MARINE BIOLOGICAL ASSOCIATION OF INDIA

MEMOIR II

THE DINOPHYCEAE OF THE INDIAN SEAS
PART I. GENUS CERATIUM SCHRANK

BY

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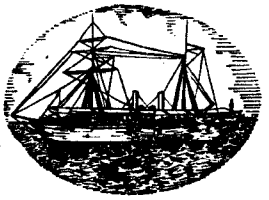

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DEDICATED TO THE MEMORY OF THE LATE

PROFESSOR M. O. PARTHASARATHY IYENGAR

EMERITUS PROFESSOR OF BOTANY,

UNIVERSITY OF MADRAS,

FOREWORD

The microscopic plant life in the sea plays a very vital primary role in the food chain therein by conversion of the inorganic nutrients into organic matter by photosynthesis. Amongst the autotrophic planktonic organisms the Dinophyceae come next in importance to the Diatomaceae. However, our knowledge of this class is far from complete and at present there is no account dealing with all the known species, particularly for the Indian Ocean region. The present Memoir will help to fill this long felt need.

Dr Subrahmanyan, the author of this Memoir is an algologist of international reputation and has been working on marine phytoplankton for over 25 years. His contributions to our knowledge of the marine phytoplankton of the seas around India are too well known to need any special mention. His account of the marine Diatoms of the Madras coast has become a standard reference for this class of algae in this region.

In this first part of the present Memoir, the most important genus, *viz.*, *Ceratium* of the Class with 78 known species and one new species from the Indian seas are dealt with. The other genera of the Class will follow.

Dr Subrahmanyan deserves high appreciation and compliments for taking pains to bring out a publication of this kind which is bound to serve as a useful work of reference for a long time to come. It is hoped that the Memoir will be well received by all interested in the systematics and ecology of plankton organisms in this country as well as outside.

The Marine Biological Association of India has great pleasure in placing this Memoir, the second in the series, before the scientific world.

Central Marine Fisheries
Research Institute,
Mandapam Camp, S. India.
January 1, 1968.

S. JONES,
President, Marine Biological
Association of India.

PREFACE

The author was attracted by the Dinophyceae forms in the plankton collections while working on the plankton Diatoms of the Madras coast almost a quarter of a century ago. The work was commenced in 1943 on the east coast and after a break of three years (1945 – '48) when he had the opportunity to examine material at Plymouth and Port Erin, it was continued on the west coast (1949–1958) and the east coast of India (1959–1962) in the Central Marine Fisheries Research Institute.

As the species of *Ceratium* are the most conspicuous elements in the sea water among the Dinophyceae, this genus is treated in the present part. Besides the original work of the author, the forms recorded earlier by workers in the Indian Ocean region are also included here. The remaining species of *Ceratium* are dealt with to cover all the species known so far.

A list of species of the Dinophyceae occurring on the west coast of India was published by the author in 1958 in which 34 species of *Ceratium* are listed, recorded until then. Studies on the magnitude of the occurrence of Dinophyceae as well as several species of the Class including *Ceratium* spp. as also their seasonal fluctuation on the west coast of India have been made by him (Subrahmanyan, 1959 and Subrahmanyan *et* Sarma, 1960). Wood (1963) has published a check list of the Dinophyceae recorded from the Indian Ocean. Out of about 79 taxa definitely recognized from all over, as many as 67 occur in the Indian Ocean region; the author has himself recorded 57 of these species from the coastal waters on either side of the Peninsula. One species recorded is new to science *viz.*, *Ceratium ramakrishnii* Subrahmanyan.

The records of *Ceratium* species in the principal investigations is shown in Table I, pp. 95 – 98, and the areas from where they have been collected and the number of species recorded are shown in Plate IX.

All the figures, unless otherwise stated, were drawn by the author using a camera lucida when the specimens were fresh as preservation considerably distorts the specimens.

The author is thankful to his colleagues Mr C. Mukundan for all the final wash drawings done by him most willingly with great skill and care;

Mr K. Rangarajan for many final line drawings; Mr N. K. Prasad for reproduction of some and Mr R. V. Rajendran for considerable secretarial assistance. He also wishes to acknowledge the help given by his son, Ramakrishnan, with Bibliography and Index work. Some of the figures are taken from standard treatises on the group and duly acknowledged.

The author wishes to record his indebtedness to the late Prof. M. O. P. Iyengar, Director, University Botany Laboratory, Madras, to whom this work is dedicated, for valuable advice in the early stages of the work when he (author) was a Research Fellow of the University of Madras; to Mr K. R. Ramanathan, of Publications Directorate, CSIR, New Delhi, his senior colleague in the University at that time for drawing his attention to the importance of this group; to Dr S. Jones, Director, Central Marine Fisheries Research Institute for his keen interest, encouragement and suggestions, for contributing the Foreward and valuable help in the publication of this Monograph as a Memoir of the Marine Biological Association of India. I thank Dr E. G. Silas for helpful suggestions and the Rev. Dr H. Santapau, S. J., Director, Botanical Survey of India, for the Latin diagnosis of *Ceratium ramakrishnii* sp. nov.

Finally, the author wishes to express his thanks to Messrs City Printers, Press Club Road, Ernakulam, Cochin-11, Kerala State, for executing the printing of this Memoir with all care and interest.

Central Marine Fisheries
Research Institute,
Mandapam Camp, S. India.
February 10, 1968.

R. SUBRAHMANYAN

CONTENTS

INTRODUCTION

The Dinophyceae form an important constituent of the marine plankton next to the Diatomaceae. While we have now much information on the marine Diatomaceae of Indian waters (Subrahmanyan, 1946; Nair, 1959), there is practically no account for the Dinophyceae. One comes across mention of a few species of *Ceratium* and *Peridinium* in some publications from India (Menon, 1931); these are not of any practical value. Several species from the Indian Ocean are illustrated in the *Valdivia Expedition Reports* (Karsten, 1907); unfortunately, detailed descriptions are lacking and the systematics followed, very much confusing. The account by Steemann Nielsen (1939) of *Ceratia* of Indian Ocean deals with distribution but descriptions and figures are wanting. Distributional and ecological accounts of *Ceratia* are available for the Pacific and Atlantic Oceans (Steemann Nielsen, 1934; Graham and Broniskovsky, 1944) and Mediterranean Sea (Jörgensen, 1920; Lopez, 1966). Karsten (1905, 1906) has also figured some species from the Atlantic and Antarctic Oceans. A list of species recorded from the south western Indian Ocean is given by Taylor (1966). Wood (1963 *a, b*) has recorded some species from the south eastern Indian Ocean.

A study of the genera *Ceratium* and *Peridinium* particularly is of great value in fisheries research as several of the species are known to react to changes in their aquatic environment, particularly temperature and nutrients, and hence could be used as indicators of water masses and their movement (Frost, 1938; Graham, 1941; Graham & Broniskovsky, 1944; Steemann Nielsen, 1939, 1940, 1944; Nordli, 1953, 1957; Mulford, 1963).

A good account of the characteristics of the Class Dinophyceae is available in *The Structure and Reproduction of the Algae* by F. E. Fritsch (1935) and a review of the physiology and biochemistry by Loeblich, III (1966); therefore, these aspects of the class are omitted here.

Most of the Dinophyceae exhibit considerable variability (Böhm, 1931 *b*; Graham & Broniskovsky, 1944; Hasle and Nordli, 1951; Nielsen, 1955; Lopez, 1966). Further, most of the *varieties* and *formae* recognized appear to be due to insufficiency of material at the authors' disposal seasonwise and data over wide regions. The studies on the *Carniegie* collections (Graham & Broniskovsky, 1944) of *Ceratium* would lead one to doubt most of such distinctions

recognized by various workers as having no reliable basis. Lopez (1966) has proposed for diverse species presenting an allometrical variation, continuously, an intraspecific nomenclature based on biometrics. According to Sournia (1966) the distinctions are evident at the level of populations but remain illusory within the individuals.

Sournia (1966) suggests two extreme types, generally two per species: i. robust and psychophile forms and ii. delicate and thermophile to represent varieties; and, for stages of transition, a parataxonomic designation composed of the epithet of the two varieties reunited by a hypen *etc.* He gives examples of 14 variable species.

Almost every type of variation in a species designated by different epithets have been encountered in the course of the present study (which has extended over a period of 20 years); robust as well as slender forms and intermediate ones. In the Indian waters the range of variation of temperature is within 6°C (24–25°C to 25–31°C; Subrahmanyan, 1959) which is unlike those in the temperate waters and most of the accounts for *Ceratium* are from temperate regions. To attribute, therefore, variations in this genus to temperature factor alone would appear to be far fetched. Many factors remain obscure and until more light is thrown definite conclusions are not possible.

The present author's studies do not lend support to the many distinctions recognized as *varieties* and *formae* in the classification; the author is inclined to agree with Graham & Broniskovsky (1944); and unless the characters are strong he has not recognized any intraspecific distinctions.

This variability in the species together with the lack of knowledge of the life history of most of the forms makes a delineation of the taxonomical characters difficult (Schiller, 1937; Grontved and Paulsen, 1949; Braarud, 1951); hence, compilation of a proper key for identification of species is not possible. Even Schiller has expressed difficulty and has not given keys for identification of the species. As mentioned by Schiller (1937, p. 354), descriptions and illustrations are the best guide for identification. The Monograph of Schiller *(op. cit.)* was of invaluable help to the author in the preparation of this account.

CLASSIFICATION

After a study of the systems adopted by various authors, the present author proposes to adopt the classification essentially based on Pascher (1927), Lindemann (1928) and Schiller (1933 – 1937), given in Fritsch (1935) and improved upon by Graham (1951). In this volume, the only genus *Ceratium* of the family Ceratiaceae is dealt with.

Synopsis of Classification of Dinophyceae

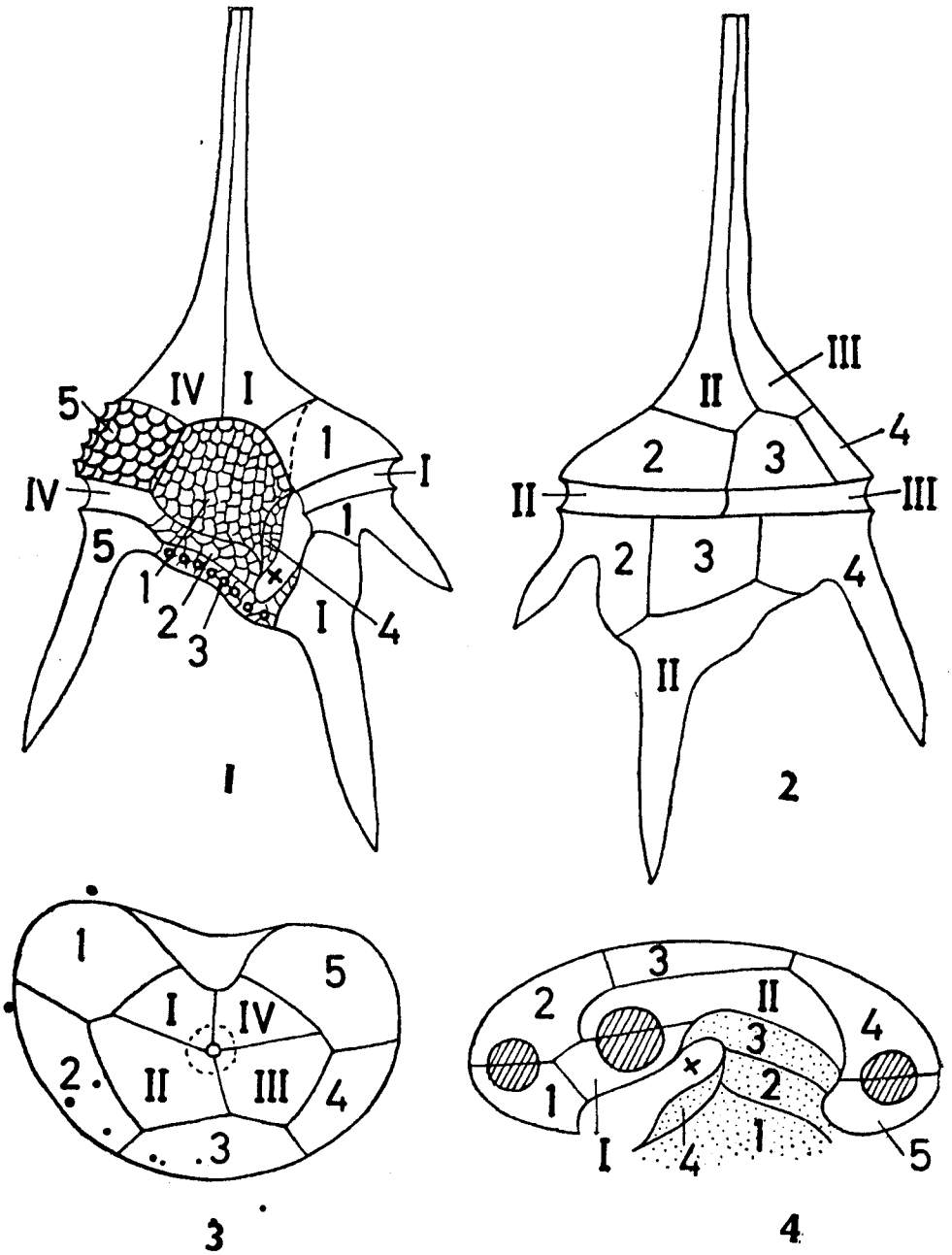
Division : PYRROPHYTA
Class : DINOPHYCEAE

Subclass: **DESMOKONTAE**
Order: *DESMOMONADALES*
Family: **Desmomonadaceae**
Order: *PROROCENTRALES*
Family: **Prorocentraceae**
Subclass: **DINOKONTAE**
Order: *GYMNODINIALES*
Families: **Pronoctiluacaceae**
Gymnodiniaceae
Polykrikaceae
Noctilucaceae
Warnowiaceae
Blastodiniaceae
Order: *AMPHILOTHALES*
Families: **Amphilothaceae**
Gymnasteraceae
Order: *KOLKWITZIELLALES*
Families: **Ptychodiscaceae**
Kolkwitziellaceae
Order: *DINOPHYSIALES*
Families: **Dinophysiaceae**
Amphisoleniaceae
Order: *PERIDINIALES*
Families: **Glenodiniaceae**
Protoceratiaceae
Dinosphaeraceae
Gonyaulacaceae
Peridiniaceae
CERATIACEAE :
Genus **CERATIUM** Schrank
Goniodomaceae
Heterodiniaceae
Pyrophacaceae
Ostreopsiaceae
Oxytoxaceae
Ceratocoryaceae
Cladopyxiaceae
Podolampaceae
Order: *RHIZODINIALES*
Family: **Amoebodiniaceae**
Order: *DINOCOCCALES*
Families: **Hypnodiniaceae**
Phytodiniaceae
Stylodiniaceae
Dissodiniaceae
Order: *DINOTRICHALES*
Family: **Dinotrichaceae**

Genus *CERATIUM* Schrank, 1793, emend Stein, 1883

Jörgensen, 1911.
Lebour, 1925, p. 142.
Lindemann, 1928, p. 92.
Schiller, 1937, p. 349.
= *Bursaria* O. F. Müller, 1773, 1786.
= *Tripos* and *Hirundinella* Bory de Vincent, 1824.
= *Cercaria* Michaelis, 1830.
= *Ceratophorus* Diesing, 1850.
= *Peridinium* Ehrenberg, 1859 p. p. (as *Peridinium eugrammum*).
= *Dimastigoaulax* Diesing, 1866.
= *Glenodinium* Diesing, 1866, p. p.
= *Poroceratium, Biceratium* and *Amphiceratium* Vanhöffen, 1896.

The genus is easily distinguished by its 2 to 4, usually long and differently shaped horns. One arises from the epitheca, the antrior horn or apical horn; two horns arise from the hypotheca (in the freshwater forms three), the posterior horns or antapical horns. Only one arises from the antapical plate, one each from the post-equatorial plates, on both sides in the freshwater species (Text-figs. 1-4). In contrast to the horns, the cell body proper is small. Cell body very variable as regards shape and size; its ventral side always concave, dorsal convex. The concave, rarely plane, transverse furrow generally lies at the centre of the body or is somewhat shifted lower, runs around as a circle, or is slightly oblique. On the ventral side, the transverse furrow is interrupted by the abdominal notch; on its left side the longitudinal furrow is situated; on the right side lies a short funnel formed of ridges (absent only in some strains of *Ceratium hirundinella*) in which the apex of the apical horn lodges during division and chain formation. In all the species, the shell consists of 16 plates. (Text-figs. 1 – 6). The transverse furrow is formed out of 4 plate pieces. The plates have in the different species, a somewhat variable orientation and size. In the sub-genus *Archaeceratium*, the ventral and dorsal apical plates are very large and are held together by a ring - shaped pad which appears poroid from outside. Hence, the two lateral apical plates are thus extraordinarily small. In the formation of the anterior horns, in the marine forms, all the four apical plates take part; in the freshwater forms, on the other hand, only three. In contrast, the posterior horns so lie in the sutures, that each is split only into two pieces. In the marine species, the left posterior horn is really an antapical end horn, as that



Text Figures 1 – 4. *Ceratium hirundinella* (O F Müller) Bergh. 1. Ventral view; the plates of the longitudinal furrow region (section through body) are strongly bordered by the longitudinal furrow (x). 2. Dorsal view 3. Epitheca plan (the anterior horn indicated by dots). 4. Hypotheca plan. (the three posterior horns are indicated by hatching the plates of the longitudinal furrow region set out by dots, the longitudinal furrow pointed out by a 'x' sign). In all the figures the apical –, transverse furrow – and antapical - plates are designated by roman, – the pre – and post – equatorial plates with arabic numerals correspondingly. (After Lindemann, 1928).

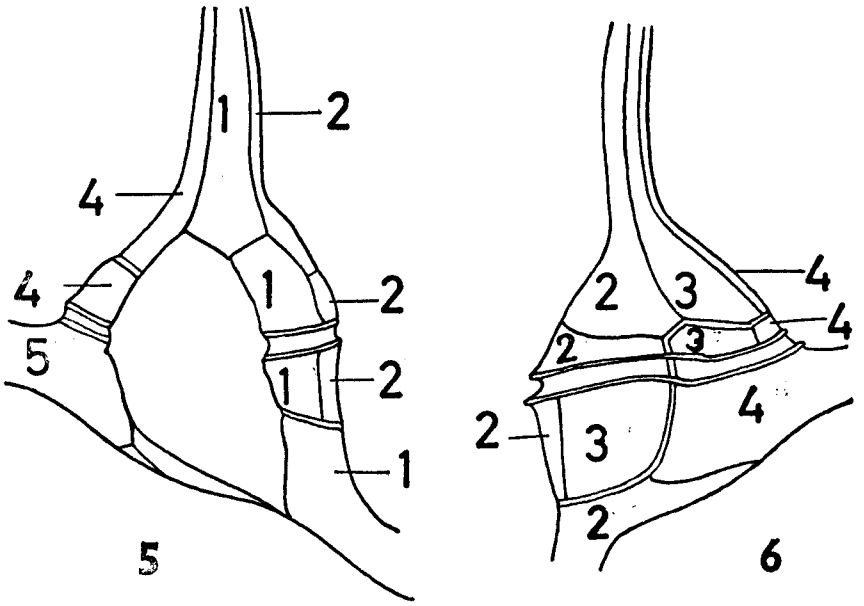
alone is formed from the antapical plates whereas the right, and in the four horned freshwater forms also, the left (accessory) is formed from the post equatorial plates; and, therefore, these should be named laternal horns (Lindemann, 1928). The abdominal section is formed of three small plates, the longitudinal furrow of two. The shell surface shows varied structures (ribs, crests, reticulation, wings) and usually pores.

In most species, numerous parietally placed dark brown chromatophores are present in the body; in some they are present in the horns as well. Products of assimilation are fat, starch and glycogen; these are often brightly coloured, yellow or red. An outer mucilage envelope often present. Stigma absent.

Propagation takes place by division of protoplast and armour while the organism is in the motile state. The nucleus divides mitotically first. This has been described in detail by Skoczylas (1958/59). The division of the armour takes place in a characteristic manner; however, not always strictly between certain plates. It is reported that it takes up to 2 hours for division and this generally takes place in the mornings. To each old half part, a new portion is built up. Thereby, each daughter individual arises out of two different old halves; hence, the younger ones could clearly be distinguished by their thinner shell part, tender and shorter horns as well as absence of large surface sculpturing. Sequence of division more frequent in marine species; therefore, daughter cells remain in contact; giving rise to chains of two to many cells. In such dimorphic chains, the first cell is somewhat different from last and these from the middle ones.

There have been several observations which led authors to be lieve that what they saw represented stages in sexual reproduction (Borgert, 1910; Entz 1909; 1924; Hall, 1925; Schneider, 1924; Zederbauer, 1904). Recently, however, von Stosch (1964, '65) has adduced more reliable evidence for sexual reproduction in this genus. According to him (1964) the *"Knäuestadium"* (Spireme-stage) of the nucleus observed by earlier workers (Borgert, 1910) represents a stage in meiosis; the *truncata* - *lineata* - and *lata* - forms met with are the microswarmers, "male gametes, which copulate with females similar to vegetative cells and which in this process, are completely (flagella ?) resorbed by the latter." This author has seen stages of copulation in the living state in *Ceratium horridum* which is monoecious. "The marine Ceratia, therefore, seem to be haplonts in which the zygotes cannot be distinguished from vegetative cells, neither by a resting stage nor by obvious differences in shape. The possibility of diplophasic mitosis, however, has not been excluded" (von Stosch, 1965).

In the freshwater forms, cyst formation is known since long. The cysts are viable even after many years, even if they get buried deep in mud or slime. In its germination, the outer covering is ruptured and a naked cell emerges — the *Gymnoceratium* Huber - Nipkow — which in essentials is identical with *Gymnodinium*. From this, after some hours, it passes into a naked *Praeceratium* stage which, however, already is possessed of all essential parts of the body up to the armour.



Text Figures 5 - 6. *Ceratium horridum* Gran (= *C. intermedium* (Jörg.) Jörg.) Arrangement of plates at centre of the body. 5. & 6. Ventral and dorsal views. (Nomenclature same as in Text figs. 1 – 4 on p. 5).

The determination of *Ceratium* species offers extraordinarily great difficulties, similar to those of the genera of Phanerogams such as *Rosa* and *Rubus*. All the parts of *Ceratium* cells are more or less highly variable. To the extent known, the variability is presumed to be caused by external factors such as temperature, salinity, *etc.* (Böhm, 1931 *b*; Steemann Nielsen, 1934; Graham and Broniskovsky, 1944; Nielsen, 1956).

According to Steemann Nielsen (1934) first the variation depends respectively on the temperature and whether the forms are of oceanic or neritic waters. Increase in the temperature of the water makes the body smaller, the horns in many species longer; same in neritic waters also. In the cold as well as neritic

waters the body becomes larger, particularly the width. Peters (1932, quoted by Schiller, 1937) found in the Atlantic ocean that the length of horn diminishes much and the body thickly sculptured every time the water was rich in nutrients; and the converse occurred when the water was deficient in nutrients. Steemann Nielsen (1934) also found a similar pattern in the Pacific Ocean. However, both the authors agree that the horn length is not related to the density of the water and does not represent an adaptation for buoyancy.

From the course of divisions, it is seen, as already stated that in every *Ceratium* after each division, two different old body parts exist. In the new formation of the top cell half, to begin with, the apical horn is short and the shell thin. Same holds good for the lower part of the body. Further, the horn length depends on whether the individual is free living or united in a chain. In *C. candelabrum, C. lunula, C. vultur* var. *sumatranum* and *C. macroceros,* this difference is particularly striking. Older individuals and particularly also winter forms (according to Peters (1932) in the forms living in eutrophic waters also) have large armour with coarse sculpture. Although the length, direction and spread of horns are very variable, we have still to employ these also for differentiation of species for lack of other suitable characters.

The extraordinary variability of *Ceratium,* not found elsewhere in the protophyta, leads to the inference that in the conception of species there exists no agreement among the different authors. The value and constancy of different systematic characters have not been proved by cultures. Attempts at culturing *Ceratium* have not met with any measure of success (Lohmann, 1908; Tschirn, 1920; Peters, 1929; Barker, 1935; Gross, 1937; Nordli, 1957). Therefore, most authors appear to follow the principle that what one can "identify" is a species.

Jörgensen (1911) has done much for the systematics of this genus. It appears, however, possible that, by better insight into the causes of variability and the systematic value of certain characters, some species may have to be given up, others shown to be assemblage of species which require to be split up.

In this connexion, the record of sexual reproduction already dealt with earlier, is of great significance. It is not improbable that the wide range of variation is a result of easy hybridization. In view of the wide variations within a species including transition forms met with during the current study

also, the writer has confined himself to the species level only in most instances; and in several instances merged the "formae" and "varieties" into the type.

The measurements employed by Jörgensen (1911) and Schiller (1937) have been adopted here: t = diameter (transverse) of transverse furrow, without the projecting ridges; V = length of anterior body, the epitheca, and h = length of posterior body, the hypotheca, both from middle line of transverse furrow, both reckoned perpendicularly up to base of anterior horn and posterior horn respectively; v = length of apical horn; L=length of left, R=length of right – posterior horns. An extended line from the middle of transverse furrow, parallel to it up to both posterior horns gives the horn spread. The angle data given have been omitted here. *For identification, the figures are to be the main guide;* keys to the species are not given for reasons stated above already.

KEY TO THE SUB-GENERA AND SECTIONS OF THE GENUS *CERATIUM* SCHRANK

I. Apical horn absent: Sub-genus **ARCHAECERATIUM** Jörgensen

1. Anterior body (epitheca) flat, apex evenly rounded: Section **Poroceratium** Vanhöffen

   [Taxa: *Ceratium praelongum* (Lemmermann) Kofoid; *C. cephalotum* (Lemmermann) Jörgensen; *C. gravidum* Gourret]

2. Anterior body flat, lanceolate, apex tapering: Section **Lanceolata** Jörgensen

   [Taxon: *C. lanceolatum* Kofoid]

3. Anterior body tapered, as also the left posterior horn, latter more or less bent dorsally: Section **Digitata** Jörgensen

   [Taxa: *C. schröteri* B. Schröder; *C. digitatum* Schütt; *C. pacificum* Wood; *C. tasmaniae* Wood]

II. Cells with anterior horn and two (in freshwater species three) posterior horns; horns closed at the apex, directed backwards, parallel or diverging; the right horn always smaller than left: Sub-genus **BICERATIUM** Schiller

1. Freshwater forms: Section **Cornuta** Jörgensen

   [Taxa: *C. hirundinella* (O. F. Müller) Bergh; *C. brachyceros* Daday; *C. cornutum* (Ehrenb.) Clap. *et* Lachm; *C. carolinianum* (Bailey) Jörgensen]

2. The body proper much broader than long (height): Section **Candelabra** Jörgensen

   [Taxon: *C. candelabrum* (Ehrenb.) Stein]

3. The body proper never broader than long, generally much longer than broad; anterior body long, horn-like: Section **Furciformia** Jörgensen

   [Taxa: *C. furca* (Ehrenb.) Clap. *et* Lachm.; *C. belone* Cleve; *C. incisum* (Karsten) Jörgensen]

4. Cell dorsiventrally strongly compressed, in outline five sided. Anterior horn generally long, posterior horns short and more or less straight: Section **Pentagona** Jörgensen

[Taxa: *C. pentagonum* Gourret; *C. teres* Kofoid; *C. lineatum* (Enrenb.) Cleve; *C. setaceum* Jörg.; *C. kofoidii* Jörg.; *C. minutum* Jörg.]

III. Cells long and narrow, dorsiventrally scarcely compressed; right horn more or less rudimentary. Anterior horn like left posterior horn, long and robust. Anterior and posterior body (hypotheca) more or less equal: Sub-genus **AMPHICERATIUM** (Vanhöffen) Gran

1. Anterior body inflated: Section **Inflata** Jörgensen

[Taxa: *C. geniculatum* (Lemmermann) Cleve; *C. bigelowi* Kofoid; *C. inflatum* (Kofoid) Jörg.]

2. Body narrow, anterior and posterior body approximately same width: Section **Fusiformia** Jörgensen

[Taxa: *C. longirostrum* Gourret; *C. falcatum* (Kofoid) Jörg.; *C. falcatiforme* Jörg.; *C. fusus* (Ehrenb.) Du Jardin; *C. extensum* (Gourret) Cleve; *C. scapiforme* Kofoid]

IV. The cell body proper flattened, ventral side concave; both posterior horns, very rarely only one, bent forwards:

Sub-genus **EUCERATIUM** (Gran) Ostenfeld

1. Only one posterior horn directed forwards.....(A)
2. Both posterior horns directed forwards.....(B)

A. Left posterior horn very short, more or less directed towards left or rear, right one bent forward: Section **Dens** Jörgensen

[Taxon: *C. dens* Ostenf. *et* Schmidt]

B. a) Both posterior horns bent forward from the course of the body, robust, closed at the tip: Section **Tripos** Ostenfeld

[Taxa: *C. tripos* (O. F. Müller) Nitzsch; *C. pulchellum* B. Schröder; *C. porrectum* (Karsten) Schiller; *C. humile* Jörg.; *C. breve* (Ostenf. *et* Schmidt) Schröder; *C. bucephalum* (Cleve) Cleve; *C. karstenii* Pavillard; *C. karstenii* forma *robustum* (Karsten) Jörg.; *C. contortum* (Gourret) Cleve; *C. concilians* Jörg.; *C. gibberum* Gourret; *C. longinum* Karsten;

C. lunula Schimper; *C. schmidtii* Jörg.; *C. symmetricum* Pavillard; *C. axiale* Kofoid; *C. euarcuatum* Jörg.; *C. arietinum* Cleve; *C. declinatum* (Karsten) Schiller; *C. azoricum* Cleve; *C. compressum* Gran; *C. carniegiei* Graham and Broniskovsky; *C. petersii* Steemann Nielsen]

b) All the horns very short, the posterior lie very close to the body: Section **Limulus** Schiller

[Taxa: *C. limulus* Gourret; *C. paradoxides* Cleve]

c) Posterior horns flattened: Section **Platycornia** Jörgensen

[Taxon: *C. platycorne* v. Daday]

d) Posterior horns divided into fingers at the apex: Section **Palmata** (Pavillard) Jörgensen

[Taxon: *C. ranipes* Cleve]

e) Posterior horns open at the end, at least one of them with the arched proximal part projecting over the posterior contour: Section **Macroceros** Pavillard

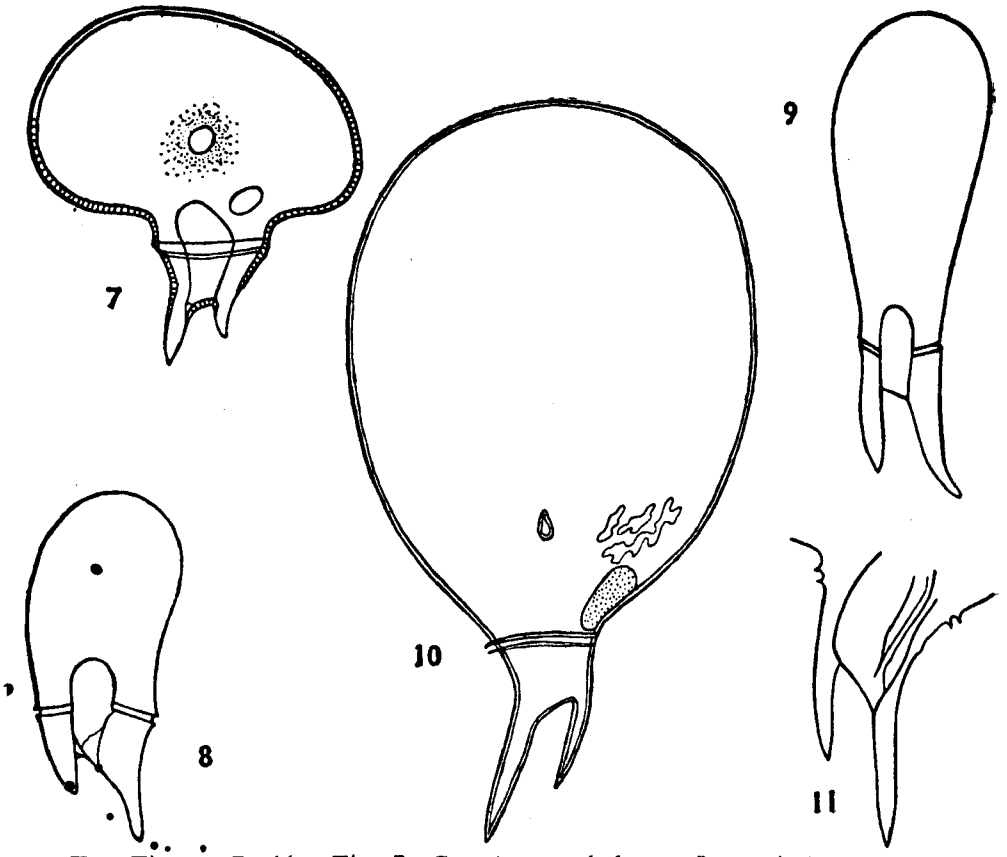
[Taxa: *C. longipes* (Bailay) Gran; *C. longissimum* (Schröder) Kofoid; *C. horridum* Gran; *C. pavillardii* Jörg.; *C. vultur* Cleve; *C. vultur* var. *sumatranum* (Karsten) Steemann Nielsen; *C. vultur* var. *productum* Wood; *C. reflexum* Cleve; *C. hexacanthum* Gourret; *C. hexacanthum* var. *aesturium* (Schröder) Schiller; *C. massiliense* (Gourret) Jörg., *C. carriense* Gourret; *C. deflexum* (Kofoid) Jörg.; *C. macroceros* (Ehrenb.) Cleve; *C. macroceros* var. *gallicum* (Kofoid) Jörg.; *C. trichoceros* (Ehrenb.) Kofoid; *C. trichoceros* var. *contrarium* (Gourret) Schiller; *C. ramakrishnii* Subrahmanyan; *C. arcticum* (Ehrenb.) Cleve]

SYSTEMATIC ACCOUNT

GENUS *CERATIUM* SCHRANK

Sub-genus **ARCHAECERATIUM** Jörgensen, 1920

Upper body without apical horn, apex rounded or acute, usually more or less broad and flat. Of the apical plates, two very large and broad, ventrally and dorsally situated, the two others, lateral, narrow and boat shaped.



Text Figures 7 – 11. Fig. 7. *Ceratium cephalotum* (Lemm.) Jörg ; ventral view From Schiller, 1937. Figs. 8 and 9. *C. praelongum* (Lemm) Kofoid; ventral views. After Wood, 1963 *b*. Figs. 10 and 11. *C. gravidum* Gourret; dorsal and ventral views of posterior end with posterior horn; from Schütt, 1895. (Figs. 7, x 280; 8 and 9, not known, 10, x 230 and 11, x 300).

Section **Poroceratium** Vanhöffen

Both the large plates connected with each other on the inside by a porous skeletal ring, which appears to be absent in *Ceratium praelongum*.

1. **Ceratium praelongum** (Lemmermann) Kofoid, 1907
(Text-figs. 8, 9)

Kofoid, 1907 *a*, Jörgensen, 1911, p. 9, fig. 9.
Böhm, 1931 *b*, p. 43, fig. 37 *a*.
Steemann Nielsen, 1934, p. 7, fig. 1.
Schiller, 1937, p. 356, fig. 387.
Wood, 1963, p. 40, fig. 148.
=*C.gravidum* var. *praelongum* Lemmermann, 1900, Karsten, 1907, pl. 50, fig. 2.

Margin in ventral view almost straight for about $\frac{3}{4}$ length, then evenly rounded with a central pore. Epitheca about twice the length of hypotheca. No apical horn. Hypotheca slightly narrowed with two tapered antapical horns. Size factors: $t = 60 - 65\ \mu$, $v = 160 - 170\ \mu$; h = somewhat smaller than t; $L = t$; $R = \frac{1}{2} - \frac{2}{3}$ L.

Tropical oceans and seas; east Indian Ocean, Coral Sea, Mediterranean, Penang, Colombo, S. E. Coast of Ceylon. Found in deeper waters.

2. **Ceratium cephalotum** (Lemmermann) Jörgensen, 1911
(Text-fig. 7)

Jörgensen, 1911, p. 13, fig. 15.
Böhm, 1931 *b*, p. 43.
Steemann Nielsen, 1934, p. 7, fig. 2.
Schiller, 1937, p. 356, fig. 388.
= *C. gravidum* var. *cepholotum* Lemmermann, 1900, Karsten, 1907, p. 243.
= *C. gravidum* var. *hydrocephala* Schröder, 1906, p. 369, fig. 44.

