. GOURRET himself has referred them to *C. gibberum* and its forms. At any rate, GOURRET's specific name should have priority over POUCHET's varietal ones.

GOURRET has two figures of "*C. gibberum*", (pl. 2, figs. 35, 35 *a*), one of "*C. gibberum* var. *sinistrum*", (fig. 34) and one of "*C. gibberum* var. *contortum*", (fig. 33). This latter variety is the following species (see below). As one of the remaining three figures, (fig. 34), obviously represents the common form with the peculiarly developed and curved right posterior horn, it was most natural to call this form f. *sinistrum*, (see fig. 67). Another, much rarer, form with a normally developed right posterior horn exists, and this form was therefore mentioned in my monograph as the main species, in spite of its rarity.

Unfortunately, the citations 35 and 35 a, (from GOURRET), have been interchanged in my monograph. The first figure in GOURRET, is fig. 35, which — as mentioned in my monograph p. 50 "fig. 35 a" — represents the same form as his var. *sinistrum* fig. 34, only with a much shorter right posterior horn and a coarse structure of the theca, with conspicuous anastomosing ribs, apparently a f. "*postico-juvenile*", as suggested in the monograph l. c. It is the second figure, 35 a, which is (probably) the "main species", with a normally developed right posterior horn. The object of this figure is to illustrate a supposedly transitional form to *C. gracile*, having a shorter and less curved right posterior horn; it is, however, very different from fig. 35 and much more similar to fig. 33, belonging to the following species. Even the fig. 34 is not quite certainly the present species; it may also be the following (see below).

Under these circumstances I should consider it most practical to change the inconvenient interpretation of the type of *C. gibberum* in my monograph and to give the rare form with the normally developed right posterior horn a special name, var. *subæquale* nov. nom., (see fig. 68). The main form might be called α *sinistrum*, or better, α *dispar*, (Pouch.). The *C. tripos* var. *dispar* Pouchet, which is reported to be frequent at Carry, is surely a very doubtful form, according to the figure in POUCHET; on account of its curved right posterior horn it must, however, certainly be either *C. arietinum*, or *C. gibberum* α *sinistrum*, or the following species, and the former of these species may be excluded on account of its rarity. POUCHET, 1893, gives besides a new figure of var. *dispar*, "drawn from nature", and this proves definitely that the species in question is *C. gibberum*.

That the main species of GOURRET is not var. *subæquale* alone, is also apparent from GOURRET's statements, for he says that it is frequent near Marseille, while var. *subæquale* is on the whole very rare. On the other hand, his figuring the same form both as main species (fig. 35) and as a separate variety, (fig. 34), may either be due to the coarse structure of the theca, found by him in the main species (see fig. 67), or to a mistake in his description of the var. *contortum*, (see below).

However, as according to the rules of nomenclature it is considered incorrect to change the interpretation of the main species, we may simply designate the two forms in question as α *subæquale* and f. *dispar* (Pouch.). This latter name has priority over f. *sinistrum* Gourr.

DADAY, (1888), found this species at Naples and described it under the name of *C. tripos* var. *curvicorne*, which CLEVE, 1901 (a), raised to the rank of a separate species, *C. curvicorne*. DADAY seems to include still other species (*C. pulchellum*, f. *eupulchellum*, fig. 4, and the following species, see below); in CLEVE, however, *C. curvicorne* is the true *C. gibberum* f. *dispar*, which should be properly considered the main species. ENTZ, 1905, (1902), figures it from the northern Adriatic, as *C. tripos gibberum* (p. 103, figs. 25—27, not 24). CLEVE, (1903), reports it from the Eastern Mediterranean in October 1902, (as *C. curvicorne*, Tunis to Egypt). PAVILLARD, 1905, found it in l'Étang du Thau, October to June, with a maximum in December. SCHRÖDER, (1906), mentions it ("*C. curvicorne*") from the northern Adriatic as very rare in March 1905, and from the "Ionian Sea" (see p. 8) as rare in March 1902; in 1911 he reports it from Lucietta in the Adriatic in July 1909 as very rare. PAVILLARD, 1907, finds it widely distributed in the Gulf of Lyons in winter; in 1916 he mentions also the main form, which he states to be exclusively hibernal, from the same gulf.

The f. *dispar* was present all along the route on the winter cruise of the "Thor", (only wanting at sts. 50, 59 in the Alboran Sea and at the shallow station 64 in Cadiz Bay). In the region of the Atlantic Current proper (from Galita westwards) it was very scarce (single specimens to 2 %), but otherwise it was somewhat more numerous, yet never occurring in great numbers (1 to a little more than 5 %). The f. *subæquale* was very rare and as a rule only present in single specimens — sts. 10 and 16 in the Ionian Sea rr to 1 %, st. 45 off the African coast, st. 60 just east of the Straits of Gibraltar rr — but at Naupaktos in the Gulf of Corinth the prevaling form (10 %).

On the summer cruise it appeared already in the northern region of the Bay of Biscay (st. 79 f. *subaequale*, st. 80 f. *dispar*), and was present farther to the south off the southern coast of Portugal (st. 86, f. *subaequale*) and at a few stations in Cadiz Bay (sts. 91, 95 f. *dispar*, st. 92 f. *subaequale*), everywhere singly. Farther on it was present in single specimens in the Straits of Gibraltar, st. 98, f. *dispar*), but was otherwise wholly wanting in the Atlantic Current proper, (sts. 98 to 113). At the next station (114, in the southern Balearic) it reappeared, and hence was almost continually present as f. *dispar* in the Western Mediterranean, mostly in small numbers (to about 5 %), only wanting at a few stations (119, 125, Genoa, 127, Tunis, 136 and 137). In the Eastern Mediterranean it was generally less frequent: in the Sidra Sea present singly at 3 out of 6 stations, in the southern Ionian Sea singly and only below the surface, likewise in the Levant except at st. 160, where it was also found in the surface. In the Aegean Sea it was only caught singly at four stations out of eleven (sts. 161, 163 below the surface, 181 and 182), in the northern Ionian Sea, however, it was again present everywhere and more numerous, (2 to over 5 % in the surface). On the return in August through the Tyrrhenian Sea it was only lacking at Naples, in the Balearic at st. 205, in the Catalonian Sea at sts. 212 and 213 and at a few stations was more numerous (sts. 204, 13 % in the surface, 209, 16 % (optimum) in the surface, 216 12 %). In the Atlantic Current proper (from st. 218) it was only present in single specimens at the first station (218), but was otherwise absent, also outside the Straits.

The f. *subaequale* was only present at st. 184 (mouth of the Corinthian Bay), was here relatively numerous (5 %) in the surface, but rr a 945 m. w., at st. 186 in the Ionian Sea, 245 and 1145 m. w., singly, at the latter level only dead cells, and at st. 192 (near the Straits of Messina) singly in the surface.

Below the surface it was found at all Mediterranean stations where deep water samples were taken, those in the Alboran Sea excepted. Sometimes it was more numerous below the surface (st. 129, 0—80 m. 4 %, as compared to 1 % in the surface, st. 199, 0—30 m. 5 % as compared to 2 % in the surface, where, however, the Ceratia on the whole were much more numerous, and st. 182, 545 m. wire $4^1/_2$ % as compared to single specimens in the (less saline) surface), sometimes wanting in the surface (sts. 152, 156, 163), generally less numerous at deeper levels, yet still in noticeable numbers at a moderate

depth (st. 128, 0—100 m. 4 %, st. 184, 945 m. w. 6 %, 187, 945 m. w. 4 %, 189, 945 m. w. 4 %, 199, 80—200 m. 5 %, 206, 1945 m. w. 4 %, 209, 945 and 1945 m. w. 10 %).

An immigration into the Mediterranean through the Straits of Gibraltar takes place in winter (January and February), but is followed by no distinct increase in frequency; in summer it seems to fail. The winter distribution suggests that there was a somewhat greater migration in January than in February, the distribution in all answering to a migration from late autumn to February. Its occurrence at st. 134 in summer might suggest a feeble migration in about April and May.

Fission stages were not rare: sts. 20, 92, 116, 129, 140, 184, 189, 204, 209 and 210, most of them between 3 and 4 o'clock a. m. (sts. 92 and 129, a cell recently divided, st. 20, here only a cell from a chain, with a corresponding short apical horn) and between 5 and 6 o'clock a. m. (st. 204, 945 m. wire, a cell, recently divided, st. 209 in the surface, a cell in regeneration and a chain of two individuals, at 945 m. wire also such a chain). Chains, always of only two individuals, were seen relatively often (beside the cases already mentioned at st. 140 and 210 between 2 and 3 o'clock p. m., at st. 184 between 2 and 3 o'clock a. m., and at st. 189 between 8 and 9 o'clock a. m.). At st. 116 a cell was seen after recent fission between 1 and 2 o'clock a. m.

Outside the Mediterranean *C. gibberum* is widely distributed throughout the warmer regions of the Atlantic and the Indian Oceans. It occurs also in the Pacific. In the Northern Atlantic it is frequent from the Florida Current and the Sargasso Sea to at least 45° N., at the Azores (Dec. to April) and in the Canary Current.

C. gibberum f. *dispar* is consequently a species indigeneous to the Mediterranean, frequent both in summer and in winter. It is renewed by emigration from the Atlantic in winter (probably from late autumn to spring), but in summer is very rare or wanting in the region of the Atlantic Current proper, and is also scarce in the southern Ionian and the Aegean Sea, where it penetrates to a certain distance, (st. 181), from the entrance to the Dardanelles. Otherwise it is generally distributed everywhere, also below the surface, here and there in greater numbers. During the summer it seems to increase slightly in numbers (through fission), especially towards the autumn.

The f. *subaequale* was very rare in the gatherings of the "Thor" in the Mediterranean (Alboran Sea, st. 60 in February, and the northern Ionian Sea Dec. and August).

31. CERATIUM CONCILIANS n. sp. (Fig. 69 p. 73).

C. tripos var. *contortum*, Gourret, 1883, (p. 35, pl. 2 fig. 33), not *C. contortum*, Cleve, 1900, (p. 14 pl. VII fig. 10). *C. gibberum* f. *sinistrum*, Jörgensen, 1911, p. p. (1911 b pl. V fig. 108).

In my monograph I have referred this form to *C. gibberum* f. *dispar*, which is no doubt its nearest ally. By working through the large collections from the summer cruise of the "Thor", I soon, however, obtained the impression that this form is a good species. It is chiefly distinguished from *C. gibberum* var. *dispar* by its curved apical horn. Generally it is somewhat smaller as well, without distinct gibbosities (of the posterior outline and the right side of the cell body) and with a somewhat less strongly developed apical horn. It lacks the coarse structure of conspicuous bladelike ribs which is so common in *C. gibberum*. Its antapical outline is usually almost evenly convex and protrudes but little beyond the bases of the postical horns. The apical horn is convex towards the dorsal and the left side. Transdiameter 72—85 μ; distance x (Jörgensen 1911 b pl. VII fig. 132 a) usually about $^1/_2 t$, in *C. gibberum* much less.

I think there can be no doubt but that this species is the true *C. gibberum* var. *contortum*, Gourret. His figure differs somewhat (from mine), but shows certain details — compare f. i. the right end of the girdle in his figure and in his description — which in my opinion greatly support my interpretation. The specimen, figured by him, rests on its posterior dorsal half; in this position the apical horn really

is directed as shown in his figure. The *C. contortum* of CLEVE is a more long-horned species with a quite different right posterior horn; I have not seen it from the Mediterranean.

On the other hand, it seems to me possible that also GOURRET's figure of *C. gibberum* var. *sinistrum* belongs to the present species, as the latter is also found with a more gibbous antapical outline, (compare also the figures quoted from ENTZ).

GOURRET describes and figures var. *contortum* as having a ventrally displaced right posterior horn, (passing before the apical horn in a ventral view), while the var. *sinistrum* has the horn in question displaced dorsally. This latter is really the case in both; this mistake may, however, have caused GOURRET to refer the specimen in fig. 33 to a separate variety. He says that is rare. At any rate the name *C. gibberum* f. *dispar* (Pouch.) takes priority over f. *sinistrum* Gourr.

ENTZ 1905 (1902) figures the present species from the northern Adriatic as *C. tripos gibberum*, "slender summer form" (p. 103 fig. 24), and probably also among *C. declinatum* as *C. tripos gracile* (p. 105 fig. 36). SCHRÖDER, 1906, records *C. contortum* from the "Ionian Sea" March 1902, rare, — most probably the present species. PAVILLARD, (1916), mentions it from the Gulf of Lyons (under *C. gibberum* f. *sinistrum*) as a preponderatingly estival form.

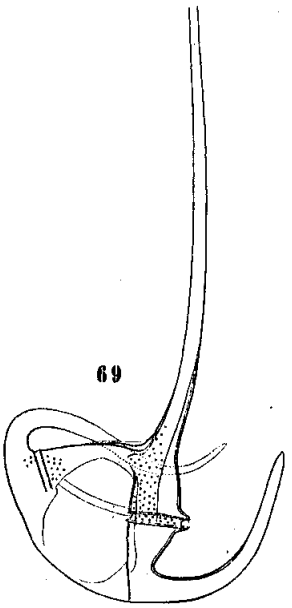


Fig. 69. *C. concilians* n. sp. St. 167 (near the entrance to the Dardanelles); August.

Unfortunately I was not aware of the specific difference between the present species and the *C. gibberum* f. *dispar*, till I had finished the examination of the winter plankton, so that I am not able at the moment to state its distribution in winter exactly. After a revision of some of the samples I can state the important fact that *C. concilians* was present at all stations examined in the Eastern Mediterranean (sts. 10, 11, 14, 15), as a rule accompanied by *C. gibberum* f. *dispar*, but somewhat more numerous than the latter species, while it was wanting in the Atlantic Current proper and in the Bay of Cadiz (sts. 45, 53, 66).

On the summer cruise it was only found sporadically untill the route had left the African coast (at st. 113): sts. 92 (Cadiz Bay), 99 (just inside the Straits) and st. 112, (eastern station off the African Coast), everywhere singly. From station 115 in the southern Balearic, however, it was continuously present at all stations, (only Tunis harbour excepted), in the Western Mediterranean, at st. 116 already in great numbers (10 %), likewise at st. 118 (10 %), at st. 119 west of Corsica even over 20 %, in the Tyrrhenian Sea 1 to 5 % and also present below the surface, off Tunis only scarce. In the Sidra Sea it was scarce, wanting at one station (145), in the southern Ionian Sea only present below the surface, (st. 152, 250 m. w. singly, 950 m. w. 3 %), in the Levant also scarce and as a rule only in single specimens, (at st. 158 yet 3 %). In the Aegean Sea it was wanting at three stations out of eleven (sts. 162, 164, 179), here and there numerous (sts. 161 and 180 10 % rel. freq., 163 in the surface 5 %), at st. 181 even abundant (almost 30 %, optimum, 38.03 ‰, 24°.6, August). It does not reach the Dardanelles. In the northern Ionian Sea it was only wanting at st. 185, (mouth of the Bay of Corinth), on the return through the Tyrrhenian Sea, however, it was absent at several stations, (196, 198, 203, 205, Barcelona) and generally scarce, except in the Catalonian Sea where it was plentiful, (sts. 209, 211, 212 almost 10 %, at the first station both in the surface and at 33—80 m.). In the region of the Atlantic Current and more westerly it was again almost wholly absent, (sts. 218, 219 in the Balearic, singly, in part only empty cells and perhaps remnants from the net from the Catalonian Sea, and from then on only singly at st. 229, just outside the Straits).

Below the surface it was everywhere present east of the Alboran Sea, except at the two stations, 128 and 132, in the Tyrrhenian Sea, where it was only seen in the surface; at two other stations, 152

and 186, it was only present below the surface. In the Tyrrhenian Sea it was somewhat more numerous below the surface, apparently at about 100 m., (st. 129, 0—80 m. 4 %, 0—600 m. 6 %, 0—1100 m. 4 %, in the surface only singly, st. 194, 1145 m. w. 4 %, in the surface singly).

Generally the species was accompanied by *C. gibberum* f. *dispar*, but in the Aegean Sea was decidedly more frequent, while in the southern regions of the Eastern Mediterranean, it was scarcer.

Fission stages were repeatedly encountered: sts. 116, 132, in fission (1 to 2 o'clock a. m.), also 134, (5 to 6 o'clock a. m.), 152 f. *juvenile* at 250 m. (11 to 12 o'clock p. m.), also 156 (12 to 1 o'clock a. m.), 161, a cell recently divided and some in incipient regeneration (3 to 4 o'clock a. m.), 167, a cell with a short apical horn, from a chain, (11 to 12 o'clock a. m.), also such a cell at st. 181, (1 to 2 o'clock p. m.), st. 216 f. *juvenile* and a cell just after fission, (5 to 6 o'clock a. m.).

The distribution in other seas is as yet very imperfectly known; at present I am only able to state its occurrence at Grapler Bank, West Indies, January 1906, and in the Florida Current, where it was very frequent and numerous in May 1910 and also was found in November 1909 and July 1910. Also near Cape San Vincent and in the Straits of Gibraltar December 1908.

C. concilians is consequently indigeneous to the Mediterranean and there is found in the surface both in winter and in summer. In the latter season it is frequent throughout the sea to some distance before the Dardanelles, also at deeper levels, except in the region of the Atlantic Current proper, where it is almost entirely wanting, being observed (with certainty) only close to the Straits. In winter, too, it seems to be lacking in that current, while it was frequent farther in, f. i. in the Ionian Sea. It seems therefore to be independent of an emigration from the Atlantic.

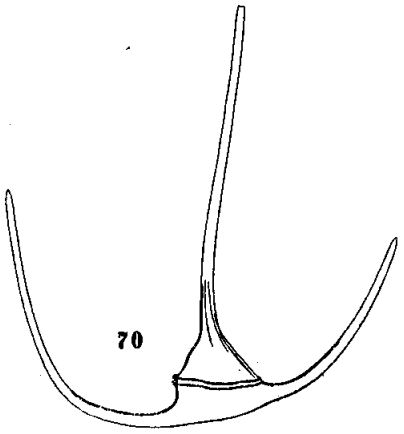


Fig. 70. *C. lunula* Schimp., f. *megaceros* Jörg., × 125. Southwestern coast of Spain, Decbr. 1908.

32. CERATIUM LUNULA Schimp. ap. Chun (Fig. 70).

Jörgensen, 1911, (b p. 51, pl. V figs. 112—115).

This stout species was first reported from the Mediterranean by myself (l. c.), from the Alboran Sea, just east of the Straits of Gibraltar. ZACHARIAS (1906), mentions to be sure a *C. lunula* from the northern Adriatic, but as it is stated to be a small species, only to 200 μ in length, it cannot be the species in question, (but is probably the *C. declinatum*).

In the material of the "Thor" it is present at no less than ten stations in winter — sts. 26, 40, 42, Galita, 45, 46, 53, 55, 57, 59 — and fifteen — sts. 129, 0—1100 m., 134, 0—75 m., 156, 250 m. wire, 160, 0—30 m., 30—100 m., 100—200 m., 182, 545 m. w., 189, 945 m. w., 205, 218, 219, 220, 223, 1950 m. w., 224, 226, 228, in the surface and at 1145 m. w., Gibraltar — in summer. As a rule it was very scarce, and at nearly half the stations only present singly, however in the eastern region of the Atlantic Current proper it was more numerous (sts. 45 8 %, optimum, 46 2 %; 218 2 %, 220 5 %), also at st. 42 south-east of Sardinia.

From the occurrence stated will be seen that this species emigrates from the Atlantic in winter, (January and February), and that this emigration is successful, causing a distinct increase at the relatively warm st. 46, on the coast of Africa. In December, 1908, the species was present at several stations in Cadiz Bay, from the south coast of Portugal to the Straits of Gibraltar and east of them, according to samples in my possession. Beyond the Atlantic Current proper it has only spread to Naples and the south-eastern coast of Sardinia in winter. It seems, therefore, probable that a migration has been going on from late autumn to at least February, — in this latter month the migration was apparently but feeble.

In summer it is only present in the surface between Sardinia and the Baleares outside the At-

lantic Current proper, more easterly, however, only at deeper levels and very rare, but as far as the inner region of the Aegean Sea. At this season there are traces of a feeble immigration into the Mediterranean through the Straits of Gibraltar in September, also now showing an increase in frequency to the east on the African Coast — sts. 218, 219, 220, here optimum in summer, 5 ‰ —, in June, however, there is none.

The only direct trace of a propagation was seen at st. 160, 100—200 m., where a cell (of f. *brachyceros* Jörg.) was seen, shortly after fission. Otherwise only chains were observed, but relatively often: at st. 45 all specimens were seen in chains, consisting partly of two, partly of three individuals (between 12 and 1 o'clock a. m.); at st. 220 a chain of three individuals (betw. 2 and 3 o'clock a. m.), at st. 160, 100—200 m. and 200—1000 m. two chains of two individuals (11—12 o'clock a. m. and 1—2 p. m.).

Its occurrence at st. 134, 0—75 m. might most naturally be ascribed to an immigration into the Mediterranean through the Straits of Gibraltar below the surface in spring (April—May); its localities in the Eastern Mediterranean may be due, either to such an immigration or more probably to a winter immigration, followed by a bearing down by vertical currents.

The two stations 223 and 228 in the Alboran Sea, where deep water samples were gathered, show a feeble emigration of the species from the Mediterranean. This may only be due to a sinking of dead cells, or of cells no longer possessing the normal power of locomotion.

Otherwise it is distributed from the tropical regions of the southern Atlantic to the Antilles Current, the Florida Current — which it follows to past Cape Hatteras — and the Azores (here in February). It is also known from the Indian Ocean and the coasts of Japan.

