

SCIENTIFIC RESULTS OF CRUISE VII OF THE CARNEGIE  
DURING 1928-1929

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BIOLOGY—III

STUDIES IN THE MORPHOLOGY,  
TAXONOMY, AND ECOLOGY  
OF THE PERIDINIALES


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HERBERT W. GRAHAM









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DEPARTMENT OF TERRESTRIAL MAGNETISM  
J. A. Fleming, Director

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Scientific Results of Cruise VII of the CARNEGIE during 1928-1929  
under Command of Captain J. P. Ault

BIOLOGY—III

Studies in the Morphology, Taxonomy,  
and Ecology of the Peridiniales

HERBERT W. GRAHAM



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## P R E F A C E

Of the 110,000 nautical miles planned for the seventh cruise of the nonmagnetic ship Carnegie of the Carnegie Institution of Washington, nearly one-half had been completed upon her arrival at Apia, November 28, 1929. The extensive program of observation in terrestrial magnetism, terrestrial electricity, chemical oceanography, physical oceanography, marine biology, and marine meteorology was being carried out in virtually every detail. Practical techniques and instrumental appliances for oceanographic work on a sailing vessel had been most successfully developed by Captain J. P. Ault, master and chief of the scientific personnel, and his colleagues. The high standards established under the energetic and resourceful leadership of Dr. Louis A. Bauer and his co-workers were maintained, and the achievements which had marked the previous work of the Carnegie extended.

But this cruise was tragically the last of the seven great adventures represented by the world cruises of the vessel. Early in the afternoon of November 29, 1929, while she was in the harbor at Apia completing the storage of 2000 gallons of gasoline, there was an explosion as a result of which Captain Ault and cabin boy Anthony Kolar lost their lives, five officers and seamen were injured, and the vessel with all her equipment was destroyed.

In 376 days at sea nearly 45,000 nautical miles had been covered (see map on p. v). In addition to the extensive magnetic and atmospheric-electric observations, a great number of data and marine collections had been obtained in the fields of chemistry, physics, and biology, including bottom samples and depth determinations. These observations were made at 162 stations, at an average distance apart of 300 nautical miles. The distribution of these stations is shown in map, which delineates also the course followed by the vessel from Washington, May 1, 1928, to Apia, November 28, 1929. At each station, salinities and temperatures were obtained at depths of 0, 5, 25, 50, 75, 100, 200, 300, 400, 500, 700, 1000, 1500, etc., meters, down to the bottom or to a maximum of 6000 meters, and complete physical and chemical determinations were made. Biological samples to the number of 1014 were obtained both by net and by pump, usually at 0, 50, and 100 meters. Numerous physical and chemical data were obtained at the surface. Sonic depths were determined at 1500 points and bottom samples were obtained at 87 points. Since, in accordance with the established policy of the Department of Terrestrial Magnetism, all observational data and materials were forwarded regularly to Washington from each port of call, the records of only one observation were lost with the ship, namely, a depth determination on the short leg from Pago Pago and Apia.

The compilations of, and reports on, the scientific results obtained during this last cruise of the Carnegie are being published under the classifications Physical Oceanography, Chemical Oceanography, Meteorology, and Biology, in a series numbered, under each subject I, II, III, etc.

A general account of the expedition has been prepared and published by J. Harland Paul, ship's surgeon and observer, under the title The last cruise of the Carnegie, and contains a brief chapter on the previous cruises of the Carnegie, a description of the vessel and her equipment, and a full narrative of the cruise (Baltimore, Williams and Wilkins Company, 1932; xiii + 331 pages with

198 illustrations).

The preparations for, and the realization of, the program would have been impossible without the generous cooperation, expert advice, and contributions of special equipment and books received on all sides from interested organizations and investigators both in America and in Europe. Among these, the Carnegie Institution of Washington is indebted to the following: the United States Navy Department, including particularly its Hydrographic Office and Naval Research Laboratory; the Signal Corps and the Air Corps of the War Department; the National Museum, the Bureau of Fisheries, the Weather Bureau, the Coast Guard, and the Coast and Geodetic Survey; the Scripps Institution of Oceanography of the University of California; the Museum of Comparative Zoölogy of Harvard University; the School of Geography of Clark University; the American Radio Relay League; the Geophysical Institute, Bergen, Norway; the Marine Biological Association of the United Kingdom, Plymouth, England; the German Atlantic Expedition of the Meteor, Institut für Meereskunde, Berlin, Germany; the British Admiralty, London, England; the Carlsberg Laboratorium, Bureau International pour l'Exploration de la Mer, and Laboratoire Hydrographique, Copenhagen, Denmark; and many others. Dr. H. U. Sverdrup, now Director of the Scripps Institution of Oceanography of the University of California, at La Jolla, California, who was then a Research Associate of the Carnegie Institution of Washington at the Geophysical Institute at Bergen, Norway, was consulting oceanographer and physicist.

In summarizing an enterprise such as the magnetic, electric, and oceanographic surveys of the Carnegie and of her predecessor the Galilee, which covered a quarter of a century, and which required cooperative effort and unselfish interest on the part of many skilled scientists, it is impossible to allocate full and appropriate credit. Captain W. J. Peters laid the broad foundation of the work during the early cruises of both vessels, and Captain J. P. Ault, who had had the good fortune to serve under him, continued and developed that which Captain Peters had so well begun. The original plan of the work was envisioned by L. A. Bauer, the first Director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington; the development of suitable methods and apparatus was the result of the painstaking efforts of his co-workers at Washington. Truly, as was stated by Captain Ault in an address during the commemorative exercises held on board the Carnegie in San Francisco, August 26, 1929, "The story of individual endeavor and enterprise, of invention and accomplishment, cannot be told."

Dr. H. W. Graham, who succeeded H. R. Seiwell as chemist and biologist, had charge of the biological work on board the Carnegie from August, 1929, until the loss of the vessel at Apia, Samoa. After his return to this country, Dr. Graham was placed in charge of the biological collections, attending to their subsequent care, segregation, and distribution to various specialists for examination and report, he himself undertaking the not inconsiderable task of reporting upon the Peridineae (Dinoflagellata).

Except for the Family Ceratocoryaceae (consisting of one genus, seven species) and the Family Goniodomaceae (one monotypic genus), which have been more or less monographically treated in their entirety, this paper



is but preliminary to a report on the Peridinales collected during the last cruise of the Carnegie. Otherwise, only certain species of three other families (Peridiniaceae, Gonyaulaceae, Ceratiaceae) of the fourteen families into which the order is subdivided are dealt with. However, Dr. Graham's studies are of fundamental importance to any adequate understanding of the structure and relationships of the species and higher categories of the Peridinales. These studies were undertaken with that particular purpose in mind. His discussion of the selected species is well illustrated and gratifyingly complete.

Further details regarding the procedure followed in making the tow-net hauls at the various oceanographic stations are given in the first volume of the Biological Reports of this series, "The copepods of the plankton gathered during the last cruise of the Carnegie," by Charles Branch Wilson (1942).

This manuscript was completed by Dr. Graham in 1938. Thus some papers printed since then are not considered.

J. A. Fleming  
Director, Department of Terrestrial Magnetism



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# STUDIES IN THE MORPHOLOGY, TAXONOMY, AND ECOLOGY OF THE PERIDINIALES

By Herbert William Graham

## Abstract

Although the Peridineae (Dinoflagellata) have been rather extensively studied, there is still very little known about many aspects of this interesting group of the Protista. The purpose of this paper is to contribute to our knowledge of the morphology, taxonomy, and ecology of this group.

It was the author's privilege to have the opportunity to study the Peridineae of the plankton samples collected on the last world cruise of the nonmagnetic research vessel Carnegie of the Department of Terrestrial Magnetism, Carnegie Institution of Washington. The extensive nature of this collection not only permitted a detailed taxonomic analysis of a large variety of species, but also afforded a good opportunity to make a study of the geographic distribution of these forms throughout the Pacific and North Atlantic oceans, based on comparable material. The simultaneous collecting of biological samples and hydrographic data also offered a rare opportunity to correlate the established distributions with oceanographic conditions.

The present paper deals with twenty-nine representatives of the order Peridinales. They are distributed among the families of the order as follows: one in Goniodomaceae; seven in Ceratocoryaceae; four in Gonyaulacaceae; sixteen in Peridiniaceae; and one in Ceratiaceae. They include six new species, three new varieties, and six new forms. Two old specific names were replaced and one subgenus raised to the rank of genus. A monographic treatment was given all the species (seven) of the family Ceratocoryaceae.

The species selected were subjected to a morphological analysis with the following objects in mind: (1) to establish a standard for the analysis and recording of the skeletal features of peridinian species; (2) to acquire a knowledge of the detailed skeletal morphology of certain species; (3) to study variation within the group by subjecting a few forms to intensive analysis; and (4) to contribute to the concepts of the relationships of the genera of the peridinales. In addition to this morphological and taxonomic treatment, each species was studied from the standpoint of geographic distribution and relationships to the following hydrographic conditions: temperature, salinity, hydrogen-ion concentration, and phosphate content.

Much of the confusion among systematists in the past regarding the Peridineae has been due to inadequate descriptions and figures. Since type specimens of peridinales usually cannot be preserved, it is imperative that the descriptions and figures of the species be not only complete but standard in nature so that adequate comparisons with other material can be made. Standard methods of measurement and of expression of body shape were introduced in the case of each genus studied.

The skeletal features of the forms treated were very carefully analyzed by microdissection. Particular attention was given the ventral area, a region of the theca of the Peridinales which was almost unknown before these investigations. A great diversity in the structure of the ventral areas of the various genera was found, although a common basic plan was evident. The

area is composed of from five to seven external plates and, sometimes, one internal plate. A nomenclature was devised for these plates which would serve to identify them and at the same time express homologies.

In some families of the Peridineae, species are well defined and there is comparatively little difficulty in determining them. In other groups, however, specific variability is so striking that no investigator has yet attempted a comprehensive taxonomic treatment. In the Peridiniaceae, for instance, the plate pattern is so variable that it cannot be successfully used for the differentiation of genera, and the body shape so variable that all attempts at specific segregation have failed. For this reason, a statistical method was applied to certain representatives of Peridinium in order to determine its efficacy in the delimitation of species. A large number of specimens was measured; the body shapes were expressed numerically; and the frequency of the various shapes was plotted. By this method groupings were obtained which indicated the delimitation of species and at the same time demonstrated the range of variation of each species.

On the basis of the comparative study of the ventral areas of the various genera it was concluded that Goniodoma is the most primitive genus; that Ceratocorys is closely related to Goniodoma but somewhat more advanced; that Gonyaulax, Acanthogonyaulax, and Spiraulax are decidedly more advanced and in addition are closely related to each other; and that the genera Peridinium and Ceratium are highly specialized and, although related, are developed along divergent lines. The comparisons of the girdle, hypotheca, and epithecal plates of these genera corroborate the conclusions arrived at from the study of the ventral area itself although these results could not have been obtained by the study of these last series of plates alone.

Some of the marine peridinales are useful in tracing the movements of oceanic water masses. The distributions of the species treated in this report were examined in relation to hydrographic conditions in order to ascertain the value of each species as an oceanographic "indicator." Of the species treated, Ceratocorys horrida and Goniodoma polyedricum were found to be the most valuable indicators of hydrographic conditions. Their distributions are closely correlated with the temperature of the water and the species are sufficiently common to make negative records of occurrence significant.

Ceratocorys horrida was found throughout the tropics and warm-temperate regions. Its limits of distribution were sharply marked and these limits coincided with the 19° C isotherm. Thus, in an intensive oceanographic investigation, an occasional record of this species in water with temperature less than 19° would indicate an intrusion of tropical water or of water mixed with water of tropical origin.

Goniodoma polyedricum, on the other hand, is a very common tropical species which can endure transfer into regions of much cooler water. It occurred at practically all the Carnegie tropical stations (where the temperatures ranged from 20° to 30° C). It was carried into

water with temperatures as low as 15° and 16° C off Japan, off California, and in the southeastern Pacific. In the Atlantic it was found near the British Isles in water with temperatures as low as 12° C. It was undoubtedly carried there in the North Atlantic West Wind Drift. Thus, this species is an excellent indicator of the intrusions of tropical water masses.

It was a notable fact that while the temperature conditions appeared to regulate the distribution of many species, no correlations could be found between the chemical composition of the water and these distributions. The most striking result obtained in regard to the relation between the chemical conditions and specific distributions was that some photosynthetic species

thrive equally well in water extremely poor in phosphate and in richer waters. The upper levels of vast areas of the middle North Pacific are practically devoid of phosphate. The concentration of phosphate ion is less than 10 mg/m<sup>3</sup>, i.e., less than 10 parts of phosphate per billion parts of water. In the case of many species studied, this area of low nutrient content was not in any measure a barrier to distribution. Thus, it is apparent that these species of peridinians can utilize extremely low concentrations of nutrient salts. This phenomenon is undoubtedly correlated with the normal seasonal appearance of peridinians following the diatom outbursts of northern waters during the spring and fall.

## INTRODUCTION

In 1928 the Department of Terrestrial Magnetism of the Carnegie Institution of Washington sent out its nonmagnetic ship Carnegie on a world cruise of all the major oceans exclusive of the Arctic. In addition to the investigations of earth magnetism there was conducted a program of oceanographic investigations. This program included the collection of plankton samples and the determination of hydrographic conditions at regular intervals. Unfortunately, the cruise was brought to an untimely end by the destruction of the vessel before it had visited the Indian and Antarctic oceans. However, 162 stations were occupied over extensive areas of the Pacific and North Atlantic oceans. In 1929 the author was placed in charge of the biological work on board, and at the termination of the cruise he was given charge of the biological collections.

The extensive nature of the collections permitted, not only a detailed taxonomic analysis, but also a study of geographic distribution based on comparable material. The simultaneous collecting of biological samples and hydrographic data also offered a rare opportunity to study the relations between the pelagic organisms and their environmental conditions.

After certain general quantitative studies of the plankton were made, a study was begun which would lead to a general knowledge of the plankton communities in the various regions and to a knowledge of the relation of the individual planktons to each other and to environmental conditions. As a foundation for this it was necessary first to compile lists of the species occurring at each station.

As a preliminary to this program the organisms in the samples were sorted according to groups and each group was submitted to a systematist for identification and analysis. The author selected the Peridineae (Dinoflagellata) for his own special study.

These introductory remarks have been made in order to give some idea of the origin of the material and of the general scientific inquiry of which this report forms a part. The discussion that follows is restricted entirely to the peridinians.

It was originally planned to make a comprehensive study of this group in the Carnegie collection mainly from the standpoint of geographic distribution and ecology. A floristic treatment, naturally, would be the founda-

tion for such a study. The analysis, however, was not far advanced before it was realized that no thorough and certain floristic treatment of the Peridineae was possible in the present state of the taxonomy of the group. It was found that not a single genus of the group was covered by an exhaustive monograph which would enable one to make identifications of the species with any degree of certainty. As a consequence, the floristic analysis had to be preceded by a thoroughgoing taxonomic study.

The present paper deals with a small part of the peridinium problem of the Carnegie material. It pertains to certain forms of the order Peridiniales which were selected for study and subjected to a careful morphological analysis with the three following objects in mind: (1) to establish a standard for the analysis and the recording of the morphology of peridinium species; (2) to acquire a knowledge of the detailed skeletal morphology of some of the species; (3) to study variation within the group by subjecting a few forms to intensive analysis; and (4) to contribute to the concepts of the relationships of the genera of the Peridiniales.

The Carnegie material afforded interesting comparative material because it contained not only rare tropical forms, but also temperate and subpolar material from widely separated regions.

Assistance in the routine census of the samples and in the preparation of preliminary camera lucida sketches was given by Mrs. N. Bronikovsky. Most of the finished ink drawings and wash drawings were executed by Mr. Charles A. Dawson. The investigations were carried out at the Hopkins Marine Station, Pacific Grove, California through the courtesy of Dr. W. K. Fisher, Director. Valuable critical advice was received throughout the investigations from Dr. Tage Skogsberg, under whose direction the work progressed. The pursuance of the investigations was made possible through the good offices of Dr. J. A. Fleming, Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, who has been in charge of the oceanographic program of the Carnegie and who has lent his continuous interest and support to the biological work. To all these I wish to express my deep appreciation for their sympathetic assistance in the furtherance of the work.



## GENERAL DISCUSSION

### MATERIAL AND METHODS

During the Carnegie expedition 162 "oceanographic stations" and 69 "surface plankton stations" were occupied. The collecting program at each "oceanographic station" included the towing of a 1 meter plankton net at the surface, and of 1/2 meter nets at 50- and 100-meter depths. The upper half of the nets was constructed of no. 10, the lower half of no. 15 silk bolting cloth. The nets were towed for 1 hour. At the "oceanographic stations," from station 11 on, duplicate quantitative samples were taken with a Pettersson plankton pump. At the "surface plankton stations" various types of silk nets were used depending on the speed of the vessel, and they were towed for different lengths of time.

Only open nets were used. This introduced a possibility of error in the census of the subsurface samples. This error, however, was not great as the length of time the nets were towed at their respective depths (1 hour) was so much greater than the length of time required for raising the net (about 2 minutes). Thus, unless there was a very pronounced density of population in an upper stratum, the proportion of upper-level organisms to the standard-level organisms would be very low. The comparison of the hauls from the three levels would reveal this.

It should be noted that all collections outside the tropics were made in the summer time. The cruise was planned so that the vessel would be in the higher latitudes of each hemisphere in its respective summer in order to avoid too rough weather. For that reason, the distributional records show no winter records outside the tropics.

The plankton samples were preserved and stored in formalin. In the laboratory the peridinium material was treated with a solution of hypochlorite, from 10 to 50 per cent, according to the nature of the material as established by experience. This reagent was applied in order to dissolve the cell contents and to weaken the thecal sutures so that the plates could be readily separated. In some instances it caused a swelling of the protoplast followed by premature rupture of the theca. For this reason, drawings were made of the specimen in various views with as much detail as could be made out before the hypochlorite treatment. In cases where there was ample material, portions of unsorted sample were given the hypochlorite treatment, but where the material was rare, single specimens were transferred with a micropipette.

After the treatment with hypochlorite for a varying length of time, depending on the material, the specimens were washed in water and, in some cases, stained with trypan blue. Specimens with oil droplets, such as Peridinium depressum, were cleared with xylol in order to dissolve the oil, which interfered with proper staining. The specimen thus treated for study was transferred to a warm flat drop of glycerin jelly by means of a micropipette and examined without a cover glass. In this medium the specimen could be oriented to any desired position, and, after the jelly cooled to room temperature

and hardened, the specimen was in a solid medium and a camera lucida drawing could be made. After observation and drawing in one view, the jelly could be melted and the specimen reoriented any number of times. The glycerin jelly was softened by placing it on a warming table heated to a temperature of 50° C. During periods of warming, the drop was covered with a small damp chamber to prevent undue evaporation of water and consequent troublesome thickening of the jelly. The specimen was manipulated by means of a micro-needle prepared by mounting a piece of spun glass from a glass-wool filter on the end of an ordinary dissecting needle. The glass hair projected about 3 millimeters beyond the point of the steel needle. As it became clogged with jelly, it was trimmed with scissors until about 1 millimeter long, when it was replaced.

The melting point of the glycerin jelly can be controlled by varying the water content. All the water was never allowed to evaporate on the warming table, however, as the jelly then had a tendency to become sticky even though more water was added. The solution of jelly kept on the warming table for the preparation of slides was at all times covered, and water was added occasionally to compensate for evaporation.

This method proved satisfactory for studying the specimens in various positions without injuring them. It is impossible to orient some material, for instance Peridinium depressum, by rolling a specimen in a water mount under a cover glass, because of the unbalanced nature of the theca in all but four positions, none of which is particularly desirable for descriptive purposes. The above method also afforded a satisfactory means of dissecting. A specimen which has been properly cleaned in hypochlorite will begin to break apart in a glycerin-jelly mount when pressure is applied with the glass hair or when it is gently touched with a fine steel needle. When the plates have begun to separate, an individual plate or group of plates may be selected and oriented to any desired position by stroking the surrounding jelly with the glass hair, without danger of crushing or losing the rest of the specimen. For the examination of details like pores, when it is necessary to use an oil-immersion objective, it is usually advisable to mount under a cover glass in glycerin jelly, water, or balsam.

All drawings were made with the aid of a camera lucida. In some cases they were later enlarged to facilitate shading.

Owing to the pronounced asymmetry of the body of some of the forms, they presented quite different profiles in different positions. Thus, the measurement of any contour may vary considerably even though the position of the body is changed but slightly. For this reason it is necessary to adopt standard positions for making measurements. In the present work the ventral view has been adopted for the principal standard position. There is some difficulty in determining the "ventral view" in some of the more asymmetrical forms, particularly in species of Peridinium with long horns. In such

forms it is necessary to bear in mind that the ventral view should be at right angles to the longitudinal axis, which axis is defined as the line running through the apical horn and bisecting the hypotheca midway between the bases of the antapical horns. It must be remembered that when a specimen comes to rest at the bottom of a drop of mounting fluid it does not present this view. When a specimen of *Peridinium depressum* comes to rest with ventral side uppermost, it presents an antero-ventral aspect, resting on the dorsal side of the girdle and on the two antapical horns. This position should not be used as the standard in measuring, since considerable variation in the optical projection of the body is caused by slight differences in the length or divergence of the antapical horns on which the organism rests. It is necessary to mount in glycerin jelly or similar medium in order to orient the specimen in the proper manner and arrange it in a proper position.

As defined in this work, the ventral view is the one in which the sulcus lies midway between the lateral sides of the body and in which the dorsal part of the girdle can be superimposed on the anterior end of the sulcus when the microscope is focused downward.

Because of the very great differences in the shapes of the various genera of the Peridinales, it is not always possible or desirable to make the same measurements

on all forms. There are particular dimensions which are significant in each genus. A description of these measurements and the method of making them will be given in the introduction to each genus.

The question of nomenclature always arises in the treatment of this group of organisms. The group has been studied by both botanists and zoologists, each using the nomenclature of his particular school. It seems futile to discuss the question whether the members of this group are plants or animals. They cannot be placed unreservedly in either the plant or the animal kingdom. We can only discuss their relative similarities to each of these kingdoms. Since one is forced to adopt either plant or animal nomenclature, it is only reasonable that the nomenclature should fit the views of the author. This author believes that the plant characteristics of the peridinians outweigh the animal. Hence, botanical nomenclature is used in this report. Many of the peridinians are photosynthetic and practically all show some signs of a cellulose-like substance in their body wall (Allmann, 1855; Klebs, 1883; Schütt, 1895; Mangin, 1907, 1908). The discovery of two filamentous algae with *Gymnodinium* spores by Pascher (1914) supports the interpretation of these forms as plants, but the discovery of an amoeba with similar spores (Pascher, 1915) tends to outweigh this discovery.

#### SURVEY OF THE ORDER PERIDINIALES

##### General Statements

The Peridineae, or Dinoflagellata, are subdivided into two main groups: the Adiniferae and the Diniferae, the former without, the latter with a girdle, i.e., a body-encircling transverse groove in which the transverse flagellum is lodged. Diniferae are divided into seven orders, one of which is the Peridinales, to which the material of this thesis belongs.

The Peridinales may be characterized briefly by the following features: The body is surrounded by a theca, which is made up of definite polygonal plates (except in prevalvate stages of Glenodiniaceae) of unequal sizes and not arranged in a bilaterally symmetrical manner. These features, especially the last one, separate the Peridinales from the Dinophysiales, which is the remaining large order with thecate and plated body, and in which the theca is divided longitudinally into right and left valves.

The most recent synopsis of the Peridineae which includes the Peridinales is that of Lindemann (1928) in Engler and Prantl's Pflanzenfamilien. Kofoid, who worked extensively on the Peridineae, never treated this order as a whole. Schiller's synopsis of the Dinoflagellata (1931 to 1933) still lacks the part on the Peridinales.

##### Families

Lindemann (1928) divided the order into fourteen families. Instead of giving abbreviated diagnoses of these, a condensation of Lindemann's key for distinguishing these families is given below in order to offer a brief survey of the order.

##### Key to the Families of the Peridinales (Lindemann, 1928, p.79)

- A. Shell tough-skinned; composed of unequally sized, indistinct, major polygons, not visible in young stages . . . . . Glenodiniaceae
- A. Shell consists of more or less heavy armor composed of dissimilar polygonal plates which are evident in young stages . . . . . B
- B. Girdle indistinctly developed as a narrow band . . . . . Podolampaceae
- B. Cell with very distinct girdle . . . . . C
- C. Cell in apical view quite or nearly circular; epitheca distinctly smaller than hypotheca, flat, lid-shaped. Either there are spinelike processes with a central axis which extend in different directions (each about as long as the body), or the antapical pole carries 2 to 3 strong spines . . . . . D
- C. Cell of other shapes; there are frequently processes or spines but these are never so long as the body nor with a central axis . . . . . E
- D. Processes or spines only on the hypotheca . . . . . Ceratocoryaceae
- D. Both epitheca and hypotheca carry long processes . . . . . Cladopyxiaceae
- E. Girdle equatorial or anterior; only one plate at the antapex, which terminates in a horn or spine . . . . . Oxytoxaceae
- E. Commonly at least two antapicals, or one antapical and one posterior intercalary; rarely one antapical, in which case there is no end spine or point . . . . . F
- F. Cell strongly flattened anteroposteriorly; antapicals none or more than two . . . . . G
- F. Cell otherwise shaped . . . . . H
- G. Antapical plates absent (?); longitudinal axis oblique

- G. At least three antapical plates present . . . . . Pyrophacaceae
- H. On ventral side of epitheca where intercalary striae converge, there is a small but conspicuous field with a porelike point . . . . . Heterodiniaceae
- H. Epitheca on the ventral side without such porelike point . . . . . I
- I. Cell with two to four characteristic horns; one apical, one to three antapical . . . . . Ceratiaceae
- I. Cell not so shaped . . . . . J
- J. Theca so strongly reticulated on the surface that the tabulation is not discernible . . . . . Protoceratiaceae
- J. Tabulation clearly evident . . . . . K
- K. Posterior intercalary present in addition to one antapical . . . . . Gonyaulacaceae
- K. Two antapicals present . . . . . Peridiniaceae
- K. Three antapicals present, one dorsal, two ventral . . . . . Goniodomaceae
- K. Only one plate at the antapex; not drawn out . . . . . L
- L. Shape spherical, without apex . . . . . Dinospaeraceae
- L. Cell flattened; apex present; comb near sulcus . . . . . Diplopsalis

Genera

The genera of the Peridinales are described principally on the basis of the number and arrangement of the thecal plates. For purposes of terminology these plates can be arranged more or less in rows running parallel to the girdle. In this report the terminology of Kofoid (1909) has been followed. On the epitheca, anterior to and touching the girdle, is a row of plates, the precingular series. Another group of plates, touching the apex, is designated the apical series. Between these two rows there may be interpolated plates called the anterior intercalaries. The girdle itself is made up of a series of plates. On the hypotheca there is a row bordering the girdle called the postcingular series. Another series, touching the antapex, is called the antapical plates. Between these and the postcingular series there may be interpolated other plates which are designated the posterior intercalaries. In the plate formulas the names of these plates have been abbreviated in the present paper as follows:

- |                          |                           |
|--------------------------|---------------------------|
| apical platelet - pl     | postcingular - po         |
| apical plate - ap        | posterior intercalary - p |
| anterior intercalary - a | antapical - ant           |
| precingular - pr         | sulcal - s                |
| girdle - g               |                           |

These abbreviations are clearer and more rapidly read than the prime signs used by Kofoid (1909).

The following list of genera of the Peridinales is compiled chiefly from Lindemann (1928). There is considerable uncertainty in regard to the limits of some genera. For example, the genus *Diplopsalis* includes five genera considered distinct by some authors. The plate formula is given as far as is known for each genus.

- Acanthogonyaulax* (Kofoid) nobis. 3ap, 0a, 9pr, 6g, 7s, 6po, 1ant.
- Amphidoma* Stein, 1883. 6ap, 0a, 6pr, 6g, ?s, 6po, 1p, 1ant.
- Blepharocysta* Ehrbg., 1873. 2ap, 1-2a, 6pr, ?g, ?s, 3po, 3ant.
- Centrodinium* Kofoid, 1907. 2ap? 0a, 6pr, ?g, ?s, 5po, 1p, 4ant.
- Ceratium* Schrank, 1793. 4ap, 0a, 5pr, 4g, ?s, 5po, 0p, 2ant.
- Ceratocorys* Stein, 1883. 2ap, 2a, 5pr, 6g, 5-6s, 5-6po,

- Cladopyxis* Stein, 1883. 4ap, 0a, 8pr, ?g, ?s, 6po, 0p, 2ant.
- Congruentidium* Abé, 1927. 4ap, 1a, 5pr, ?g, ?s, 5po, 1p, 2ant.
- Dinosphaera* Kofoid and Mich., 1912. 3ap, 1a, 6pr, 6g, ?s, 5po, 0p, 1ant.
- Diplopsalis* Bergh, 1882. 3-4ap, 0-2a, 6-7pr, ?g, ?s, 5po, 0p, 1-2ant.
- Dolichodinium* Kofoid and Adamson, 1933. 4ap, 0a, 6pr, 6g?, ?s, 6po, 0p, 3ant.
- Glenodinium* Stein, 1883. Variable pattern.
- Glenodiniopsis* Wolosz., 1916. 7ap?, 0a?, 8pr, ?g, ?s, 7po, 2ant.
- Gonyaulax* Diesing, 1886. Formula for genus uncertain.
- Goniodium* Pavillard, 1927c. 4ap, 0a, 6pr, 9g?, ?s, 6po, 2a, 3ant.
- Goniodoma* Stein, 1883. 3ap, 0a, 7pr, 6g, 5s, 5po, 0p, 3ant.
- Heterocapsa* Stein, 1883. 4ap, 2a, 6pr, ?g, ?s, 5po, 0p, 2ant.
- Heterodinium* Kofoid, 1906. 3ap, 1a, 6pr, 6 (??) g, ?s, 7po, 0p, 3ant.
- Lissodinium* Matzenauer, 1933. 3(2?)ap, 0a, 5pr, ?g, ?s, 5po, 4ant.
- Murrayella* Kofoid, 1907. 2-4ap, 1a, 6pr, ?g, ?s, 4po, 0p, 1ant.
- Ostreopsis* J. Schmidt, 1901. 3ap, 0a, 7-8pr, ?g, ?s, 4po?, 1ant?
- Oxytoxum* Stein, 1883. 5ap, 0a, 5pr, ?g, ?s, 5po, 0p, 1ant.
- Pachydinium* Pavillard, 1915. 3ap, 0a, 5pr, ?g, ?s, 5po, 0p, 3ant.
- Peridiniella* Kofoid and Mich., 1911. 4ap, 3a, 7pr, 6g, ?s, 6po, 1p, 1ant.
- Peridinium* Ehrbg., 1840. 2-5ap, 0-8a, 6-7pr, 3-6g, 5-6s, 5-6po, 0p, 2ant.
- Podolampas* Stein, 1883. 2ap, 1a, 6pr, ?g, ?s, 3po, 4ant.
- Protoceratium* Bergh, 1882. 2ap, 0a, 6?pr, 6?g, ?s, 6po, 0p, 3ant.
- Pyrodinium* Plate, 1906. 3ap, 0a, 6-7pr, 8g, ?s, 5po, 1p, 1ant.
- Pyrophacus* Stein, 1883. 5-9ap, 2?a, 9-13pr, ?g, ?s, 9-13po, 0-2p, 3-4ant.
- Spiraulax* Kofoid, 1911. 4ap, 1a, 6pr, 6g, 6s, 6po, 1p, 1ant.

State of Knowledge of Morphology

In the above list there are thirty genera covering more than five hundred species. Although the generic classification of these species is based primarily on the plate pattern, our knowledge of this feature is far from complete, as can be seen by a glance at the above list. Many generic diagnoses are based on the analysis of only one or a few species. In many cases the tabulation given by the authors is admittedly only approximate. Some of the recorded generic plate formulas are decidedly incomplete; e.g., for five genera not even the major plates of the epitheca and hypotheca have been reported with certainty. Among those genera for which formulas of the major epithecal and hypothecal plates have been reported without reservation, seventeen have not had the number of girdle plates reported or this number is uncertain. In only three genera had the ventral area been investigated before the present work.

Under these conditions it is a matter of course that all the generic diagnoses may be subjected to more or less radical alterations on the application of more critical morphological analysis. Further, a more extensive study of the various species will undoubtedly result in revised concepts of genera as well as of species.