Simple species. Epitheca somewhat inflated (see figure), otherwise resembles *C. praelongum* (Lemm.) Kofoid. $t = 45\mu$; $v = 130\ \mu$; $h = \frac{2}{3}\ t$; $L = h = \frac{2}{3}\ t$; $R = \frac{1}{2}\ L$. Breadth of epitheca 170 μ

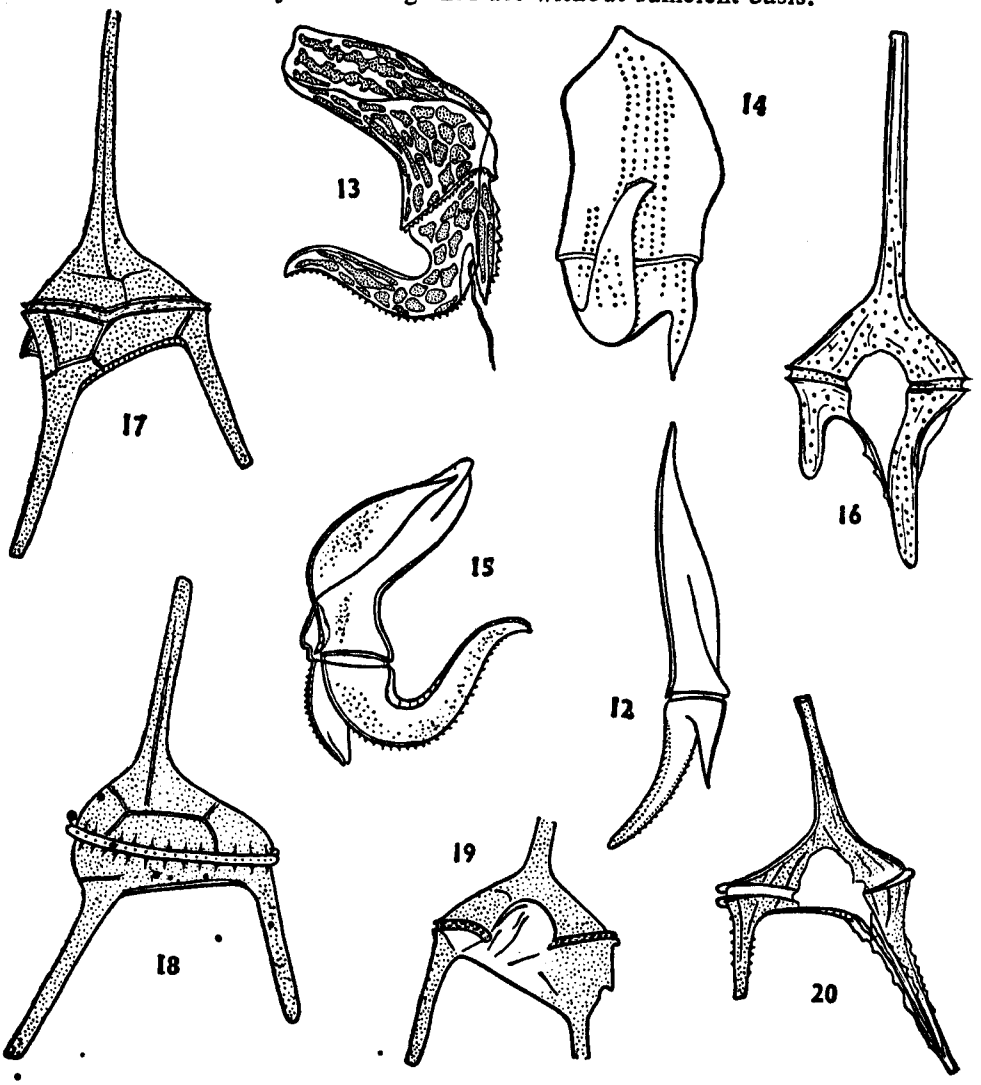
In the tropics of oceans. Usually in deeper waters (100 - 50 m samples). Indian Ocean 10° N, 62°E and 12° N, 58°E.

3. **Ceratium gravidum** Gourret, 1883
(Text figs. 10, 11)

Schütt, 1895, p. 11, fig. 41.
Cleve, 1901, p. 14; 1903, p. 341.
Jörgensen, 1911, p. 10, fig. 8; 1920, p. 8, fig. 4.
Steemann Nielsen, 1934, p. 8, figs. 3, 4; 1939, p. 6.

Schiller, 1937, p. 357, fig. 389.
Wood, 1954, p. 272, figs. 186 *a* – *c*.

Easily recognizable species by its chracteristic round to oval epitheca. No anterior horn evident though Schütt depicts a tiny rudimentary one (see figure). The species is very variable, particularly in the shape of epitheca, hence the *varieties* and *forms* recognized are without sufficient basis.



Text-figures 12–20. Fig. 12. *Ceratium schroeteri* B. Schroeder; dorsal view. From Schiller 1937. Figs. 13, 14, 15. *C. digitatum* Schütt. 13 and 15, lateral view; 14, dorsal view. 13 and 14, after Schütt, 1895; 15, after Jörgensen,

Widely distributed warm water form. Gulf of Aden, Red Sea, Arabian Sea, Indian Ocean, Mediterranean (Gulf of Marseilles). Bottom form occurring usually between 100 - 200 m. depth.

Section **Digitata** Jörgensen, 1911

Epitheca pressed flat, almost leaf like, towards the apex pointed or rounded and somewhat bent dorsalwards. The left posterior horn also bent in the same direction. The large dorsal and ventral plates without the connecting ring.

4. **Ceratium schroeteri** B. Schröder, 1906
(Text-fig. 12)

Schröder, 1906, p. 368, fig. 43.
Jörgensen, 1911, p. 12, fig. 14.
Schiller, 1937, p. 358, fig. 391.
$=C.$ *furca* var. *schröteri* Karsten, 1907.

Easily recognizable species. Epitheca flattened, towards apex pointed. Left posterior horn bent dorsally, with fine warts on it. Right posterior horn directed backwards, straight. See figure. $t=50$. Total length 385 μ.

Indian Ocean and Arabian Sea; Pacific. Rare warm water species.

5. **Ceratium digitatum** Schütt, 1895
(Text-figs. 13, 14, 15)

Schütt, 1895, pl. 12, fig. 42.
Jörgensen, 1911, p. 12, fig. 13; 1920, p. 6, figs. 1, 2.
Steemann Nielsen, 1934, p. 8, fig. 5.
Schiller, 1937, p. 358, fig. 392.

Epitheca strongly dorsally bent, in side view appearing almost collapsed, rather flat, at the top suddenly narrowed into a blunt point. Cross section of body convex on the dorsal side, concave on the ventral side. Posterior horns very unequal. Left horn bent round towards dorsal side and directed obliquely forwards, at the apex again bent back; thick, strongly spiked. Right horn many times smaller, straight, sharply pointed. $t=50\ \mu$; $v=90\mu$; $R=25\ \mu$.

1920. Figs. 16–20. *C. candelabrum* (Ehrenb.) Stein. Fig. 16, ventral view; from Schiller 1937. Figs. 17 and 18, dorsal views; 19 and 20, ventral views; after Schiller 1937. Figures illustrate variation in the species. (Fig. 13, x 235; Figs. 13 and 14, x 320; 15, x 280; 16, not given; 17, 18 and 19, x 320; 20, x 245).

Rare warm water form. In all oceans.

Sub-genus BICERATIUM Schiller, 1937

Cells with anterior horn and two (in freshwater species three) posterior horns; horns closed at the apex, directed backwards, parallel or diverging; the right horn always smaller than the left.

Section Cornuta Jörgensen, 1911

Apical horn clearly marked, thick, straight or bent to the right and ventrally. Body dorsiventrally flattened. Number of posterior horns 1–3, the right one arising closely below the transverse furrow, however, at times absent. All freshwater species belong here.

6. **Ceratium hirundinella** (O. F. Müller) Bergh, 1882
(Pl. I, fig. 2)

Jörgensen, 1911, p. 14, figs. 19 20 *a, b.*
Schiller, 1937, p. 359, fig. 396 *a.*
= *Bursaria hirundinella* O. F. Müller 1773, p. 63; 1786, p. 117, pl. 17, figs. 9, 12.
= *C. tetraceros* Schrank, Kisselev, 1950, p. 255.

Cells strongly flattened, dorsiventrally. Apical horn long and narrow, at the tip suddenly blunt. Posterior portion low and broad. Two well developed and one small posterior horn, one antapical and two post-equatorial, differ among themselves in length and direction. Armour surface sculptured with closely placed warts and ridges.

Freshwater form widely distributed. Recorded on the west coast of India occasionally during influx of freshwater into the inshore region in June and / or July, evidently brought in on account of heavy rainfall.

Section Candelabra Jörgensen, 1911

Cells low, dorsiventrally little flattened, cross section, therefore, more or less circular. Horns well developed.

7. **Ceratium candelabrum** (Ehrenb.) Stein, 1883
(Text-figs. 16–20)

Schütt, 1895, pl. 9, fig. 38.
Cleve, 1901, p. 14; 1903, p. 340.
Paulsen, 1908, p. 88, fig. 120.

Jörgensen, 1920, p. 11.
Lebour, 1925, p. 143, figs. 45 *b, c;* pl. 30, fig. 2.
Böhm, 1931 *b*, p. 8, fig. 3.
Steemann Nielsen, 1934, p. 8, figs. 6, 7.
Schiller, 1937, p. 364, fig. 401.
Graham & Broniskovsky, 1944, p. 17, fig. 6.
Wood, 1954, p. 272.

= *Ceratium candelabrum* (Ehrenb.) Stein f. *commune* Böhm.

Böhm, 1931 *a*, p. 351, figs. 1, 2.
Schiller, 1937, p. 365, figs. 401 *a, b*.

= *Ceratium candelabrum* (Ehrenb.) Stein f. *curvatulum* Jörgensen.

Jörgensen, 1920, p. 15, fig. 6.
Schiller, 1937, p. 365, figs. 402, *a, b, c*.
Wood, 1954, p. 273, fig. 187 *a*.
Subrahmanyan, 1958, p. 439.

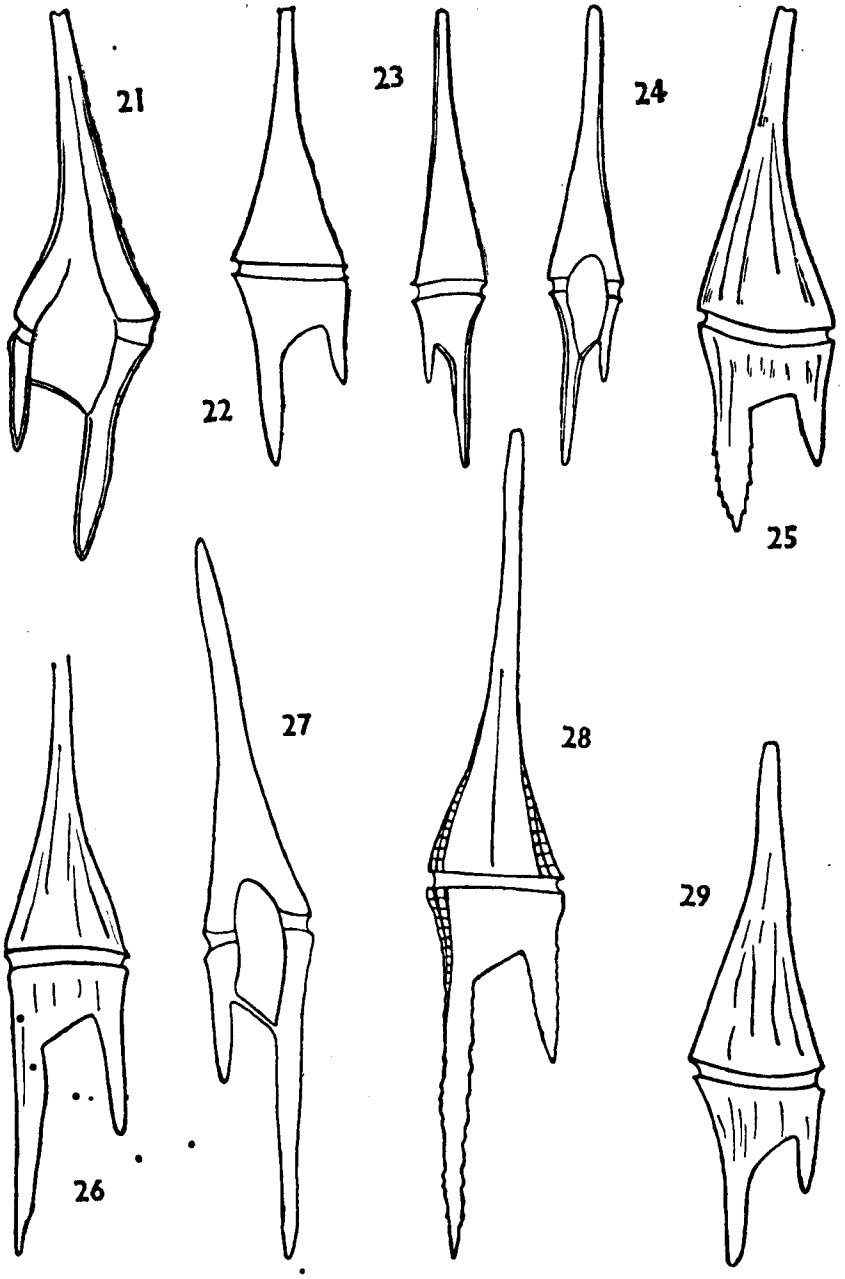
= *Ceratium candelabrum* (Ehrenb.) Stein f. *depressum* Pouchet.

Böhm, 1931 *b*, p. 8, figs. 3 *a, c, d*.
Schiller, 1937, p. 366, fig. 403.
Graham & Broniskovsky, 1944, p. 17–18.
Wood, 1954, p. 273, fig. 187 *b*.
Subrahmanyan, 1958, p. 439.

= *C. candelabrum* var. *dilatum* (Gourret) Jörgensen, 1911, p. 16, figs. 4, 5, 22.
= *C. candelabrum* var. *depressum* (Pouchet) Jörgensen, 1920, p. 13, fig. 5.
= *C. candelabrum* var. *algerence* Schiller, 1928, p. 410, fig. 28.

Body as broad as high. Anterior portion short, cone shaped, suddenly tapering at the sides into the apical horn. Apical horn straight or somewhat arched. Posterior portion very low particularly right side; therefore, obliquely diagonal. Posterior horns short or long, thick or slender, straight or more or less bent, diverging or parallel. Species very variable; many forms recognised by some authors. Graham and Broniskovsky have illustrated the variation in this species (1944, fig. 6). Text-figs. 16, 17, 18, 19 and 20 may be referred to here.

Widely distributed in all the warm seas, extends into the temperate region. Arabian Sea, Indian Ocean, Malay Archipelago. In the east and west coast waters of India.



Text-figures 21 – 29. *Ceratium furca* (Ehrenb.) Claparède *et* Lachmann. Figs. 21, 24 and 27 ventral views, rest dorsal views. (21, 23, 24, 25, 26 & 28, x 500; 22, 29, x 400; 27, x 260).

Section **Furciformia** Jörgensen

Epitheca with clear apical horn, straight or bent. Cell body proper generally longer than broad. Right posterior horn does not arise close behind transverse furrow.

8. **Ceratium furca** (Ehrenb.) Claparède *et* Lachmann, 1859
(Pl. II, Figs. 7 – 12; text-figs. 21 – 29)

Schütt, 1895, pl. 9, fig. 37.
Cleve, 1901, p. 13; 1903, p. 341.
Paulsen, 1908, p. 90, fig. 122.
Jörgensen, 1920, p. 17, figs. 7 – 12.
Lebour, 1925, p. 145, pl. 30, fig. 3.
Böhm, 1931 *b*, p. 8, figs. 4 – 8.
Steemann Nielsen, 1934, p. 9, figs. 8 – 9.
Schiller, 1937, p. 367, figs. 404, 405.
Graham and Broniskovsky, 1944, p. 18, fig. 7.
Wood, 1954, p. 274, figs. 189 *a, b, c.*
= *C. hircus* Schröder, Schiller, 1937, p. 369, fig. 406; Taylor, 1966, p. 463.
= *C. furca* var. *berghii* (Jörg.) Schiller, 1937, p. 367
= *C. furca* var. *eugrammum* (Ehrenb.) Jörgensen, 1911, p. 17, figs. 24 – 26; Schiller, 1937, p. 368; Subrahmanyan, 1958, p. 439.

In view of the variations noticed in this species and their close relationship in transition forms, all the varieties and formae described under this species are not recognized here and are all merged into the species. Most of the variations are possibly stages in the growth of the species.

Epitheca uniformly tapering and drawn out into a long or short apical horn. Posterior horns parallel to slightly divergent; the left one robust and approximately double as long as the right; both generally end in a point.

Warm water form in all seas. Neritic than oceanic. Red Sea, Gulf of Aden, Sunda Sea, Indian Ocean, Arabian Sea, Zanzibar, Kangaroo Islands. Bass Straits, Southern Ocean.

9. **Ceratium belone** Cleve, 1900
(Text-fig. 30)

Cleve, 1900, p. 3, pl. 7, fig. 13; 1901, p. 14
Jörgensen, 1911, p. 19, figs. 28 *a, b;* 1920, p. 19, fig. 28 *a, b.*

Steemann Nielsen, 1934, p. 10, fig. 10.
Schiller, 1937, p. 369, fig. 407 *a*.
Wood, 1954, p. 275.
=*C. pacificum* Schröder, 1906, p. 368, fig. 42, *a, b*. (non *C. pacificum* Wood, 1963).
=*C. furca longum* Karsten, 1906, pl. 23, fig. 5 *a, b, c*.
=*C. furca* var. *longa* Karsten, 1907, p. 257.

Long narrow species not to be confused with any other. Epitheca above the transverse furrow slightly broadened, then gradually tapering to the apex. Hypotheca uniformly broad, double so long as broad. Posterior horns very unequal, parallel, smooth; left one robust, with rather thick-walled apex; right one only half so long, much narrower, sharply pointed, thin-walled. The whole cell smooth, only little compressed; cell wall on the dorsal side strongly thickened; here the apical horn slightly arched. $t=25$–32μ; $h=50\mu$; $v+V=350$–450μ; $L=150\mu$; $R=50$–60μ.

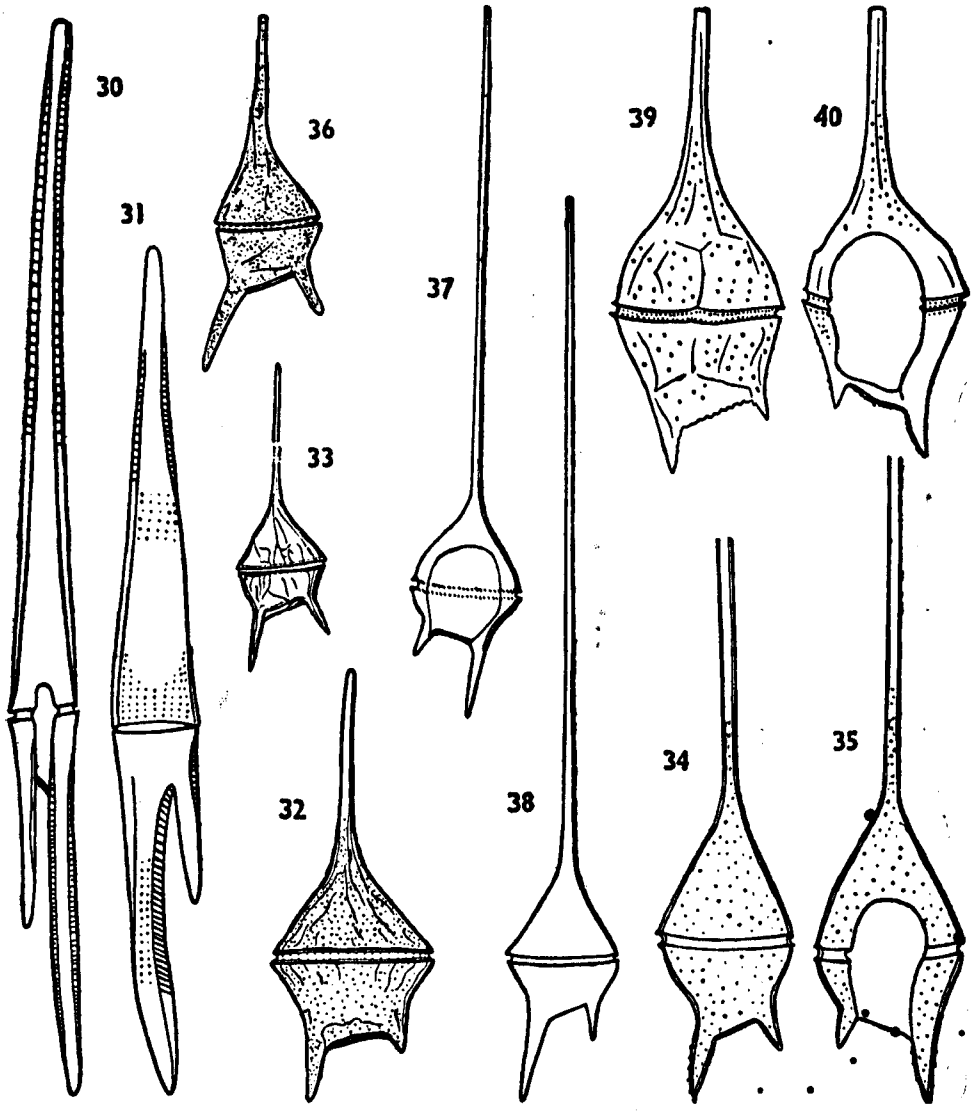
Interoceanic warm water form. Indian Ocean, Red Sea, Gulf of Aden, Arabian Sea; Atlantic, west coast of Africa, American coast; Mediterranean; Pacific Ocean; Japan; Humboldt Current.

10. **Ceratium incisum** (Karsten) Jörgensen, 1911
(Text-fig. 31)

Jörgensen, 1911, p. 19, figs. 29, 30; 1920, p. 22, fig. 13.
Böhm, 1931 *b*, p. 12, fig. 9 *a*.
Steemann Nielsen, 1934, p. 10, fig. 11.
Schiller, 1937, p. 370, fig. 407 *b*.
Wood, 1954, p. 275, fig. 190.
=*C. furca incisum* Karsten, 1906, pl. 28, figs. 6 *a, b*.
=*C. furca* var. *incisa* Karsten, 1907, p. 227.

Epitheca very narrow lancet-shaped, quite uniformly narrowed from the transverse furrow up to the apex where it becomes horn-like, and runs as a rod slightly bent dorsally. Hypotheca uniformly broad. Posterior horns very unequal, smooth, almost parallel; the left approximately twice as long and thick as the right, a little dorsally and laterally bent. Cell wall on the dorsal side thickened. Left horn thick, at the apex blunt; right one thinner, sharper and straight. $t=34$–40μ; $h=t$ or smaller; $v+V=200\mu$; $L=ca$ 100–120μ; $R=50$–60μ.

Atlantic, African west coast; Mediterranean; Indian Ocean, Red Sea; Pacific Ocean, Japan. Rare warm water form.



Text-figures 30 – 40. Fig. 30. *Ceratium belone* Cleve; ventral view; (after Jörgensen) Fig. 31. *C. incisum* (Karsten) Jörg.; dorsal view; (after Jörgensen, 1920). Figs. 32, 33. *C. pentagonum* Gourret; dorsal view; (after Böhm, 1931 *b*). Figs. 34, 35. *C. teres* Kofoid; dorsal and ventral views; (after Schiller, 1937). Fig 36. *C. lineatum* (Ehrenb.) Cleve; dorsal view; (from Schiller, 1937). Fig. 37, 38. *C. setaceum* Jörgensen; ventral and dorsal views; (36, after Jörgensen; 37, from Schiller 1937). Figs. 39, 40 *C. minutum* Jörgensen; dorsal and ventral views; (after Lebour, 1925). (30,x250; 31, 36, 37, 38,x340; 32, 33, not known; 34, 35, x 250; 39, 40, *circa* x 390).

Section Pentagona Jörgensen, 1911

Cells dorsiventrally strongly compressed. In outline five-sided. Anterior horn generally long, posterior horns short and more or less straight.

11. Ceratium pentagonum Gourret, 1883

(Text-figs. 32, 33)

Gourret, 1883, p. 45, pl. 4, fig. 58.

Jörgensen, 1911, p. 20, figs. 31, 32; 1920, p. 24, figs. 15–17.

Böhm, 1931 *b*, p. 12, fig. 9 *b*.

Steemann Nielsen, 1934, p. 11, fig. 12.

Schiller, 1937, p. 370.

=*C. furca* var. *baltica* Schütt, 1895, pl. 9, fig. 36; Karsten, 1907, p. 228 *et seq.*

=*C. lineatum* var. *robustum* Cleve, 1900, p. 925, fig. 6.

=*C. furca pentagonum* (Gourret) Lemm., Karsten, 1906, pl. 23, fig. 7.

=*C. pentagonum* f. *robustum* (Cleve) Jörgensen, 1911, p. 20, pl. 2, fig. 32; 1920, pp. 24–28. fig. 17 (as var. *robustum*).

=*C. pentagonum* var. *turgidum* Jörgensen, 1911, p. 21, pl. 2, fig. 33.

=*C. pentagonum* var. *tenerum* Jörgensen, 1920, p. 26, fig. 16.

=*C. pentagonum* var. *subrobustum* Jörgensen, 1920, p. 26, fig. 15; Peters, 1932, p. 32, pl. 3, fig. 15 *a;* Schiller, 1937, p. 371.

=*C. subrobustum* Steemann Nielsen, 1934, p. 11, fig. 13.

Medium size species. Transverse furrow lies a little below the middle of the body if the horns are not reckoned.

Epitheca below three sided, sides straight which are perpendicular to one another. Above the epitheca merges suddenly into a long thin apical horn which is straight or quite weakly bent. In the robust forms, the apical horn below is somewhat broader and beset with winged lists. Otherwise uniformly broad up to apex; usually thin and thin-walled. Hypotheca flatly trapezoidal with first convex and then concave side contours. Antapical contour habitually oblique, forms a small angle with transverse furrow. Posterior horns short, shorter than *t*, the right one at least 2/3 of the left one, both apices slightly diverging. Sculpture usually tender; however, in large forms longitudinal lists and large clear pores occur and usually also the three horns exhibit winged lists. $t = 62 - 77\mu$; Length of body proper approximately $= t$; apical horn length variable, 100–200μ; $h = 32 - 34\mu$; L less than h; $R = 2/3\ L$ but variable.

Several forms have been named based on armour appearance (*vide* synonyms above). These forms, such as f. *robustum* (Cl.) Jörg., f. *subrobustum* Jörg.,

f. *turgidum* Jörg., and f. *tenerum* (Jörg.) Schiller (refer Schiller, 1937) have no sound basis (Jörgensen himself doubts whether these characters always hold good!) in view of the changes in the armour brought about by the nutrient status of the water and also temperature changes.

In the warm and southern temperate waters sometimes, up to 60° S. Indian Ocean, Red Sea, Gulf of Aden, Arabian Sea, Zanzibar and the Antarctic.

12. Ceratium teres Kofoid, 1907
(Text-figs. 34, 35)

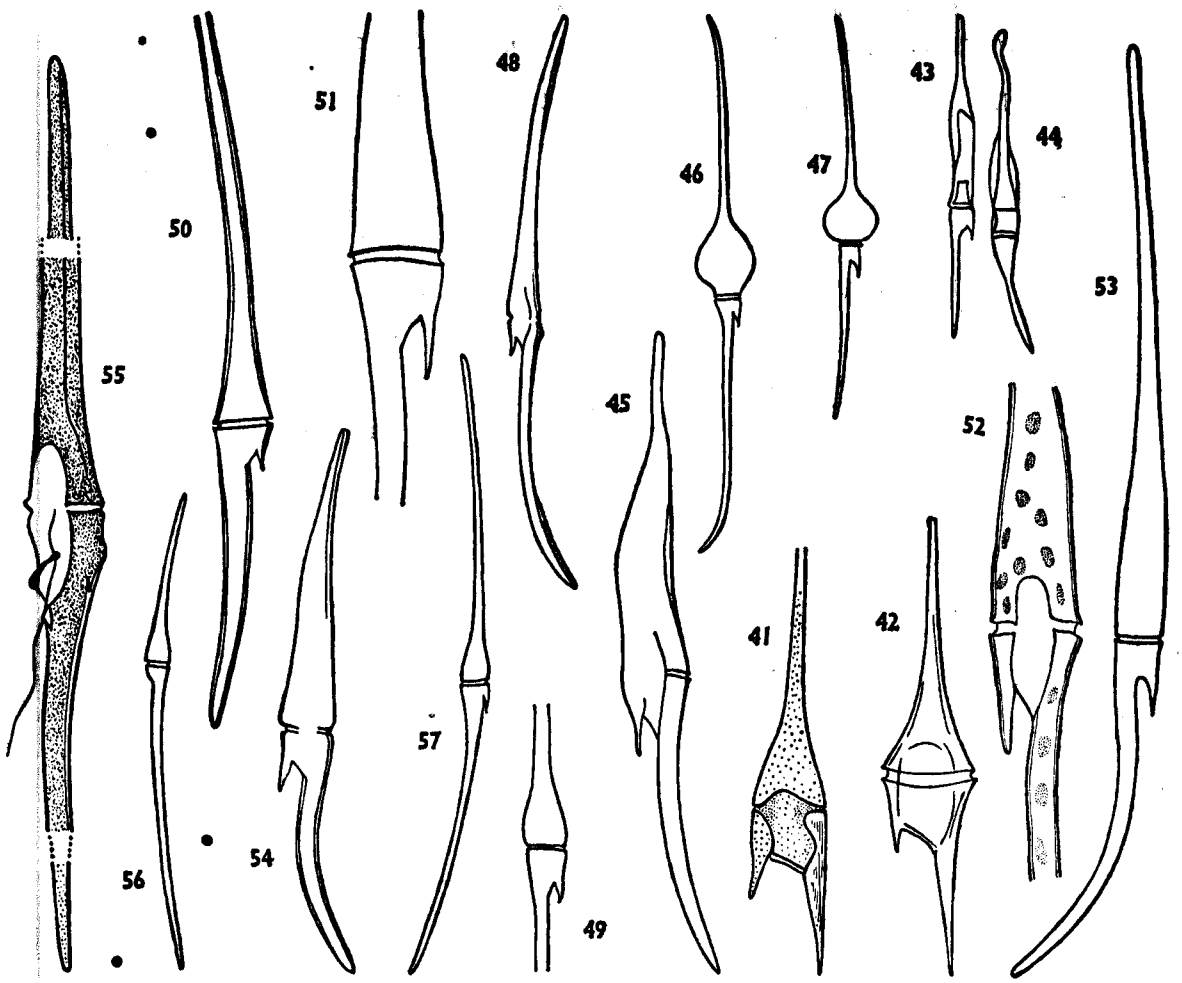
Kofoid, 1907 *b*, p. 308, figs. 34–36.
Jörgensen, 1911, p. 21, pl. 2, figs. 34, 35.
Böhm, 1931 *b*, p. 12, fig. 9 *d*.
Steemann Nielsen, 1934, p. 11, fig. 14.
Schiller, 1937, p. 372, figs. 409 *a*, *b*.
Wood, 1954, p. 277, fig. 193.
Subrahmanyan, 1958, p. 439.
=*C. teres* f. *subturgidum* Jörgensen, 1920, p. 28, fig. 18.

Epitheca elongated, three-sided with a little convex contour which forms an angle of 45–50°. Hypotheca somewhat narrowed with oblique bottom contour; posterior horns clearly divergent right from the base. Apical horn more or less long. Sculpture usually tender; however, at times coarsely sculptured forms with short apical horn beset with winged lists occur. Body low as in *C. pentagonum*. Transverse furrow below middle. $t = 31–56\mu$; length of body = almost $1\frac{1}{2}$ to 2 *t*; $V = circa\ 2\frac{1}{2} - \frac{1}{2}\ t$. Species does not keep when preserved.

Interoceanic warm water form. Frequent in the Mediterranean; Atlantic Ocean, west coast of Africa, Azores; Arabian Sea, west coast of India, rarely, between Ceylon and Sumatra, west of Java; Pacific: south of Japan and Californian coast.

13. Ceratium lineatum (Ehrenb.) Cleve, 1899
(Text-fig. 36)

Cleve, 1899, p. 36; 1900, p. 221; 1901 *a*, p. 14; 1903, p. 341.
Jörgensen, 1911, p. 22, figs. 36, 37.
Schiller, 1937, p. 372, fig. 410.
=*Peridinium lineatum* Ehrenberg, 1854 *a*, pl. 35 A, fig. 24 *c*; 1854 *b*, p. 240.
=*Ceratium fusca* v. *baltica*, *C. debile* Vanhöff, Cleve, 1901, p. 14.



Text-figs. 41–57. Figs. 41–42. *Ceratium kofoidii* Jörg., ventral views; (after Schiller, 1937). Figs. 43, 44, 45 – *C. geniculatum* (Lemm.) Cleve. 43 – 44 (after Wood, 1963 *a*), 45, ventral view (after Jörgensen. 1920). Figs. 46, 47 – *C.bigelowii* Kofoid, dorsal views; 46, (from Schiller, 1937; 47, after Wood, 1963 *a*). Figs. 48, 49 – *C. inflatum* (Kofoid) Jörgensen, ventral and dorsal views; (from Schiller, 1937). Figs. 50, 51, 52 – *C. longirostrum* Gourret; 50, 51, dorsal views, 52 ventral view, with chromatophores; (original). Fig. 53 – *C. falcatum*, (Kofoid) Jörg., dorsal view; (after Jörgensen, 1920). Fig. 54 – *C. falcatiforme* Jörgensen, ventral view; (after Jörgensen, 1920). Fig. 55 – *C. fusus* (Ehrenb.) Du Jardin, ventral view; (after Lebour, 1925). Figs. 56, 57 – *C. extensum* (Gourret) Cleve, ventral and dorsal views; (after Jörgensen, 1920). (41, 42, x 150; 43, 44, 47, 48, 49, not given; 51, 52, x 380; 50, 53, 54, x 280; 55. x 500; 45, 46, 56, 57, x 70).

=*C. (lineatum) robustum* Cleve, 1901 *a*, p. 14.
=*C. setaceum robustum* Peters, 1932, p. 33, pl. 3, figs. 15 *b, c*.

Body longer than broad. Epitheca triangular in outline with almost straight sides and an angle of 40° - 60°. Hypotheca sharply trapezoidal, slighely narrowed towards posterior with moderately inclined antapical body contour (angle about 10°–25°). Transverse furrow slightly below the centre. Apical horn massive, long; posterior horns diverging to almost parallel. Chromatophores reddish yellow. $t = 25\text{-}47\mu$; length of body about $1\frac{1}{2}$ *t*; *V* = *ca* 2 *t*; *L* = less than *t*.

In temperate and cold parts of the Atlantic, European coasts; Pacific; Arabian Sea, Indian Ocean, Malaya Archipelago.

14. **Ceratium setaceum** Jörgensen, 1911
(Text-figs. 37, 38)

Jörgensen, 1911, p. 23, figs. 40, 41; 1920, p. 31, fig. 19.
Steemann Nielsen, 1934, p. 12, fig. 16.
Schiller, 1937, p. 373, fig. 411.
Graham and Broniskovsky, 1944, p. 22, fig. 11 *a*.
Wood, 1954, p. 278, figs. 194 *a, b*.
Subrahmanyan, 1958, p. 439.
=*C. furca* var. *baltica* Entz., 1902, Böhm, 1931 *c*, p. 353.

Body small, slender, broad. Hypotheca towards posterior narrowed with first convex and then concave contour. Posterior horns robust, pointed. Left horn double the size of the right one. Apical horn generally robust, with spirally beset longitudinal lists, at times thin and long. $t = 45\text{-}54\mu$; $h = 26\text{–}30\mu$; $V = 200 - 280\mu$; *L* less than *t*; *R* more than $\frac{1}{2}$ *L*. Species resembles *C. pentagonum*, described above.

Rare warm water form. Hitherto known from Atlantic and Pacific Oceans. In the Mediterranean in deep waters (1950 m) probably the resting stage and not vegetative. Observed on the west coast of India on a few occasions.

15. **Ceratium kofoidii** Jörgensen, 1911
(Text-figs. 41, 42)

Jörgensen, 1911, p. 23, figs. 38, 39; 1920, p. 33, fig. 20.
Steemann Nielsen, 1939, p. 8.
Schiller, 1937, p. 373, figs. 412 *a, b*.
=*C. böhmii* Graham and Broniskovsky, 1944, p. 22, fig. 12

Small slender species, smallest of the genus. Transverse furrow placed somewhat below middle. Epitheca three-sided with straight or slightly convex contour and long very thin apical horn which at base somewhat broad and generally beset with winged lists. Hypotheca broader than long, towards posterior slightly narrowed with almost straight or very slightly concave contour lines. Posterior horns very unequally long usually small and drawn into a long fine apex, diverging, the left double as long as the right one or even more. Antapical contour line sharply oblique. Posterior horns usually beset with fine teeth, similar small teeth are present frequently on the sides of body. Teeth particularly stand out at base of left horn. Sculpture tender, at times pores present. This species differs from *C. pentagonum* in its small size, smaller body and proportionately long, thin, posterior horns. In shape and size nearer to *C. teres*, but, differs in the shape of hypotheca. A slender species than *C. lineatum*. $t = 23$–34; length of body 43–50μ; $h = ca\ 2/3\ t$; $V = 94$–145μ; $L = 20$–37μ; $R = 9$–17μ.

Rare warm water form. Surface to 950 m (resting stages). Indian Ocean, Arabian Sea, Singapore; Formosa Channel; Atlantic, Bengula Current, Florida Current, west of S. Africa; Pacific Ocean, Japan, west coast of America.

16. **Ceratium minutum** Jörgensen, 1920
(Text-figs. 39, 40)

Jörgensen, 1920, p. 34, figs. 21-23.
Lebour, 1925, p. 145, pl. 30, fig. 4.
Schiller, 1937, p. 374, figs. 413 *a* - *c*.
Wood, 1954, p. 279, fig. 196.
Subrahmanyan, 1958, p. 439.
=*C. eugrammum* Kofoid, 1907 *a*, p. 26, fig. 3; 1907 *d*, pp. 25–28, fig. 34.