C. lunula seems therefore to possess only a relatively short life in the Mediterranean and to be essentially dependent on an emigration from the Atlantic, which seems to take place from autumn to the heart of winter, and perhaps to spring. Its area in the surface only extends to Naples in winter, in summer not even so far; more easterly it only occurs sporadically at deeper levels, where it seems to be able to keep alive for months and occasionally to propagate.

33. CERATIUM ARCUATUM Cleve (Fig. 71 p. 76).

Cleve, 1900, (p. 13, pl. VII fig. 11), not *C. tripos* var. *arcuatum* Gourret. *C. Karstenii* Pavillard, 1907, Jörgensen, 1911, (b p. 53, pl. V fig. 116, pl. VI fig. 117).

This widely distributed warm water species was perhaps first observed in the Mediterranean by Schröder, (1900), who figured it as *C. tripos* var. *macroceras* f. *inflexa* "Gourret" (l. c. fig. 17 *h*). The dimensions of Schröder's figures — as calculated from the stated enlargement — are wrong; however, when multiplied by 2,7, they seem to answer to the real dimensions of the species figured. With this correction the transdiameter of the species in question would be about 90 µ, which agrees in reality with that of *C. Karstenii.*

Entz, 1905 (1902), figures this species from the northern Adriatic, as *C. tripos arcuatum,* (p. 107, figs. 31, 32, p. 109 figs. 44, 45). Pavillard, 1907, who at first stated the great difference between the *C. arcuatum* of Cleve and the *C. tripos* var. *arcuatum* of Gourret, reports it from the Gulf of Lyons, where it is sometimes abundant. Schröder, 1911, finds it rare to frequent on the coast of Dalmatia.

As mentioned above p. 57 I am afraid we must let *C. arcuatum* Cleve stand as the correct name for the species in question, since, according to the rules of nomenclature, now adopted, the first specific name is to be used instead of the first name at all.

On the winter cruise of the "Thor" it was present at all stations in the Mediterranean, except sts. 15 (Straits of Otranto), 35, (off Monaco) and 60, just east of the Straits of Gibraltar. Outside the latter it was wanting at the two stations in Cadiz Bay, next to the Straits, sts. 62, 64, and present at the others in small numbers or singly. Obviously a successful emigration from the Atlantic takes place in

January and February, with a great increase in frequency at the eastern stations in the Atlantic Current proper, from 1 % at station 58 in the Western Alboran Sea to 10 % (of rel. freq.) at st. 46 on the African Coast to the east; at st. 53 even much more. Farther to the east it becomes rather scarce, especially in the Ligurian Sea, where it is only found singly at one of the two stations; otherwise it varies in relative frequency from 1 to 5 % (off the south coast of Italy). In the region of the Atlantic Current proper the forma *Karstenii* (see below) seems to be rare.

On the summer cruise it did not appear before Cadiz Bay, at st. 89 off the south coast of Portugal, singly, and was only present at four stations, 89, 92, 95, singly, 91 (f. *Karstenii*) 3 %. Inside the Straits it was only wanting at the first station, 99, but from st. 100 was almost continually present all along the route (not noted for sts. 109, (Coast of Africa), 117, 120 in the Balearic in June—July and 203 in August, sts. 122, 125 in the Ligurian Sea, 127, 132 in the Tyrrhenian Sea in July and 198 in August, Tunis Harbour, sts. 153, 155 off Barca and more easterly, and sts. 211, Barcelona, 212 in the Catalonian Sea).

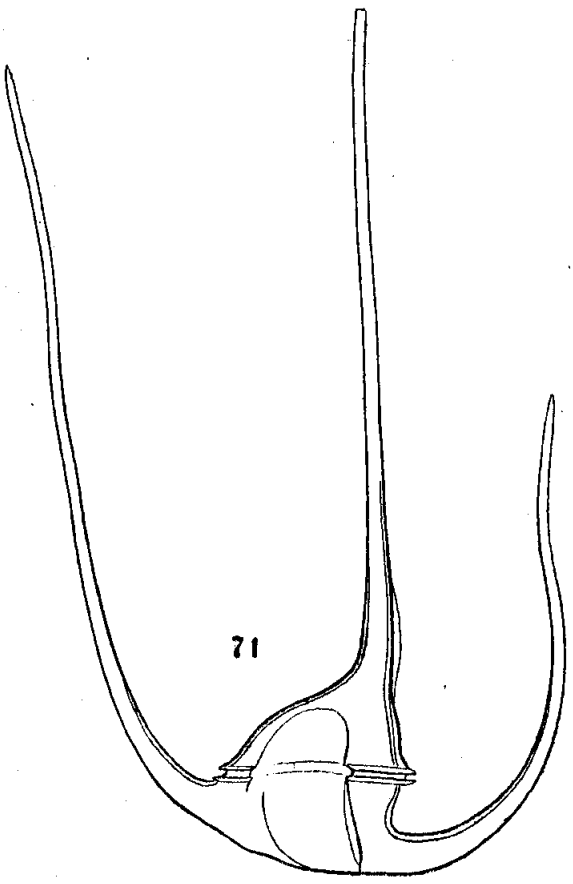


Fig. 71. *C. arcuatum* Cleve, α *Karstenii* (Pavill.). Taormina (Sicily); January.

In the Alboran Sea in June it soon became abundant (sts. 106 20 %, 108 and 112 15 %, 110 and 111 10 %, 113 20 %). Still plentiful off the north coast of Sardinia it follows up to the Ligurian Sea, where it was scarce, and remains so through the Tyrrhenian Sea to station 134 off Tunis, where it was again plentiful (10 % in the surface and even 15 % from 0 to 75 m.). In the Syrtis Major it was again abundant, to 15 % at st. 148; in the Southern Ionian Sea, however, scarce, and also scarce in the Levant — yet 5 % at st. 158 — and at most stations in the Aegean Sea, but here sometimes numerous (sts. 161 5 %, 162 10 %, 183 5 %). It follows close up to the Dardanelles, and occasionally enters the Sea of Marmora (singly at st. 170, 20—80 m., where the salinity is up to 38.42 ‰).

In the northern Ionian Sea it was present everywhere, at st. 185 only singly, otherwise varying from 2 to over 5 %. On the return through the Tyrrhenian Sea it was generally scarce, (wanting at st. 198), but at Naples more numerous, (5 %); on the cross section through the Balearic plentiful at st. 205 (15 %) and 206, (over 5 %). In the Catalonian Sea it was generally very scarce and even wanting at three inner stations, but abundant at the southern station 215. Thence it was abundant all the way to the Straits of Gibraltar, where it again suddenly became very scarce (west of them). Farther on it was only gathered at both stations (229, 231) in Cadiz Bay, 237 and 238 off the north coast of Portugal, and at Brest, everywhere singly. The sudden increase in frequency east of the Straits proves a successful migration of the species from the Atlantic, and this migration seems also to extend to stations 215—217, south and north of Ibiza.

A migration from the Atlantic took place in December 1908, too, when the species — according to samples in my possession — was present from Cape San Vincent to off Alicante.

C. arcuatum Cleve occurs in the Mediterranean in two forms which — chiefly in the western regions — may be well distinguished, but seem to pass over into each other by intermediate forms. One

of them is the form figured in my monograph (l. c., figs. 116, 117), the other is stouter, with a less convex antapical outline and especially with somewhat more oppositely directed proximal regions of the posterior horns. The first form mentioned answers to the main species of CLEVE and to *C. Karstenii* Pavillard, and is the one most easily recognized; I shall therefore here call it by a special name, α *Karstenii* (Pavill.) (see fig. 71). As already mentioned, it is figured in my monograph, but only as two individuals with special singularities (fig. 116 has an unusually long right posterior horn and fig. 117 is an individual with a short apical horn — probably from a chain — and a singular flexion in its right posterior horn). In the region of the Atlantic Current proper the α *Karstenii* was rare, as also outside the Straits; east of them it appeared at st. 112, (the first more saline station on the coast of Africa), in June, and at st. 221, (with a high temperature), in September. Farther in the f. *Karstenii* was generally present all the way, together with the other form, which corresponds better to var. *robustum* (see the description Jörgensen l. c., as fig. 118 a special deviating form is figured there).

Below the surface *C. arcuatum* Cleve was also present throughout the Mediterranean (only st. 132 excepted), at a moderate depth. F. *Karstenii* was often present in the surface, the other form at deeper levels, f. i. in August and September in the Western Mediterranean. At st. 134 off Tunis — where both forms were numerous — this was also the case (α *Karstenii* in the surface 10 ‰, the other form at 0—75 m. 15 ‰). At some stations the species was just as numerous below the surface, or even a little more so, (sts. 129, 0—80 m., 134, 0—75 m., as just mentioned; st. 152, 250 m. wire, st. 199, 0—30 m., st. 209, 33—80 m.).

Sometimes *C. arcuatum* Cleve was the predominating species among the Ceratia; as at stations 216, (35 ‰), 219, (45 ‰, optimum, 23°.7, 36.76 ‰), 221, (30 ‰), all in the western area in September.

Fission stages were seen several times: st. 101 two cells after a recent fission (8 to 9 o'clock a. m.), st. 112 a cell in regeneration (12—1 a. m.), st. 113 many halved cells (3—4 a. m.), st. 158 a cell in regeneration, (3—4 a. m.), st. 206, a halved cell (1—2 a. m.), st. 216, four cells in regeneration and one halved, (5—6 a. m.), and st. 219, a cell in regeneration, (7—8 a. m.).

In other seas *C. arcuatum* Cleve is frequent, apparently being rather common in the warmer regions of the Atlantic and the Indian Oceans. It is also present in the Pacific. It occurs in the Florida Current, the Antilles Current, the Gulf Stream as far as southwest of Ireland, the Azores, the Canary Current and the Sargasso Sea.

To sum up, *C. arcuatum* Cleve is frequent in the Mediterranean, both in summer and in winter, but especially present in great numbers in the region of the Atlantic Current proper. During winter it decreases greatly in numbers outside that region, but the stock is renewed throughout the year by emigration from the Atlantic, followed by an obvious increase in numbers in the Alboran Sea and along the coast of Africa. Under the influence of the salter and warmer water a less marked metamorphosis of forms apparently takes places in summer, in consequence of which the f. *Karstenii* generally becomes the more numerous form except in the region of the Atlantic Current proper, where the contrary seems to be the rule.

Sectio IX. **LIMULUS** Jörgensen.

34. **CERATIUM LIMULUS** Gourret (Fig. 72 p. 79).

Jörgensen 1911, (b p. 57, pl. VI fig. 122).

This peculiar species, which may only be confounded with *C. azoricum*, though it is easily distinguished by the two humps at the basis of its apical horn, was first mentioned by POUCHET, 1883, as *C. tripos* var. *limulus*. He remarks that he uses a name from the manuscript of GOURRET.

It was first mentioned from the Mediterranean by GOURRET, (1883), who found it "less abundant" at Marseilles. DADAY, (1888), reported it from Naples, CLEVE, (1903), from the sea between Tunis and

Sicily, in October 1902, and from the Alboran Sea in February 1903. PAVILLARD, (1905), reports it from Étang du Thau as very rare, occurring from November to March, ZACHARIAS, (1906), from Algeria May 1903, (yet his *C. limulus* var. *contorta* excluded, which is *C. gibberum* f. *dispar*), and SCHRÖDER, (1906), from the "Ionian Sea" March 1902, rr. PAVILLARD, 1907, reports it as occurring every winter in the Gulf of Lyons, and 1916, as occurring there especially in winter. SCHRÖDER, (1911), found it to be very rare on the coast of Dalmatia in July 1909 (only at Lucietta, rr).

On the winter cruise of the "Thor" it proved very rare in the Eastern Mediterranean: sts. 12, (Gulf of Taranto), 14, (Southern Adriatic), 20 and Taormina Roads, (Sicily), everywhere singly except at st. 14, where 2 % rel. freq. In the Tyrrhenian Sea it was frequent, only wanting at two stations (off Naples and st. 27), but only in small numbers (mostly 1 %, at st. 26 2 %). In the Ligurian Sea and the northern Balearic it was very rare, and only present in small numbers at st. 33 north-east of Corsica, and from st. 40 south-east of Sardinia to just before the Straits of Gibraltar at st. 58 it was only present at the two stations 45 and 53 in very small numbers (to 1 %). From st. 58 it again became more frequent, only wanting at the shallow station, 64, in Cadiz Bay, still scarce (to 2 %) except at the two stations 66 and 69, where it became suddenly abundant, 20 and 15 % respectively. The optimum answers here to a salinity of 36.36 ‰ and a temperature of 15°.8, in February.

On the summer cruise it was first caught on the outward route in Cadiz Bay, at st. 91, where it was rare, but already at the next station 92, it was abundant (45 %, optimum). Farther on it occurred in very small numbers (singly to 1 %) at sts. 93, 95, 96, and in the Straits of Gibraltar and just east of them at sts. 98, 99 singly. Hence it was wholly absent in the Atlantic Current proper and did not appear before the sts. 118 (1 %) and 120 (2 %) in the Northern Balearic. It was present in the Ligurian Sea at two out of four stations, 122 (5 %) and 125 (less than 1 %); in the Tyrrhenian Sea more frequent, only wanting at one station (127); to the south more numerous, and at st. 132 rather abundant (8 %). Off Tunis it was present at four out of eight stations, rather scarce, but near the west coast of Sicily (sts. 138, 139, 140) 3 to 5 %, otherwise in the Sidra Sea, however, wanting (in the surface). Off Barca it occurred at st. 152 singly, but farther on was only present below the surface at two stations in the Levant (156, 160) to the station 186 in the northern Ionian Sea, where it again became more frequent, being present at all stations, however only below the surface as far as the station 190, just south of the Straits of Messina. Hence through the Tyrrhenian Sea and as far as west of Sardinia it was only wanting at two stations, (196 and Naples), and was sometimes present in relatively great numbers, (sts. 194, 1145 m. wire, 197 and 199, 0—30 m. 5 %). Between Sardinia and the Baleares, in the northgoing branch of the Atlantic Current, (sts. 205—206), it was again wanting. In the Catalonian Sea it was only found as empty cells in the surface at one station, (213), but was present below the surface, (st. 209, 33—80 m. 5 %, 85—200 m. singly, 945 m. wire 2 %, 1945 m. w. singly). Farther on only just east of the Straits of Gibraltar, (st. 228 in the surface and at 1145 m. wire, singly) and outside of them, (sts. 229, 231 in the surface singly, at 1145 m. wire 9 %, in Cadiz Bay, and st. 234 in the surface, 95—200 m. and 200—700 m. singly, 0—25 2 %, and st. 237, off the coast of Portugal, singly).

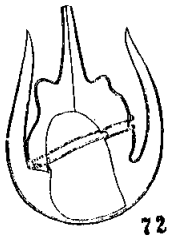
This species was present below the surface at all stations in the Mediterranean where deep water samples were gathered, except in the Aegean Sea, in the Gulf of Corinth and at the three stations 132, (south-east of Sardinia), 206, (in the central Balearic) and 223, (Alboran Sea). At half the number of these stations (for deep water samples) it was wanting in the surface (sts. 209, 126, 134, 189, 187, 186, 156, 160, from the west to the east). In the northern Ionian and in the Tyrrhenian Seas it was more or less obviously more numerous at a deeper level, (sts. 126, 275 m. w. 2 %, 128, 0—100 m. 1 %, 129, 0—600 and 0—1100 m. 3 %, 186, 245 m. wire 5 %, 187, 100—190 m. over 10 %, 194, 1145 m. w. and 199, 0—30 m. 5 %, 209, 33—80 m. 5 %, 945 m. w. 2 %), and also at the only station for deep water samples in Cadiz Bay, (st. 231, 1145 m. w. 9 %).

Fission stages were seen outside the Mediterranean, in Cadiz Bay: at st. 66, (optimum of frequency) many cells in regeneration, (8 to 9 o'clock a. m.), st. 92, a cell halved, (3 to 4 o'clock a. m.), st. 95 a cell after recent fission, (5 to 6 o'clock a. m.). In the Mediterranean, I only saw a cell after recent fission at st. 204, off the southwest coast of Sardinia. At st. 160, however, I observed an abnormally developed individual, with a rudimentary right posterior horn, (as in *C. pulchellum* f. *eupulchellum*) and a less adpressed left horn. This station was the last one where the species was gathered.

An emigration from the Atlantic takes place in January and February, but seems to be only moderately successful, the species being far more numerous outside than inside the Straits. In December, 1908, the species was also present both out- and inside the Straits, according to samples in my possession. In summer, both in June and September, there was ample occasion for migration from the Atlantic, as the species was numerous in Cadiz Bay (in June even optimum of frequency at st. 92); however, east of the Straits it reached only a little distance (sts. 99 and 228). The immigration into the Mediterranean must therefore be considered a failure at that season.

Otherwise this species is distributed throughout the warmer regions of the Atlantic and the Indian Oceans. It is also present in the Pacific. It occurs in the Florida Current, the Antilles Current, the Sargasso Sea, at the Azores (all the year) and in the Canary Current, and northwards sometimes reaches the entrance to the Channel.

C. limulus is, therefore, present in the Western Mediterranean both in summer and in winter, especially frequent in the Tyrrhenian Sea, but seldom in greater numbers. In the Eastern Mediterranean it is very rare and scarce, almost entirely wanting in the surface, but at deeper levels present in small numbers as far as Rhodes, somewhat more numerous in the northern Ionian Sea. It is only renewed through emigration from the Atlantic to a feeble degree, with a positive result apparently only in winter, or probably from late autumn to spring (May).


72

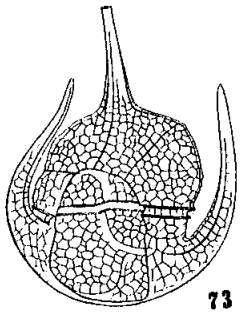

73

Fig. 72. *C. limulus* Gourr. Straits of Gibraltar, Dec. 1908. Fig. 73. *C. paradoxides* Cleve. Azores, February 1907.

35. CERATIUM PARADOXIDES Cleve (Fig. 73).

Jörgensen, 1911, (b p. 57, pl. VI fig. 123).

This species, similar to the preceding one, but easily distinguished by its regular reticulate structure and the absence of "humps", has only been reported from the Mediterranean by Cleve, (1903): Alboran Sea at 36° N 4° W (somewhat south of the station 101) in February 1903, 15°.1 C., 36.62 ‰. In the gatherings of the "Thor" I only saw it at the station 231, in Cadiz Bay, at 1145 m. wire, two individuals; September.

Otherwise it is found in the tropical and subtropical regions of the Indian Ocean and the Atlantic, where it seldom extends to the warmer temperate regions. It occurs at the Azores, (February and March) and in the Canary Current.

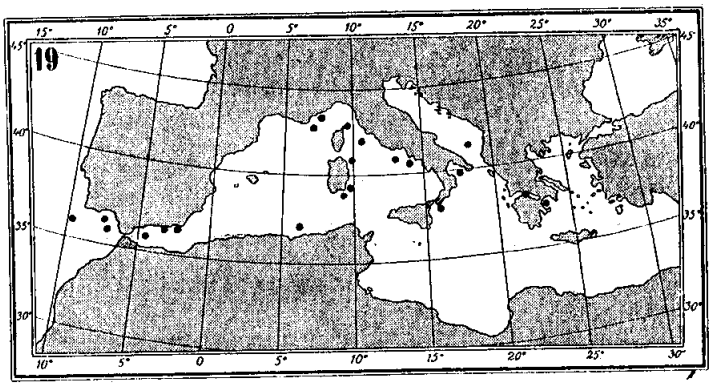
Sectio X. PLATYCORNIA Jörgensen.

36. CERATIUM PLATYCORNE v. Daday (Figs. 74, 75, p. 81).

Jörgensen, 1911, (b, p. 58, pl. VI figs. 124—126, includ. *C. lamellicorne* Kofoid, figs. 127, 128, and *C. compressum* Gran, pl. III fig. 57 and pl. IV fig. 81).

This species with its flattened and broadened posterior horns cannot easily be confounded with others, except when it occurs as var. *compressum* (Gran). Even in this form it is well distinguished from all similar species through its spinulate-alate horns. It is, however, exceedingly variable in the development of the posterior horns.

With this, as a basis, there are three principal forms, which have been considered separate species, also (with some doubt) by myself. After having seen the gatherings of the "Thor" I wholly agree with PAVILLARD, (1907, 1916) and GRAN, (1911) in referring them to one and the same species, the name of which must be *C. platycorne* ("*platicornis*") v. Dad. The type of DADAY, — according to his figure, (1888 p. 101), not to his description which is in Hungarian, — is the broad-horned form which, in contradistinction to the others, is more frequent in the tropical and subtropical regions. Unfortunately DADAY's figure illustrates a very rare case, one of the posterior horns being (distally) bisected; I think, however, we may designate this most special form as f. *incisum*, under α as a unit of higher rank.



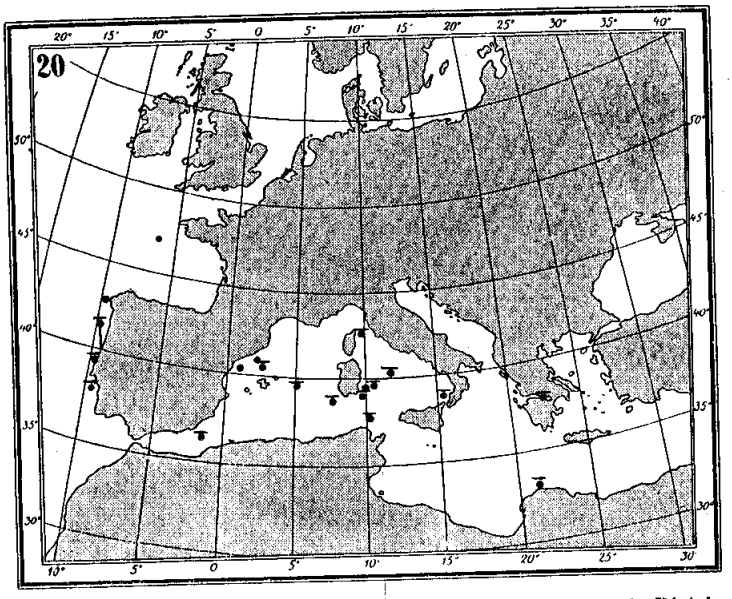


Chart 19. Distribution of *C. platycorne* in winter. Chart 20. Distribution of *C. platycorne* in summer.