Over 1200 papers have been written on the Peridinales. More than 900 of these contain systematic or flo-

ristic treatments of some group or groups of the Peridineae; the remaining 300 deal with cytological, ecological, and physiological problems. Of the systematic papers, less than 5 per cent present critical analytical treatments of the species from either the taxonomic or the morphologic viewpoint.

#### Forms Treated in this Report

Of the fourteen families in the order Peridinales, this report deals with representatives of five. A monographic treatment has been given of the monogeneric family Ceratocoryaceae. This was due to the fact that ample material was available for making a complete skeletal analysis of every known species. Whereas in Ceratocoryaceae species are not difficult to define, in the family Peridiniaceae the species seem to be in an unstable condition; extreme variability frequently makes a delimitation of species a difficult task, indeed. One genus in this family was selected for study, viz., Peridinium. Of its two hundred or more species, those related to Peridinium depressum Bailey were selected for intensive studies of the variation in body shape and plate pattern. Representatives from other parts of this large genus were also analyzed, viz., P. crassipes Kofoid, P. truncatum n.sp., and P. pallidum Ostenfeld. In an attempt to probe further into the interfamily relationships, work was also done on three other families: Ceratiaceae, Goniodomaceae, and Gonyaulacaceae. One species from each of the first two was investigated, viz., Ceratium pavillardii Jørgensen and Goniodyma polyedricum Pouchet; and from the family Gonyaulacaceae four species were analyzed: Gonyaulax pacifica Kofoid, Gonyaulax fusiformis n.sp., Acanthogonyaulax spinifera (Murray and Whitting) Graham, and Spiraulax kofoidii new name.

Of the twenty-nine forms treated in this paper, there are six new species, three new varieties, and six

new forms. Two old specific names have been replaced. Following is a complete list of the forms included in this report:

Family Goniodomaceae  
Goniodyma polyedricum Pouchet

Family Ceratocoryaceae  
Ceratocorys horrida Stein  
C. armata (Schütt) Kofoid  
C. reticulata n.sp.  
C. aultii n. sp.  
C. bipes (Cleve) Kofoid  
C. skogsbergii n. sp.  
C. gouretii Paulsen

Family Gonyaulacaceae  
Gonyaulax pacifica Kofoid  
G. fusiformis n.sp.  
Acanthogonyaulax spinifera (Murray and Whitting) Graham  
Spiraulax kofoidii new name

Family Peridiniaceae  
Peridinium depressum Bailey  
P. depressum var. parallelum Broch  
P. depressum var. rectius n. var.  
P. depressum var. convexius n. var.  
P. depressum f. bisintercalares n.f.  
P. depressum f. multitabulatum n.f.  
P. claudicanoides n.sp.  
P. oceanicum Vanhöffen  
P. oceanicum var. tenellum n.var.  
P. oceanicum f. spiniferum n.f.  
P. oceanicum f. bisintercalares n.f.  
P. oceanicum f. tricornutum n.f.  
P. crassipes Kofoid  
P. truncatum n.sp.  
P. truncatum f. acutum n.f.  
P. pallidum Ostenfeld

Family Ceratiaceae  
Ceratium pavillardii Jørgensen

## RELATIONSHIPS AMONG THE GENERA

### General Considerations

Our ideas of the relationships of the genera must at present be based on the degree of similarity in the skeletal structures, since the cytology of the order is altogether too little known to be used for this purpose. Fortunately, the skeletons of these forms are complex and hence present a multitude of morphological characters useful in taxonomic studies. These characters have not been the basis for any satisfactory discussion of intergeneric relationships; indeed, so far no one has ventured into such a discussion. Ideas concerning these relationships have been expressed only by the grouping of the genera into families, without any discussion of the justification for doing so (see, however, Lebour, 1922, on the origin of Peridinium).

The absence of such evolutionary studies is probably due to the apparent lack of order in the great variety of plate patterns which are presented by the various genera. It is extremely difficult to select, from this kaleidoscopic array of patterns, characters which are of fundamental generic or family importance. As stressed

above, however, the incompleteness and undoubted inaccuracies in our knowledge of the skeletal features have greatly aggravated this situation. Doubtless the situation in nature is not so chaotic as present knowledge indicates.

The skeletal features which are the most fundamental from the standpoint of taxonomy are the number and arrangement of the thecal plates. The body shape, the lists and spines, and other such characters are of secondary importance.

In regard to the number of plates, there are various ways in which evolution may have taken place. For instance, primitive forms may have had relatively few plates and evolution may have progressed by the splitting of plates or by the insertion of newly formed plates; or the primitive forms may have had a large number of plates and evolution may have proceeded by the fusion and loss of plates; or the processes of increase and decrease may have taken place simultaneously in different parts of the body.

Whatever has been the progress of evolution, it has not been uniform or parallel in all parts of the theca. Today there are some genera with the same number of

plates in the hypotheca as in the epitheca (Heterodinium), some with more plates in the hypotheca (Centrodinium), and the majority have more in the epitheca than in the hypotheca. This is an expression of the well-known principle of the independent evolution of particular organs or organ systems which is so amply illustrated throughout the Metazoa.

In regard to the arrangement of plates it is even more difficult to attempt a reconstruction of evolutionary trends than in the case of the number of plates. We do not know of any forms which represent definite transitional stages between the unarmored Dinoflagellata and the Peridiniales. Thus, we have no reasonably certain information as to which are the most primitive patterns. As a consequence, we find ourselves forced to undertake a search for features which are more or less universal, and to start from the assumption that such characters represent the primitive condition.

The peridinium skeleton is divided naturally into four parts and, for purposes of evolutionary discussions, it is advisable to consider these separately. They are: the epitheca, the hypotheca, the girdle, and the ventral area.

Because of the unreliability of many of the published generic diagnoses, the present discussion of relationships is based entirely on the forms treated in this report. The skeletal features of these are known with certainty. Since the ventral area has been the main target in the present work and, since the comparison of the ventral areas has been the most fruitful in showing intergeneric relationships, it will be taken up first.

#### Ventral Area

The ventral area was almost unknown in the Peridiniales when this investigation was started. Since then, however, Abé (1936) has begun a reclassification of the genus Peridinium on the basis of the structure of this region, and Tai and Skogsberg (1934) have demonstrated the importance of this feature in the Dinophysiales.

A study of this area in various genera of the Peridiniales has shown that there is a rather small and fairly constant number of plates, and that the shape and arrangement of these plates differ fundamentally in the different genera.

General shape. There has been an extensive evolution of the general contours of the ventral area in the Peridiniales. The area is seen in its simplest form in Goniodoma, where it is comparatively flat and lacks intricate structures. Furthermore, in this genus there is no distinct delimitation of the sulcus proper. In Ceratium the ventral area is specialized, being broad and relatively large, with extremely hyaline plates and with a small sulcus on the left side. In the other genera investigated, there is a deep sulcal groove, in many cases so deep and narrow that no indication of the tabulation can be ascertained without dissection. In Spiraulax, Gonyaulax fusiformis, and Acanthogonyaulax the posterior part of the ventral area flares out into more or less expanded areas which cannot be considered part of the sulcus proper. In Peridinium this does not occur and the sulcus proper is usually limited. In this case the sulcus usually lies to the left side of the ventral area, although there is considerable variation in this respect within the genus. In P. truncatum, for example, the right sulcal plate is on a level with the major body plates, as is also the left limb of the posterior plate, and the left sulcal

plate is turned in so that it forms the side wall of a deeply embedded groove.

In most of the forms of the Peridiniales represented in this report the two sides of the body are about equal in size, and as a consequence, the ventral area appears in or near the mid-ventral line when the organism presents the ventral view. In Gonyaulax pacifica, on the other hand, a differential growth has taken place by which the left side has grown decidedly larger than the right. A consequence of this is that when the organism presents the ventral aspect, the ventral area lies decidedly to the right and the axis of the sulcus has been so rotated that only the plates of the right side are visible.

Plate pattern. The ventral area in the forms investigated is composed of from five to seven external plates. (Fig. 1.) As regards homologues, however, there are eight plates, as is shown by the fact that in Acanthogonyaulax, which has seven plates, there is a left accessory but no posterior accessory; and in Gonyaulax pacifica, which also has seven plates, there is a posterior accessory but no left accessory.

Thus, the generalized composite picture of the ventral area has eight external plates. These are: an anterior, a posterior, a left and a right, with accessories to the left, right, and posterior, plus an intercalary in the right posterior region. All border on the flagellar pore except the posterior sulcal (Goniodoma excepted) and the intercalary sulcal. In addition to these external plates, in Peridinium there is an internal plate lying along the right side of the pore.

The anterior sulcal plate (as, fig. 1) forms the anterior edge of the pore in all genera except in Acanthogonyaulax, where it has migrated anteriorly. The anterior plate in all cases lies against the proximal end of the girdle and in some genera it forms a distinct part of the girdle, as, for instance, in Goniodoma. Frequently this plate has a considerable extension into the epitheca, viz., in Goniodoma, Gonyaulax, and Spiraulax. In Peridinium the anterior plate bears part of the anterior internal process. It can be concluded that the anterior sulcal plate is an important plate in the thecal complex of the peridinium skeleton. It is a conservative plate, occupying a key position at the head of the flagellar pore, at the proximal end of the girdle, and in the epithecal pattern. Only in Acanthogonyaulax is it removed from its position at the head of the pore, but even in this genus it lies at the proximal end of the girdle. Its shape varies considerably from genus to genus, but none of the differences are radical. It may be squarish to linear with various numbers of sides or irregularities. Frequently the anterior cingular list is extended across it, as in Goniodoma and Gonyaulax.

The posterior sulcal plate (ps, fig. 1) is another important element. It is conservative in being always present, but it has undergone a much greater diversification than the anterior sulcal plate. It is always removed from the flagellar pore except in Goniodoma. In most genera it flares out into a relatively wide expanse on the ventral aspect of the hypotheca. This expansion may be elliptical (Gonyaulax and Spiraulax) or winged (Acanthogonyaulax). In Ceratocorys it is rather obscure, being rectangular and not wider than the anterior part of the sulcus. It attains its greatest complexity in the genus Peridinium, where it is very intricate and lies at the posterior end of a deep sulcal groove. In this genus it is more or less horseshoe-shaped with a narrow cen-

tral part, a wide right limb lying posterior to the right sulcal plate, and a narrow or wide limb on the left side running along the left side of the left sulcal plate. In some species (*P. truncatum*) it assumes a size equal to that of some of the major body plates. It bears some of the elements of the more complicated list systems of the Peridinales.

The left sulcal plate (ls, fig. 1) is present in all genera. It has undergone little evolution of shape, but varies in position in the sulcal tabulation. It is always anterior to the posterior plate, however, and on the left side of the area, and it always borders the flagellar pore. It may form the entire left edge of the pore, as in *Peridinium* and *Goniodoma*; it may form the posterior edge and part of the left edge of the pore, as in *Gonyaulax*; or it may form only the posterior edge of the pore as in *Spiraulax* and *Ceratocorys*; or only part of the posterior edge, as in *Acanthogonyaulax*.

In only one genus, *Acanthogonyaulax*, is there a left accessory sulcal plate (la, fig. 1). This lies not contiguous to the left sulcal plate, but anterior to the flagellar pore on the left side of the sulcus.

On the right side of the ventral area there may be from one to three plates between the anterior and the posterior; viz., one in most species of *Peridinium*, two in *Goniodoma*, *Ceratocorys*, and *Peridinium pallidum*, and three in *Gonyaulax*, *Acanthogonyaulax*, and *Spiraulax*. When only one plate is present, it is the right sulcal plate (rs, fig. 1). Anterior to this plate there may be a right accessory sulcal plate (ra, fig. 1); posterior to it, an intercalary sulcal plate (i, fig. 1). Either the right or the right accessory, or both, borders the pore, but the intercalary never does. Sometimes the right is not in contact with the pore, as in *Goniodoma* and some species of *Ceratocorys*. In such cases the right accessory and the anterior sulcal plates form the right edge of the pore. In addition to these seven plates there is frequently an eighth, the posterior accessory sulcal plate (pa, fig. 1). This lies between the posterior edge of the pore and the posterior plate as in *Peridinium*, or it may be squeezed out of contact with this plate as in *Gonyaulax pacifica*. It occurs only in these two genera.

**Discussion.** It is obvious that there is a great diversity in the tabulations of the ventral areas of the various genera in the Peridinales. In spite of this diversity, however, a common basic plan is evident.

After a careful comparison of the ventral areas of the various genera, a type of tabulation was devised which may represent an approximation of the ancestral condition (fig. 1A). This reconstructed ventral area is quite similar to that of *Goniodoma* with the major exception that its posterior sulcal plate does not touch the flagellar pore. Since all genera except *Goniodoma* have this plate removed from the pore, *Goniodoma* must be considered aberrant in this respect. This primitive ventral area is thus composed of five plates: an anterior sulcal, a posterior sulcal, a right and a left sulcal, and a right accessory sulcal. These plates are approximately equal in size and all border the pore except the posterior sulcal. The sulcal ring is complete.

If this reconstruction of the ancestral ventral area is used as a key, a comparison of this area in the various genera yields the following results:

**Goniodoma:** This is, without doubt, the most primitive of the genera investigated, since its ventral area

is the simplest of those studied, being different from the ancestral condition only in having the posterior plate touching the flagellar pore. Its ventral area is very simple in outline and contour; the flagellar pore is fully exposed; there are no internal skeletal structures; and the sulcal lists are poorly developed. There are only five plates. These are subequal in size and show no complex contours. The sulcal ring is complete.

**Ceratocorys:** The genus *Ceratocorys* is evidently closely related to *Goniodoma*. The sulcal plates, also five, are simple in structure, and apparently are homologous with the five present in *Goniodoma*. There has been a narrowing of the sulcus, however, and a slight enlargement of the posterior sulcal plate. The sulcal ring has broken on the left side and the posterior sulcal plate has taken up a position posterior to the right sulcal plate so that it alone forms the posterior end of the area. The last two characters are carried through the other genera except that the ring is not broken in *Peridinium*. Thus although *Ceratocorys* is closely related to *Goniodoma*, it represents a definite advance over that genus.

**Gonyaulax, Acanthogonyaulax, Spiraulax:** These genera show striking similarities. Their ventral areas are greatly elongated and sigmoid in outline, with greatly enlarged posterior sulcal plate. The number of plates has increased to six or seven. The sulcal ring is broken. The sulcus proper is a narrow groove occupying only part of the ventral area. All the plates of the primitive area are present, and in addition, there is an intercalary lying on the right side between the right and the posterior sulcal plates. In addition to these, *Gonyaulax pacifica* has a posterior accessory plate just posterior to the pore. In *Acanthogonyaulax* there is a left accessory sulcal plate just anterior to the pore, and the anterior sulcal plate is unique in being removed from the pore.

**Peridinium, Ceratium:** These two remaining genera are widely divergent from the previous genera and each of them is unique in regard to its sulcal structures. In *Peridinium* the primitive number of external plates, i.e., five, has been retained, except in *P. pallidum*; and the sulcal ring is unbroken. Each sulcal plate, however, is singularly modified, particularly the posterior, and internal sulcal structures have developed. Sulcal lists are prominent and the sulcus proper is deeply embedded in the left side of the area in such a way that it is not exposed to view. *Ceratium* is characterized by the development of a wide and large flat ventral area extending over the ventral side of the body, and covered by hyaline plates. This type is to be found nowhere else in the Peridinales.

It can be concluded from the above studies that *Goniodoma* represents the most primitive genus investigated; that *Ceratocorys* is closely related to it but is somewhat more advanced; that *Gonyaulax*, *Acanthogonyaulax*, and *Spiraulax* are decidedly more advanced and in addition are closely related to each other; and that the genera *Peridinium* and *Ceratium* are highly specialized and developed along divergent lines.

Thus, the genera cannot be arranged in a single evolutionary series. Evolution has apparently progressed in divergent directions within the order and these divergent directions are expressed by an apparently natural grouping of the genera.

The Girdle

The number of girdle plates has not been generally determined by previous workers, and has frequently been omitted from generic plate formulas. Therefore, this feature is known for only a limited number of genera. This is the more deplorable since there are indications from the present investigations that the number of girdle plates may be important from a taxonomic standpoint.

All the genera treated in this report have six girdle plates except Peridinium and Ceratium, which have four. Six is also recorded for certain other genera not treated in this report. Other numbers have been questionably reported (see p. 3), but these aberrant numbers must be checked by careful dissection before they can be included in evolutionary discussions. The number is thus apparently constant and it is probable that six is the primitive number. Any deviation from this number should, at least for the present, be interpreted as a divergent feature.

In regard to the relationships among the genera treated here, the number of girdle plates fits into the scheme devised by a comparison of the ventral areas and, at the same time, indicates a greater unity in the order as a whole. The six girdle plates in Goniodoma, Ceratocorys, Gonyaulax, Acanthogonyaulax, and Spiraulax bring these genera more closely together. The divergent number, four, in Peridinium and Ceratium corroborates the previous conclusion that these two genera have been separated from the ancestral form for a long period of time.

The Hypotheca

When considering the hypotheca, we have to deal not only with the number of plates, but also with the pattern which these plates assume. For intergeneric studies it is sufficient to limit the discussion of patterns to a consideration of the number of plates in the individual series, inasmuch as the relative positions of the plates and the course of the sutures are usually of specific value only. Thus, the expression of plate pattern is itself reduced to numbers.

Table 1. Comparison of number of plates in the four parts of the theca of the genera treated in this report

Genera	Epi-theca	Hypo-theca	Girdle	Vent. area	Total
Goniodoma . . . . .	11	8	6	5	30
Ceratocorys . . . . .	10	8	6	5	29
Gonyaulax . . . . .	12	8	6	6-7	33
Acanthogonyaulax . .	13	8	6	7	34
Spiraulax . . . . .	12	8	6	6	32
Peridinium . . . . .	16	7	4	5-6	32-33
Ceratium . . . . .	10	7	4	?	21+

In regard to the total number of plates in the hypotheca, the genera treated here are divided into two groups (see table 1). The first group has eight plates and includes all the genera except Peridinium and Ceratium. The second group has seven plates and includes these two genera. There is a striking parallelism here with the number of girdle plates, which substantiates the assumptions based on the comparison of ventral areas alone that Peridinium and Ceratium are divergent from the other genera.

In regard to the tabulation of the hypotheca a similar grouping is indicated, except that Goniodoma is separated from related genera (see table 2). There are, thus, three groups: Goniodoma with hypothetical formula 5po, 0p, 3ant; Ceratocorys, Gonyaulax, Acanthogonyaulax, and Spiraulax with formula 6po, 1p, 1ant; and Ceratium and Peridinium with formula 5po, 0p, 2ant. This corroborates the conclusions derived from a study of the ventral areas, but emphasizes the fact brought forth by the position of the posterior sulcal plate that Goniodoma represents a short, independent side branch, even though close to Ceratocorys. The approximate similarity of the pattern of Goniodoma with that of Peridinium and Ceratium must be considered a result of convergence, since the three equally sized antapicals of Goniodoma present a fundamentally different plan from that of Peridinium or Ceratium.

Table 2. Comparison of plate formulas of genera treated in this report

Genera	pl	ap	a	pr	g	s	po	p	ant
Goniodoma . . . . .	1	3	0	7	6	5	5	0	3
Ceratocorys . . . . .	1	2	2	5	6	5	6	1	1
Gonyaulax . . . . .	1	3	2	6	6	6-7	6	1	1
Acanthogonyaulax . .	1	3	0	9	6	7	6	1	1
Spiraulax . . . . .	1?	4	1	6	6	6	6	1	1
Peridinium . . . . .	2	4	3	7	4	5-6	5	0	2
Ceratium . . . . .	1	4	0	5	4	?	5	0	2

The Epitheca

In considering the epitheca we have to deal with both the number and the arrangement of the plates, as in the case of the hypotheca. The total number of plates in the genera investigated ranges from ten to sixteen, and it shows no correlation with the grouping of the genera indicated by the other parts of the theca (see tables 1 and 2). In the other genera of the Peridinales, not included in this report, the number of epithecal plates is also extremely variable, as is shown by the above list of generic plate formulas (p. 3). When we turn to the arrangement of these plates we find that here, too, no generic grouping can be made which will parallel that made on the basis of the hypotheca, girdle, and ventral area. In fact, of the genera reported here, no two have the same epithecal formula (table 2). It is thus evident that the evolution of the epitheca has been in many directions and that it has been decidedly independent of the evolution of the other parts of the theca.

Summary

On the basis of the above comparisons of the various parts of the peridinian skeleton, it is thus possible to draw some conclusions regarding the relationships of the genera studied and to postulate certain aspects of the course of evolution in the group. When the term "relationships" is used here, it is clearly understood that the true relationship is not always indicated by morphology. Results obtained in the field of genetics have clearly demonstrated that the closest morphological similarities do not always represent the closest relationships. For the time being, however, we must build our genetic discussion of the peridinians on the assumption that morphological similarities express degrees of relationship, unless evidence clearly demonstrates that the similarities are due to convergence.

The comparison of the morphological features of the ventral areas of the forms in this report indicates that Goniodoma is the most primitive genus investigated. This is shown by the simplicity of contours, size equality, and small number of plates, viz., five, and by the closed sulcal plate ring around the pore. At the same time, the fact that the posterior sulcal plate is in contact with the pore shows that Goniodoma does not lie on the main line of descent but that it represents a short, independent evolutionary branch near the base of the general evolutionary path. Closely related to Goniodoma, but distinctly more advanced, and representing a short, special side branch, is Ceratocorys, which has the same number of sulcal plates. In this genus, however, the ventral area is narrowed, the sulcal ring is broken, and the posterior sulcal plate is somewhat enlarged. Still more advanced than Ceratocorys, and closely related to each other, are Gonyaulax, Acanthogonyaulax, and Spiraulax, in which the ventral areas are elongated and sigmoid, the posterior plate is greatly expanded, and the number of plates has increased to six or seven. Highly specialized and widely separated from all the above genera and also from each other are Peridinium and Ceratium. The ventral area of Peridinium has a complex arrangement of intricate plates and lists, whereas in Ceratium this structure is a wide, flat ex-

pense of hyaline plates.

The comparison of the girdle plates corroborates the above conclusions, inasmuch as it separates the genera Peridinium and Ceratium from the others. At the same time, it indicates that these two genera are mutually closer than either of them is to the remaining genera.

The comparison of the total number of hypothecal plates shows an exact parallelism with that of the girdle plates; there are seven in Peridinium and Ceratium and eight in the others, thus again bringing Peridinium and Ceratium together.

The patterns of the hypothecal plates separate Goniodoma from Gonyaulax, Acanthogonyaulax, and Spiraulax, showing, as is stressed above, that Goniodoma does not form a direct ancestral type.

The comparison of the epithecal plates does not contribute to this picture, but rather indicates an independent structural differentiation. No two of the genera have the same epithecal formula.

Thus we are able to build up a plan of evolution and relationships of the genera treated in this report, based primarily on the ventral area and nicely corroborated by the girdle and hypothecal tabulations (see fig. 2). As more accurate knowledge is gained of the other genera of the Peridinales, it is hoped that these, too, will fit into this general scheme.



## SYSTEMATIC DESCRIPTION

As indicated on page 4, the following families are included in this paper: Peridiniaceae, Ceratocoryaceae, Gonyaulacaceae, Goniodomaceae, Ceratiaceae. The arrangement of the families does not indicate relationships, but rather expresses the degree to which the families have been studied; the first ones the most intensively.

## Family PERIDINIACEAE

**Diagnosis.** "Shape of the cell variable, spherical to longish; small horns often on the hypotheca. Apex present or absent. Girdle circular or somewhat spiraled; there are right and left spirals. Theca in 'youth' quite thin, later usually developed into stronger theca which falls apart into dissimilarly shaped polygonal plates. Tabulation very different, variable, malformations even common. It is scarcely possible to set up for *Peridinium* and its relatives, general valid plate patterns; mostly there are 6-7 precingular plates, 5-6 postcingular, and 2 antapical plates which only in *Diplopsalis* may be coalesced. The tabulation of the epitheca is more variable than the hypotheca. Surface of the theca with areolae, papillae, spines, lists, or pores; seldom smooth. Plasma of marine forms sometimes colored. Stigmas in freshwater forms rare and little considered, often pale. In marine forms pusules. Chromatophores often in large numbers. Plasma inclusions, starch, fatty substances, pyrenoids, rods (rhabdosomes). Nucleus roundish to longish. Colony formation in one case. Formation of cysts after casting of theca. Different kinds of reproduction. Length 18 microns to 300 microns. Fresh-, brackishwater, and marine." (Lindemann, 1928, p. 88.)

Three genera are established at present. They can be differentiated in the following manner according to Lindemann (1928, p. 88):

- A. Only one of the antapical plates drawn out into a short, hollow horn or spinelike point; shape  $\pm$  spindle-shape . . . . . *Heterocapsa*
- B. Cell otherwise shaped
- a. Shape at both poles more or less ellipsoidally compressed; at the left margin of the longitudinal furrow (on the hypotheca) is a conspicuous list which can reach over to the antapex; antapical plates two, rarely one . . . . . *Diplopsalis*
- b. Otherwise shaped, two antapical plates . . . . .  
 . . . . . *Peridinium*

**Remarks.** The above description and key clearly indicate the insufficiency of our present knowledge. This allows us to make neither a clear-cut definition of the family Peridiniaceae as contrasted with the remaining families, nor to establish generic diagnoses and descriptions which will fit into the family description and at the same time be exclusive and distinct. It should be emphasized that Lindemann (1928) was not at fault. His attempt at classifying the Peridinea was remarkably successful, considering the meager data at his disposal. The only genus of the family treated in this report is *Peridinium*.

## Genus PERIDINIUM Ehrenberg

## Diagnosis

See Lindemann, 1928, p. 89.

## Description

**Remarks.** Because of our present hazy conception of this genus, a redescription is necessary. The following description is based solely on the representatives in which the skeletal morphology has been worked out in detail. It is intended to be but tentative and thus to be filled in and rounded out as more material accumulates. It must be stressed, however, that amendment should be made only on the basis of material obtained by the complete dissection of specimens and of material subjected to a statistical analysis of form variation.

**Dimensions.** Among the forms in this report the total length ( $l$ ) varied from 44 microns in *P. pallidum* to 275 microns in *P. truncatum*; the diameter ( $d$ ) from 35 microns in *P. pallidum* to 200 microns in *P. truncatum*. Many other forms ascribed to this genus are smaller; e.g., *P. faerøense* is 16 microns in diameter.

**Shape.** All the forms treated in this report, except *P. pallidum*, possess three well-developed horns, although many other species ascribed to the genus are hornless and some even spineless, and, in extreme cases, completely spherical. Whether all these species should be regarded as generically identical cannot be decided at this time. The body is usually longer than wide, but may be spherical, though rarely wider than long. All the forms here treated are much longer than wide, owing primarily to the long horns, the  $l/d$  ratio being as high as 1.5 in *P. truncatum*. The  $h/d$  ratio, which expresses the length of the body exclusive of the antapical horns ( $h$ ) relative to the diameter, varies from 0.53 in *P. claudicanoides* to 1.76 in *P. depressum* var. *tenellum*. The angle which expresses the amount of anteroposterior compression of the body  $\alpha$  varies from  $78^\circ$  in *P. depressum* to  $139^\circ$  in *P. depressum* var. *convexius*.

**Girdle.** The girdle is more or less equatorial, sometimes encircling the body in one plane, but usually forming either a descending or an ascending spiral. Although it is usually displaced, there is never any overhang. It seldom encircles the body at right angles to the longitudinal axis, but is deflected from this position; in the forms treated herein, this deflection is from  $10^\circ$  to  $15^\circ$ . The girdle may or may not be excavated.

**Sulcus.** The sulcus is a groove on the ventral side of the body extending from the ends of the girdle, or from somewhat anterior to them, to the antapex of the body. In it lies the flagellar pore. The pore is usually oval in shape and the theca of the sulcus is so constructed that the pore opens laterally instead of directly ventrally. The plate complex of the sulcus may spread out to some extent, forming a wide ventral area with the sulcus proper located within it.

**Plate pattern.** If the broad generic concept of Lindemann (1928) is accepted, there are a great number of plate patterns represented in the members of *Peridinium*. This is particularly true of the epitheca. The

only constancy in the entire pattern in Peridinium s. l. is the absence of posterior intercalaries and the presence of two antapicals. For abbreviations of the names of the plates, see above, p. 3.

In the forms treated in this report the pattern of the major body plates is as follows:

4ap (5 in P. depressum f. multitabulatum n.f.);  
3a (2 in P. depressum f. bisintercalares and P. oceanicum f. bisintercalares n.f.);  
7pr (8 in P. depressum f. multitabulatum n.f.);  
4g; 5po; 0p; 2ant.

The four girdle plates are of unequal length. The third is the longest, comprising all the dorsal and lateral sides of the girdle and, in P. pallidum, most of the ventral side also. The other three lie ventrally and are comparatively small. The girdle plates may be very significant in the classification of the genus, the number being of generic value, and the pattern subgeneric. The determination of the girdle plates has too often been neglected in analysis of the thecal pattern, in spite of the fact that their dissection is not difficult.

The epitheca of Peridinium is in an unstable condition, as will be pointed out later. In all species dissected, however, there was found an apical ring platelet and a ventral apical platelet. No variation was found in the number of girdle plates nor in the hypotheca except in P. oceanicum f. tricornutum n.f.

Probably the most important region of the theca to be investigated at the present time is the ventral area or sulcal region. This is a very complex area made up of several plates. The necessity of dissection in determining these structures has retarded our knowledge of them. Kofoid (1909) reported on this region in P. steinii, but it is not certain that complete dissections were made and his analysis must be verified before being accepted into the general concept of the ventral area of Peridinium. Fauré-Fremiet and Puigeandau (1922) indicated plates in the ventral area of several species of Peridinium including P. oblongum and P. crassipes. They show seven plates. These must have been drawn from the authors' imagination, as they bear no relation whatever to the actual tabulation of these species. The same may be said for the sutures shown encircling the antapical horns (fig. 9). The only detailed analysis of this area in the genus so far published which is at all acceptable, is that of Abé (1936) for Peridinium ovatum and related forms. These analyses can be incorporated into the general scheme developed from our own several analyses in widely separate representatives of the genus.

Certain features of the plate pattern of the ventral area in the genus Peridinium are conservative; others vary from species to species. The number of plates is not constant in the genus, but varies from five to six; different plates may be wanting. The conservative elements are represented by four plates: an anterior, a posterior, a right, and a left sulcal plate. These plates are conservative in that they are always present and always have the same relation to each other and to the flagellar pore. They do vary considerably in shape, however, in the different species. The anterior sulcal plate occupies the area between the ends of the girdle and joins the posterior end of the first apical; it extends to the anterior edge of the flagellar pore. The posterior plate is a very complex structure, the most complex plate so far found in the peridinian skeleton. Its shape is roughly that of a U in which one limb has been rotat-

ed so that its axis lies at right angles to that of the other. The curve of the U is narrow, and the limbs are expanded into wide areas. The details of the shape will be described under each species. The right plate is the largest of the ventral area and forms the right edge of the flagellar pore. It extends from the anterior to the posterior sulcal plate. It bears a prominent list on its left margin, the right accessory sulcal list, which overlies the pore and may bear processes which project into the protoplast. This plate is a prominent element of the ventral area in undissected specimens. The left sulcal plate is deeply set in the sulcus and is not clearly seen without proper cleaning or dissecting of the specimen. It is, however, fairly large and forms the left side of the ventral area and the left edge of the flagellar pore. It is one of the most constant elements of the area and varies but little from species to species. In addition to these four principal plates, the ventral area may have three other plates, although all of these never occur simultaneously. They are: the right accessory sulcal plate, the posterior accessory sulcal plate, and the right internal sulcal plate. The right accessory sulcal plate lies against the distal end of the girdle. It was found only in P. pallidum and it represents simply the anterior end of the left sulcal plate in other forms. The posterior accessory sulcal plate lies between the right and the left and the posterior sulcal plates, thus forming part of the posterior margin of the pore. It occurs in all the species, and is comparatively large in P. truncatum (24 microns long) and extremely minute (about 2 microns long) in the other species investigated. The right internal sulcal plate is a part of the complex internal skeleton on the inner side of the right sulcal plate. It was found only in P. crassipes and P. depressum.