In the ventral aspect, anterior portion of body three-sided in outline and with almost straight sides which form an angle of about 60°. Lower portion obliquely trapezoidal with almost straight contours. Posterior horns very short. Lower ridge of transverse furrow not much developed. $t = 25$ to 38 μ, dorsiventral diameter half as large.

Atlantic Ocean, temperate region. Being small form, passes through the net, hence distribution uncertain. West coast of India on a few occasions.

Sub-genus **AMPHICERATIUM** (Vanhöffen) Gran

Section **Inflata** Jörgensen, 1911

Cell body long and narrow, sometimes slightly flattened, sometimes not flattened. Right posterior horn very small, often rudimentary or even absent;

the left, on the other hand, very long and robustly developed, so that the hypotheca with the horn approximately equally as long or longer than the epitheca with apical horn.

17. Ceratium geniculatum (Lemmermann) Cleve, 1901
(Text-figs. 43, 44, 45)

Cleve, 1901 *b*.
Jörgensen, 1911, p. 24, figs. 42, 43; 1920, p. 34, fig. 24.
Böhm, 1931 *b*, p. 43, figs. 37 *c*, *d*.
Steemann Nielsen, 1934, p. 13, fig. 17.
Schiller, 1937, p. 375, fig. 414 *a*.
Wood, 1954, p. 279, fig. 197.
= *C. fusus* var. *geniculatum* Lemmermann, 1900, pl. 1, figs. 17.
= *C. tricarinatum* Kofoid, 1907 *b*, p. 173, pl. 3, fig. 20.
= *C. geniculatum* var. ? Wood, 1963a, p. 40, fig. 145.

Epitheca, in ventral view, in front of transverse furrow first narrowed a little with concave sides, then somewhat inflated and widened and in the upper third suddenly drawn into an apical horn. Body cross section three-sided brought about by three large longitudinal ridges which are frequently less developed in young individuals and, therefore, easily over looked. Left posterior horn very robust, twice bent, first ventrally and to the right, then dorsally and to the left. Right posterior horn straight at least five times shorter than the left. t = 35 to 40μ; h = somewhat smaller than t; v = (without horn)130–140μ; V = 65–75μ; R = somewhat smaller than t.

Rare warm water type. Indian Ocean, South India, East Africa, between Ceylon and N. Sumatra; Pacific Ocean; Atlantic Ocean, Gibralter.

18. Ceratium bigelowii Kofoid, 1907
(Text - figs. 46, 47)

Kofoid, 1907 *c*, p. 170, pl. 3, fig. 22.
Jörgensen, 1911, p. 25, fig. 44.
Böhm, 1931, p. 43, fig. 37 *b*.
Steemann Nielsen, 1934, p. 13, fig. 18; 1939, p. 8.
Schiller, 1937, p. 376, fig 414 *b*.
Wood, 1963, p. 39, fig. 143.

Epitheca globose, much larger than hypotheca, tapering into a long slightly bent apical horn; hypotheca small with one horn very short and the other very long bent towards end. Clearly distingushed by the egg shaped inflation of the epitheca on which the long, slightly bent apical horn is placed. $t = 40\ \mu$; $v = 4\ t$; entire length $= 900 - 1030\ \mu$.

Rare. Indian Ocean, south of India; Pacific Ocean between Galapagos and Pomotu.

19. **Ceratium inflatum** (Kofoid) Jörgensen, 1911
(Text - figs. 48, 49)

Jörgensen, 1911, p. 25, figs. 45,46, 48 *a*; 1920, p. 35, fig. 25.
Böhm, 1931 *b*, p. 14, figs. 10 *a*, *b*.
Schiller, 1937, p. 376, figs. 415 *a*, *b*.
Graham & Broniskovsky, 1944, p. 23, fig. 110*s*.
Wood, 1954, p. 281, fig. 198.
Subrahmanyan, 1958, p. 439.
= *C. pennatum* f. *inflata* Kofoid, 1907 *c*, pl. 2, fig. 13.
= *C. fusus* var. *concavum* Gourret, 1883, pl. 4, fig. 64; Karsten, 1907, p. 230.

Epitheca and hypotheca little differentiated in size. Epitheca rather broad, however, much longer than broad, quickly transists into apical horn which, therefore, appears deposited. Apical horn at first uniformly broad, towards apex narrowed a little, dorsally somewhat bent. Hypotheca broader than long, narrowed towards posterior; left horn very long, robust, distal dorsally strongly arched. Right horn very small, thin and pointed. Usually cell wall at no place thickened; however, at times, the curvatures on concave sides thickened. $t = 34$–40μ; h a little less than t; $v = 1\frac{1}{4} - 1\frac{1}{2}\ t$; $V = 400 - 500\mu$; $L = 340$-400μ; $R = 13$-24μ; total length $780 - 900\mu$ or up to 1000μ.

Warm water form of oceans and adjacent seas. Indian Ocean, Red Sea, Arabian Sea, Bay of Bengal, between Ceylon and Sumatra; Atlantic Ocean, Gibralter Strait, Azores, between Cuba and Haiti; South China Sea, East China Sea, Japan.

Section 'Fusiformia Jörgensen'

Epitheca small, approximately twice as wide as the hypotheca and the transapical diameter.

20. **Ceratium longirostrum** Gourret, 1883
(Text-figs. 50, 51, 52)

Jörgensen, 1920, p. 37, figs. 26, 27.
Schiller, 1937, p. 376, figs. 416 *a, b.*
Graham & Broniskovsky, 1944, p. 24, figs. 11 *T* - *V.*
Wood, 1954, p. 281, fig. 199.
Subrahmanyan, 1958, p. 439.
= *C. pennatum* f *propria* Kofoid, 1907 *c*, p. 172, pl. 2, fig. 12.
= *C. pennatum* var. *scapiforme* Jörgensen, 1911, p. 27, fig. 47 *a* - *d.*

Epitheca very long, narrow, gradually narrowed, at times without any limitation, merging towards apex into an apical horn which is, bent towards dorsal side. Hypotheca towards posterior a little narrowed, somewhat longer than broad. Left posterior horn long, behind the centre more or less bent a little strongly dorsalwards and at the concave side of curvature strongly thickened. A similar wall-thickening noticed at corresponding place on apical horn. Right horn clear, however, small, narrow and thin, blunt to pointed. $t = 20–35\mu$; $v+V = 290–400\mu$; *L* (with left horn) = 200 - 300μ; *R* (with right horn) = 11 - 35μ; total length = 500 - 700μ.

This species resembles *C. inflatum* particularly in side view but distinguished by its long narrowed body without clearly demarcated apical horn, the usual wall thickening at the bent portions as well as the smaller size.

Warm water form. Atlantic Ocean from 28°S to Azores, Mediterranean; Red Sea. Arabian Sea, Indian Ocean, 37°S to 7°N; Pacific Ocean; Japan; west coast of America.

21. **Ceratium falcatum** (Kofoid) Jörgensen, 1920
(Text-fig. 53)

Jörgensen, 1920, p. 39, fig. 28.
Steemann Nielsen, 1934, p. 14, fig. 22; 1939, p. 8.
Schiller, 1937, p. 377, fig. 417 *a.*
Wood, 1954, p. 281, fig. 200.
= *C. pennatum* Cleve, 1900 *a.*
= *C. pennatum* forma *falcata* Kofoid, 1907 *c*, p. 172, pl. 2, fig. 14.
= *C. pennatum* var. *falcatum* Jörgensen, 1911, p. 27, fig. 48 *b.*

Characterised by the slightly bent or almost straight apical horn which is considerably longer than the left posterior horn. Epitheca above all almost

equally broad, then, rapidly narrowed into apical horn. Proportionately the overall length of epitheca to hypotheca 1:1.56 in sections. Left antapical abruptly curved. $t = 18 - 20\mu$; $v + V = 263 - 276\mu$; $h + L = 170 - 190\,\mu$.

Warm water form. Arabian Sea, Indian Ocean, Red Sea, Zanzibar; West of Bass Straits; Mediterranean; Gibralter.

22. **Ceratium falcatiforme** Jörgensen, 1920
(Text-fig. 54)

Jörgensen, 1920, p. 40, fig. 29.
Böhm, 1931 *b*, p. 45.
Steemann Nielsen, 1934, p. 14, fig. 23.
Schiller, 1937, p. 378, fig. 417 *a*.
= *C. inflatum falcatiforme* Peters, 1932, p. 36.

Somewhat similar to *C. longirostrum*; smaller. Epitheca similar to that of *C. longirostrum*, gradually merges into the anterior horn which is somewhat bent. One of the posterior horns, the larger one, bent clearly. Length of epitheca 144–153 μ; hypotheca *ca* 128 μ.

In view of the great variations, a distinction between this species and *C. falcatum* is difficult to establish.

Interoceanic warm water form. Mediterranean Sea; Indian Ocean.

23. **Ceratium fusus** (Ehrenb.) Du Jardin, 1841
(Text-fig. 55; pl. 1, figs. 3 - 6)

Gleve, 1901 *a*, p. 14.
Paulsen, 1908, p. 90, fig. 123.
Jörgensen, 1911, p. 29, figs. 51 – 53; 1920, p. 41, fig. 30.
Lebour, 1925, p. 146, pl. 31, fig. 1.
Böhm, 1931 *b*, p. 14, figs. 10 *c* – *f*.
Steemann Nielsen, 1934, p. 14, figs. 25, 26.
Schiller, 1937, p. 378, figs. 418 *a*, *b*.
Graham & Broniskovsky, 1944, p. 25, fig. 11 E.
Wood, 1954, p. 282, fig. 202.
Subrahmanyan, 1958, p. 439.
= *Cercaria fusus* Michaelis, 1830, Schiller, 1937, p. 379.
= *Peridinium fusus* Ehrenberg, 1833, p. 271; 1834, p. 25, pl. 2, fig. 3.

=*P. seta* Ehrenberg, 1859, p. 792; 1873, p. 3, figs. 5, 6.
=*Cerattum pellucidum* Gourret, 1883, pl. 1, fig. 20; pl. 4, fig. 66.
=*Amphiceratium fusus* Vanhöffen, 1899.
=*Ceratium seta* Kent, Kofoid, 1908 *b*, p. 387.
=*C. fusus* var. *schüttii* Lemm., Schiller, 1937, p. 379, fig. 418 *c*.
(=*C. fusus* Schütt, 1895, pl. 9, fig. 35).
=*C. fusus* var. *seta* (Ehrenb.) Jörgensen, 1911, p. 29, fig. 55; Schiller, 1937, p. 379, fig. 418 *d;* Subrahmanyan, 1958, p. 439.

Epitheca long and gradually tapered into a long almost uniformly broad, towards the apex only slightly narrowed, dorsally slightly bent, often merging into an almost straight, apical horn. Hypotheca suddenly narrowed, longer than broad. Left posterior horn narrow dorsally uniformly more or less bent, rarely straight; right horn little developed or not developed.

Authors describe a number of varieties (*vide* synonyms above). As the characters are not stable, there appear to be no basis for recognition of varieties and formae Paulsen could not recognise the varieties noted by Jörgensen in the Mediterranean. Steemann Nielsen did not find the varieties of the Mediterranean significant. Graham & Broniskovsky also consider the distinctions not significant. In the present account, therefore, no varieties and formae are recognised; all are merged into the species.

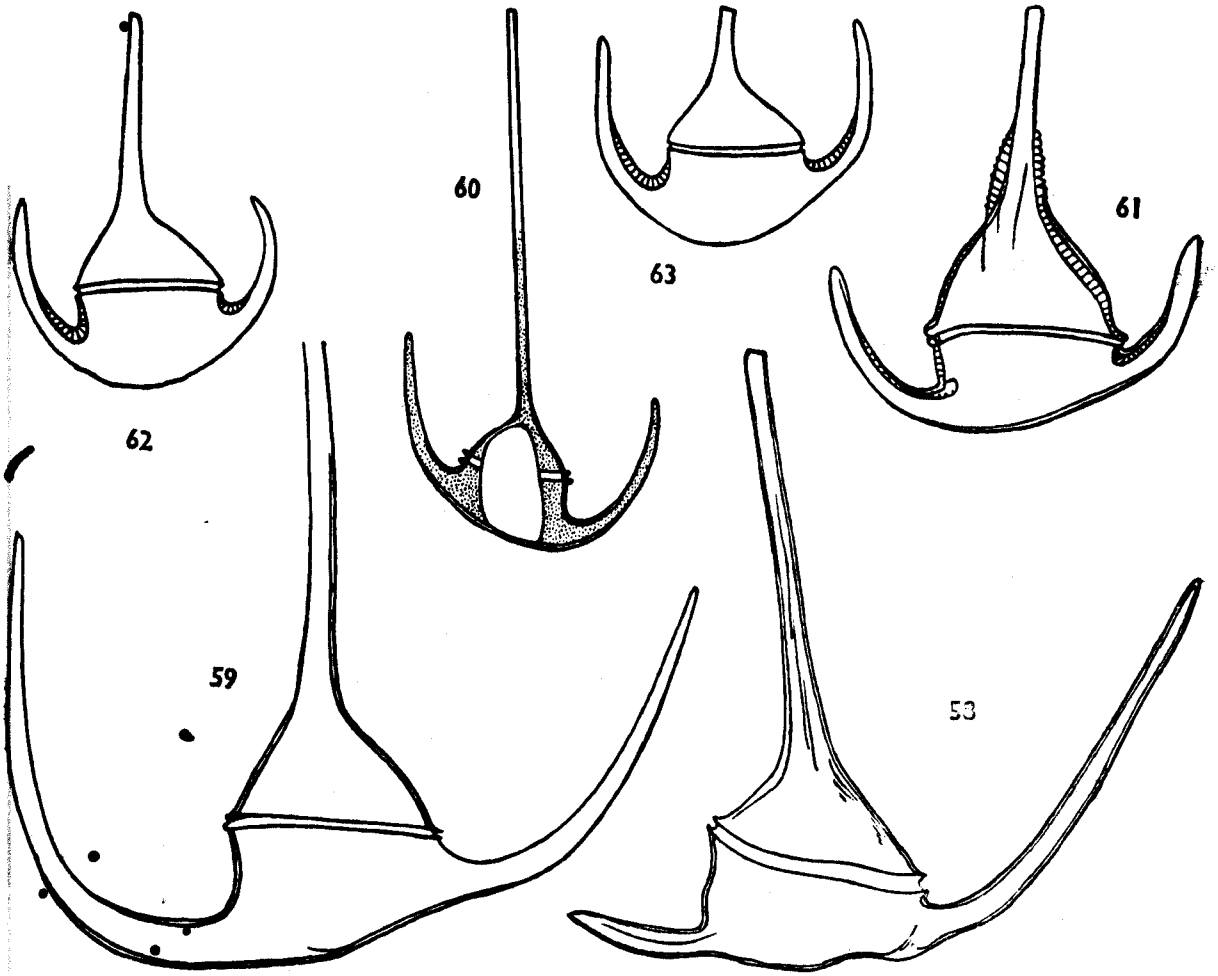
Warm water of all seas. Often causes phosphorescense. Indian Ocean, Red Sea, Gulf of Aden, Arabian Sea; Boeton Straits; S. and W. coast of Australia.

24. Ceratium extensum (Gourret) Cleve, 1901
(Text-figs. 56, 57)

Cleve, 1901 *a*, p. 14; 1903, p. 340.
Paulsen, 1908, p. 91.
Jörgensen, 1911, p. 28, fig. 50 *a;* 1920, p. 14, fig. 31.
Lebour, 1925, p. 146, fig. 463.
Peters, 1932, p. 36, pl. 2, figs. 10 *d*, 14 *f*.
Steemann Nielsen, 1934, p. 14, fig. 24.
Schiller, 1937, p. 380, figs. 419 *a, b*.
=*C. furca* var. *mediterraneum* Gourret, 1883, p. 49, pl. 1, fig. 13.
=*C. fusus* var. *stricta* Okamura *et* Nishikawa, 1904, p. 128, pl. 6, fig. 25.
=*C. strictum* Kofoid, 1907 *c*, p. 172; Jörgensen, 1911, p. 27, figs. 49 *a, b;* 1920, p. 45, fig. 32.

=*C. biceps* Kofoid, 1908 *a*, figs. 21 – 24; 1908 *b*, p. 389.

=*C. extensum* f. *strictum* (Okamura & Nishikawa) Steemann Nielsen, 1934, p. 14, fig. 24.



Text-figures 58 – 63. Fig. 58 – *Ceratium dens* Ostf. *et* Schmidt; dorsal view; (original). Fig. 59. *C. tripos* (O. F. Müller) Nitzsch; dorsal view; (original). Fig. 60. *C. pulchellum* B. Schröder; ventral view; (after Schiller, 1937) Fig. 61. *C. porrectum* (Karsten) Schiller; dorsal view; (from Schiller, 1937). Figs. 62, 63. *C. breve* (Ostf. *et* Schmidt) Schröder; dorsal views; (after Böhm, 1931 *b*). (58 – x 240; 59 – x 365; 60 x 265; 61 x 215; 62 and 63 not given.)

Species very long. Epitheca long, narrow, generally transformed into a long, straight, narrow, apical horn. Hypotheca regularly narrowed, longer than broad. Left posterior horn usually long, dorsally oriented but straight; right

posterior horn absent. t = 23 - 30 μ ; h = somewhat larger than t; $v + V$ = 300 - 520 μ; L = 750 - 1280 μ. Overall length of cell upto 2mm.

Tropical oceanic form. Red Sea, Arabian Sea, Gulf of Aden, Malay, Indian Ocean, west of Australia; South China Sea; Atlantic, 27° S to 39° N, British Isles; Mediterranean.

Sub-genus **EUCERATIUM** (Gran) Ostenfeld

Cell body large and broad, more or less flatly compressed, always two posterior horns present which are mostly bent towards the front. Right posterior horn rarely small, almost always equally long, at times even longer than the left.

Section **Dens** Jörgensen, 1911

Right posterior horn characteristically bent towards front and long; the left, however, quite short, directed towards the side or backwards.

25. **Ceratium dens** Ostf. *et* Schmidt, 1901
(Text-figs. 58; pl. III, fig. 16)

Cleve, 1903, p. 340.
Jörgensen, 1911, p. 31, fig. 58.
Böhm, 1931 *b*, p. 15, fig. 11.
Steemann Nielsen, 1934, p. 15, fig. 27.
Schiller, 1937, p. 381, figs. 420 *a, b*.
Wood, 1954, p. 284, fig. 204.
Subrahmanyan, 1958, p. 439.
= *C. dens* var. *reflexa* Schmidt, 1901, p. 131, fig. 2.

Rather large, robust species of characteristic shape. Body somewhat broader than long. Epitheca low, half as long as broad. Apical horn well developed, rather uniformly broad, broadened at base; even in the intermediate cells of chains rather long, generally longer than right posterior horn; at times shorter. Hypotheca low, double as broad as long with proportionately slightly inclined posterior contour. Left horn, strikingly short measuring only 2/3 of transdiameter, inclined to left and somewhat ventral and directed backwards, straight or bent, with short, closed apex. Right horn bent round uniformly from the base, divergent towards apical horn, long, somewhat narrower than both the other horns. Armour sculpture very robust; humps, irregularly bent lists and large clear pores. t = 77 μ; $v = \frac{1}{2} t$; h = a little more than $\frac{1}{2} t$; V = 160 - 220 μ; R = 2/3 V to slightly more than V; L = 2/3 +.

Rare warm water form. Common on the west coast of India, Indian Ocean, Red Sea, Gulf of Aden, Arabian Sea; Boeton Strait; east coast of Africa 6° S; Sumatra, Gulf of Siam. Bangkor Straits; Pacific Ocean.

26. **Ceratium tripos** (O. F. Müller) Nitzsch, 1917
(Pl. III, figs. 17, 18; text-fig. 59)

Cleve, 1901 *a*, p. 14; 1903, p. 342.

Paulsen, 1908, p. 77, figs. 102 - 107.

Jörgensen, 1911, p. 35, figs. 1, 2, 65 - 79; 1920, p. 46, figs. 33 - 39.

Lebour, 1925, p. 148, figs. 32, 33.

Böhm, 1931 *b*, p. 15, fig. 12; 1931 *c*, p. 356, figs. 7 - 10.

Steemann Nielsen, 1934 p. 17, figs. 32, 33; 1939, p. 10.

Schiller, 1937, p. 382. figs. 383, 385.

Graham & Broniskovsky, 1944, p. 25.

Wood, 1954, p. 284

= *Cercaria tripos* O. F. Müller, 1786, p. 136, pl. 19, fig. 22.

= *Peridinium tripos* Ehrenberg, 1833, p. 272; 1838, p. 255, pl. 22, figs. 18, 1, 3.

= *Ceratium tripos* f. *balticum* Schütt, 1892, p. 266, fig. 49; Jörgensen, 1911, p. 35, fig. 65; Schiller, 1937, p. 384, fig. 421 *d*.

= *Ceratium arcuatum* Vanhöffen, 1897, pl. 5, fig. 14.

= *C. neglectum* Ostenfeld, 1903, p. 584, fig. 135. (= *C. tripos* var. *atlantica* f. *neglecta* Paulsen, 1908, p. 78, fig. 103).

= *C. tripos* var. *atlanticum* Ostenfeld, 1903, p. 584, figs. 132, 133; Paulsen, 1908, p. 78, fig. 102; Jörgensen, 1911, p. 36, figs. 69 - 73; 1920, p. 47, figs. 33 - 36; Schiller, 1937, p. 384, fig. 421 *a*.

= *C. tripos* f. *subsalsam* Ostenfeld, 1903, p. 584, fig. 134; Jörgensen, 1911, p. 36, figs. 66, 67. (*C. tripos* var. *subsalsa* Paulsen, 1907, p. 12; 1908, p. 79, fig. 104)

= *C, tripos* f. *hiemale* Paulsen, 1908, p. 22, fig. 31; Jörgensen, 1911, p. 36, fig. 68.

= *C. tripos* f. *neglecta* (Osterf.) Paulsen, Jörgensen, 1911, p. 37, fig 74.

= *C. tripos pulchellum* f. *tripodioides* Jörgensen, 1920, p. 50, figs. 40 - 42.

= *C. pulchellum* f. *tripodioides* Jörgensen, 1920, p. 50 figs. 41, 42.

= *C. tripos* f. *ponticum* Jörgensen, Schiller, 1937, p. 384, fig. 421 *c*.

= *C. pulchellum* var. *indicum* Böhm, 1931 *b*, p. 45. fig. 38.

= *C. tripodioides* (Jörgensen) Steemann Nielsen, 1934, p. 15, fig. 28.

= *C. tripos* f. *tripodioides* (Jörg.) Paulsen, Schiller, 1937, p. 384, fig. 421 *b*.

= *C. tripos* (O. F. Müller) Nitzsch Subsp. *tripodioides* Jörgensen, Steemann Nielsen, 1939, p. 10.

Very variable, large species. Body approximately as broad as long or longer. Epitheca low, frequently twice as broad as long. Left side contour

concave, right side strongly convex. Hypotheca as long as the anterior body or a little longer, its left side contour more or less concave. All the horns robust. Right posterior horn generally clearly weakly developed than left, diverges little towards apical horn, often runs parallel with it, rarely converging. Direction of left posterior horn often corresponds with the right. Sometimes, in old individuals winged lists develop.

Very variable as regards size and form of body as well as relative size and direction of the three horns, naturally also in the form of armour structure. Causes of variability known only in part. Temperature and salinity are believed to bring about the variations.

Large number of varieties and forms are known since long which were once again increased by Jörgensen. Peters (1932) remarks that, according to *Meteor* collections, more varieties could be recognized. Owing to the fluctuating variability of this species, the task to encompass all the multifarious forms systematically and particularly to differentiate is very difficult.

Specimens which agree with varieties and forms listed above have been met with. The characters used for such distinctions, size of the horns, the arc and divergence of the horns, and the habitat, are not constant to warrant such distinctions. Rarely two specimens from the same sample agree in all respects!

Widely occurring species. North Sea and neighbouring seas of the Atlantic up to East Sea; Mediterranean; East and West coast of India, Arabian Sea, Malay Archipelago, Indian Ocean; the Pacific; Australian waters.

27. **Ceratium pulchellum** B. Schröder, 1906
(Text-fig. 60)

Schröder, 1906, p. 358, fig. 27.
Jörgensen, 1911, p. 33, figs. 59 – 62; 1920, p. 50, fig. 46.
Böhm, 1931 *b*, p. 15.
Steemann Nielsen, 1934, p. 16, fig. 31.
Schiller, 1937, p. 386, figs. 422 *a, b*.
Graham & Broniskovsky, 1944, p. 27, figs. 14 *B – F*.
Wood, 1954, p. 286, fig. 206 *a*.
= *C. tripos* var. *gracile* B. Schröder, 1900, pl. 1, fig 17 *e*.
= *C. pulchellum* f. *postico juvenile* Jörgensen, 1911, p. 33, fig. 61.
= *C. pulchellum* f. *semipulchellum* Jörgensen, 1920, p 55, figs 43, 44: Schiller, 1937, p. 387, figs. 423 *a, b;* Wood, 1954, p. 286, figs. 206 *b, c;* Subrahmanyan, 1958, p. 439.

=*C. tripos* f. *dalmaticum* Böhm, 1931 *c*, p. 379, figs. 33 – 35.

=*C. tripos* Peters, 1932, p. p., p. 37, pl. 1, figs. 5 *a, b.*

=*C. tripos pulchellum* Peters, 1932, p. 39, pl. 4, fig. 20.

=*C. semipulchellum* Steemann Nielsen, 1934, p. 16, figs. 29, 30.

=*C. pulchellum* f. *dalmaticum* (Böhm) Schiller, 1937, p 387, figs. 424 – 426.

=*C. tripos* subsp. *semipulchellum* (Jörg.) Graham & Broniskovsky, 1944, p. 26, figs. L – N.

Body always longer than broad. Posterior contour clearly convex, particularly right side. Anterior horn strikingly long and robust, uniformly broad up to apex, rarely broader in the middle than at end. Hypotheca with slightly concave, upto almost straight and slightly inclined left side contour. Posterior contour of cell convex, usually uniformly merging with left posterior horn, whereas the right is clearly delimited (slightly so with very small right horn). Posterior horns rather short, less robust than apical horn, the left one particularly beautifully and uniformly arched, at the ends directed almost parallel with apical horn, or the left sometimes somewhat divergent. The right horn is usually clearly weakly developed than the left, usually not much, at times it is very small. Sculpture usually tender or unclear; in older individuals, the pores are clear and lists along transverse furrow well developed as also right horn robustly developed. Winged lists absent.

The species usually distinguished by its very long, robust apical horn. At times, however, the posterior horns are spread out and the apical horn short which give this species a great similarity with *C. tripos* and *C. porrectum*. Sometimes confusions arise when ill-developed specimens are met with.

The species clearly differs from *C. tripos* in its long, robust, apical horn, clearly smaller cell body (longer than broad), in its slightly swollen left contour and slightly convex right side contour. Further, the cell is slightly compressed and even whereas *C. tripos* is thicker with horns shifted ventrally more from the body plane. The right horn at the base is directed more forwards. $t = 60–66\mu$; v = *ca* 2/3 – 3/4 t; h = somewhat more than v; $V = 240 – 300\ \mu$; rarely smaller; R very variable, less than L.

Widely distributed warm water species. Mediterranean; Atlantic Ocean, American Coast, African west coast, half way to Brazil, West Indies; Indian Ocean, Madagascar to Sunda Islands, Arabian Sea, Zanzibar; Pacific Ocean, Japan.

28. Ceratium porrectum Karsten, 1907
(Text-fig. 61)

Jörgensen, 1911, p. 34, figs. 63, 64.
Böhm, 1931 *b*, p. 45.
Schiller, 1937, p. 389, fig. 427 *a*.
= *C. tripos porrectum* Karsten, 1907, pl. 51, figs. 6 *a*, *b*.
= *? C. divaricatum* Kofoid, 1908 *b*, p. 380, fig. 31.
= *C. porrectum* f. *megasomum* Jörgensen, 1911, p. 34, fig. 64.

Robust species. Left contour of epitheca moderate to strongly convex, abruptly drawn out into a robust short anterior horn, which is strikingly broadened at the base and in old, large individuals is beset with toothed ridges; distal portion narrowed. Posterior horns uniformly arched, generally rather short, approximately as long or at times longer than cell body, at the apex diverging, parallel to rarely somewhat converging; the right horn usually somewhat slender and shorter. Armour robust with lists and pores and winged lists. $t = 60\text{-}68\ \mu$, rarely 94 μ; $V = 80 - 150\ \mu$.

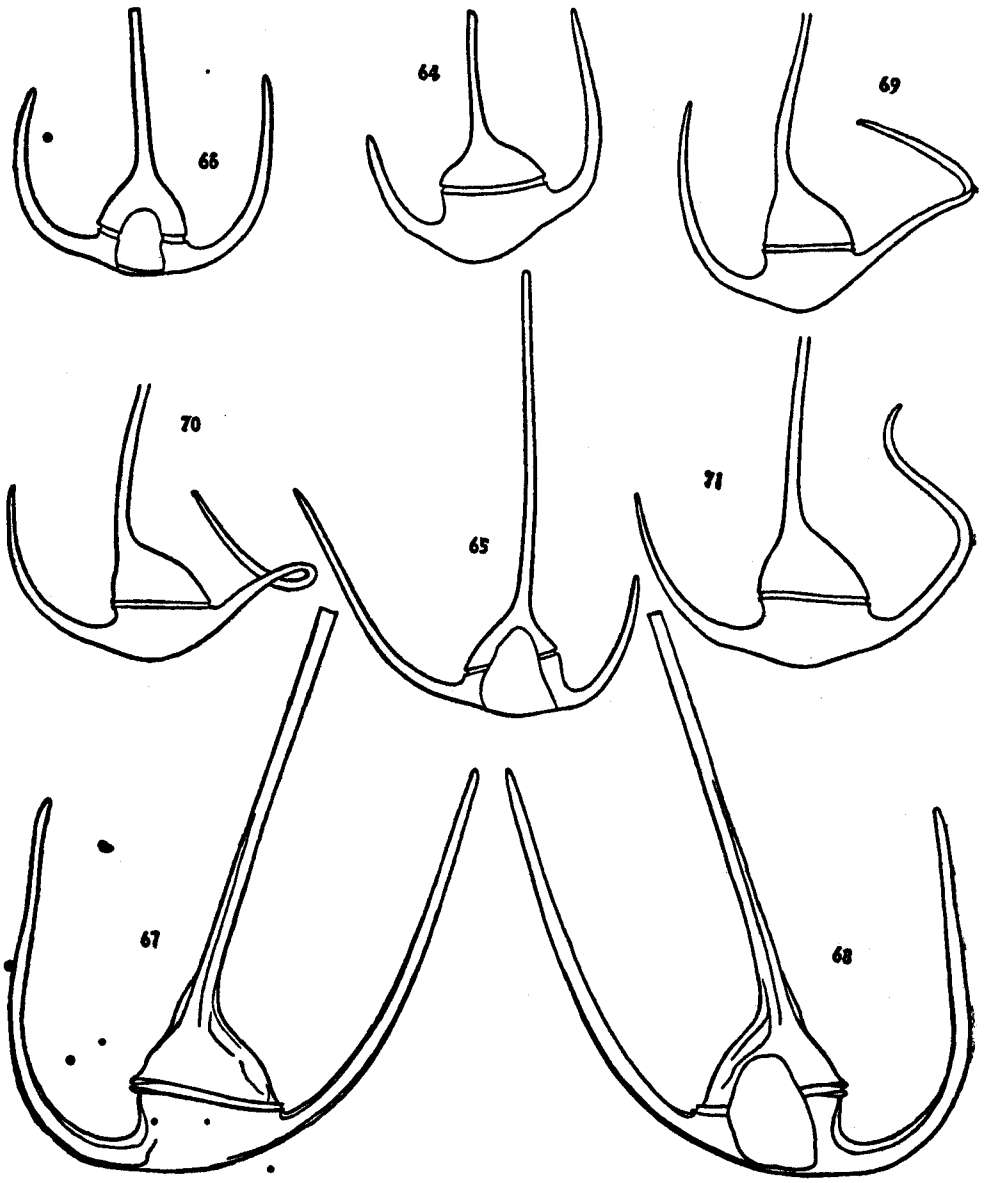
This species is variable particularly in the size of body as well as size and direction of horns. Young forms seem similar to *C. pulchellum*, remind one, however, also of *C. tripos*, as the anterior horn is rather short and not well-developed. Some resemblance is also seen with *C. breve*, particularly relating to size of body and robust posterior horns. A very robustly developed specimen (f. *megasomum* Jörgensen, 1911, p. 34, fig. 64) resembles *C. tripos* f. *neglecta*.

In the Seychelles; Indian Ocean, South of India.

29. Ceratium humile Jörgensen, 1911
(Text-figs. 64, 65)

Jörgensen, 1911, p. 40, figs. 82, 83.
Böhm, 1931 *b*, p. 45.
Steemann Nielsen, 1934, p. 17, fig. 34.
Schiller, 1937, p. 390, fig. 428.
Graham & Broniskovsky, 1944, p. 27, fig 14 *A*.
Wood, 1954, p. 287, fig 208.
Subrahmanyan, 1958, p. 439.

Large species but horns short. Epitheca low; hypotheca up to double the height of epitheca. Posterior contour strongly convex, and therefore, more



Text-figures 64 – 71. Figs. 64, 65 – *Ceratium humile* Jörgensen; dorsal and ventral views; (64, from Schiller, 1937; 65, after Steemann Nielsen, 1934). Fig. 66 – *C. bucephalum* (Cleve) Cleve; ventral view; (from Schiller, 1937). Figs. 67, 68 – *C. karstenii* Pavillard; dorsal and ventral views; (original). Figs. 69, 70, 71 – *C. contortum* (Gourret) Cleve; dorsal views; (after Böhm, 1931 *b*). (64, x 185; 65, 66, x 175; 67, 68, x 130; 69, 70, 71, not given).

or less bulged. Anterior horn almost uniformly broad, at base slightly broader, very short in cases of chain formation or many times longer than the body. Left posterior horn similarly short, frequently slightly longer than the body, up to one and half times, at base almost perpendicular or a little forward directed, beautifully arched. Right posterior horn significantly longer, slightly arched, right from base directed forwards. The apices of apical and right horn coverage a little, those of apical and left horn more or less diverge. Cell concave and posterior horns appear shifted out of ventral side. Older individuals with sculptured wall, beset with humps and lists.

Distinguished from *C. tripos* by the longer right posterior horn particularly by the varving sizes of epitheca and hypotheca. It is closely related to *C. breve*. The elongated right posterior horn reminds one of *C. karstenii* but is different otherwise. $t=66$ to 80μ; $v=$somewhat larger than $\frac{1}{2}$ t; $h=ca\ \frac{2}{3}\ t$; $V=\frac{1}{2}$–$2t$; $L=1$–$\frac{1}{3}t$; $R=ca\ 2\ t$.

Rare. In neritic warm water of Pacific, Japanese waters; Malacca Straits, Sumatra coasts, east and west Coast of India.

30. Ceratium breve (Ostenfeld *et* Schmidt) Schröder, 1906
(Pl. III, figs. 13–15; text-figs. 62, 63)

Schröder, 1906, p. 358.
Jörgensen, 1911, p. 40, fig. 84.
Böhm, 1931 *b*, p. 18, figs. 17, 18.
Steemann Nielsen, 1934, p. 18, figs. 35, 36.
Schiller, 1937, p. 391, figs. 429 *a, b*.
Graham & Broniskovsky, 1944, p. 27, figs. 14 *G–P*.
Wood, 1954, p. 288, figs. 209 *a, b*.
Subrahmanyan, 1958, p. 439.
=*C. tripos* var. *parallela* Schmidt, 1901, p. 210.
=*C. tripos azoricum* Karsten, 1906, pl. 20, figs. 3 *a, b*.
=*C. tripos azoricum* var. *brevis* Ost. *et* Schmidt, Karsten, 1907, pl. 48, figs. 1 *a,b*.
=*C. breve* var. *curvulum* Jörgensen and var. *parallelum* (Schmidt) Jörgensen, 1911, p. 41, figs. 85, 86, respectively.

Medium sized, short horned robust species.. Epitheca more or less half as long as broad. Left side contour weak, right strong and irregularly convex. Apical horn short. Hypotheca mostly clearly longer than the epitheca, up to one half times as long as body, with convex contour, that it is either

equally convex or in the middle strongly bulged and on both sides mostly quite similarly passes into the two horns. Posterior horn unusually robust. Left one is always a little stronger and larger than the right, in case it is equal below, then, it is straight or bent in a beautiful arch up to the apex and more or less runs parallel with the apical horn. The right horn bent only below, then, more or less straight up to apical horn slightly or strongly bent and converging strongly towards the apical horn. $t = 64 - 85\mu$; $v = 34 - 42\mu$; $V = 47 - 196\mu$; $L = 2/3 - 1\frac{1}{2}$ times as long as the body.

According to Steemann Nielsen, the classification according to Jörgensen into varieties is wrong since they overlap one another. Frequently forms occur with strongly arched right posterior horn.

Warm water form of the oceans. Red Sea and Arabian Sea, Indian Ocean; Boeton Straits; Zanzibar; Atlantic Ocean, west coast of Africa, between Cuba and Haiti.

31. **Ceratium bucephalum** (Cleve) Cleve, 1901
(Text-fig. 66)

Cleve, 1901 *a*, p. 14.
Paulsen, 1908, p. 76, fig. 100.
Jörgensen, 1911, p. 47, figs. 99, 101; 1920, p. 68.
Schiller, 1937, p. 392, fig. 430.
Wood, 1954, p. 288, figs. 210, *a*, *c*.
Subrahmanyan, 1958, p. 439.
= *C. tripos* var. *bucephalum* Cleve, 1897, p. 302, pl. 8, fig. 5.
= *C. arcuatum* Vanhöffen, 1897, pl. 5, fig. 13.
= *C. tripos* var. *berghii* Lammermann, 1900, p. 363.
= *C. heterocamptum* Paulsen, 1908, p. 76, fig. 101.
= *C. bucephalum* var. *heterocamptum* Jörgensen, 1911, p. 48, fig. 101.