The form which KOFOID calls *C. lamellicorne*, with more expanded and narrower posterior horns, less or not broadened towards their apices, prevails in more temperate seas; as mentioned by PAVILLARD, (1916), numerous intermediate forms, however, occur. From st. 134 off Tunis, 125—200 m., I saw an individual of *C. lamellicorne*, having the posterior horns in their distal region suddenly and broadly dilated to the breadth in the main form α. A form, transitional between the two, is var. *cuneatum* (Jörgensen l. c. fig. 126), which on the one hand is merged into *C. lamellicorne*, on the other into the typical form, (see fig. 74). Habitually similiar forms occur which are the typical broad-horned one, only with shorter or incompletely developed posterior horns.

The correct name of this narrow-horned variety is var. or f. *dilatatum* Karsten, (1905); its posterior horns are usually strongly developed and a little dilated towards their ends. Here are numerous forms, also such as those already mentioned, which through f. *cuneatum* merge into the main form α. A very distinguished and elegant form is figured here, (fig. 75); it was found at three stations in the median part of the Mediterranean, (st. 126, 100—200 m., st. 132, 195—600 m., st. 200, in the surface) and was very different from the common form (transdiameter only 43—47 μ, cell body less robust, tapering into a long and relatively thin apical horn).

In the extremities of its area the var. *dilatatum* occurs with still narrower posterior horns, which may assume the normal subterete form, otherwise common among the Ceratia. This obviously takes place by a removal of the ends of the horns (autotomy, Kofoid) and a succeeding regeneration (see Jörgensen 1911 c pp. 227, 228).

DADAY, (l. c.) first reported this species from the Mediterranean (Naples). PAVILLARD, (1905) found it in Étang du Thau near Cette, where it proved very rare, November and December. In 1907 he mentions it from the Gulf of Lyons; it is said to appear there in October, to become rather numerous in

December and to vanish in the spring. SCHRÖDER, (1911), reports it as very rare on the coast of Dalmatia (only singly at Lucietta, 100 and 200 m.).

On the winter cruise of the "Thor" (Chart 19) it was gathered at about half of the Mediterranean stations, usually in single specimens. The main species was noted for sts. 12, 14, Naupaktos, 18 (2 % of rel. freq.), 20 (2 %), 26, 31, 35 (2 %), 38, 55 and 57. It was continually present (at all stations) from st. 29 off Naples to st. 38 off the north-east coast of Sardinia. In Cadiz Bay it was present at the three outer stations (66, 68, 69, here 2 %), wanting at the two inner. The var. *dilatatum* was noted for sts. 29, 40, 55 and 59, and transitional forms to α from Naupaktos and sts. 31, 36, 42, 46. There was a feeble emigration from the Atlantic through the Straits in January and February, and also in December (specimens in my possession).

On the summer cruise (Chart 20) it was almost wholly wanting in the surface, being only observed singly at three stations, 200, south-east of Sardinia, and 210, 213 in the Catalonian Sea, at all three stations var. *dilatatum*. Otherwise it was only present below the surface, again at about half the number of stations where deep water samples were gathered. In the Eastern Mediterranean it was wanting, except α at st. 152, 950 m. w. (off Barca) and at st. 184, 945 m. w. (in the Gulf of Corinth), singly, and var. *dilatatum*, singly, at st. 189, (near Cape Spartivento) 945 m. w. Otherwise it was only wanting at the western station 228, and a single station, 128, 0—100 m., in the Tyrrhenian Sea. It remains at a relatively very deep level, apparently 100 m. below the surface, or somewhat more, (therefore wanting at st. 128). In Cadiz Bay it was wanting, and there was no migration from the Atlantic either in June or in September; off the coast of Portugal the species was, however, present both in June, — st. 81, 100 m. wire, 25 % var. *dilatatum*, st. 84, 10—25 m. 1 % var. *dilatatum* with single specimens of α — and in September — st. 234, 25—100 m., singly, and st. 239 (near Cape Finisterre) 2 %, here both α and var. *dilatatum*. Farther to the north the species was only observed at st. 79 in the Bay of Biscay in June, where a few individuals of var. *compressum* and of var. *dilatatum* with horns, not broadened distally, were found. The localities, not already mentioned, were the following: sts. 129, 0—1100 m. (α), 134, 75—125 m. (α), 194, 1145 m. w., α and var. *dilatatum* answering to fig. 75), 199, 945 m. w. α, 204, 945 m. w. α and var. *dilatatum*, 206, 1945 m. w. α (f. *cuneata*) and var. *dilatatum*, 209, 85—200 m., α and several specimens of the long-horned var. *dilatatum*, 945 m. w. α, 1945 m. w. var. *dilatatum*, 223, 1950 m. w., α. Everywhere the species was very scarce or only present singly. The f. *cuneata* was rather frequent, in winter as a robust short-horned form, more frequent in the region of the Atlantic Current proper. In this region also the above mentioned f. *incisum* was found singly in winter, (sts. 46, 55, 59), twice with a bisected right, once with a similar left, posterior horn. Otherwise both α and var. *dilatatum* are found, in winter as well as in summer, and, on an average, about equally numerous.

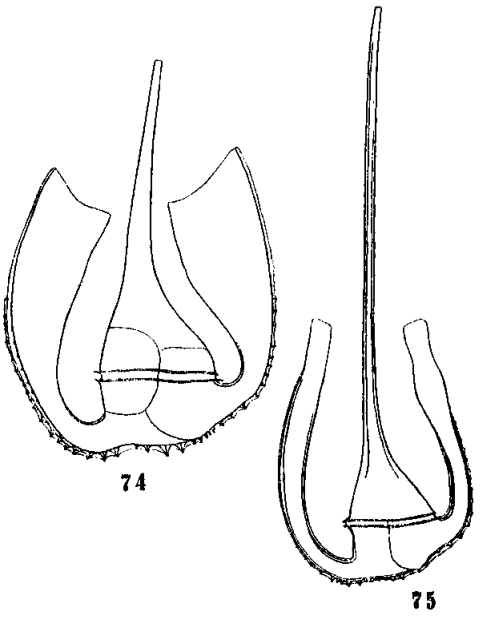


Fig. 74. *C. platycorne* Dad., a form, intermediate between the main species and f. *cuneatum* Jörg. Naupaktos; December. Fig. 75. *C. platycorne* Dad., a long-horned form of var. *dilatatum* (Karst.). St. 194 (north of the Straits of Messina) 1145 m. wire; August.

Fission stages were only observed once in the Mediterranean: st. 55, f. *incisum* as f. *antico-juvenile* (in February, 8 o'clock a. m.).

Otherwise the main species is distributed in the tropical, subtropical and warmer temperate regions of the Atlantic, the Indian and the Pacific Oceans, var. *dilatatum* extending both farther north and south.

The species is found in the Antilles Current, the Gulf Stream, at the Azores (in February and April) and in the Canary Current.

Summarizing, we find *C. platycorne* in small numbers in the surface of the Mediterranean in winter, all to the waters near Greece (Gulfs of Corinth and Aegina), especially frequent in the Tyrrhenian, the Ligurian and the northern Balearic Seas. In summer it is almost entirely wanting in the surface, but is frequent as single specimens at a deeper level (about 100 m.) in the Western Mediterranean, especially in the Tyrrhenian Sea. In the Eastern Mediterranean, however, it is very rare. It immigrates into the Mediterranean from the Atlantic in winter, probably from late autumn to winter minimum.

Sectio XI. **PALMATA** (Pavillard) Jörgensen.

37. **CERATIUM RANIPES** Cleve (Fig. 76, p. 83).

Jörgensen, 1911, (b pp. 60, 61, pl. VI figs. 129—131, *C. palmatum* and var. *ranipes*).

This singular species was first reported from the Mediterranean by Schröder, (1900), who figured it from Naples under the name of *C. tripos* var. *macroceras* f. *palmata*, (pl. 1 fig. 17 *o, p*). Perhaps it had already been detected there by v. Daday 1885, who describes (in Hungarian) a *C. tripos* var. *spinosa*, which — to judge from the name — might be either *C. ranipes* or *C. platycorne*. The latter species is, however, on the same occasion described as a new species.

Though Schröder's denomination is a little older, the species name, *C. ranipes* Cleve, (1900 p. 15, pl. VII fig. 1) must be considered the most correct name for the present species, according to the rules of nomenclature (now) adopted. It has the additional advantage that the more common form becomes the main species; Schröder's rarer form may then be called var. *palmatum*.

Cleve, (1903) mentions the species from the Alboran Sea, a little east of the Straits of Gibraltar (4° W), in February 1903, Schröder, (1906) from the "Ionian Sea" March 1902, singly, and Pavillard 1916, from the Gulf of Lyons ("rather rare").

As in the case of the preceding species, with which this one has several common characteristic features, as f. i. spinulate-alate horns, the development of the modified posterior horns is very variable. The two most important forms are the typical, (see fig. 76) with its more or less distinctly unilaterally directed "fingers" of uniform breadth or narrowing distally, and the var. *palmatum* (Schröd.) with uniformly spread and very long fingers — but usually much shorter "arms" — often or usually swollen at their tips. This latter form is generally much rarer. However, in many cases it is impossible to decide with any certainty, which of the two forms mentioned are present, because — as Pavillard, (1916), also remarks — the "hands" are very often lacking. In what follows I have therefore only listed var. *palmatum* in cases when its determination was quite certain; and so this variety may perhaps occur somewhat more frequently than one may conclude from the localities stated.

On the winter cruise of the "Thor" it was present at about two thirds of all Mediterranean stations, more frequent to the east and especially to the west, but remarkably rare in the middle regions, (the Tyrrhenian and the Ligurian Seas). In the Eastern Mediterranean it was wanting at three (out of eleven) stations, (11, 12, Port Alice) and was everywhere present singly or in very few specimens, var. *palmatum* being found only at the western st. 10. In the Tyrrhenian Sea it only occurred singly at three stations, sts. 25 and 28 off Naples and st. 40 south-east of Sardinia. In the Ligurian Sea and in the northern Balearic it was entirely wanting, in the region of the Atlantic Current proper, on the other hand continually present at all stations, and relatively numerous. Its occurrence in this region proves a very successful immigration into the Mediterranean from the Atlantic in February and especially in January, the species being scarce just east of the Straits, but gradually — though not evenly — increasing in frequency to the east, to 5 % (rel. freq.) or more at the three eastern stations, (46, 45, Galita). Outside the Straits it was present at the three outer stations (66, 68, 69) in small numbers (singly to 2 %). It

was also present outside and inside the Straits in December 1908, (according to samples in my possession). Var. *palmatum* was only stated for sts. 60 and 69, at both stations singly, together with the main species.

On the summer cruise the species proved very rare, being only observed singly at eight stations in the Mediterranean and at two in Cadiz Bay: sts. 95, (var. *palmatum*?), 129, 0—1100 m., (var. *palmatum*), 152, 250 m. w., 156, 250 m. w., 160, 30—100 m. (var. *palmatum*), 182, 545 m. w., 189, 945 m. w., 206, 1945 m. w., 228, 1145 m. w., 231 in the surface (var. *palmatum*). Accordingly it was only seen in the the surface in Cadiz Bay; otherwise it occurs at about one third of all stations where samples from a deeper level were taken, spread over all the different regions except the Catalonian Sea, but relatively most frequent in the Eastern Mediterranean. In summer no migration from the Atlantic is to be traced.

Fission stages were not seen.

Otherwise it is widely distributed, but generally very scarce, in the tropical and subtropical regions of the Atlantic and the Indian Oceans. Occurs also in the Pacific and in the warmer temperate regions of the Atlantic, northwards to 50° N. in the middle of the Atlantic. It is present in the Antilles Current, the Florida Current, the Sargasso Sea, the Gulf Stream and at the Azores (in December).

Consequently *C. palmatum* is only regularly present in winter in the surface of the Mediterranean, throughout the sea, but generally very scarce and (may be?) wanting in the northern regions. In summer it is (generally) wholly wanting in the surface, but occurs sporadically at a moderate depth throughout the sea. It emigrates from the Atlantic in December to February (or probably from late autumn to winter minimum) and has probably only a relatively short life time as a Mediterranean species.

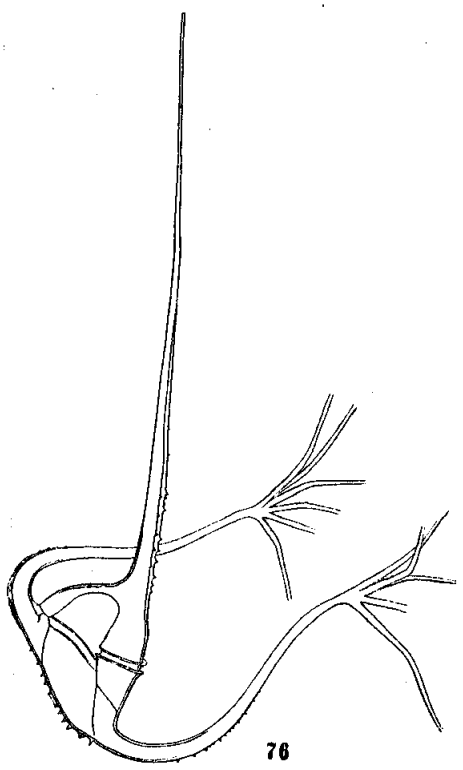


Fig. 76. *C. ranipes* Cleve. Taormina (Sicily); January.

Sectio XII. MACROCERAS Ostenfeld.

38. CERATIUM MACROCEROS (Ehrb.) Vanhöffen (Fig. 77, p. 88).

Jörgensen, 1911, (b p. 63, pl. VII figs. 132—135).

The main species, which is so common in the North Sea, has not been found in the Mediterranean, where only the subspecies *gallicum* (Kofoid) occurs (see fig. 77).

It was first reported from the Mediterranean already by Gourret, (1883), who figured it from Marseilles, (pl. 2 fig. 41) under the name of *C. tripos* var. *macroceros*. He mentions it as very rare there, having only seen one specimen. Schröder, (1900), found it at Naples and figured it, (pl. 1 fig. 17 *f*) as *C. tripos* var. *macroceros*, to which he referred a series of "forms" (figs. 17 *g—p*), representing seven other species. Entz, 1905, (1902) figures it from the northern Adriatic as *C. tripos macroceras*, (p. 100, figs. 13—15; figs. 13, 14 are f. *californiense*) and partly as *C. furca* var. *baltica* (p. 99 fig. 8). Cleve, (1903), found it between Crete and Egypt, 26 to 30° E., on the route Brindisi — Port Said, in October 1902, and in the Alboran Sea, from west of the Straits of Gibraltar to 4° W., in January 1903. Pavillard, 1905, mentions it from the Étang du Thau near Cette as "less abundant", from October to June, with a maximum in December, — Schröder, 1906 from the northern Adriatic in March, August and September, rare, from the route Brindisi — Port Said in October 1901, rare, and from the "Ionian Sea" March 1902, frequent. Zacharias, (1906), lists a *C. macroceros* from the Mediterranean, but as he observed "specially gigantic forms" at Palermo, his species is not likely to be the present one. Pavillard, 1907, reports it

from the Gulf of Lyons as rare, — in all these cases the species is called *C. macroceros*, — and SCHRØDER, 1911, from the northern Adriatic as frequent, but scarce on the coast of Dalmatia, also partly occurring in the brackish region.

On the winter cruise of the "Thor" it was present all the way except at the northern stations of the Tyrrhenian and the Balearic Seas, (sts. 31, 36, at the latter station, however, present as the degenerated f. *californiense*), and in the Ligurian Sea (sts. 33, 35). Otherwise it was only wanting at sts. 27, Galita and 50 (the latter sample was in poor condition). Its (relative) frequency varied greatly, from over 5 % as a mean value in the northern Ionian Sea to scarcely 2 % in the Tyrrhenian. At Taormina Roads the rel. frequency was 15 %, (optimum in winter, here the prevailing species), and in the southern Adriatic, (st. 14), 10 %. In the region of the Atlantic Current proper, (Gibraltar to Tunis) it was present everywhere, but only with a low frequency, of 1 % to 4 % at the easterns stations. It was also present everywhere in Cadiz Bay (in February), from 1 to 4 % (at the outer stations).

An immigration into the Mediterranean through the Straits of Gibraltar was obviously going on in January and February — also in December according to samples in my possession, probably from autumn (to judge from the distribution) — with a slightly increasing frequency toward the east.

On the summer cruise in June, the main species was met with in greater numbers about as far as Lisbon, (sts. 79, 80, 84, 85), on an average 10 % rel. freq., to about 35.5 ‰ of salinity and a temperature of 17°. Farther on a similar robust form was only seen singly at Cadiz except at st. 87, (near Cape Vincent), where the main form was still present in smaller numbers together with the subspecies *gallicum*. This latter appeared at station 86, where the salinity was near to 36 ‰ with 18°, and was hence more or less abundant, to 30 % at st. 91, where it was the predominating species. Inside the Straits it was plentiful in the Atlantic Current proper, with a frequency increasing from 5 % at the western stations to 10 % as a mean value at the eastern; in this region it was only wanting at a single station in the Alboran Sea and had its optimum (20 %), at the most eastern station, (113). Outside this region, however, the distribution is not continuous. In the Balearic Sea it was wanting at four out of eleven stations of the middle region (sts. 116—119), otherwise with a frequency of about 5 %; in the Ligurian Sea very scarce, except at the southern station 122, where there was 5 %, and wanting at two of the four stations. In the Tyrrhenian Sea it was wanting at most stations (only present at sts. 129 and 126, at the latter also wanting in the surface) and very scarce; the same was the case in the south-eastern Balearic, off Tunis, where it was wanting at three out of eight stations. Here, however, it was plentiful below the surface at st. 134. In the Sidra Sea it was very scarce near Sicily, but plentiful in the Syrtis Major, (5 % at st. 148 and even 10 % at st. 151), and hence continually present at all stations to a short distance before the Dardanelles, (wanting at sts. 164, 165, 179, 180, and 183 in the Gulf of Aegina). In the southern Ionian Sea it was rather scarce, but more plentiful below the surface, (10 % at st. 152, 250 m. wire), in the Levant everywhere plentiful, 10 to 15 %, — below the surface scarcer, and in the Aegean Sea still plentiful off the coast of Asia Minor, especially at the southern stations, whilst more westerly, as far as Euboea, only present singly. It thus seems to avoid fresher water. Strange to say it was seen singly in the surface at st. 172 in the Black Sea (perhaps only a remnant from the net; such a delicate, long-horned species may easily stick fast there).

In the northern Ionian Sea in August it was only wanting at st. 190 near Sicily; it was generally scarce, but a little more numerous below the surface. In the Tyrrhenian Sea on the return voyage it was exceedingly rare, only present at two stations, (in the surface at st. 194 and at Naples, on the section of the Balearic only at two out of five stations, singly, again a little more frequent below the surface. In the Catalonian Sea it only was seen at two stations (at st. 209 below the surface, singly, and at st. 215), but hence again continuously present and from st. 218 on the African Coast in the Atlantic Current suddenly plentiful, though irregularly varying in frequency from 2 to 40 % (at sts. 220, 40 %, and 223, 35 %,

the predominating species). Outside the Straits it was by far the predominant species at both stations in Cadiz Bay, (st. 229 65 %, st. 231 70 %, optimum, 21°.3, 36.42 ‰, in September) and off the southern coast of Portugal, (st. 234, 45 % in the surface and 0—25 m., singly below 100 m., st. 235 30 %). Northwards it becomes gradually scarcer: Lisbon, a coarse form 2 %, sts. 237 10 %, 238 5 %; at the colder station 239, (Cape Finisterre, 14°.4) the subspecies *gallicum* was wanting and replaced by the main species; — in the Bay of Biscay, however, it reappeared at sts. 242, 243, about 5 % (here again a higher temperature, 17°.2) and a coarser form at st. 245 near Brittany, the most northern locality for the subspecies *gallicum*.

As has already been mentioned, the main species was found in September at the colder station 239, but did not become prevailing before at the more shallow stations near Brittany, sts. 246 and Brest.

Below the surface, the subspecies *gallicum* was present at most of the Mediterranean stations, where corresponding samples were gathered, but was wanting at 6 (out of 22 stations: 132 south-east of Sardinia, 128, 194, 199 in the Tyrrhenian Sea, 204 south-west of Sardinia, and 182 in the Aegean Sea). It was more numerous below than in the surface at st. 134, 0—75 m. 5 %, 75—125 m. 10 %, against less than 1 % in the surface, st. 152, 250 m. wire 10 %, 950 m. wire 5 %, against 2 % in the surface, st. 163, 0—80 m. 5 %, st. 187, 0—25 m. 5 %; it was seldom wanting in the surface (sts. 126, but singly at 275 m. wire, 209, 1 % at 33—80 and 200—1000 m.).

Fission stages were relatively very frequent; they were seen, in all, at 14 stations in the Mediterranean, 6 of which are situated in the region of the Atlantic Current proper. The greatest number of young forms were seen at st. 109, (coast of Africa), where nearly half the number of individuals counted were in regeneration (6^{20} o'clock a. m.).