The apex of the theca is quite complex, with the same general structure throughout all the species investigated. Only three of the four apical plates actually extend to the apex; the first is subtended by a narrow plate, the ventral apical platelet. The apical ends of this and of the second to fourth apical plates are joined together around the apical pore platelet, which is a ring embedded in the apex.

Structure of thecal wall. Little is known of the detailed structure of the thecal wall. It is quite thick in all the species investigated. Its exact thickness is difficult to determine, but it is probably 1 to 2 microns in the thinner parts and considerably more in the thicker parts. The surface is variously marked with reticulations or tubercles. All the species are porulate at least in the larger plates; sometimes some of the sulcal plates are entirely smooth.

In the species investigated, all plates are fastened together by rabbet joints, as has been shown for other species by Peters (1928). This joint is constructed as follows: Along each suture of the theca there is attached to one of the two adjoining plates a strengthening membrane which underlaps the adjacent plate, forming a rabbet joint (fig. 3A). Thus there are an external and an internal suture separated from each other by the width of the membrane. These membranes are an integral part of the plate to which they are attached and cannot be detached from it. They occur whether or not there is an intercalary zone. When such a zone is present, the external suture divides it approximately in the middle, so that when the two plates are separated, half of the zone remains attached to the plate without the membrane and half to the plate with the membrane. Since

the rabbeting membrane is apparently of the same width in specimens with and without intercalary zones, there must be some intercalated material at the internal suture as well as at the external suture, as shown in figure 3B. If this be true, then there is an internal as well as an external intercalary zone with the internal suture bisecting it approximately in the middle.

**Lists.** Although never developed to the extreme degree that they are in some members of the Dinophysiales, nevertheless, lists form a prominent part of the thecal morphology of Peridinium. The girdle lists are always well developed and the posterior girdle list is usually confluent with the sulcal lists. The ventral area has a complex system of lists. This area is usually enclosed by the right, posterior, and left sulcal lists, and internal to these there may be right, posterior, and left accessory sulcal lists. These will be described under each species. The apex is another region of complexity as regards lists. It is encircled by a list made up of parts of three lists attached to the apical plates. These lists always extend down the ventral side of the body as far as the posterior end of the ventral apical platelet, but may extend down the ventral and lateral sides of the body part way or entirely to the girdle. These will be described in detail in the individual species descriptions. No prominent body lists are developed except along plate sutures. The transverse ridges across the girdle sometimes, however, take on the character of lists.

**Spines.** Antapical spines are developed in some species (e.g. P. pallidum) in place of antapical horns. No other spines occur. The "apical spines" and the "antapical spines," internal to the antapical horns sometimes indicated in published figures, are not spines at all but are optical effects produced by the curvature of lists.

#### Historical Review

Peridinium is the largest and probably the most widespread genus of the Peridineae. More than two hundred species have been described. Thirty-eight of these are fresh-water forms, the rest are marine.

There are many morphological characters in addition to the general body shape which can be used in defining the species. Unfortunately, however, these characters are variable. Because of the pronounced intra- and interspecific plasticity, the genus is the most difficult in the Peridineae from the standpoint of the systematist. So far no one has had the courage to attempt a generic monograph, a fact which is fortunate since it would, necessarily, have been only an abortive attempt because of our ignorance in regard to the pertinent data. Such a treatment can be made only after we have acquired a thorough knowledge of the thecal morphology of each of the species.

Furthermore, the generic concept is one of the vaguest in the Peridineae. It has been very changeable, being sometimes narrow, sometimes broad. For example, Lindemann's concept (1928) of the genus included four described genera besides Peridinium of previous authors. Generally speaking, the confusion in the genus progressed as the number of described forms increased. It is fair to predict, however, that, when all the members of this vast genus have been thoroughly analyzed, a satisfactory classification will be evolved in spite of the variation in some features which now baffle our attempts.

The first grouping of the species of Peridinium was

made by Gran (1902). He divided the genus into two subgenera: Proto-peridinium and Euperidinium. Proto-peridinium was adopted by Gran from Bergh (1881), who applied this name to a group of species to which he assigned generic value. The name Euperidinium, on the other hand, was introduced by Gran. Proto-peridinium, according to Gran, is characterized by solid antapical spines and by a right-handed girdle, i.e., on the ventral side of the body the right (distal) end of the girdle is located anteriorly to the left (proximal) end. Euperidinium is characterized by hollow antapical horns and by a left-handed girdle, i.e., the left end of the girdle is displaced anteriorly. Gran listed the following species: Proto-peridinium: P. pellucidum Bergh s. l., P. ovatum Pouchet, P. decipiens Jörg., P. steinii Jörg., P. globulus Stein, Euperidinium: P. conicus Gran, P. pentagonum Gran, P. divergens Ehr. s. s., P. depressum Bail. s. l.

This classification was satisfactory for the few species that were known at that time and was accepted by many authors. Later investigators, however, revealed forms which could not be classified on the basis of these criteria. For instance, forms were found with a left-handed girdle, but with solid antapical horns. Furthermore, forms with no definite displacement of the girdle in either direction were discovered.

Paulsen (1908) used Gran's classification in the treatment of thirty-nine species of Peridinium although he was compelled to acknowledge exceptions to the system. Thus, in Proto-peridinium he included two species, P. findlandicum Paulsen and P. granii Ostenfeld, which have hollow horns. Those forms in which there is no displacement of the girdle he placed in Euperidinium. The description of this subgenus was further qualified by the statement that there are usually hollow horns. Paulsen was the first to show discrepancies in the Granian classification.

Broch (1910) noted the inadequacy of the classification based on the displacement of the girdle and the structure of the antapical horns. He also pointed out that the arrangement of the plates of the theca afforded a ready diagnostic means. Although he grouped his ten species from Val di Bora under the subgenera Proto-peridinium and Euperidinium, he carefully described under each species the conformation of the first apical plate and figured the plate pattern for each form.

Finally, Jörgensen (1913) made a comprehensive reclassification of the genus on the basis of the plate pattern, using the number of plates that border the first apical as a primary character in the formation of subgenera and the pattern of the dorsal plates as the criterion for the division of the subgenera into sections.

Jörgensen divided the genus Peridinium into two subgenera, Orthoperidinium and Metaperidinium, and discarded the subgeneric names used by Gran. Orthoperidinium is characterized by a first apical which touches only four of the major plates of the epitheca; the second apical and first precingular are on the left side, the fourth apical and seventh precingular on the right side (fig. 4A). Metaperidinium is characterized by a first apical plate which borders five or six of the principal plates of the epitheca; the second apical and the first and second precingulars are on the left side, the fourth apical and the seventh, or the sixth and seventh, precingular on the right side (fig. 4B, C).

Orthoperidinium was divided into three sections, principally on the basis of the dorsal epithecal plates, as follows:

Tabulata, in which the second anterior intercalary borders the third and fourth or the fourth and fifth precingular plates (fig. 5C).

Conica, in which the second anterior intercalary touches the third, fourth, and fifth precingulars (fig. 5B).

Oceanica, in which the second intercalary touches only the fourth precingular (fig. 5A).

Metaperidinium was divided into four sections, as follows:

Pyriformia, in which the second anterior intercalary plate touches two precingular plates, as in section Tabulata of Orthoperidinium (fig. 5C).

Paraperidinium, in which the second intercalary borders the third, fourth, and fifth precingulars (fig. 5B); the first apical plate is bounded by six of the major plates of the epitheca (fig. 4C): the second apical and first and second precingulars on the left side, the fourth apical and sixth and seventh precingulars on the right side. Jörgensen did not give this group subgeneric rank because there was considerable variation in the length of the suture between the first apical and sixth precingular plates; the suture is sometimes quite short.

Humilia, in which the second intercalary touches only the fourth precingular (fig. 5A); with solid antapical horns.

Divergens, as Humilia but with hollow antapical horns.

Jörgensen thus established not less than seven categories for the grouping of the species of Peridinium. The number had thus become greater than when Gran devised his simple classification, and it demanded a more rigorous examination of the material.

Although the thecal plates in Peridinium were known by Jörgensen to present several patterns, the number of plates in the theca was considered by him to be constant. He (1913) described the genus as having three anterior intercalary plates. Forms which had only two intercalaries and which had been included in Peridinium by others he placed in a new genus, Archaeoperidinium (fig. 6B).

Jörgensen's comprehensive classification of the Peridinium species on the basis of the plate pattern laid the foundation for a clearer understanding of the composition of, and the relationships within, the genus than had ever before been possible. It promised to end the taxonomic difficulties which this genus presented. His classification was accepted by practically all later workers up to the present time and has been extremely helpful.

As is shown in this paper, however, even this system is not adequate for the proper classification of the great number of variants which occur.

Paulsen (1931) revised the system of Jörgensen (see also Peters, 1928, and Dangeard, 1927). He considered the classification of Jörgensen unnatural, and proposed a system in which not only the plate pattern, but a combination of plate pattern and other characters was used. He abolished the subgenera of Jörgensen but retained the sections with some revision.

Paulsen (1931) referred to Jörgensen's Archaeoperidinium as a subgenus of Peridinium, as had been done by Lebour (1925) and others. This subgenus is characterized by having only two anterior intercalary plates.

The second subgenus, with three intercalary plates, Paulsen called Veroperidinium. This is equivalent to the subgenus Peridinium proper of Lebour.

Paulsen divided the subgenus Archaeoperidinium into two sections:

Avellana, in which the two intercalaries are equal.

Excentrica, in which the two intercalaries are very unequal.

The subgenus Veroperidinium he divided into eight sections, seven of which corresponded roughly to the sections of Jörgensen. The eighth section, Paradivergentia, was new. A summary of his sections of Veroperidinium follows. In describing the relation of the dorsal plates he used the terms "quadra," "penta," and "hexa" to designate the number of sides on the second anterior intercalary, and "ortho," "meta," and "para" to designate a four, five, or six-sided first apical.

Pellucida: Para hexa, rarely para penta or quadra or meta hexa. Right-handed. Without antapical horns; has two, or more frequently three, antapical spines. This section corresponds to Paraperidinium of Jörgensen.

Humilia: Meta quadra. Right-handed, without horns, but often with two antapical spines.

Pyriformia: Meta penta, rarely quadra or hexa. Right-handed, without antapical horns, but in general has two antapical spines.

Tabulata: Ortho penta or hexa or quadra. Left-handed or with circular girdle. Cell round, without horns or spines, or with slight spines.

Paradivergentia: Para quadra or hexa. Right-handed or with circular girdle; with two hollow antapical horns.

Divergentia (= Divergens Jörgensen): Meta quadra, rarely penta. Girdle circular or right-handed; with two hollow antapical horns.

Oceanica: Ortho quadra, rarely penta or hexa (or even para). Left-handed. Girdle oblique relative to the longitudinal axis of the body. Epitheca narrows into an apical horn; two hollow antapical horns.

Conica: Ortho hexa, more rarely penta or quadra. Girdle circular or left-handed. Body square or rhomboid in ventral view, without apical horn but usually with two hollow antapical horns.

Paulsen's classification is an improvement over Jörgensen's (1913), for it takes into consideration the occurrence of a greater number of combinations of characters. In so doing, however, Paulsen acknowledged the occurrence of a greater number of variations in the characters which have been used as fundamental taxonomic units.

All the classifications devised so far have been based on a certain stability of the plate pattern within the species, particularly in the region of the first apical plate and the dorsal epithecal plates. Furthermore, all are based on the presence of three anterior intercalary plates in Peridinium proper. As is shown below, in the present investigations, forms in the section Oceanica have been found with only two intercalary plates.

It should finally be noted that should a subgeneric classification be re-established for the sections, this must be done with due consideration to the international rules of nomenclature. When a new classification is proposed, there is no justification for the introduction of completely new terms. Old names must be retained, with only the termination changing if they are given altered rank (International Rules of Botanical Nomenclature, 1935, art. 51). These rules were completely disregarded by Jörgensen and Paulsen. Thus Gran's subgenus Protoperidinium, for instance, has not been perpetuated.

### Methods of Study

**Selection of material.** Since it would have been an insurmountable task to treat a really representative number of species of this large genus, a compromise plan of study had to be devised. For the sake of rendering an initial contribution to the exact knowledge of the thecal morphology of *Peridinium*, representatives from each of the major groups of the genus were selected for detailed dissection, viz., *P. depressum* from *Orthoperidinium*, *P. crassipes* and *P. truncatum* from *Metaperidinium*, and *P. pallidum* from *Paraperidinium*. The results of these investigations give some information about both the generic unity and the interrelationships of the lower than generic groups.

In addition to these detailed dissection studies, a statistical analysis was made of *Peridinium depressum* and of its relatives comprising the Formenkreis *Peridinium depressum* of Broch (1906). This work was undertaken in order to establish a method of attack on a very variable group. Thus, these studies have a threefold purpose: first, to acquire a knowledge of skeletal morphology; second, to learn something of specific interrelationships and generic unity; third, to inquire into the nature of specific variability, a feature of exceptional significance in this group.

**Measurements.** In determining the size and in computing ratios expressive of the shape of the *Peridinium* body, certain measurements were used. Measurements made with the specimen presenting the ventral face (p. 1) are indicated schematically by figure 7. Designations of dimensions in that figure are as follows: *a*, length of right antapical horn, considering the base of the horn as a curved continuation of the lateral body contour running to the base of the right side of the sulcus; *b*, thickness of the right antapical horn measured midway between its base and apex; *d*, diameter of the body at the girdle; *h*, distance between the end of the apical horn and the base of the right side of the sulcus; *l*, total length, or distance between the ends of the apical and right antapical horns;  $\alpha$ , the angle representing the degree of convexity of the lateral profile. The angle  $\alpha$  is constructed with its vertex in the girdle at the right edge of the body, and with its sides intersecting the body walls at points at a distance from the vertex equal to one-fourth of *d*.

Measurements made with the specimen presenting the apical view are indicated schematically by figure 8. Designations of dimensions in that figure are as follows: *g*, dorsoventral diameter measured through the midbody; *r*, in some species, e.g., *P. truncatum*, it is necessary to measure the prolongation of the ventrolateral limbs of the body in the equatorial region. The value *r* is obtained as follows: Construct a line passing through the apex (*b*) and the farthest point on the right limb (*a*). On this line erect a perpendicular at point *c*. The point *c* is determined by its distance from *a* which equals one-third *g*. The thickness of the limb, *r*, is measured along this perpendicular.

Various features of the body shape can be expressed by the dimensional proportions. The best reference for most of these ratios is the diameter (*d*). It can be measured in either the ventral or the apical view and is in itself a good standard for the absolute size of the specimen.

The general body form can be expressed by the

angle  $\alpha$  and the ratio of the length to the diameter of the body. In computing the latter ratio, *h*, was frequently used instead of, or in addition to, *l* because a slight displacement of the specimen sometimes caused more error in *l* than in *h* on account of the divergence of the right antapical horn in some forms. The distance *h* does not include the antapical horn, which has a tendency to vary more than the apical horn, so that the value *h/d* gives a more accurate criterion of the length of the body than does the ratio *l/d*.

In expressing the relative length of the antapical horns, it is usually necessary to measure only one of these structures, as the variation is usually proportional. In this work the length of the right horn was measured, as it usually presents a truer value because of its lesser degree of inclination in the ventral view. The length relative to the diameter of the cell, *a/d*, was then computed. For the relative thickness of the antapical horns the ratio *b/a*, the thickness of the right antapical horn in relation to its length, was computed.

Where the shape of the body in apical view was important, the *g/d* ratio was computed. The thickness of the lateral limbs in apical view was found to be best expressed by the ratio *r/g*.

The width of the girdle was always measured and many smaller measurements referred to this.

### Peridinium depressum Bailey and related forms

**Introductory remarks.** Broch (1906) designated as the "Formenkreis *Peridinium depressum* Bailey" a group of highly variable and intergrading forms closely related to *P. depressum* Bailey. This species is an *Orthoperidinium* with a four-sided second anterior intercalary plate. The members of the group present one of the most difficult taxonomic problems of the Peridineae. They have been studied by several investigators, whose results have been at variance and decidedly confusing. Because of this fact, and since the Carnegie collection was rich in these forms, this group was subjected to an intensive analysis in order not only to solve the problems of this particular group, but also to formulate methods and concepts which might be applied to the genus as a whole or to other groups of the Peridineae which present a series of variable and intergrading units.

**Diagnosis.** The group as conceived in this report includes all the species of *Orthoperidinium* in which the plane of the girdle is inclined to the longitudinal axis. All these species are confined to Jørgensen's section *Oceanica*. They are, indeed, the only forms now known in the entire genus with a strongly inclined girdle, except *P. amplum* Matzenauer. In the latter species, however, the apical and antapical horns do not lie in the same plane, a feature characteristic of the "Formenkreis." The species in this group are mostly large, usually with prominent horns, and the girdle is left-handed.

**Extent of the group.** The following forms have been described in the literature:

- P. depressum* Bailey (1855)
- P. depressum* f. *brevisulcatum* Dangeard (1927a)
- P. parallelum* Broch (1906)
- P. saltans* Meunier (1910)
- P. antarcticum* Schimper (Karsten, 1905)

*P. claudicans* Paulsen (1907)  
*P. polymorphum* Lindemann (1924)  
*P. oceanicum* Vanhöffen (1897a, 1897b)  
*P. oceanicum* f. *arupinense* Broch (1910b)  
*P. oceanicum* var. *parvulum* Mangin (1913)  
*P. oblongum* Aurivillius (1898)  
*P. oblongum* var. *symmetricum* Dangeard (1927a)  
*P. oblongum* var. *inaequale* Dangeard (1927a)  
*P. oblongum* var. *latidorsale* Dangeard (1927a)  
*P. obliquum* Dangeard (1927a)  
*P. murrayi* Kofoid (1907)  
*P. murrayi* var. *occidentale*, Pavillard (1931)  
*P. murrayi* var. *orientale* Matzenauer (1933)

In the present report only those forms occurring in the Carnegie collection are treated. They are:

*P. depressum* Bailey  
*P. depressum* var. *parallelum* Broch  
*P. depressum* var. *rectius* n.var.  
*P. depressum* var. *convexius* n.var.  
*P. depressum* f. *bisintercalares* n.f.  
*P. depressum* f. *multitabulatum* n.f.  
*P. claudicanoides* n.sp.  
*P. oceanicum* Vanhöffen  
*P. oceanicum* var. *tenellum* n.var.  
*P. oceanicum* f. *spiniferum* n.f.  
*P. oceanicum* f. *bisintercalares* n.f.  
*P. oceanicum* f. *tricornutum* n.f.

**Methods of study.** The first well-considered classification of the Peridinium depressum group was based on the principles outlined by Jørgensen (1913) for the genus as a whole. This classification presupposes a stability in the number and arrangement of the major plates of the theca. The inadequacy of the last assumption when applied to the Peridinium depressum group will be clear from the following historical review and consideration.

Jørgensen (1913) described the genus Peridinium as having the following pattern: 4ap, 3a, 7pr, 5po, 2ant. Lebour (1925) and Paulsen (1931) broadened the concept of the genus. They included Jørgensen's Archaeperidinium, which has only two intercalary plates, and divided the genus into two subgenera: Peridinium with three, Archaeperidinium with two intercalary plates. In the present investigations, forms in the section Oceanica of the subgenus Peridinium were found with only two intercalary plates (pp. 21, 24); and Dangeard (1927b) reported a variety with only one intercalary (see next paragraph). Thus, this subgeneric character has been shown invalid.

From the Peridinium depressum group the following examples of plate variation may be given. Barrows (1918) described a specimen of P. oceanicum, which is closely related to P. depressum, with the ventral epithelial plates of the Paraperidinium type. Dangeard (1927b) described what he called a variety of P. depressum with the ventral epithelial plates of Paraperidinium and the dorsal plates of the section Pyriformia. Considering the body form and the inclined girdle of this specimen, along with its plate pattern, it is either a distinct variety or a species, unquestionably belonging to the group related to P. depressum. Dangeard (1927b) also described some aberrant plate patterns in P. oblongum. These variants he designated as varieties, as follows: var. symmetricum, with the usual dorsal epithelial pattern of the section Oceanica; var. *inaequale*, with the pattern of the section Tabulata; and var. *latidorsale*, with only one intercalary plate (subgeneric character). This single intercalary plate borders plates 2pr, 3pr,

4pr, and 5pr according to his figure. In his table (p. 11) he states that it also borders plate 6pr.

Barrows (1918) was of the opinion that there are only four unstable areas in the theca of Peridinium. Variation, he maintained, occurs only in the areas at the two sides of the first apical, and at the sides of the second intercalary along with the adjacent plates involved in any pattern. Other variable areas, however, were found later. Peters (1928) described two patterns in P. depressum in regard to the epithelial plates.

The variation on the lateral sides of the epitheca involves plates 2ap, 2pr, 1a, and 3pr on the left side and 4ap, 6pr, 3a, and 5pr on the right side (fig. 9). The various patterns will be referred to in the pages to follow as the first and second symmetrical, and the first and second asymmetrical patterns. In the first symmetrical pattern, 2ap touches 3pr, and 4ap touches 5pr (fig. 9A). In the second symmetrical pattern, 2pr touches 1a, and 6pr touches 3a (fig. 9B). In the first asymmetrical pattern, 2pr touches 1a but 4ap touches 5pr (fig. 9C). In the second asymmetrical pattern, 2ap touches 3pr but 6pr touches 3a (fig. 9D).

Peters (1928) reports all four of these patterns in P. depressum. Lindemann's (1925, figs. 10, 11) figures of P. marinum (= P. depressum) show the first symmetrical and the first asymmetrical patterns. In the Carnegie material they were not all found in the same species. In P. depressum the first symmetrical and first and second asymmetrical were found; in P. oceanicum the first symmetrical and first asymmetrical; in P. claudicanoides the second symmetrical and first asymmetrical.

These patterns are not stable features of the theca. The length of the critical sutures between the four plates in question on each side of the shell varies. In species where more than one pattern occur, there is an intergradation of the different patterns. Specimens occur in which the edges of the four plates meet at a common point, representing an intergrade between two patterns. Lebour (1925, pl. 23d) shows this condition on both sides of the theca, but this may be an error in drawing. Peters (1928) found the common intersection on each side of the theca in different specimens. In the Carnegie material this condition was found only in P. depressum and only on the left side (fig. 9E). These observations upset Barrow's contention that the edges of four plates never meet in a common point and that an intergradation never occurs between two alternate plate patterns (1918, pp. 453, 455).

In order to study this intergradation and present it graphically, measurements were made of the critical sutures in species in which the first symmetrical and first asymmetrical patterns occur. The following computation was made: The length of the critical suture on the left side was divided by the length of the critical suture on the right side and the quotient called the x-ratio. In the symmetrical pattern the ratio was considered a positive quantity and in the asymmetrical a negative quantity. Obviously, in the case of the intergrade pattern (fig. 9E) the ratio was zero.

The x-ratio was computed for 144 specimens of P. depressum, P. oceanicum, and varieties selected at random. The ratios were grouped into 0.10 unit classes and the frequency of the classes plotted (fig. 10). It is evident that in the Carnegie material the symmetrical was the commoner pattern, occurring in about 87 per cent of the specimens. The commonest x-ratios were from +0.5 to

+1.0. Two intergrades were found in these random samplings, represented by the two specimens with x-ratios of 0.0. In the symmetrical pattern the critical suture on the left side varied from 0 to 1.6 times as long as the one on the right side; in the asymmetrical pattern the alternate suture varied from 0 to 0.9 times the one on the right side.

These observations show definitely that plate pattern in this group of species is not a stable feature but that there is a variation both in the length of the sutures and in the relative position of the plates, and that between two patterns there is a continuous line of intergrades.

Thus, it is evident that the epithelial plate pattern alone cannot be used for the classification of the species related to P. depressum and that it must be used with considerable discretion in other parts of the genus as well.

The hypothetical pattern is constant throughout the genus, so that it, too, cannot be used. In the present investigations the tabulation of the ventral area was studied. Although it differs greatly in different parts of the genus, it was found to be identical throughout the "Formenkreis P. depressum." Thus, the plate pattern of no part of the theca is of any value in classifying the units of the group now under consideration.

For this reason, a new method had to be devised for this purpose. In order to determine whether or not specific and varietal segregations can be made on the basis of body shape, the material in the Carnegie collection related to P. depressum was studied from this standpoint. The results showed that the "Formenkreis P. depressum" is made up of several units, some of specific value, others of varietal, and that these are expressed by the shape of the body.

In order to make proper segregations on the basis of body shape, it is necessary that this feature be described by numerical expressions so that the frequency of variations can be plotted. In order that the accumulated information of the various workers may be comparable, these numerical expressions must be of a standard nature. For instance, the conclusions in the present work stand partly in opposition to those arrived at by Peters (1928). Even though this is in most part due to the different material used, it is probably also due to the different methods employed in measuring the body proportions. For this reason, the proposed standard methods for orienting and measuring the specimen described above (pp. 1, 2, 13) were used in this work.

When numerical expressions are used, a large number of specimens can be measured, the body proportions computed, the values grouped into convenient classes, and the frequency of these classes plotted. In the interpretation of the frequency diagrams, it is necessary to have in mind a standard expression of the species concept. The following definitions of the various units have been used in this report.

It is assumed that a species represents a group of individuals which is morphologically distinct or nearly so in one or more features. The presence of intergrades in a very small proportion of the specimens is not considered to vitiate the specific segregation. Varieties may be considered incipient species which also have a certain morphological distinctness but which are

connected with the main species by a higher proportion of intergrades. Forms are considered as temporary expressions due either to internal or to environmental causes. They are characterized by rarity of occurrence. These are the main concepts which have been used in the classification of the Carnegie material given below.

Example of application of method. The first problem in the "Formenkreis" to be attacked by the statistical method was the determination of the validity of P. oceanicum Vanhöffen as a specific unit.

Vanhöffen (1897a) figured P. oceanicum as a species similar to P. depressum but longer and more slender. This was accepted as a valid species by most authors. Peters (1928), the only previous investigator to make a numerical study of the body proportions in this group, took exception to this. On the basis of antarctic material and of one sample of North Sea material, he concluded that P. oceanicum represents simply one end of a line of variation which includes both P. depressum and P. oceanicum, although he recognized "broad" and "slender" forms.

In the present investigations 170 random specimens of the "Formenkreis" from widely scattered Carnegie stations in the North Atlantic were measured and the  $h/d$  ratios computed. The frequencies of the length, width, and  $h/d$  classes were plotted as shown in figures 11-13. As is apparent from figure 11, this group of specimens was homogeneous so far as length was concerned. Some length classes were somewhat more common than others, but they were all connected by numerous intergrades. There was no indication of separated variation groups. Similar results were obtained in a study of the frequency of the diameter classes (fig. 12). This indicated an even more unified group except for the small group at the 70-micron and 75-micron classes, which further observation of the material failed to justify as a distinct unit.

The diagram of the plotted frequencies of the  $h/d$  ratios, however, indicated two variation groups (fig. 13). One centered about the 0.90-unit class, the other around 1.35. The extremes of the first group ranged from 0.65 to 1.20 and of the second group from 1.20 to 1.75.

We have here a basis for assigning specific values to two forms: a broad form, P. depressum, in which the  $h/d$  ratio is less than 1.20; and a slender form, P. oceanicum, in which that ratio is more than 1.20. Any specimen with an  $h/d$  ratio of about 1.20 must be considered a transitional form between the two species. One such was found in the above samplings, as indicated in the diagram. It must also be concluded, therefore, on the basis of the above studies, that these two species are very close. Indeed, more extended studies of other material may bring them closer than is indicated by the above data.

It is clear from these studies, however, that we are not dealing here with a single homogeneous group, and that P. oceanicum does not represent simply one end of a line which includes both P. depressum and P. oceanicum, as Peters (1928) contended.

The further application of this statistical method in this group will be taken up in the discussions under the particular species.

*Peridinium depressum* Bailey  
(Figure 14)

- Peridinium depressum* Bailey, 1855, pp. 12-13, pl. figs. 33, 34. Jørgensen, 1899, p. 36, tabs. 4, 18, 30, 44, 58, 72. Ostenfeld, 1900, p. 57, tabs. 2-7. Cleve, 1900b, p. 257. Jørgensen, 1901, p. 34. Gran, 1902, pp. 186, 191-192. Jørgensen, 1905, p. 109. Van Breeman, 1905, p. 43. Broch, 1906, pp. 151-157, fig. 1. Paulsen, 1907, pp. 11, 15. 1908, pp. 39, 53, fig. 67. Broch, 1908, p. 5. 1910, pp. 51-52, fig. 26. Meunier, 1910, p. 27. Paulsen, 1913, pp. 276-279, pl. 46. Mangin, 1913, pp. 158-160, 162-164, 166-169, 171, 177-178, 180, 187, 220-222, fig. 9, tabs. 1-3. Jørgensen, 1913, pp. 5-6. Forte, 1922, pp. 89, 188, 207. Lebour, 1925, p. 119, pl. 23, figs. a-f. Dangeard, 1926, p. 322, fig. 10. Dangeard, 1927b, p. 2, figs. 1A-1C. Paulsen, 1930, pp. 55, 68. Pavillard, 1931, pp. 55, 64-65, 111-112, 114-115, 121, 123, 125, 127, 129, 131, 133, 137, 157, 159, 161, 165, 169, 173, 177, 183, 185, 191, pl. 2, figs. 6A-6E. Gran, 1933, p. 162, 180.
- ? *Peridinium divergens*  $\gamma$  *reniforme* Ehrenberg, 1854, p. 240. Meunier, 1910, p. 23, pl. 1, figs. 1-4.
- Ceratium divergens* Claparède and Lachmann, 1861, p. 71, pl. 13, fig. 23.
- Peridinium divergens*, Bergh, 1881, pp. 63, 67, 70, 73. Bergh, 1882, pl. 15, fig. 45. ? Stein, 1883, pl. 11, figs. 1, 2. Vanhöffen, 1897a, pp. 267-268, pl. 5, fig. 1. Cleve, 1900a, figs. 15, 16. Meunier, 1910, pl. 2, figs. 45, 46. Lebour, 1917, p. 186. Meunier, 1919, pp. 12-14, pl. 15, figs. 1-5.
- Peridinium divergens* variété, Pouchet, 1883, p. 40, pls. 20, 21, fig. 23.
- Peridinium divergens* var. *reniforme*, Pouchet, 1883, p. 40, pls. 20, 21, figs. 24-27.
- not *Peridinium divergens* var. *typus*, Pouchet, 1883, p. 38, pls. 20, 21, figs. 20, 21. Ostenfeld, 1899, p. 60, 84, tabs. 1-8.
- Peridinium divergens* var., Schütt, 1895, pl. 13, figs. 43(22), 43(24). Meunier, 1910, pl. 1 (bis), figs. 1, 2, 7, 8.
- Peridinium divergens* var. *depressa*, Aurivillius, 1898, p. 55. Ostenfeld, 1899, pp. 60, 70, 86, tabs. 1-8.
- Peridinium elegans* Cleve, 1900a, in part, pl. 7, fig. 16.
- Peridinium depressa*, Ostenfeld, 1900, tab. 1.
- Peridinium divergens* var. *depressum*, Karsten, 1907, p. 466.
- Peridinium kofoidii* Fauré-Fremiet, 1908, pp. 224-226, fig. 11, pl. 16, fig. 12. Mangin, 1913, p. 222.
- Peridinium marinum* Lindemann, 1925, pp. 98-99, figs. 7-11.
- Peridinium marinum* var. *travectum* Lindemann, 1925, p. 99, fig. 12.

**Dimensions.** Length of body ( $l$ ) 187 (114-228) microns; diameter ( $d$ ) 137 (108-160) microns. Width of girdle, about 7 microns. Eighty specimens were measured.

**Shape.** Length of body, exclusive of antapical horns, normally equal to diameter of body at girdle as shown by the  $h/d$  ratio, which is 1.00 (0.77-1.18). The angle  $\alpha$  is  $95^\circ$  ( $78^\circ$ - $105^\circ$ ). The  $a/d$  ratio is 0.39 (0.21-0.65); that is, length of right antapical horn normally about 0.4 times width of body at girdle. The  $b/a$  ratio is 0.14 (0.08-0.27); that is, right antapical horn normally about 0.14 times as thick as long.