A small species. Body longer than broad. Epitheca rather long with convex side contours. Apical horn moderately long, straight or at the base somewhat bent towards apex, narrowed. Hypotheca not or a little shorter than epitheca. Posterior contour convex and gradually merges into the posterior horns or in the middle slightly bulged. Posterior horns arise transverse to the body, robust, equal in size, or the right one little smaller, beautifully and uniformly arched, at the apex almost straight shorter or longer, never reach the level of the apex of the apical horn. All the horns lie approximately in the same plane and converge

usually at the apices. Sculpture little striking, however, frequently low winged lists occur along apical horn, as well as short irregularly bent longitudinal lists occur scattered over the armour. In ventral view the sides of apical horn and the convex sides of posterior horns are dentate, never the posterior contour. Chromatophores many, plate-like in the cell body, in the arms long and ribbon like. $t = 54 - 64\ \mu$; $h = 28 - 37\mu$; v = little smaller than h; $V = 89 - 180$.

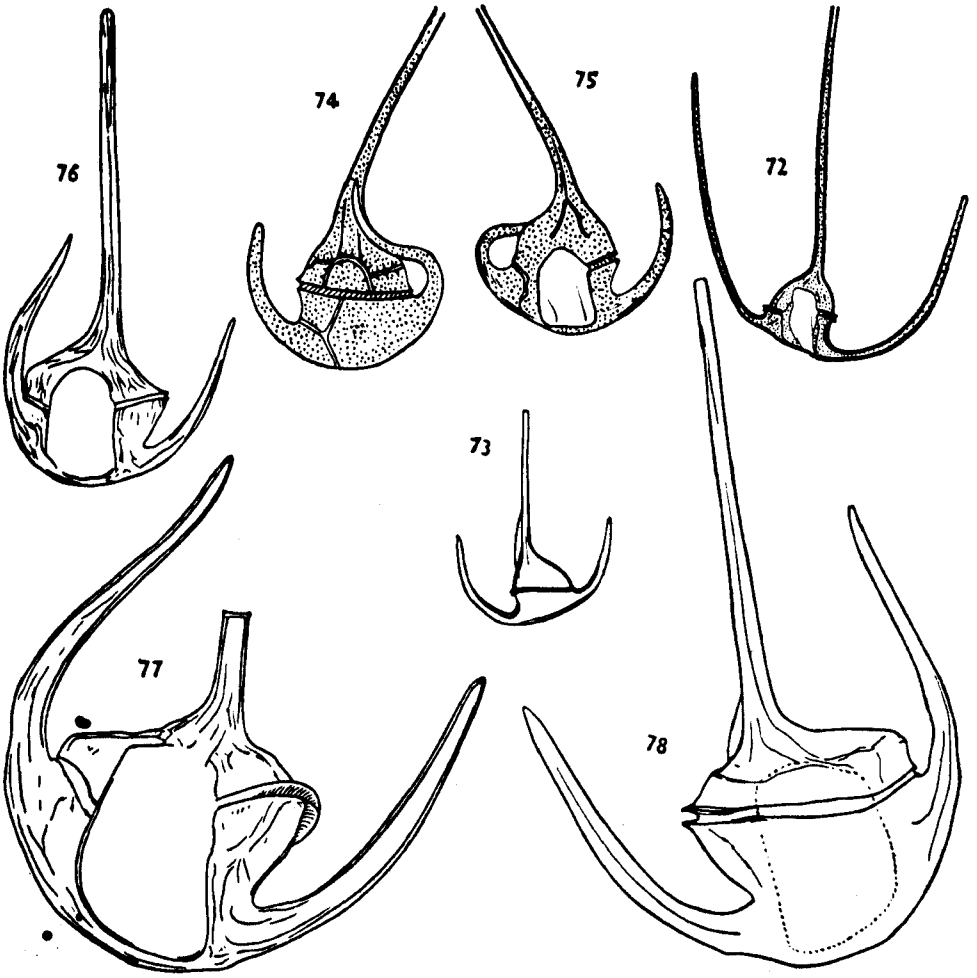
N. Atlantic, North Sea, Norwegian Coast, Florida Stream; Arabian Sea, Gulf of Aden, Indian Ocean; Japan.

32. Ceratium karstenii Pavillard, 1907
(Text-figs. 67, 68)

Pavillard, 1907, p. 152.
Jörgensen, 1911, p. 53, figs. 116, 117.
Steemann Nielsen, 1934, p. 23, fig. 51.
Schiller, 1937, p. 393, figs. 431 *a*, *b*.
Wood, 1954, p. 289, figs. 211 *a*, *b*.
= *C. arcuatum* (*tripos* var.) Cleve, 1900, p. 13, Pl. 7, fig. 11.
= *C. arcuatum* Gourret, Cleve, 1903, p. 339; Jörgensen, 1920, p. 75, fig. 71; Böhm, 1931 *b*, figs. 24, 25; Karsten, 1906, pl. 20, figs. 13 *a*, *b*, 14.
= *C. tripos lunula* Karsten, p. p. 1906, pl. 20, figs. 8 *a*, *b*, 10, 11.
= *C. schrankii* Kofoid, 1907 *b*, p. 306, figs. 29 *a* - 31.
= *C. tripos schrankii* Karsten, 1907, pl. 51. figs. 3 *a*, *b*.
= *C. lunula* var. *robusta* Karsten, p. p. 1907, pl. 64, fig. 5 *a*, (non *b*).
= *C. okamuri* Schröder, Karsten, 1907, p. 407; Wood, 1963 *c*, p. 13.

Large species. Epitheca very oblique, right side contour clear, and often strongly convex, much longer than the somewhat convex left. Hypotheca approximately same length as epitheca with very oblique, however slightly concave left side contour. Posterior contour unequally convex, generally quite gradually merging into the left horn; not, however, the right which is more or less clearly set out. Apical horn rather long and thin, below a little broad, bent right at base, then almost straight or quite a little twisted; the extension of the same cuts the posterior contour near the starting point of the left horn. Posterior horns unequal; the left uniformly bent, relatively short, generally twice as long as body only; the right one, however, only slightly bent, $1\frac{1}{2} - 2$ times as long as left. Both horns exhibit the peculiarity that the distal parts are thinner, much tender and very flabby, whereby these parts frequently do not take any definite direction. The transition to the stiff proximal part is rather sharp that here the right horn is

more or less bent. The species form chains in which the anterior-most cell possesses a long apical horn whereas the length of these horns in the other cells is so adjusted that the apices of the three horns lie in a straight line; sculpture tender.



Text-figures. 72-78. Fig. 72, 73-*Ceratium karstenii* f. *robustum* (Karsten) Jörgensen; ventral and dorsal views; (72, after Schiller 73, from Schiller 1937). Figs. 74, 75 - *C. conciliens* Jörgensen; dorsal and ventral views; (after Schiller, 1937). Figs. 76, 77, 78 - *C. gibberum* Gourret. 76, 77. ventral views, 78, dorsal view; (original). (72, x 100; 73, x 95; 74, 75, x 210; 76, x 180: 77, 78, x 380).

Very variable species. t = 80 - 100 μ; V = *ca* 170 μ in the intermediate cells of chain, end cells V = 380 - 425 μ; R = 230 - 500 μ.

(Distribution refer below).

33. Ceratium karstenii forma robustum (Karsten) Jörgensen, 1911
(Text-figs. 72, 73)

Jörgensen, 1911, p. 54, fig. 118.
Schiller, 1937, p. 394, figs. 432 *a*, *b*.
Subrahmanyan, 1958, p. 439.
=*C. tripos arcuatum* var. *robusta* Karsten, 1907, pl. 48, figs. 6 *a*, *b*.
=*C. tripos lunula* Karsten, p. p., 1906, pl. 20, figs. 9 *a*, *b*.
=*C. tripos arcuatum* Karsten, p. p., 1906, pl. 20, figs. 13 *a*, 14; 1907, p. p. pl. 48, fig. 4.
=*C. tripos arcuatum* forma *atlantica* Karsten, p. p., 1906, pl. 20, figs. 15 *a*, *b*.
=*C. arcuatum* Kofoid, 1908 *b*, p. 376, figs. 25, 26.

This f. *robustum* described by Jörgensen is very possibly a mature specimen of the species. The characters of this form are: More robust than type. Anterior horn at the base strongly broadened with entire margin beset with winged lists, at the base slightly but strikingly bent, at times almost straight, usually thus not so much laterally displaced. Right side contour of epitheca slightly convex. Posterior contour of cell mostly straight. The proximal part of the posterior horns very robust. Right posterior horn at base strongly bent at times like a stump; of varying length, partly, as in the type, with long thin point and more or less clearly, longer than the left; partly both horns up to the tip firm and approximately equally long. Sculpturing robust, armour thick-walled with large more or less numerous longitudinal lists. Posterior horn thickened at concave sides. $T=72-102\mu$; $V=264-420\mu$; $R=145-300\mu$.

In the warm water of all oceans and neighbouring seas. Red Sea, Gulf of Aden, Arabian Sea, Indian Ocean, Sumatra, Zanzibar; Atlantic Ocean, South of Africa to La Plata upto 37° N on the American east coast, Gulf Stream, South west of Ireland; Mediterranean; Pacific, East China Sea. Both species and *forma* have same distribution.

34. Ceratium contortum (Gourret) Cleve, 1901
(Text-figs. 69, 70, 71)

Cleve, 1901 *a*, p. 14; 1903, p. 340.
Jörgensen, 1911, p. 55, fig. 120.
Böhm, 1931 *b*, p. 23, fig. 20.
Steemann Nielsen, 1934, p. 23, figs. 52, 53; 1939, p. 13.
Schiller, 1937, p. 395, fig. 433.

=*C. gibberum* var. *contortum* Gourret, 1883, pl. 2, fig. 33.
=*C. contortum* Cleve. 1900 *d*, p. 14, pl. 7, fig. 10.
=*C. subcontortum* B. Schröder, 1906, p. 358, figs. 28 *a*, *b*.
=*C. saltans* B. Schröder, 1906. p. 359, figs. 29 *a*-*c*.
=*C. contortum* var. *saltans* Jörgensen, 1911, p, 56, figs. 121 *a*, *b*.
=*C. contortum* f. *subcontortum* (Schörder) Steemann Nielsen, Schiller. 1937, p. 396, fig. 434.

Large species; shows similarity to *C. longinum* and *C. karstenii;* however, distinguished by the characteristic bent of right posterior horn.

Epitheca very oblique, with particularly convex left side contour and apical horn far displaced to left. Hypotheca approximately same length as the epitheca with very oblique left side contour. Posterior contour convex, more or less strongly bulged; frequently right side little curved and merges uniformly into the right horn. Apical horn at base strongly leftwards and dorsally bent so much that the orientation of the horn above the flexure goes mostly outside the posterior contour, otherwise twisted (weakly sigmoid), often very long. Posterior horns more or less unequally long, the right longer, rarely of same length as, very rarely shorter than the left. The left horn is shaped as in *C. karstenii* and the apex directed approximately parallel with apical horn. The right, at the end, is approximately bent a third towards dorsal side and then bent around more or less towards apical horn and runs bow-like; rarely is the sharp flexure not existing or only indicated and both the posterior horns then are generally in an oblique direction approximately parallel or converging a little, very rarely are they directed parallel with apical horn. $t = 66 - 81\mu$; *V*, varying length, $255 - 400\mu$, upto even $730\ \mu$.

Warm water species. 0 - 100 metres. Indian Ocean, Arabian Sea, Red Sea, Gulf of Aden, Malay; Freemantle; South China Sea, Gulf of Siam, Malacca, Bangkor Straits; Pacific Ocean, Japan; Atlantic Ocean, American Coast, Gulf Stream, north west Spanish coast.

35. **Ceratium concilians** Jörgensen, 1920
(Text-figs. 74, 75)

Jörgensen, 1920, p. 72, fig. 69.
Böhm, 1931 *a*, p. 379, figs. 36 *a* - *c*; 1931 *b*, p. 24, fig. 21 (*non*).
Schiller, 1937, p. 396, figs. 435 *a*, *b*.
Wood, 1954, p. 290, fig. 213.

=*C. tripos* var. *contortum* Gourret, 1883, p. 35, pl. 2, fig. 33.
=*non C. contortum* Cleve, 1900, p. 14, pl. 7, fig. 10.
=*C. gibberum* forma *sinistrum* Gourret, p. p., Jörgensen, 1911, p. 50, fig. 108.

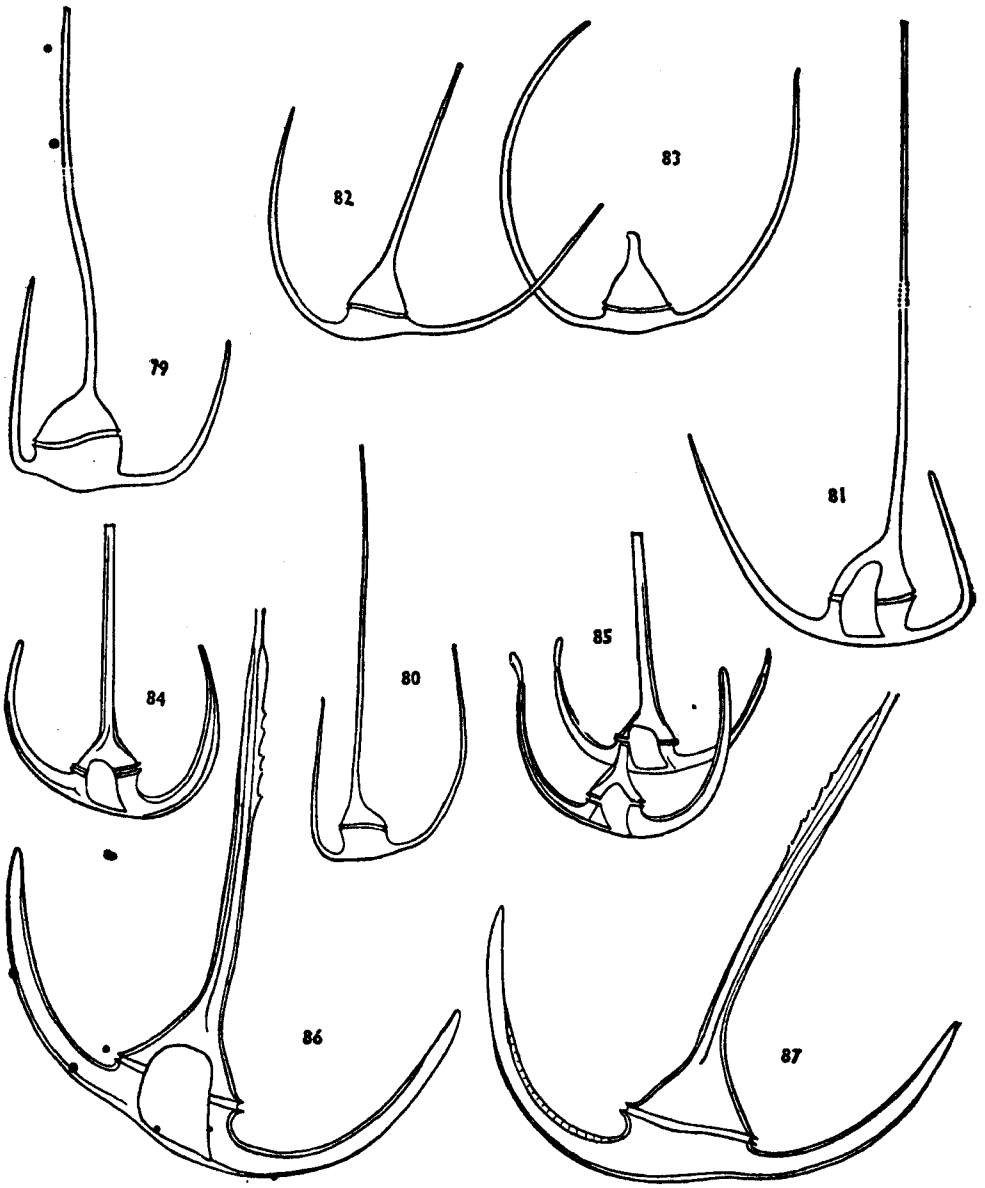
Body not rough; posterior contour more or less humpbacked towards left. Armour smooth without strong ribs and meshes. Apical horn bent, convex towards left and dorsally. Right posterior horn uniformly bent from base towards the dorsal side of the body, distal portion often again somewhat bent in the direction of the apical horn. $t = 62 - 85\ \mu$.

Interoceanic warm water surface species. Indian Ocean; west of Bass Straits; Mediterranean; West Indies, Florida Current.

36. Ceratium gibberum Gourret, 1883
(Text-figs. 76, 77, 78)

Paulsen, 1908, p. 75, fig. 98.
Jörgensen, 1911, p. 49, figs. 106, 107, 109; 1920, p. 70, figs. 67 – 68.
Lebour, 1925, p. 152, fig. 49.
Peters, 1932, p. 44, pl. 3, figs. 13 *c*.
Steemann Nielsen, 1934, p. 22, fig. 48.
Schiller, 1937, p. 397, figs. 436 *a, b*.
Graham & Broniskovsky, 1944, p. 33, figs. 17 *D – G*.
Wood, 1954, p. 290, figs. 214 *a, b*.
Subrahmanyan, 1958, p. 439.
=*C. gibberum* f. *sinistrum* Gourret, p. p., 1883, p. 36, pl. 2, fig. 34; Jörgensen, 1911, p. 50, figs. 107, 109. (= *C. gibberum* f. *postico-juvenile* Gourret, 1883, pl. 2, fig. 35 *a*; =*C. tripos* f. *dispar* Pouchet, 1883, Jörgensen, 1911, p. 50).
=*C. tripos* var. *megaceros* Pouchet, 1883, Schiller, 1937, p. 397.
=*C. tripos* var. *curvicornis* v. Daday, p. p. 1888, pl. 3, figs. 12, 14, 17; Cleve, 1900 *d*, pl. 7, fig. 2.
=*C. curvicorne* v. Daday, Cleve, 1901, p. 14; 1903, p. 340.
=*C. tripos gibberum* Karsten, 1907, p. 249.
=*C. gibberum* f. *dispar* (Pouchet) Jörgensen, 1920, pp. 70 – 72, fig. 67; (=Jörgensen, 1911, p. 50, figs. 107, 109).
=*C. gibberum* f. *subaequale* Jörgensen, 1920, p. 70 – 72, fig. 68. (=1911, fig. 106).
=*C. concilians* forma *dispar* (Pouchet) Böhm, 1931 *b*, p. 24, fig. 21; 1931 *c*, p. 379, fig. 36 *D, E*.

Resembles *C. concilians* but differs in its rugged structure. Body thick, slightly flattened. Epitheca low, the angle of side contours in the dorsiventral



Text-figures 79 – 87. Figs. 79, 80, 81 – *Ceratium longinum* Karsten; 79 and 80, dorsal views; 81, ventral view; (79 and 81, after Karsten 1906; 80, from Schiller, 1937). Figs. 82-87 – *C. lunula* Schimper. 82, 83 and 87, dorsal view; 84, 85 and 86, ventral views. 85, a chain of two cells. (82, 83, 84, 85, after Graham and Bronisko\sky, 1944; 86 and 87, (original). (79, 81, x 105; 80, x 150; 82 – 85, x 85; 86, 87, x 125).

position generally obtuse, left side contour almost straight, the right straight to strongly convex. Anterior horn at base more or less bent towards left, then almost straight, of varying length; base beset with protuberances which follow the margin and are often costate across. Hypotheca longer than epitheca with much inclined left side contour. Antapical contour strongly convex, more or less raised like a hump. Left posterior horn robust, uniformly arched. Right posterior horn shaped variously, right from the base strongly towards front and ventrally oriented, then dorsally bent, often also bent in various other manner. Armour always well developed; pores and irregularly anastomising longitudinal lists present which form meshes on both sides; species variable as regards size and shape of body and direction of anterior horn. $t = 71 - 105\mu$; v = a little less than t; $h = 2/3 - 3/4t$; $V = 136 - 250\mu$.

Red Sea, Gulf of Aden, Arabian Sea, Indian Ocean; Freemantle Harbour; Boeton Straits; Pacific Ocean, Japan; Atlantic Ocean, N. American Coast, Gulf Stream, Azores; Mediterranean.

37. **Ceratium longinum** Karsten, 1906
(Text-figs. 79; 80, 81)

Karsten, 1906, pl. 21, figs. 18 *a, b.*
Jörgensen, 1911, p. 54, figs. 119 *a, b.*
Schiller, 1937, p. 398, fig. 438.
= *C. arcuatum* forma *caudata* Karsten (p. p. ?) 1906, pl. 20, figs. 14 *a, b.*
= *C. tripos arcuatum* var. *caudata* Karsten, 1907, p. 240.

Very similar to *C. karstenii* and *C. contortum.* Posterior contour of cell straight or apparently convex, both sides almost quite similar which at the base pass over precisely into opposite-to-each-other directed posterior horns. Anterior horn displaced to left, at the base bent clearly towards left (beyond dorsal), very long, usually slightly sigmoid, at the base beset with ridges at the margin. Posterior horns strongly ventrally displaced, directed obliquely towards apical horn often parallel under one another. The right is usually almost straight and only bent near base; the left, however, uniformly bent and at the apex diverging relative to the apical horn or bent towards it. As the body plane swerves much from those of posterior horns, in ventral view apparently one horn lies very near to the apical horn than the other. The right posterior horn arises immediately below the transverse furrow, more or less away than in *C. karstenii.* The length of posterior horns varies very much. The differing curvature of the apices, particularly when they are thin and soft, could be caused by the preserving medium. $t = 82 - 100\ \mu$; body length = t; $V = 550 - 800\ \mu$.

Rare warm water form. Atlantic, (west of Africa) and Indian Oceans, Arabian Sea.

38. **Ceratium lunula** Schimper, 1900
(Pl. III, fig. 19; pl. VII, fig. 33; text-figs. 82–87)

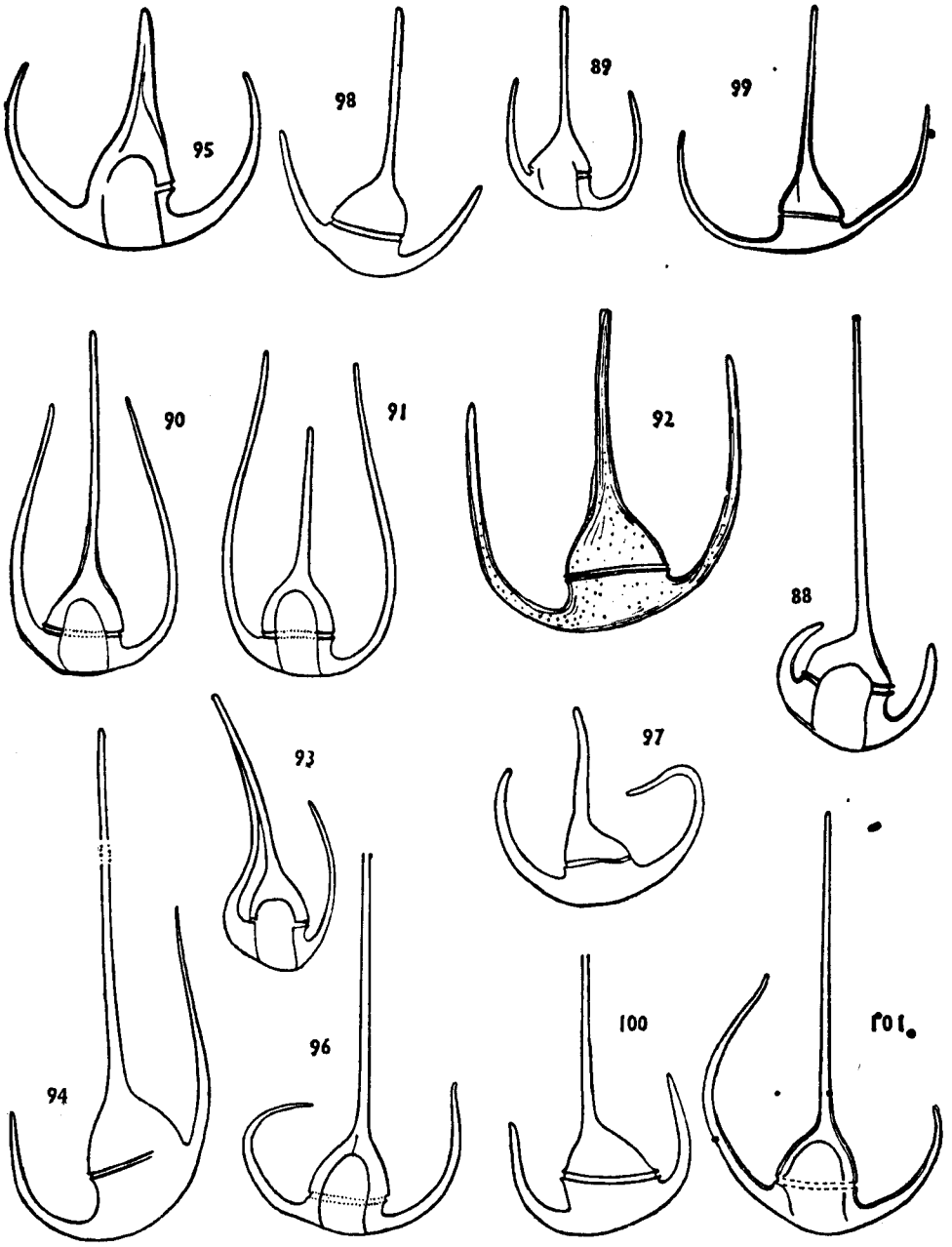
Karsten, 1906, pl. 20, figs. 12 *a, b.*
Jörgensen, 1911, p. 51, figs. 112–115; 1920, p. 74, fig. 70.
Böhm, 1931 *b*, p. 30, fig. 26.
Steemann Nielsen, 1934, p. 23, fig. 50.
Schiller, 1937, p. 399, figs. 439 *a, b.*
Graham and Broniskovsky, 1944, p. 33, figs. 17 *J – N.*
Wood, 1954, p. 291, figs. 215 *a, b.*
Subrahmanyan, 1958, p. 439.
= *C. arcuatum* Okamura *et* Nishikawa, 1904, pl. 6, figs. 3, *a*, 4.
= *C. tripos lunula* (Schimper) p. p. Karsten, 1906, pl. 20, figs. 8–12; 1907, pl. 51, figs. 5 *a, b.*
= *C. tripos anchora* (Schimper) Karsten, 1907, p. 407.
= *C. lunula* f. *megaceros* Jörgensen, 1911, p. 51, figs. 112 *a, b.*
= *C. lunula* f. *brachyceros* Jörgensen 1911, p. 52, figs. 114, 115.

Epitheca almost triangular in section, slightly oblique with straight to weakly convex side contours. Hypotheca shorter than the epitheca, about same height, with slightly convex posterior contour. Anterior horn of first cell of chain very long, robust, almost straight or varyingly bent; on the other hand, the anterior horn in the other cells of chains very short; the two posterior horns very long and more or less divergent, or oriented parallel towards the apex. When anterior horn is long, the posterior horns are generally shorter and often symmetrically arched. In the chain, individual members do not lie in the same plane but are more or less arranged crosswise. $t = 85 - 100\mu$; $v = 42 - 60\mu$.

Warm water form. Indian Ocean, Arabian Sea, Somali Coast, Southern Indian Ocean; African Coast, Danish West Indies between Cuba and Haiti, Florida Stream, Azores, Gibralter Strait; Pacific Ocean off Japan.

39. **Ceratium schmidtii** Jörgensen, 1911
(Text – fig. 38)

Jörgensen, 1911, p. 50, figs. 110, 111.
Böhm, 1931 *b*, p 24, fig. 22.
Steemann Nielsen, 1934, p. 18, fig. 37.



Text-figs. 88 – 101. Fig. 88 – *Ceratium schmidtii.* Jörgensen; ventral view; (from Schiller, 1937). Figs. 89, 90, 91, 92 – *C. symmetricum* Pavillard; 89–91 ventral views; (after Jörgensen, 1911, 1920); 92 – dorsal view; (from Schiller, 1937). Fig. 93 – *C. axiale* Kofoid; ventral view; (from Schiller 1937). Fig. 94–

Schiller, 1937, p. 400, fig. 440.
Wood, 1954, p. 291, figs. 216 *a, b.*
Subrahmanyan, 1958, p. 439.
=*C. curvicorne* Schmidt, 1901, p. 215, figs. 3, 4; *non* v. Daday, *nec* Cleve.

Cells large with short horns. Epitheca very high. Hypotheca longer than epitheca, left side contour slightly oblique. Posterior contour convex, generally passes over very gradually into both poterior horns. Anterior horn long, at base insignificantly bent leftwards and broadened, generally observed with short winged ridges which are dentate. Posterior horns very broad at the base, quickly bent around towards front, shorter than the body; left almost straight, at the apex parallel to apical horn; the right straight, or bent, converging towards apical horn, then at the apex suddenly towards the body and dorsally directed. Body concave. Both posterior horns strongly oriented towards ventral side, the right at the apex dorsally inclined. Sculpture tender. $t=76\mu$; $h=50\mu$; $V=250\mu$.

Somewhat similar to *C. gibberum* from which it differs by the regular body, very short and basally well developed horns and the less convex posterior contour.

Rare warm water form of Indian and Pacific Oceans; South China Sea, Arabian Sea, west-south-west of Cape Comorin, west coast of India, east of Ceylon, east coast of Malacca.

40. Ceratium symmetricum Pavillard, 1905, 1907
(Text-figs. 89, 90, 91, 92)

Pavillard, 1907, p. 152.
Steemann Nielsen, 1934, p. 19, figs. 40, 41.
Schiller, 1937, p. 401, figs. 441 *a, b, c, d.*
Wood, 1954, p. 292, figs. 217 *a–c.*
=*C. tripos* var. *gracile* Gourret, 1883, p. 24, pl. 1, fig. 1.
=*C. tripos* var. *gracile* Schröder, p. p. 1900, pl. 1, fig. 17 *c.*

C. euarcuatum Jörgensen, dorsal view; (from Schiller, 1937). 95 to 97 – *C. arietinum* Cleve; 95, 96 dorsal views; 97 ventral view; (after Jörgensen. 1920). Figs. 98. 99, 100, 101 – *C. declinatum* (Karsten) Schiller; 98 to 100, dorsal views, 101, ventral view; (98 from Schiller, 1937; 99, 101 after Jörgensen, 1920, 100, original). (88, 92, not given; 89, 90, 91, 93, x 190; 94, 98, x 280; 95, 97, 99, x 210; 96, x 150; 98, 101, x 280; 100, x 180).

=*C. tripos coarctatum* Karsten, 1907, p. p. 229, 230.
=*C. gracile* (Gourret) Jörgensen, 1911, p. 44, figs. 92, 93; 1920, p. 59, figs. 55–59; including *C. gracile coarctatun* f. *orthoceros* Jörgensen, 1911, p. 44, fig. 55; and var. *symmetricum* (Pavillard) Jörgensen, 1911, p. 44, fig. 94; Böhm, 1931*c*, p. 358, fig. 11.
=*C. coarctatum* Pavillard, 1923, p. 917.
=*C. aultii* Graham and Broniskovsky, 1944, p. 30, fig. 15 *F*.

Medium sized robust form. Body much longer than broad, rather compressed. Left side contour strongly convex slightly close towards the apical horn, right side convex. Apical horn straight or a little bent, robust, mostly rather long. Hypotheca of almost same length as epitheca with strongly convex posterior contour which usually merges into the quite gradually bent posterior horns generally a little longer than right, beautifully uniformly bent, at the apex convergent towards apical horn, rarely parallel with the same, up to 4 times as long as the body. Right horn slightly bent, 2/3 of distal portion almost straight, convergent at apex towards apical horn, rarely parallel. Transverse furrow lists very clear except in young individuals. Armour of old individuals rather robust, pores and irregularly bent short lists, as well as winged lists at margins, sometimes dentate, present at base of apical horn, inner concave sides of posterior horns and posterior contour.

Variable species, hence the several *formae* based on horn length, nature of armour *etc.* $t = 50\text{–}200\mu$; $V =$ usually $68\text{-}200\mu$; $L = 1\frac{1}{2}\text{–}4$ times as long as body; $R =$ variable.

Warm water form. Indian Ocean, Arabian Sea, Bay of Bengal, Sumatra waters; Pacific Ocean; Japanese waters; South Atlantic, Azores; Mediterranean.

41. **Ceratium axiale** Kofoid, 1907 *c*
(Text – fig. 93)

Kofoid, 1907 *c*, p. 170, pl. 4, fig. 26.
Jörgensen, 1911, p. 46, fig. 96
Steemann Nielsen, 1934, p. 20, fig 42; 1939, p. 12.
Schiller, 1937, p. 402, fig. 442.
=*C. tripos axiale* (Kofoid) Karsten, 1907, p. 311.

Posterior contour strongly convex, left side often hump-like. Body narrower than long, epitheca and hypotheca approximately same length. Anterior horn

generally bent, at the centre. Left posterior horn similarly bent, directed towards front right from the base as also right side of the body and more or less approximated to the apical horn and then oriented similarly; only rarely converging towards the apical horn and approximating. Right horn almost pressed to the body, right at base directed forwards, at the apex and outer half clinging to apical horn or parallel to it, about same length as left one or longer. Posterior contour unequally convex. $t = 51\mu$; $V = 162\mu$.

Rare warm water form. Indian Ocean, mostly in 5–100m, Pacific and Atlantic Oceans.

42. **Ceratium euarcuatum** Jörgensen, 1920
(Text-fig. 94)

Jörgensen, 1920, p. 56, fig. 54.
Steemann Nielsen, 1934, p. 18, fig. 38; 1939, p. 11.
Schiller, 1937, p. 402, fig. 443.
= *C. tripos* var. *gracile* B. Schröder, p. p. 1900 (?), pl. 1, fig. 17 *d.*
= *C. arcuatum* (Gourret) Pavillard, Jörgensen, 1911, p. 43, figs. 90, 91.
= *C. filicorne* Steemann Nielsen, 1934, p. 19, fig. 39; 1939, p. 12.
non C. arcuatum Cleve, 1901, p. 13, pl. 7, fig. 11.
nec Karsten, 1906, pl. 20, figs. 13, 14.
nec Karsten, 1907, pl. 48, fig. 4.
nec Böhm, 1931 *b*, p. 26, figs. 23 - 25.

Body flatly pressed, much longer than broad. Posterior contour extremely uniformly convex and almost quite gradually passes on into posterior horns. Right posterior horn small and uniformly bent, almost from the base directed forwards, longer or of same length as left, at the extremity often converging towards the mostly straight, thin anterior horn. Left posterior horn similarly arched, distal converging a little towards apical horn, or directed similarly with it. Transverse furrow weakly developed at the right (often almost invisible in halves of newly divided cells. Shell very tender. $t = 49 - 60\ \mu$; $V = 145 - 360\ \mu$; $L = ca$ two times as long as body. The grounds for creating *C. filicorne* Steemann Nielsen based on length and divergence of the horns are not reliable; hence merged with *C. euarcuatum* here.

Warm water form. Atlantic, west of S. Africa, American coast; Mediterranean; Indian Ocean (between Ceylon and Sumatra), Arabian Sea.

43. Ceratium arietinum Cleve, 1900
(Text-figs. 95, 96, 97)

Cleve, 1900, p. 13, pl. 7, fig. 3.
Jörgensen, 1911, p. 48, figs. 102 – 105; 1920, p. 62, figs. 60 – 62.
Böhm, 1931 *c*, p. 358.
Steemann Nielsen, 1934, p. 21, fig. 45.
Schiller, 1937, p. 403, fig. 414.
Wood, 1954, p. 294, fig. 221 *a*.
=*C. heterocamptum* Ostenfeld *et* Schmidt, 1901, p. 165; Cleve, 1903, p. 341.
=*C. tripos arietinum* (Cleve) Karsten, 1907.
=*C. arietinum* f. *regulare* Jörgensen, f. *detortum* (Stüwe) Jörgensen, f. *gracilientum* Jörgensen, 1920, figs. 60, 61 and 62 respectively; Schiller, 1937, p. 404, figs. 444, *a*, *b*, *c*, respectively; f. *valens* Jörgensen, 1911, fig. 102.

Medium sized species. Anterior horn right at the base somewhat bent left, then straight, towards apex, however, frequently again slightly bent to left. Left horn beautifully and uniformly bent, at the apex mostly more or less converging towards apical horn, rarely with the same similarly oriented. Right horn very robust, but uniformly bent towards the apex, which is generally pointed and at times twisted.