In summer a well-marked immigration into the Mediterranean from the Atlantic is going on, both in June and in September, followed, especially in this latter month, by an obvious increase in frequency eastwards (optimum 40 % rel. freq. at st. 220, where the species was by far the predominating one, 36.56 ‰ of salinity at a temperature of 18°.8). The absolute optimum was met with at st. 229 just outside the Straits, likewise in September: 70 %, 36.42 ‰, 21°.4.

Otherwise the subspecies *gallicum* is one of the more common species of warmer seas, widely distributed in the tropical regions of all three main oceans. It occurs in the Antilles Current, the Florida Current (at least to north of Cape Hatteras), the Sargasso Sea, the Gulf Stream (at least to west of Ireland), at the Azores (in any case from February to July) and in the Canary Current. The coarser main species is especially abundant in the North Sea and thence southwards to the Bay of Biscay, northwards to Spitzbergen and the Barent Sea, and eastwards into the Skager Rack and the Cattegat; besides, occurring abundantly off the American coast inside and north of the Florida Current, from the mouth of Cheasapeake Bay northwards.

According to the data stated *C. macroceros* subsp. *gallicum* is found throughout the Mediterranean all the year, (at least) in summer almost to just before the entrance to the Dardanelles, but at that season is generally scarce outside the Atlantic Current proper — where it is abundant — and its continuation from the Syrtis Major to the Levant. It is rare in the innermost eastern and northern regions of the Western Mediterranean and is apparently in part wanting there in winter, during which season it generally greatly decreases in numbers (in the surface). It is renewed by a lively immigration into the Mediterranean from the Atlantic throughout the year, but especially in summer and autumn.

39. CERATIUM MASSILIENSE (Gourret, Karsten) Jörgensen (Figs. 78—80, p. 88).

C. massiliense Karsten 1906 (p. 145), Jörgensen, 1911, (b p. 67, pl. VII figs. 140—142).

The oldest name of this species common to all warmer seas is *C. tripos* var. *massiliense*, Gourret, 1883, (p. 27, pl. 1 fig. 2, not 2 a, which is the following species). According to the adopted rules of nomen-

clature this varietal name must, however, yield to the specific name first published. I shall therefore here try to explain as briefly as possible which names — in my opinion — are to be considered in this matter.

The name, *C. massiliense* "Gourret" is first met with in KARSTEN, 1906 p. 145, but without any description or suggestion of the characteristics of the species in question. He only mentions that he considers it specifically different from his two new species "*C. tripos protuberans* n. sp." "and *C. tripos macroceroides* n. sp.", which are well described and figured.

The same year, (1906), SCHRÖDER describes and figures a new species, *C. aequatoriale* (p. 361 fig. 32), which is the present species. At the same time he establishes, (p. 363 fig. 34), a "*C. volans* Cleve *forma*", which, — to judge from the figure cited, which answers even better than fig. 32, — must also be the same species, the supposed specific differences being found in the length and the degree of divergence of the horns, which, however, in the Ceratia are very variable characters and of little specific value. Besides, (on p. 326) he lists a "*C. undulatum* Schröd.", without any description, evidently synonymous to "*C. tripos* var. *macroceras* f. *undulata*" Schröder, 1900, which is chiefly again the present species, (see below).

I cannot at the moment state the accurate date of publication of the paper of SCHRÖDER cited, but it cannot have been printed before July, 1906, (compare l. c. p. 319), while the work of KARSTEN was delivered to print already in December, 1905. The new specific names of the latter author have therefore most probably the priority, not to mention the fact that they are much better founded.

The first name of this species in KARSTEN, (l. c.) is *C. massiliense* "Gourret", which — according to the above statement — must in any case include both the present and the following species, as KARSTEN quotes both figures in Gourret, 2 and 2 a. In the following year (1907) PAVILLARD adopts this specific name — *C. massiliense* "(Gourret), Karsten" — but he applies it to the second figure, 2 a, while the first one, fig. 2, is referred to *C. aequatoriale* Schröd., — this latter name being thus chosen for the present species. This was probably done because fig. 2 a was still lacking a separate denomination, while SCHRÖDER's name could be used for fig. 2. In my opinion, however, fig. 2 represents a species which includes both the *C. volans* Cleve 1900 and the *C. carriense* Gourr. (see the following species), so that at any rate the name *C. massiliense* Pavillard, 1907, obtains no priority. It was not until 1911, in my monograph, that GOURRET's two figures were referred to separate species in such a way that the first one, fig. 2, was reserved for *C. massiliense*, while the second was applied to another species (see the following).

Therefore, the question seems to me to be: may the present species still (correctly) be called *C. massiliense* (Gourret, Karsten) Jörgensen? In my opinion the proper intention of the name "*C. massiliense* Gourret" in KARSTEN's treatise was only to emphasize that a species existed closely allied to his new species, *C. protuberans* and *C. macroceroides*, which he did not dare to unite with them, as it was only known to him from GOURRET's figures. However, as this species was later found to coincide with or include the two supposedly new ones, we may, I think, consider that the latter have become superfluous and may be abandoned in favour of the name *C. massiliense* (Gourret). According to the international rules of zoological nomenclature (1901) — not the botanical, (1906), — the name *C. massiliense* Pavillard, 1907, should be kept, this author being the first one to separate the two species included in *C. massiliense* (Gourret); but in the present case, as this *C. massiliense* Pavill. already possesses an older name, it seems to me that the name adopted in my monograph 1911, may be deemed the correct one, even according to zoological nomenclature.

From the material of the "Thor", I am still more convinced that PAVILLARD's and my own interpretation (l. c.) of GOURRET's two figures 2 and 2 a is right. I propose only to change the rank of var. *armatum* to that of a form.

The main species might be called, α *macroceroides* (Karst.). Var. *protuberans* (Karst.) is often or mostly so well distinguished that it may very well be considered a separate species, but I am under the impression that, in very many cases, it is quite impossible to keep it distinct from the typical form. It

seems to me generally to be less confined to tropical and subtropical regions than this latter form, but both of them include many "forms" of a lower systematic rank. A more distinguished one is f. *armatum* (Karst.), which seems adapted to the colder and less saline border regions. It was only caught at st. 79 near Brittany.

Var. *protuberans* is, in many cases, habitually very similar to *C. tripos* and may easily be confounded with it, if special care is not taken.

GOURRET found this species (the following one also included) to be the most frequent one at Marseilles. DADAY reports it from Naples, (1888), (*C. tripos* v. *massiliense* Gourret). SCHRÖDER, (1900), figures it from Naples, (summer 1898), as *C. tripos* var. *macroceras* f. *undulata* (pl. 1 figs. 17 k, m, not l). ENTZ, 1905, (1902), figures it from the northern Adriatic p. 101 figs. 17, 18 as "full-grown large *C. tripos macroceras*" and fig. 16, a (probably) degenerate form, as "young form with a smaller body", besides on p. 109 fig. 40 as summer-form of *C. tripos macroceras* and fig. 41 as *C. inaequale*. PAVILLARD, (1907), reports it as *C. aequatoriale* Schröd. from the Gulf of Lyons, where it was by far the most numerous species of Ceratium in summer. SCHRÖDER, (1911), found both α *macroceroides* and the var. *protuberans* to be very frequent and often very numerous on the coast of Dalmatia in July 1909. PAVILLARD, 1916, remarks that the main species is very frequent in the Gulf of Lyons in summer and in autumn, and that var. *protuberans* is rather rare there, but always easily distinguished. DE TONI and FORTI mention it from Genoa, (1916).

On the winter cruise of the "Thor" it was present everywhere, in the median regions, however, generally scarce. The mean value of its relative frequency in the Ionian Sea was 5 %, yet increasing to 12 % at station 11 in the middle of the sea, in the southern Adriatic (st. 14) 2 %, in the Tyrrhenian Sea 2 % (from 1 to 4), in the Ligurian Sea 5 %, and in the northern Balearic 1 %. In the western region of the Atlantic Current proper the rel. frequency was, on an average, 5 %, increasing eastwards to 15 % at several stations. Optimum in winter st. 53 (17 %, 37.25 ‰, 13°.9).

In Cadiz Bay in winter over 5 % rel. freq. A successful immigration into the Mediterranean from the Atlantic is evidently going on at that season.

On the route outwards in summer the species was already observed in small numbers as f. *crassum* at st. 79 in the northern region of the Bay of Biscay, — a coarse, rather short-horned form with a conspicuous theca structure, and spinulate-alate horns. Farther on it was, however, not encountered before st. 87 off Cape San Vincent, but hence continually present at all stations (only not noted for sts. 117 and 198). In the region of the Atlantic Current proper it was abundant in June, with 30 % as a mean value of relative frequency, but even 70—75 % (optimum st. 99) just east of the Straits of Gibraltar, otherwise in the Balearic 10 % and wanting at one station, (117), in the Ligurian Sea on an average 10 %, but very varying as to numbers, from 1 to 20 %; in the surface of the Tyrrhenian Sea over 5 %; in the surface of the south-eastern Balearic 5 %; in the Sidra Sea 10 %, but nearly 30 at st. 151, in the southern Ionian Sea, off Barca, rather scarce; in the surface of the Levant 10 %, to 20 % at st. 155; in the Aegean Sea 10 % on an average, but very scarce near the Dardanelles and very numerous at st. 161, (30 %). The var. *protuberans* also enters the Sea of Marmora: st. 170, 0—20 m. 5 % (salinity up to only 26.9 ‰), 20—80 m. 3 % (salinity to 38.42 ‰), 85—200 m. singly; st. 175, 350 m. wire, singly, also at Constantinople singly in the surface. In the northern Ionian Sea it was abundant to the east, in the surface, on an average nearly 15 %; in the Tyrrhenian Sea scarcer, 5 % (and wanting at st. 168); in the Balearic scarce near Sardinia, but 24 % at st. 206; in the Catalonian Sea 5 % in the surface; in the Balearic south-west of the Baleares abundant, to nearly 30 % (at st. 217), on an average 18 %, and in the Atlantic Current in September about 8 %, but more numerous at the eastern stations, (st. 221 15 %, st. 224 10 %).

In Cadiz Bay in September it was very scarce in the surface, but plentiful (10 %) at 1145 m. wire, both α and var. *protuberans*. Farther northwards the main species was only gathered at st. 234,

south of Lisbon, 25—100 m., singly, and at st. 239, near Cape Finisterre, 4 %, whilst var. *protuberans* was present in great numbers off the coast of Portugal, from 25 % in the surface at st. 234, to 2 % at st. 239, and was also found at Brest and a little farther to the north (st. 247), singly.

In winter in the region of the Atlantic Current, the main species was more numerous than the var. *protuberans*, while, on the contrary, this latter variety often more was numerous in the inner regions.

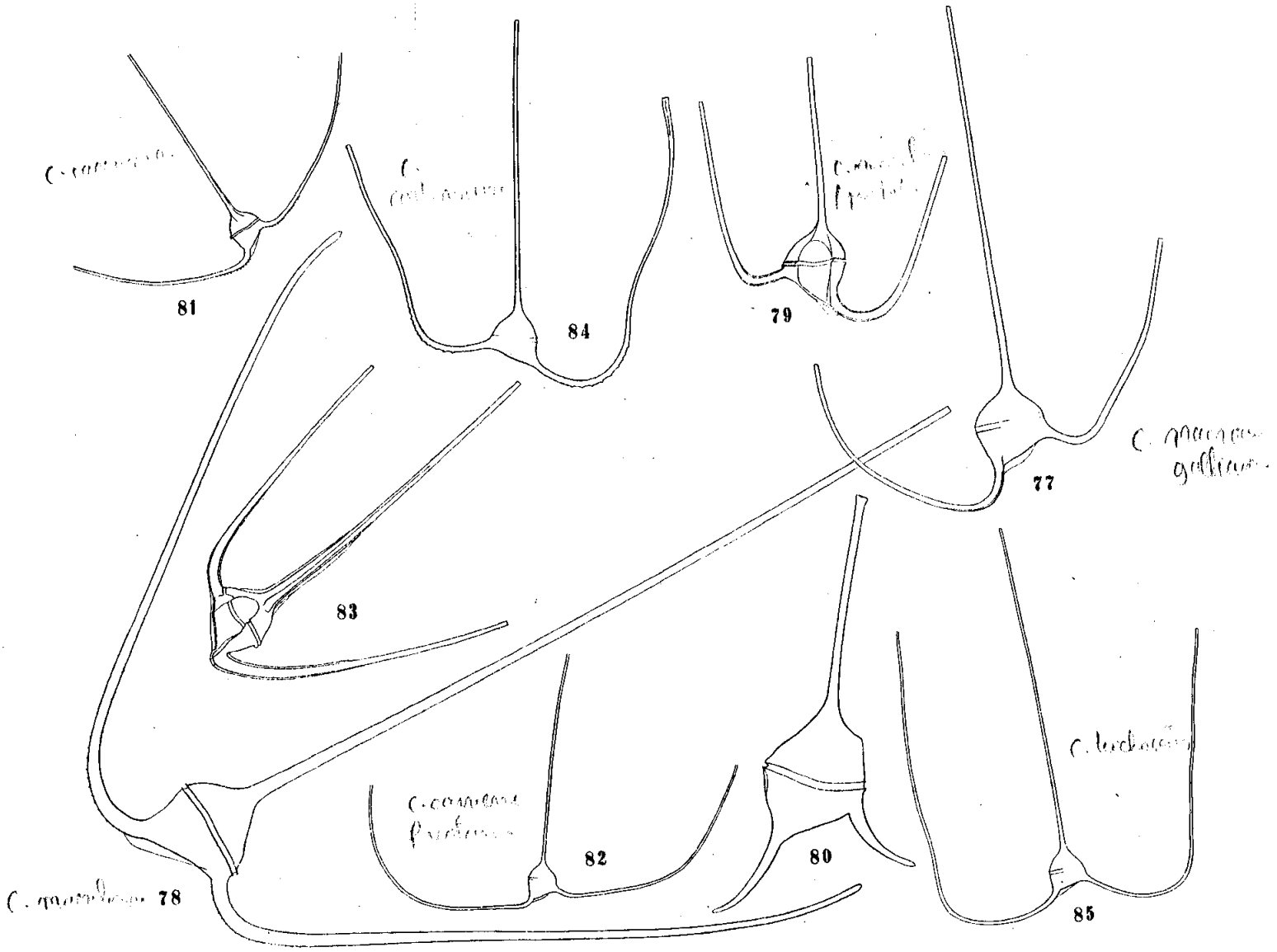


Fig. 77. *C. macroceros* subsp. *gallicum* (Kof.). Straits of Gibraltar, Dec. 1908. Fig. 78. *C. massiliense* (Gourr., Karst.) Jörg. Tortugas, × **220.** Fig. 79. *C. massiliense* var. *protuberans* (Karst.), × **125.** Straits of Gibraltar, Dec. 1908. Fig. 80. A degenerate form, answering to f. *californiense* of *C. macroceros* subsp. *gallicum*, probably belonging to *C. massiliense* var. *protuberans*. St. 170 (Sea of Marmora), 0—20 m.; August. Fig. 81. *C. carriense* Gourr. Monaco, × **70.** Fig. 82. *C. carriense* var. *volans* Cleve, a short-horned f. *rectangulatum* nov. f. South-west coast of Spain, Dec. 1908, × **70.** Fig. 83. *C. Pavillardii* Jörg. Monaco, × **125.** Fig. 84. *C. contrarium* (Gourr.) Pavill. Taormina (Sicily); January, × **125.** Fig. 85. *C. trichoceros* (Ehrb.). Straits of Gibraltar, Dec. 1908, × **125.**

At stations where samples from a lower level were taken, the species often proved to be more numerous below the surface, which generally seemed to be the case where samples from the upper 100 m. were gathered (st. 128, 0—100 m. 12 % as compared with 3 in the surface, st. 129, 0—80 m. 21 %, but

only 5 in the surface, st. 134, 0—75 m. 17 %, 5 in the surf., st. 160 even 52 % at 0—30 m. as compared with 13 in the surface, st. 194 6 % at 1145 m., only 1 % in the surf., st. 209, 33—80 m. 28 %, only 2 in the surf., st. 231, 1145 m. 10 %, in the surface singly, st. 234, 25—100 m. 60 %, 25 in the surf.). Below the surface, var. *protuberans* was decidedly more numerous and very often only present here (st. 128, 0—100 m. 5 %, st. 129, 0—1100 m. 6 %, st. 134, 75—125 m. 8 %, st. 160, 0—30 m. 22 %, 30—100 m. 5 %, st. 194, 1145 m. w. 3 %, st. 199, 80—200 m. 5 %, st. 204, 945 m. w. 6 %, st. 206, 1945 m. w. 4 %, st. 209, 33—80 m. 21 %, at all these stations wanting in the surface; st. 228, 1145 m. w. 3 %, in the surf. 1 %, st. 231, 1145 m. w. 4 %, singly in the surf., st. 234, 25—100 m. 60 % as compared with 25 % in the surface). This proves that the main species seems to be more frequent in summer somewhere between 0 and 100 m. than in the surface, at st. 160 between 0 and 30 m., while var. *protuberans* generally prefers lower levels and is found at a greater depth.

Fission stages were frequent. They were seen at two stations in Cadiz Bay, (st. 95 many cells after recent fission, 5 to 6 o'clock a. m.), at three stations in the Atlantic Current proper in June, (st. 112 two cells in regeneration, one just divided and two in a chain, 12 to 1 o'clock a. m., st. 113 many cells recently divided, 3 to 4 o'clock a. m.), at one station in the Ligurian Sea, at four in the Tyrrhenian, at two in the Balearic outside the Atlantic Current, (st. 216 five cells (out of 24) in regeneration), at two stations in the Levant, one in the Ionian and one in the Aegean Seas. Most of the young stages were found between 5 and 6 o'clock in the morning.

In summer the optimum of frequency was encountered at st. 99 just east of the Straits of Gibraltar, where there was over 75 % rel. freq., in June; outside the Mediterranean there was an optimum at st. 234, 25—100 m., over 60 %, in September, var. *protuberans*. At three stations there was a frequency greater than 50 %, (sts. 98, 99, 160, 0—30 m.); these give 37.15 ‰ as a mean value of salinity with a temperature of 19°.1, the optimum alone 36.26 ‰ and 16°.8. The secondary optimum in September gives 35.95 ‰ and 15°.3 (for the var. *protuberans*).

At station 170, in the Sea of Marmora, where var. *protuberans* was found in very little saline water between 0 and 20 m., some cells of the remarkable form, answering to *C. californiense* Kofoid, in this case, however, belonging to var. *protuberans*, were observed, (see fig. 80). They were of smaller dimensions, (*t* in the figure 57 μ) and their occurrence here again proves them to be (most probably) caused by poor conditions of life. The specimen figured has, most probably, belonged to a heteromorphous chain, (compare the dilated and irregular end of the apical horn).

Outside the Mediterranean *C. massiliense* seems to be more or less common throughout the warmer regions of the three main oceans. It occurs in the Antilles Current, the Florida Current (to past Cape Hatteras), the Sargasso Sea, the Gulf Stream, the Azores (at least in February and in July) and the Canary Current.

From the above data we see that *C. massiliense* is present everywhere in the Mediterranean, both in winter and summer, but is much more numerous in the latter season. Var. *protuberans* penetrates into the depth of the Marmora Sea and in summer is rather rare in the surface of the median and inner regions, but is common there below the surface, (apparently at about 100 m.). Though the species is undoubtedly indigeneous to the Mediterranean and propagates there, an effective migration from the Atlantic takes place throughout the year, especially in early summer.

40. CERATIUM CARRIENSE Gourret (Figs. 81, 82, p. 88).

Gourret, 1883, (p. 38, pl. 4 fig. 57). *C. tripos* v. *massiliense* Gourret in part (l. c. pl. 1 fig. 2 a). *C. volans* Pavillard 1905 (p. 54, pl. 1 fig. 1). *C. massiliense* Pavillard, 1907, (p. 226).

After PAVILLARD, 1907 has cleared up GOURRET's two figures, 2 and 2 a, only a few words for the justification of the name of this species will be necessary. GOURRET did not separate this species from

the preceding one, which is readily understood, as the essential difference between both species — compare the base of the left posterior horn in the figures — is very slight in comparison with the habitual similarity and the great variation in the divergence of the horns in both species. In fact, in many cases a most careful observation is necessary to avoid confusion. Nevertheless, his *C. carriense* is undoubtedly the present species and the same which he figured under the name of *C. tripos* var. *massiliense* in fig. 2 a. This is due to a mistake frequently found in GOURRET, a confusion of the ventral with the dorsal view, on account of which he believes he had discovered an essential difference in the form of the girdle. By comparison of his figures 2 a and 57, which really represent one and the same species, it will be seen that in the latter figure he has drawn the very conspicuous left ventral part of the girdle, in stead of the dorsal. The main form of the present species exhibits in a dorsal view just that course of the girdle on the ventral side, which is different from its direction on the dorsal one.