Cell body very asymmetrical. Roughly, the mid-body is a lenticular mass depressed along an anteroventral-posterodorsal axis running at an angle of about  $55^\circ$  to plane of girdle. Epitheca tapers abruptly on lateral and dorsal faces, but gradually on ventral side, into an apical horn which extends along an axis which lies at an

angle of about  $65^\circ$  to the axis of depression of mid-body. Hypotheca terminates in two antapical horns which are pointed and more slender than the apical horn. Right antapical horn may lie parallel to axis of apical horn, but usually diverges somewhat laterally to the right. The left one is shorter than the right and diverges from it laterally and ventrally. The girdle leaves the sulcus on the left side of the body, curving forward to a point about halfway to the left side of body, where it begins to turn gradually backward. This backward curvature is continued entirely around the body, so that the distal end of the girdle terminates on the right side of the sulcus from 1.5 to 2.5 girdle widths behind the proximal end. This does not represent the maximum displacement of the girdle, however, which occurs between the distal end and the front of the curvature to the left of the sulcus. This displacement is about 3 girdle widths. The displacement of the girdle can be seen only when the specimen is viewed ventrally. When the specimen is allowed to come to rest in a drop of water on its posterodorsal surface, a position commonly represented in published figures, no displacement of the girdle is evident (fig. 14A). Girdle not concave. Body reniform in apical or antapical view, with the indentation at sulcus. The  $g/d$  ratio, about 0.75. Ventral area narrow, with more or less parallel sides, 2.0 to 2.5 girdle widths wide. Sulcus proper deeply embedded, extending to ant-apex. Anteriorly the ventral area extends very slightly beyond proximal end of girdle.

**Plate pattern.** The first symmetrical and first asymmetrical patterns occurred in the proportion of about 4 to 1. The frequency distribution of the two patterns is shown in figure 10.

The apical horn terminates in a more or less truncated apex, about 8 microns in diameter. This region is much more complex than was at first supposed. It is not formed simply by the apical ends of the four apical plates. In fact, the first apical plate ("rhomboid plate" of Kofoid or "Rautenplatte" of Butschli) does not extend entirely to the apex. The first apical, or rhomboid, plate terminates about 9 microns below the apex, where it borders on a narrow ventral apical platelet (v.a.p., fig. 15) which extends to the apex. This platelet is almost rectangular in outline, about 9 microns long and slightly more than 2 microns wide. Its posterior end is convex, where it fits into an equivalent concavity in the anterior end of the rhomboid plate. This convexity may be slight or, in some cases, extreme. Since the rhomboid plate does not reach the apex, it is not an apical plate, strictly speaking. It seems desirable, however, to retain the term "first apical" for this plate because the ventral apical platelet is extremely small and perhaps not equivalent to the other apicals. The possibility of the homology of this platelet with the major plates of the other genera, however, should not be overlooked.

The exterior of the apex is formed by the ventral apical platelet on the ventral side and the anterior ends of the second, third, and fourth apical plates on the left, dorsal, and right sides, respectively. The joining of these plates is strengthened interiorly by a pore platelet, sleeve-like in form, around which the ends of the exterior plates fit snugly. This apical pore platelet (a.p.p., fig. 15) is about 5 microns in diameter and 3 microns long. Its walls are about 1.5 microns thick, so that the apical pore, representing the bore of this sleeve, is about 2 microns in diameter.

The girdle is composed of four plates (1g-4g, fig.



16). The first girdle plate (1g) is a short plate, about 5 microns long, at the proximal end of the girdle, where it borders the anterior plates of the ventral area. The second girdle plate (2g) extends from 1g between plates 1pr and 1po, as far as the lateral edges of the latter plates, so that the suture 2g/3g is continuous with the sutures 1pr/2pr and 1po/2po. The third girdle plate (3g) is very long and runs completely around the dorsal side of the body to a corresponding suture on the right ventral side at the lateral edges of plates 7pr and 7po. The fourth girdle plate (4g) runs from 3g to the right side of the sulcus forming the distal end of the girdle.

The skeletal structure of the ventral area is very complex as compared with the skeletal composition of the rest of the body. Externally the sulcus is composed of five plates (figs. 17, 18; pl. 1, figs. A, B). The anterior sulcal plate (a.s.) is at the right anterior end of the ventral area. Its anterior end runs slightly into epitheca above proximal end of girdle; posteriorly it expands and forms the anterior edge of flagellar pore. The left sulcal plate (l.s.) composes most of left side of sulcus. Its right edge forms the left edge of flagellar pore. The posterior sulcal plate (p.s.) is a narrow, roughly U-shaped plate constituting posterior end of sulcus. The right sulcal plate (r.s.) occupies right side of sulcus and its left edge forms right edge of flagellar pore.

From both the anterior and posterior edges of the flagellar pore, there extend into the cell body two internal processes, the anterior pore process (a.p.p.) and the posterior pore process (p.p.p.). These processes (figs. 17B, 18A, B) are curved in cross section so that they form grooves running into the cell body, apparently forming supporting structures for the two flagella which emerge from the cell body at the flagellar pore. The anterior pore process is constructed principally of an internal extension of the posterior edge of the anterior sulcal plate. On the right side, it is tied to the right sulcal plate by the right internal sulcal plate (r.i.s.), which runs along the entire right edge of the process, and posteriorly along the left interior edge of the right sulcal plates, and part way along the posterior pore process. Along its entire course it is underlaid by a membrane (m) attached to its adjacent plates. The left side of the anterior pore process is formed in part by the anterior groove list (a.g.l.), which also extends part way along the external portion of the anterior sulcal plate. The groove in the posterior pore process, as it comes to the surface, runs posteriorly to the end of the sulcus. The internal portion of this groove, i.e., the posterior process, is formed on the right side principally by an extension of the right sulcal plate. The posterior and left sides are formed by a separate plate, the posterior accessory sulcal plate (p.a.s.). Where the posterior groove runs along the exterior, however, it is overlaid by a listlike process originating from the sides of the posterior and right sulcal plates, the posterior groove list (p.g.l.). The exterior extension of the posterior groove is open on the left side but covered ventrally by this list (figs. 17, 18C; pl. 1, figs. A, B).

The right edge of the flagellar pore is bounded by the right accessory sulcal list (r.a.s.), which is attached along the edge of the right sulcal plate. In its posterior portion it joins with the posterior groove list.

A cross section of the right sulcal plate (fig. 18D) shows the curvature of that plate as well as the relative position of the right accessory sulcal list and the membrane to which the right internal plate attaches.

Thecal wall. Surface of plates sculptured with irregular reticulation which is difficult to demonstrate, except at intersections, where it is raised into irregular points.

Pores occur throughout all major plates, irregularly scattered and bearing no relation to reticulations; absent in girdle plates.

Boundaries between plates vary from simple sutures to wide intercalary zones. Rabbit joints present in all parts of theca (see p. 10). Intercalary zones and rabbit membranes occur in the girdle at the 2g/3g and the 3g/4g sutures corresponding to the similar structures in the plates of the epitheca and hypotheca adjacent to the girdle (fig. 16A).

Lists. Cingular lists 8 to 10 microns wide, usually somewhat broader at the left ventral side. They are strengthened at the base by short ridges which connect with similar strengthenings in the girdle and body plates, and at the outer edge by ridges which extend about halfway to the center of the list (pl. 1, fig. A).

The apical list (fig. 15; pl. 1, fig. C) encircles the apex dorsally and laterally, but ventrally it runs down each side of the ventral apical platelet and extends part way down the sides of the first apical plate. It forms a collar around the apex about 2 microns in height, slightly funnel-shaped with serrated edge. Toward the posteroventral ends, the list diminishes in width gradually and terminates on each side of the first apical plate about 5 microns below the anterior end of that plate. Laterally, from the apex, there is a list on each side which runs from the apical list posteriorly. The right lateral list (r.l.l.) extends down the suture between the third and fourth apical plates, and the left lateral list (l.l.l.) extends down the suture between the second and third apicals. These lists are of the same width as the apical list near the apex, but narrow gradually and end at points about two-thirds of the way down the third apical plate. The origin of the apical and lateral lists is not as might be expected from a study of an intact specimen. Separation of the apical units, as shown in figure 15B, demonstrates the attachment of the lists. The apical list is composed of three parts: the dorsal, right, and left segments. The dorsal segment of the apical list (d.l.) and the lateral apical lists are continuous and are attached to the third apical plate along its anterior and lateral edges. The left segment of the apical list (l.a.l.) with its continuation down the ventral side of the horn is attached to the second apical plate along its anterior and anteroventral edges. The right segment of the apical list (r.a.l.) with its continuation down the ventral side of the horn is attached to the fourth apical plate along its anterior and anteroventral edges.

In an intact specimen it is difficult to see the apical list except where one looks through considerable thickness of the list in the arcs which are tangent to the lines of vision. It thus appears as two spines in whatever longitudinal view the specimen is observed. This explains the real nature of the prominences which are frequently shown in figures of this species.

The more carefully drawn figures of this species have shown that the first apical plate terminates below the apex, but the space anterior to it has been indicated as a separation continuous with the apical pore. This space, as is now shown, is occupied by the ventral apical platelet.

The ventral area is almost entirely bounded by a system of lists which are attached to the body plates

surrounding the area. On the left side a wide list, the left sulcal list (l.l.), runs along the first postcingular plate (to which it is attached) to the suture between this plate and the first antapical plate. This list is a continuation of the posterior cingular list. The posterior sulcal list (p.l.) extends from the above suture around the posterior end of the sulcus to the suture between the second antapical and the fifth postcingular plates. It is attached to the sulcal edges of the two antapical plates. Where this list turns from the sides of the sulcus down to the posterior end, it runs parallel with the line of vision when the specimen is viewed ventrally. When viewed on an intact specimen, this list is visible frequently only at the posteroventral corners of the sulcus, where considerable thickness of the upturned list results in greater interference of light and gives the impression of two spines. Specimens have often been figured with these two "spines" at the bases of the antapical horns. The posterior right sulcal list (p.r.l.) extends from the posterior cingular list to the suture between the fifth postcingular and second antapical plates. It is attached to the former plate and is continuous with the posterior cingular list. The right and left sulcal lists, when seen from the apical or antapical ends, appear as two spines near the ends of the cingular lists and have frequently been so drawn or referred to as "teeth" at the base of the antapical horns. The anterior right sulcal list (a.r.l.) is a structure of the epitheca. It borders the right edge of the sulcus which extends into the epitheca, but is attached to the sulcal edge of the seventh precingular plate and is continuous with the anterior cingular list.

**Variation.** There is variation in the habitus of the species, as can be seen from the specimens presented in figure 19. It should be noted that the differences in the habitus of these specimens are due chiefly to the variations in the length, thickness, and degree of divergence of the antapical horns, and in the length of the apical horn. That the pronounced differences in the shape of the mid-body which are suggested by this figure are more apparent than real, was demonstrated by proportional measurements of the specimens. These measurements all fell within the limits of the species (p. 16).

For variation in the plate pattern, see p. 14. The tabulation of the ventral area and girdle is constant.

**Comparisons.** The species of the "Formenkreis" P. depressum comprise the greater part of the section Oceanica of Orthoperidinium. They can be distinguished from the other species of the section by the inclined girdle. Also, the other species are mostly much smaller, e.g., P. obtusum Karsten and P. bulla Meunier.

Within the "Formenkreis," P. depressum can be distinguished from the other species by its body shape. It is very similar to P. oceanicum (see p. 15), but can be distinguished from the latter by its lower  $l/d$  ratio (less than 1.20) and lower angle  $\alpha$  (less than  $105^\circ$ ).

Peridinium claudicanoides n.sp. of this "Formenkreis" can be separated from P. depressum by its cuneate antapical horns and by its  $b/a$  ratio, which is greater than 0.23.

**Historical.** Bailey (1855) described and figured P. depressum in an easily identifiable manner. Some early authors, e.g., Pouchet (1883) and Cleve (1900b), considered this form to be identical with P. divergens Ehrenberg (1840). Others, e.g., Bergh (1881) and Meunier (1910), were somewhat more discriminating and considered P. depressum to be identical only with the variety

which Ehrenberg (1854) described as P. divergens  $\gamma$  reniforme. It is possible that this variety and P. depressum are identical, but since the figure of Ehrenberg (p. 240) cannot be identified with any measure of certainty, and since Bailey's figures are readily recognizable, it is advisable to retain the now universally accepted name depressum for this species.

Since the importance of the plate pattern in the classification of the species of this genus was not realized until the present century, and since neither Ehrenberg nor Bailey indicated the tabulation for the two species in question, considerable confusion developed regarding these forms. There was even a tendency to lump all large forms of Peridinium under one species, viz., P. divergens Ehrenberg, which was the first to be described in the genus.

After Broch (1910) and Jørgensen (1913) had demonstrated the importance of tabulation in this genus, it became necessary to determine the plate patterns of the various species which had been described earlier.

In the case of P. depressum this was not difficult, as the figures of Bailey are easily identifiable. This form has the Orthoperidinium tabulation, one which was first indicated for this species by Pouchet (1883, pl. 21, fig. 26) under the name of P. divergens var. reniforme.

In the case of P. divergens, it is impossible to establish the tabulation except on an arbitrary basis, since neither the description nor the figures of Ehrenberg are identifiable. The first figures of tabulation shown under the name of P. divergens are those of Stein (1883), but unfortunately, as Lebour (1925) states, Stein figured at least three species under this name. It is not difficult, however, to select figures 2 to 6 of plate 11, as those which are most likely to represent Ehrenberg's P. divergens. For the sake of clarifying the confused synonymy of this species, these figures should be accepted, as Lebour suggested, as establishing the tabulation of P. divergens. The pattern is that of the section Divergens, Metaperidinium, of Jørgensen.

The specific distinctness of P. depressum and P. divergens has been fully realized by most workers in this field for a considerable period. Meunier, as late as 1919, figured P. depressum under the name of P. divergens; however his argument to discard the former name seems invalid.

Peridinium kofoidii, described by Fauré-Fremiet (1908), is undoubtedly a long-horned form of P. depressum with roughened antapicals. The apical view shows only three apical plates, but this is probably an error in drawing, for the dorsal apical plate is difficult to demonstrate in this view.

**Distribution.** Very common in the boreal Atlantic Ocean (Paulsen, 1908; Lebour, 1925) and in the Antarctic (Karsten, 1905; Peters, 1928). Matzenauer (1933) found it frequently in the Indian Ocean and Forti (1922) in the Mediterranean. Böhm (1936) reported it from the Pacific between Hong Kong and Shanghai, where its occurrence was sporadic. It is apparently a cosmopolitan species having centers of abundance in the cooler regions of both hemispheres.

In the Carnegie collection this species was found at 35 stations: 22 in the Atlantic, 13 in the Pacific. There are 72 records of occurrence: 34 rare, 28 occasional, 6 common, and 4 abundant. It was found about equally at the three levels, with 20 records for the surface, 17 for 50 meters, and 20 for 100 meters. There are 48 net records and 24 pump records. It was found only in the

northern hemisphere and in the months from May to September.

The Carnegie records exhibit a very curious distribution, being widely scattered in the Atlantic but limited in the Pacific (fig. 20). In the Atlantic the species occurred from north of the Faeroes Islands as far south as latitude 13°4' north. Its center of abundance was the Grand Banks of Newfoundland, where it occurred in enormous numbers clogging the collecting nets, particularly at 50 and 100 meters depth. In the Pacific it was restricted to a line of stations off Japan and the western Aleutian Islands, stations 111 to 122.

This species was found in a great range of hydrographic conditions. The surface temperatures at the stations where it occurred at any depth varied from 6°9' to 27°6' C. The ranges of hydrographic conditions in situ were as follows: temperature, -1°6' to 26°7' C; salinity, 32.7 to 37.2 o/oo; pH, 7.86 to 8.27; phosphate, 3 to 184 mg PO<sub>4</sub>/m<sup>3</sup>.

It is obvious from the above data that the factor limiting the distribution of P. depressum has not yet been identified. Considering the varied conditions under which the species was found in the Atlantic, it is difficult to explain its peculiarly restricted distribution in the Pacific unless its occurrence is normally sporadic, as Böhm (1936) indicated was the case in the southwestern Pacific.

It is of interest to note that the species exhibited its greatest variation in the region of the Grand Banks of Newfoundland (station 13), where conditions were extreme. In this region the surface temperature was 11°27', whereas at 25 meters 0°75' was recorded. At 50 meters the temperature was only -1°64' and at 100 meters 1°10'. Curiously enough, the richest collection of P. depressum made by the Carnegie was at the Grand Banks station at 50 meters. It cannot be concluded that low temperatures are favorable to this species, because it is quite possible that the production of this population occurred at a higher level. It at least indicates that P. depressum can endure low temperatures. The species seems to be eurythermal to a high degree, for it was again found in the tropics at temperatures as high as 26°7'. South of station 15 (latitude 39° north), however, it was always found below the surface, a fact which may have been due to the higher temperatures prevailing at the surface. It should be noted that the higher concentration of nutrients which occurs below the surface in the warmer waters may have been responsible for this distributional peculiarity.

Since the species has a distribution which cannot be correlated with any known hydrographic condition, it is at present of no value as an oceanographic indicator.

Peridinium depressum var. parallelum Broch  
(Figures 21, 22)

Peridinium parallelum Broch, 1906, pp. 153-157, fig. 2. Paulsen, 1907, pp. 11, 15; 1908, pp. 39, 54, fig. 68. Broch, 1908, p. 5. Broch, 1910, p. 52. Mangin, 1913, p. 221. Paulsen, 1913, p. 279, pl. 47. Pavillard, 1931, pp. 56, 114-116, 121, 123, 159, 161, 163, 167, 169, 175, 183, 185, 187, pl. 2, fig. 7A, B.

Peridinium divergens var. Schütt, 1895, pl. 13, fig. 43 (23). Meunier, 1910, pl. 1 (bis), figs. 3, 4.

Peridinium antarcticum Schimper in Karsten, 1905, pp. 37, 38, 40, 43-51, 53-57, 59-61, 64-68, 131-132, pl. 19, figs. 1-4. Broch, 1906, p. 153. Paulsen, 1931 p. 55.

Peridinium depressum subsp. parallelum Broch, 1906, p. 151.

Peridinium divergens antarcticum, Karsten, 1907, pp. 225, 416.

Dimensions. Length of body (l) 132 (100-160) microns. Diameter of body (d) 120 (94-138) microns. Forty-nine specimens were measured.

Shape. This variety is usually more rotund than the main species, with short and slender antapical horns, frequently solid part way or entirely to the base, usually straight and parallel. The h/d ratio is 0.84 (0.73-0.96). The a/d ratio is 0.24 (0.16-0.29). The b/a ratio is 0.15 (0.10-0.20). The angle  $\alpha$  is 110° (94°-129°).

Plate pattern. Tabulation of major body plates as in P. depressum with addition of second asymmetrical pattern found in one specimen. It should be noted that the first symmetrical and first asymmetrical patterns occurred in about the same proportion as in P. depressum (fig. 10). Tabulation of girdle and ventral area also as in main species.

Variation and comparisons. Broch (1906) separated this variety on the basis of solid antapical horns. This is not a good character, however, as Peters (1928) has demonstrated. In our material the solidity of the horns was a function of the thickness of these structures. The thinner horns were solid part way or entirely to the base.

The angle  $\alpha$  is low owing to the greater convexity and shortness of the body. When the specimens were examined, this convex curvature of the body seemed characteristic, and in the early part of these investigations it was thought that the variety could be distinguished on the basis of this character alone. When 108 random specimens of the main species and of var. parallelum were measured, however, and the frequency of their angle  $\alpha$  values was plotted, it was found that this feature is not specific (fig. 23). Rather than two separate groups, the frequency distribution suggests a series of variable and intergrading units. Since these results could not be corroborated by the study of additional characters, the attempt to separate the variety on this basis was abandoned.

Because of the fact that var. parallelum appeared to have shorter horns than P. depressum, a study was made of the relative lengths of the antapical horns. The a/d ratio, representing the length of the right antapical horn in relation to the width at the girdle, was computed for 108 random specimens. The values obtained were grouped into 0.03-unit classes and the frequencies plotted (fig. 24). This study also showed that there is no complete separation of two groups. There is an indication of two groups, however, intergrading at the a/d class of 0.31. This grouping corresponds well to other differences in habitus, etc. This was the best numerical measure that could be found to delimit var. parallelum, a fact that clearly shows the uncertain status of this unit.

Since further knowledge of the differences in the distribution of these two forms is needed, it is desirable that the occurrence of the forms be kept separate in plankton lists. As shown by the above frequency studies, the most effective separation of the variety can be made by means of the relative length of the antapical horns. In the present work, the a/d ratio of 0.30 was taken as the point of separation between P. depressum and var. parallelum.

**Historical.** Broch (1906) described this form as a subspecies of *P. depressum* Bailey and later (1910a) treated it as a distinct species. Paulsen (1908) judged it to be a valid species, as did Pavillard (1931) and others. Peters (1928), however, considered it to be completely within the variation limits of *P. depressum*. In a study of a vast amount of antarctic material, he stated that he found the form always had hollow horns, but in one sample from the North Sea he found the horns sometimes solid and sometimes hollow. In all dimensional ratios studied by him he found a variation frequency which suggested the presence of only one systematic unit. He did not consider the  $a/d$  ratio, however.

A form resembling var. *parallellum* was described by Schimper (in Karsten, 1905) as *P. antarcticum*. Peters (1928), who studied both northern and antarctic material, considered these two forms to be identical. Matzenauer (1933), however, treats *antarcticum* as a forma of *P. depressum*. Since there is no antarctic material in the *Carnegie* collection, it was not possible to subject this southern form to the analysis applied to var. *parallellum*, with the result that no direct comparisons could be made between the two forms.

**Distribution.** Broch (1906) considered this form a boreal or boreo-antarctic species and stated that in 1905 it did not come farther south along the Norwegian coast than latitude 62° north. It must be remembered that he was considering the solid-spined individuals which probably represent the extremes of the variety. Paulsen (1908) stated that it occurred as far south as the Skagerrack. It occurs in the Antarctic according to Peters (1928) and in the Indian Ocean according to Matzenauer (1933). The present records are the first for the Pacific.

In the *Carnegie* collection this variety was found at 15 stations: 13 in the Atlantic, 2 in the Pacific. There are 26 records of occurrence: 8 rare, 11 occasional, 7 common. It was found about equally at the three levels, with 9 records for the surface, 9 for 50 meters, and 8 for 100 meters. There are 20 net records and 6 pump records. It was found only in the northern hemisphere, in the months from July to September.

This variety had a distribution in the *Carnegie* collection similar to that of the main species in that it was found at widely scattered stations in the Atlantic but was restricted in the Pacific (fig. 20). In the Atlantic it was found in the North Sea (station 6h), at the stations in the region of Iceland, on the line between Iceland and the Grand Banks of Newfoundland at all stations except one, and as far south as latitude 11° north (station 23). It did not occur, however, in a single surface sample south of latitude 42° north (station 13a). In the Pacific it was found only at two stations, viz., stations 128 and 130, off California.

The variety occurred in a great range of hydrographic conditions. The surface temperatures at the stations where it occurred at any depth varied from 8.4 to 27.2 C. The hydrographic conditions *in situ* were as follows: temperature, -1.6 to 22.4 C; salinity, 32.7 to 36.8 o/oo; pH, 7.87 to 8.26; phosphate, 5 to 176 mg PO<sub>4</sub>/m<sup>3</sup>.

It is thus evident that this form cannot be considered a strictly low-temperature variety, as Broch (1906) suggested. It may have its origin and center of greatest abundance in the cold regions, but it is highly eurythermal. It is hardly possible that var. *parallellum* repre-

sents an ecological variant, since it often occurs mixed with *P. depressum*.

*Peridinium depressum* var. *rectius* n.var.  
(Figure 25)

**Dimensions.** Length of body ( $l$ ) 124 (113-135) microns. Diameter of body ( $d$ ) 84 (76-92) microns. Width of girdle about 6 microns. Two specimens were measured.

**Shape.** Lateral outline in ventral view almost straight between girdle and bases of horns. This fullness of body results in high angle  $\alpha$ . The  $h/d$  ratio is 1.10 (1.07-1.19). The  $a/d$  ratio is 0.38 (0.37-0.38). The  $b/a$  ratio is 0.17 (0.16-0.18). The angle  $\alpha$  is 120° (111°-130°). In lateral view the apical horn is continuous with the body lines. All horns relatively stout. Lengths of antapical horns similar to those in *P. depressum*, but there is little divergence in any direction. Body narrower dorsoventrally than in *P. depressum*; sometimes narrow elliptical in apical view (fig. 25A).

**Plate pattern.** The epithecal tabulation is of the first symmetrical pattern. In our specimens the x-ratio was +0.6 and +0.7. Tabulation of other parts as in main species.

**Body wall.** Intercalary zones wide. Plates thinner and surface sculpturing much less developed than in most specimens of *P. depressum*. Other details same as in main species.

**Comparisons.** This variety expresses a tendency toward a dorsoventral flattening of the body, and a tendency toward a loss of the strong depression of the body which results in a decrease in the inclination of the girdle. In all these characters it differs from both the main species and var. *parallellum*. It is further differentiated from var. *parallellum* in its longer and stouter antapical horns. It is distinguished from var. *convexius*, described below, by its straight, instead of conspicuously convex, body contours.

In general appearance var. *rectius* is similar to *P. oceanicum* var. *parvulum* Mangin (1913) from Saint-Vaast-la-Houge. It differs from this principally in having a low  $h/d$  ratio. The  $h/d$  ratios computed from Mangin's figures range from 1.24 to 1.45, which places var. *parvulum* definitely in the *P. oceanicum* group. Furthermore, the sides of var. *parvulum* are more convex than in var. *rectius*. Mangin did not show a side view, nor did he state the degree of dorsoventral flattening. (Fig. 10b, 10d of Mangin are ventral views drawn from the dorsal side.)

**Distribution.** This variety was found at only two stations: stations 6 and 32, both in the Atlantic (fig. 20). The former station was southwest of the British Isles and the latter in the Caribbean Sea. At the northern station the form was collected with the net at 50 and 100 meters, in May; at the southern station with the pump at the surface, in October. It was rare in each case. The ranges of hydrographic conditions at these stations were as follows: temperature, 11.3 to 28.0 C; salinity, 35.5 to 36.0 o/oo; pH, 8.08 to 8.23; phosphate, 2 to 41 mg PO<sub>4</sub>/m<sup>3</sup>.

The wide range in temperatures indicates that this form is eurythermal. Thus, var. *rectius* is probably a rare but widely distributed variety of *P. depressum* Bailey. Type locality: *Carnegie* station 32.

*Peridinium depressum* var. *convexius* n. var.  
(Figure 26)

**Dimensions.** Length of body ( $\bar{l}$ ) 122 (105-135) microns. Diameter of body ( $\bar{d}$ ) 81 (76-88) microns. Width of girdle about 5 microns. Three specimens were measured.

**Shape.** Body very convex in ventral view and does not flare out in girdle region as in *P. depressum*. The  $\bar{h}/\bar{d}$  ratio is 1.08 (0.96-1.21). The angle  $\alpha$  is  $128^\circ$  ( $114^\circ$ - $139^\circ$ ). In the girdle region the body is compressed dorsoventrally so that it is not so convex in lateral view. The  $\bar{g}/\bar{d}$  ratio is about 0.70. Antapical horns similar to those in *P. depressum* although somewhat more abruptly pointed. The  $\bar{a}/\bar{d}$  ratio is 0.40 (0.36-0.46). The  $\bar{b}/\bar{a}$  ratio is 0.19 (0.16-0.23).

**Plate pattern.** Epithecal tabulation is of the first symmetrical pattern. Other parts of theca as in main species.

**Comparisons.** This variety exhibits a peculiar combination of features. It shows a tendency toward a rounding of the lateral contours of the body as in var. *parallellum*, but retains the horn length of *P. depressum*. There is also a tendency toward a dorsoventral flattening, showing a convergence toward the shape of *P. depressum* var. *rectius* and *P. oceanicum* var. *tenellum*. Variety *convexius* can be distinguished from *P. depressum* by its large angle  $\alpha$ ; from var. *parallellum* by its longer antapical horns; and from var. *rectius* by its convex lateral contours.

**Distribution.** This variety was found at 11 stations: 3 in the Atlantic and 8 in the Pacific. There are 28 records of occurrence: 10 rare, 17 occasional, and 1 common. The records were less frequent for the surface; there were 5 records for the surface, 11 for 50 meters, and 12 for 100 meters. There are 18 net records and 10 pump records. The variety was found in both hemispheres, from May to August in the northern, and from November to January in the southern.

In the Atlantic this variety was found at three stations, all in or along the Gulf Stream, between longitudes  $46^\circ$  and  $54^\circ$  west (fig. 20). In the Pacific it occurred in three regions: (1) off Colombia, station 39; (2) in the Humboldt Current, off Peru, stations 69 and 70; (3) in a series of stations in the region of Japan, stations 109-112, 116.

This form probably has its origin in regions of warm water and it does not seem to endure transfer into cold conditions. The surface temperatures at the stations where it occurred at any depth varied from  $16.1^\circ$  to  $27.4^\circ$  C. The ranges of hydrographic conditions *in situ* were as follows: temperature,  $6.7^\circ$  to  $27.4^\circ$  C; salinity, 33.8 to 36.5 o/oo; pH, 7.68 to 8.23; phosphate, 3 to 233 mg  $\text{PO}_4/\text{m}^3$ .

It may be concluded that this is a rare warm-water form, sometimes being carried into colder regions. It is not common enough to be of value as an indicator of the intrusions of water of tropical origin. Type locality: *Carnegie* station 14.

*Peridinium depressum* forma *bisintercalares* n. f.  
(Figure 27)

**Dimensions.** Length of body ( $\bar{l}$ ) 182 (160-205) microns. Diameter ( $\bar{d}$ ) 132 (125-140) microns. Width of girdle about 5 microns. Two specimens were measured.

**Shape.** Body as in *P. depressum*. The  $\bar{h}/\bar{d}$  ratio is 0.98 (0.95-1.02). The angle  $\alpha$  is  $96^\circ$  ( $95^\circ$ - $96^\circ$ ). Length and divergence of antapical horns variable. The  $\bar{a}/\bar{d}$  ratio is 0.37 (0.32-0.43). The  $\bar{b}/\bar{a}$  ratio is 0.12 (0.10-0.15).

**Plate pattern.** Epithecal tabulation is of the first symmetrical pattern except that there are only two instead of three anterior intercalary plates. In the measured specimens the x-ratio was +0.46 and +2.50.

**Comparisons.** The distinctive feature of this form is the presence of two, instead of three, anterior intercalary plates, a peculiarity also occurring in *P. oceanicum* (p.24). This pattern is not caused simply by the fusion of two of the intercalary plates. Although one specimen of *P. oceanicum* was found that indicated such a fusion (p.25), in all other cases some more fundamental rearrangement had occurred. The suture between the two plates was located medially where no suture normally occurs when three plates are present, and the dorsal pattern was quite symmetrical.

**Remarks.** Since the subgenus *Peridinium* is founded on the presence of three anterior intercalary plates, the discovery of the two-intercalary forms in *P. depressum* and *P. oceanicum* necessitates the revision of the description and fundamental classification of the genus. This plate pattern was too common in the material studied to be passed over simply as "aberrant." It was estimated that from 1 to 2 per cent of the specimens of *P. depressum* and *P. oceanicum* in our material showed this pattern, although in the former species it occurred only at one station and in the latter at three.

**Distribution.** This form was found only at station 13 at 50 meters on the Grand Banks of Newfoundland in August 1928. The hydrographic conditions were as follows: temperature,  $-1.6^\circ$  C; salinity, 33.4 o/oo; pH, 7.87; phosphate, 59 mg  $\text{PO}_4/\text{m}^3$ . Type locality: *Carnegie* station 13.

*Peridinium depressum* forma *multitabulatum* n. f.  
(Figure 28)

**Dimensions.** Length of body ( $\bar{l}$ ) 160 microns. Width of body ( $\bar{d}$ ) 135 microns. Width of girdle about 5 microns. One specimen measured.

**Shape.** Body shape as in *P. depressum*. The  $\bar{h}/\bar{d}$  ratio is 0.90. The  $\bar{a}/\bar{d}$  ratio is 0.28. The  $\bar{b}/\bar{a}$  ratio is 0.24. The angle  $\alpha$  is  $99^\circ$ .

**Plate pattern.** The first apical plate is divided medially by a suture without intercalary striae; the first precingular is divided transversely; the fourth precingular is divided by a suture in the longitudinal axis; the first and second intercalary plates are displaced to the left so that 2a touches 2pr and the suture between 2a and 3a lies in the longitudinal axis of the body. There seems to be a tendency toward formation of a cleavage plane, cutting the body into right and left valves as in the *Dinophysoidae*.