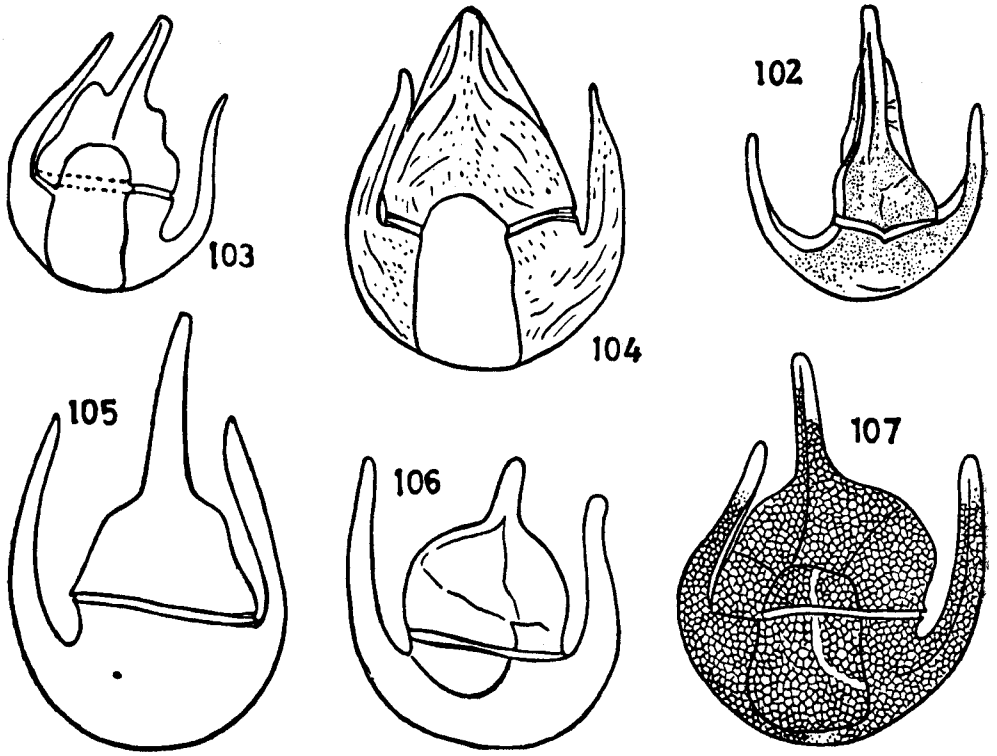
Four forms are recognised by Jörgensen, (*vide* synonyms above), However, the distinguishing characters are not strong to warrant such distinction.

Warm water form, below 50 m. Indian Ocean, Arabian Sea, Red Sea; West Australia; Atlantic Ocean, African and American Coasts; Mediterranean.

44. Ceratium declinatum (Karsten) Jörgensen, 1911
(Pl. IV, fig. 20; text-figs. 98 – 101)

Jörgensen, 1911, p. 42, figs. 87 – 89; 1920, p. 66, figs. 63 – 65.
Böhm, 1931 *b*, p. 19; 1931 *c*, p. 399, fig. 12.
Steemann Nielsen, 1934, p. 22, figs. 46, 47.
Schiller, 1937, p. 404, fig. 445.
Wood, 1954, p. 293, figs. 218 *a* – *c*.
Subrahmanyan, 1958, p. 439.
=*C. tripos* var. *gracile* B. Schröder, p. p., 1900, pl. 1, figs. 17 *a*, *b*, *non c*, *d*, *e*; *non* Gourret, 1883, pl. 1, fig. 1; *nec.* Ostenfeld *et* Schmidt, 1901, p. 165, fig. 14.

=*C. tripos gracile* Entz., 1902; *C. tripos* Pavillard, 1905; and *C. gracile* Pavillard, 1905; Schiller, 1937, p. 405.
=*C. tripos heterocamptum* Karsten, p. p., 1907, pl. 48, fig. 3.
=*C. tripos declinatum* Karsten, 1907, pl. 48, figs. 2 *a, b*.
=*C. declinatum* subsp. *angusticornum* Peters, Steemann Nielsen, 1939, p. 13.



Text-figures. 102 – 107. Fig. 102–*Ceratium azoricum* Cleve; dorsal view; (from Schiller, 1937). Figs. 103, 104, 105 – *C. limulus* Gourret. 103 and 104, ventral views, 105, dorsal view; (103, after Jörgensen; 104 and 105, from Schiller, 1937). Figs. 106 and 107 – *C. paradoxides* Cleve; dorsal and ventral views; (106, after Wood, 1963 *a*, outline only; 107, after Jörgensen, 1920). (102, 103, 105, x 350; 107, x 310; 104, 106, not known).

Small slender species. Body pressed flat, longer than broad, all three horns lie approximately in the body plane; anterior horn generally straight, usually oriented not quite perpendicular to transverse furrow. Hypotheca somewhat shorter than epitheca, with convex posterior contour which passes over entirely or almost quite gradually into the beautifully uniformly arched left posterior horn whereas the right is clearly set different. Left posterior horn rather short, however, robust, longer, at times also shorter than the body; right longer but

weaker than the left, only bent at the base; at the apex often more or less bent outwards, however, in young posterior halves shorter, weaker and directed clearly toward the apical horn. Transverse furrow ridge weakly developed on the right side.

The characters of the varieties and forms recognized by Jörgensen are not strong enough in this variable species to warrant such separation.

Warm water form. Indian Ocean, Arabian Sea, Zanzibar coast, Sunda Islands region; Atlantic Ocean, African and N. American coasts.

45. **Ceratium azoricum** Cleve, 1900
(Text-fig. 102)

Cleve, 1900, p. 13, pl. 7, figs. 6, 7; 1903, p. 340.
Cleve, 1901, p. 13.
Paulsen, 1908, p. 76, fig. 99.
Jörgensen, 1911, p. 47, figs. 97, 98; 1920, p. 69, fig. 66.
Lebour, 1925, p. 151, fig. 48.
Böhm, 1931 *c*, p. 359, fig. 14.
Steemann Nielsen, 1934, p. 20, fig. 43.
Schiller, 1937, p. 406, fig. 447.
Wood, 1954, p. 295, figs. 222 *a*, *b*.

Body flattened, also curved laterally. Epitheca and hypotheca more or less equal. Apical horn short, robust, a sort of prolongation of epitheca, tapering, sometimes winged. Hypotheca convex, almost humped; posterior horns short, their base continuous with hypotheca, wide, tapering quickly to a point, both directed forwards, diverging or converging. $t = 38 - 51\,\mu$; $v = 26\mu$; h = lesser than v; $V = 42 - 68\,\mu$.

Indian Ocean, Arabian Sea, Colombo, Sumatra; S. W. Coast of Australia; South Atlantic Ocean, Azores; Mediterranean.

Section LIMULUS Schiller

All three horns very short, the posterior ones lie close to the body.

46. **Ceratium limulus** Gourret, 1883
(Text-figs. 103, 104, 105)

Gourret, 1883, p. 33, pl. 1, fig. 7.
Cleve, 1903, p. 341.

Karsten, 1907, p. 247.
Jörgensen, 1911, p. 57, fig. 122; 1920, p. 77, fig. 72.
Böhm, 1931 *b*, p. 31, fig. 27 *b*.
Steemann Nielsen, 1934, p. 24, fig. 45.
Schiller, 1937, p. 407, figs. 448 *a* – *c*.
Graham and Broniskovsky, 1944, p. 35, fig. 19 *A*.
Wood, 1954, p. 296, figs. 223 *a*, *b*.
=*C. tripos* var. *limulus* Pouchet 1883, Schiller, 1937, p. 407.

Body longer than broad. Epitheca with characteristic shape, rather high, both sides of apical horn beset with two very clear crescent shaped or raised humps. Side contours convex below and concave above. Hypotheca as long as epitheca; left side contour short, generally a little convex. Posterior contour evenly rounded, approximately semi-circular, completely evenly merging into both the posterior horns. Apical horn broadened at the base, very short, slightly bent obliquely directed towards transverse furrow. Both the posterior horns right from base directed forwards, rarely bent, approximately parallel with apical horn at the apex, in some instances the right one arched outwards, both about the same size, approximately as long as the body or shorter. The right posterior horn arises immediately below the transverse furrow and nestles close to the body whereas the left horn is a little separated from it. Sculpture robust, large pores and lists present, the latter branched here and there; however, small regular net work but forming only a few large meshes.

But for the humps, this species is difficult to distinguish from *C. paradoxides* and *C. azoricum*.

Warm water form. Upto 200 m. depth. Arabian Sea, Red Sea, Malaya; Australian waters; Atlantic, east coast of N. America and Brazil, Azores, English Channel, south of Africa.

47. **Ceratium paradoxides** Cleve, 1900
(Text-figs. 106, 107)

Cleve, 1900, p. 15, pl. 7, fig. 14; 1903, p. 342.
Jörgensen, 1911, p. 57, fig. 123; 1920, p. 79, fig. 72.
Steemann Nielsen, 1934, p. 24, fig. 55.
Schiller, 1937, p. 408, fig. 449.
Wood, 1954, p. 296; 1963, p. 40, fig. 147.

Similar to *C. limulus* but larger. Epitheca obliquely and irregularly pentagonal, left side bulged, above both sides of apical horn sharply set out without humps; side contours polygonal convex. Hypotheca a little shorter, with very oblique, shorter, a little concave left side contour. Posterior contour usually semi-circularly convex, completely merging equally into the two posterior horns. Apical horn at base broader, short, bent, only slightly oblique to the transverse furrow. Left posterior horn, slightly, however, uniformly bent, at the apex runs parallel with apical horn. Right posterior horn a little smaller, lies close to the body converging towards the apical horn, at the apex bent clearly outwards and runs somewhat parallel with it. Sculpture very characteristic; the entire surface is beset with large number of similar sized polygonals which are formed by regular anastomosed raised lists and are as broad as the transverse furrow. t = 72 - 78μ; h = 42 - 45μ; V = *ca* 50μ.

Larger than *C. limulus* from which this species is easily distinguished by the absence of humps at base of apical horn and by the sculpture of numerous polygones.

Warm water form. Upto 500 m. Arabian Sea and Indian Ocean, south west region; northern part of Atlantic Ocean; Azores, west coast of N. Africa, Bengula Current.

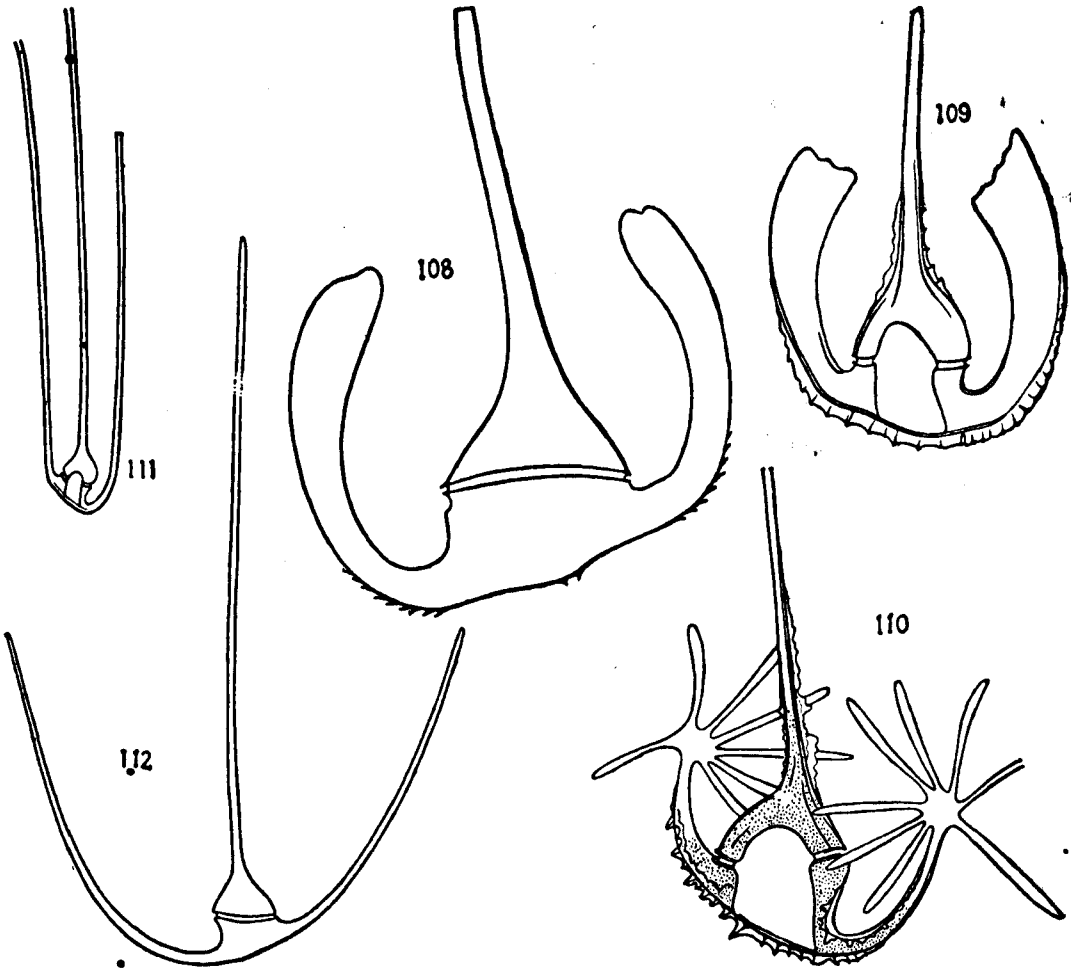
Section **PLATYCORNIA** Jörgensen, 1911

Posterior horns flattened in the body plane.

48. **Ceratium platycorne** von Daday, 1888
(Text-figs. 108, 109)

Cleve, 1903, p. 342.
Paulsen, 1908, p. 74, fig. 97.
Jörgensen, 1911, p. 58, figs. 124, 125; 1920, p. 79, figs. 74, 75.
Lebour, 1925, p. 153, fig. 50.
Böhm, 1931 *b*, p. 31, fig. 27 *a*; 1931 *c*, p. 361, fig. 15.
Steemann Nielsen, 1934, p. 24, figs. 56, 57.
Schiller, 1937, p. 408, figs. 450 *a*, *b*.
Wood, 1954, p. 297, fig. 226.
= *C. tripos* var. *aurita* Cleve, 1897, p. 26, pl. 2, fig. 29.
= *C. tripos* forma *dilatata* Karsten, 1905, pl. 19, figs. 9, 10.
= *C. tripos platycorne* Karsten, p. p. 1907, pl. 48, fig. 10 *a*.

= *C. dilatum* Kofoid, 1907 *c*, p. 171, pl. 4, fig. 25.
= *C. lamellicorne* Kofoid, 1908 *b*, p. 185, fig. 28.



Text-figures 108 – 112. Fig. 108, 109 – *Ceratium platycorne* v. Daday; dorsal and ventral views; (108 after Lebour, 1925; 109, after Böhm, 1931 *b*). Fig. 110 – *C. ranipes* Cleve, ventral view; (after Böhm 1931 *b*). Figs. 111, 112 – *C. longissimum* (Schröder) Kofoid; ventral and dorsal views; (111, from Schiller, 1937; 112, after Jörgensen 1920). (111, x 280; 112, x 190; 108, 109 and 110, not given).

= *C. compressum* Gran, 1912, pl. 3, fig. 57, pl. 4, fig. 81. (*non C. compressum* Gran, 1902).
= *C. platycorne* subsp. *dilatatum* (Karsten) Steemann Nielsen, 1939, p. 13.
= *C. platycorne* f. *dilatatum*, f. *cuneatum*, f. *incisum* Jörgensen, 1920, p. 81.

Body longer than broad. Epitheca elongated and narrow, with slightly convex side contour. Hypotheca shorter than epitheca, with straight or slightly concave, not oblique, side contour. Posterior contour somewhat convex, clearly set out on both sides by the horns. Apical horn rather long, straight or slightly bent, broad at base, narrowed towards apex. Posterior horns robust, well developed, from base suddenly bent forward and fashioned flat in the body plane, the inner contour line closely approximating the body. Right posterior horn right from beginning directed a little forward. The identically broad basal piece of posterior horns are very short, much shorter than the flattened portion of them. Sculpture usually little striking; at times longitudinal lists present. On the posterior contour more or less spike-like winged lists occur which extend as finely spiked hem on the outerside of posterior horns. Such spikes rarely present on apical horn also. $t = 48 - 64\mu$; $h + b = 30 - 40\mu$; $V = 140 - 250\mu$.

Based on the nature of the posterior horns, Jörgensen, (1920) has described different phenotypes, such as: f. *dilatatum* (Karsten) Jörg. (fig. 450 *a*, Schiller, 1937) f. *cuneatum* Jörg. (Fig. 450 *b*, Schiller, *op. cit.*); f. *incisum* Jörg., the distal portion with dissected margin. These have not enough basis for separate status.

Warm water form. In the Gulf Stream, Canaries, southern part of Atlantic; Mediterranean; Arabian Sea, Indian Ocean; Bass Strait, Pacific Ocean; Japan; west of San Diego.

Section PALMATA (Pavillard) Jörgensen, 1911

Posterior horns divided finger-like at their ends.

49. Ceratium ranipes Cleve, 1900
(Text-fig. 110)

Cleve, 1900, p. 15, pl. 7, fig. 1; 1903, p. 342.
Jörgensen, 1920, p. 82, fig. 76.
Böhm, 1931 *b*, p. 31, figs. 28, 29; 1931 *c*, p. 361.
Steemann Nielsen, 1934, p. 24, fig. 58.
Schiller, 1937, p. 409, fig. 451 *a*.
Wood, 1954, p. 299, fig. 227.
= *C. tripos* var. *digitatum* and var. *furcellata* Lemmermann, 1900; Schiller, 1937, p. 410.
= *C. tripos* var. *macroceros* f. *palmata* Schröder, 1900, p. 16, pl. 1, figs. 170 *O*, *P*.
= *C. palmatum* (Schröder) Schröder Karsten, 1907; Jörgensen, 1911, p. 60, figs. 129 and 131.

=*C. palmatum* var. *ranipes* (Cleve) Jörgensen and var. *furcellatum* (Lemm.) Jörgensen, 1911, p. 61, figs. 130 (former).

=*C.* (*ranipes* Cl. var.) *palmatum* Schröder, Cleve, 1901, p. 14.

=*C. ranipes* Cleve f. *palmatum* (Schröder) Jörgensen, Schiller, 1937, p. 410, fig. 451 *b*.

Easily distinguished by the finger-like divided ends of more or less long and differently directed posterior horns. Body approximately as long as broad. Epitheca broad, low, strongly oblique, with unequally concave side contours. Hypotheca longer than epitheca; left contour mostly oblique, concave or almost even. Posterior contour usually rather strongly and unequally convex, clearly demarcated from both posterior horns. Apical horn at base clearly bent and broadened, towards apex thin and often weakly twisted, rather long. Posterior horns relatively short, upto the "fingers" usually only once or twice as long as the body more or less dorsally bent, the branched ends thereby lying behind the body. Left posterior horn at the base slantingly directed backwards, then suddenly bent round forward or uniformly bent, the end sometimes parallel with apical horn. Right posterior horn appears already at the base somewhat directed forward, usually towards the apical horn and dorsalwards arched, at the apex directed somewhat at right angles to apical horn or at times even backwards. At the end of the posterior horns is seen a flattening across or lamina with very long "fingers" spread out in all directions whose number is variable (5 – 12). These fingers are of varying length, straight or bent at their ends, and shaped like small pestles and closed. At the posterior margin of the cell and on the convex sides of posterior horns numerous small spikes are present, and, occasionally, particularly in older individuals, on the apical horn also.

This characteristic species is usually found along with *C. gibberum*.

In view of the variable characters such distinctions as those based on the length of fingers, thickening of their tips, *etc.*, recognition of separate taxa are not reliable.

Warm water species, widely distributed, sparcely occurring. Malay Archipelago, Arabian Sea, Indian Ocean, Gulf of Aden; S. W. Australia; Pacific Ocean; Japan; Atlantic Ocean, southern point of Africa to Florida Stream on east coast of America, Azores; Mediterranean.

Section MACROCEROS Pavillard, 1907

Both posterior horns bent towards front, mostly open at their ends. At least one posterior horn projects more or less away over the posterior contour.

50. Ceratium longipes (Bailey) Gran, 1902
(Plate IV, figs. 21, 22)

Paulsen, 1908, p. 85.

Jörgensen, 1911, p. 84, fig. 178.

Lebour, 1925, p. 156, pl. 31, fig. 2.

Schiller, 1937, p. 410, figs. 452 *a*, *b*.

Wood, 1954, p. 300, fig. 229.

Subrahmanyan, 1958, p. 439.

= *Peridinium tripos* Ehrenberg p. p., and *P. longipes* Bailey, Schiller, 1937, p. 410.

= *Ceratium tripos* var. *tergestina* Hensen, Schütt, 1892, p. 70 (302), fig. 76, 4 *b*.

= *C. tripos* var. *longipes* Cleve, 1897, I, 302, pl. 8, fig. 2.

= *C. tripos* var. *horridum* Cleve, 1897, I, 302, pl. 8, fig. 4.

= *C. longipes* f. *oceanica* Ostenfeld, 1903, p. 586, figs. 140, 141.

= *C. longipes* f. *balticum* Ostenfeld, 1903, p. 586, fig. 142; Paulsen, 1908, p. 85, fig. 116; Jörgensen, 1911, p. 84, fig. 179 (as var.); Schiller, p. 411, fig. 452 *c*; Subrahmanyan, 1958, p. 439.

= *C. longipes* f. *ventricosum* Ostenfeld, 1903, p. 586, fig. 143; Paulsen, 1908, p. 86, fig. 117; Jörgensen, 1911, p. 85, fig. 180 (as var.); Schiller, p. 411, fig. 452 *d*.

Medium sized or small species. Apical horn strongly bent. Epitheca almost triangular in outline, left side strongly convex and more so than the right. Hypotheca longer than epitheca, distinctly broadened on the posterior side giving the whole body a triangular appearance. Posterior margin rarely sunk in the left more distinctly than the right, coming off at an angle from the posterior horn, usually a little convex. All the horns robust, near apices narrowed. Left posterior horn first obliquely directed backwards and then bent forwards. Right posterior horn usually longer, straight near the base and then quickly bent forward. Tips of apical and right horns almost parallel or converging slightly; those of left and apical horn diverging. Posterior horns usually shorter than the apical horn. Theca sculptured, robust with coarse ridges; pores present. Along the apical horn and convex outer parts of the posterior horns, the lists are somewhat dentate. Variable species.

Temperate regions of Atlantic Ocean extending into the Arctic. North Sea, East Sea, Norwegian Coast, North of Florida Stream; Arabian Sea; Australian waters.

51. Ceratium longissimum (Schröder) Kofoid, 1907
(Text-figs. 111, 112)

Jörgensen, 1911, p. 82, fig. 173; 1920, p. 100, fig. 93.
Schiller, 1937, p. 413, fig. 454 *a*, *b*.
Steemann Nielsen, 1939, p. 15.
= *C. tripos* var. *macroceros* f. *longissima* Schröder, 1900, p. 16, pl. 1, fig. 171.

Medium sized species distinguished by the extraordinarily long closely lying horns; body longer than broad.

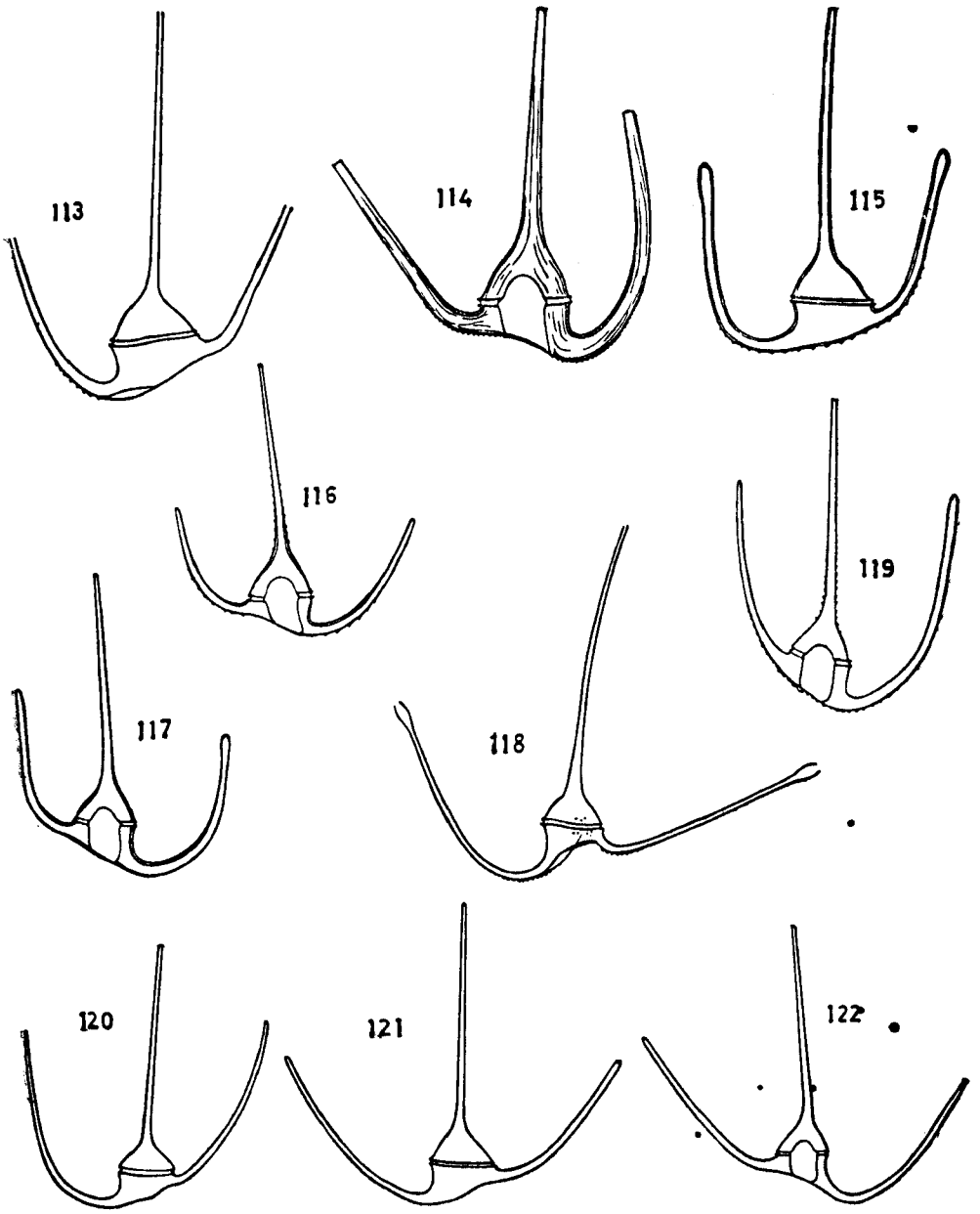
Epitheca inclined, rather high (long) with strongly convex left and slightly convex right side contour. Hypotheca somewhat longer, with almost straight, however, very obliquely placed leftside contour. Posterior contour not depressed, weakly convex, almost uniformly merging into the left horn. The posterior horns abruptly bent round forwards, by and large directed parallel to the apical horn, however, sometimes, a little bent here and there and at the apex somewhat diverging. The left horn at the base, oblique, directed backward, but quickly bent around, in the lower part uniformly bow-like. The right horn arises perpendicularly, only close to the origin bent, somewhat longer than left. Armour consists of small, however, robust longitudinal lists and low marginal winged lists at the proximal part of horns as well as posterior contour. $t = 64\mu$; $h = 43\mu$; $b = 1/7h$; $V = 952\mu$.

Two forms are recognised by Jörgensen, f. *longissima* (Fig. 111) and f. *subdivaricatum* Jörgensen (Fig. 112) based on nature of the horns; as this character is not reliable, these forms are not accorded separate status here.

Warm water form. Atlantic Ocean; Mediterranean; Indian Ocean.

52. Ceratium horridum Gran, 1902
(Text-figs. 113 - 128)

Gran, 1902, p. 54, 193, 194.
Ostenfeld, 1903, p. 584, figs. 136 - 139.
Jörgensen, 1920, *(partim)* p. 96, fig. 86.
Lebour, 1925, p. 155, pl. 34, fig. 2.
Böhm, 1931 *b*, p. 41, figs. 86 *a - c*; 1931 *c*, p. 365.
Schiller, 1937, p. 413, figs. 455 *a - c*; p. 415, fig. 456.
Wood, 1954, p. 300, figs. 230 *a*, *b*; p. 301, figs. 231 *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*.
= *C. tripos* var. *horrida* Cleve, 1896, p. 302, fig. 4.
= *C. tripos* var. *scotica* Ostenfeld, 1899, Paulsen, 1908, p. 83.

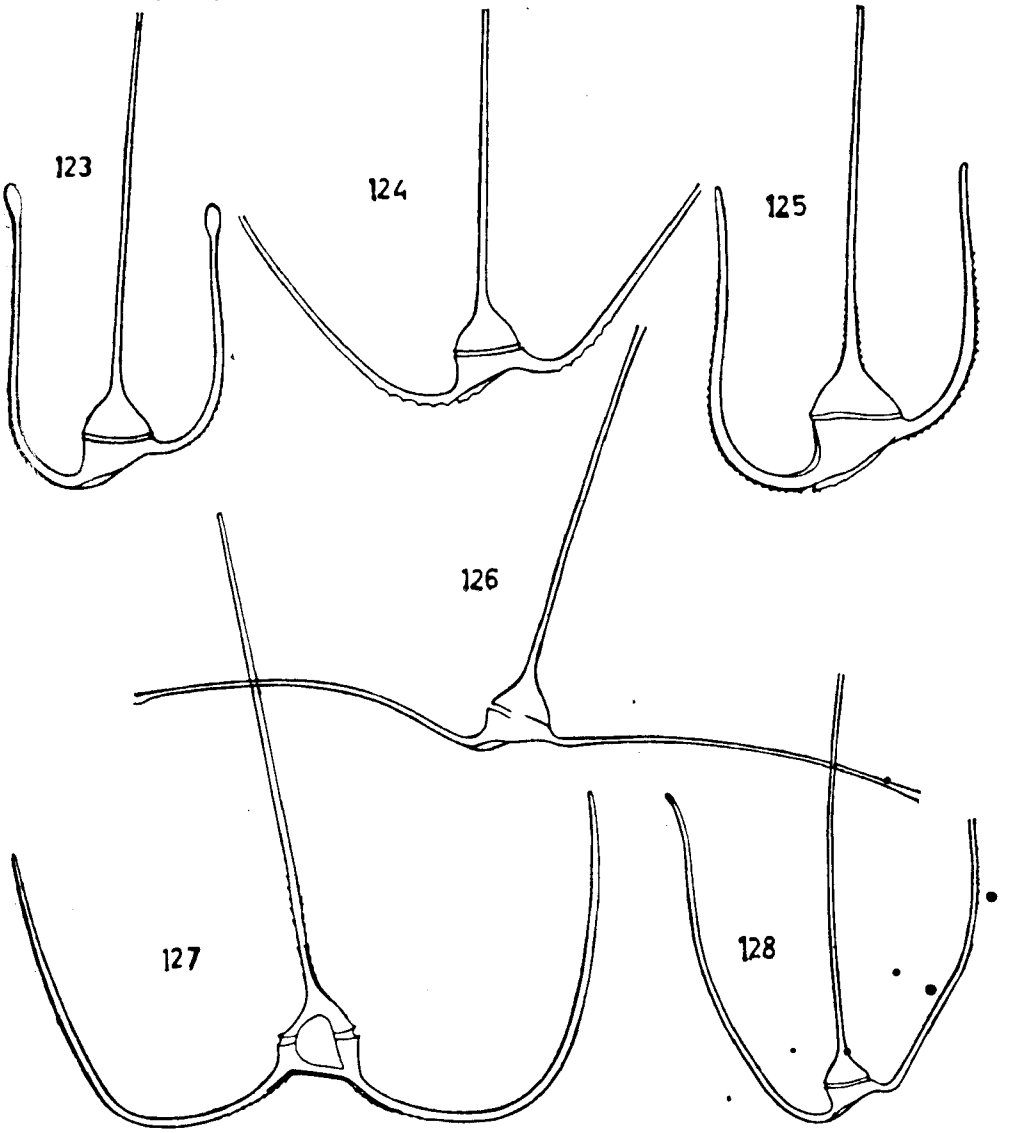


Text-figures 113 – 122. *Ceratium horridum* Gran. figs. 113, 115, 118, 120, 121 – dorsal views; rest ventral views; variable species, different specimens including those known under synonymy (*vide* text). (113, 114 and 118 from Schiller 1937; rest after Böhm 1931 *b*). (113, x 280; 118, x 210. Rest not given).

= *C. tripos* var. *macroceros* f. *intermedia* Jörgensen, 1899, Paulsen, 1908, p. 83.
= *C. tripos* var. *scotica* f. *horrida* Ostenfeld, 1900, Paulsen, 1908, p. 83.
= *C. patentissimum* Karsten, 1906, pl. 21, figs. 23, 23 *a*.
= *C. tripos volans* f. *recurvata* Karsten, 1906, pl. 21, fig. 22.
= *C. tripos flagelliferum* f. *angusta* Karsten, p. p. 1906, pl. 22, fig. 33 *b*.
= *C. buceros* Zacharias S. dilat. 1906, Schiller, 1937, p. 415, figs. 456, 457.
= *C. tripos intermedium* (Jörg.) Karsten, 1907, p. 250.
= *C. tripos inversum* Karsten, 1907, p. 539.
= *C. tripos inclinatum*, Karsten, 1907, pp. 229, 230.
= *C. tripos inclinatum* var. *minor* Karsten, 1907, pl. 51, fig. 9 *a*, *b*.
= *C. inclinatum* Kofoid, 1907 *b*, p. 303, pl. 25, figs. 16 - 21.
= *C. tripos longipes* (Bail.) Cleve, Karsten, 1907, pl. 48, fig. 11.
= *C. tripos buceros* Karsten p. p. 1907, pl. 48, fig. 16.
= *C. claviger* Kofoid, 1907 *c*, p. 170, pl. 4, fig. 27; Jörgensen, 1911, p. 80, figs. 168, 169.
= *C. mollis* Kofoid, 1907 *b*, p. 304, pl. 27, fig. 26; Jörgensen, 1911, p. 81, figs. 170 - 172.
= *C. intermedium* (Jörg.) Jörgensen, Paulsen, 1908, p. 83, fig. 111, 112; Jörgensen, 1911, p. 83, figs. 174 - 76.
= *C. batavum* Paulsen, 1908, p. 84, fig. 114.
= *C. tenue* (Ost. *et* Schmidt) Jörgensen, 1911, p. 77, fig. 163; Steemann Nielsen, 1939, p. 15.
= *C. leptosomum* Jörgensen, 1911, p. 80, fig. 167.
= *C. horridum* Gran, Jörgensen, 1920, p. 96, (partim) figs. 87 - 90.
= *C. buceros* f. *tenue* (Ost. *et* Schmidt) Schiller, 1937, p. 415, figs. 456 *a*, *b*.
= *C. buceros* f. *molle* (Kofoid) Schiller, 1937, p. 417, fig. 457 *a*.
= *C. molle* Kofoid, Steemann Nielsen, 1939, p. 15.

Rather small or medium sized species, short horned and robust. Epitheca triangular in outline with weakly convex sides, shorter than the hypotheca. Posterior margin distinctly indented on the right, less so on the left, almost straight or slightly convex, making an angle on the right with the horn. Apical horn well developed at the base, often slightly bent, straight towards the tip. Left posterior horn directed obliquely to left, then bent forward, then, converging or diverging in relation to the apical horn. Right posterior horn near its origin slightly directed backwards, then bent forward running almost parallel to or diverging from the apical horn. Theca sculpture not striking; sometimes, however, irregular ridges, usually dentate, present at the curvatures of the posterior horns and apical horn.

Very variable species. Number of forms recognised by Jörgensen (1911) and Paulsen (1908); these are not of much significance. Forms with body slightly



Text-figures 123 – 128. *Ceratium horridum* Gran. Different specimens of the species. 127, ventral view; (original). Rest dorsal views, (from Schiller 1937). (123, 125, 126, x 210; 128, x 125, 127, x 150. 124 – not given).

longer than broad and thinner spines have been described as *C. buceros* Zacharias s. dilat, with several formae. (*vide* Schiller, 1937, p. 415 *et seq*). As these

characters could be due to the stages in the development, *C. buceros* and formae are merged with *C. horridum.*

North Atlantic, English Channel, Norwegian Coast; East coast of N. America; Arabian Sea, Indian Ocean, Red Sea, West and South Australia.

53. Ceratium pavillardii Jörgensen, 1911
(Text-figs. 129, 130)

Jörgensen, 1911, p. 74, figs. 157, 158; 1920, p. 92, fig. 83.
Böhm, 1931 *c*, p. 364, fig. 19.
Schiller, 1937, p. 418, figs. 458 *a, b.*
Steemann Nielsen, 1939, p. 15.
Wood, 1954, p. 304, figs. 232 *a, b.*
= *C. vultur* Pavillard, 1905, Schiller, 1937, p. 418.

Rather large form. Epitheca almost triangular in outline with left side convex, almost straight oblique right side. Hypotheca longer than epitheca with very oblique straight left side. Posterior contour steep, little depressed, angularly limited. All horns with robust base and thin distal portions. Apical horn long. Left posterior horn arises somewhat obliquely towards posterior directed obliquely backwards and to the left, then near the base bent at right angles and directed obliquely forward and diverging. Right posterior horn at base directed across, then evenly bent forward and straight and diverging. At the apex the horns *V* (apical) and *L* (left) diverge, more or less, likewise, however, less the horns *V* and *R* (right). Armour robust consists of numerous large and small irregularly twisted longitudinal lists and on the horns throughout their length winged-lists, however, small and edentate. The winged lists of posterior horns are small, at the flexure of the left horn occurs a stellate list which is particularly clear in dorsal view. $t = 74 - 85\mu$; $h = 43 - 48\mu$; $b = 8 - 14\mu$; $V = 160 - 420\mu$.