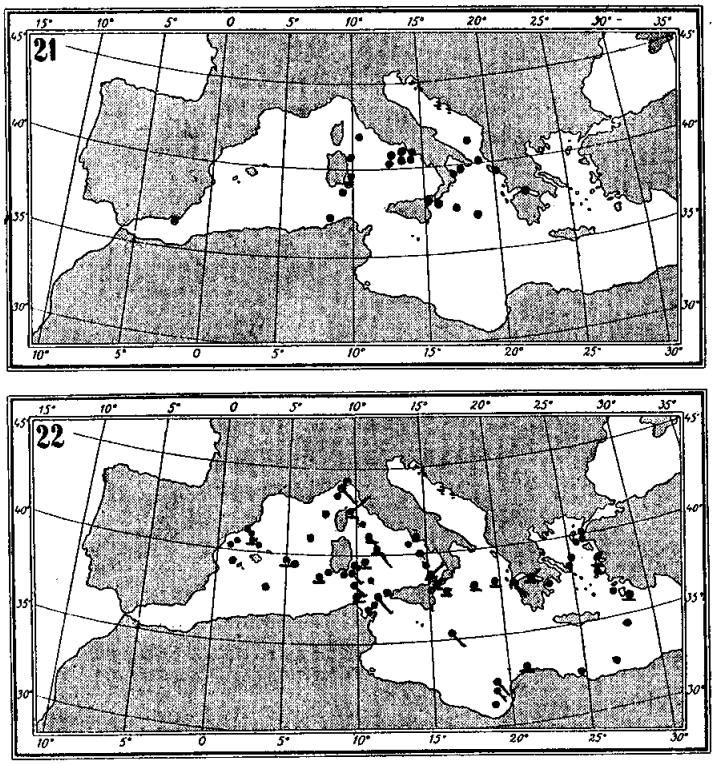


Chart 21. Distribution of *C. carriense* in winter. Chart 22. Distribution of *C. carriense* in summer.

Var. *volans* (Cleve) is decidedly much more frequent than the typical form of GOURRET and differs from it especially in having as a rule much longer and more spreading horns and a more delicate texture. The Mediterranean form of this variety — which is connected by transitional forms with the main species — is usually very characteristic in shape and perhaps deserves a special name, f. i. f. *rectangulatum* (see fig. 82).

GOURRET reports this species as rather frequent near Marseilles; CLEVE, (1903), found it from the south-eastern Balearic to the middle of the Sidra Sea in October, 1902. PAVILLARD, (1905), figures it (as *C. volans*), from the Étang du Than near Cette, (November—December, rare); 1907 he finds it predominating together with the preceding species in the Gulf of Lyons during the warmer season. Var. *volans* is said to be very numerous there towards the end of the summer (October). He suggests that this variety — which he lists as a separate species, "*C. patentissimum* Ostenf. and Schm." — may only be a seasonal form of *C. carriense* ("*C. massiliense*"). SCHRÖDER, (1911), mentions the main species from the northern Adriatic as very rare and scarce in July 1909, while var. *volans* was very frequent and sometimes numerous.

On the winter cruise of the "Thor" this species was continually present at all stations in the Eastern Mediterranean except at Naupaktos, but generally rather scarce; at st. 14 in the southern Adriatic it was only present singly, otherwise with a rel. frequency of 1 to 5 %; at st. 15 in the Straits of Otranto, however, 10 %. It was present at all stations off Naples except one (25), but scarce, 1 to 2 %. In the Ligurian Sea and the northern Balearic, (st. 36), it was wanting; off the coast of Sardinia, however, present everywhere, but very scarce, singly to 1 %, and in the region of the Atlantic Current only present singly at one or two stations, (45 and perhaps 55), 1 %. In Cadiz Bay it was wholly absent, also in summer.

On the summer cruise it was not found before at st. 115; and so, wholly absent in the Atlantic Current proper. In the Balearic it was wanting at two stations, (117, 119) out of 11, occurring only singly to 1 %; at st. 116, however, there was 5 %. In the Ligurian Sea it was wanting at one station,

(125), at the three others, present in very varying numbers, from 2 % at Genoa to 20 % at st. 123. In the Tyrrhenian Sea it was present everywhere, often abundant, but again in very varying numbers, from 1 % in the surface of st. 128 to 25 % in the surface of st. 129. Off Tunis, in the south-eastern Balearic, it was very scarce; wanting at st. 135 and in Tunis harbour, but numerous towards Sicily, (st. 138 15 %, st. 139 5 %); in the Sidra Sea abundant at the two western stations, 143, 145 (15 %) and at st. 147, (10 %), but wanting at sts. 140, 151; in the southern Ionian Sea 5 % in the surface, at st. 152, wanting at st. 153; in the Levant scarce, singly to 2 %, at st. 160, 0—30 m., 5 %, at one station, (155), wanting; in the Aegean Sea scarce, singly to 3 %, wanting at two stations (162, 180) out of eleven, sporadic to just before the Dardanelles. In the northern Ionian Sea it was present everywhere, with a rel. frequency from 1 % in the surface on the coast of Sicily, (st. 192), to 15 % at the mouth of the Gulf of Corinth. On the return voyage through the Tyrrhenian Sea in August it was only wanting at st. 198, with a frequency from 1 to 5 % in the surface; on the cross-section of the Balearic, wanting at one station (205) out of five, otherwise scarce or present only singly; in the Catalonian Sea everywhere present except at Barcelona, but hence wholly wanting on the rest of the route.

Where samples from deeper water were taken it was present at all stations below the surface, except at the two western stations in the Alboran Sea, (223 and 228), and at sts. 132 (no good samples), 156 and 182 (near Euboea). In most cases it was still present in moderate numbers above 100 m. or less, sometimes more numerous below than in the surface, (st. 128, 0—100 m. 8 %, only 1 % in the surf., st. 160, 0—30 m. and st. 192, 545 m. wire 5 %, singly in the surf., st. 194, 1145 m. w. 15 %, 5 % in the surf., st. 209, 33—80 m. 5 %, 1 % in the surf.), at one station, (163 on the coast of Asia Minor), wanting in the surface.

Fission stages were seen: st. 123, several cells after recent fission and in an incipient regeneration, and at st. 132 many halved cells, between 1 and 2 o'clock a. m., st. 129 (optimum) many cells shortly after fission, 3 to 4 o'clock a. m.; st. 133 halved cells, 9 to 10 o'clock p. m.

The optimum at st. 129, (25 %) answers to a salinity of 37.95 at a temperature of 21°.8.

In summer var. *volans* was almost solely present, chiefly as f. *rectangulatum*; in winter the main species at least was much more numerous and apparently always the prevailing form.

This species was also present in December, 1908, as f. *rectangulatum* in the Bay of Cadiz. It is remarkable both on account of its varying frequency, certainly due to an occasionally much increased rate of propagation — compare above st. 129 under fission — and for the apparent want of emigration from the Atlantic.

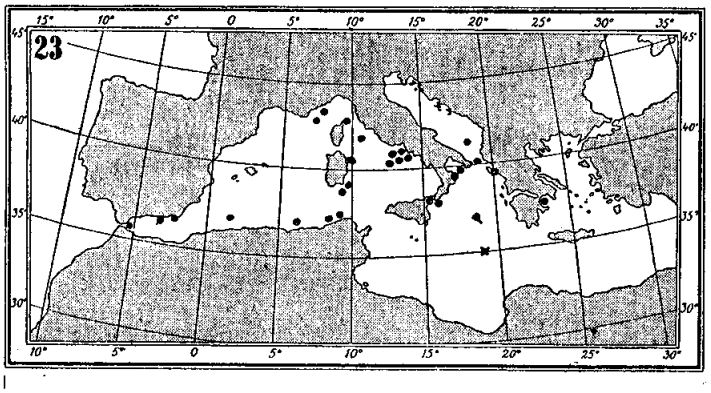
Otherwise this species seems to be common in moderate numbers in the tropical and subtropical regions of the three main oceans, extending far northwards by means of the Gulf Stream. It occurs in the Antilles Current, the Florida Current, the Sargasso Sea, at the Azores (March, August, September, November) and in the Canary Current.

C. carriense is therefore undoubtedly indigeneous to the Mediterranean, where it is found almost everywhere in the Eastern Mediterranean and in the Tyrrhenian Sea, in winter as well as in summer, when it extends to just before the Dardanelles. Its frequency varies greatly (locally), but decreases generally during winter to a low value, to swell occasionally in summer. In the region of the Atlantic Current proper it is seldom found; the stock seems therefore to be almost wholly independent of an emigration from the Atlantic, though such a one may take place from late autumn to spring, but only to a very feeble degree except perhaps in late autumn. In the northern and western regions of the Balearic it is perhaps also (almost?) wanting in winter.

41. CERATIUM PAVILLARDII Jörgensen (Fig. 83 p. 88).

Jörgensen 1911 (b p. 74, pl. IX figs. 157 a, b, 158).

This characteristic species, with the sharp bend at the base of the left posterior horn, was already figured from Naples by Schröder 1900, under the name of *C. tripos* var. *macroceras* f. *undulata*, (pl. 1 fig. 17 m, not k, l), a chain of three individuals. It is most probably the *C. vultur*, which Cleve, (1903), reports from the sea between Sicily and Barca, January 1903, the true *C. vultur* being otherwise unknown in the Mediterranean. Pavillard, (1905), figured it from the Étang du Thau near Cette, (pl. 1, fig. 2, very rare, in Novbr.). Schröder, (1906), reports it from the "Ionian Sea", March 1902, frequent (+). Pavillard, (1907), finds it always present in the Gulf of Lyons in winter, where it is rather frequent, (Pavillard, 1916).



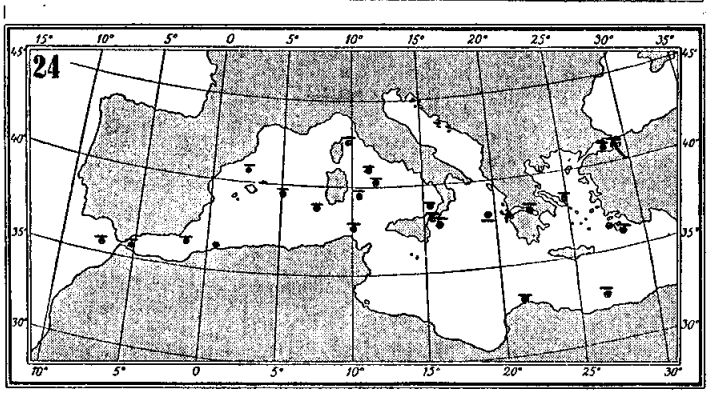


Chart 23. Distribution of *C. Pavillardii* in winter. × Cleve (1903).
Chart 24. Distribution of *C. Pavillardii* in summer.

On the winter cruise of the "Thor" it was present at all stations in the Mediterranean except eight, (the shallow stations Naupaktos, off Naples, 27, 39, 58 and besides 10, 53 and 59), everywhere in small numbers, optimum 5 % at st. 11, in the middle of the Ionian Sea. In Cadiz Bay it was wholly absent (in February).

On the summer cruise it was only observed in the surface at four stations, (161 off Asia Minor, 185 and 186 in the northern Ionian Sea, and st. 220 in the Atlantic Current, off the coast of Africa), but it proved to be present at all stations where deep water samples were gathered, except three (sts. 132, 163, 187). Besides it was present in the depth of the Marmora Sea, where — strange to say — it had its optimum of frequency (st. 170, 20—80 m. and 85—200 m. 10 %, 15.6 to 14°.2, 26.9 to 38.48 ‰; st. 175, 350 m. wire nearly 5 %, 1150 m. w. 1 %). Here, at st. 170, 20—80 m., in the upper layers of the intruding salter water from the Aegean Sea, a cell was also seen in an incipient regeneration after fission, 3 o'clock p. m.; the form occurring here was a thin- and long-horned one, without the alate lists and the conspicuous coarse theca-structure which is so common in this species and its near ally, *C. vultur*. Similar delicate forms were, however, also found at some other stations, f. i. st. 186, 1145 m. wire, and 199, 80—200 m., in both cases accompanying the coarser form.

At the other stations of deep water samples it occurred nearly always only singly: sts. 126, 100—200 m. and 275 m. wire, 128, 0—100 m., 129, 0—80 m., 134, 0—75 m. and 75—125 m., 152 and 156, 250 and 950 m. w., 160, 0—30, 30—100, 100—200 m., 182, 545 m. w., 184, 945 m. w., 3 %, 186, 245 and 1145 m. w., 189, 945 m. w., 192, 545 m. w., 194, 1145 m. w., 199, 80—200 m., 945 m. w., 204, 945 m. w., 206, 1945 m. w., 209, 33—80 m. 3 %, 945 m. w. 5 %, 223, 1950 m. w., and 228, 1145 m. w. Usually then, it seems to occur from somewhat below to somewhat above 100 m. Outside the Mediterranean it was only observed at st. 231 in Cadiz Bay, at 1145 m. wire, singly.

I also saw it in a sample from the Straits of Gibraltar in December, 1908.

Its general distribution is as yet very little known, it is, however, found in all three warmer main oceans. It occurs in the Antilles Current, the Sargasso Sea and at the Azores, (in February).

In this species chains are relatively very frequent. They always prove a preceding fission, but in this species are obviously far more persistent than usual. Chains of two individuals were observed at sts. 12 (2 to 3 o'clock p. m.), 16, (8 to 9 o'clock p. m.), 126, 275 m. w. (9 to 10 o'clock p. m.), 152, 250 m. wire (11 to 12 o'clock p. m.), 194, 1145 m. w. (5 to 6 o'clock a. m.), 160, 30—100 m., 10 to 11 o'clock a. m.), 100—200 m. (11 to 12 o'clock a. m.); chains of three individuals were rarer: sts. 11 (2 to 3 o'clock p. m.), 186, 1145 m. w. (12 to 1 o'clock a. m.) and 209, 945 m. w. (5 to 6 o'clock a. m.).

According to the data stated, *C. Pavillardii* is found in small numbers in the surface throughout the Mediterranean in winter. In summer, however, it is almost wholly wanting in the surface, but present almost everywhere at some deeper level, say 50 to 125 m., usually only singly. It penetrates into the depth of the Marmora, where it is found propagating and relatively abundant in August. There is an emigration from the Atlantic in December to February — probably from late autumn — with some increase in frequency at the eastern stations of the Atlantic Current proper.

42. CERATIUM CONTRARIUM (Gourret) Pavillard (Fig. 84, p. 88).

Pavillard, 1905, (p. 53, pl. 2 fig. 1). *C. inflexum* Jörgensen, 1911, (b p. 76, pl. IX figs. 160, 161).

This common species was already detected by Gourret (1883), who has figured it under three different names, *C. tripos* v. *inflexum* (p. 29, pl. 3 fig. 44), *C. tripos* v. *typicum* (p. 31, pl. 2 fig. 36), and *C. tripos* v. *contrarium* (p. 32, pl. 3 fig. 51). He found it frequent at Marseille. Strange to say, he mentions no connection between the two former new varieties; the latter has been established on account of the frequent mistake, — a reversed symmetry.

Daday, (1888), mentions this species from Naples, as *C. tripos* v. *typicum* Gourret, Schröder, (1900), figures it from the same locality as *C. tripos* var. *macroceras* f. *undulata*, (pl. 1 fig. 17 l, not k, m) and a slightly deviating form as *C. tripos* v. *macroceras* f. *claviceps* (l. c. fig. 17 n). It is certainly included in the *C. flagelliferum* which Cleve, (1903), reports from the Mediterranean, (Octob. 1902, from the Eastern Alboran Sea to Egypt; Jan. 1903 about half-way between Barca and Sicily); most probably these records refer to the present species, with the exception of the latter, which may belong to (or include) the following species (which seems to be absent from the surface in summer). Entz, 1905, (1902), (p. 109 fig. 43), figures a species from the northern Adriatic as *C. tripos macroceros*, which seems to be the present species. Pavillard, (1905), reports it from the Étang du Thau: November to June, maximum in December. Schröder, (1911), found it frequent in the northern Adriatic on the coast of Dalmatia, where it was only numerous in the brackish region. Pavillard, (1916), reports it from the Gulf of Lyons as perennial and very common. De Toni and Forti, (1916), mention it from Genoa.

The oldest varietal name is *C. tripos* var. *inflexum* Gourret, which was used as name for the species by Kofoid 1907, (and by myself 1911). The oldest specific name is *C. flagelliferum*, Cleve, 1900, (p. 14, pl. VII fig. 12), which, however, includes both this and the following species, (see Jörgensen 1911 b p. 77). Pavillard, 1905, named it *C. contrarium*, which therefore attains priority as a specific name; his figure, (1905 pl. 2 fig. 1) is undoubtedly this species.

On the winter cruise of the "Thor" this species was present at all stations east and north of the south coast of Sardinia, (sts. 10 to 42, only wanting at one station off Naples), but was entirely wanting in the region of the Atlantic Current from the eastern part of the Alboran Sea as far as Tunis, (sts. Galita to 55). Farther to the west it was again present at all stations, (sts. 57 to 69), but only scarce, (1 to 2 % of rel. freq.) except at the two western stations in Cadiz Bay (st. 69 10 %). In the Ionian Sea it was generally rather scarce, mean value 3 to 4 %, but at Taormina, 10 %; in the southern Adriatic (st. 14) 5 %, and in the Gulf of Aegina nearly 10 %. In the Tyrrhenian Sea its relative frequency was on an average 3 to 4 %, but up to nearly 10 % at the south-western st. 42. The interrupted distribution in the

region of the Atlantic Current proves that there was no successful migration from the Atlantic in January, nor in February, but perhaps in this latter month an incipient one.

On the summer cruise it appeared first a little north of Cape San Vincent, (st. 86, the first station with a higher salinity, near to 36 ‰), and was hence continuously present except at the shallow station Cadiz, but with an irregular (relative) frequency, varying outside the Straits from less than 1 to 20 % (at the more saline st. 96), on an average 5 %. Farther on it was everywhere present in the Atlantic Current proper, again irregularly varying as to frequency, from 1 to 20 % (at st. 103). Outside that region it was generally scarcer and more discontinuous, now and then wanting, but sometimes, on the contrary, plentiful. In the Balearic, outside the Atlantic Current proper, it was wanting at 5 (out of 15) stations (117, 119, 133, 137, 138), nearly 10 % at st. 120 and below the surface at sts. 126 (120—500 m. and 275 m. wire) and 128 (0—100 m.) in the Tyrrhenian Sea, where it was scarce or mostly wanting in the surface (sts. 127, 128, 129, 131). In the Sidra Sea it was only wanting at the eastern shallow station 151, in the Syrtis Major plentiful, (5 to 10 %); off Barca at st. 152 3 to 5 %, in and below the surface, but at the shallow station 153 only singly; in the Levant wanting at one station, (155), at st. 156 in the surface over 10 %, on an average 5 %; in the Aegean Sea singly to more than 5 %, (sts. 163, 181), only wanting at one station (162); and in the Gulf of Aegina over 20 %. It penetrates into the depth of the Marmora Sea, where it is plentiful in the eastern region: st. 170, 0—20 m. 25 % (optimum), 20—80 m. over 5 % — at this station a long- and thin-horned f. *claviceps* Schröder, but the claviform dilations generally wanting at the tips of the posterior horns —, st. 175, 30 m. wire and 350 m. wire 5 %, 1150 m. w. 2 %, and single cells in the surface at both stations.

Everywhere present in the northern Ionian Sea (1 to 5 %), more plentiful in the middle region, in the Tyrrhenian Sea on the return in August, however, again rare and scarce, wanting at four of eight stations; only somewhat more plentiful in the depth of st. 194 (1145 m. wire 5 %).

On the cross-section of the Balearic it was very scarce and wanting at two stations, (203, 205); in the Catalonian Sea only wanting at one, (212), 1 to 10 %, (sts. 211 and 209, 33—80 %), south-west of the Baleares 1 to 5 %, and thence continuously present and generally numerous in the region of the Atlantic Current proper, singly (at st. 219) to 10 % (sts. 221, 225, 226, Gibraltar). Outside the Straits in September singly or very scarce, except in the depth of st. 231, (over 5 %), and at st. 238 off the north coast of Portugal, where 15 % (the last warm and more saline station). Farther on it was absent.

In deeper water the species proved to be present everywhere. It was only found in the surface at sts. 128, 129 and 199 in the Tyrrhenian Sea, (in July and August), but it was more numerous at several stations below than in the surface, (st. 126 see above, less than 1 % in the surface, st. 120, 0—1100 m. 5 %, absent in the surf., sts. 194 and 209 see above). Strange to say, the optimum was in the Marmora Sea, in remarkably little saline water (st. 170, 0—20 m., salinity only up to 26.9 ‰, temp. 24.8 to 15°.6, between 20 and 80 m., reaching down into the highly saline water from the Aegean Sea, only 7 %). This might suggest that the species is euryhaline, but stenothermous (or thermophilous), which also would explain its occurrence in the brackish region on the Dalmatian coast, (see above).

There are, however, several forms. There is a well-distinguished, long-horned form with elegantly spread and incurved posterior horns, recalling the beautiful f. *inclinatum* (Kofoid) of the much smaller species *C. tenue*. I think we may call it f. *claviceps* (Schröder), as it generally answers to that form, but — as mentioned above — usually wants the dilated claviform horn ends, which are only seldom to be found. The delicate form, which was so numerous in the Marmora Sea, had usually only the left half of the girdle conspicuously developed (i. e. provided with distinct lists), a case frequently encountered in similar summer forms.

Fission stages were frequent in summer: sts. 89, 92 and 113, cells after recent fission (3 to 4 o'clock a. m.), 112 (12^{20} a. m.), 123 (1^{05} a. m.), 134 (5 a. m.), 152, 250 m. wire (11—12 p. m.), 950 m. wire,

st. 143 and st. 156 (12—1 a. m., at the latter station 3 out of 7 individuals in regeneration), 158 (5^{10} a. m.), 161 (3^{10} a. m.), 187, 945 m. wire (6 p. m.), 223 (4^{35} a. m.) and 226 (3 p. m.). Degenerate forms, answering to f. *californiense* of *C. macroceras* (and *gallicum*), were found singly at sts. 96, (9^{40} a. m., here *C. contrarium* was the predominating species) and 33 (6^{30} p. m.); beside this latter case signs of propagation were only seen once in winter (st. 39, a cell in regeneration at 7^{20} o'clock a. m.).