**Comparisons.** This form, of which only one specimen was recorded, is peculiar only in its tabulation.

**Remarks.** The aberrant behavior of the tabulation in this form strikingly demonstrates the caution which must be applied in using the plate pattern as the fundamental feature of classification.

**Distribution.** This form occurred in the surface sample at station 2 in the North Atlantic Drift in May 1928. The hydrographic conditions were as follows:

temperature, 20.5°C; salinity, 36.4 o/oo; pH, 8.23; phosphate, 58 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 2.

*Peridinium claudicanoides* n.sp.  
(Figure 29)

Dimensions. Length of body ( $l$ ) 166 (154-180) microns. Diameter ( $d$ ) 141 (123-150) microns. Width of girdle about 5 microns. Ten specimens measured.

Shape. Mid-body similar to that of *P. depressum*. The angle  $\alpha$  is 94° (79° to 101°). The  $h/d$  ratio is 0.75 (0.53-0.94). The body is compressed along an antero-ventral-posterodorsal axis, running at an angle of about 55° to the plane of the girdle. The epitheca tapers into a short truncated apical horn which is flattened laterally at the end so that it is from 1.1 to 1.5 times as wide in lateral as in ventral view. The horn extends along an axis which lies at an angle of about 65° to the axis of depression of the body. The hypotheca terminates in two stout pointed antapical horns which are more or less triangular in outline. The  $a/d$  ratio is 0.30 (0.27-0.31). The  $b/a$  ratio is 0.28 (0.23-0.35). In lateral view the axis of the right antapical horn is in line with the axis of the apical horn, but in ventral view it is seen to diverge to the right. The left antapical horn is shorter than the right and diverges from it laterally and ventrally. The girdle follows approximately the same course as in *P. depressum*.

Plate pattern. The tabulation of the epitheca is of the second symmetrical, rarely the first asymmetrical, pattern. Tabulation of other parts of theca as in *P. depressum*.

Body wall. The external surface of the theca is faintly marked with an irregular reticulation which is raised at the intersections so that under low magnification the surface appears spinulose. Pores are scattered irregularly over the surface, and bear no relation to the reticulations.

The plates are bordered by simple sutures or wide intercalary zones. Rabbet joints occur as in *P. depressum*.

Comparisons. This species is close to *P. depressum*. The mid-body has about the same form as in that species although somewhat more expanded in the girdle region, as is expressed by the low angle. It differs further from *P. depressum* in the shorter and stouter apical horn, and in the stout cuneate antapicals. Furthermore, it may usually be distinguished from *P. depressum* by its plate pattern, which is the second symmetrical. The last feature is not quite reliable, however, since one specimen was found with the first asymmetrical pattern, a tabulation occurring frequently in *P. depressum*.

Distribution. *P. claudicanoides* was found at 9 stations: 5 in the Atlantic and 4 in the Pacific (fig. 20). There are 13 records of occurrence: 11 rare, 1 occasional, and 1 common. It was found more often at the surface, with 7 records for the surface, 3 for 50 meters, and 3 for 100 meters. There are 11 net records and 2 pump records. The species was found in May in the north temperate regions of the Atlantic, and in October and November on both sides of the equator in the tropical Pacific.

In the Atlantic this form was found at four stations in the North Atlantic West Wind Drift, stations 1, 1a, 2,

and 3; and at one station in the Caribbean, station 32. In the Pacific it occurred only off the coast of Colombia and Ecuador, stations 35, 35a, 35b, and 40. It is thus much more restricted in its distribution and occurs in the Pacific at quite different places from *P. depressum*.

The surface temperatures at the stations where it occurred at any depth varied from 15.5 to 28.0°C. The ranges of hydrographic conditions *in situ* were as follows: temperature, 13.8 to 27.0°C; salinity, 30.0 to 36.4 o/oo; pH, 7.85 to 8.25; phosphate, 15 to 138 mg PO<sub>4</sub>/m<sup>3</sup>.

*Peridinium claudicanoides* thus appears to be a rare, warm-water species possibly with a restricted distribution. It will be noted that it occurred in a wide range of salinities but never in the barren waters with low phosphate content. If this correlation is correct, it is an unusual feature for a tropical form. Type locality: Carnegie station 2.

*Peridinium oceanicum* Vanhöffen  
(Figure 30)

- Peridinium oceanicum* Vanhöffen, 1897a, pl. 5, fig. 2. Vanhöffen, 1897b, pp. 1-2. Jörgensen, 1905, p. 109. Van Breeman, 1905, p. 44. Broch, 1906, pp. 154-156. Paulsen, 1907, p. 16, fig. 21. Paulsen, 1908, pp. 39, 54. Meunier, 1910, p. 27. Broch, 1910, p. 190. Schröder, 1911, pp. 17-19, 21, 40. Mangin, 1913, p. 156. Paulsen, 1913, pp. 279-281, pl. 48. Jörgensen, 1913, pp. 5-6. Meunier, 1919, pp. 15-19, pl. 15, figs. 7-23, pl. 16, figs. 21-23. Paulsen, 1931, p. 66, fig. 37, p. 55. Pavillard, 1931, pp. 56-57, 111, 125, 127, 129, 131, 133.
- Peridinium divergens*, Stein, 1883, pl. 10, fig. 7.
- Peridinium depressum* var. *oceanica*, Ostenfeld, 1900, p. 57, tables 2-7. Gran, 1902, p. 192.
- Peridinium divergens* var. *elegans* Cleve, 1900b, p. 260. Karsten, 1906, pp. 206, 209, 210, 213, 216, 217, 243, 245-247, 249, 257, 258, 260-261, 265-266, 268, 272, 274-277, 279, 285, 287, 289, 293, 295-296, 298, 301, 311-312, 317-318, 328, 330-330, 337, 352-356, 416, 447, 450, 540. Karsten, 1907, p. 416.
- Peridinium depressa* var. *oceanica*, Ostenfeld, 1900, tab. 1.
- Peridinium elegans* var., Karsten, 1905, pp. 34, 132, pl. 19, figs. 5, 6.
- Peridinium elegans*, Karsten, 1905, pp. 179, 208.
- Peridinium depressum oceanicum* f. *typica* Broch, 1906, p. 152.
- Peridinium oceanicum* f. *typica* Broch, 1906, pp. 154-157, fig. 3. Broch, 1910, pp. 190-191.
- Peridinium divergens oceanicum* Karsten, 1907, p. 224, 227, 228, 230-232, 257, 260-261, 272, 281, 290, 416, 447, 450, 472, 540.
- Peridinium oceanicum* var. *typica* Paulsen, 1908, p. 55, fig. 69. Mangin, 1913, p. 222. Lebour, 1925, p. 121.
- Peridinium ozeanicum*, Schröder, 1911, pp. 16, 25.
- Peridinium murrayi* var. *occidentalis* Pavillard, 1931, pp. 57, 114, 121, 147, 151, 153, 171, 181, 185, 187, 189, fig. 9B, pl. 2.
- Peridinium murrayi* var. *orientalis* Matzenauer, 1933, p. 465, fig. 46b.

Dimensions. Length of body ( $l$ ) 246 (225-268) microns. Diameter of body ( $d$ ) 124 (108-137) microns. Width of girdle about 5 microns. Thirty-four specimens measured.

Shape. Body shape similar to *P. depressum* (see p. 16) but longer and more slender with relatively long horns. The  $h/d$  ratio is 1.42 (1.27-1.68). The  $a/d$  ratio is 0.58 (0.48-0.74). The  $b/a$  ratio is 0.12 (0.07-0.15). The angle  $\alpha$  is 119° (109°-135°).

**Plate pattern.** The tabulation is of the first symmetrical pattern, rarely of the first asymmetrical. The latter was observed in one specimen only. The  $x$ -ratio varied from +0.70 to +1.30 in the symmetrical patterns and was -1.1 in the specimen with the asymmetrical pattern. Tabulation in other regions as in *P. depressum*.

**Body wall.** Details of thecal structure the same as in *P. depressum*. In the tropical specimens the body walls were thinner and the surface sculpturing less developed than in the northern representatives.

**Variation and comparisons.** This species is closely related to *P. depressum*, from which it may be distinguished by its greater  $h/d$  ratio (greater than 1.20) and by its greater angle  $\alpha$  (greater than  $105^\circ$ ). (See p. 15.)

There are a great number of variants of *P. oceanicum*, which have caused considerable trouble among investigators of this group. (See below.) It is not likely that this group will be dealt with in an orderly manner until the description of the body shape is expressed numerically, thus allowing frequency studies for the establishment of groupings and intergradations.

From the *Carnegie* material 82 specimens with  $h/d$  ratios greater than 1.20, i.e., specimens belonging to *P. oceanicum* and varieties, were selected at random from widely scattered oceanic stations in the North Atlantic and Pacific, and measured. The frequency of their length classes (fig. 31) indicates two distinct groups: one with lengths from 140 to 200 microns; the other with lengths from 220 to 270 microns. Although the two groups are distinct, they are, nevertheless, close together. Since observation of the habitat corroborates this grouping, it seems justifiable, for the present at least, to consider the body length as a specific feature separating *P. oceanicum* from its varieties. The group with greater length is the main species.

In *P. oceanicum* proper the body form shows a certain stability, but in the group of smaller forms the variation is extreme (fig. 33). No secondary grouping of these smaller forms could be accomplished. Therefore they were lumped into a single group, var. *tenellum* n. var.

In addition to this variety, which was separated on the basis of body length and form, three other variants of *P. oceanicum* were found which were aberrant in other features; forma *spiniferum* n.f. and f. *tricornutum* n.f. were segregated on the basis of accessory horns (pp. 24 and 25), and f. *bisintercalares* n.f. was established on the presence of only two anterior intercalary plates (p. 24).

**Historical.** Vanhöffen (1897a, pl. 2, fig. 5) figured a specimen similar to *P. depressum* but longer and more slender. No reference was made to this figure in the text; but in another paper Vanhöffen (1897b) gave a list of species including the name "*P. oceanicum* Vanhöffen," which has generally been supposed to refer to this figure. No description of the species was given by Vanhöffen nor was the plate pattern shown.

This form has been almost universally accepted as a distinct species related to *P. depressum* (Jørgensen, 1905; Broch, 1906, 1910; Paulsen, 1907, 1908, 1913; Mangin, 1913; Pavillard, 1931). Peters (1928) alone has combined it with *P. depressum*. Our own observations also indicate that it should be given specific rating. At the same time, it is certainly not so easily distinguishable as was formerly supposed.

Karsten (1906) confused this species with *P. ele-*

*gans* Cleve, a species related to *P. grande* Kofoid. Karsten's records of *P. divergens* var. *elegans*, as he states later (1907), refer to *P. oceanicum* Vanhöffen. Cleve (1900b) also confused these two forms.

Kofoid (1907a) described a form, *P. murrayi*, as "resembling *P. oceanicum*" but with "lower epitheca with more concave sides, longer horn, and longer and more divergent antapical horns." A figure was given, and the length given as 250 microns and the width 135 microns. This form seems to have a certain constancy and is probably specifically distinct. It was figured later by Pavillard (1931) and Matzenauer (1933). It is, however, difficult to distinguish Pavillard's *P. murrayi* var. *occidentalis* and Matzenauer's *P. murrayi* var. *orientalis* from *P. oceanicum* Vanhöffen.

**Distribution.** This is a widely spread species. It has been frequently reported from various parts of the Atlantic (see Paulsen, 1908; Lebour, 1925; and Pavillard, 1931) and from the Mediterranean (Forti, 1922). Karsten (1905) reported it from the Antarctic. Karsten (1907) and Matzenauer (1933) recorded it in the Indian Ocean. The only records for the Pacific are those of Böhm (1936) between Hong Kong and Shanghai.

In the *Carnegie* collection this species was found at 9 stations, all in the Atlantic. There are 17 records of occurrence: 6 rare, 5 occasional, 5 common, and 1 abundant. It was found about equally at the three levels, with 6 records for the surface, 5 for 50 meters, and 6 for 100 meters. There are 14 net records and 3 pump records. All the records are from July and August 1928.

The species was found at all stations between Iceland and Labrador, at two stations in the North Atlantic Drift (stations 15 and 16), and at one station in the North Equatorial Current, station 21 (fig. 20). It was most abundant in the area between Iceland and Labrador. The fact that it was not found on the run from Washington to Plymouth during May might indicate that this particular occurrence was seasonal. The complete absence of the main species from the Pacific is very remarkable. All the Pacific material could definitely be placed in var. *tenellum* because of the shorter length.

The surface temperatures at the stations where *P. oceanicum* occurred at any depth varied from  $8.4$  to  $26.0$  C. The ranges of hydrographic conditions *in situ* were as follows: temperature,  $4.0$  to  $26.6$ ; salinity, 34.7 to 36.8 o/oo; pH 7.90 to 8.32; phosphate, 4 to 78 mg  $PO_4/m^3$ .

It is obvious from these observations that this species is not restricted to water masses of particular characteristics even though its center of abundance is definitely in the colder regions.

*Peridinium oceanicum* var. *tenellum* n. var.  
(Figures 32, 33)

**Dimensions.** Length of body ( $l$ ) 179 (150-205) microns. Diameter ( $d$ ) 91 (70-106) microns. Width of girdle about 7 microns. Twenty-seven specimens measured.

**Shape.** Similar to main species but less slender. The  $h/d$  ratio is 1.40 (1.25-1.76). The angle  $\alpha$  is  $126^\circ$  ( $110^\circ$ - $142^\circ$ ). The  $a/d$  ratio is 0.58 (0.42-0.67). The  $b/a$  ratio is 0.12 (0.08-0.16).

**Plate pattern.** Epithecical tabulation is of the first symmetrical pattern. Other areas of theca also as in main species.

Variation and comparisons. The variants of *P. oceanicum* are innumerable. In the Carnegie material all of them could be separated from the main species by their shorter length (p. 23). These shorter forms, however, did not allow further segregation, although they did not appear to present a homogeneous group. Hence they were all lumped into the single variety treated here. There was a great variation in the length, divergence, and thickness of horns, and in the shape of the mid-body. The numerous varieties of the species presented by other authors have usually been figured in only one position, viz., the resting position. The relationships of these forms to each other and to var. *tenellum* cannot be determined until statistical studies of body shape are made. This, of course, cannot be done until standard methods of presentation and measuring have been adopted.

Historical. Mangin (1913) described *P. oceanicum* var. *parvulum* as a characteristic form at Saint-Vaast-la-Hougue. Broch (1910b) described *P. oceanicum* f. *arupinensis* as the typical form of the Mediterranean.

The most commonly cited variant of *P. oceanicum*, however, is *P. oblongum* Aurivillius (1898). The current conception of this form seems to be that it is a small neritic variety of *P. oceanicum*. If, however, we are to accept the figures referred to by Aurivillius, we must consider this form not only smaller than *P. oceanicum*, but of a somewhat different shape. Aurivillius referred to figures 39 and 40 of Bergh (1882) and figures 44,1 to 44,5 of Schütt (1895). In these specimens the sides of the body are much straighter than in *P. oceanicum*, and the apical horn is less definite.

Some recent workers (e.g. Böhm, 1936) are including under var. *oblongum* forms with very rounded bodies and distinct, long apical horns. As stated above, the relationships of these forms cannot be determined until frequency studies have been undertaken.

Broch (1910) stated that *P. oceanicum* and *P. oblongum* have a list only on the right side of the sulcus, and that f. *arupinensis* differs in having lists on each side. Our observations of *P. oceanicum* and its variants showed that their morphology agrees with that of all other members of the section *Oceanica* in the presence of a list on each side of the sulcus. This list is, however, frequently difficult to demonstrate.

Distribution. This variety is widely distributed. In the Carnegie material it was found at 60 stations: 14 in the Atlantic and 46 in the Pacific. There are 138 records of occurrence: 85 rare, 48 occasional, 3 common, and 1 abundant. It was found oftener in the upper levels, with 56 records for the surface, 42 records for 50 meters, and 39 records for 100 meters. It was found in both hemispheres and in all months of the year.

It occurred in widely scattered areas of the Atlantic and Pacific oceans (fig. 20). In the Atlantic it was found in the North Atlantic Drift, south of the British Isles, off the southeast coast of Iceland, and in the Caribbean Sea. In the Pacific it occurred at all stations in the general area between Ecuador and the Tuamotus, at Easter Island, at three stations south of latitude 36° south, at 11 stations in the three equatorial currents in the central Pacific, at 4 stations off Japan, and at 4 stations off the west coast of the United States.

It was found over a great range of hydrographic conditions. The surface temperatures at the stations where it occurred at any depth varied from 10.3 to

28.6 C. The ranges of hydrographic conditions in situ were as follows: temperature, 6.7 to 28.6 C; salinity, 32.7 to 36.5 o/oo; pH, 7.71 to 8.39; phosphate, 8 to 220 mg PO<sub>4</sub>/m<sup>3</sup>.

This form is apparently of world-wide distribution, occurring in a wide range of hydrographic conditions. It is noteworthy, however, that it was not found at the Carnegie stations where the phosphate content of the water was low, that is, less than 8 mg per cubic meter. This correlation may be significant in explaining its distribution, since in the warmer areas the phosphate content is often less than 4 mg/m<sup>3</sup>. Type locality: Carnegie station 14.

*Peridinium oceanicum* forma *spiniferum* n.f.  
(Figure 34)

Dimensions. Length of body ( $\bar{l}$ ) 225 (209-241) microns. Diameter ( $\bar{d}$ ) 131 (122-140) microns. Width of girdle about 5 microns. Three specimens were measured.

Shape. The  $\bar{h}/\bar{d}$  ratio is 1.23 (1.19-1.29). The angle  $\alpha$  is 112° (104°-124°). The  $\bar{a}/\bar{d}$  ratio is 0.47 (0.43-0.52); the  $\bar{b}/\bar{a}$  ratio is 0.11 (0.09-0.14). The distinctive feature of this form is the presence of an accessory horn, usually spine-tipped, on the fourth apical plate either in the center of the plate or anteriorly. In the specimens observed, this feature did not entail any change in plate pattern.

Plate pattern. Of the three specimens recorded, two showed the first symmetrical and one the first asymmetrical pattern. In one specimen there was a lengthening of the suture between 3a and 4pr with consequent shortening of the suture between 3pr and 4pr.

Comparisons. This form has been placed in *P. oceanicum* because most of the specimens had an  $\bar{h}/\bar{d}$  ratio greater than 1.20. Furthermore, the horns are attenuated as in that species. The mid-body shows a certain similarity to *P. depressum* in its strong depression, indicated by the comparatively low angle  $\alpha$ . This is not enough, however, to come wholly within the range of *P. depressum*.

Distribution. This is one of the diverse forms which originate on the Grand Banks of Newfoundland, where organisms are subjected to violent changes in environmental conditions (p. 19). It was found in the 50- and 100-meter samples at station 13 on the Grand Banks of Newfoundland in August 1928. The ranges of hydrographic conditions in which it was found were as follows: temperature, -1.64 to -1.10 C; salinity, 33.4 to 33.6 o/oo; pH 7.87; phosphate, 59 to 63 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 13.

*Peridinium oceanicum* forma *bisintercalares* n.f.  
(Figure 35)

Dimensions. Length of body ( $\bar{l}$ ) 203 (187-224) microns. Diameter of body ( $\bar{d}$ ) 105 (91-125) microns. Width of girdle approximately 5 microns. Three specimens were measured.

Shape. Similar to *P. oceanicum*. The  $\bar{h}/\bar{d}$  ratio is 1.40 (1.38-1.41). The angle  $\alpha$  is 128° (121°-135°). The  $\bar{b}/\bar{a}$  ratio is 0.13 (0.13-0.15).

Plate pattern. The tabulation of the epitheca in the specimens examined was of the first symmetrical pat-



tern except that there were two, instead of three, intercalaries. In one of the three specimens examined, the suture between the two intercalaries was so displaced to the right of the median body line that it appeared to be the normal suture between 2a and 3a and that the left plate represented a fusion of 1a and 2a. In the other specimens, however, as in the two-intercalary form of *P. depressum*, the suture between the two intercalaries was medially located and thus indicated a more fundamental change in the organization of the plate pattern.

**Comparisons.** This form occupies the same position relative to *P. oceanicum* that *P. depressum* f. *bisintercalatum* does to *P. depressum*. It is distinguished from *P. oceanicum* only by the presence of two instead of three anterior intercalary plates.

**Occurrence.** This form appeared at three stations, all in the Atlantic: in the North Atlantic West Wind Drift (station 2) at the surface, on the Grand Banks of Newfoundland (station 13) at 50 meters, and in the Caribbean Sea (station 31) at 100 meters. Its relative abundance at the last station was occasional; at the other two stations, rare. The ranges of hydrographic conditions in which it was found were as follows: temperature,  $-1.64$  to  $22.56$  C; salinity, 33.4 to 36.5 o/oo; pH, 7.86 to 8.23; phosphate, 28 to 58 mg  $PO_4/m^3$ .

It is obvious from the above data that the aberrant pattern exhibited by forma *bisintercalares* does not appear under any limited set of hydrographic conditions. Thus, it is probable that the causes of the development of this pattern are genetic rather than environmental. Type locality: Carnegie station 13.

*Peridinium oceanicum* forma *tricornutum* n.f.  
(Figure 36)

**Dimensions.** Length of body ( $\bar{l}$ ) 203 microns. Diameter ( $\bar{d}$ ) 120 microns. Width of girdle about 5 microns. One specimen was measured.

**Shape.** The general dimensional relationships are similar to those in *P. oceanicum*. The  $\bar{h}/\bar{d}$  ratio is 1.21. The angle  $\alpha$  is  $110^\circ$ . The  $\bar{a}/\bar{d}$  ratio is 0.48. The  $\bar{b}/\bar{a}$  ratio is 0.13. The left side of the mid-body is swollen into a roughly hemispherical protuberance involving both the epitheca and the hypotheca. The proximal end of the girdle has an unusual displacement anteriorly, over four girdle widths.

**Plate pattern.** The epithecal tabulation is of the first symmetrical pattern. The x-ratio is +1.43. The hypothecal side of the hemispherical protuberance is drawn out into a hollow horn with attenuated tip. This horn is composed of one plate representing an additional or posterior intercalary plate, inserted between the first, second, and third postcingular and the first antapical plates.

**Comparisons.** Whether this form represents a premature development of the theca during division, or whether it is an expression of a definite tendency in the thecal variation, cannot be determined. It is unique in that it is the only specimen observed in which any variation occurs in the hypotheca.

**Remarks.** Names were assigned with hesitancy to such aberrant forms as f. *tricornutum* and f. *spiniferum* because of the realization that these forms may represent pathological conditions. Since there were no definite indications of the pathological nature of the specimens examined, however, and since some species of the Peridinales, e.g., *Ceratium hirundinella*, normally

have multiple horns, it was decided to assign names to these forms, thus expressing the possibility of their representing incipient species.

**Distribution.** The specimen was collected in August 1928 in the 50-meter sample at station 13 on the Grand Banks of Newfoundland, where so many variants of *P. depressum* and *P. oceanicum* were found. The hydrographic conditions were as follows: temperature,  $-1.64$  C; salinity, 33.4 o/oo; pH, 7.86; phosphate, 60 mg  $PO_4/m^3$ . Type locality: Carnegie station 13.

Artificial Key to the Units of the Section Oceanica  
Treated in this Report

- A. The  $\bar{h}/\bar{d}$  ratio less than 1.20; or if greater, the angle  $\alpha$  less than  $105^\circ$  . . . . . B  
A. The  $\bar{h}/\bar{d}$  ratio more than 1.20 and the angle  $\alpha$  greater than  $105^\circ$  . . . . . H  
B. The angle  $\alpha$   $105^\circ$  or less . . . . . C  
B. The angle  $\alpha$  greater than  $105^\circ$  . . . . . F  
C. Epitheca with 2 intercalary plates . . . . .  
    . . . . . *P. depressum* f. *bisintercalatum* n.f.  
C. Epitheca with 3 intercalary plates . . . . . D  
D. Epitheca composed of 17 major plates . . . . .  
    . . . . . *P. depressum* f. *multitabulatum* n.f.  
D. Epitheca composed of 14 major plates . . . . . E  
E. Antapical horns cuneate;  $\bar{b}/\bar{a}$  ratio greater than 0.23; epithecal pattern usually second symmetrical . . . . .  
    . . . . . *P. claudicanoides* n.sp.  
E. Without this combination of characters . . . . .  
    . . . . . *P. depressum* Bailey  
F. The  $\bar{a}/\bar{d}$  ratio less than 0.30 . . . . .  
    . . . . . *P. depressum* var. *parallellum* Broch  
F. The  $\bar{a}/\bar{d}$  ratio more than 0.30 . . . . . G  
G. Lateral contours of body convex . . . . .  
    . . . . . *P. depressum* var. *convexius* n.var.  
G. Lateral contours of body straight or slightly convex . . . . .  
    . . . . . *P. depressum* var. *rectius* n.var.  
H. Epitheca with 2 intercalary plates . . . . .  
    . . . . . *P. oceanicum* f. *bisintercalares* n.f.  
H. Epitheca with 3 intercalary plates . . . . . I  
I. Fourth apical plate bearing a prominent spine . . . . .  
    . . . . . *P. oceanicum* f. *spiniferum* n.f.  
I. Fourth apical plate not bearing a prominent spine . . . . .  
    . . . . . J  
J. Hypotheca with an intercalary plate bearing a horn . . . . .  
    . . . . . *P. oceanicum* f. *tricornutum* n.f.  
J. Hypotheca without such a plate . . . . . K  
K. Total length ( $\bar{l}$ ) less than 210 microns . . . . .  
    . . . . . *P. oceanicum* var. *tenellum* n.var.  
K. Total length ( $\bar{l}$ ) more than 210 microns . . . . .  
    . . . . . *P. oceanicum* Vanhöffen

*Peridinium crassipes* Kofoid  
(Figure 37)

*Peridinium crassipes* Kofoid, 1907a, pp. 309-310, pl. 31, figs. 46, 47. Paulsen, 1907, p. 17, fig. 24. Paulsen, 1908, p. 58, fig. 73. Broch, 1908, p. 5. Broch, 1910b, p. 52, fig. 27. Okamura, 1912, p. 18, pl. 4, figs. 63a-c. Lindemann, 1924, p. 230, pl. 4, figs. 80-86. Peters, 1928, p. 42, figs. 11a-h. Matzenauer, 1933, p. 467, fig. 50. Böhm, 1936, p. 41, fig. 16c.

**Dimensions.** Length of body ( $\bar{l}$ ) 105 (88-120) microns. Width of body ( $\bar{d}$ ) 111 (90-130) microns. Width ( $\bar{g}$ ) 80 (65-94) microns. Width of girdle about 6 microns.

Twenty-two specimens were measured.

**Shape.** Body short and wide, resembling somewhat *P. depressum* var. *parallelum* Broch. The  $l/d$  ratio is 0.95 (0.80-1.04). The  $h/d$  ratio is 0.76 (0.60-0.86). In ventral view both the epitheca and the hypotheca rather abruptly constricted distally. The angle  $\alpha$  is  $89^\circ$  ( $74^\circ$ - $102^\circ$ ). Apical horn  $1/4$  to  $1/3$  total length of epitheca; base broad. Apex about 1 girdle width in diameter. Ant-apical horns terminated by solid spines. Right horn about 2 girdle widths longer than the left. There is no dorsoventral compression of the body in the girdle region, so that in apical view, the body is almost circular except for the deep indentation at the sulcus, which is about 3 girdle widths deep. The  $g/d$  ratio is 0.73 (0.64-0.80). There is sometimes a slight development of ventral limbs in the girdle region (as seen in apical view), but this is not very marked.

The girdle is equatorial, sinistral, displaced about 2 girdle widths. The ends of the girdles themselves are scarcely (about 0.5 girdle width) displaced, however, owing to the posterior curvature of the distal end. There is no girdle overhang; the girdle ends are separated by the anterior end of the ventral area. Girdle slightly concave. In side view the girdle is seen to be inclined at an angle of  $75^\circ$  to the longitudinal axis (the axis running from the apex to the antapex of the body).

The ventral area extends from the anterior edge of the girdle posteriorly to the antapex, which is located almost centrally (when specimen is seen in antapical view). Area subtruncate anteriorly; rounded posteriorly; left side almost straight; right side angular so that the greatest width, equaling about 4 girdle widths, occurs about one-third of distance from girdle to right antapical horn. Right side of ventral area on a level with, and taking a prominent place in, the ventral aspect of main body; but left side of area scarcely evident on the main body. Flagellar pore roughly elliptical in outline and about 2.5 girdle widths long, lying in the middle of sulcus proper, which occupies left half of ventral area. Sulcus rotated on its longitudinal axis in such a way that pore faces more to the left than ventrally. Sulcus and pore covered by left sulcal list.

**Plate pattern.** Epithecate plate pattern typical of *divergens* group, with first apical touching precingulars 1, 2, and 7, and apicals 2 and 4; and with second anterior intercalary touching only fourth precingular (fig. 37A). Precingular plates fairly evenly spaced around girdle. Precingular 2 has a somewhat smaller girdle margin than its fellow, precingular 6, on the right side, but this discrepancy is not nearly so pronounced as in the case of *P. truncatum* (p. 28).

Hypothecal pattern typical of genus (fig. 37C). At apex there are 2 platelets in addition to apical plates, as in *P. depressum*. Ventral apical platelet about 1 girdle width long. Apical pore platelet a ring structure similar to that in *P. depressum*.

Girdle consists of four unequal plates (fig. 37D). First girdle plate (g1) is a short, squarish plate adjacent to the ventral area. The second and fourth (g2, g4) about equal in length and occupying the ventral portions on the two sides of girdle. Lateral and dorsal sides of girdle composed of the long third girdle plate (g3).

Ventral area composed of six plates (fig. 37E, F). Only four of these are visible in undissected specimens, the other two hidden as in the case of *P. depressum*. All plates homologous with those in *P. depressum*, a species with a ventral area in many respects similar to that of

*P. crassipes*. (See comparisons.) **Anterior sulcal plate** (as) occupies most of the anterior part of the area and forms anterior margin of flagellar pore. **Left sulcal plate** (ls) comprises most of the left side of sulcus and forms left edge of flagellar pore. **Right sulcal plate** (rs) occupies most of right side of ventral area, is raised practically to the level of the main body plates, as in *P. truncatum* (p. 28), and forms right margin of flagellar pore and sulcus proper. **Posterior sulcal plate** (ps) forms posterior part of the area and is U-shaped in outline. Its right side is expanded into a squarish process which lies posterior to right sulcal plate. Its middle portion is very narrow. Its left side is elongated into a slender process which borders posterior left edge of the sulcus and is raised to the level of the body plates, fitting in between the first postcingular and first apical plates. This portion bears the posterior part of the left accessory sulcal list on its inner margin. At the posterior edge of flagellar pore between the right and the left sulcal plates is a small, squarish, trough-shaped plate, the **posterior accessory sulcal plate** (pas). Along the right side of pore, underneath the left edge of the right sulcal plate, is a thin plate, the **right internal sulcal plate** (ris), which has a posterior arm turned into the body of the specimen. A similar projection into the protoplast at the anterior edge of the pore is not a separate plate but a process on the under side of the anterior sulcal plate.

**Body wall.** Body plates and some sulcal plates covered with a light reticulation which is usually irregularly raised at the angles of the meshes. Size of meshes, except over rabbeting membranes, from 0.3 to 0.5 girdle width. Over these membranes, in individuals without intercalary zones, the meshes are noticeably larger, 0.6 girdle width or more; but reticulations are much less well developed, the thecal wall appearing thinner; and no pores occur. In the more finely reticulated areas, there are fairly regularly spaced pores, usually one per mesh. In these areas the thecal wall is thicker and the meshes of the reticulations sometimes give the appearance of pits, although their edges are always angular. The girdle plates do not bear these reticulations, but have irregular transverse ridges which usually extend only halfway from the edge of the girdle, and may be connected, forming a sort of reticulation. There are no pores in the girdle although the median line of the girdle has a spongy nature. Intercalary zones are common.

**Lists.** Girdle lists about 1 girdle width wide and strengthened by small ribs which extend centripetally from outer margin halfway to body. These ribs are placed from 0.2 to 0.3 girdle width apart. In the apical region there is a system of lists similar to that in *P. depressum* except that the most distal parts are less well developed. The lists running down the body from the apex are larger than in *P. depressum*, sometimes being as much as 1.5 girdle widths wide. The lateral ones (attached to ap3) usually visible in ventral and dorsal views. The right and left segments of the apical list (ral, lal, fig. 37G), which run down the ventral side of the body and are attached to the fourth and second apicals, respectively, are clearly seen when specimen is viewed in lateral aspect.