This species is at times confused with *C. vultur;* differs, however, so well from it as also *C. vultur* var. *sumatranum* by the very short to almost absent basal piece of left horn. Otherwise it is close to *C. vultur* var. *sumatranum,* resembles the same also with regard to the right horn which, however, in *C. pavillardii* is uniformly bent. It differs from the above principally in its higher epitheca with pointed angle with the very short basal piece of left horn, the different armour structure and the spread out horns.

Warm water form. Indian Ocean, Southern and Pacific Oceans (Japan), Australian waters; Atlantic, Azores, Bengula Current; Mediterranean.

54. Ceratium vultur Cleve, 1900
(Text-fig. 131)

Cleve, 1900, p. 15, pl. 7, fig. 5; 1901, p. 15; 1903, p. 343.
Steemann Nielsen, 1934, p. 27, fig. 67.
Schiller, 1937, p. 418, figs. 459 *a*, *b*.
Graham & Broniskovsky, 1944, p. 41, figs. 23 *A* - *H*.
Wood, 1954, p. 304, fig. 233 *a*.
= *C. robustum* Ostenfeld *et* Schmidt, 1901, Cleve, 1903, p. 342.
= *C. tripos* var. *neglecta* Karsten, p. p. 1905, pl. 19, fig. 12, *non* fig. 12 *a*; *non* *C. neglectum* Ostenfeld, 1906.
= *C. robustum* Schröder, 1906, p. 361, fig. 31.
= *C. japonicum* Schröder, 1906, p. 361, figs. 33 *a* - *c*.
= *C. tripos robustum* Karsten, 1907, pl. 48, figs. 13 *a* - *c*.
= *C. vultur* var. *japonicum* (B. Schröder) Jörgensen, 1911, p. 73, figs. 152 *a*, *b*.

Epitheca rather low, with convex side contours which form an approximate right angle with one another. Hypotheca significantly longer than epitheca with clear convex and oblique left side contour. Posterior contour strikingly steep, somewhat depressed, both sides delimited at an angle from the outward running posterior horns, the angle generally little striking as they are beset with well developed winged lists. The proximal part of all three horns are very robustly developed, the distal part much narrowed. The left horn is at first slightly obliquely directed backwards, then more or less suddenly bent around at right angles, runs arched forwards or is somewhat more laterally directed. The right horn arises invariably behind the transverse furrow and is at first generally directed across and then almost at once in a blunt angle bent forward; it is quite straight or meanders S-like or in the distal portion uniformly arched in contrast to the flexure junction where, as a rule, an abrupt direction change exists.

The species forms frequently chains in which the end member presents a different appearance to the following members. It has a long straight or weakly bent apical horn usually long, beset with broad winged dentate lists below, as posterior horns which are almost only bent at the base and for the remaining part straightened and run approximately parallel with apical horn. Also these posterior horns are besides, beset with large irregular finely dentate winged lists on their concave as well as convex sides. The next member has very short apical horn only 1 – 2 times as long as the body with broad, however, slightly dentate winged lists and very long posterior horns which are spread out so that they are

found on both sides of the forward member and stretch even upto the apex of the apical horn. The basal member of the chain exhibits quite different appearance than the first in that the posterior horns are spread out. Sculpture robust; wall thickness unusually large, numerous fine pores present which form long canals in the thick wall and give a streaked appearance.

This species is easily distinguished by its uncommonly broad lists and thick walls. $t = 57 - 62\mu$; $h = 36 - 38\mu$; $b = ca\ h$; V = upto 300μ or more, in the intermediate cells of chain only $85 - 100\mu$.

Warm water form. Atlantic, Indian Ocean, Gulf of Aden to Sumatra; Pacific Ocean, East China Sea, South of Japan.

55. **Ceratium vultur** var. **sumatranum** (Karsten) Steemann Nielsen, 1934
(Pl. V, figs. 27, 28; Pl. VI, fig. 31; text-figs. 132, 133)

Steemann Nielsen, 1934, p. 27, figs. 65, 66.
Schiller, 1937, p. 419, figs. 460 *a - c*.
Wood, 1954, p. 305, fig. 233 *d*.
Subrahmanyan, 1958, p. 439.
=*C. vultur* Ostenfeld *et* Schmidt 1901, Schiller, 1937, p. 419.
=*C. tripos* var. *neglecta* Karsten p. p. 1905, pl. 19, fig. 12 *a*.
=*C. tripos vultur* Karsten, 1907, pl. 48, figs. 14 *a, b*.
=*C. tripos buceros* Karsten p. p., 1907, pl. 51, fig. 8.
=*C. tripos vultur* var. *sumatranum* Karsten, 1907, pl. 48, figs. 15 *a, b;* pl. 51, fig. 14.
=*C. sumatranum* (Karsten) Jörgensen, 1911, p. 73, figs. 153, 154; Steemann Nielsen, 1939, p. 15.
=*C. sumatranum* f. *angulatum* Jörgensen, 1911, p. 74, fig. 155.
=*C. sumatranum* var. *recurvum* Jörgensen, 1911, p. 74, fig. 156 (as f. *recurvum* in Schiller, 1937, p. 419, fig. 460 *c*.)

Medium sized, robust, with spread out posterior horns and very short broad body. Epitheca very low, often 3 times as broad as long, with slightly convex leftside contour. Hypotheca double as long as epitheca with often slightly convex to about straight, rarely concave, at times slightly oblique left side contour. Posterior contour somewhat depressed, right clear, left at times not clear due to corresponding posterior horn circumscribing it, rather steep. Apical horn broad and frequently beset with large marginal or usually separated dentate winged lists; that of the anteriormost cell very long, short in the intermediate cells,

often even shorter than the body. The left horn only with short, posteriorly directed basal piece, then suddenly at right angles bent around and directed straight obliquely forwards, often distantly spread out or at times even the distal portion bent around backwards. The right horn with a correspondingly short basal piece, towards right and backwards oriented, the distal portion almost straight, rarely (as in intermediate cells of chain) like the left horn bent back again. Habit of chain resembles type species. Armour robust, winged lists, clear pores as well as winged lists of horn present throughout.

Rare warm water form. Atlantic Ocean; rare, Indian Ocean, frequent from Red Sea to Zanzibar and east to Sumatra; Pacific, Japan.

56. **Ceratium vultur** var. **productum** Wood, 1963
(Text-fig. 134)

Wood, 1963, p. 16, fig. 53.

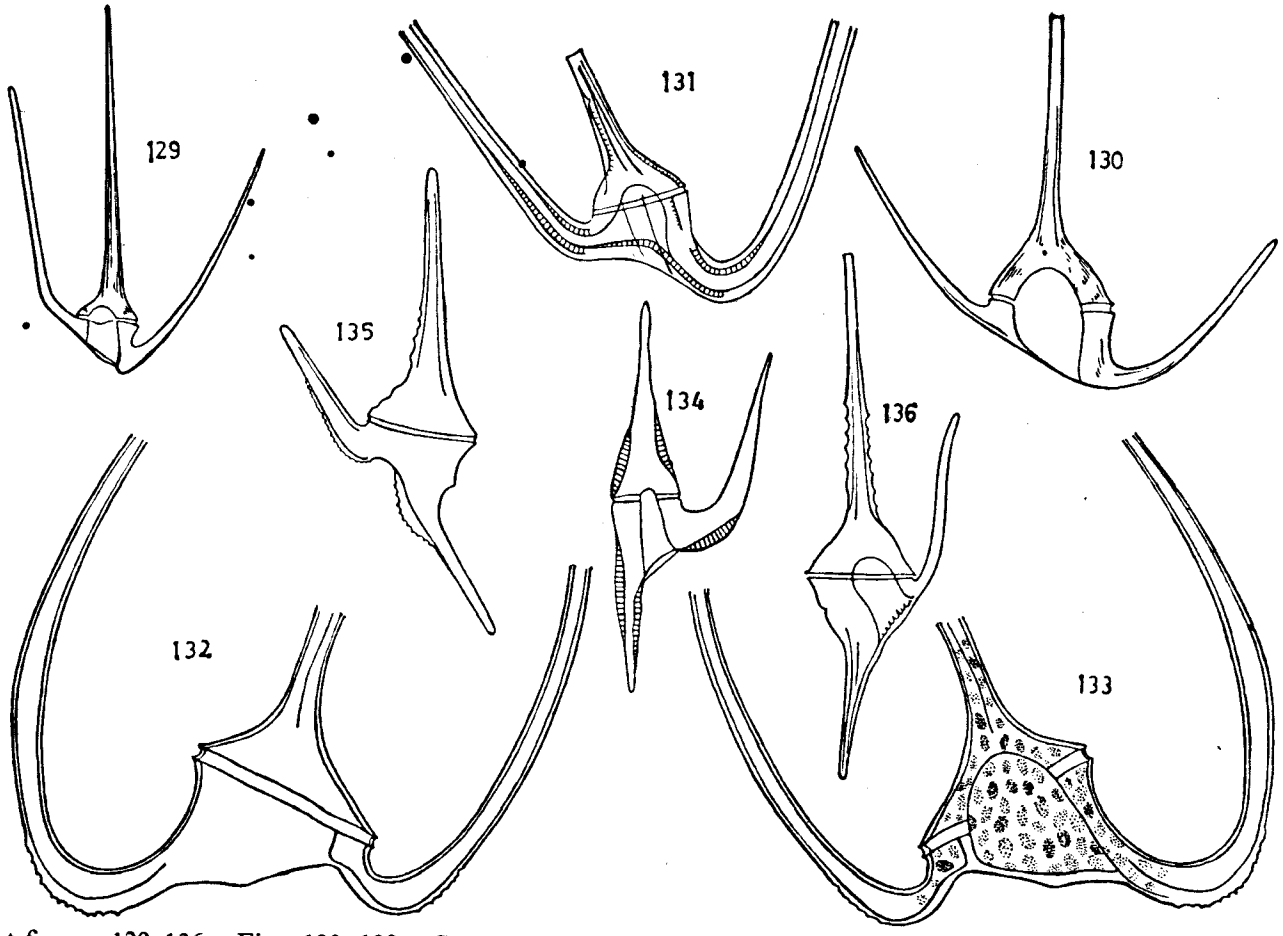
Differs from the type in having a stout, tapering right posterior horn directed Posteriorly throughout its length.

East Indian Ocean.

57. **Ceratium reflexum** Cleve, 1900
(Text-figs. 135, 136, 137, 138, 139)

Cleve, 1900, p. 15, pl. 7, figs. 8, 9; 1903, p. 342.
Karsten, 1907, pl. 48, fig. 9.
Jörgensen, 1911, p. 87, fig. 184.
Steemann Nielsen, 1934, p. 29, fig. 74.
Schiller, 1937, p. 420, fig. 461.
Wood, 1954, p. 305; 1963, p. 40, fig. 149.

Medium size, species of very characteristic habit. Body slightly compressed. Epitheca broad and low. Hypotheca almost double as long as epitheca. All three horns, particularly the apical one, at base widened and thickwalled towards apex, narrow and thinwalled, at the proximal part, beset with more or less clear somewhat dentate winged lists. Lists well developed on transverse furrow. Left horn at the base first oblique, directed backward, then bent back and somewhat twisted. Right horn approximately same length or usually somewhat longer, at the base directed perpendicular to body, then suddenly bent forward, almost straight, below diverges 20 – 25° relative to apical horn. Armour usually clear



Text-figures 129-136. Figs. 129, 130 – *Ceratium pavillardii* Jörgensen. ventral views; (129, after Jörgensen, 1920; 130 from Schiller). Fig. 131 – *C. vultur* Cleve; ventral view; (after Cleve, 1900). Figs. 132, 133 – *C. vultur* var. *sumatranum* (Karsten) Steemann Nielsen; dorsal and ventral views; (original). Fig. 134–*C. vultur* var. *productum* Wood; ventral view; (after Wood, 1963*b*). Figs. 135, 136 – *C. reflexum* Cleve; dorsal and ventral views; (after Cleve, 1900). (129, x 200; 131, 132, 133, 135, 136, x 250; 130 and 134, not given).

with small, but robust, twisted lists and striking pores. In the orientation of posterior horn this species is unique. In other respects it resembles *C. vultur* var. *sumatranum*. $t = 55 - 68\mu$; $h = 37 - 43\mu$; $v = 170 - 220\mu$.

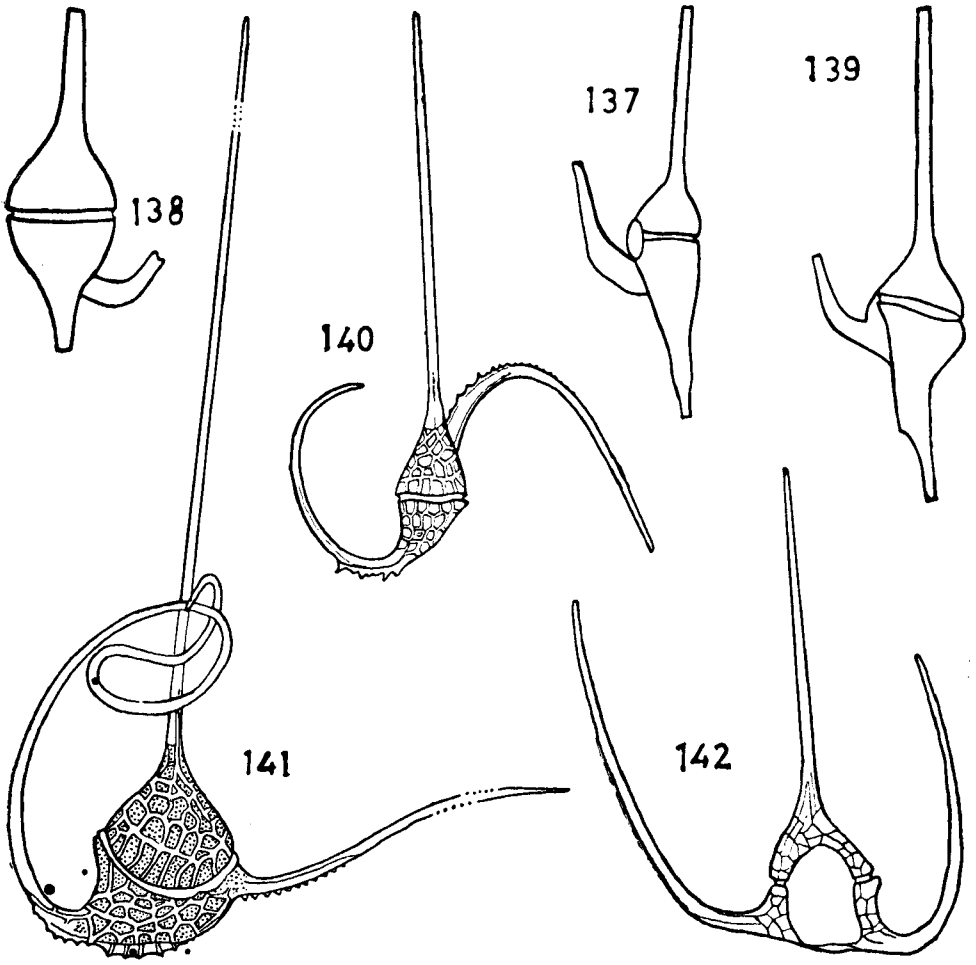
Rare tropical form. Occurs in deeper water. Red Sea, Gulf of Aden, Indian Ocean.

58. **Ceratium hexacanthum** Gourret, 1883
(Text-figs. 140, 141)

Gourret, 1883, p. 36, pl. 3, fig. 49.
Jörgensen, 1920, p. 101, fig. 94.
Böhm, 1931 *a*, p. 366 figs. 22, 23; 1931 *b*, p. 42.
Schiller, 1937, p. 421, figs. 462 *a* – *c*.
Wood, 1954, p. 306, figs. 234 *a*, *b*.
= *C. tripos* var. *inaequale* Gourret, 1883; p. 30, pl. 1, fig. 3.
= *C. reticulatum* (Pouchet) Cleve, 1903, p. 342; Paulsen, 1908, p. 82, fig. 110; Karsten, 1907; Jörgensen, 1911, p. 86, figs. 182, 183, non *C. reticulatum* Imhof.
= *C. hexacanthum* Gourret f. *contortum* (Lemm.) Jörgensen, 1911; Schiller, 1937, p. 422, fig. 462 *b*.
= *C. hexacanthum* var. *contorta* Lemmermann, 1900, p. 347, pl. 2, figs. 20, 21; Karsten, 1907, pp. 240, 250.
= *C. recticulatum* var. *contorta* Lemm. Karsten, 1907, p. 240.
= *C. hexacanthum* Gourret f. *spirale* (Kofoid) Schiller, 1937, p. 422, fig. 462 *c*.
= *C. reticulatum* var. *spiralis* Kofoid, 1907 *b*, p. 305, pl. 27, figs. 27, 28; Karsten, 1907, p. 287.

Large and very long horned species with concave body, approximately same length or a little longer. Epitheca not very oblique, rather low with little convex contour. Left side contour of hypotheca almost straight. All three horns long, proximal part thin and thin walled and pliable, bent in different directions none lying in the body plane. Posterior contour convex, set out on either side by the horns, not, however, limited from these by clear angle, nor depressed. Anterior horn sinuous to rather strongly bent, proximal third ventrally directed, then gradually bent back. Left horn at base slightly towards back, however, strongly ventrally directed, then somewhat separated further from the body, bent forward, then straight and converging towards anterior horn. Right posterior horn first directed at right angles to apical horn, somewhat bent and twisted, then very long and often hair-thin. Armour sculpture characteristic, with lists and a regular large meshed net work forming numerous polygones which are unequal in form and size. Proximal part of posterior horn at the outside beset with spike-like lists throughout, as also posterior contour of cell. Differs from other *Ceratium* spp. in this unique sculpturing; only *C. paradoxides* possesses such, but polygones smaller.

Two forms are recognized by some authors based on contour of posterior horns, *viz.*, *Ceratium hexacanthum* Gourret forma *contortum* (Lemm.) Jörgensen, (1911, p. 87; Schiller, 1937, p. 422, fig. 462 *b*), and *Ceratium hexacanthum* forma



Text-figures 137 – 142. Figs. 137, 138, 139 – *Ceratium reflexum* Cleve; ventral and dorsal views (138); (137 and 138 after Wood, 1963 *a*; 139, after Steemann Nielsen, 1934). Figs. 140, 141, – *C. hexacanthum* Gourret; lateral and dorsal views; (from Schiller, 1937). Fig. 142 – *C. hexacanthum* var. *aesturium* (Schröder) Schiller; ventral view; (from Schiller 1937). (139, x 240; 141, x 350. Rest not given).

spiralis (Kofoid) Jörgensen (1911, p. 87; Schiller, 1937, p. 422, fig. 462 *c*). There are not enough bases for separation. The writer has merged these two with the type.

59. **Ceratium hexacanthum** Gourret var. **aesturium** (Schröder) Schiller, 1937.
(Pl. VI, fig. 32; text-fig. 142)

Schiller, 1937, p. 422, fig. 462 *a*.
=*C. aesturium* Schröder, Böhm, 1931 *a*, p. 366, fig. 21; Jörgensen, 1920, p. 102.

The posterior horns bent forward and run parallel with the anterior horn unlike in the type.

Type and variety commonly distributed in all warm waters. Red Sea, Gulf of Aden, Arabian Sea, Indian Ocean, African east coast to Sumatra; Bass Straits; Marmara Sea; Pacific Ocean, Japan; Atlantic Ocean, Mediterranean.

60. **Ceratium massiliense** (Gourret) Jörgensen, 1911
(Pl. IV, Fig. 23; Pl. VII, figs. 34, 35)

Jörgensen, 1911, p. 66, figs. 140 – 142; 1920, p. 85, figs. 78 – 80.
Böhm, 1931 *a*, p. 362, figs. 16 – 18; 1931 *b*, p. 35, fig. 32.
Steemann Nielsen, 1934, p. 25, figs. 60 – 62.
Schiller, 1937, p. 422, figs. 463 *a* – *d*.
Graham & Broniskovsky, 1944, p. 38, figs. 22 *E* – *L*.
Wood, 1954, p. 306, figs. 235 *a*, *b*, *c*.
=*C. tripos* var. *massiliense* Gourret p. p., 1883, p. 27, pl. 1 fig. 2; *non* 2 *a*.
=*C. volans* Ostenfeld *et* Schmidt, 1901, Schiller, 1937, p. 424.
=*C. aequatoriale* Schröder, 1906, p. 361, fig. 32.
=*C. volans* Cleve f. Schröder, 1906, p. 363, fig. 34.
=*C. undulatum* Schröder, 1906, p. 326.
=*C. tripos macroceroides* Karsten, 1906, pl. 22, figs. 28 *a*, *b*.
=*C. tripos macroceros* Karsten, p. p 1906, pl. 22, fig. 29 *a*, *non b-d*; *non C. macroceros* (Ehrenb.) Cleve, Pavillard, 1909, p. 226.
=*C. tripos intermedium* f. *aequatorialis* Schröder, Karsten, 1907, p. 49, figs. 21 *a*, *b*.
=*C. tripos macroceros* var. *crassa* Karsten, 1907, pl. 39, figs. 27 *a* – *d*.
=*C. tripos robustum* var. ? Karsten, 1907, pl. 51, fig. 7.
=*C. tripos volans* Cleve, Karsten, 1907, p. 331.
=*C. massiliense* f. *macroceroides* (Karsten) Jörgensen, 1911, p. 66 figs. 140 – 142; Schiller, 1937, p. 424, fig. 235; Wood, 1954, p. 308; Subrahmanyan, 1958, p. 440. (The principal form).
=*C. massiliense* f. *armatum* (Karsten) Jörgensen, 1911, p. 67, fig. 146, as var. *armatum*; Schiller, 1937, p. 424, fig. 463 *b*; Wood, 1954, p. 308, fig. 235 *b*;

Subrahmanyan, 1958, p. 440. (=*C. tripos macroceros* f. *armata* Karsten, 1905, pl. 19, fig. 8; *C. tripos longipes* f. *ventricosa* Karsten, 1906, pl. 21, figs. 26, 26 *a*; *C. tripos longipes* var, *cristata* Karsten, 1907, pl. 48, figs. 12 *a-c*.

= *C. massiliense* forma *protuberans* (Karsten) Jörgensen, 1911, p. 67, figs. 143-145 as var. *protuberans*; 1920, p. 85, figs. 78, 80; Schiller, 1937, p. 424, figs. 463 *c, d;* Wood, 1954, p. 308, fig. 235 *c*; (= *C. tripos protuberans* Karsten, 1906, pl. 22, figs. 27 *c – g; a, b*?.

= *C. tripos tergestinum* Karsten, 1906, pl. 21, fig. 24.

= *C. tripos longipes* Karsten, p. p. 1907, pl. 48, fig. 11 *b* not *a*.

= *C. tripos intermedium* var. *hundhausenii* (Schröder) Karsten, 1907, p. 338.

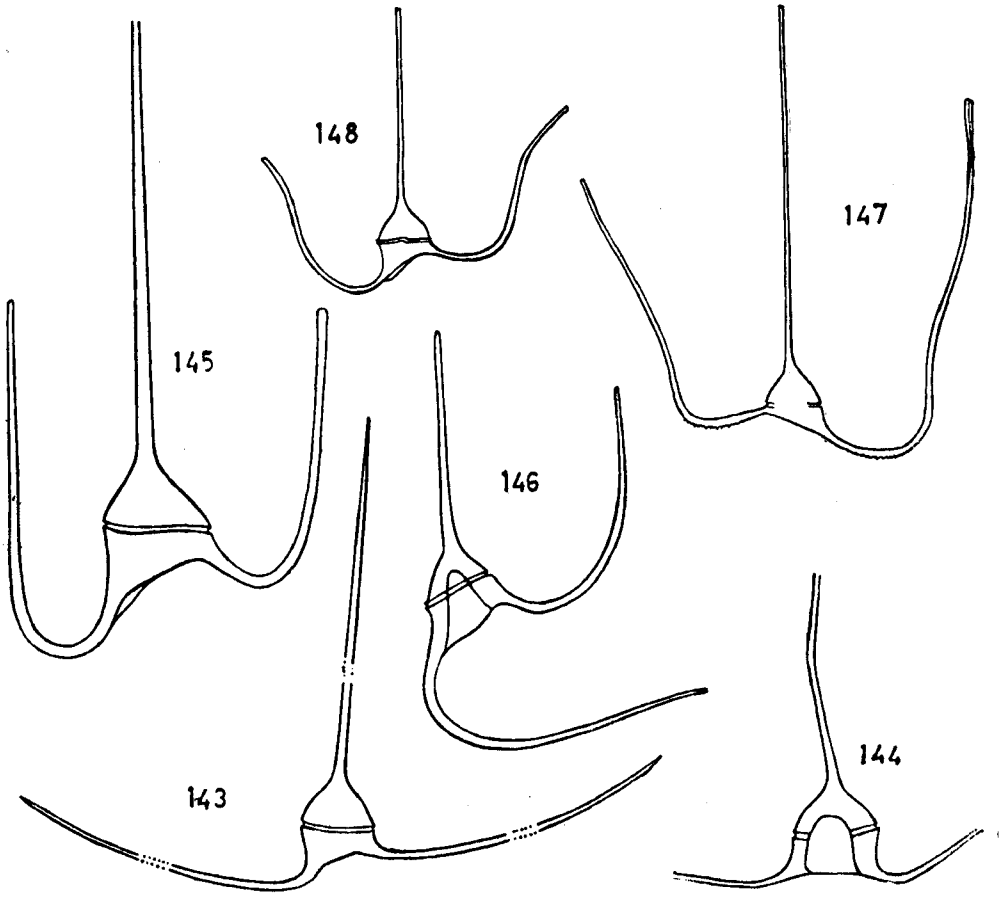
= *C. tripos flagelliferum* var. *crassa* Karsten, 1907, pl. 49, figs. 25 *a – c*.

= *C. massiliense* var. *protuberans* (Karsten) Jörgensen, 1920, p. 86.

= *C. protuberans* (Karsten) Paulsen, 1931, p. 89, fig. 56.

Large, very long-horned species; body approximately as long as broad. Epitheca oblique, usually with moderately convex side contours. Hypotheca usually a little longer than epitheca, rarely same length with concave left side contour. Posterior contour (in ventral view) almost straight or a little concave. Apical horn usually long and thin; at the base slightly broader; in old individuals and some of those designated "forms", however, strongly widened, straight or a little bow-like, frequently bent in the dorsi-ventral direction, sigmoid. Posterior horns characteristic; they arise almost perpendicular to one another (angle 90°–120°) then curve round soon at right angles and run afterwards almost in a straight line more or less strongly diverging or are very frequently beautifully curved, at times wavy or weakly sigmoid with bent-in apices; the left horn forms thereby a large angle with the apical horn. On the posterior contour is to be found a large long winged list (and two below) which is beautifully dentate on the left side. The right horn arises invariably below the transverse furrow and is well delimited by the posterior contour, whereas the left horn is not clearly delimited. Armour usually slightly strong; at times one finds large pores and many longitudinal lists as well as low winged lists which usually run along the length of apical horn on its under side and the concave proximal part of the posterior horns. The winged lists of apical horn are slightly dentate above, below margin entire. The horns vary much in direction in relation to body plane, the apical directed ventrally so also proximal part of posterior horns, particularly those of right one. The starting point of apical horn and the part of the dorsal portion of epitheca lie, mostly dorsal, whereas the remaining part is shifted ventralwards. t = 68 - 87μ; h = 43 – 50μ; b = less than $\frac{1}{2}$ h; V, variable upto 650μ.

Several forms are recognised by authors (refer to the numerous synonyms mentioned above) based on body size, length, configuration and divergence of posterior horns and so on. The species is a very variable one, and all kinds of



Text-figures 143 – 148. Figs. 143, 144 – *C. carriense* Gourret; dorsal and ventral views; (after Karsten, 1907). Figs. 145, 146 – *C. deflexum* (Kofoid) Jörgensen; dorsal and ventral views; (145, after Böhm, 1931 *b*; 146, from Schiller, 1937). Fig. 147 – *C. trichoceros* (Ehrenb.) Kofoid; ventral view; (after Jörgensen, 1920). Fig. 148 – *C. trichoceros* var. *contrarium* (Gourret) Schiller; dorsal view; (from Schiller, 1937). (143, 144, 147, 148, x 125; 145, x 100; 145, not given).

transitional forms are met with, probably due to hybridization. Hence there is no real basis for distinction into *varieties* and *formae*.

Warm water species in all oceans. Atlantic, from 29°S to northern limit of Florida Stream on east coast of America, Azores; Mediterranean; Indian

Qcean, Red Sea to Sunda Islands, upto 38°S, Arabian Sea; Boeton Straits; South China Sea, East China Sea; Pacific, Japan.

61. **Ceratium carriense** Gourret, 1883
(Pl. VII, Fig. 36; text-figs. 143, 144)

Jörgensen, 1911, p. 68, figs. 147 *a, b;* 1920, p. 89, fig. 81, 82.
Böhm, 1931 *a*, p. 363; 1931 *b*, p. 37.
Steemann Nielsen, 1934, p. 26, fig. 64.
Schiller, 1937, p. 425, fig. 464–66.
Graham & Broniskovsky, 1944, p. 39, fig. 22 *A*.
Wood, 1954, p. 308, figs. 236 *a, b*.
= *C. tripos* var. *massiliense* Gourret, p. p. 1883, p. 27, pl. 1, fig. 2 *a, non* 2.
= *C. volans* Pavillard, 1905, Schiller, 1937, p. 425.
= *C. massiliense* Pavillard, 1907, p. 226.
= *C. carriense* f. *volans* (Cleve) Jörgensen, 1911, figs. 148 *a, b,* 149 *a, b,* as var. *volans;* 1920, p. 82; Schiller, 1937, p. 426, fig. 465; Wood, 1954, p. 309, 236 *a;* Subrahmanyan, 1958, p. 440. (= *C. volans* Cleve, 1900, p. 15, pl. 7, fig. 4; 1903, p. 343; *C. tripos* var. *volans* f. *strictissima* Karsten, 1906, pl. 21, fig. 21).
= *C. carriense* Gourret f. *ceylanicum* (B. Schröder) Jörgensen, 1911, figs. 150 *a, b;* Schiller, 1937, p. 427; (= *C. ceylanicum* B. Schröder, 1906, p. 363, fig. 35; *C. elegans* Schröder, *l. c.*, p. 364, fig. 36; *C. tripos* var. *elegans* (Schröder), Karsten, 1907, p. 338, pl. 49, fig. 18 *a, b*.

Rather large and robust species with compact body which is somewhat longer than broad. Shows some similarities with *C. massiliense*. Epitheca with somewhat strongly convex left and weakly convex right-side contour. Hypotheca little longer than broad, the left side contour however straight or quite weakly convex. Anterior horn moderately long, at base widened and thick-walled, here beset with low, however, long winged lists, which are dentate below over whole margin, above slightly dentate. Posterior horns robust, towards apex thinner, the left at the starting point forms a small angle with the extension of the apical horn, runs for a short stretch inclined to posterior and leftwards, then bends round rather suddenly forwards and forms a rather proportionately large arch, which at its apex more or less diverges a little with the apical horn or at times is directed almost parallel with it. The right horn runs similar, bends around, however, a little further gradually, is on the whole little twisted. Posterior contour of cell rather widely depressed, rather oblique on both sides; left, however, clearly limited from the posterior horn by a clear angle; both angles of same

magnitude or left somewhat more, both clearly blunt. Armour rather robust, represented by longitudinal lists and pores. At the convex flexure of posterior horns generally clear spiked winged lists occur, and on the posterior contour two clear winged lists, one longer, another low and, on the left side another, a short high and rounded one; both are sparsely dentate. $t = 68 - 77\mu$; $b = \text{Ca } \frac{1}{2}\,t$; $V = 300 - 600\mu$.

This species is very similar to *C. massiliense* that one often gets confused; it differs, however, from the robust form of *C. massiliense* only in the sunken posterior contour and the angular demarkation of the same with left posterior horn, then by the slightly straight basal piece of the horn and the farther more spread right horn whose proximal part forms next an obtuse angle. Since both the species are variable, numerous *varieties* and *forms* have been described in which characters of both species are mingled. (See figs. 17, 18 in Böhm, 1931 *a;* Schiller, 1937, fig. 464 b). In fact, Gourret considered both species as one.

Here, the two forms recognised by earlier authors, f. *volans* and f. *ceylanicum* (refer synonyms above) are included in the type.

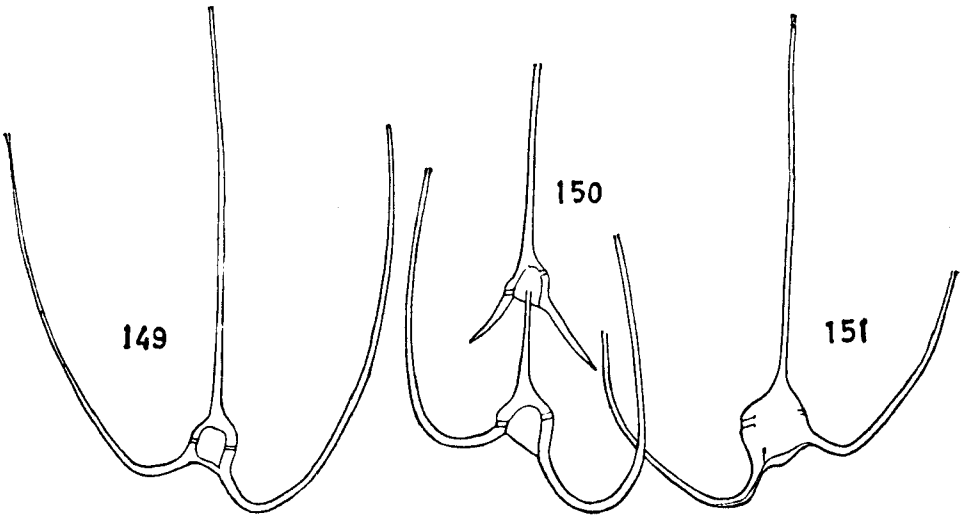
Common warm water form in all seas. Red Sea, Gulf of Aden, Arabian Sea, Malaya, Indian Ocean, west and south coasts of Australia, Mediterranean; Bengula Current; Azores; Japan.

62. **Ceratium deflexum** (Kofoid) Jörgensen, 1911
(Text-figs. 145, 146)

Jörgensen, 1911, p. 64, figs. 138, 139.
Böhm, 1931 *b*, p. 37, figs. 33, 34.
Steemann Nielsen, 1934, p. 25, fig. 63.
Schiller, 1937, p. 428, figs. 467 *a, b.*
= *C. macroceros deflexum* Kofoid, 1907 *b*, p. 304, pl. 24, figs. 13 – 15.
= *C. tripos macroceros* Karsten, p. p. 1907, pl. 49, figs. 26 *a, b;* pl. 51, figs. 11 *a,b.*
= *C. californiense* Karsten, 1907, pl. 51, fig. 15.
= *C. recurvatum* Schröder, 1906, p. 367, fig. 40; Karsten, 1907.

Rather large long horned species, with less spread strongly ventrally directed posterior horns. Epitheca slightly oblique, low, with convex side contours. Hypotheca, a little longer than epitheca, with almost straight and slightly oblique left side contour. Posterior contour almost straight inclined. Apical horn long, almost or wholly straight, below hefty. Posterior horn slightly stretched out gradually arched, distal portion straight. The angle between the proximal

and middle part of right horn less than in *C. macroceros.* The right horn arises invariably below the transverse furrow. The clearance *h* relatively small, approximately *h* or a little larger or smaller. On the posterior contour occurs rather a high winged list, the left much higher, and right merges almost straight on to dorsal side. The posterior horns are significantly ventrally directed. Transverse furrow normal. Posterior horns smooth at bends not beset with teeth. $t = 54 - 64\mu$; $h = 38 - 43\mu$; $b = ca$ h; $V = 210 - 425\mu$.



Text-figures 149 – 151. Figs. 149, 150 – *Ceratium macroceros* (Ehrenb.) Cleve; ventral views; (from Schiller, 1937). Fig. 151 – *C. macroceros* var. *gallicum* (Kofoid) Jörgensen; dorsal view; (from Schiller, 1937). (149, 150 -x 100; 151-x 200).

Rare warm water form. East of Ceylon; Indian Ocean, Red Sea to Sumatra; eastern Australia, Boeton Strait; Great Barrier Reef, South Equatorial Current; South China Sea, east coast of Malacca, Gulf of Siam; East China Sea; Pacific, Panama region, west coast of N. America.

63. **Ceratium macroceros** (Ehrenberg) Cleve, 1900
(Pl. IV, Fig. 24; Pl. V, figs. 25, 26; Pl. VI, figs. 29, 30; text-figs. 149, 150).

Cleve, 1900, p. 227; 1901, p. 14; 1903, p. 342.
Paulsen, 1908, p. 81, fig. 109.
Jörgensen, 1911, p. 63, figs. 132 *a, b,* 133; 1920, p. 83, fig. 77.
Lebour, 1925, p. 155, pl. 35 *(C. horridum* ? *).*
Böhm, 1931 *b,* p. 38, fig. 35 *a;* 1931 *c,* p. 364.

Schiller, 1937, p. 428, fig. 468.
Graham & Broniskovsky, 1944, p. 37, figs. 21 *B* - *F*.
Wood, 1954, p. 310, fig. 238 *a*.
Subrahmanyan, 1958, p. 440.
= *Peridinium macroceros* Ehrenberg, 1840, Schiller, 1937, p. 429.
= *Ceratium tripos* var. *macroceros* Clap. *et*. Lachm., 1859, Schiller, 1937, p. 429; Gourret, 1882, pp. 26 – 27, pl. 2, fig. 41.
= *C. macroceros* Cleve, 1901 *b*, p. 227.
= *C. tripos* var. *scotia* Schütt, p. p. 1892, Schiller, 1937, p. 429.
= *C. californiense* Kofoid, 1907 *b*, p. 302, pl. 23, figs. 8 – 9; Karsten, p. p. 1907, p. 312.
= *C. tripos macroceros* var. *tenuissima* Karsten, 1907, pl. 49, figs. 28 *a* – *c*.