C. contrarium is rather common in the tropical, subtropical and warmer temperate regions of the Atlantic and the Indian Oceans, probably also in the Pacific, where it occurs off the coasts of Japan, at least to 36° N. It is present in the Florida Current, the Antilles Current, the Sargasso Sea, the Gulf Stream, at the Azores (at least in February and July) and in the Canary Current.

In the Mediterranean it is present everywhere, both in summer and in winter, but may be wanting off the African coast (in the Atlantic Current) in winter. It is especially numerous in summer all into the Sea of Marmora, when it is sometimes the predominating species, but with a very varying frequency. During the winter it decreases greatly in numbers, is, however, effectively renewed by a large emigration from the Atlantic in summer, probably going on from early spring to late autumn.

43. CERATIUM TRICHOCEROS (Ehrenberg) Kofoid (Fig. 85 p. 88).

Jörgensen, 1911, (b p. 75, pl. IX fig. 159).

This very long-horned species, very similar to the preceding one, but distinguished by the different direction at the base of the left posterior horn, (see figures 84, 85) and the much smaller "body", was already detected by Ehrenberg, who described it, (1859), as *Peridinium trichoceros* from Trieste and, fortunately, later (in 1873) also figured it. As mentioned under the preceding species it is included with the latter in Cleve's *C. flagelliferum*, which may only be determined by means of Cleve's figure (Cleve 1900 pl. VII fig. 12) which only seems applicable to *C. trichoceros* (cfr. Jörgensen l. c.), though it does not show one of the characteristic features of this species, the correct direction of the left horn at its base, while he especially emphasizes the small dimensions of the body. This disagreement is, however, most probably only due to an incorrect drawing. But the distribution of *C. flagelliferum*, recorded by Cleve and other authors after him, certainly for the most part refers to *C. contrarium*. Both species seem quite independent of each other, in spite of their great similarity.

Schröder, (1911), reports it as frequent in the northern Adriatic in July 1909, as a rule scarce, in greater numbers at the most northern locality, south of Rovigno.

On the winter cruise of the "Thor" it was found present at about half the stations (19 of 37) in the Mediterranean, everywhere only singly to 1 %, except in the Adriatic (st. 14) 2 % (but wanting at st. 15), and off the south-east coast of Italy, where it was somewhat more numerous, (sts. 10, Port Alice and 12, nearly 5 % rel. frequency). It was most rare in the Atlantic Current, where it only was present singly at three stations, (53, 59, 60) in February. In Cadiz Bay it also was very rare: sts. 66, 68, singly. The localities not already mentioned were the following: sts. 16, 18, 20, Taormina, off Naples, 23, 26, 28, 31, 33, 38, 42.

On the summer cruise it was only observed at two stations in the Western Mediterranean: off Naples and at st. 206 in the median Balearic, 1945 m. wire, singly in August. In the Eastern Mediterranean it was only found sporadically in the Ionian Sea and in the Levant (sts. 152, 250 and 950 m. wire, singly, 160, 0—30 m. 3 %, 30—100 m. 14 % (optimum), 185 and 189, 945 m. wire, singly), but was more frequent in the Aegean Sea: st. 163, 0—80 m. 5 %, hence singly in the surface at all stations to the Dardanelles, sts. 164—168, 179, but wanting at the western stations north of Euboea, where it occurred at st. 182 singly at 545 m. wire. In the Dardanelles, only single empty cells were seen, in the Marmora Sea it was wanting.

In summer it was consequently absent from the surface except on the northern half of the west coast of Asia Minor and at the two stations Naples and 185, (at the mouth of the Gulf of Corinth).

The optimum at st. 160, 30—100 m., answers to a high salinity, 38.91 to 39.05 ‰ and a temperature between 15 and 21°.

Fission stages were only seen once, at st. 182, 545 m. w., a cell not completely regenerated after fission, between 10 and 11 o'clock p. m.

Outside the Mediterranean the species is distributed in the tropical and subtropical regions of all three main oceans. It occurs in the Antilles Current and in the Florida Current to north of Cape Hatteras. I have previously seen it from the Straits of Gibraltar and the Alboran Sea in December, 1908, (Jörgensen 1911 b).

Summing up, — *C. trichoceros* is rare and scarce in the Mediterranean except in the Aegean Sea, where it seems to be perennial and able to propagate. Otherwise it is found sporadically in winter in the surface throughout the sea, but is rare and scarce west of Naples. In summer it seems to be exceedingly rare in the Western Mediterranean and is, on the whole, only found exceptionally in the surface outside the Aegean Sea, while below the surface it may be present at intervals. A feeble emigration from the Atlantic seems to go on in winter, probably from late autumn to February.

44. CERATIUM HORRIDUM Gran, s. dilat. (Figs. 86—92 p. 97).

Gran, 1902, (p. 194). *C. intermedium* Jörgensen, 1911, (b p. 83, pl. X figs. 174—176), *C. molle* (l. c. p. 81, pl. IX fig. 170, pl. X figs. 171—172) and *C. tenue* (p. 77, pl. IX figs. 162—166) included.

In working with the Ceratia of the "Thor" it proved impossible to keep *C. tenue* Jörgensen l. c. separate. I found numerous transitional forms, especially in the summer plankton, showing, — in my opinion — that each species may obtain the various distinguishing features, which should characterize the other. For instance, they usually differ greatly in the development of the theca and the horns, *C. molle* being a relatively coarse form, whilst *C. tenue*, and especially the two extreme forms, *C. inclinatum* Kofoid and *C. tenuissimum* Kofoid, being (as a rule), very delicate, with extremely thin horns. There exist, however, forms of *C. molle*, with the same delicate texture and the same long horns as in *C. tenue*. Sometimes forms occur which possess horns that in their proximal half are similar to those of *C. molle*, but show long and thin prolongations, answering to the horns in *C. tenue*. There is also every possible transitional form, from the widely spread posterior horns of *C. buceros*, diverging almost directly from each other, to the more or less parallel horns of *C. molle*.

It has, moreover, proved less natural to keep *C. intermedium* Jörgensen separate from *C. molle*, though they are usually relatively easy to distinguish. On one hand are forms which must probably be referred to *C. molle*, occurring however, as far north as Bergen (the sea off the coast January and October 1901, see Jörgensen l. c. pl. X fig. 175 from the latter locality), and, on the other, a form which must belong to *C. intermedium* (see fig. 86) observed in the Mediterranean in the Alboran Sea (st. 57).

The easiest way of treating the difficult question of listing the more important forms according to their natural relationship, would be to enter them as "small-species" (petites espèces). I prefer, however, to classify them under one common specific name, as this will better answer to the actual conditions.

The oldest name of a form, belonging to this collective species, is *C. tripos* var. *scotica* Schütt, (1892), which however includes *C. macroceros* (see for instance Gran, 1902, p. 195). Cleve, (1896), has likewise figured a *C. tripos* var. *horrida* (l. c. fig. 4) which may be this species, but is at least as likely to represent *C. longipes* var. *oceanicum* Ostf. (both on account of the figure, the description and the distribution). The first certain name is *C. tripos* var. *macroceros* f. *intermedia* Jörgensen, 1899, (p. 42, pl. I fig. 10). This name must, however, now give place to the earliest specific name, *C. horridum* Gran, (1902).

If we try to let this name comprise all the forms mentioned above — i. e. *C. intermedium* Jörg., *C. molle* Kof., *C. inclinatum* Kof., *C. buceros* Zach., *C. tenuissimum* Kof. — we will have a species with a very wide distribution. Therefore a northern form has developed, the subspecies α *horridum* (Gran), distributed as far north as the subarctic waters north of northern Norway, and a southern one. The former comprises the varieties *genuinum* Gran (see fig. 86), *intermedium* (Jörgensen) Gran, with the f. *frigida* Pauls. (f. *gracilis* Jörgensen) and the more delicate form with spread posterior horns, var. *batavum* (Pauls.). If we wish to keep this northern form (or series of forms) distinguished from the southern as a separate species, the corresponding species-name for the southern form must, I think, be *C. buceros* Zacharias s. dilat., this latter name being older than the other specific names in question, viz. *C. inclinatum* Kof., *C. molle* Kof., *C. tenuissimum* Kofoid and (perhaps) *C. claviger* Kof. I shall therefore call this southern series

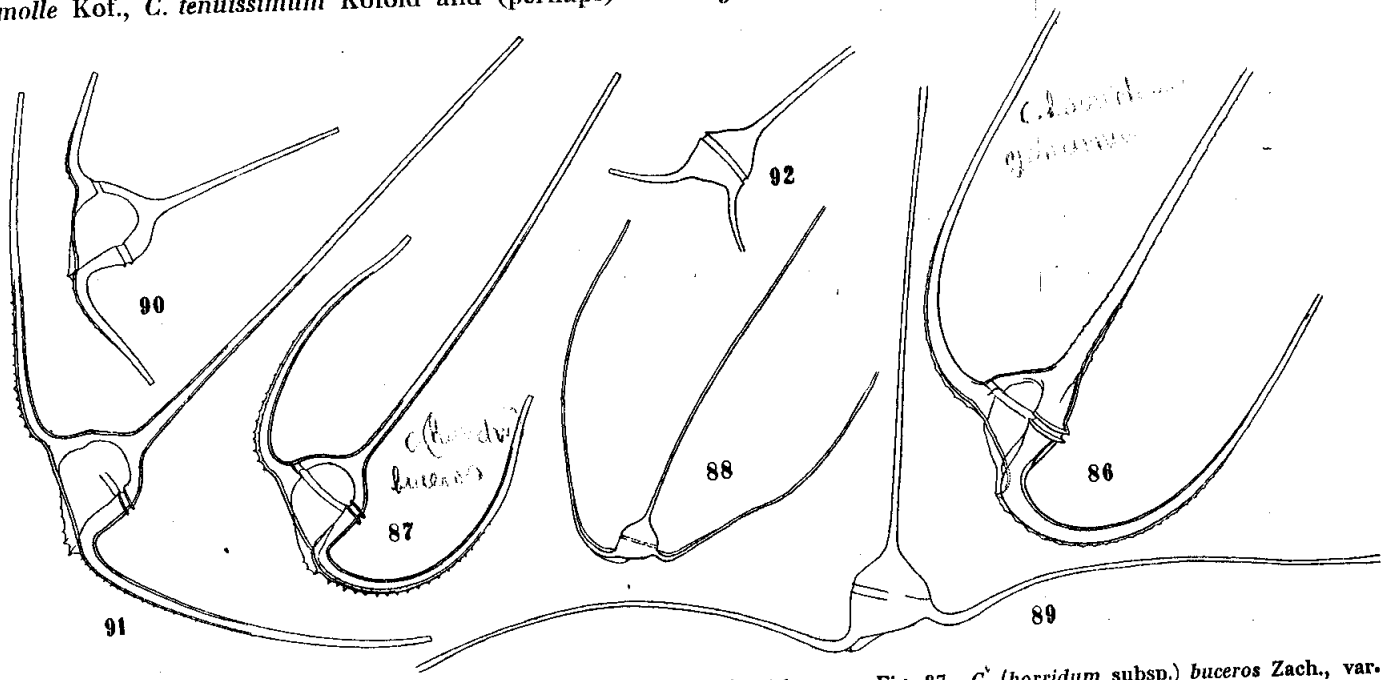


Fig. 86. *C. horridum* Gran, α *genuinum* Gran. St. 57 (Alboran Sea); February. Fig. 87. *C.* (*horridum* subsp.) *buceros* Zach., var. *molle* (Kof.). St. 23 (off Naples); January. Fig. 88. *C.* (*horridum* subsp.) *buceros* Zach., f. *inclinatum* (Kof.). Cadiz Bay, Dec. 1908. Fig. 90. *C.* (*horridum* subsp.) *buceros* Zach. Straits of Gibraltar, Dec. 1908. Fig. 91. *C.* (*horridum* subsp.) *buceros* Zach., var. *denticulatum* n. var. St. 23 (off Naples); January. Fig. 92. *C.* (*horridum* subsp.) *buceros* Zach., a degenerate form, answering to f. *californiense* (Kof.) of *C. macroceros* subsp. *gallicum*. St. 62 (Cadiz Bay); February. Fig. 89. *C.* (*horridum* subsp.) *buceros* Zach., f. *tenuissimum* (Kof.). Cadiz Bay, Dec. 1908. ×125.

of forms subsp. *buceros* (Zacharias), which again comprises more or less coarse forms, var. *molle* (Kof.) (see fig. 87), with more or less parallel horns, and delicate forms, var. *tenue* (Ostenf. and Schmidt), usually with more or less spreading thin horns. The latter variety contains a number of more or less marked "forms", the f. *inclinatum* (Kof.) (see fig. 88), the f. *tenuissimum* (Kof.) (see fig. 89), the f. *buceros* (Zacharias) (see fig. 90), differing only from the preceding in having shorter posterior horns, and the f. *denticulatum* n. f. (fig. 91).

C. claviger Kofoid (see Jörgensen l. c. p. 80, pl. IX figs. 168, 169) undoubtedly belongs to the same series of forms, near the var. *molle*, and it ought probably to be united with that variety only as a form of it, f. *claviger*, remarkable for the dilated ends of the posterior horns. When these claviform ends are present, the form in question is readily distinguishable, but when they are wanting — which seems to be the usual case[1] — it seems most difficult or impossible to distinguish between *C. molle* Kof. and *C. cla-*

[1] My words l. c. p. 81, that the ends are "usually" dilated, were only meant to designate the characteristic of the typical form.

viger Kof. The subtile differences (see Jörgensen l. c. p. 81, under *C. molle*) are insufficient for a certain determination.

For a more detailed description of all these forms I must refer to my monograph. I shall here only mention that the f. *denticulatum* (see fig. 91) is a frequent form in the Mediterranean, with more or less widely spread posterior horns, in this respect intermediate between f. *tenuissimum* (f. *buceros*) and f. *inclinatum*, but coarser than this latter form and usually provided with conspicuously serrate lists at the antapical outline (on and between the horns). It is also figured by PAVILLARD, (1916, pl. I fig. 5).

Perhaps forms of the present species may have occasioned the two figures of *C. minus* and *C. parvum* in GOURRET (pl. 1 figs. 10, 11), the former of which resembles *C. buceros* in the shape of the body, the latter in the small size (transdiameter about 50 μ). Both are figured with very short or almost wanting horns; in certain forms of *C. buceros* the horns are, however, very thin and pale, so that they may be overlooked except in their proximal region. The *C. minus* (l. c. p. 39), was found at Marseilles in November, which may correspond to the occurrence of the present species in the surface.

The first certain record of its occurrence in the Mediterranean seems to be found in ENTZ, 1905, (1902), who figures f. *tenuissimum* from the northern Adriatic as *C. patentissimum*, (p. 109 fig. 42). At least, this figure must represent either *C. tenuissimum* Kofoid or *C. carriense* var. *volans*, but I have myself never seen similar forms of the latter from the Mediterranean. PAVILLARD, (1905), reports *C. intermedium* Jörg. from the Étang du Thau near Cette, (rare from November to May, maximum in December) and from the Gulf of Lyons (1907); he mentions from the latter locality the great variability of the species, especially in regard to the direction of the posterior horns. Later, 1916, he mentions from that Gulf both *C. molle* and *C. tenue* as rather frequent there, but only in winter; besides, he figures (pl. 1 fig. 6), a form, which, with some doubt, he refers to *C. claviger* Kof., remarking that he has never succeeded in observing any claviform dilations of the horns at their tips. He also mentions the near mutual relationship of all these forms and — justly — emphasizes the great accordance between *C. intermedium* and the form which he figures as *C. claviger*.

SCHRÖDER, (1911), only mentions *C. molle*, as rare in the northern Adriatic, (July, 1909).

On the winter cruise of the "Thor" this collective species proved present at all stations except three, (Naples, Galita and st. 50), usually as subsp. *buceros* (= *C. tenue* Jörg. 1911), but not as the typical form or f. *tenuissimum* (Kof.), which was generally rare and especially scarce, but occurred all along the route. Also the coarser form, var. *molle* (Kof.), was rarer and scarcer, rarely reaching 5 % of rel. freq., yet in the Gulf of Aegina 10 %. A form, apparently *C. claviger* without the claviform ends, was seen in several specimens (5 % of rel. freq.) at st. 60 just east of the Straits (in February), and at st. 68 in Cadiz Bay single specimens of the "heteromorphous" form, answering to the f. *californiense* of *C. macroceros* (subsp. *gallicum*) (see fig. 92).

In winter the number of individuals varied in the different regions. In the Ionian Sea there was a mean value of rel. frequency of 10 %; in the southern Adriatic the species was scarce, in the Tyrrhenian Sea on an average, 5 %. In the Atlantic Current from the Straits to Tunis the species was the predominating one and very numerous next to the Straits, (st. 60 30 %, st. 59 25 %), but farther to the east much scarcer, only from 1 to less than 5 %. In Cadiz Bay it was very numerous, on an average 30 % and the predominating species at three of the five stations, up to 45 % (st. 64). The typical form of the subspecies, *buceros*, answering to *C. buceros* Zacharias and the f. *tenuissimum* (Kof.), occurred at about half the number of stations, singly or as very scarce, only somewhat more numerous at st. 20, (5 %), st. 59 (3 %) and st. 60, (5 %). In Cadiz Bay this form was very scarce. The f. *denticulatum* was wanting in the region of the Atlantic Current proper, but was otherwise frequent and often the prevailing form.

In summer the distribution of the species was very different. On the route outwards it appeared for the first time below the surface off the north coast of Portugal, (st. 81, 100 m. wire, single specimens),

but was present in the surface at all stations (except st. 92) from Cape San Vincent to just east of the Straits, (st. 99). In this region the var. *molle* was the most frequent form, at the shallow station Cadiz, numerous, 15 %, otherwise, however, more or less scarce; the typical form of subsp. *buceros* was very rare, only a few specimens at st. 95, likewise f. *inclinatum* (st. 91), whilst var. *tenue* was otherwise somewhat more frequent, (yet only to 1 % of rel. freq.). Within the Straits the species was only exceptionally present in the surface, mostly as var. *tenue*: sts. 98 (var. *molle*), 99, (also var. *molle*), 156, 158 (here also f. *tenuissimum*), 160 (5 %, otherwise, at most 2 %), 163, 167 (f. *denticulatum*), 186, 187, 194 (also v. *molle*), 195, 200 (with v. *molle*), 204, (empty cells), 206, 210, 211, 220. Where samples from deeper water were taken, it proved, however, to be present almost everywhere, but only at a relatively considerable depth, (only absent at sts. 128, 0—100 m. and 192, 545 m. wire). In several of these deep water samples it was abundant: st. 126, 100—200 m. nearly 50 % (var. *molle* scarce), 275 m. wire 25 %, st. 134, 75—125 m. 15 %, and 125—200 m. 40 % (var. *molle*), st. 152, 250 and 950 m. w. 25 % (with f. *denticulatum* and f. *tenuissimum*), st. 156, 250 m. w. 25 % (with f. *denticulatum* and f. *tenuissimum*), st. 160, 0—30 m. 5 % (f. *inclinatum*), 30—100 m. nearly 40 % (almost half the number f. *inclinatum*, f. *tenuissimum* singly), 100—200 m. 30 % (with f. *inclinatum* and single specimens of f. *tenuissimum*, st. 163, 0—80 m. 20 % (with single specimens of f. *denticulatum*), 184, 945 m. w. 10 %, st. 187, 100—190 m. 15 % (with f. *tenuissimum*), st. 194, 1145 m. w. 10 % (with f. *denticulatum*), st. 199, 80—200 m. 50 % (with single specimens of f. *denticulatum*). Accordingly, in the Tyrrhenian Sea it seemed to be most numerous between 100 and 200 m., likewise in the south-eastern Balearic (st. 134), but in the Levant (and the Aegean Sea?) somewhat nearer to the surface. It penetrates with the salt water from the latter sea into the Marmora, where it was remarkably numerous at the eastern station, 170, (20—80 m. 30 %, 85—200 m. even over 50 %, mostly f. *denticulatum*), at the western st. 175, however, only scarce, (350 m. wire 1 %, 1150 m. w. 5 %).

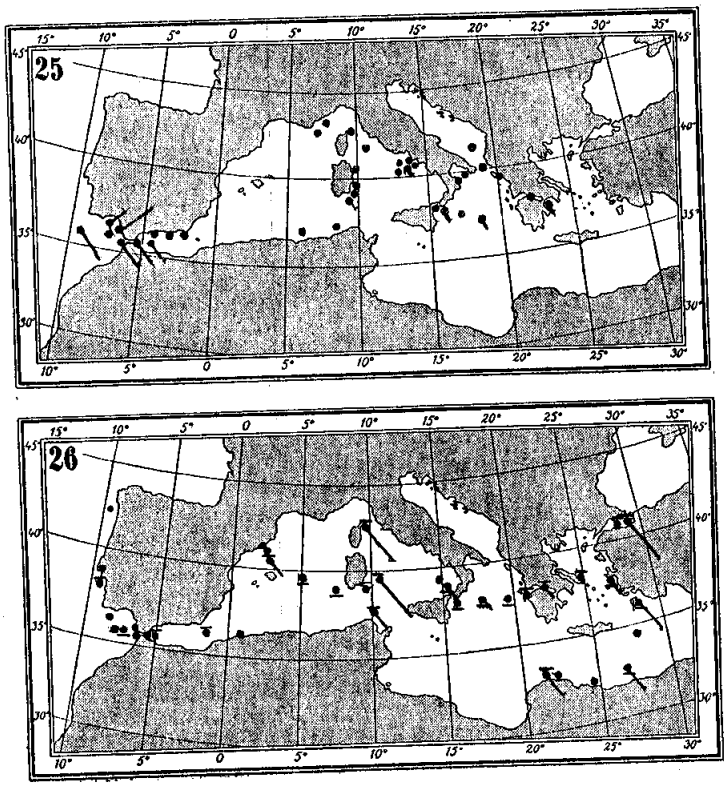


Chart 25. Distribution of *C.* (*horridum* subsp.) *buceros* in winter.
Chart 26. Distribution of *C.* (*horridum* subsp.) *buceros* in summer.