Lists in the sulcal region well developed. **Left sulcal list** continuous with posterior girdle list and attached to po; continuous posteriorly with the **left accessory sulcal list** (la), which is attached to the right edge of the left limb of the posterior sulcal plate (ps). The

left sulcal and the left accessory sulcal lists form the functional left sulcal list. They are very broad, about 1.5 girdle widths wide, except at their point of junction, where they are constricted to 0.7 girdle width. Posteriorly, the left accessory sulcal list extends as a free sail about 1.5 girdle widths long. These two lists extend more or less laterally over the sulcus, covering all its left half and the flagellar pore. Right sulcal list very small. Posterior sulcal list well developed medially, having a width of about 0.7 girdle width, but rapidly diminishes anteriorly as it runs up the sides of the sulcus. The right accessory sulcal list (ras) is thick and narrow, overhangs the flagellar pore on its right side, and continues posteriorly to the posterior sulcal plate, forming a trough with the posterior accessory sulcal plate. There is no posterior accessory sulcal list.

"Spines." Solid antapical spines end antapical horns. They are about 2 girdle widths long; the right is slightly longer than the left. cursory examination of intact specimens in ventral view shows a spine posteriorly at each side of sulcus. Spines are simply optical effects produced by the greater absorption of light at points where line of vision falls on tangents of the curvature of the posterior sulcal lists. Lists are difficult to see because of transparency, except at these spines.

Comparisons. Peridinium crassipes is distinguished from other species of Metaperidinium by its short, broad body and by its short horns.

It is of particular interest to compare the ventral area of P. crassipes with that of P. depressum and that of P. truncatum, since crassipes has a structure which in some respects is transitional between the latter two species. The margins of the ventral area are similar to those in P. truncatum. The body sutures have the same relation to those of the ventral area as in that species. The tabulation of the ventral area is transitional between P. depressum and P. truncatum. The largest plate of this area, the right sulcal, is raised so that it forms part of the body proper, as in P. truncatum. On the other hand, the region immediately surrounding the flagellar pore agrees well with P. depressum. There are internal structures at the anterior and posterior ends of the pore. A semilunar structure occurs at the right edge of the pore on the internal surface of the right sulcal plate. This structure is composed partly of an internal plate, the right internal sulcal plate, as in P. depressum. The very small posterior accessory sulcal plate is probably homologous to the similar plate in P. depressum and the larger plate of the same name in P. truncatum.

The sulcal list system is also transitional between P. depressum and P. truncatum. The right accessory sulcal list ends at the posterior end of the right sulcal plate, as in P. depressum; it does not join with any posterior accessory list as is the case in P. truncatum. The course of the left accessory sulcal list is as in P. truncatum. Otherwise the lists of the posterior region of the sulcus are quite different from those in that species and are similar to those in P. depressum. There is no posterior accessory list connecting the right and left accessory lists, and the left accessory list extends posteriorly as a free lobe.

Historical. Kofoid (1907a) described this species from the neritic plankton off San Diego, California.

Paulsen (1908) considered figs. 43, 1-2 of Schütt (1895) to represent this species, but in our opinion this is uncertain. The side view (fig. 43, 2) might well be P.

crassipes, but the dorsal view (fig. 43, 1) does not show sufficient expansion in the girdle region.

The antarctic form reported by Peters (1928) is distinctly different from the northern form, but Peters considers the two forms to fall within the limits of a single species. The antarctic form has a peculiar angularity of the body and thickness of antapical horns not found in the northern form.

Jørgensen (1913) separated P. curtipes from P. crassipes, on the basis of its yellow, instead of pink, color; its greater expansion in the girdle region, and the shape of the girdle on the left ventral side. Lebour (1925) accepted this species of Jørgensen but Peters (1928) rejected it. Peters pointed out that species of Peridinium cannot be distinguished by their color, as this is variable. He also was of the opinion that the shapes of the body and girdle are indistinguishable in P. curtipes and P. crassipes. Matzenauer (1933) accepted P. curtipes and figured a specimen with even greater expansion of the girdle region than that of Jørgensen's species, and with short, conical, divergent antapical horns.

Since both these species have been very inadequately figured, and especially since very little is known regarding any morphological feature of P. curtipes, it is not possible at this time to pass a proper judgment on the authenticity of P. curtipes.

The ventral area of P. crassipes had not been analyzed until the present investigations. Kofoid's (1907a) figures show that certain parts of the area are prominent and on a level with the main body plates, but even the main features of the area are omitted and the flagellar pore is erroneously indicated at the anterior end of the ventral area.

Distribution. Peridinium crassipes is probably widespread. If we consider Jørgensen's P. curtipes as Peters (1928) suggested, we have records of occurrence from all parts of the Atlantic (Lebour, 1925). Under the name P. crassipes, it was reported from the Antarctic by Peters (1928), and from the Indian Ocean by Matzenauer (1933), and from the Mediterranean by Forti (1922) and Issel (1928). In the Pacific it was reported from San Diego, California, by Kofoid (1907a), and from the eastern Pacific, between Hong Kong and Shanghai, by Böhm (1936).

The Carnegie collection furnishes many new localities for this species in the Pacific, viz., 50 widely scattered stations in the tropical and subtropical regions (fig. 38). There are 107 records of occurrence; 63 rare and 44 occasional. It was found about equally at the three levels, with 30 records for the surface, 39 for 50 meters, and 38 for 100 meters. There are 14 pump records and 93 net records. The species was found in both hemispheres in all months of the year except June, July, and August. The records of "occasional" are scattered irregularly over its range.

The Carnegie records of P. crassipes are limited entirely to the Pacific. In the eastern Pacific it was not found north of Guam, whereas in the western Pacific it occurred as far north as latitude 33° north and as far south as latitude 40° south.

The surface temperatures at the stations where the species occurred at any depth varied from 15.0 to 28.6 C. The ranges of hydrographic conditions in situ were as follows: temperature, 10.8 to 28.3 C; salinity, 31.6 to 36.4 o/oo; pH, 7.76 to 8.47; phosphate, 3 to 159 mg PO<sub>4</sub>/m<sup>3</sup>.

The distribution of *P. crassipes* at the Carnegie stations is unexplainable unless we assume that the occurrence is sporadic. The species is eurythermal and has been found by other investigators over wide areas of the Atlantic, from the tropics to the North Sea, yet it was absent from all Carnegie stations in the Atlantic. In the Pacific, in the Carnegie collection, it occurred mostly in the warmer regions but was not found on the line of stations between Guam and San Francisco, which passes through both cold- and warm-water regions. It did occur, however, in the southeastern Pacific in water of low temperature.

*Peridinium truncatum* n.sp.  
(Figures 39-41)

Dimensions. Total length ( $l$ ) including the apical and right antapical horns 230 (196-265) microns. Length ( $h$ ) from tip of apical to posterior end of sulcal 161 (138-210) microns. Diameter ( $d$ ) 159 (130-200) microns. Diameter ( $g$ ) 80 (65-105) microns. Width of girdle 5-6 microns. Twelve specimens were measured.

Shape. Body shape characterized by pronounced features. Mid-body compressed anteroposteriorly in girdle region, especially at the sides, to such a degree that the lateral sides are scarcely thicker than the girdle is wide (fig. 39E). In contrast with this extreme compression of the mid-body, all the horns are so long that the epitheca as well as the hypotheca is about 1.5 times longer than the dorsoventral diameter. The  $l/d$  ratio is 1.45 (1.27-1.57). The  $h/d$  ratio is 1.01 (0.91-1.17). The angle  $\alpha$  is  $47^\circ$  ( $34^\circ$ - $65^\circ$ ). The rapid taper of the mid-body into the horns is roughly the same on all sides; thus the horns are almost symmetrical and the marginal curvatures of the mid-body are similar in ventral and lateral views. All horns are tubular distally and elongated. Distal one-third to one-half of antapical horns are of uniform diameter. End of apical horn about 1.5 girdle widths wide; ends of antapicals about 1 girdle width. Antapical horns truncate to slightly rounded, but never pointed.

In apical view the body is basically reniform but with ventrolateral limbs greatly elongated. Since the prolongation of these limbs is a fundamental characteristic of the species, it is necessary to express it numerically in order that a proper delimitation of the species may be obtained. For this reason, the width of the limb ( $r$ ) was measured as described on page 13 (fig. 8). This width is best expressed as a fraction of  $g$ . The  $r/g$  ratio in this species is 0.47 (0.43-0.51). Although this ratio is sufficient to characterize the species, it is noteworthy that the length of each limb, measured from the apex of the body, is at least 1.25 times the dorsoventral diameter of the body. Another measurable feature which is significant in this connection is the ventral projection of these limbs; this projection, beyond the median ventral point, is usually 0.5 times the dorsoventral diameter of the body. The  $g/d$  ratio is also characteristic, being 0.48 (0.41-0.54).

There is practically no real displacement of the girdle, although there is frequently an apparent one if the specimen is not seen in an exact ventral view. This apparent displacement may be dextral or sinistral depending on the direction of displacement of the specimen. Girdle ends separated by the wide anterior portion of the ventral area. In lateral view the girdle is seen to be

inclined about  $15^\circ$  to the longitudinal axis. It is only slightly concave.

Ventral area occupies a large part of ventral surface of body. About half the area of the right ventral portion of the hypotheca and part of the posterior left portion are composed of elements of the ventral area. These parts of the ventral area occupy an integral part of the body and are set into the general body contours without any break. Sulcus proper composed of the central elements of the ventral area (see below). Flagellar pore oval, about 3 girdle widths long, and situated somewhat anterior to center of ventral area. The sulcus is so rotated on its longitudinal axis that the pore faces to the left rather than ventrally. Pore covered by sulcal lists so that it does not face the exterior directly.

Plate pattern. Pattern of major body plates typical of divergens group. At the apex of body, there are 2 platelets in addition to the apical plates. Ventral apical platelet long and narrow, more than 7 girdle widths long, lying just anterior to the first apical and between the second and fourth (fig. 39C, E). Apical pore platelet is a ring platelet, set inside the ends of apicals 2, 3, and 4, and the ventral apical platelet.

Epithelial pattern not symmetrical in respect to precingular plates. Precingular 2 is much narrower, both relatively and actually, than corresponding plate on right side, precingular 6. The girdle border of pr2 usually less than one-fourth that of pr6 (fig. 39A). To compensate for this, pr3 has a much longer girdle margin than its fellow pr5 on the right side. Precingular 2 narrows very markedly toward girdle, so that its width at girdle may be as little as one-half its greatest width.

Girdle composed of four unequal plates (fig. 39G). First girdle plate somewhat narrower than long (fig. 39D). Second and fourth extend on either side of sulcus almost to the most ventrolateral points of girdle on each side. The rest of the lateral and dorsal parts of girdle consist of the extremely long third plate.

Pattern of hypothecal plates typical of divergens group. Sulcal plates take a prominent place in the ventral aspect of body, a characteristic feature in this species. Right sulcal plate occupies a large part of ventral surface of hypotheca. The left limb of the posterior sulcal plate fits into the major body plates between the first postcingular and first antapical (fig. 39E) in such a way that it might be mistaken for a major body plate in undissected specimens.

Ventral area composed of five plates, all external (fig. 39D). Anterior sulcal plate occupies most of the area between the ends of the girdle and forms anterior margin of flagellar pore. It bears a process at its posterior end which projects into the cell body. Left sulcal plate occupies the left central and the posterior central regions of the ventral area and, in its anterior half, forms the left margin of the flagellar pore. Posterior sulcal plate more or less U-shaped, forms posterior part of ventral area, is far removed from flagellar pore, and is very complex. Its left limb forms a large, four-sided area in the hypotheca, extends from antapex halfway to girdle, and fits into the hypothecal pattern posterior to first postcingular. Its right limb lies posterior to sulcal plate and is also raised to a position where it must be considered part of the hypothecal pattern (fig. 39E). The right sulcal plate, which is the largest in the ventral area, extends from posterior sulcal plate to epitheca, where it has a narrow extension lying against the distal end of girdle and against seventh precingular. It

its middle part it forms the right margin of flagellar pore. It is definitely raised to a position equivalent to that of a hypothecal plate. In its anterior half it has a dome-shaped prominence which rises over the flagellar pore (fig. 41). At the middle of the left side of this plate, at the posterior end of the flagellar pore, there is a process which projects into the cell body (fig. 39F). Between the posterior half of the left sulcal plate and the posterior half of the right sulcal plate there lies a narrow plate about 4 girdle widths long, the posterior accessory sulcal plate, the homologue of the very minute plate at the posterior end of the flagellar pore in P. depressum and P. crassipes. Anteriorly it touches the flagellar pore, and posteriorly, where it borders the posterior sulcal plate, it is about 3 times wider than at the anterior end. There is no detachable semicircular plate such as occurs in P. depressum and P. crassipes.

**Body wall.** Entire surface of the major body plates and of all the sulcal plates, except the left and posterior accessory sulcal plates, covered with a very prominent coarse and regular reticulation. Plates lacking this are entirely smooth. Reticulation so deep on apical and antapical horns, especially in their distal parts, that it gives the impression of "spininess" along the edge of the horns. Girdle plates with irregularly spaced transverse ridges which may extend completely across the girdle or only part way from the margin on either side. The major body plates, the girdle plates, and the sulcal plates are pierced by minute, irregularly scattered pores. Arrangement of these pores bears no relation to reticulations. Usually one or two pores per mesh; those on the girdle plates not arranged in rows.

Intercalary zones not found in our material, except in two specimens.

**Lists.** Girdle lists comparatively narrow, usually less than 1 girdle width wide; strengthened by fairly regularly spaced ribs, usually extending completely from body to outer edge, but in some cases extending only part way from body or from outer edge.

The apical list system similar to that in P. depressum, except for a lesser development generally and for the absence of the lateral lists. The lists in this region are only 0.25-0.50 girdle width wide. Apical list encircles apex and is composed of three segments: the dorsal, right, and left. Dorsal segment attached to tip of third apical and not joined by any lateral lists as in P. depressum, P. crassipes, and P. pallidum. Right and left segments are attached to apical and ventral edges of second and fourth apical plates and continue down the ventral side of the body only as far as the posterior end of the ventral apical platelet (at the anterior end of the first apical plate). Ventral apical platelet is set deeply between these two lists (fig. 39C, E, H).

Development of sulcal lists in this species is of particular interest. Left sulcal list is well developed in respect to its width, which is from 1.0 to 1.5 girdle widths. The list extends laterally over the left anterior part of the sulcus, overlapping the anterior end of the right accessory list and flagellar pore. It is continuous with the posterior girdle list and is attached to the first postcingular plate. Therefore, it can extend only halfway down the side of the ventral area. At this point it joins the left accessory sulcal list, which is just as wide as the left list but projects ventrally from the body. It is attached to the left limb of the posterior sulcal plate, and is continued around the posterior region of the sulcus as the posterior accessory sulcal list. This list, which is

attached to the posterior sulcal plate, is narrower than the last mentioned list and joins the posterior sulcal list at the right posterior corner of the ventral area. Posterior sulcal list is a poorly developed list along the posterior margin of the ventral area. It is composed of two segments: the left segment, which is attached to the first antapical plate, and the right segment, which is attached to the second antapical plate. Right sulcal list is absent. In other species it runs along the right edge of the right sulcal plate (attached, however, to body plates) and defines the right margin of the sulcus proper. In this species its absence coincides with the raising of the right sulcal plate to the position of a major body plate. The functional list to the right of the sulcus proper in this species is the right accessory sulcal list. It is attached to the left edge of the right sulcal plate. It extends laterally over the flagellar pore and the posterior part of the sulcus. Posteriorly it connects with the posterior accessory sulcal list but has a free lobe extending posteriorly (fig. 39D, E). The posterior accessory list extends along the anterior edge of the middle and right parts of the posterior sulcal plate.

**Comparisons.** This species is rather closely related to P. elegans Cleve (a species not treated in this report) but may be distinguished from the latter by its greater expansion in the girdle region, much greater development of the ventrolateral body limbs, truncated antapical horns, and shape of the second precingular plate. The  $r/g$  ratio is 0.47, as compared with 0.84 for P. elegans. The second precingular plate in P. truncatum narrows toward the girdle, whereas in P. elegans it widens. The girdle margin of this plate in P. truncatum is less than one-fourth that of  $po_6$ ; in P. elegans that margin is more than half that of  $po_6$ . Furthermore, P. truncatum is a larger species, with an  $h/d$  ratio on the average greater than that of P. elegans.

A comparison between the ventral areas of P. truncatum and P. depressum is of interest. Although the areas are constructed on the same fundamental plan, with all plates homologous, they show many marked differences in pattern, contours, and lists.

The sulcal plates in P. truncatum show a definite tendency to become major body plates. Thus a smaller number of plates form the sulcus proper in P. truncatum than in P. depressum. In P. depressum the left limb of the posterior sulcal plate is quite inconspicuous, whereas in P. truncatum it is prominent and fits into the main body complex posterior to  $po_1$ . The right limb of the posterior sulcal plate likewise is prominent in undissected specimens of P. truncatum, whereas in P. depressum it is quite obscure. The right sulcal plate in P. truncatum is a prominent feature of the ventral aspect of the hypotheca, whereas in P. depressum it is a comparatively obscure plate of the sulcus. In P. depressum it has a trough running the length of it, whereas in P. truncatum this plate is convex and actually humped in the anterior half. In the sulcus of P. depressum there is a right internal sulcal plate; in P. truncatum this is absent. The posterior accessory sulcal plate is minute in P. depressum, but in P. truncatum it is 4 girdle widths long.

The positions of the sulcal plates in relation to the plates of the body differ considerably in the two species. In P. truncatum the suture between  $po_5$  and  $ant_2$  reaches the ventral area in the middle of the right sulcal plate, whereas in P. depressum this suture runs much more posteriorly and reaches the ventral area in the middle

of the right arm of the posterior sulcal plate. The suture between *pol* and *ant1*, although not exactly comparable in the two species, shows a fundamental difference in its course. In *P. depressum* it reaches the sulcus far posteriorly, whereas in *P. truncatum* it reaches the sulcus about midway of its length, about at the midpoint of the left sulcal plate. In *P. truncatum* the left limb of the posterior plate extends anteriorly to meet this suture. All together these differences in sulcal plate pattern are greater than the differences between the typical epithelial patterns of the ortho and meta groups of the genus.

The sulcal list systems of *P. truncatum* and *P. depressum* are as fundamentally different as are the plate patterns. In *P. depressum* the functional border list of the right side of the ventral area is the right sulcal list (*rl*, fig. 17), which is attached to the body plates along the right edge of the ventral area. In *P. truncatum* this list is practically undeveloped and the functional right border list is the right accessory sulcal list (*ras*, fig. 39), which in *P. depressum* is located deep within the sulcus proper. There is a similar difference between these two species as regards the left side of the sulcus. The posterior girdle list and the anterior part of the left sulcal list are continuous in both species, but the posterior part of the left sulcal list has quite different positions in the two species. In *P. depressum* this part is located at the left margin of the deep sulcus and is continuous with the anterior part of the left sulcal list and with the posterior sulcal list, which, in turn, runs around to meet the right sulcal list. Thus, the ventral area is bordered by three lists: the primary left, the posterior, and the right sulcal lists. In *P. truncatum*, concomitant with the expansion of the ventral area, these bordering lists have been subordinated or lost completely and there has been a development of accessory lists bordering the sulcus proper, which occupies only a limited part of the ventral area. The anterior part of the left sulcal list connects with the left accessory sulcal list (*la*), which is joined to the posterior accessory sulcal list (*pal*); this, in turn, is joined to the right accessory sulcal list (*ras*).

The ventral area of *P. truncatum* is not so different from that of *P. crassipes* as it is from that of *P. depressum*. For a comparison of these features in *P. truncatum* and *P. crassipes*, see "Comparisons" under *P. crassipes*.

The very marked differences in the structure of the ventral areas which were found in these species, as exemplified by the comparison of *P. depressum* and *P. truncatum*, are of the greatest importance to the taxonomy of the genus. It is probable that the future classification of the species of *Peridinium* will be based on the morphology of the ventral area.

**Historical.** The figures of Okamura (1912, pl. 4, fig. 58a-c) given under *P. fatulipes* probably refer to this species. Otherwise, it apparently has not been reported before.

**Distribution.** *Peridinium truncatum* was found at 24 stations, all in the Pacific. There are 46 records of occurrence: 27 rare, 16 occasional, and 3 common. It was found less at 100 meters than at the other levels, with 16 records for the surface, 20 for 50 meters, and 10 for 100 meters. There were 41 net records and 5 pump records.

The species was not found south of 16° south nor north of 34° north. There was no definite center of a-

bundance. The records of "occasional" were scattered throughout the range. One of the records of "common" was near Panama (station 35a), the other two were northeast of Samoa (station 157).

The surface temperatures at the stations where the species occurred at any depth varied from 18.7 to 29.4 C. The ranges of hydrographic conditions *in situ* were as follows: temperature, 14.4 to 29.2 C; salinity, 29.7 to 35.9 o/oo; pH, 7.82 to 8.39; phosphate, 4 to 189 mg PO<sub>4</sub>/m<sup>3</sup>.

This is apparently a strictly tropical species, perhaps confined to the Pacific. Waters of low nutrient content are apparently no barrier to it, as there were 5 records in water containing less than 10 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 35.

*Peridinium truncatum* forma *acutum* n.f.  
(Figures 40C, D)

**Dimensions.** Length of body (*l*) 238 microns. Length (*h*) 168 microns. Diameter (*d*) 168 microns. Diameter (*g*) 98 microns. Width of girdle 6 microns. One specimen measured.

**Shape.** Body shape close to average for species in all respects except in the length of antapical horns and the *g/d* ratio. The *l/d* ratio is 1.42. The *h/d* ratio is 1.00. The *g/d* ratio is 0.58. The *r/g* ratio is 0.46. The angle  $\alpha$  is 63°. Antapical horns more slender, with pointed ends, the right more so than the left. The specimen observed had broad intercalary zones, so that there was a wider spread of the antapical horns than otherwise would have been the case. Dorsoventral diameter greater than in the main species. The angle  $\alpha$  is near the maximum for the species. In all other respects the shape fits description of main species. Plate pattern apparently similar in all details.

**Distribution.** This form was found only at station 104, in the western Pacific northwest of the Marshall Islands, in May. It was collected in the 100-meter tow. The hydrographic conditions *in situ* were: temperature, 25.3 C; salinity, 35.3 o/oo; pH, 8.21; phosphate, 7 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 104.

*Peridinium pallidum* Ostenfeld  
(Figures 42, 43)

*Peridinium pallidum* Ostenfeld, 1899, p. 60. Ostenfeld, 1900, p. 58. Ostenfeld, (1903) p. 581, figs. 130, 131. Cleve, 1900a, p. 17, pl. 7, figs. 21, 22. Jörgensen, 1905, p. 110. Paulsen, 1907, p. 14. Paulsen, 1908, pp. 48-49, fig. 60. Broch, 1910b, p. 45, fig. 17. Meunier, 1919, pl. 15, figs. 24-29. Lebour, 1925, p. 134, pl. 28, fig. 1a-d. Peters, 1928, pp. 31-33, fig. 7a-c.

*Peridinium pellucidum* Gran, 1902, p. 186. not *Peridinium divergens pallidum* Karsten 1906, pl. 23, fig. 13a, b.

**Dimensions.** Length of body, including right antapical spine, (*l*) 94 (44-128) microns. Length (*h*) 78 (38-107) microns. Transdiameter (*d*) 73 (35-98) microns. Diameter (*g*) 45.9 (33-56) microns. Angle  $\alpha$  121.5° (105°-148°). Width of girdle 5 (3-6) microns. Eighteen specimens were measured.

**Shape.** Body in ventral view roughly squarish in outline, somewhat longer than broad. The *h/d* ratio is

1.07 (0.95-1.28). Epitheca almost triangular, with apex more or less prolonged into apical horn, which may be almost absent or as much as 2 girdle widths long. Hypotheca shorter than epitheca. Thus, the girdle is somewhat posterior. Hypotheca subtruncate with indentation at sulcus. The two antapical processes thus formed can scarcely be termed horns. Body well rounded in girdle region. In apical or antapical view ovate, compressed dorsoventrally. The  $g/d$  ratio is 0.68 (0.53-0.90). In side view body also subovate. Girdle dextral, displaced 0.5 to 1.0 girdle width, not excavated, inclined (in side view) at an angle of about  $25^\circ$ . No girdle overhang. Ventral area angular in outline, extending from anterior margin of girdle to antapex, and deeply embedded in body. Sulcus lies to the left, overhung by the major body plates. Flagellar pore oval in outline, centrally located in ventral area and covered by the right accessory and left sulcal lists (fig. 43B, C).

**Plate pattern.** Epithelial tabulation para, hexa. Apex has a ring platelet and a ventral apical platelet (fig. 43A, D). Four girdle plates. The first girdle plate is wider than long and extends somewhat into sulcus (fig. 42H). Second girdle plate short and squarish. The third girdle plate comprises most of the girdle and encircles the body almost to ventral area on right side (fig. 42F). Fourth girdle plate short and rectangular, about twice as long as wide, located at distal end of girdle.

Ventral area composed of six plates: anterior, left, posterior, posterior accessory, right, and right accessory (fig. 42H). **Anterior sulcal plate** (as) long, extending from apical plate to anterior edge of flagellar pore. At the pore it has an internal spongy structure composed of prongs or forks which fit into similar structures on the left and right sulcal plates making an interlocked joint. **Left sulcal plate** (ls) forms left edge of flagellar pore and its anterior end touches first girdle plate. It has a thickened ridge along its right edge which forms left edge of pore. **Posterior sulcal plate** (ps) forms posterior part of ventral area and is almost U-shaped. Its left arm very narrow and carries posterior segment of left sulcal list. Its right arm lies posterior to **right sulcal plate** (rs). The latter plate occupies most of right side of ventral area and posterior half of its left edge forms the right edge of flagellar pore. It bears the thick right accessory sulcal list, which projects over the pore, as well as internal processes similar to those in *P. depressum*. There is, however, no detachable internal plate. Between the right and the posterior sulcal plates, at the posterior edge of pore, there is a very small irregular plate, the **posterior accessory sulcal plate**. It is not more than two to three microns long and thus of almost indeterminate shape. Anterior to the right plate and opposite distal end of girdle, there is a short rectangular plate, the **right accessory sulcal plate**. This plate has been found only in *P. pallidum*, which was the only one investigated with a right-handed girdle. It is possible that the presence of this plate goes with the right-handed girdle, for in such a displaced girdle either the right sulcal plate must be longer or else there must be an additional plate to occupy the increased distance on the right side of the sulcus between the distal girdle end and the antapex.

**Body wall.** Surface of body plates covered with irregular short ridges and tubercles. Pores scattered over the major plates and the right, left, and posterior sulcal plates. Very irregular row of extremely small pores in mid-line of girdle plates. Very small trans-

verse ridges may extend from outer margins of girdle plates toward middle. Intercalary zones common and may be quite wide. Intercalary striae run across these. Rabbeting membranes well developed and may be as much as 2 girdle widths wide.

**Lists.** Girdle lists well developed, usually about 1 girdle width wide. Apical lists well developed, sometimes more than 1 girdle width wide, similar to those in *P. depressum* but wider and more extensive (fig. 43A, D). Apical list encircles apex; composed of 3 segments: dorsal, right, and left. Right and left segments (r.a.l., l.a.l.) are attached to apical and ventral edges of second and fourth apical plates and continue down ventral side of body sometimes as far as girdle. In this case the proximal segments of these lists are attached to second and sixth precingular plates. Dorsal segment of the apical list (d.l.) attached to third apical plate and continuous with lateral lists. **Right lateral list** (r.l.l.) and **left lateral list** (l.l.l.) run down sides of body, frequently to girdle, in which case their intermediate segments are attached to first and third intercalary plates and the proximal, or girdle, segments are attached to third and fifth precingular plates (fig. 42B).

Sulcal lists are also well developed. **Left sulcal list** extends laterally over sulcus, about 1 girdle width wide. Its anterior segment attached to first postcingular and continuous with posterior girdle list. Its posterior segment attached to left arm of posterior sulcal plate. Left sulcal list terminates posteriorly in mid-region of this plate (fig. 42H). **Posterior sulcal list**, which is attached to sulcal margins of antapical plates, and the **right sulcal list**, which is attached to the second antapical and fifth postcingular plates, are poorly developed except where they converge and run up the right antapical spine. (Fig. 42H). When intercalary striae occur along the right border of the ventral area there is a weak development of the right sulcal list on each edge of the zone. **Right accessory sulcal list**, which is attached to the right sulcal plate, is well developed and overhangs flagellar pore.

Other body lists may develop to a minor degree along the sutures of the major body plates.

**Spines.** The two rounded processes of the antapex are terminated by spines; the right usually longer than the left. Length of right spine is 12.4 (7-17) microns. Each spine composed of united short body lists. On the right spine, one of these lists is continuous with left sulcal list and one with posterior sulcal list. There are at least two others which run out of the second antapical plate with no relation to sutures. The left spine has four or more short lists which bear no relation to sutures. One of these articulates transversely with, and runs out of, the left sulcal list. It can be disarticulated from it. (Fig. 42H).

**Variations.** This species varies considerably in size and shape. The length varies by three times (44-128 microns). The compression of the body is rather uniform in most specimens ( $g/d$  ratio is about 0.68) but some specimens were found with more circular girdle section, with  $g/d$  ratio as high as 0.90 ( $g/d$  ratio of circle, of course, 1.00). Width of girdle is remarkably constant in its absolute values, about 5 microns. This is particularly noticeable in small specimens, where the girdle is, then, relatively wide. The plate pattern in this species seems to be in a fairly stable state. Only one aberration was found. In this the fourth and fifth precingular plates were fused. The length of the antapical spines varies in accordance with the variation in devel-

opment of the lists of the body. The right spine varies in length from 7 to 17 microns.

**Comparisons.** This is the only species of the para group included in this report. It is of particular interest to compare the ventral area of this species with that of species of other parts of the genus. Previous investigators have considered *Paraperidinium* more closely related to *Metaperidinium* than to *Orthoperidinium*. An examination of the ventral areas of the representatives presented in this report, however, indicates that *Paraperidinium* is more closely related to the ortho group than to the meta. Although the ventral area of *P. pallidum* is distinctive, it resembles in general that of *P. depressum* more than that of *P. crassipes* or that of *P. truncatum*. The entire ventral area is depressed in *P. pallidum*, so that it does not take part in the major body plate complex. In this respect *P. pallidum* resembles *P. depressum*. Similarly, the ventral area is bordered by the primary sulcal lists rather than by the accessory ones, even though the right sulcal list may be double in specimens with intercalary zones. The ventral area of *P. pallidum* differs from that of *P. depressum* significantly only in the absence of the right internal sulcal plate and in the presence of the right accessory sulcal plate. Its only resemblance to that of *P. crassipes* and to that of *P. truncatum* is in the relative position of the sutures between the first and fifth postcingulars and the antapical plates. These sutures join the ventral area about halfway between the antapex and the girdle, instead of near the posterior end of the area as in *P. depressum*.

The absence of antapical horns does not seem to alter the structure of the ventral area in any fundamental way.

Of the species so far analyzed, this is the only one in which the sutures between the girdle plates are so near the ventral area, that is, in which the second and fourth girdle plates are so short. In other species these sutures are in line with the sutures of the major body plates.

**Historical.** This species is very closely related to *P. pellucidum* (Bergh) Schütt and, in fact, may include that species. If so, the name *pellucidum* has priority (Bergh, 1881). In her comparison of these two species, Lebour (1925) gives size and shape differences: *P. pellucidum*, length 40-68 microns (without spine?), breadth 36-70 microns; *P. pallidum*, length 70-96 microns, breadth not stated. In the *Carnegie* material the  $h$  values vary from 38 to 107 microns with no grouping of the values that would suggest the presence of two species or varieties. The diameters vary, similarly, from 35 to 98 microns. Only eighteen specimens were measured, however, and it is possible that additional material would indicate the possibility and desirability of separation. Lebour (1925) states that the compression is very slight in *P. pellucidum* and gives a figure with circular girdle section (pl. 28, figs. 2c, 2d). In the *Carnegie* material the  $g/d$  ratio was found as high as 0.90, and this was not correlated with small size but, on the contrary, was found in one of the largest specimens of the collection. Lebour gives the theca as finely reticulate for *P. pellucidum* but gives no figures. *Peridinium pellucidum* is supposed to be a neritic form (Lebour, 1925) and thus would not be expected to be found in the *Carnegie* material.