Medium sized, long horned species; body thick, concave; longer than broad; the posterior horns open at the tips. Epitheca not very oblique, broad and depressed, with convex sides. Hypotheca somewhat longer than epitheca, with a strongly oblique left side. Posterior margin almost straight on both sides making an oblique angle with the backward directed posterior horns. Apical horn long, broad at the base, straight or slightly bent. Posterior horns first directed backward, then rather suddenly bent forward, diverging more or less from one another and in relation to the apical horn; later they make a broad arc and are, at the tips, nearly or quite parallel with the apical horn. The right posterior horn arises somewhat behind the transverse furrow and is strongly ventrally directed. Theca sculpture strong, rather numerous irregularly bent longitudinal ridges and large pores present. At the bends the posterior horns are usually heavily toothed. t = 45 – 57 μ. Chromatophores always present in abundance. t = 48 – 57 μ; h = 34 – 40μ; b more than h upto 2 h; V = 270 – 400μ.

Temperate regions of all seas; in the Tropics rare. Indian Ocean, Malay Archipelago, Gulf of Aden, Red Sea, Singapore, Zanzibar; Freemantle; N. Atlantic; Norwegian Sea; English Channel, American Coast.

64. **Ceratium macroceros** var. **gallicum** (Kofoid) Schiller, 1937
(Text-fig. 151)

Schiller, 1937, p. 430, fig. 469.
Wood, 1954, p. 311, fig. 238 *b*.
Subrahmanyan, 1958, p. 440.
= *C. tripos* var. *macroceros* Gourret, 1883, pl. 2, pp. 26 – 27; pl. 2, fig. 41.
= *C. tripos macroceros* Karsten, p. p., 1906, pl. 22, figs. 29 *b* – *d*, vix *a*.

= *C. gallicum* Kofoid, 1907 *b*, p. 302, pl. 24, figs. 10 – 12.
= *C. californiense* Kofoid, p. p. 1907 *b*, p. 302, pl. 23, figs. 8 – 9; Karsten, p. p. 1907, p. 312.
= *C. gallicum* (Kofoid) Jörgensen, 1911, p. 63, figs. 134, 135 (as subsp.).
= *C. macroceros* subsp. *gallicum* (Kofoid) Steemann Nielsen, 1939, p. 14.

In all essential characters like species, but somewhat smaller and delicate. Body shape as in species. The transverse furrow is very frequently displaced to the right fully or partially. The posterior horns divergent at beginning a little and are sharp, almost bent round at an angle, the angle between the proximal and the middle part of apical horn is usually a little less than 90°; in species the angle is 90° or more. Armour sculpture not clear; in older individuals, clear but more delicate than species. $t = 45 - 55\mu$; rarely 70μ.

Warmer seas. Atlantic Ocean, south of Africa to northern limit of Florida Stream on the east coast of America; Azores, Mediterranean; Indian Ocean, 25°S 56°E to Arabian Sea and towards Sumatra. Pacific Ocean, San Diego, Japan.

65. **Ceratium trichoceros** (Ehrenberg) Kofoid, 1908 *b*
(Pl. VII, fig. 37; text-fig. 147)

Kofoid, 1908 *b*, p. 388.
Jörgensen, 1911, p. 75, figs. 159 *a, b;* 1920, p. 95, fig. 85.
Böhm, 1931 *c*, p. 365.
Steemann Nielsen, 1934, p. 27, fig. 68.
Schiller, 1937, p. 430, fig. 470.
Graham & Brøniskovsky, 1944, p. 40, fig. 22 *B*.
Subrahmanyan, 1958, p. 440.
Wood, 1954, p. 311, fig. 239 *a*.
= *Peridinium trichoceros* Ehrenberg, 1859, p. 791; 1873, p. 3, pl. 1, fig. 1.
= *Ceratium flagelliferum* Cleve, 1900, p. 14, pl. 7, fig. 12.
= *C. tripos flagelliferum* Karsten, 1905, p. p. pl. 22, fig. 31 *b* not *a, c, d.*
= *C. tripos flagelliferum* f. *crassa* Karsten, 1906, pl. 22, figs. 32 *a, b.*

Small, but long-horned species; body longer than broad. Epitheca slightly oblique. Side contours slightly convex. Hypotheca a little shorter than the epitheca; left-side contour almost straight. Posterior contour slightly oblique, left vaguely depressed. All the three horns normally very thin, long, at the apex approximately directed parallel. The left posterior horn situated on a very short and somewhat on an apparent basal piece obliquely to left and directed,

backwards then slightly bent and in a large rather uniform arch bent forwards, at the outer 2/3 almost straight or slightly undulated. The right posterior horn similarly bent but without flexion at base. Both arches of the posterior horns lie almost equally separated from behind and are approximately of same size. The clearance from the starting point of right horn to the hindmost point of same usually about = $2t$. The winged lists of the posterior horns narrow on the left, scarcely broader. Transverse furrow (?) clear only on left side. Armour not clear; usually more or less slightly dentate; posterior horns on their convex side of arch, particularly on their separated parts, respectively on left and right, more or less strongly dentate. $t = 37 - 48\ \mu$; $h = 23 - 28\mu$; $V = 200 - 420\mu$.

Warm water form; widely distributed. Atlantic Ocean, N. W. of Danish West Indies; Tortugas, Florida Stream on N. American Coast; west coast of S. Africa; Mediterranean; Indian Ocean, from Red Sea to East Malacca; east of Zanzibar, Arabian Sea; East China Sea; Pacific, Japan.

66. **Ceratium trichoceros** (Ehrenb.) Kofoid var. **contrarium** (Gourret) Schiller, 1937
(Text-fig. 148)

Schiller, 1937, p. 431, fig. 471.
= *C. tripos* var. *typicum* Gourret, 1883, p. 31, pl. 1, fig. 36.
= *C. tripos* var. *inflexum* Gourret, 1883, pl. 3, fig. 44.
= *C. tripos* var. *contrarium* Gourret, 1883, pl. 3, fig. 51.
= *C. tripos* var. *gourretii* Lemmermann, 1900, Schiller, 1937, p. 431.
= *C. tripos* var. *macroceros* f. *claviceps* Schröder, 1900, pl. 1, fig. 17 *n;* f. *undulata* Schröder, p. p. 1900, pl. 1, fig. 17.
= *C. flagelliferum* Cleve, 1901 *a*, p. p. 217; 1901 *b*, p. 14; 1903, p. 341.
= *C. flagelliferum* var. *filiformis* Okamura *et* Nishikawa, 1904, p. 126, pl. 6, fig. 11.
= *C. tripos flagelliferum* var. *angusta* p. p. Karsten, 1906, pl. 22, fig. 33 *a, b.*
= *C. tripos flagelliferum* var. *undulata* Schröder, Karsten, 1907, p. 410, pl. 49, fig. 23.
= *C. tripos flagelliferum* var. *major* Karsten, 1907, p 410, pl 48, fig. 22.
= *C. inflexum* (Gourret) Kofoid, Jörgensen, 1911, p. 76, figs. 160 *a, b;* 161 *a, b,* vix *C. inflexum* Schröder, 1906, p. 362.
= *C. contrarium* (Gourret) Pavillard, Jörgensen, 1920, p. 93, fig. 821; Böhm, 1931 *c*, p. 365; Steemann Nielsen, 1934, p. 27, fig. 67.

Slightly larger than species. Body as in species; left-side contour of hypotheca clearly oblique and somewhat concave. Epitheca relatively broader. Posterior contour of cell a little inclined merging into the left horn almost evenly,

horn not clearly delimited from contour, thus a bent at the base is absent. The clearance from the origin point of right horn to the hindmost point of the same is approximately little more than *t*. Otherwise the horns similar to those of the species; but clearly robustly developed and irregular at the distal part; often undulate, bent and frequently diverging in relation to one another and apical horn. The arch of both horns are about same as in species; that of right horn is usually smaller and not lying so farther back as of left. Sculpture as in species; teeth at the bends of the posterior horn absent mostly and are, if they occur, present at the hindmost part of arch. The winged list, if present, drawn out like teeth backwards on the posterior contour on left side. Transverse furrow clear. $t = 51–68\mu$; $h = 34–40\mu$; $V = 300–560\mu$.

Warm water form. Atlantic Ocean, 28°S to north of Florida Stream on American coast, up to Azores; Mediterranean; Indian Ocean, 25°S to 56°E upto Arabian Sea, Red Sea, Gulf of Aden and upto Sumatra; Pacific Ocean, Japan.

67. **Ceratium ramakrishnii** Subrahmanyan, n. sp.

(Pl. VIII, figs. 38 – 40)

Robust long-horned species. Epitheca dome-shaped in outline contributing almost 2/3 of the body. Body not compressed. Anterior horn long, straight, at base with wings and ridges. Hypotheca with posterior contour somewhat concave in ventral view, practically indistinguishable from the bases of the posterior horns. Posterior horns robust, beautifully arched and directed forward. Left posterior horn in dorsal view with slightly broader base. Transverse furrow well defined, with prominant ridge. Chromatophores absent. Colourless species. Nucleus large, clear. Abdominal notch large and prominant. $t = 78 – 85\ \mu$; $v = 2\ h$.

In the plankton of the waters off Calicut, on the west coast of India. Recorded in April and May, 1949.

Diagnosis for:

Ceratium ramakrishnii spec. nov.

Species robusta longe corniculata. Epitheca tholiformis ambitu, efformans prope duos trientes totius corporis. Corpus haud compressum. Corna anterius longum, rectum, ad basin alatum et procatum. Hypotheca cum ambitu posteriore aliquantum concava aspectu ventrali, vix distinguenda e basibus cornuum posteriorum. Cornua posteriora robusta, pulchre arcuata et prorsum directa. Cornu

sinistrum posterius aspectu dorsali paulo latius ad basin. Sulcus transversus bene definitus, jugo eminente. Chromatophora nulla. Species incolora. Nucleus amplus, distinctus. Incisura abdominalis ampla et eminens. $t = 78–85\mu$; $v = 2h$.

In plancto in aquis ad Calicut ad oras indicas occidentales, mensibus aprili et maio anni 1949.

This species is named after the author's father, the late P. S. Ramakrishna Iyer, but for whose persistent encouragement and considerable sacrifices, it would not have been possible for him to take up research as a career.

SPECIES OF

CERATIUM

KNOWN FROM OTHER OCEANS

Section **LANCEOLATA** Jörgensen, 1911

Characters of section same as species below.

68. **Ceratium lanceolatum** Kofoid, 1907
(Text-fig. 152)

Kofoid, 1907 *c*, p. 172, pl. 3, fig. 17.
Jörgensen, 1911, p. 13, fig. 15.
Schiller, 1937, p. 357, fig. 390.

Epitheca flattened, lancet shaped, probably somewhat arched dorsally, towards apical pore taking a pointed course. Hypotheca almost same width approximately as long as broad. Posterior horns directed backwards, left one with thinner and longer apex; the right half as long, somewhat bent, stout. $t = 19\text{-}22\mu$, total length 95 – 122μ.

Rare warm water form. Hitherto recorded from Pacific off Peru from 3 close stations.

Section **DIGITATA** Jörgensen

69. **Ceratium pacificum** Wood, 1963
(Text-fig. 155)

Wood, 1963 *a*, p. 42, fig. 151.
(*non C. pacificum* Schröder, 1906 = *C. belone* Cleve, 1900).

Epitheca large, somewhat swollen and produced into a bent apical horn; girdle narrow, depressed; hypotheca small, one antapical horn slightly curved and spur-like; the other long, straight for about half length then curved at an angle of 30 - 45°. Length 300μ.

Is a distinct form probably closest to *C. schroeteri*. The long antapical horns and clearly differentiated apical horn are unique.

Off Bougainville Island in the Solomon Slot.

70. **Ceratium tasmaniae** Wood, 1963
(Text-fig. 156)

Wood, 1963*a*, p. 42, fig. 152.

Epitheca and hypotheca of equal width; apical (anterior) horn strong, short, bent ventrally; antapicals (posterior) unequal, one short, slightly curved

ventrally, the other strong and recurved, ending anteriorly. Length 200μ. This species seems to belong to the Section Digitata.

Recorded at 30° S. latitude off Norfolk Island.

Section **CORNUTA** Jörgensen

71. **Ceratium brachyceros** v. Daday, 1907
(Text-fig. 158)

v. Daday, 1907, p. 245, fig. A.
Schiller, 1937, p. 362, fig. 398 *a*, *b*.
$=$*C. hirundinella* var. *brachyceros* Ostenfeld, 1909, p. 171, fig. 2.

Strikingly short, however, species with body very broad. Only three horns developed. Two posterior horns run almost parallel to one another. Apical horn open, at times closed. Armour thick, with very fine reticulations. Breadth 30 - 70 μ. Length 90 - 195 μ.

Known from the tropical lakes of Africa and Asia only.

72. **Ceratium cornutum** (Ehrenb.) Clap. *et* Lachm. 1858/61
(Text-fig. 159)

Jörgensen, 1911, p. 13, fig. 16.
Schiller, 1937, p. 363, fig. 399.
$=$ *Peridinium cornutum* Ehrenberg 1838, p. 255, pl. 22. fig. 17.
$=$ *Dimastigoaulax cornutum* Diesing, 1866, Jörgensen, 1911, p. 13.

Body large, horns short, hence appearing plump in habit. Apical horns inclined to right and at the front slightly bent, at the apex obliquely blunt and open. Posterior horns short, running straight, pointed, closed. Surface reticulate with four-sided or hexagonal meshes. Cyst thick - walled, irregularly oval; the origin of future horns readily distinguishable. $t = 75-80\,\mu$; $v. = \frac{1}{10}t$, $h = \frac{1}{2}t$; $L = ca\ \frac{1}{2}t$.

Present in ponds and puddles of Europe and N. America.

73. **Ceratium carolinianum** (Bailey) Jörgensen, 1911
(Text-fig. 160)

Jörgensen, 1911, p. 14, figs. 17, 18.
Schiller, 1937, p. 367, fig. 400.

Body dorsi – ventrally compressed. Epitheca very low, many times broader than long, at the right side laterally drawn out; therefore the contour hier with broad flat keel. Apical horn clearly demarcated, curved towards right, narrowed at apex. Posterior horns two, right arising close to transverse furrow, left with a broad base. Surface sculptured with areolations. t = 77 μ; $v = h$ = smaller than $\frac{1}{2}$ t; L = *ca* $\frac{1}{2}$ t.

Freshwater species known from North America, Scotland and Norway.

Sub-genus **AMPHICERATIUM** (Vanhoffen) Gran

Section **INFLATA** Jörgensen

74. **Ceratium scapiforme** Kofoid, 1907
(Text-figs. 153, 154)

Steemann Nielsen, 1934, p. 13, fig. 19.
= *C. pennatum* var. *scapiforme* (Kofoid) Jörgensen, 1911, p. 27, figs. 47 *a–d*.

Epitheca without real apical horn; seen in the lateral aspect it is even somewhat flattened. Kofoid describes the epitheca as bladder–like; but it is clear he has not examined his specimens from the lateral aspect. The length amounts to 500 μ.

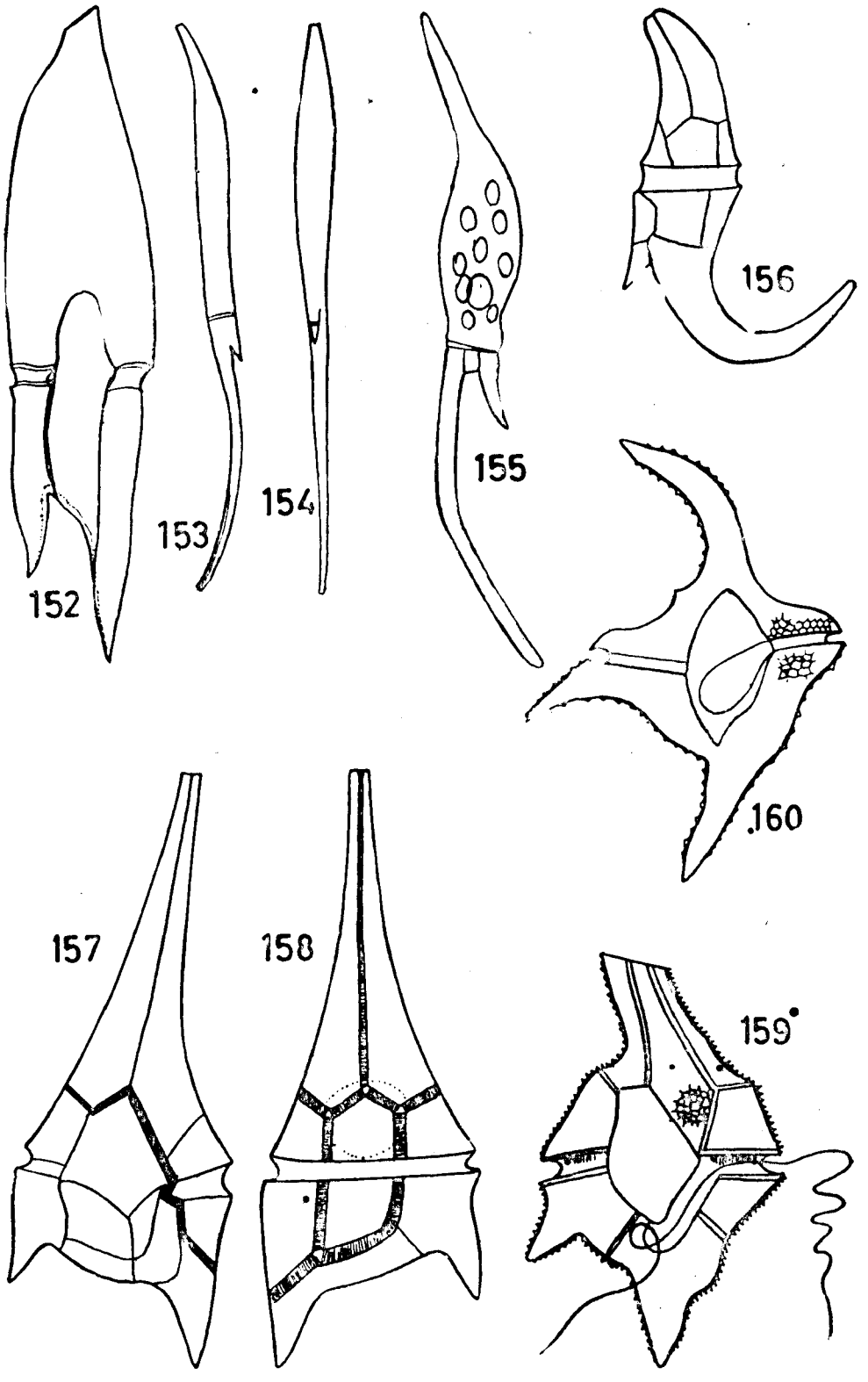
Known only from the Pacific Ocean. (The reference in Wood (1963 *c*) of record of this species in the Indian Ocean, citing Steemann Nielsen, 1939, is wrong; there is no reference to this species in Steemann Nielsen, 1939)

Section **TRIPOS** Ostenfeld

75. **Ceratium compressum** Gran, 1902
(Text-fig. 161)

Paulsen, 1908, p. 81, fig. 108.
Jörgensen, 1911, p. 39, figs. 57, 81.
Lebour, 1925, p. 150, fig. 47 *a*.
Schiller, 1937, p. 390, fig. 427 *b*.
Kiselev, 1950, p. 248, fig 424.
(*non C. compressum* Gran, 1912 = *C. platycorne* v. Daday)

Body strongly compressed. All the horns in about the same plane. Epitheca high, with weakly convex to straight contour which make an acute angle with one another, about 60° or less; epitheca merges into a strongly developed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apical horn. Posterior horns broad, identically bent with tapering apices, distal ends almost, parallel, left slightly diverging a little from apical horn, the right slightly coverging. Right posterior horn slightly smaller than left. Theca with numerous strong ridges; well developed spine lists on apical horn and smaller ones on posterior horns and margin. $t = 56\mu$; $v+V = 146\,\mu$.

Rare species, known from certain localities in the temperate Atlantic.

76. **Ceratium carnegiei** Graham & Broniskovsky, 1944
(Text-fig. 162 - 164)

Graham & Broniskovsky, 1944, p. 35, fig. 18 *A – C*

Transdiameter (*t*) 92.5 (90 - 100) μ. Curvature of antapical (posterior horns) similar to that of *C. lunula*. Apical (anterior) horn long and straight or slightly curved to right. Body of epitheca slightly to greatly inflated. In extreme cases, the walls are parallel for about one transdiameter from the girdle, at which point they may be expanded to greater than girdle diameter. Body wall thick and covered with numerous lists as in the robust specimens of *C. lunula*.

Recorded from the Pacific.

77. **Ceratium petersii** Steemann Nielsen, 1934
(Text-fig. 165)

Steemann Nielsen, 1934, p. 20, fig. 44.
Schiller, 1937, p. 406, fig. 446.
Graham & Broniskovsky, 1944, p. 31, fig. 161.
=*C. bucephalum* Cleve, Peters, 1932, p. 39, pl. 3, fig. 16 *c*.

A species intermediate between *C. bucephalum* and *C. azoricum*. *C. petersii* differs from *C. azoricum* in its coarser structure, larger trans-diameter (50 – 57μ),

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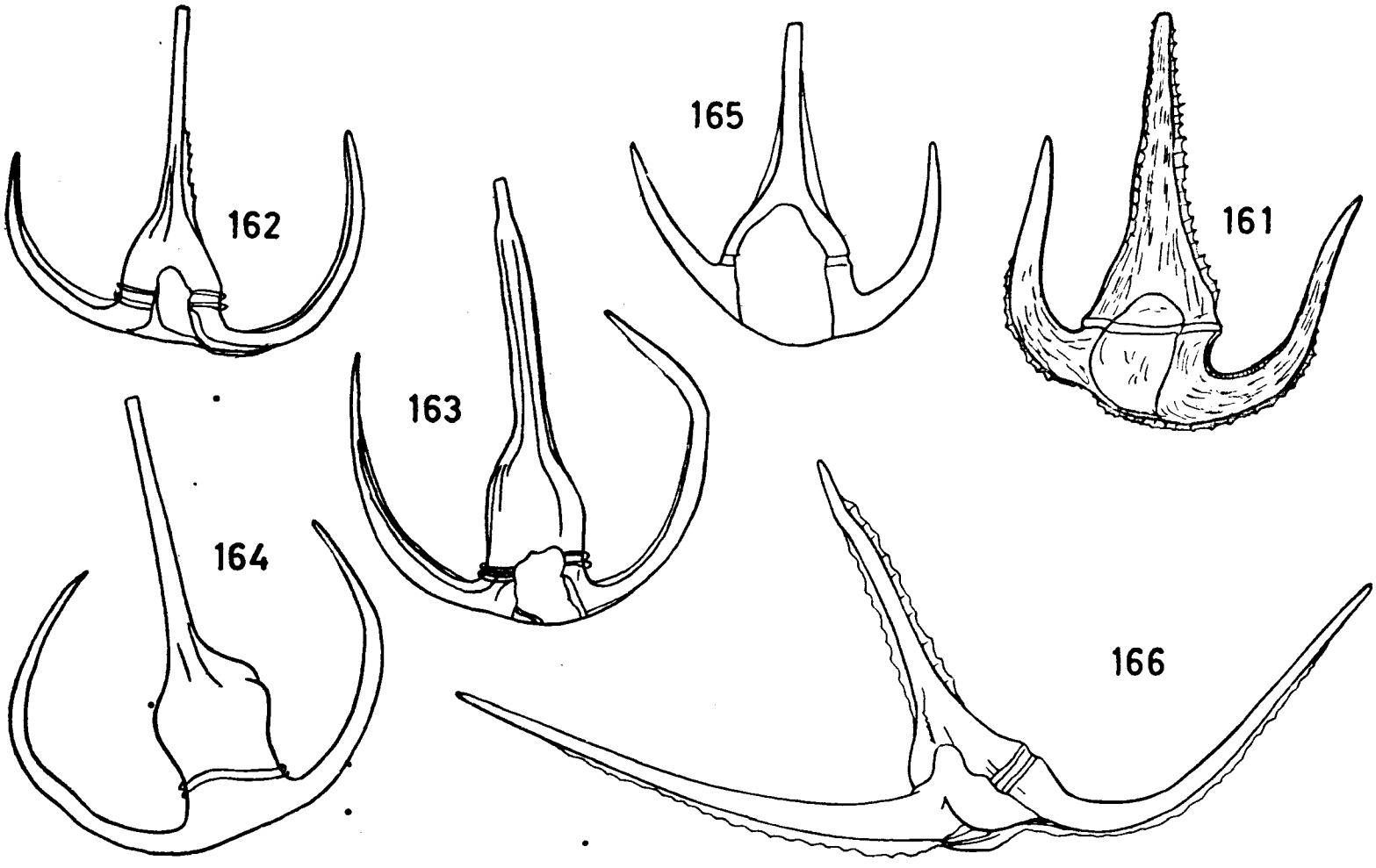
Text-figures 152 – 160. Fig. 152 – *C. lanceolatum* Kofoid; ventral view; (from Schiller, 1937). Figs. 153 & 154 – *C. scapiforme* Kofoid. 153 - dorsal view, 154 - lateral view; (from Steemann Nielsen, 1934). Fig. 155 – *C. pacificum* Wood. Fig 156 – *C. tasmaniae* Wood. (155, 156, after Wood, 1963). Figs. 157, 158 – *C. brachyceros* v. Daday, ventral and dorsal views, (from Schiller, 1937). Fig 159 – *C. cornutum* (Ehrenb.) Clap. *et* Lachm., ventral view; (from Schiller, 1937). Fig. 160 – *C. carolinianum* (Bailey) Jörg.; ventral view, (from Schiller, 1937). (152, x 1050; 153 & 154, x 150; 159, x 375; 160, x 435 Others not known).



Text-figures 161 – 166. Fig. 161 – *C. compressum* Gran. Ventral view; (from Schiller, 1937). Figs. 162, 163, 164–*C. carnegiei* Graham & Broniskovsky. 162 & 163 – ventral views. 164 – dorsal view; (after Graham & Broniskovsky, 1944). Fig 165–*C. petersii* Steemann Nielsen; ventral view; (after Steemann Nielsen, 1934). Fig. 166 – *C. arcticum* (Ehrenb.) Cleve; ventral view; (from Paulsen, 1908). (161 x 390; 165, x 300; 166, x 335. Rest not known).

greater horn spread (120 - 145μ), presence of winged ridges at the base of anterior horn and inner side of posterior horns. It is distinguished from *C. bucephalum* by the clear convex posterior contour. Apical horn is always short. This species has some similarity with *C. symmetricum*.

In the upper 50 m. Pacific Ocean.

Section **MACROCEROS** Pavillard

78. **Ceratium arcticum** (Ehrenb.) Cleve, 1901
(Text-fig. 166)

Cleve, 1901 *b*, p. 207.
Paulsen, 1908, p. 86, fig. 18.
Jörgensen, 1911, p. 85, fig. 181.
Schiller, 1937, p. 412, fig. 453.
= *Peridinium arcticum* Ehrenberg, 1853; Schiller, 1937, p. 412.
= *Ceratium tripos* var. *arctica* Clap. *et* Lachm., 1858; Schiller, 1937, p. 412.
= *C. tripos* var. *labradorica* Schütt, Kent, 1881, p. 454, pl. 24, fig. 36; Cleve, 1897, p. 302, pl. 8, fig. 3; Okamura and Nishikawa, 1904, p. 125, fig. 14.
= *C. labradoricum* Vanhöffen, 1897, pl. 5, fig. 8.

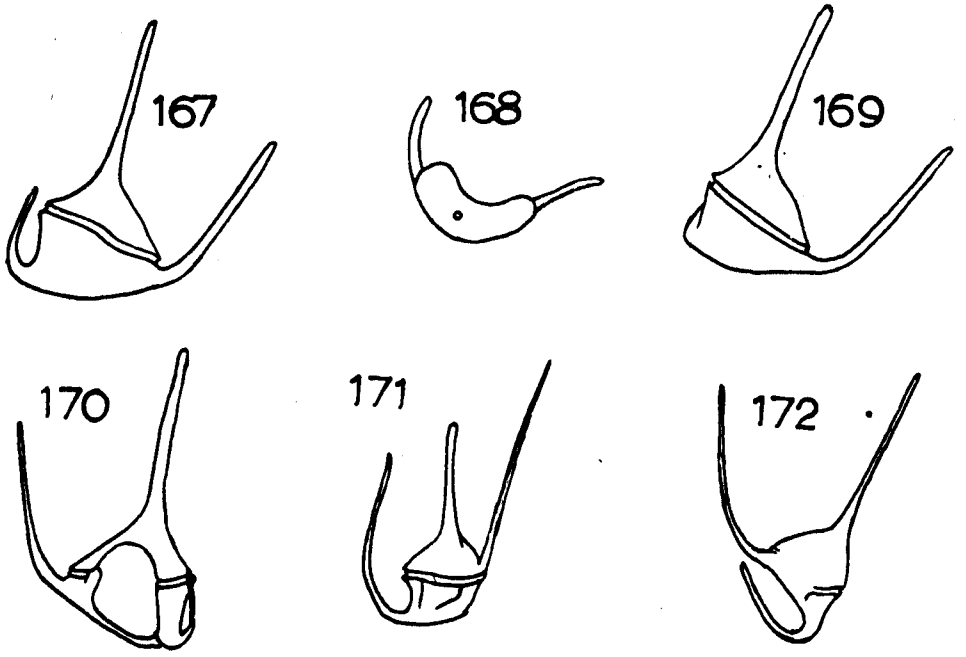
Medium sized species with strongly prominent horn; otherwise like *C. longipes*. Body as broad as long or a little broader. Epitheca with very convex side contour. Hypotheca longer than epitheca, left side contour almost straight, not obliquely placed, but perpendicular to the transverse furrow and approximately parallel with the lower part of the apical horn. Posterior contour somewhat convex, not depressed. The apical horn strongly bent. Left horn at the base inclined towards posterior, uniformly arched; however, rather slightly bent. Right horn arises opproximately across, then at once bent round forwards at a blunt angle, otherwise straight. The three horns diverge strongly. Armour robust, numerous irregularly placed undulated lists present. Along the apical horn and the convex sides of posterior horns usually broad or coarse dentate lists occur. On the posterior contour also some clear marginal winged lists present. t = 51–60μ; h = 40μ; V = 165 –204 μ.

This species is characteristic of the Arctic. East coast of America up to Davis Strait and even farther north; Newfoundland Banks; northern Norwegian Waters. Rarely in the English Channel, Gibralter Straits and Azores at depths; northern Pacific, Japanese waters.

79. * Ceratium egyptiacum Halim, 1963
(Text-figs. 167 – 172)

Halim, 1963, p. 497, figs. 15–18.
=*C. egyptiacum* f. *suezensis* Halim, 1965, p. 174, fig. 1, *4 et 5.*

Body massive, more or less triangular, besides broader than high. The apical horn robust, relatively short, attaining scarcely a length of 1½ times the breadth of the body. Right posterior horn is well formed, longer than apical horn, however, less thick. The left horn, on the contrary, short and slender, exceeds scarcely the transverse furrow; it is curved in ventrally in such a manner that dorsally only the base of the horn is visible. t = upto 77 μ.



Text-figures 167 – 172. *Ceratium egyptiacum* Halim. Fig. 168 – apical view; 170 & 172 – ventral views; rest dorsal views. (167 – 170, after Halim, 1963; 171 & 172, after Halim, 1965; magnification not given).

The orientation of the left posterior horn is a characteristic feature of this species by which the species is easily recognized.

In the Lake Timsah of the Suez Canal.

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* From a recent paper received after the text of the present account was completed. This species comes under Section Tripos.

TABLE I

RECORDS OF SPECIES OF *CERATIUM*

REGION AND REFERENCE CONCERNED (ONLY MAJOR ACCOUNTS CONSIDERED)

Known and acceptable species, varieties and forms of genus CERATIUM	Atlantic Ocean Karsten 1906	Indian Ocean Karsten 1907	North Sea Paulsen 1908	Mediterranean Joergensen 1920	Northern Seas Lebour 1925	South Pacific Steemann Nielsen 1934	Indian Ocean Steemann Nielsen 1939	Pacific & N. Atlantic Graham & Broniskovsky 1944	Russian Waters Kiselev 1950	Australian Waters Wood 1954-1963	West Mediterranean Lopez 1966	South West Indian Ocean Taylor 1966	Indian Waters Present Account
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Genus *Ceratium* Schrank													
1. §*C. arcticum* (Ehr) Cleve			+		+			+	+				
2. *C. arietinum* Cleve	+	+	+	+		+	+	+	+	+	+	+	+
3. **C. axiale* Kofoid		+				+	+	+		+			+
4. *C. azoricum* Cleve	+	+	+	+	+	+	+	+	+	+	+		+
5. *C. belone* Cleve		+		+		+	+	+	+				+
6. *C. bigelowii* Kofoid						+	+	+		+			+
7. §†*C. brachyceros* Daday													
8. *C. breve* (Ostenf. *et* Schmidt) Schröder	+	+				+		+		+		+	+
9. *C. bucephalum* (Cleve) Cleve			+	+	+				+	+			+
10. *C. candelabrum* (Ehrenb.) Stein		+	+	+	+	+	+	+	+	+	+	+	+
11. §*C. carnegiei* Graham & Broniskovsky								+					
12. §†*C. carolinianum* (Bailey) Jörgensen									+				
13. *C. carriense* Gourret	+	+		+		+	+	+		+	+	+	+
14. *C. cephalotum* (Lemm.) Jörg.		+				+	+	+		+		+	+

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15. §*C. compressum* Gran			+		+			+	+	+			
16. **C. conciliens* Jörg.		+		+		+	+	+		+	+	+	+
17.§†*C. contortum* (Gourret) Cleve						+	+	+		+			+
18. *C. cornutum* (Ehrenb) Clap. *et* Lachmann									+				
19. *C. declinatum* Karsten		+		+		+	+	+	+	+	+	+	+
20. **C. deflexum* (Kof.) Jörg.						+	+	+		+			+
21. *C. dens* Ostenf. *et* Schmidt						+	+			+			+
22. *C. digitatum* Schütt		+		+		+	+	+		+		+	+
23. **C. euarcuatum* Jörg.		+		+		+	+	+		+	+		+
24. *C. extensum* (Gourret) Cleve			+	+	+	+	+	+	+	+	+	+	+
25. **C. falcatiforme* Jörg.				+		+	+			+	+	+	+
26. *C. falcatum* (Kof) Jörg.				+		+	+	+		+	+	+	+
27. *C. furca* (Ehr.) Clap. *et* Lachm.	+	+	+	+	+	+	+	+	+	+	+	+	+
28. *C. fusus* (Ehr.) Dujardin	+	+	+	+	+	+	+	+	+	+	+	+	+
29. *C geniculatum* (Lemm.) Cleve		+		+		+	+	+		+		+	+
30. *C. gibberum* Gourret	+	+	+	+	+	+	+	+	+	+	+	+	+
31. *C gravidum* Gourret	+			+		+	+	+	+	+		+	+
32. *C. hexacanthum* Gourret	+	+	+	+	+	+	+	+	+	+	+	+	+
33. *C. hexacanthum* var. *aesturium* (Schröder) Schiller					•								+
34. †*C. hirundinella* (O. F. Müller) Bergh.			+		+				+	+			+
35. *C. horridum* Gran	•	+	+	+	+	+	+	+	+	+	+	+	+
36. *C. humile* Jörg.						+	+	+		+			+
37. *C. incism* (Karsten) Jörg.	+			+		+	+	+		+		• +	+

1	2	3	4	5	6	7	8	9	10	11	12	13	14
38. *C. ramakrishnii* Subrahmanyan													+
39. *C. inflatum* (Kof.) Jörg.		+		+		+	+	+	+	+	+	+	+
40. *C. karstenii* Pavillard	+	+		+		+	+		+	+	+	+	+
41. *C. karstenii* f. *robustum* (Karsten) Jörg.													+
42. *C. kofoidii* Jörg.				+		+	+	+	+	+		+	+
43. §*C. lanceolatum* Kof.						+							
44. *C. limulus* Gourret	+	+		+		+	+	+		+	+	+	+
45. *C. lineatum* (Ehr.) Cleve			+	+	+			+	+	+		+	+
46. *C. longinum* Karsten	+	+							+	+			+
47. *C. longipes* (Bailey) Gran			+		+				+	+			+
48. *C. longirostrum* Gourret				+		+	+	+		+	+	+	+
49. **C. longissimum* (Schröder) Kofoid				+		+	+	+		+			+
50. *C. lunula* Schimper	+			+		+	+	+		+		+	+
51. *C. macroceros* (Ehr.) Cleve		+		+	+	+	+	+	+	+	+	+	+
52. *C. macroceros* var. *gallicum* (Kof.) Jörg.	+		+										+
53. *C. massiliense* (Gourret) Jörg.	+	+		+		+	+	+		+	+	+	+
54. *C. minutum* Jörg.				+	+				+	+		+	+
55. §*C. pacificum* Wood										+			
56. *C. paradoxides* Cleve				+		+	+	+		+		+	+
57. **C. pavillardii* Jörg.				+			+			+			+
58. *C. pentagonum* Gourret	+	+		+		+	+	+	+	+	+	+	+
59. §*C. petersii* Steemann Nielsen						+		+		+	+		
60. *C. platycorne* v. Daday		+	+	+	+	+	+	+	+	+	+	+	+
61. *C. porrectum* Karsten		+								+		+	+

1	2	3	4	5	6	7	8	9	10	11	12	13	14
62. *C. praelongum* (Lemm.) Kof.		+				+	+	+		+			+
63. *C. pulchellum* B. Schröder				+		+	+	+		+		+	+
64. *C. ranipes* Cleve	+	+		+		+	+	+		+	+	+	+
65. **C. reflexum* Cleve		+				+	+	+		+			+
66. §*C. scapiforme* Steemann Nielsen						+							
67. *C. schmidtii* Jörg.						+	+			+	+	+	+
68. *C. schröteri* B. Schröder		+		+						+		+	+
69. *C. setaceum* Jörg.				+		+	+	+		+		+	+
70. *C. symmetricum* Pav.	+	+		+		+	+	+		+	+	+	+
71. §*C. tasmaniae* Wood										+			
72. *C. teres* Kofoid				+		+	+	+		+	+	+	+
73. *C. trichoceros* (Ehr.) Kofoid	+	+		+		+	+			+	+	+	+
74. *C. trichoceros* (Ehr.) Kofoid var. *contrarium* (Gourret) Schiller	+							+					+
75. *C. tripos* (O. F. Müller) Nitzsch	+	+	+	+	+	+	+	+	+	+	+	+	+
76. *C. vultur* Cleve		+				+	+	+		+		+	+
77. **C. vultur* var. *productum* Wood													+
78. *C. vultur* var. *sumatranum* (Karst.) Steemann Nielsen													+
79.***C. egyptiacum* Halim .													