Outside the Straits on the return voyage in September it was scarce at both stations in Cadiz Bay, somewhat more numerous at Lisbon, (5 %), and otherwise only present singly below the surface at st. 234, south of Lisbon, (25—100 m. and 95—200 m.) and at st. 238 near the north coast of Portugal, the last warm and salt station.

F. *denticulatum* was rare and scarce in summer.

Strange to say, fission stages were seen very seldom: st. 89, var. *molle* after fission, 3 to 4 o'clock a. m., st. 126 and st. 160 halved cells, st. 204, 945 m. w., var. *molle* in regeneration, 5 to 6 o'clock a. m. Besides, at st. 68 in Cadiz Bay heteromorphous forms (after a recent fission).

I am afraid that the change in interpretation of this polymorphous species, as proposed here above, and the change of names, will not be considered happy, except in so far as some authors may prefer the collective name *C. horridum* to distinguishing several different troublesome varieties or forms.

This would, however, be a step backwards and must be avoided. One must be careful not to mingle forms, which do not really belong to the same evolutional series. In this case a considerable metamorphosis seems to take place in the course of the year, which we as yet only know insufficiently. The moderately coarse form of the subspecies *buceros*, the f. *denticulatum*, seems, f. i., to be a special winter form of the Mediterranean. As this form is rare in summer, except in the eastern Marmora, while the species is abundant in several localities at that season, this form seems to have been transformed into delicate forms of the var. *tenue* (after a series of fissions).

In summer there was only a feeble trace of an emigration from the Atlantic in June and in September, of var. *molle* and var. *tenue* with f. *tenuissimum*; in winter there was a possibility for a very great immigration into the Mediterranean through the Straits of Gibraltar, but it seems to have attained only moderate success, to judge from the rapid decrease in frequency east of the Straits. The occurrence of so large numbers below the surface in summer is very remarkable, as fission stages were so rarely seen; in this delicate species they may perhaps be more easily overlooked, or the cells in question may be less resistant.

This species is especially well adapted to a drifting with the currents. In the forms with more widely spread horns the lists of the girdle are generally little developed and more or less indistinct towards the right side, which may suggest a more passive drifting than usual. It is the more remarkable that these delicate forms so numerous in the depth are so rare in the surface in summer.

Outside the Mediterranean the subspecies *buceros* seems to be very frequent in the warmer regions of all three main oceans. It occurs in the Antilles Current, the Florida Current, the Sargasso Sea, at the Azores (at least in February and April) and in the Canary Current. It was present from Cadiz Bay to the south-east coast of Spain in December, 1908. The subspecies *horridum* reaches northwards into the Barent Sea, to the southern coast of Iceland and to a line from this region straight to the west as far as towards the cold East-Greenland Current. In the material of the "Thor" from the region between Cadiz Bay and the Channel it was present in June only at the shallow station 84 on the west coast of Portugal, and in September at the remarkably cold st. 239, near Cape Finisterre (a form near var. *batavum* (Pauls.)), but did not become frequent before station 246 west of Brittany and northwards.

To sum up: *C. horridum* subsp. *buceros* is frequent all over the Mediterranean in winter as well as in summer. At the former season it occurs everywhere in the surface, but is only moderately numerous or scarce, in the latter it is very rare and scarce in the surface or mostly absent from there, but is present everywhere at deeper levels, mostly also in large numbers. Both var. *tenue* and var. *molle* emigrate from the Atlantic in winter, probably from late autumn to spring, in summer there is only a feeble trace of such a migration. In the course of the year a metamorphosis of forms seems to take place, producing chiefly delicate forms in summer and moderately coarse ones in winter. A special Mediterranean form of the latter is the f. *denticulatum* (fig. 91).

C. horridum subsp. *horridum* was only observed in the Mediterranean at st. 57, in the Alboran Sea in February, (f. *genuinum*, only less coarse and spiny than in northern regions).

45. CERATIUM LONGISSIMUM (Schröd.) Kofoid (Fig. 93 p. 101).

Jörgensen, 1911, (b p. 82, pl. X fig. 173).

This very rare species was already detected by SCHÜTT and figured by him, (1892 p. 267 fig. V a), but without a denomination. SCHRÖDER re-discovered it at Naples and figured it, (1900 pl. 1 fig. 17 *i*), under the name of *C. tripos* v. *macroceras* f. *longissima*. Later, (1911), he mentions it as very rare in July 1909, off the Dalmatian coast, (Selve and Lucietta, from 100 and 200 m. depth). PAVILLARD, (1916), reports it from the Gulf of Lyons as rather rare and only occurring in winter.

It has proved to be a most characteristic species, hardly to be confounded with any other, especially distinguished by the lack of indentation of the antapical outline — which makes it similar to the

species of the section Tripos — and the very long horns. SCHRÖDER's remark, (1900 p. 16), added to his fig. 17 *i*, "in a somewhat deviating form", made me believe that he had figured a specimen which deviated somewhat from that which he properly wished to designate by the new name, f. *longissima*, so that I was in doubt as to the correct identification of the specimen figured by me (l. c.), from the South Equatorial Current. From his last essay, (1911 p. 48), we learn that the words in question only refer to a slight difference in SCHÜTT's figure, which removes every doubt as to the identity.

On the winter cruise of the "Thor" it was observed at five stations in the Eastern Mediterranean, (sts. 10, 11, 16, 20, Taormina, singly to 1 % of rel. freq.), and at only one in the Western (st. 28 off Naples, singly). On the summer cruise it was only present below the surface at three stations in the Eastern Mediterranean, singly to 1 % (st. 160, near Rhodes, 100 to 200 m., st. 186, 245 and 1145 m. wire, and st. 187, 945 m. w., both in the northern Ionian Sea) and in the depth of the Marmora (st. 170, 20—80 m. 1 %, 85—200 m. 10 %, optimum, 38.45 ‰, 14°.5, and st. 175, 350 and 1150 m. wire, singly).

There were two forms, one answering to the figures quoted, with very long horns, the posterior ones nearly parallel to the apical one and rather close to it, and another form, f. *subdivaricatum* n. f. (fig. 93), usually with shorter posterior horns which are more spread. This latter form was present both in summer (sts. 186, 187) and in winter (Taormina). In the depth of the Marmora Sea the typical form prevailed.

The transdiameter of the Mediterranean specimens varied from 62 to 74 μ, the length of the apical horn from ½ to over 1 mm. The posterior horns were always shorter, the left one from 210 to 910 μ long, the right 170 to 840 μ. The distance *h* was always about 5 μ, *x* in f. *subdivaricatum* $> t$, in the typical form $< t$, *y* in the former ⅓ to ½ *x*, in the latter ¼ to ⅓ *x*, $\angle \alpha_l$ about 75°, $\angle \alpha_r > 90°$, on an average about 100°, $\angle \delta$ 25 to 30°, $\angle \beta$ about 170 to 185°.

Fission stages were not seen except at Taormina, where a cell was found, which seemed incompletely regenerated.

At present I am only able to state a single locality for its occurrence outside the Mediterranean (see Jörgensen l. c.), at 0° 30′ N 18° W, west of the Gulf of Guinea, in the South Equatorial Current, (German South Polar Expedition st. 130).

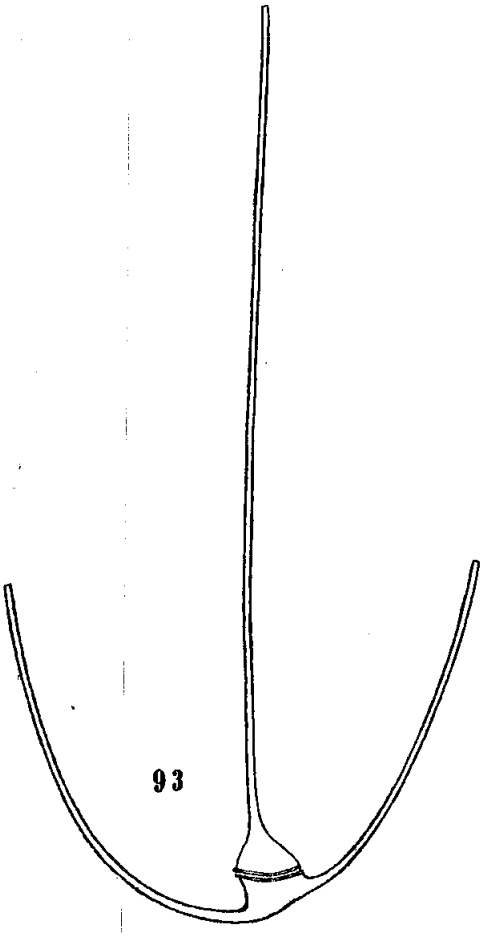


Fig. 93. *C. longissimum* (Schröd.) Kof., f. *subdivaricatum* n. f. St. 186 (Ionian Sea), 1145 m. wire; August.

It seems to be a tropical species which may occasionally emigrate from the Atlantic (in late autumn?), and is carried down by vertical currents in winter and may keep alive for months in the relatively temperate layers of the Eastern Mediterranean. It seems very improbable that it is really indigeneous there.

46. CERATIUM HEXACANTHUM Gourret (Fig. 94 p. 102).

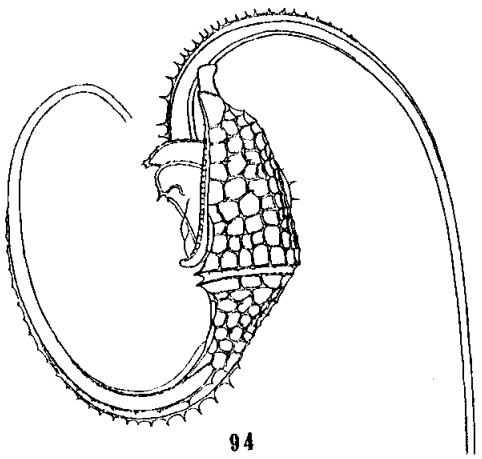
Jörgensen 1911 (b p. 86, pl. X figs. 182, 183).

STEIN already figured a plate of this species from the "Mediterranean", (1883 pl. 17 fig. 3) under the name of *C. tripos* var. GOURRET, (1883), detected it at Marseilles and described it under two different names, *C. tripos* v. *inæqualis* (p. 30, pl. 1 fig. 3) and *C. hexacanthum* (p. 36, pl. 3 fig. 49). The latter name has the priority as a specific name, but the oldest is *C. tripos* var. *reticulatum* Pouchet, (1883, from Brit-

tany). In this case the change of name is a happy one, f. i. to avoid confusion with *C. reticulatum* Imhof (which is *C. hirundinella*).

The first name in GOURRET, *C. tripos* v. *inæquale*, is founded on a poor figure (of pl. 1), where the transverse furrow has been drawn on the wrong side of the right posterior horn. GOURRET has evidently had some difficulty in explaining this figure and was not aware of its great accordance in other respects with that of *C. hexacanthum*, in spite of the characteristic common feature, the reticulations of the theca.

The species is further mentioned by IMHOF 1891, from Venice; by ENTZ, 1905, (1902) from the northern Adriatic, ("*C. trip.* v. *macroceras* f. *inaequalis*", p. 109 figs. 46, 47), by CLEVE, 1903, from the southern Balearic, (2 to 12° E., Octob. 1902), by PAVILLARD, 1905, from the Étang du Thau, (November to June, maximum in December), by ZACHARIAS, 1906, (northern Adriatic November, Naples May and June, Ligurian Coast July 1905), by PAVILLARD, 1907, and 1916, from the Gulf of Lyons throughout the year, varying in numbers), and by SCHRÖDER 1911, from the northern Adriatic, (in July 1909 frequent).



94

Fig. 94. *C. hexacanthum* Gourr., var. *hiemale* Pavill. St. 26 (off Naples); January.

There are several forms. The typical one, figured by GOURRET, is the most frequent and is characterized by the direction of the posterior horns, the left being nearly parallel to the apical one, while the right is directed almost perpendicularly to the latter (see Jörgensen l. c. pl. X fig. 183). As var. *contortum* Lemm. KARSTEN (1906 pl. XXIII fig. 2) has designated the form or forms with the left posterior horn crossing the apical one (more or less obliquely) and tending to be parallel with the right one. Such forms are rather frequent and pass apparently insensibly over into the main species. Var. *contortum* Lemm. is, however, a much more distinguished form, with both posterior horns crossing the apical (but in different planes). In f. *spiralis* Kofoid the left posterior horn is coiled up at its tip in a spiral, the right having about the same direction as in the main species. This form therefore will be easily recognized, when this distal part of the left posterior horn is present; however, specimens found in plankton samples are often in want of these fragile horn ends.

PAVILLARD, (1916 p. 20), figures a special winter form from the Gulf of Lyons, f. *hiemalis*, with the right posterior horn strongly curved dorsally. I think this is the same as is represented in my figure 94, here. It is a robust form, apparently best agreeing with var. *contortum* Lemm., but with the left posterior horn forming an incipient spiral. In an oblique apical view this form has a very characteristic wheel-like appearance; the left horn is curved round ventrally, the right dorsally. In my opinion this form belongs to f. *spiralis* Kof. which varies remarkably in shape in different views.

In the brackish region of the Dalmatian coast at Sebenico, SCHRÖDER has detected a special form, var. *æstuarium*, *C. æstuarium* Schröd. (1911 p. 48), with both posterior horns nearly parallel to the apical one and with a more delicate theca, lacking the complete reticulations and the large winged lists. It was found there abundantly.

On the winter cruise of the "Thor", *C. hexacanthum* was present almost everywhere, only not observed in two samples of a less good condition and at st. 60 near the Straits of Gibraltar. It was generally scarce, single specimens to 3 %, only exceptionally in greater numbers, at st. 12 off Port Alice nearly 10 %. Var. *hiemale* was observed several times as a chain of two individuals, at st. 18, 20, 25, 26, 27, 29, 42 and 45. In Cadiz Bay the species was very scarce, but present everywhere, except at the shallow station, 64.

On the voyage outwards in June, 1910, it appeared singly already in the northern part of the Bay of Biscay (sts. 79, 80), but then not before the station 87 off Cape San Vincent. Hence it was continuously present to a little distance east of the Straits, (st. 99), only wanting at two stations (91, 94), but only in single specimens to 2 % (in the Straits, st. 98). Farther on, in the Atlantic Current proper, it was rare and very scarce, (sts. 108, 112, 113), wanting at most stations, but became suddenly much more frequent, as the route left this current (st. 114 still singly, but st. 115 10 % and st. 116 25 %). Farther on it was present nearly everywhere, but only here and there numerous. In the Balearic it was wanting at one station, but numerous at only three (sts. 115, 116 and 118, here 20 %, otherwise singly to 2 %), in the Tyrrhenian Sea only wanting at one station (125), 1 to 5 %; in the south-eastern Balearic again plentiful at several stations (133, 134, 137, 139, 15 to 20 %, at st. 138 even the predominating species, 30 %), wanting only in Tunis harbour; in the Sidra Sea rather scarce, 1 to 3 %, off Barca rare, wanting at the two shallow coast stations 151, 153; in the Levant everywhere, 1 to 5 %; and in the Aegean Sea only wanting at station 162, but rather scarce, to 3 %, except at the stations 181, 182, where 10 %. It penetrates into the Dardanelles and the Sea of Marmora, where it is present also in the surface, (st. 170, 0—20 m. 5 %, st. 175 1 %), but is more numerous at a deeper level, (st. 175, 30 and 350 m. wire 3 %, 1150 m. wire 1 %). In the northern Ionian Sea it was present everywhere, singly to 5 %, in the depth at st. 186 (1145 m. wire) 10 %, on the return in August through the Tyrrhenian Sea scarce, singly to 2 %, wanting at four (out of eight) stations; on the section through the Balearic present at all stations, 1 to over 5 %; in the Catalonian Sea 1 to 5 %, wanting at one station; and southwest of the Baleares very rare and scarce, only at one (of three) stations, singly. In the region of the Atlantic Current proper it was entirely wanting, in Cadiz Bay, however, present at both stations, though only singly. Farther on only observed in small numbers at st. 237 off the northwest coast of Portugal.

As a rule the species was present everywhere below the surface in the area of its distribution, only wanting at st. 132 and 163 (beside the two stations 223 and 228 in the Alboran Sea). Sometimes it was more numerous there than in the surface, (st. 128 in the surface singly, 0—100 m. 4 %, st. 160 in the surface singly, 0—30 m. 10 %, st. 182 545 m. w. 5 %, st. 186, 1145 m. w. 10 %, st. 187 in the surface, 1 %, 0—25 m. 5 %). In the Eastern Mediterranean it seemed most numerous in the upper layers, just below the surface, (st. 160, 0—30 m. and st. 187, 0—25 m.), but was otherwise generally most frequent in the very surface.

In summer the main form was by far prevailing. The spurious var. *contortum* of Karsten, mentioned above — it might perhaps provisionally be designated by a special name, f. *homomallum* — was seen at some stations in the Eastern Mediterranean, (sts. 152, 163, 182 in the surface and at 545 m. wire) and at sts. 128 and 129 in the Tyrrhenian Sea, 0—100 m. and 0—1100 m., everywhere only singly, except in the surface of st. 182, where there were several specimens. In the Sea of Marmora a similar form prevailed. Here, also, the influence of the fresher water was plainly seen: most of the specimens observed were of a delicate structure with only incomplete reticulations of the theca and somewhat smaller transdiameter than the few coarser individuals, thereby showing some features common with the brackish form *C. æstuarium* Schröd., though with differently directed posterior horns. The var. *hiemale* was only observed once, at st. 152, 250 m. wire, even here not quite certainly.

At station 182, 545 m. wire, a heteromorphous form, answering to the f. *californiense* of *C. macroceros* subsp. *gallicum* was observed. At this station there is fresher water (from the Dardanelles) in the surface.

Fission stages were seen. In winter they were only suggested by the occurrence of chains of two individuals, mostly belonging to the var. *hiemale* (sts. 26, 29, 42, 45, respectively at 6^{40} o'clock a. m., 2^{15} p. m., 9^{40} p. m., 0^{15} a. m.). In summer young stages were seen at sts. 99, 134, 165 and 237, and halved cells at sts. 123, 126, 129, 132, 133, 136, 138, 158, 182, 186. In this long-horned species, damaged cells

and fragments of such will be frequently found, probably especially when a fission or a regeneration is going on.

The winter optimum was at st. 12 in December, with a salinity probably close to 38 ‰ and a temperature of 14°.2, in summer at st. 138 between Tunis and Sicily (30 ‰, 37.57 ‰, 23°.5, July).

An emigration from the Atlantic takes place in January and February, accompanied by an indistinct increase of frequency to the east — which may either suggest a feeble (increasing) propagation eastwards or a more plentiful migration in January than in February — probably from late autumn to (late?) spring. In June there were signs of a feeble migration, but none in September.

Outside the Mediterranean the species seems to be frequent — but apparently nearly always scarce — in all warmer seas. In the Atlantic it is present in the Antilles Current, the Florida Current, the Gulf Stream — which it follows up to between the Norwegian west coast, (Aalesund), and Iceland, July 1898, CLEVE, (1901 a) — at the Azores, (apparently all the year) and in the Canary Current.

C. hexacanthum is thus indigeneous to the Mediterranean, occurring throughout the sea in winter as well as in summer, (at the latter season) reaching the Sea of Marmora, where it is only numerous below the surface. It reaches its greatest frequency in summer (July), at a moderately high salinity in the median regions of the sea. In winter it would probably become very scarce but for a successful emigration from the Atlantic, apparently going on from late autumn to late spring or early summer.

III. GENERAL ACCOUNT OF THE RESULTS OF THE INVESTIGATIONS OF THE "THOR" AS REGARDS THE CERATIA.

1. General remarks on the distribution of the species. Indigeneous and allogeneous species.

A characteristic feature of the Mediterranean plankton is the occurrence of a considerable number of "winter species", which are either entirely wanting in summer plankton or at least more or less rare and scarce at that season. (Compare f. i. PAVILLARD, 1905, 1907 and 1916). The material of the "Thor" has proved, however, that these species are generally also present in summer, but only — or almost only — at deeper levels. In fact there is only a single species which is exclusively hibernal, *C. geniculatum*.

The number of such winter species is surprisingly great, almost half the total number of species, and — strange to say — among these winter species, are found just those of a more decidedly tropical or subtropical character, as *C. digitatum, C. belone, C. Kofoidi, C. geniculatum, C. lunula, C. platycorne, C. palmatum* and *C. trichoceros*. Other species of a similar distribution, — chiefly at a deeper level in summer, but in winter in the surface — are *C. gravidum, C. setaceum, C. euarcuatum, C. gracile, C. arietinum, C. azoricum, C. Pavillardii* and *C.* (*horridum* subsp.) *buceros* (*C. tenue*), together with *C. longissimum*, which was not observed in the surface in summer, and *C. incisum*, a tropical species, which was only found at one station in the Levant below the surface.

SCHRÖDER, (1906), reports the latter species from the "Ionian Sea", (HUNDHAUSEN, March 1902), together with *Ceratium Schroeteri*. I have, however, above (p. 8) mentioned that the geographical position (in Schröder l. c.) does not answer to that sea. Moreover, as this sample is also said to contain *Dinophysis miles*, Cleve, a species which hardly may be confounded with any other, I should think it most probable that this sample has been taken outside the Mediterranean (perhaps in the Arabian or the Red Sea).