In our opinion the existence of two separate forms must be held in doubt until a further study is made of the small neritic forms. If they are distinct from the form

found in the *Carnegie* material, then other characters than size and shape must be found to distinguish them.

**Distribution.** Common in the northern North Atlantic (Paulsen, 1908; Lebour, 1925). Reported from the Mediterranean by Forti (1922). Rare in the Antarctic (Peters, 1928). Not reported from the Indian Ocean by Matzenauer (1933) nor from the Pacific by Böhm (1936).

In the *Carnegie* collection this species was found at 28 stations; 16 in the Atlantic and 12 in the Pacific. There are 57 records of occurrence: 27 rare, 28 occasional, and 2 common. It was found about equally at the three levels although somewhat more frequently in the upper levels, with 22 records for the surface, 20 for 50 meters, and 15 for 100 meters. There are 44 net records and 13 pump records. It was found mostly in the northern hemisphere, with only 1 station in the southern, and from May to September.

In the Atlantic it occurred at most of the northern stations and as far south as 34° north (station 17). In the Pacific it was found at three series of stations: off Japan (stations 113-114, 116-117); between San Francisco and Honolulu (stations 133-137); and in the western series crossing the equatorial currents (stations 97-98, 101-102). There was no center of abundance; the records of "occasional" were scattered over its range.

The surface temperatures at the stations where this species was found at any depth varied from 8.4 to 28.3°C. The ranges of hydrographic conditions *in situ* were as follows: temperature, -1.6 to 28.3°C; salinity, 33.4 to 36.6 ‰; pH, 7.87 to 8.47; phosphate, 3 to 99 mg PO<sub>4</sub>/m<sup>3</sup>.

*Peridinium pallidum* is probably a widespread species of sporadic occurrence. It can endure a wide range of hydrographic conditions, and factors limiting its production are not indicated in the present data. It can develop in low concentrations of nutrients, as is shown by 19 records in water with less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

#### Family CERATOCORYACEAE Lindemann

**Diagnosis.** Shape angular to rounded, no prominent horns. Epitheca rounded, hornless, spineless, usually low. Hypotheca angular to rounded, usually bearing prominent spines. Girdle anterior to equator, sinistral, not concave, without overhang. Ventral area narrow, depressed anteriorly; flagellar pore at anterior end. Girdle and sulcal lists well developed. Ventral epithecal pore present on a2. Plate formula: apical closing platelet, 2ap, 2a, 5pr, 6g, 5-6po, 1p, 1ant, 5-6s. Marine. Only one genus, which includes seven species.

#### Genus CERATOCORYS Stein

##### Diagnosis

See family diagnosis (monogeneric)

##### Description

**Size.** Length of body ( $l$ ) varies from 38 microns in *C. gourretii* to 99 microns in *C. armata*. Width at girdle in ventral view ( $d$ ) from 28 microns to 114 microns in the same species, respectively.

**Shape.** Body angular in all species except *C. gourretii*, *C. horrida* being the most angular. At girdle, body is squarish to circular or subovate. Girdle placed almost equatorially in *C. armata* and *C. reticulata*, in all



other species more anteriorly, reaching the most anterior position in *C. gourretii* and *C. horrida*. The  $e/1$  ratio varies from 0.16 in *C. gourretti* to 0.46 in *C. reticulata*. Girdle displaced from 0.5 to 2.5 girdle widths; its ends separated by anterior end of ventral area.

Angularity of body pronounced in lateral view, except in *C. gourretii*, which is circular to ovate. In other species epitheca triangular or triangular with truncated apex. Hypotheca, in lateral view, squarish to triangular, but always with an oblique shearing posteroventrally (except in *C. gourretii*) which displaces the posterior end of the sulcus some distance from antapex, sometimes as much as half the distance to the girdle. In *C. bipes* the shape characteristic of the genus somewhat obscured by presence of two posterior lobes, one ventral and one dorsal.

Greatest width of body is at girdle in all species except *C. gourretii* and *C. horrida*. In the former species, this occurs about midway between girdle and antapex, and in the latter species, just posterior to girdle.

In ventral view, also, body is quite angular in most species. Epitheca dome-shaped to triangular in all species, but may be very low in *C. gourretii* and *C. horrida*. Hypotheca triangular to squarish. Degree of "squarishness" expressed by the angle  $\beta$ . This angle was not measured in *C. horrida* and *C. gourretii*, as their lateral edges are not straight, making accurate measurements impossible. Fortunately, determination of this angle is not necessary for the differentiation of these species. *Ceratocorys horrida* is the most squarish of the genus, and its antapex is the broadest; *C. gourretii* is rounded antapically. In other members the most triangular is *C. reticulata*, with an average angle  $\beta$  of  $37^\circ$ . The other species vary between this value and  $15.5^\circ$ , which is found in *C. skogsbergii*.

**Plate pattern.** For plate formula, see family diagnosis (p. 32). Number of plates, twenty-nine, constant. Apical pore covered by a closing apical platelet, as in *Gonyaulax*; a platelet not attached to any body plate.

There are four plates in apical region, but only two of these may be considered apical plates, as the other two do not touch the apical closing platelet (fig. 47C). First apical squarish and surrounds left and dorsal edges of platelet; second apical is an elongated ventral plate and surrounds right and ventral edges of apex. First anterior intercalary squarish and lies to the right of apex between apicals 1 and 2. Second anterior intercalary, like second apical, very narrow and lies along left edge of second apical although it does not touch apex; bears ventral epithecal pore.

The first three precingular plates occupy the first three quadrants of the epitheca, and the fourth and fifth occupy the fourth quadrant (fig. 44B). Fifth precingular is smaller than the rest and lies posterior to second anterior intercalary and second apical plates.

There are six girdle plates of approximately equal length.

There are five or six postcingulars; when five, there is an extra plate in the sulcus, the homologue of the first postcingular. For this reason the numbering of the plates is kept uniform in all species, so that in the species with only five apparent postcingulars (*C. gourretii* and *C. skogsbergii*) the extra sulcal plate is designated postcingular 1. Postcingulars 1 and 2 are small and always separated from 3 by a prominent list. Postcingulars 3 to 6 are large and comprise, along with the antapical plate, the main body of the hypotheca. Poste-

rior intercalary lies to the left of sulcus between postcingulars 1 and 2, and antapical plate.

The single antapical plate occupies most of the antapex but is displaced to the right so that the left edge of antapex is formed by the turned-under edges of the third and fourth postcingulars, which are much longer than the postcingulars of the opposite side (fig. 47A, B).

Ventral area composed of five or six plates (figs. 44A, 58A): an anterior, a posterior, a left, a right, a right accessory, and sometimes a left accessory which is homologous with the first postcingular in other species. When the flagellar pore is long, it may border the right sulcal plate for half its length (*C. horrida*, fig. 47B), but usually the left plate extends so far anteriorly that the pore is quite remote from the right plate (*C. aultii*, fig. 56A).

The plate pattern in *Ceratocorys* is remarkably constant. In the main body plates practically no variations were found. This is in striking contrast to the condition in the genus *Peridinium*, where there are interspecific differences as well as variations within the species. In the ventral area of *Ceratocorys* there are variations to be described below, but the number of plates is constant.

**Body wall.** Surface smooth to rugose and pitted in all species except *C. reticulata*, which has a heavy reticulation. Girdle with two rows of pores. Pores also occur in sulcal plates and in main body plates. In *C. reticulata* pores not demonstrated, but probably present.

Flagellar pore approximately on a level with distal end of girdle. Apical "pore" covered by a platelet as in *Gonyaulax*. Ventral epithecal pore about midway between apex and girdle on right edge of second anterior intercalary plate near its posterior end. This also recalls *Gonyaulax*.

**Lists.** Girdle lists attain their greatest width in *C. horrida*. Usually with short, strengthening ribs running radially. In addition to these ribs other heavy riblike structures may be seen when the specimen is viewed in apical or antapical aspect. These are not girdle list ribs, but transverse girdle lists seen on end (figs. 49E, 54C). They are attached to the girdle, are spaced at fairly regular intervals, and may attain a width exceeding 1 girdle width and divide the girdle into a series of chambers.

Lists may be developed at the borders of all plates and, in addition, on the surface of the antapical plate. Lists of *C. horrida* particularly wide and prominent. Two lists are especially important: a list extending ventrally from right edge of po3, the ventral body list; and one extending dorsally from dorsal edge of po4, the dorsal body list. In *C. horrida* and *C. gourretii* these bear prominent spines.

In addition to these two lists and to the posterior cingular list, there are, on the hypotheca, four nonspinulate lists. The right sulcal list runs along left edge of po6 and is continuous with distal end of posterior girdle list. The left sulcal list is attached along right edge of po1 or po2 and of posterior intercalary plate, joining posterior cingular list anteriorly and, sometimes, continuous with list of ventral antapical spine posteriorly. The right lateral and left lateral lists run from posterior cingular list down lateral sides of body a short distance; the former list at ventral edge of po5, the latter at ventral edge of po4. These two lists may be absent.

Lists of the epitheca more variable than those of other parts of body. In general there is a list for each suture, although in old specimens the list may not be im-

mediately adjacent to the suture.

**Spines.** Prominent hypothecal spines are a characteristic of the genus. All species bear them on the antapical plate, and two species, *C. horrida* and *C. gourretii*, have, in addition, a dorsal and a ventral spine. Dorsal spine produced in dorsal body list and ventral spine in ventral body list. Antapical plate normally bears two spines in *C. bipes*, three in *C. skogsbergii* and *C. gourretii*, and four in *C. horrida*, *C. armata*, *C. reticulata*, and *C. aulatii*. When four spines are present, they occur at the four edges of the antapical plate. When three are present, it is the spine of the right corner that is absent; when two, the spines of the right and left corners are absent. Smaller spines, representing thickenings in various body lists, may occur. There are "brushes" in the long spines of *C. horrida* and *C. gourretii*; in the other species spines smaller and usually simple.

The spines of *Ceratocorys* are formed on the plan of the junction of four lists and are not hollow as has frequently been reported in the past. Each spine, when viewed on end, presents the form of a cross (fig. 49I, K). This effect is more pronounced at the base of the spine, where the lists are wider, but is evident to a certain extent even at the tip. On the antapical spines the lists are frequently quite short, not running onto the body to any extent (figs. 47, 58); but in other cases they may extend to adjacent spines to join with their lists (figs. 49G, 59D). Lists of dorsal and ventral spines (*C. horrida* and *C. gourretii*) are more extensive. The anterior member of each runs up to, and joins with, the posterior girdle list. The "brushlike" or "featherlike" effect presented by the distal half of these spines is due to the formation of side ribs or riblets from the center of the spine along each of the four lists. This structure gives a very dense appearance to outer parts of spines. There is, in addition, a thickening where the four lists converge, forming a sort of solid shaft, and a similar thickening at the base of the spines where these join the body. This thickening is especially pronounced distally, usually forming a club-shaped mass on which the riblets are superimposed.

The four elements of these spines cannot be separated; each is an integral part of the whole. The spines do, however, occasionally break off. Specimens have been found with stubs of spines and with only the thickening at the base remaining (figs. 49H, 59D). Spines have been observed in the process of breaking off. In such cases no separation of the four lists could be observed; there was a shear transverse cleavage. Whether this is autotomy representing an adjustment to a change in external environment, as Kofoid (1908) has suggested in the case of *Ceratium*, is impossible to say.

Although these spines occur approximately along sutures, they do not in any case run at the very edge of a plate. There is always a zone between the base of the spine and the actual suture. This is true of most of the nonspinate lists of the body as well, except in very recently divided individuals. In such individuals, however, the spines on the new moiety have not yet developed.

#### Reproduction

Binary fission is the only type of reproduction definitely known in the genus (see p. 36). Daughter cells with one moiety undeveloped were found in *C. horrida*, *C. armata*, and *C. gourretii*. The line of fission is irregularly oblique, to the right of the longitudinal axis in

the epitheca and to the left of it in the hypotheca. To the right moiety on the epitheca go precingulars 3, 4, and 5. The fission line runs to the left of the flagellar pore, so that the right moiety gets all the sulcal plates except the anterior. It receives also postcingulars 5 and 6 and the antapical plate (figs. 48, 53C).

#### Methods of Study

As an aid to defining the species of this genus, certain body dimensions were utilized. These are illustrated in figure 45. All measurements of the body were made with the specimen presenting the full ventral view. The length of body ( $l$ ) was measured from the apex of the body, excluding the lists, to the most posterior part of the body, excluding the spines and lists, which, in this view, is near the dorsal part of the specimen. The diameter of the body at the girdle ( $d$ ) is self-evident. The relative length is expressed by the  $l/d$  ratio. The height of the epitheca ( $e$ ) was measured from the apex of the body to the proximal end of the girdle at its anterior edge. This dimension is always expressed as a fraction of the body length ( $e/l$  ratio). The angle  $\beta$  is the angle which the left contour of the body makes with the longitudinal body axis, A-B. This angle gives a measure of the amount of narrowing of the body posteriorly.

#### Historical Review

The genus was first reported by Stein (1883), who figured *C. horrida* in several views. The larger plates of the theca were distinctly shown and the attachments of all the six spines correctly indicated. The pattern of the major plates is easily established from Stein's figures.

In the same year this species was described and figured by Gourret (1883) under the name *Dinophysis jourdanii*, which later became attached to another species, *C. gourretii* Paulsen (see p. 43). Schütt (1895) reported a third species under the name *Goniodoma acuminatum* var. *armatum*; and Cleve (1903) reported another species under the name *Goniodoma bipes*. These last three species were later ascribed to their proper genus by Kofoid (1910), who appreciated the resemblances of their plate patterns to that of *Ceratocorys horrida* Stein.

Murray and Whitting (1899) figured, under *Ceratocorys spinifera*, a species of *Gonyaulax* and a species of *Ceratocorys*. The latter species was renamed *C. magna* in the revision of the genus by Kofoid. This revision, thus, included five species. We owe to Kofoid the proper allocation of all these forms to the genus *Ceratocorys*. He did not figure any of the species, however, and did not analyze the sulcal plate pattern.

Following Kofoid's (1910) revision, only one possibly valid species has been introduced, viz., *Ceratocorys kofoidii* Paulsen (1931, p. 36, fig. 22A-C). This species, which is related to *C. gourretii*, was not found in the Carnegie collections. Paulsen's sketches do not furnish much more than the general body outline. He gives the length as 115 microns. This exceeds the length of any specimen of the genus *Ceratocorys* which the author has ever measured, the longest being a specimen of *C. armata*, which measured 99 microns. This size can best be appreciated if we contrast it with that of *C. gourretii*, which is the smallest species of the genus, and has a length of 49 (38-62) microns. In Paulsen's description of *C. kofoidii* it is stated that that species is related to *C. gourretii*, that it differs in the less rounded form,

higher epitheca, and absence of wings between the spines. There is no comment on the extraordinary size, which, if correctly given, would be the outstanding characteristic of the species.

The true relationships of this species cannot be decided until the morphology is known in detail. The species probably belongs to the subgenus *Protoceratocorys*. *Ceratocorys kofoidii* has not been treated elsewhere in this report because of the imperfect knowledge of its thecal morphology.

The present report includes seven species, three of which are new. One of Kofoid's (1910) species has been listed as uncertain. Furthermore, the species have been arranged into two subgenera, the first attempt at a subgeneric division of *Ceratocorys* so far made.

#### Systematic Position

*Ceratocorys* is probably most closely related to the genus *Goniodoma*. This is indicated especially by the number of plates in the two genera and by the patterns of their ventral areas (see p. 6).

*Ceratocorys* is characterized by 29 plates, the smallest number found among the genera investigated in this report (see p. 7). The number of epithelial plates, including the apical closing platelet, is only 10; and the number of hypothecal plates is only 8. There are 6 girdle plates and only 5 sulcal plates. *Goniodoma* agrees with *Ceratocorys* in all these particulars except in the number of epithelial plates, this being 11 instead of 10.

The actual relationship of these two genera is probably not so close as the agreement in the number of plates suggests. For instance, although the number of hypothecal plates is the same, the tabulation is quite different: *Ceratocorys* has 6 postcingulars (2 of which are minute), 1 small intercalary, and 1 antapical; *Goniodoma* has 5 postcingulars (subequal in size), no intercalaries, and 3 antapicals.

The relationship of *Ceratocorys* to *Goniodoma* is perhaps better demonstrated by the tabulations of the ventral areas, a fact particularly evident from the species of *Ceratocorys* with a short flagellar pore, such as *C. armata* (cf. figs. 1, 53). The pattern of *Ceratocorys* approaches that of *Goniodoma* more than that of any other genus investigated, but differs from it in the following features: in *Goniodoma* the sulcal ring is complete; the posterior sulcal plate touches the pore; and the left sulcal plate is large and forms the left side of the pore.

The ventral areas of these two genera further agree in their simplicity of contours, although in *Ceratocorys* the area is narrower and there is a very definite depression of the left side to form a sulcus, whereas in *Goniodoma* the area is almost flat and a sulcus proper is absent.

In the presence of the ventral epithelial pore, *Ceratocorys* resembles not only *Goniodoma* but also *Gonyaulax* and other related genera. Since there seems to be no uniformity among the various genera as to which plate bears this pore, the position of this structure in *Ceratocorys* may be of no value in indicating relationships.

*Ceratocorys* is not closely related to any genus other than *Goniodoma* (see p. 8).

#### Relationships of the Species

In a discussion of the interspecific relationships, we have to deal with the following morphological characters: degree of angularity of body; bipedal hypotheca; number of major hypothecal plates; number of sulcal plates; number of hypothecal spines; presence of dorsal and ventral spines; and presence of brush spines.

On the basis of the most fundamental of these characters, the difference in plate pattern, we can group the species into two subgenera: *Protoceratocorys* n. subgen. and *Euceratocorys* n. subgen. *Protoceratocorys* has po1 in the sulcal complex, so that there are 6 functional sulcal plates and only 5 postcingulars. *Euceratocorys* has po1 definitely in the postcingular series, so that there are 5 sulcal plates and 6 postcingulars.

*Protoceratocorys* includes two species: *C. skogsbergii* and *C. gourretii*. *Ceratocorys skogsbergii* has an angular body and no dorsal or ventral spine; *C. gourretii* has a rounded body and dorsal and ventral brush spines as well as four antapical brush spines. It is thus evident that the two species of this subgenus are distinct.

*Euceratocorys* includes five species: Of these *C. horrida* is isolated by being the only one with dorsal and ventral spines, and brush spines. It is further separated from the other species of the subgenus by its angular body, extreme development of lists, and low epitheca.

*Ceratocorys bipes* is unique in its bipedal body shape and in the presence of only two antapical spines. *Ceratocorys aultii* is a small species with four antapical spines and with body little compressed posteriorly. *Ceratocorys armata* and *C. reticulata* are the only two species of the genus which show close mutual relationships. They are both compressed posteriorly and have three or four antapical spines.

The evolution in this genus, thus, has been very divergent (see fig. 46). The ancestral form of the genus probably was small, spherical, and with four simple antapical spines. If this assumption is correct, there has been, in the subgenus *Protoceratocorys*, the development of the angular body and reduction of spines in *C. skogsbergii*; on the other hand, there has been a retention of the primitive body shape but development of brush and dorsal and ventral spines in *C. gourretii*, the two species having separated at an early time.

Of the five species in the subgenus *Euceratocorys*, *C. aultii* may be considered the most primitive, having four antapical spines and rather rounded body. *Ceratocorys armata* and *C. reticulata* have developed only in size and toward a more pointed antapex. *Ceratocorys bipes* represents a trend toward bilobed antapex and loss of all but two spines, which are somewhat more developed than in the primitive species. *Ceratocorys horrida* has reached the highest development of angularity of body and development of spines and lists. It probably was separated from the primitive form at an early date.

It will be noted that the tendency to develop dorsal and ventral spines is correlated with the tendency to develop brush spines of considerable length. These developments occur in both subgenera: in the very small round species, *C. gourretii*, and in the large angular species, *C. horrida*. This must be considered convergence,

as the plate patterns of these two species exhibit sub-generic differences.

*Ceratocorys* is probably a very old genus, a conclusion suggested by the clear-cut definition of its species along divergent lines, and by the high degree of constancy of the species. *Ceratocorys horrida* and *C. armata* are the most variable units. It should be noted, however, that their variations are not in the nature of transitions toward the other species of the genus.

#### Artificial Key to the Species of *Ceratocorys*

- A. Prominent dorsal and ventral spines present as well as antapical spines . . . . . B
- A. Prominent spines developed only on the antapical plate . . . . . C
- B. Small rotund species, diameter 28-55 microns . . . . . C. gourretii
- B. Large angular species, diameter 43-92 microns . . . . . C. horrida
- C. Hypotheca greatly compressed laterally toward the antapex, angle  $\beta$  usually greater than  $22^\circ$  . . . . . D
- C. Hypotheca not greatly compressed laterally toward the antapex, angle  $\beta$  less than  $22^\circ$  . . . . . F
- D. Antapex projected into 2 lobes, antapical spines 2 . . . . . C. bipes
- D. Antapex not projected into 2 lobes, antapical spines 3 or 4 . . . . . E
- E. Surface pitted,  $l/d$  ratio usually greater than 1.00 . . . . . C. armata
- E. Surface coarsely and heavily reticulated,  $l/d$  ratio less than 1.00 . . . . . C. reticulata
- F. Antapical spines 4, postcingular 1 clearly visible in ventral view . . . . . C. aultii
- F. Antapical spines 3, postcingular 1 scarcely or not at all visible in ventral view . . . . . C. skogsbergii

#### Subgenus EUCERATOCORYS n. subgen.

Sulcal plates five; postcingulars six. First postcingular plate clearly evident in ventral view without dissection, overhangs flagellar pore. Type species: *C. horrida* Stein.

#### *Ceratocorys horrida* Stein (Figures 47-50)

- Ceratocorys horrida* Stein, 1883, p. 20, pl. 6, figs. 4-11. Schütt, 1895, pl. 6, figs. 25 (1), 25 (2). Murray and Whitting, 1899, in part, p. 329, pl. 30, fig. 5b. Okamura, 1907, pl. 4, fig. 25a-c. Kofoid, 1910, pp. 180-181. Jørgensen, 1911b, p. 146. Forti, 1922, p. 78, fig. 73. Lindemann, 1925, pp. 99-101, figs. 13-19. Mangin, 1926 (1922), p. 71. Dangeard, 1927c, pp. 342-343, figs. 7a, 8a-c. Issel, 1928, p. 273. Pavillard, 1916, p. 24. Pavillard, 1931, pp. 100-101, pl. 3, figs. 17A, 17B. Paulsen, 1931, p. 35. Matzenauer, 1933, p. 452, figs. 20a-20c.
- Dinophysis jourdani* Gourret, 1883, p. 79, pl. 3, fig. 55.
- ? *Ceratocorys tridentata* Daday, 1888, p. 103, pl. 3, fig. 3.
- Ceratocorys horrida* var. *longicornis* Lemmermann, 1899, p. 350, 371.
- Ceratocorys horrida* forma *tridentata* Entz, 1902, p. 139, fig. 33.
- Ceratocorys horrida* var. *africana* Karsten, 1907, p. 419, pl. 52, figs. 1-3.

*Ceratocorys horrida* var. *extensa* Pavillard, 1931, p. 101. Matzenauer, 1933, pp. 452, 497, fig. 20d.

? *Ceratocorys hirsuta* Matzenauer, 1933, p. 453, fig. 23.

*Peridinium globulus* [*lapsus pennae*], Lindemann, 1925, p. 99.

**Dimensions.** Length of body ( $l$ ) 69 (38-97) microns. Diameter of body at girdle in ventral view ( $d$ ) 67 (43-92) microns. Greatest diameter of body in this view usually just posterior to girdle. Eighty-four specimens measured.

**Shape.** Body usually longer than broad. The  $l/d$  ratio is 1.07 (0.87-1.35). Epitheca low, dome-shaped. The  $e/l$  ratio is 0.24 (0.14-0.31). In apical or antapical view, body squarish to circular at girdle. Girdle displaced about 1 girdle width. Hypotheca very angular, four-sided, usually somewhat constricted in the middle. Antapex broad, sometimes nearly as broad as girdle region, making sides almost parallel. Body longer on left side than on right (fig. 47B). Posteroventral shearing quite marked (fig. 47D, E). The angle  $\beta$  was not measured for this species because the lateral edges of the body were not sufficiently straight to allow an accurate measurement.

**Plate pattern.** Second anterior intercalary narrow and sometimes quite hidden between high lists surrounding it, so that its presence can be determined only by dissection. First anterior intercalary may or may not be indicated by lists. Left sulcal plate very small and placed posteriorly, so that the flagellar pore is long and borders the right sulcal plate for half its length.

**Body wall.** Thecal wall regularly covered with pronounced pits except in intercalary zones. In these zones there is an irregular and variable scattering of pores and, sometimes, pits and ridges. Ventral epithelial pore always present although difficult to demonstrate because it is placed between high lists surrounding second anterior intercalary plate.

**Lists.** All body lists well developed. Girdle lists very extensive, their width usually exceeding five times the girdle width and sometimes almost half the diameter of body. These lists are strengthened by many narrow irregular ribs, which usually run in from the edge of the list (fig. 47C) but may occur in the center of the list or run out from the body as well (fig. 49B). Posterior girdle list usually has fewer of these ribs than the anterior (cf. figs. 47A, 4C). Girdle transverse lists well developed (fig. 49E). Right sulcal list usually clear of spines. Lists of body spines well developed; those of antapical spines may or may not join with each other. Body lists of epitheca about 0.5 girdle width in height. Those along the sutures of the precingulars run out onto the girdle list (fig. 47C).

**Spines.** The long brush spines in this species are very striking and characteristic. There are four antapicals, one dorsal, and one ventral spine. They average about 66 microns in length, or about as long as diameter of body, but may attain a length of 120 microns. All spines have "brushes" on their distal half which in some cases, in heavily sculptured individuals, extend to the body (fig. 49B). Structure of brushes described on page 34.

**Reproduction.** Fission line typical of genus (p. 34). Since the ventral and dorsal spines are attached to the third and fourth postcingulars, which belong to the left moiety, and since the antapicals belong to the antapical plate, which goes with the right moiety, there is a great

discrepancy in the appearance of the two daughter cells immediately after fission (fig. 48A-I). These new specimens have frequently been mistaken for taxonomic units (see under "Historical," below).

Reproduction may, possibly, take place by the production of autospores. One specimen was found in sample 284, station 50 (fig. 50), which indicated that the entire shell was newly formed, and similar specimens were found in sample 563, station 95. The walls of the first specimen were very thin, the pores were small without pits, the lists were embryonic, and the spines were absent. A slight indication of the formation of two of the antapical spines was found in the usual position. The size was normal for the adult. This specimen strongly suggests that ecdysis of the shell occurs in this species and that one or more new individuals are formed from the old protoplast with the formation of entirely new shells.

**Variation.** Although the size of the specimens of the Carnegie material varied, these specimens represented a homogeneous group and no separations of a taxonomic nature could be made on this basis. The same held true for the length of spines. Figure 51 shows the distribution of the frequency of various horn lengths in Carnegie material. It is evident from this that, so far as horn length is concerned, only one species can be detected. Lemmermann (1899) described var. longicornis as having a horn length of 60 microns and Pavillard (1931) described var. extensa with horns 120 to 130 microns long. Sixty microns is near the average for this species in Carnegie material (fig. 51). There are not, however, enough data in the 120-micron range to test the validity of Pavillard's var. extensa. Short-horned forms are shown in figures 49D and F; long-horned forms in figures 49A, C, and G.

There is considerable variation in the thickness of the thecal walls, in the thickness of the lists and spines, and in the ornamentation of the body generally. One frequently finds strongly sculptured individuals like that shown in figure 49B. There is every gradation from this to the more delicate forms represented by figure 47. These variants are not taxonomically distinct. The heavily sculptured individuals apparently do not represent a response to changed environmental conditions, as no correlation could be found between their occurrence and the hydrographic conditions. In four cases specimens with thin and specimens with thick thecae were found in the same sample; in five cases such specimens were found at the same station. It is probable that the strong ornamentation indicates age, and thus that there is a continuous accretion of skeletal material in the course of the life of the individual.

Occasionally supernumerary spines are developed. These always appear in already existing lists, usually in the spine lists as double spines (fig. 49C, F). Sometimes a spine fails to develop (fig. 49D). Lindemann (1925, fig. 18) reports a specimen with only three antapical spines. The absence of one spine in his figure 19, however, may be caused by the particular view of the specimen. Karsten's Ceratocorys horrida var. africana is a many-spined form.

**Historical.** Ceratocorys horrida was first established by Stein (1883, p. 159). Stein's figures are remarkable for their clarity and accuracy and far excel any illustrations of the genus since published.

Lindemann (1925, p. 101) apparently was not aware of Kofoid's (1910) revision of the genus. Lindemann

stated that the tabulation in this species is uncertain and variable, and that there are always four precingular plates (there are in fact five) and one intermediate plate which breaks up into a number of plates, the pattern being variable as indicated by the lists crossing this plate. As shown by the present investigations, careful dissection reveals that the pattern is constant. The number of plates in the apical region, as well as in all other parts of the theca, does not vary, although the pattern is not always indicated by the development of lists across the apical region.

Ceratocorys tridentata Daday (1888) was accepted by Entz (1905) and Kofoid (1910) as a short-horned form of C. horrida. In the writer's opinion, however, this form cannot possibly belong to C. horrida because of its elongated shape, high epitheca, and absence of ventral and dorsal spines. Indeed, in the figure there is nothing to indicate that it even belongs to the genus Ceratocorys.

Ceratocorys horrida var. longicornis Lemmermann (1899) and probably C. horrida var. extensa Pavillard (1931) are long-horned variants of no systematic importance. Karsten's (1907) C. horrida var. africana, figured with eight feathered and two simple spines, is also a variant of no systematic importance (see above).

Dinophysis jourdanii Gourret (1883) must be included in the synonymy of C. horrida (see p. 43 under C. gourretii).

Ceratocorys hirsuta Matzenauer (1933) must be placed in the list of doubtful species. In his description, Matzenauer states that the species is similar to C. armata but has longer, very tufted spines. His figure (p. 453, fig. 23), however, shows the body shape and girdle lists of C. horrida. There are four antapical spines but no dorsal or ventral ones. This specimen is possibly the right daughter cell of C. horrida (see p. 36 and above).

Entz, as early as 1905, correctly described fission in this species, opinions of later workers notwithstanding. His indication of the skeletal fission line was correct except for details of the sulcal area.

The form to which Mangin (1926, p. 71) referred was probably the left (two-spined) daughter cell, as Dangeard (1927c) stated. Mangin's statement reads, "La plupart des individus sont caractérisés par de puissantes cornes latérales aux angles de la valve inférieure, mais il existe des formes divergentes dans lesquelles deux épines très développées sont opposées l'une à l'autre, les autres épines restant très minces."

Dangeard (1927c) understood the fission line of this species and the significance of the two-spined specimens. He presented clear drawings of the left (two-spined) moiety although he indicated the fifth precingular plate incorrectly as going to the left moiety.

Pavillard (1931) curiously refused to accept the two-spined form as a division form in spite of the clear drawings of the fission line by Entz (1905) and Dangeard (1927c) and the statement by Kofoid (1910) that "short horns appear at fission in the younger parts of the skeleton of otherwise long-horned forms." Pavillard suggested, on the other hand, that these forms might be identical with his var. extensa, which is characterized by the length and straightness of the horns rather than by any difference in their number.

Matzenauer (1933) apparently followed Pavillard's interpretation of Mangin, but considered var. extensa separate from Mangin's "forme divergente." He gives figures under both titles.

**Distribution.** *Ceratocorys horrida* is a widespread tropical and subtropical species. It has been found frequently in the Atlantic (Schütt, 1895; Jörgensen, 1911b; Dangeard, 1927c; Pavillard, 1931). It is common in the Mediterranean (Gourret, 1883; Daday, 1888; Kofoid, 1910; Pavillard, 1916; Lindemann, 1925; Issel, 1928). In the Pacific it was reported from the open North Pacific by Lemmermann (1899), from San Diego by Kofoid (1910), and from Japan by Schröder (1906) and Okamura (1907). It also occurs in the Indian Ocean (Karsten, 1907; Matzenauer, 1933).