* * Not recorded by author in this region.
** Recent record from Suez.
† Fresh water species.
§ Not recorded from Indian Ocean so far.

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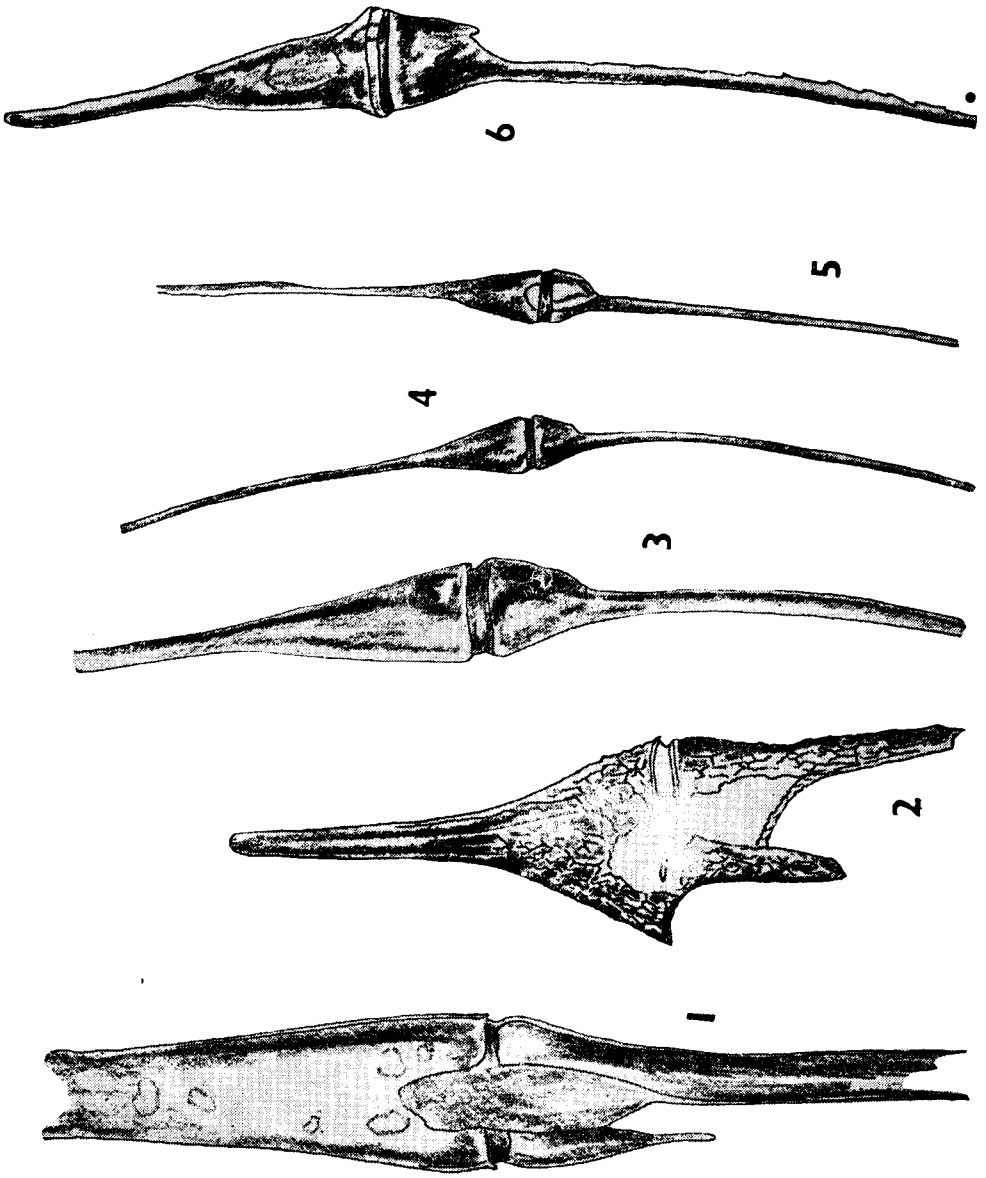
PLATES I – IX

PLATE I

Fig. 1. *Ceratium longirostrum* Gourret
Ventral view; x 760

Fig. 2. *C. hirundinella* (O. F. Müller) Bergh
Ventral view. x 760.

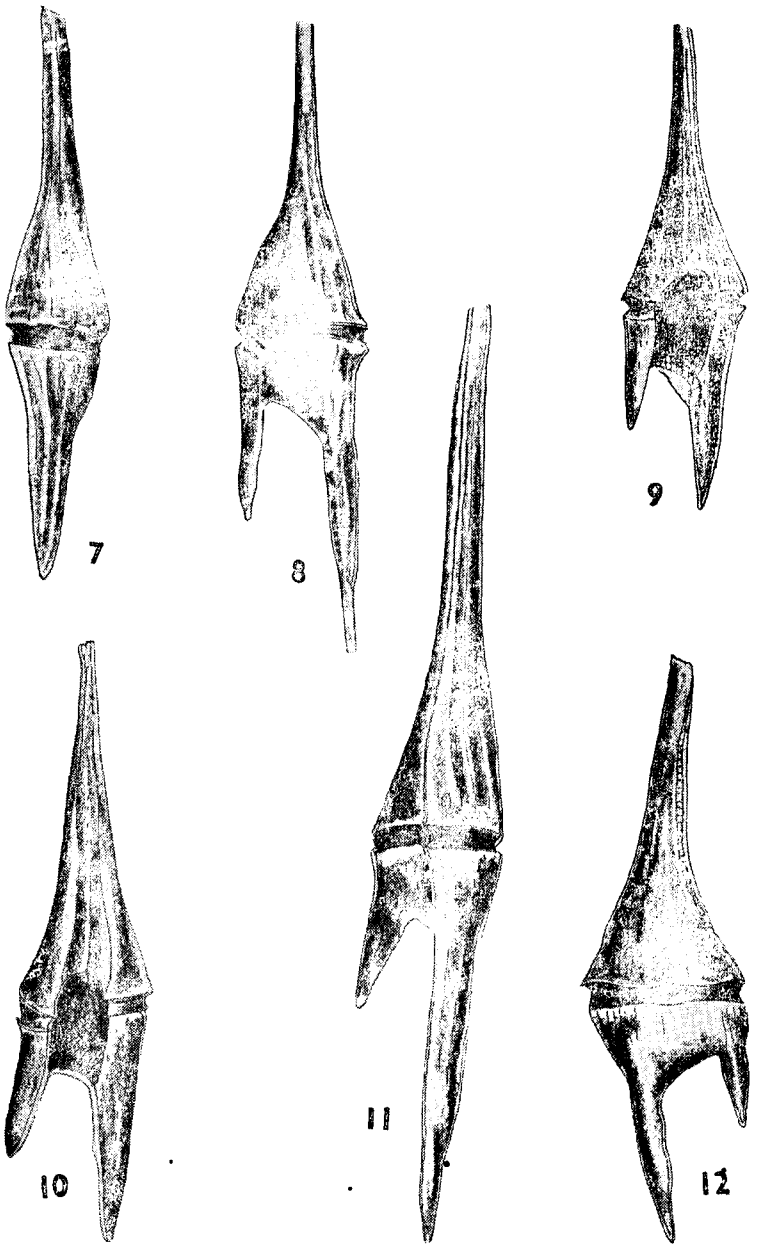
Figs. 3–6. *C. fusus* (Ehrenb) du Jardin
Dorsal views. In 5, the notch is also shown.
Different variations of the species met with.
3 – x 760; rest x 360.



R. Subrahmanyan · On *CERATIUM* Schrank

PLATE II

Figs. 7-12. *Ceratium furca* (Ehrenb.) Claparède *et* Lachmann
Different variations of the species recorded.
7 - lateral view; 12, dorsal view; rest ventral view.
7,8,12 - x 510; 9 - x 420 10 and 11 - x 350.



R. Subrahmanyan - On *CERATIUM* Schrank

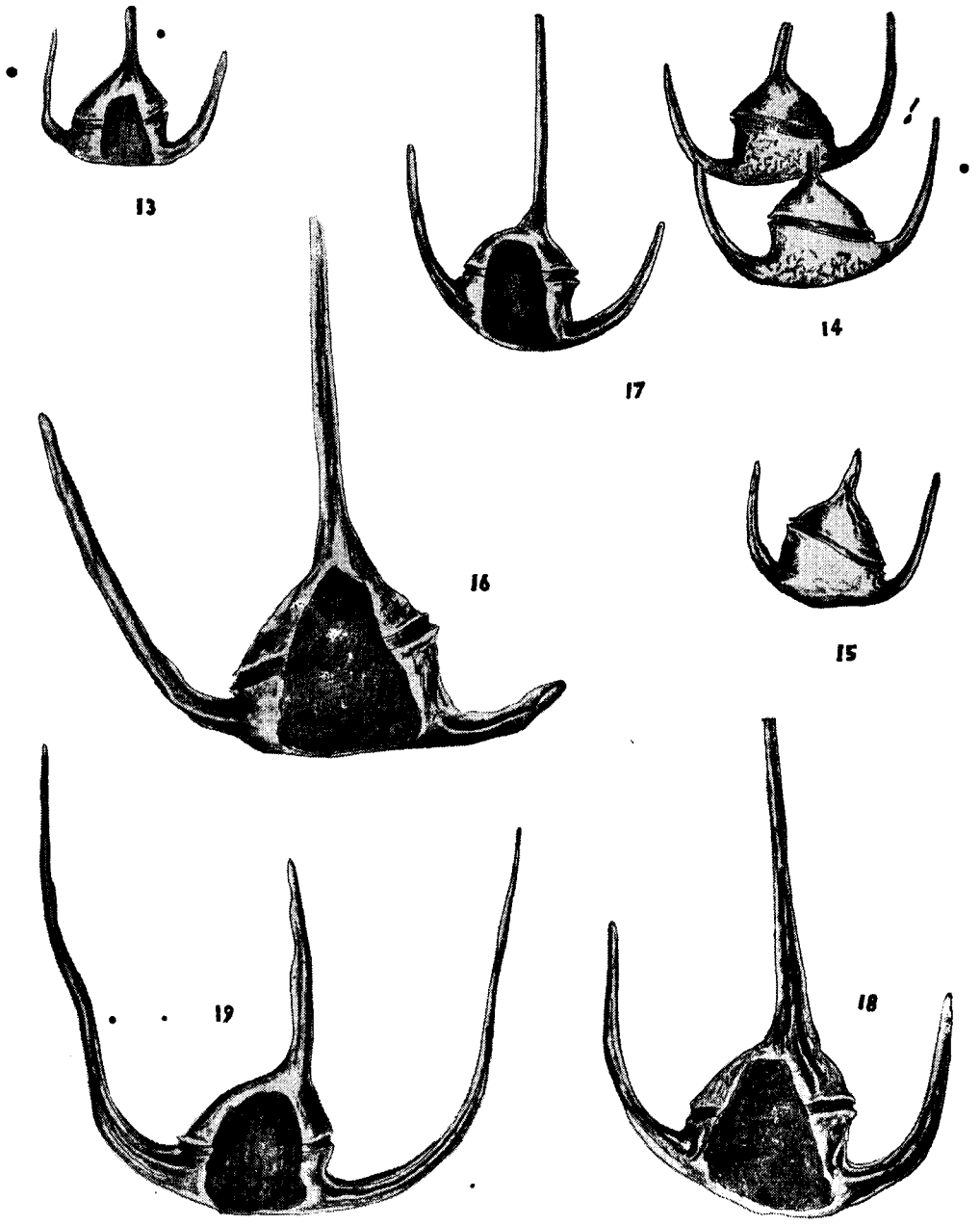
PLATE III

Figs. 13, 14, 15. *Ceratium breve* (Ostenfeld *et* Schmidt) Schröder
13 - ventral view; 14 - dorsal view, chain of two cells.
15 - dorsal view of cell. All x 180.

Fig. 16. *C. dens* Ostenf. *et* Schmidt
Ventral view x 250.

Figs. 17, 18. *C. tripos* (O. F. Müller) Nitzsch
Ventral views. 17 - x 150; 18 - x 200.

Fig. 19. *C. lunula* Schimper
Ventral view. x 150.



R. Subrahmanyan – On *CERATIUM* Schrank

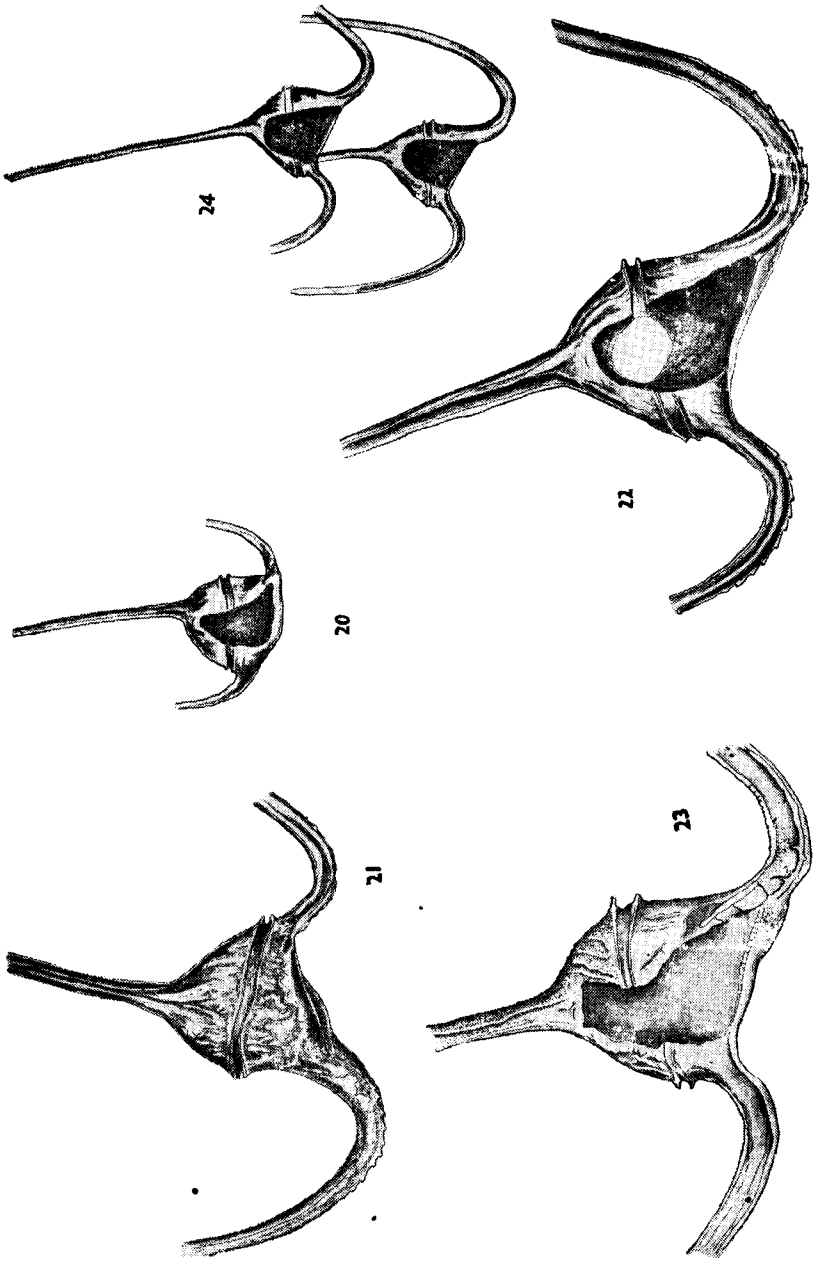
PLATE IV

Fig. 20 *Ceratium declinatum* (Karsten) Schiller
Ventral view, x 160.

Figs. 21-22. *C. longipes* (Bailey) Gran
Dorsal and ventral views.
21 - x 265. 22 - x 360.

Fig. 23. *C. massiliense* (Gourret) Jörgensen
Ventral view, x 335.

Fig. 24 *C. macroceros* (Ehrenberg) Cleve
A chain of 2 cells.
Ventral view, x 160.

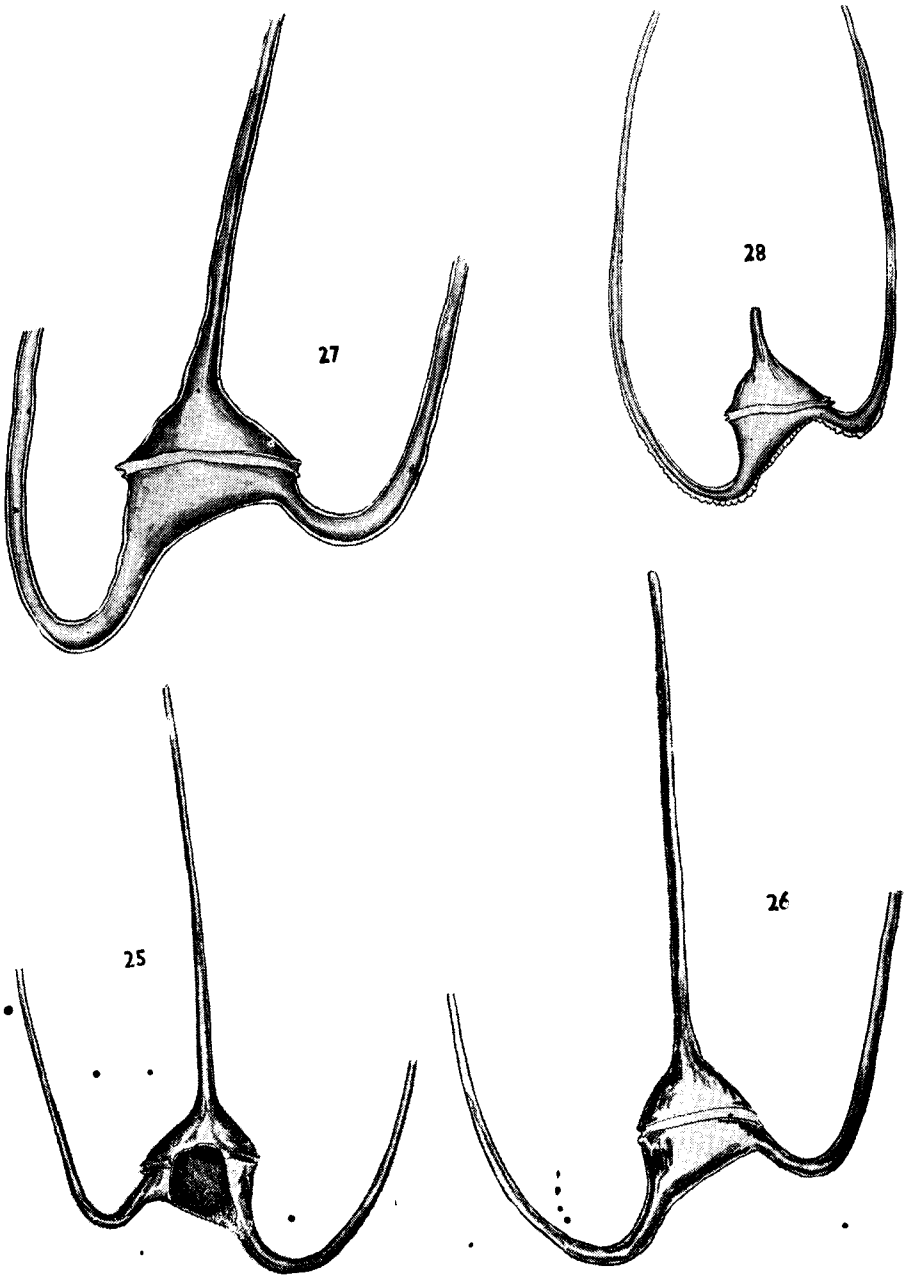


R. Subrahmanyan – On *CERATIUM* Schrank

PLATE V

Figs. 25–26. *Ceratium macroceros* (Ehrenb) Cleve
Ventral and dorsal views x 150.

Figs 27 – 28. *C. vultur* var. *sumatranum* (Karsten) Steemann Nielsen
Dorsal views. 27 – x 250 28 – x 150



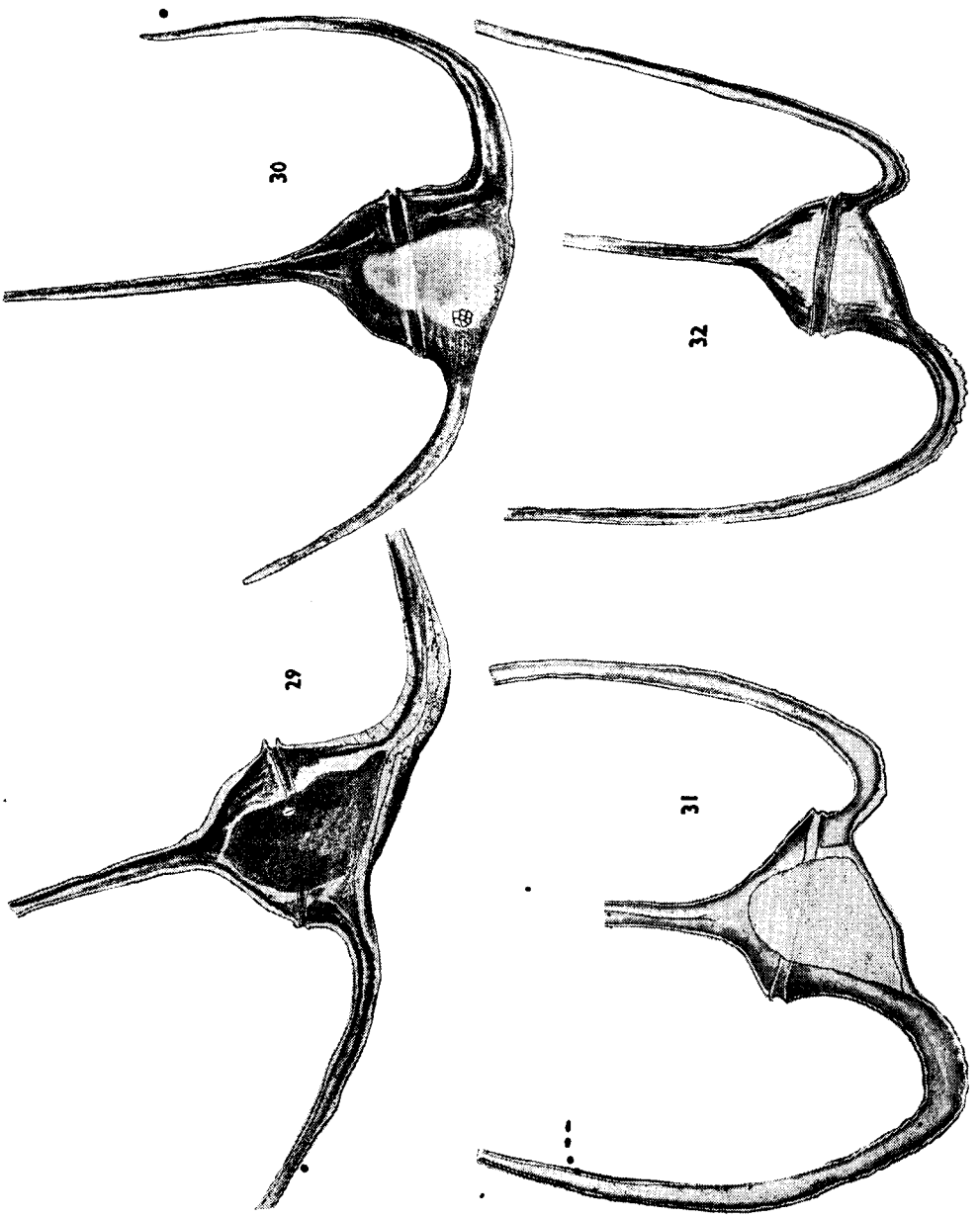
R. Subrahmanyan – On *CERATIUM* Schrank

PLATE VI

Figs. 29–30. *C. macroceros* (Ehrenb.) Cleve
Ventral and dorsal views.
29 – x 200, 30 – x 300.

Fig. 31 *C. vultur* var. *sumatranum* (Karsten) Steemann Nielsen.
Ventral view. x 250.

Fig. 32. *C. hexacanthum* var. *aesturium* (Schröder) Schiller
Ventral view x 300.



R. Subrahmanyan - On *CERATIUM* Schrank

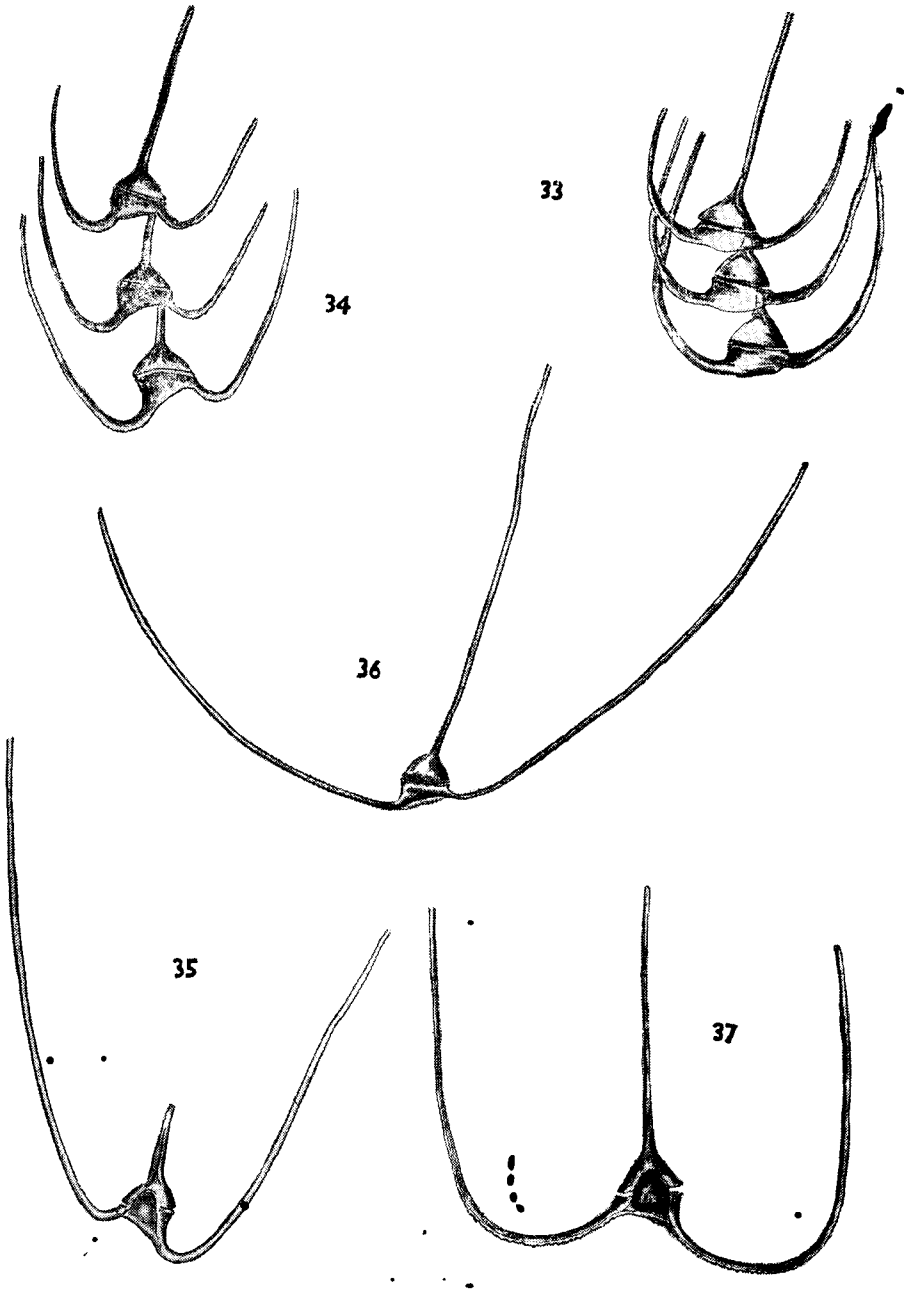
PLATE VII

Fig. 33 *Ceratium lunula* Schimper
Dorsal view, x 85.

Figs. 34-35. *C. massiliense* (Gourret) Jörgensen
34 - Ventral view of a cell, x 150.

Fig. 36. *C. carriense* Gourret
Dorsal view, x 45.

Fig. 37. *C. trichoceros* (Ehrenb.) Kofoid
Ventral view, x 180.



R. Subrahmanyan – On *CERATIUM* Schrank

PLATE VIII

Figs. 38-40. *Ceratium ramakrishnii* n. sp.

38 - Dorsal view of complete cell, x 65.

39 - Dorsal view, portion of cell, x 490.

40 - Ventral view, x 210.

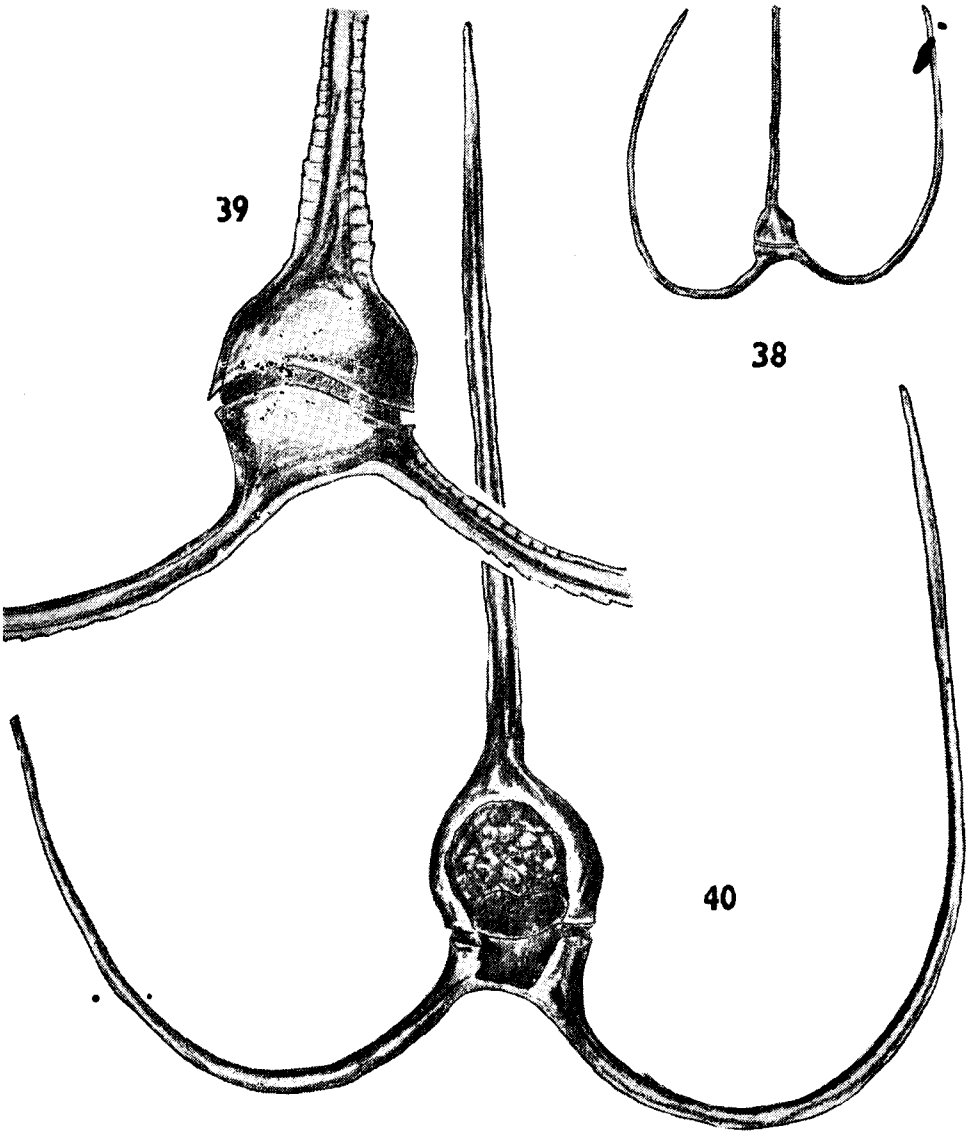


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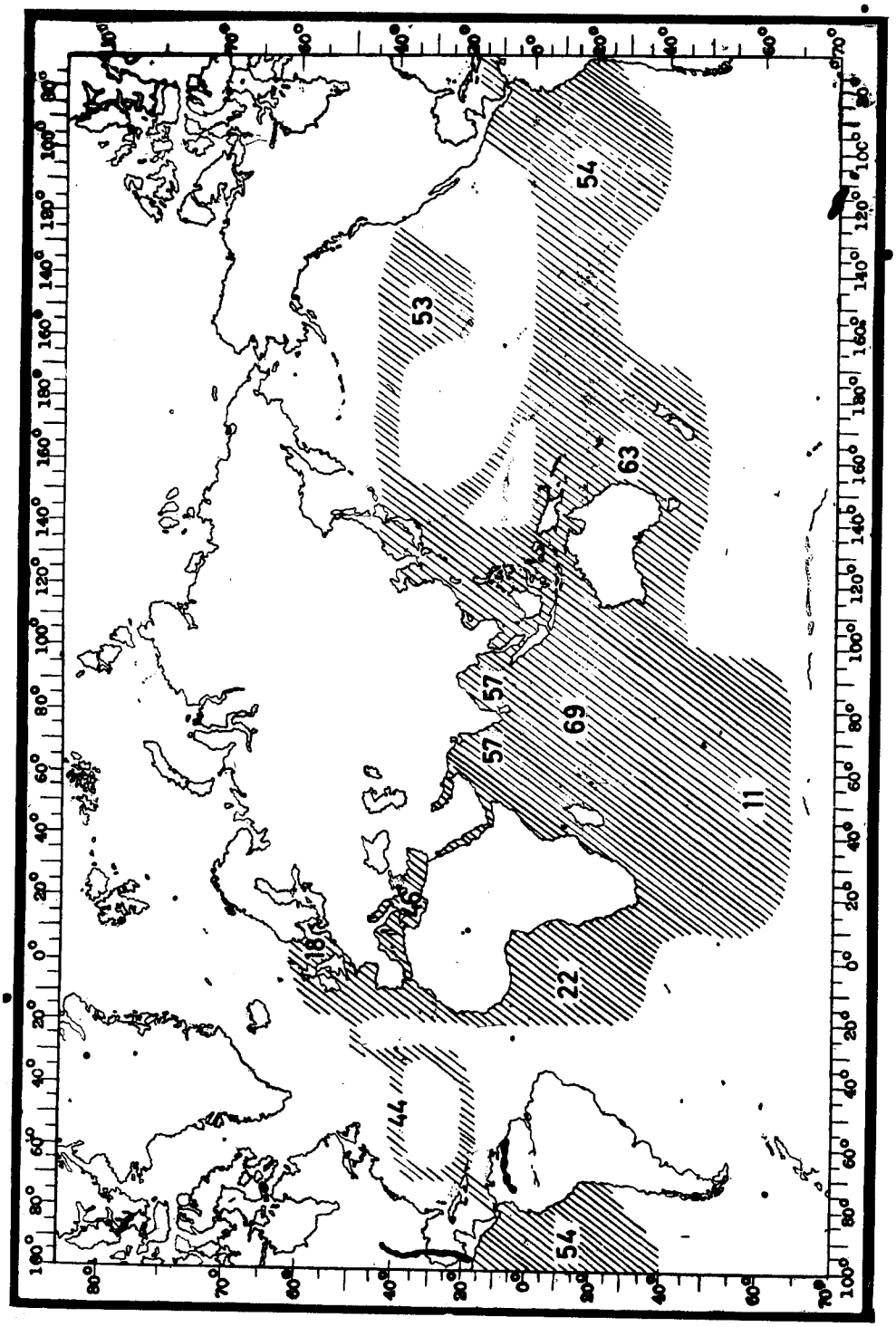
PLATE IX

Known distribution of *Ceratium* species in the different oceans. The hatched portion represents the areas where most of the work has been done. The numbers denote the number of species recorded in the areas.



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INDEX

[Valid species are given in italics and synonyms in roman. Pagination in italics denote where taxa are described and that in bold face where figures are given.]