A common feature of these "winter species" is that they are evidently more or less dependent on an emigration from the Atlantic through the Straits of Gibraltar, taking place in the colder season. From the material of the "Thor", only a February migration can be directly traced, based on the frequency of the species in question in Cadiz Bay and the Alboran Sea, from which regions only samples from February, 1909, are at hand. Indirectly, however, the observed winter distribution may also give some evidence of the probable rate of migration in other seasons. Thus, specimens found at stations 45 and 46 prove a migration through the Straits in January, and the presence of the species at the stations off Naples, (sts. 23 to 28), and off the south-east coast of Sardinia, (sts. 39 to 42), are most probably due to a late autumn migration, about in November, provided that the species is rare or wanting in that region in summer. Reasoning thus, I have stated above, in Chapter II, under each species the rate of migration, which seems to be probable from its distribution. In some cases the signs of such a migration are only few and discontinuous, or almost wanting, for instance in *C. digitatum* and, still more so, in *C. incisum*; this is, however, to be expected in the case of such rare species, and is by no means a proof that they are truly indigeneous.

I think there can be no doubt but that the species which immigrate into the Mediterranean from the Atlantic through the Straits of Gibraltar come chiefly from the median or southern region of the Gulf Stream which passes in the neighbourhood of the Azores or immediately north of them, and reaches the Spanish Peninsula at about Cape Finisterre, there dividing into a northern and a southern branch. This latter carries the organisms on to the Straits, if they are not directly transported into the Bay of Cadiz through more southerly flowing parts of the same current. Comparing the distribution of the species in- and outside the Mediterranean, as stated above in Chapter II, we see that they are all found in the Florida Current or at the Azores, with the sole exception of *C. longissimum*, which, however, judging from SCHÜTT, 1892, — who figures it without a denomination as fig. V a, page 267 — seems also to have been observed by him in the Florida Current. On the other hand, only a small number of species are known from the Florida Current without being as yet observed in the Mediterranean, viz. *C. breve*, *C. contortum* (verum), *C. longinum*, *C. vultur*, *C. sumatranum* and *C. reflexum*.

I shall try to explain briefly, how this startling state of things seems to me to come about — that just the subtropical species invade the Mediterranean in the colder season, and thence pass into the inhospitable deeper layers of the Eastern Mediterranean.

On account of the more or less long journey before these species reach the Straits of Gibraltar they may be expected to arrive there in another season than that in which these subtropical species extend farthest to the north. This will probably be in the northern summer off the American Coast north of Cape Hatteras, and they are therefore not likely to reach the Spanish Coast before several months later. The northern branch of the Gulf Stream, passing north of the Spanish Peninsula, carries some southern species up to the entrance of the Channel, f. i. *C. candelabrum*, *C. platycorne*, var. *dilatatum* and var. *compressum*, *C. gibberum*, *C. azoricum* and *C. hexacanthum* (see Jörgensen 1911 c), and they arrive here partly in late autumn (November), but mostly in February. The appearance of such species in Cadiz Bay in late autumn to winter and early spring seems therefore natural.

A comparison of the hydrographical conditions off the coast of Portugal and in Cadiz Bay in June and September proves a greater salinity and a higher temperature in these regions in the latter month. I myself possess some notes on observations from December, 1908. In the Straits of Gibraltar Dec. 6th there was a salinity of 36.76 $^0/_{00}$ and a temperature of 18°, a little west of Cadiz 36.63 $^0/_{00}$ and 17°.5, and off the south coast of Portugal Dec. 7th 37.07 $^0/_{00}$ and 18° at a spot, answering to about 15 miles north-west of st. 89. These figures, which are likely to be trustworthy at least as regards the salinity, seem to show a high salinity and temperature in Cadiz Bay as late as in the first half of December.

The immigration into the Mediterranean through the Straits of Gibraltar of the subtropical winter species mentioned above therefore probably, for the main part, takes place in late autumn.

But how is it that they appear (almost) only below the surface in the inner Mediterranean in summer?

The following will, I think, be a natural explanation of this strange fact. In winter, the Atlantic Current carries in (slightly) warmer water in the western region of the Mediterranean; this will keep to the surface, as its salinity is lower than that of the Mediterranean water. The species, immigrating at this season in and near the surface of the Straits, will be likely to be distributed in the surface, which answers to the distribution found by the "Thor" in winter, when plankton was only gathered in the surface. This cools down at that season, causing vertical currents which until the middle of winter gradually extend deeper. On account of these movements a mixing of the layers takes place, producing a more or less uniform condition, of plankton as well as of salinity and temperature. Consequently, some of the organisms in the surface will be carried down to deeper layers, and some from the latter will be raised to the surface.

After the winter-minimum has been reached, this mixing of the layers down to the more saline ones will cease, and the organisms remain at practically the same level. On account of the horizontal movement the uniform distribution in a vertical direction will, however, gradually give place to a most heterogeneous one, with different species at different levels. The layers near the surface glide away, making room for new ones, with species from a later migration or derived from other parts of the sea. This movement must be supposed to become gradually slower towards the depth, so that the respective layers answer better to the state of things in winter, the nearer they are to the hydrographical winter minimum (which, however, probably will sink slowly).

So far, I think, all is clear. Where samples from deeper levels were taken, during the summer cruise of the "Thor", the plankton in the upper layers down to a small depth, where only a diurnal mixing up, due to the cooler nights, takes place, — as deep as 10 or seldom to 25 m., — was uniform and answered to that of the very surface; in greater depths, however, it was quite different, usually also different at different levels. This deep water plankton contains just the surface species of the winter samples.

What then has become of the plankton in the surface layers?

In those regions of the sea which are immediately influenced by the Atlantic Current — in just these regions the vertical movement of winter cannot extend far towards the depth on account of the much more saline layers beneath — the corresponding surface layers may be sought farther in, in the direction of the current. Sometimes, though not often, winter species, which otherwise are only found at a greater or less depth, have been found here and there in the surface in summer at sts. 160 to 167 off the coast of Asia Minor, — more frequently, both in the surface and deeper, at the stations in the northern Ionian Sea. Some signs were present that the plankton of deeper layers at more westerly situated stations answers to that of less deep ones at more easterly stations. This was seen by a comparison between stations 152, 156 and 160. Such a comparison cannot, however, be easily made, as the "wire-samples" do not allow a definite determination of the depth, in which the sample in question was gathered. A special investigation of the deep sea plankton is desirable and will probably give great results.

In contradistinction to the "winter species", those which immigrate into the Mediterranean through the Straits in summer, together with those which do not immigrate at all, are distributed over the surface also in summer. They are also found below the surface. There is, however, the essential difference, that, while the winter species are generally more numerous or at any rate not scarce at deeper levels, the latter is generally the case with the summer species, which are often almost wanting there. While there is not a single winter species which does not occur in summer at deeper levels in the Eastern Mediterranean,

provided that it has been able to reach this part of the sea, it is, however, not possible to find any species, immigrating exclusively in summer, which might be used as a test, whether an organism, also under these circumstances, would appear below the surface in summer.

It appears to be a general law that the Atlantic Current in summer — or properly in July — already in the region off Tunis carries the transported surface organisms down below the surface. Apparently this view is strongly supported by the hydrographical data, which show that the well-marked minimum of salinity at the important station 134, is to be found considerably below the surface, at about 50 m. Hydrographers, however, seem to ascribe this striking fact only to the concentration of the surface water by evaporation, which of course undoubtedly plays an important part. Though I am not well enough informed on the matter to have a sufficiently well-founded opinion on this subject, at present, it seems to me possible that the Atlantic water has here sunk to a small depth, as it must be supposed to have passed the Straits of Gibraltar early in the spring, presumably in May or April (the layer at 50 m.). I am in possession of a plankton sample from the Straits in May (14th, 1909), which is indicated as belonging to water of a high salinity, 37.3 $^0/_{00}$, but of a remarkably low temperature, 13°. This seems strange (if it is not a question of water, raised from the depth, see below). It seems, however, probable that the temperature at that time may have been lower outside the Straits than in the Mediterranean, and it may then be probable that this water, running quickly east-wards, where the temperature probably increases, may be covered by the surrounding water of the Mediterranean.

It is also possible that organisms can not stand the influence of the burning sun in the height of summer, and perhaps of the increasing salinity in the surface. A primary consequence of such an influence might be a reduced locomotion, which would cause the cells to sink down and accumulate in deeper layers. This would explain the fact that in summer certain species are wholly wanting in the surface, but may be found in great numbers at a deeper level, and in such cases mostly at a considerable depth. This is the case with *C. horridum* subsp. *buceros* (*C. tenue*) for instance, a very delicate species, which is likely to be easily carried on by movements of the water.

The "winter species" are generally obviously "allogeneous", not indigeneous, seeming more or less distinctly dependent on an emigration from the Atlantic through the Straits of Gibraltar. On the contrary, most of the "summer species" are more or less independent of such an invasion and may therefore be considered indigeneous. No definite limit can, however, be drawn between allo- and indigeneous species, and it is sometimes quite impossible to decide definitely, whether the species in question justly belongs to the former or to the latter group. All species are "perennial" in the Mediterranean in the sense that they are found there in summer as well as in winter, two only excepted, *C. geniculatum*, which is only observed in winter, and *C. incisum*, which (on the cruises of the "Thor") was only caught in summer. In very rare species, which are most probably allogeneous, the traces of an emigration from the Atlantic may be very scarce or wholly wanting, (*C. incisum*), — while in common species, which in every respect make the impression of being indigeneous, a migration may be obvious.

One of the best distinguishing features should be the power of propagation. On account of this I have noted cases where fission stages, or incompletely regenerated cells, were seen. Though these notes are certainly incomplete, and a number of cases are likely to have been overlooked, there has yet proved to be relatively few species, where no propagation was observed (*C. euarcuatum*, *C. azoricum*, *C. belone*, *C. incisum*, *C. falcatiforme*, *C. geniculatum*, *C. horridum* subsp. *buceros*, *C. Kofoidii*, *C. longirostrum*, *C. longissimum*, *C. ranipes* and *C. platycorne*), and in at least two of these (*C. euarcuatum* and *C. buceros*) the very irregular frequency points definitely towards an occasional fission. Besides, several of these species are so rare — which, however, at once proves the absence of a lively propagation — that fission stages are likely to be overlooked. In several species only a single fission stage was observed, always in summer (*C. digitatum*, *C. setaceum*, *C. strictum*, *C. teres* and *C. trichoceros*). The number of fission stages was gener-

ally less in winter than in summer, also relatively, taking into consideration the greater number of summer samples. The "summer species" usually showed many more cases of fission in summer than in winter, while the reverse was the case in the winter group, where, however, fission was on the whole much rarer.

I have already repeatedly mentioned the occurrence in the Mediterranean of decidedly tropical or subtropical species. They are as a rule more or less distinctly confined to deeper levels of the Eastern Mediterranean in summer and show no (or very rare) propagation. True northern species, with an exclusively northern distribution, do not occur in the Mediterranean, except some doubtful individuals in exceptional cases, *C. tripos* var. *atlanticum* and *C. horridum*. On the other hand, there are cosmopolitan species with more or less distinctly distinguished northern and southern forms, f. i. *C. furca*, *C. fusus* and *C. horridum*, of which these southern forms are Mediterranean, and species with a chiefly southern distribution, but which extend northwards to the region between Cadiz Bay and the Channel, (*C. arietinum*, *C. azoricum*, *C. gibberum*, *C. gracile*, *C. hexacanthum*, *C. platycorne* (var. *dilatatum* and var. *compressum*)). Of these latter species northern forms may be present.

2. Ceratia as indicators of currents. Hints for future investigations.

Among the numerous samples of the "Thor" I have searched for those in such immediate communication with each other, that the plankton of one of them might be supposed to reappear (mainly) at the others. I think I have found such communication between the winter stations off Naples, (sts. 23 to 28) and those off the south-eastern coast of Sardinia, (39 to 42). The connection appeared both in the occurrence of the same species and in the frequency of the latter. Only in six out of thirty nine cases (15 %) was no accordance observed, and in all these cases this was due to the absence at one group of stations of species which at the other only occurred singly or in very small numbers. Between stations 25 and 40 this gives a mean velocity of 12 miles a day, for the latter half of January.

A similar communication — in 31 of 39 cases — seemed to exist between sts. 108 and 134, in the surface, giving a mean velocity of 25 miles a day, in June—July, for that region, between sts. 134 and 194 at some deeper level, answering (for st. 134, 75—125 m.) to 6.2 miles a day in July—August, and between sts. 106 and 217 (only 2.7 miles a day). The latter connection (apparently observed in 32 of 39 cases) does not answer to the hydrographical report, but seems to be supported by experiments (4 and 5) with driftbottles and by the hydrographical data.

Though the cruises of the "Thor" have given a relatively complete picture of the distribution of the Ceratia in the Mediterranean, still much is left for future investigations. Firstly the plankton of the Eastern Mediterranean, which hitherto is too little known. Then the distribution of the Ceratia in late autumn, about in November, and perhaps in April—May. As is mentioned above, the deep sea plankton should be thoroughly studied, also in winter, e. g. to state whether the tropical and subtropical plankton of deeper water in summer is also present in winter in the inner regions, in the surface and beneath. Perhaps these species may survive the winter here on account of the inconsiderable variation of salinity and temperature.

I think it might be of great importance, if the route were chosen with the purpose of obtaining a communication between several stations in the way mentioned above, so that the same plankton might be studied in two or more regions of the sea. With the present knowledge of hydrography this could be done without difficulty.

IV. LITERATURE

Claparède et Lachmann: Études sur les Infusoires et les Rhizopodes, 2. Mém. de l'Inst. Génevois, tom. V—VI. Génève 1858—59.

Cleve, P. T., 1896: Report on the Phyto-Plankton collected on the Expedition of H. M. S. "Research" 1896. 15th annual Report of the Fishery Board of Scotland, part III, no. X.

— 1900: Notes on some Atlantic Plankton-Organisms. K. Sv. Vet. Akad. Handl., Bd. XXXIV No. 1. Stockholm 1900.

— 1901 a: The Seasonal Distribution of Atlantic Plankton Organisms. Göteborg 1900.

— 1901 b: Plankton from the Southern Atlantic and the Southern Indian Ocean. Öfvers. K. Sv. Vet. Ak. Förh. 1900, No. 8. Stockholm 1901.

— 1902: Additional Notes to the Seasonal Distribution of Atlantic Plankton Organisms. Göteborg 1902.

— 1903: Report on Plankton collected by Mr. Th. Wulff during a voyage to and from Bombay. Arkiv för Zoologi utgif. af K. Sv. Vet. Ak., Bd. I. Stockholm 1903.

Daday, E. v.: (Systematische Übersicht der Dinoflagellaten des Golfes von Neapel). Természetrajzi Füzetek 1887—88. In Hungarian. De Toni e Forti in Atti d. Real. Ist. Veneto d. Sc., L. & A. 1916—17, tom. 76, 2.

Ehrenberg, C. G., 1859: Über das Leuchten und über neue mikroskopische Leuchtthiere des Mittelmeeres. Monatsber. d. Berliner Akad. 1859.

— 1873: Die das Funkeln u. Aufblitzen des Mittelmeeres bewirkenden unsichtbar kleinen Lebensformen. Festschrift z. Feier des 100-jährigen Bestehens d. Gesellschaft naturf. Freunde zu Berlin. Berlin 1873.

Entz, G., jun. 1905 (1902): Beiträge z. Kenntnis d. Peridineen. Math. u. naturwiss. Ber. aus Ungarn, Bd. XX. Leipzig 1905.

— 1909: Über die Organisationsverhältnisse einiger Peridineen. Math. u. naturwiss. Ber. aus Ungarn, Bd. XXV.

Gourret: Sur les péridiniens du golfe de Marseille. Ann. d. Musée d'hist. nat. de Marseille, Zool., tom. I, no. 8. Marseille 1883.

Gran, H. H., 1902: Das Plankton des Norwegischen Nordmeeres. Rep. on Norweg. Fishery- a. Marine-Investigations, vol. II, no. 5. Bergen 1902.

— 1911: Hjort, The "Michael Sars" North Atlantic Deepsea Expedition 1910, p. 368. The Geographical Journal, vol. 37, no. 4.

Jörgensen, E., 1899: Protophyten u. Protozöen im Plankton aus der norwegischen Westküste. Bergens Museums Aarbog 1899, no. VI. Bergen 1900.

— 1911 a: in Year Book of the Carnegie Institution of Washington, no. 9, department of Marine Biology, annual report 1910.

— 1911 b: Die Ceratien. Leipzig 1911.

— 1911 c: Ceratium, in Resumé des observations sur le plankton des mers explorées 1902—1908. Bulletin trimestriel du conseil permanent international pour l'exploration de la mer, II. Copenhague 1911.

Karsten, G., 1905: Das Phytoplankton des Antarktischen Meeres. Wissenschaftliche Ergebn. d. deutschen Tiefsee-Expedition auf dem Dampfer Valdivia 1898—99, Bd. II, Teil II, Lief. 1. Berlin 1905.

— 1906: Das Phytoplankton des Atlantischen Ozeans. Ibid., Lief. 2. Berlin 1906.

— 1907: Das indische Phytoplankton. Ibid., Lief. 3. Berlin 1907.

Kofoid, C. A., 1907 a: New Species of Dinoflagellates. Bulletin of the Museum of Comparative Zoology at Harvard College, vol. L, no. 6. Cambridge, Mass., 1907.

— 1907 b: On Ceratium eugrammum and its related species. Zool. Anzeig., Bd. XXXII, pp. 25—28.

— 1907 d: Dinoflagellates of the San Diego Region, III. Univ. of California Publications in Zool., vol. III, no. 13. Berkeley 1907.

— 1908: Notes on some obscure species of Ceratium. Ibid., vol. IV, no. 7, 1908.

Krümmel: Handbuch d. Oceanographie.

Lohmann: Untersuch. z. Feststellung des vollständig. Gehaltes d. Meeres an Plankton. Wiss. Meeresuntersuch. hrsgb. v. d. Kom. z. Untersuch. d. deutschen Meere in Kiel u. d. Biol. Anst. auf Helgoland, Abt. Kiel. N. F., Bd. X. Kiel 1908.

Nielsen, J. N.: Hydrography of the Mediterranean and the adjacent waters. This Report vol. I p. 77. Copenhagen 1912.

Okamura a. Nishikawa: A List of the species of Ceratium in Japan. Annot. Zool. Japon, vol. V, 3. Tokyo 1904.

Ostenfeld, C. H., 1903: Phytoplankton from the sea around the Faeröes. Botany of the Faeröes, II. Copenhagen 1903.

Ostenfeld og Paulsen, 1904: Planktonprøver fra Nord-Atlanterhavet. Meddelelser om Grønland XXVI. Kjøbenhavn 1904.

Ostenfeld og Schmidt: Plankton fra det røde Hav og Adenbugten. Vidensk. Meddel. fra den naturhistoriske Forening i Kjøbenhavn 1901.

Pavillard, J., 1905: Recherches sur la flore pélagique de l'étang du Thau. Trav. de l'Inst. Botan. de l'Univ. de Montpellier, sér. mixte, no. 2. Montpellier 1905.

— 1907: Sur les Ceratium du Golfe du Lion. Bull. de la Soc. Bot. de France, LIV. Paris 1907.

— 1909: Sur les Péridiniens du Golfe du Lion. Ibid., LVI. 1909.

— 1916: Recherches sur les Péridiniens du Golfe du Lion. Trav. de l'Inst. Botan. de l'Univ. de Montpellier, sér. mixte, no. 4. Cette 1916.

Pouchet, G., 1883: Contribution à l'hist. d. Cilio-flagellés. Journal de l'anat. et de la physiol., XIX. Paris 1883.

— 1893: Histoire naturelle, in Voyage de "La Manche". Nouv. Arch. d. miss. scientif., tom. V.

Schiller, J.: Bericht üb. die botan. Unters. u. deren vorläufige Ergebn. der III. Kreuzung S. M. S. "Najade" im Sommer 1911. Oesterr. bot. Zeitschr. Jahrg. 1912 No. 10.

Schröder, B., 1900: Das Phytoplankton des Golfes von Neapel. Mitteil. ans d. zool. Station zu Neapel, XIV. Berlin 1900.

— 1906: Beiträge z. Kenntnis des Phytoplanktons warmer Meere. Vierteljahrschr. d. naturf. Gesellsch. in Zürich, Jahrg. 51. Zürich 1906.

— 1911: Adriatisches Phytoplankton. Sitz.-ber. d. kais. Ak. d. Wiss. in Wien, math.-nat. Kl., Bd. CXX, Abt. 1.

Schütt, F., 1892: Das Pflanzenleben d. Hochsee. Ergebn. d. Plankton-Exped. d. Humboldt-Stiftung, Bd. I. Kiel u. Leipzig 1892.

— 1895: Die Peridineen d. Plankton-Expedition, I. Ibid., Bd. IV. 1895.

Stein, F. R. v.: Die Naturgeschichte d. arthrodelen Flagellaten. Der Organismus d. Infusionstiere, Bd. III, 2. Leipzig 1883.

Stüve, W., 1909: Phytoplankton aus dem Nord-Atlantik im Jahre 1898 u. 1899. Engler's Botan. Jahrb. f. Syst., Pflanzengesch. u. u. -geographie, Bd. 43.

Vanhöffen, E.: Die Fauna u. Flora Grönlands. Grönl.-Exped. d. Gesellsch. f. Erdkunde zu Berlin 1891—93, Bd. II, Teil I. Berlin 1897.

Zacharias, O., 1906: Über Periodizität, Variation u. Verbreitung d. Planktonwesen in südlichen Meeren. Archiv f. Hydrobiologie u. Planktonkunde, Bd. I. Stuttgart 1906.