In the *Carnegie* collection the species was found at 114 stations: 18 in the Atlantic, 96 in the Pacific (fig. 52). There were 360 records of occurrence; 154 rare, 162 occasional, and 44 common. It was found less frequently with increase in depth, with 159 records for the surface, 113 for 50 meters, and 88 for 100 meters. There were 273 net records and 87 pump records. It was found in both hemispheres and in practically all months of the year.

This species occurred at almost all the *Carnegie* stations in the tropics (fig. 52). In the Atlantic it occurred at all but six stations south of 40° north; in the North Pacific it occurred at all but one station south of 35° north; in the South Pacific it occurred at all stations north of 34° south except in the regions near South America. It was absent in the Humboldt Current at three stations near the Galapagos. It was rather uniformly distributed throughout its range; the records of "occasional" and "common" were widely scattered throughout the tropics.

The surface temperatures at the stations where it occurred at any depth varied from 17.5 to 29.5 C. The ranges of hydrographic conditions *in situ* were as follows: temperature, 11.4 to 29.5 C; salinity, 29.7 to 37.0 o/oo; pH, 7.17 to 8.47; phosphate, 2 to 189 mg PO<sub>4</sub>/m<sup>3</sup>.

Although *C. horrida* is never abundant, it is one of the commonest of the tropical peridiniids. For this reason it is an excellent indicator of tropical water. According to the *Carnegie* observations the species does not endure any great lowering of the temperature and consequently would not indicate water of tropical origin very far from its source. For instance, in the North Atlantic Drift the species drops out suddenly where the water temperature at the surface falls below 19° C (station 3). In the cold California Current it was not found until the temperature had risen to 19.3 C (station 131). South of Easter Island in the southeastern Pacific it again dropped out where the temperature fell below 19° C (station 58). Off Japan it was not found in water with a surface temperature below 23.2 C.

These observations indicate that the active reproduction of *C. horrida* probably does not take place in water of a temperature below 20° C and that the organisms carried into cooler regions seldom survive a temperature below 19° C. In the region off South America this species was conspicuously absent at 13 stations where the temperature at the surface was above 19°. At these stations the temperatures were mostly between 19° and 21° although at stations 71 to 74 the temperatures were from 23.5 to 25.3 C. The absence of *C. horrida* from this series of stations can probably be attributed to the influence of the Humboldt Current, which is composed of water of antarctic origin mixed with water upwelling along the coast. The movement of this water has a westerly component away from the continent. This water is being constantly warmed as it progresses.

Even though it may reach a temperature sufficiently high for *Ceratocorys horrida*, however, it does not contain this species because of the lack of inoculation. Thus, the eastern limit of the species in this region is pushed westward by the drift from the edge of the Humboldt Current. Inoculation probably takes place along this border in an irregular and sporadic nature during fluctuations of the dynamic conditions, probably through eddies from the Easter Island region. That this type of inoculation is probable is suggested by the isolated occurrence of *C. horrida* at station 61a, with a surface temperature of 17.5, the only record where the temperature was below 19°. The water in that region must have been a local mass very recently detached from the tropical mass to the northwest.

*Ceratocorys horrida* is probably an important organism in the economy of the tropical and subtropical seas. It was found throughout the regions where the phosphate content of the water was less than 10 mg PO<sub>4</sub>/m<sup>3</sup>. At many of these stations the observed values were less than 5. The nitrates, it is assumed, were equally low. The nutrient requirements of this species must be extremely low.

The wide range of salinities in which the species was found indicates that the species is not very sensitive in respect to the salinities found in oceanic conditions. It occurred in the Panamic region in salinities as low as 29.7 o/oo.

*Ceratocorys armata* (Schütt) Kofoid  
(Figures 53, 54)

- Ceratocorys armatum* Kofoid, 1910, p. 181.  
*Ceratocorys armata*, Schiller, 1929, pp. 412-413, fig. 31a, b. Forti, 1922, p. 83, pl. 6, fig. 72.  
*Goniodoma acuminatum* var. *armatum* Schütt, 1895, p. 153, pl. 9, figs. 32 (1), 32 (2). Lindemann, 1925, p. 98, figs. 5, 6.  
*Goniodoma fimbriatum* Murray and Whitting, 1899, p. 325, pl. 27, fig. 1a, b.  
*Ceratocorys spinifera* Murray and Whitting, 1899, p. 329, pl. 30, fig. 6c.  
*Goniodoma armatum*, Schmidt, 1901, p. 135.  
*Gonyaulax fimbriatum* Schröder, 1906, p. 329.  
 ? *Ceratocorys armata*, Matzenauer, 1933, p. 453, fig. 22.

**Dimensions.** Length of body (*l*) 79 (54-99) microns. Diameter (*d*) 70 (47-93) microns. Greatest diameter of body at the girdle. Thirty-five specimens were measured.

**Shape.** In ventral aspect body roughly ovate to kite-shaped (fig. 53A). The *l/d* ratio is 1.09 (0.97-1.24). Epitheca triangular to high dome-shaped. The *e/l* ratio is 0.38 (0.31-0.46). At girdle the body is squarish to circular with a ventral depression. Girdle displaced about 1.5 girdle widths. Antapex narrow, so that the angle  $\beta$  is comparatively obtuse: 31° (22°-38°). Hypotheca cut off obliquely so that the ventral end of antapical plate is about one-third of the way to girdle from the dorsal end. Thus, the body is much more angular in lateral view than in the ventral aspect (fig. 53D).

**Plate pattern.** Right sulcal plate is much longer than in other species and extends posteriorly for half its length into a shoulder of the posterior sulcal plate (fig. 53). Left sulcal plate short, so that the right sulcal plate touches the flagellar pore.

**Body wall.** Thecal wall regularly pitted on all major plates except along the suture zones. In these zones

secondary thickenings running into the lists may develop with age. There are scattered pores in the sulcal area, as is shown in figure 53A. Ventral epithelial pore usually not evident without dissection.

**Lists.** Width of cingular lists 1.25 to 2.00 girdle widths, somewhat greater ventrally than dorsally. These lists may bear short delicate ribs in the middle or, in heavily sculptured individuals, may have strong ribs running from the body to the edge of the lists. Girdle transverse lists frequently very well developed (fig. 54C). Lists occur along all the sutures of body plates. There is a heavy ridge running along the left edge of the right accessory sulcal plate extending from the left posterior corner of the fifth precingular plate to the flagellar pore and along the right edge of the pore.

**Spines.** Dorsal and ventral spines absent. Antapical spines three or four (figs. 53E, 54B, D). One list of ventral antapical spine usually continuous with left sulcal list. The right antapical spine near but not at the junction of po5, po6, and ant1. Dorsally there are two, rarely one, spines. When two, these spines are joined by a list. These dorsal antapical spines are independent, i.e., they are not attached to the marginal lists of the antapical plate as is the case with the other species of the genus. At various curvatures of the body lists, particularly at apex and antapex, there are apparent but not real spines, especially in strongly sculptured individuals.

**Reproduction.** Division is typical of the genus. Both right and left daughter cells have been found. A daughter cell with new right moiety is shown in apical view in figure 53C.

**Variation.** There is the usual variation in the thickness of the walls and extent of surface sculpturing due to age. Figure 54A, and B shows a specimen in which the entire theca, including the intercalary zones, is composed of thick, heavily ornamented walls. The two dorsal antapical spines may be situated near the corners of the antapical plate or more or less close together (fig. 54D); or they may be fused into one in the center of the dorsal side of this plate (figs. 53E, 54E). The girdle lists may be entirely without spines or they may have short, thickening ribs running from the outer edge or may have heavy ribs extending from the body.

**Historical.** This species was first described by Schütt (1895), who figured a form with two dorsal antapical spines under the name *Goniodoma acuminatum* var. *armatum*. *Goniodoma fimbriatum* Murray and Whitting (1899) is identical with this species. The apical view of *Ceratocorys spinifera* Murray and Whitting (pl. 30, fig. 6c) probably also refers to this species. These authors' apical view of a "mature specimen" (pl. 30, fig. 6d) may belong to this species. It is peculiar only in its large size. It is 142 microns in diameter according to the magnification given by these authors. The widest specimen in the Carnegie collection is 93 microns, the mean is 70 microns. Kofoid (1910, p. 182) described a new species, *C. magna*, on the basis of this figure. It does not seem desirable to retain this name among the valid species, as there is always the possibility of a mistake in magnification and there is no other feature of this figure to distinguish it from *C. armata*. Kofoid (1910, p. 181) was the first to bring *C. armata* under the genus *Ceratocorys*, where it properly belongs. Lindemann (1925), however, was apparently unaware of Ko-

foid's (1910) revision and lists it under the Schüttean designation (p. 98, figs. 5, 6). He states that the plate pattern is a little uncertain and questions the position of the form in the genus *Goniodoma*. He even suggests a relation to the genus *Phalacroma*. Matzenauer's *C. armata* (1933, fig. 22) must be considered questionable. The hypotheca is too long for this species; only two spines are indicated; and, all together, the figure gives the impression of representing an undeveloped specimen.

**Distribution.** *Ceratocorys armata* is a widespread tropical and subtropical species. It has been reported from the Atlantic by Schütt (1895), Murray and Whitting (1899), Schmidt (1901), Pavillard (1931); from the Mediterranean by Schmidt (1901), Schröder (1906), Kofoid (1910), Pavillard (1916), Issel (1928), Lindemann (1925), Schiller (1929), Forti (1922); from the Pacific by Schmidt (1901), Lemmermann (1904), Kofoid (1910); and from the Indian Ocean by Schmidt (1901), Schröder (1906).

In the Carnegie collection this species was found at 79 stations: 11 in the Atlantic, and 68 in the Pacific. There are 163 records of occurrence: 94 rare, 60 occasional, and 9 common. It was found less frequently with increasing depth. There are 87 records for the surface, 41 for 50 meters, and 35 for 100 meters. There are 117 net records and 46 pump records. The species was found in both hemispheres and in all months but June. The species was rather widespread at the tropical and subtropical stations (fig. 52). In the Atlantic it did not occur north of 40° north; and in the Pacific it occurred between 35° north and 35° south latitude.

The surface temperatures at the stations where the species occurred at any depth varied from 19° to 29.4°C. The ranges of hydrographic conditions *in situ* were as follows: temperature, 14.3 to 29.4°C; salinity, 30.0 to 36.8 o/oo; pH, 7.80 to 8.39; phosphate, 2 to 151 mg PO<sub>4</sub>/m<sup>3</sup>.

*Ceratocorys armata* was found almost entirely within the range of *C. horrida*, and its distribution is probably limited by the same factors that limit the latter species. It is a much rarer form than *C. horrida*, so that its records of occurrence are not so continuous. This does not necessarily mean, however, that its occurrence is sporadic. Its occurrence outside the range of *C. horrida* was in the southeastern Pacific between Easter Island and South America at stations 62, 63, and 64a, where the surface temperatures were between 19° and 20°. This exception probably was due to a local inoculation of this general region similar to that of *C. horrida* at station 61a.

The data indicate that *C. armata* is more limited to the warm water than is *C. horrida*. The species is not found regularly enough within its range, however, to allow us to consider as really significant the negative records along the limits of the distributional area. It occurred in the North Atlantic Drift as far to the north as did *C. horrida*, viz., to station 2, where the temperature was 20.5°. Beyond the California Current it did not appear until a surface temperature of 22.9° was attained; off Japan it did not occur where the temperature of the surface water was less than 23.9°; and south of Easter Island it was found as far south as station 57, where the surface temperature was 19.0°. It is not sufficiently common to be of great value as an indicator of tropical water; its presence is significant but not its absence.

*Ceratocorys reticulata* n.sp.  
(Figure 55)

**Dimensions.** This is the largest species of the genus. Length of body ( $l$ ) 93 (84-98) microns. Diameter of body ( $d$ ) 99 (86-114) microns. Greatest diameter of body is at the girdle. Four specimens were measured.

**Shape.** In ventral aspect the body is almost diamond-shaped, somewhat truncated posteriorly (fig. 55A). This species is unique in that the body width always exceeds the length;  $l/d$  ratio is 0.94 (0.86-0.97). Epitheca subconical, the highest of any species of the genus. The  $e/l$  ratio is 0.42 (0.40-0.46). Thus, the girdle is nearly equatorial. At girdle, body is nearly circular with a depression ventrally (fig. 55B). The wide girdle region and almost pointed antapex result in a comparatively obtuse angle  $\beta$ , the greatest of the genus:  $37^\circ$  ( $38^\circ$ - $39^\circ$ ). The two sides of hypotheca nearly equal in length. Anterior displacement of ventral side of antapex very small (fig. 55C). Girdle displaced about 1 girdle width.

**Thecal wall.** Surface completely covered with a heavy reticulation except in parts of ventral area and on the posterior intercalary plate. Pores could not be demonstrated in the meshes of this network nor in the girdle.

**Plate pattern.** Left sulcal plate extends sufficiently far forward so that the right sulcal plate does not touch flagellar pore.

**Lists.** Girdle lists short, approximately 1 girdle width wide, strengthened with regularly spaced ribs running from the body completely to outer edge. These ribs are continuous with the girdle transverse lists and divide girdle into a series of chambers. Body lists typical of genus. All sutures clearly indicated by low lists or thick ridges. Right sulcal list usually supported by several heavy spines (fig. 55C).

**Spines.** Dorsal and ventral spines absent. Antapical spines simple, three in number; one of them ventral at posterior end of sulcus, the other two dorsal. The latter are connected with the antapical lists by their own connecting lists (fig. 55D).

**Reproduction.** Division stages were not found. In the specimen shown in figure 55, however, the lists of the right half of the body were not all well developed, indicating a certain degree of immaturity of the specimen.

**Variation.** The species is constant. Variations in size and shape have already been given above.

**Distribution.** In the Carnegie collection this species was found at 30 stations: 1 in the Atlantic, 29 in the Pacific. There are 41 records of occurrence: 36 rare and 5 occasional. The species was found somewhat more often at 50 meters than at other depths, with 9 records for the surface, 20 for 50 meters, and 12 for 100 meters. There are 4 pump records and 37 net records. The species was found in both hemispheres and from September to May.

*Ceratocorys reticulata* is a distinctly tropical species. Although it occurred at scattered stations as widely separated as Guam and Panama, it was not found north of latitude  $30^\circ$  north in the North Pacific nor south of  $18^\circ$  south in the South Pacific (fig. 52). In the Atlantic it occurred at  $13^\circ$  north, in the North Equatorial Current.

The surface temperatures at the station where the species occurred at any depth varied from  $20.4$  to  $29.5$  C. The ranges of hydrographic conditions *in situ* were as follows: temperature,  $19.5$  to  $29.3$  C; salinity, 30.0 to 36.3 o/oo; pH, 8.09 to 8.42; phosphate, 3 to 60 mg  $PO_4/m^3$ . Type locality: Carnegie station 28.

*Ceratocorys aultii* n.sp.  
(Figure 56)

**Dimensions.** Length of body ( $l$ ) 68 (63-71) microns. Diameter ( $d$ ) 61 (55-65) microns. Three specimens were measured.

**Shape.** Similar in general appearance to *C. skogsbergii*, which belongs to the subgenus *Protoceratocorys*. Slightly longer than wide. The  $l/d$  ratio is 1.11 (1.09-1.15). Epitheca high dome-shaped to subconical. The  $e/l$  ratio is 0.35 (0.30-0.38). Girdle displaced about 2.5 girdle widths. Body almost circular in apical view. Antapex broad; angle  $\beta$  thus comparatively acute:  $21^\circ$  ( $20^\circ$ - $21^\circ$ ). Posteroventral obliquity pronounced (fig. 56D). In specimens with wide intercalary zones, the dorsal antapical spines are displaced ventrally so that there is a flattening of the antapex dorsal to the spines which produces a superficial resemblance to *C. skogsbergii* (fig. 56D).

**Body wall.** Surface regularly covered with small pits. Intercalary zones covered with a faint network of large reticulations. Ventral epithecal pore inconspicuous. Pores scattered in sulcus (fig. 56A).

**Plate pattern.** Left sulcal plate extends anteriorly so that the right plate is quite remote from flagellar pore (fig. 56A).

**Lists.** Girdle lists of medium width; about 1.5 to 2.0 girdle widths wide. Strengthening ribs usually not well developed. Transverse girdle lists, however, well developed, as are sulcal lists. General body lists not well developed.

**Spines.** Dorsal and ventral spines absent. Four antapical spines at the four corners of antapical plate. Spines simple, about 3 to 4 girdle widths long. The dorsal and left members connected by a common list (fig. 56A, B, D), as are sometimes the ventral and right spines. Left sulcal list runs onto ventral antapical spine. Ventral and left sometimes closely approximated. It is not unlikely that in some specimens these spines may be fused into one spine, considering that this condition is sometimes found in *C. armata*, of which much more material is available.

**Reproduction.** Daughter cells were not found.

**Distribution.** In the Carnegie collection this species was found at 15 stations, all in the Pacific. There are 21 records of occurrence, all rare. The species was found more frequently with increasing depth, with 5 records for the surface, 6 for 50 meters, and 10 for 100 meters. There are 14 net records and 7 pump records. The species was found in both hemispheres; during January to May in the southern hemisphere, in September and October in the northern hemisphere.

The stations at which this species was found are in widely-scattered regions of the North and South Pacific (fig. 52). Three of these stations are east of Guam; four between San Francisco and Hawaii; four near the Samoan Islands; one east of the Tuamotus; and three south and east of Easter Island.

The surface temperatures at the stations where the species occurred at any depth varied from  $16.9$  to  $29.5$  C. The hydrographic conditions *in situ* were as follows: temperature,  $14.3$  to  $29.3$  C; salinity, 34.4 to 36.3 o/oo; pH, 8.05 to 8.39; phosphate, 3 to 46 mg  $PO_4/m^3$ .

*Ceratocorys aultii* is a rare, tropical species, probably widespread in tropical waters but seldom collected because of its sparse population. Its greatest abun-



dance may be below 100 meters, since in the Carnegie observations its frequency of occurrence increased with depth to that level. The species was found within the geographic range of C. horrida, except in the southeastern Pacific, where there were two stations (stations 62 and 65) outside that range. The correlation of its distribution with water of temperatures above 19° was closer than in the case of C. horrida. Nowhere was C. aultii found where the surface water had a temperature less than 19° C. It can live in water of low nutrient content. There are eight records of its occurrence in water containing less than 10 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 57.

*Ceratocorys bipes* (Cleve) Kofoid  
(Figure 57)

Ceratocorys bipes Kofoid, 1910, p. 183. Dangeard, 1927c, p. 343, fig. 9a.  
Goniodoma (?) bipes Cleve, 1903, p. 371, fig. 2a-d.  
Ceratocorys (?) asymmetrica Karsten, 1907, p. 419, pl. 47, fig. 9a-d.

**Dimensions.** Length of body ( $l$ ) 83 (80-88) microns. Diameter ( $d$ ) 73 (70-77) microns. Six specimens were measured.

**Shape.** Body longer than broad. The  $l/d$  ratio is 1.13 (1.04-1.24). Girdle placed well forward; ends displaced about 0.5 girdle width. Epitheca low dome-shaped. The  $e/l$  ratio is 0.28 (0.24-0.34). Hypotheca irregular in shape; roughly squarish in lateral aspect but subcuneate in ventral aspect. The angle  $\beta$  24° (17°-28°). At antapex there are two bulbous swellings, one dorsal and one ventral. Each is terminated by a long, prominent spine, directed ventrally, giving the species its characteristic appearance. Dorsal bulb medially situated and involves parts of po<sub>4</sub>, po<sub>5</sub>, and ant1 (fig. 57E). Ventral lobe somewhat to the left of median line. It involves posterior parts of the left side of sulcus and of pl<sub>1</sub>, as well as part of po<sub>3</sub> and ant1. Right side of sulcus not involved in this lobe, so that the right ventral contour of the body in right lateral view approximates the typical Ceratocorys shape (fig. 57C).

**Body wall.** Thecal surface covered throughout with circular pits except on parts of sulcus. Pores could not be demonstrated in pits. Ventral epithelial pore inconspicuous.

**Plate pattern.** Second anterior intercalary narrow and almost hidden between list ridges bordering it. Ridge between as and ra rises to touch right edge of po<sub>1</sub>, so that flagellar pore is completely arched over in its middle. Left sulcal plate short, so that right sulcal plate touches flagellar pore.

**Lists.** Girdle lists relatively short, about 1 girdle width wide; strengthened by stout spines running out as continuations of body wall, almost or entirely to outer edges. These ribs are continuous with partitioning lists or ridges on girdle plates. Surface of girdle may consist of two rows of small chambers or, more often, of one row of deep chambers with prominent partitioning lists (fig. 57A). Sulcal lists and ventral body list are quite wide (fig. 57C, D, F) and supported by several ribs. Main body sutures usually evidenced by thick ridges or wide bands of undifferentiated heavy thecal material, the latter probably representing growth zones.

**Spines.** Dorsal and ventral spines absent. Antapical spines two; they occur at dorsal and ventral corners

of antapical plate, and appear as long, sharp spines, as much as 4 girdle widths long. They are simple but formed on the same principle as those of C. horrida (p. 33). Ventral component of ventral antapical spine usually continuous with left sulcal list.

**Reproduction.** Fission probably is typical of the genus although no recently divided forms were found.

**Variation.** This species is very constant as to size, shape of body, and number of spines. One specimen was found (fig. 57C), however, in which each antapical spine was represented by two short spinelets.

**Historical.** This species was first described by Cleve (1903) as Goniodoma (?) bipes. Later Karsten (1907) hesitatingly placed it in the genus Ceratocorys, species asymmetrica. Kofoid (1910) placed it definitely in its proper genus.

**Distribution.** Ceratocorys bipes is a rare tropical species seldom reported. It was recorded once from the Red Sea and Arabian Seas (Cleve, 1903), once from the Indian Ocean (Karsten, 1907), and once from the Atlantic (Dangeard, 1927c). It had not been reported from the Pacific before the Carnegie investigations.

In the Carnegie collection the species was found at 22 stations: 1 in the Atlantic and 21 in the Pacific. There are 31 records of occurrence: 29 rare and 2 occasional. It was found more frequently with increase in depth, with 3 records for the surface, 11 for 50 meters, and 17 for 100 meters. The 2 records of "occasional" were at 50 and 100 meters. There are 9 pump records and 22 net records.

The single occurrence in the Atlantic was at station 2, in the North Atlantic Drift (fig. 52). In the Pacific the species occurred at widely scattered regions, but all records were well within the range of C. horrida. There were 2 stations south of Japan, 2 north of Hawaii, 8 in the equatorial currents of the central Pacific, and 9 between the Galapagos and Easter Islands.

The surface temperatures at the stations where the species occurred at any depth varied from 20.8 to 29.4° C. The ranges of hydrographic conditions in situ were as follows: temperature, 18.2 to 29.3° C; salinity, 34.4 to 36.4 o/oo; pH, 7.93 to 8.37; phosphate, 4 to 60 mg PO<sub>4</sub>/m<sup>3</sup>.

Ceratocorys bipes is a rare tropical species, perhaps widespread but seldom collected because of its sparse numbers. It is strikingly restricted to the warm tropical water masses, much more so than most other species of the genus. Thus, although it was found off Japan at latitude 34° north in water with a surface temperature of 23.2 (station 112), it was not found near the influence of either the California Current or the Humboldt Current. It was found in the southeastern Pacific, south of Easter Island, but the temperatures there were above 20°. It can live in water low in nutrients; e.g., there were six records in water having a phosphate content less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

Subgenus PROTOCERATOCORYS n.subgen.

Sulcal plates six, postcingulars five. Sixth sulcal plate homologous with first postcingular of Euceratocorys. For this reason the designation po<sub>1</sub> is retained for this plate. This plate is small and is turned down to form the left edge of the sulcus along side of flagellar pore, and is not evident in the ventral view of an intact specimen. Type species: C. gourretii Paulsen.

*Ceratocorys skogsbergii* n.sp.  
(Figure 58)

**Dimensions.** One of the smallest species of the genus. Length of body ( $l$ ) 66 (63-69) microns. Diameter ( $d$ ) 58 (56-59) microns. Two specimens were measured.

**Shape.** Similar in general appearance to *C. aultii* of *Euceratocorys*. Body longer than broad. The  $l/d$  ratio is 1.15 (1.13-1.17). Epithea of medium height, with girdle placed well forward. The  $e/l$  ratio is 0.33 (0.32-0.34). Girdle displaced about 0.5 girdle width. Body almost circular in apical view (fig. 58B). Hypotheca squarish at antapex; somewhat constricted near middle. Antapex broad, so that sides of hypotheca do not converge at a great angle with longitudinal body axis. The angle  $\beta$   $15.5^\circ$  ( $15^\circ$ - $16^\circ$ ), the smallest of any species for which this angle could be measured. The posteroventral corner of antapex is truncated obliquely at an angle of about  $45^\circ$  to longitudinal axis (fig. 58D). Dorsal hypothecal plates (po4 and po5) extend to and around antapex, forming part of the most posterior end of body. Antapical plate alone forms the obliquity and is not rounded so as to form antapex, as is the case in *C. horrida* (fig. 47E).

**Body wall.** Surface covered with small pits. Intercalary zones may have small irregular markings and pores. Ventral area variously ornamented with reticulations and pores (fig. 58A). Ventral epithecal pore inconspicuous.

**Plate pattern.** Second anterior intercalary sometimes touches apex and thus becomes, actually, an apical. It is usually wide enough to be quite evident.

**Lists.** Girdle lists small, about 1 girdle width wide. Strengthening ribs regularly spaced, usually running out from body wall. When the girdle plates are dissected away from the body plates to which the girdle lists are attached, an extremely thin membrane is seen to be attached to the girdle plate. In intact specimens this membrane lies in contact with the list. Transverse girdle lists fairly well developed. Body lists, except the ventral one, not well developed. Body sutures may or may not be indicated by such lists. The ridge to the right of flagellar pore rises to meet po1, forming an arch over the posterior part of pore.

**Spines.** Dorsal and ventral spines absent. Antapical spines three; straight and simple, about 2.5 girdle widths long, placed at dorsal, ventral, and left corners of antapical plate. They were not connected by lists in the specimens examined, although the left sulcal list ran onto the ventral spine.

**Reproduction.** Evidence of fission was not found.

**Distribution.** This species was found at 10 of the *Carnegie* stations, all in the Pacific. There are 11 records of occurrence, all rare. The species exhibited a tendency to be more common at the surface, with 5 records for the surface, 4 for 50 meters, and 2 for 100 meters. There are 2 pump records and 9 net records.

In its geographic distribution, this species was restricted to the southern and western Pacific (fig. 52). There was 1 station off Japan (station 113), 2 in the North Equatorial Current (stations 91 and 100), 4 east of Samoa, and 3 southwest of Easter Island.

The surface temperatures at the stations where the species occurred at any depth varied from  $22.8^\circ$  to  $28.7^\circ$  C. The ranges of hydrographic conditions *in situ* were as follows: temperature,  $21.5^\circ$  to  $28.7^\circ$  C; salinity,

34.7 to 36.2 o/oo; pH, 8.22 to 8.39; phosphate, 8 to 40 mg  $PO_4/m^3$ .

This is a very rare tropical species. There are so few records of its occurrence that no distributional correlation would be significant. There were 2 records of its occurrence in water with less than 10 mg  $PO_4/m^3$ . Type locality: *Carnegie* station 51a.

*Ceratocorys gourretii* Paulsen  
(Figure 59)

*Ceratocorys gourretii* Paulsen, 1931, p. 36.

*Phalacroma jourdanii* Schütt, 1895, p. 64, pl. 4, fig. 20, 1-4. Entz, 1902, p. 130, figs. 6-8. Entz, 1905, pp. 111, 113, figs. 1-4.

*Ceratocorys horrida*, Murray and Whitting, 1899, p. 329, pl. 30, fig. 5a.

*Phalacroma Ceratocorys* Entz, 1902, pp. 135-144, figs. 26, 33. Entz, 1905, pp. 120-127, figs. 22-28, pp. 111, 134-142.

*Ceratocorys jourdanii* Kofoid, 1910, pp. 183-185. Forti, 1922, p. 84, pl. 6, fig. 74. Dangeard, 1927c, p. 343, fig. 7b. Pavillard, 1931, p. 101. Matzenauer, 1933, p. 452, fig. 21.

not *Dinophysis jourdanii* Gourret, 1883, p. 79, pl. 3, fig. 55 (= *C. horrida* Stein).

? *Dinophysis gales*, Pouchet, 1883, p. 28, fig. G, no. 3.

? *Dinophysis jourdanii*, Klebs, 1884.

? *Dinophysis armata* Daday, 1888, p. 193, pl. 3, fig. 6.

**Dimensions.** Smallest species of the genus. Length of body ( $l$ ) 49 (38-62) microns. Diameter ( $d$ ) 42 (28-55) microns. Greatest diameter of body in ventral view 48 (34-60) microns. Nineteen specimens were measured.

**Shape.** Body unique in its subspherical to obovoid shape, with absence of the angularity characteristic of other members of the genus. The pronounced curvature of the body causes the anterior circumference of the girdle to be considerably shorter than the posterior (fig. 59D, E, F, G). Body circular to subovate in apical view (fig. 59B), always slightly longer than wide. The  $h/d$  ratio is 1.22 (1.06-1.57). Angle  $\beta$  not measured for this species because of curvature of lateral margins. Epithea low dome-shaped, with girdle far forward as in the genus *Phalacroma*, with which the species has been confused. The  $e/l$  ratio is the smallest in any species of the genus: 0.20 (0.16-0.22). Greatest width of body about halfway from girdle to antapical margin. Girdle displaced about 1 girdle width.

**Body wall.** Thecal wall regularly covered with very small pits. Ventral epithecal pore conspicuous. In intercalary zones the pits are either absent or fewer than on original portions of plates (fig. 59H).

**Plate pattern.** Second anterior intercalary narrow and hidden between lists. Sometimes no other plates are indicated by lists except at left side of sulcus. First postcingular reduced to a small triangular plate joining anterior sulcal and second postcingular plates. It forms left edge of flagellar pore. Second postcingular more distally located than anterior sulcal plate and partly overhangs the pore as the first postcingular does in the subgenus *Euceratocorys*. Right accessory sulcal plate long. Right sulcal plate comparatively short, so that it barely touches flagellar pore (fig. 59A).

**Lists.** Girdle lists about 1.5 girdle widths wide, strengthened by cross ribs running either from body or from outer edge of lists. Partitioning lists on the girdle not well developed. Right and left sulcal lists always quite evident, as are the lists bordering a2 and the

apical pore platelet. Along other sutures of body, lists may be absent and dissection is necessary to determine plate boundaries.

**Spines.** Dorsal and ventral spines present; antapical spines three. All spines have "brushes" as in *C. horrida*. Antapical spines located at the ventral, dorsal, and left corners of antapical plate. They lie almost in a straight line because of the oblong shape of the antapical plate (fig. 59C). Their dorsoventral lists are continuous (fig. 59D). Autotomy of the spines is common. Figure 59D shows a specimen with autotomy of the dorsal spine.

**Reproduction.** Two daughter cells with old left moieties were found. These showed mature dorsal and ventral spines, but the antapical spines were minute (fig. 59E, G).

**Variation.** There is comparatively little variation in the shape of this species, although the size is variable. The greatest variation is in the spines, which may be variously bent, long or short, single or double. Figure 59F shows a specimen with a double ventral spine and with an extra, simple spine in the dorsal list. Sometimes the central core of the spine may not extend to the body (fig. 15E, G). In such cases the cruciform structure of the spines is not developed.

**Historical.** This species was clearly figured by Schütt (1895, pl. 4, fig. 20, 1-4), who, however, confused it with *Dinophysis jourdanii* Gourret (1883). Schütt assigned his specimens and Gourret's species to the genus *Phalacroma*, under the name *P. jourdanii*. Entz (1902, 1905) accepted this interpretation and, in addition, made the rather strange suggestion that this species represented a transition between the genera *Phalacroma* and *Ceratocorys*. Kofoid (1910) definitely recognized the true generic relationship of the Schüttian species and placed this form in the genus *Ceratocorys*. Jörgensen (1911b), apparently unaware of Kofoid's revision, expressed the opinion that Schütt's species belongs to *Ceratocorys*. Kofoid, however, accepted Gourret's figure as representing this form. In the writer's opinion Gourret's species (pl. 3, fig. 55) is quite obviously *C. horrida* Stein, reported in the same year. In this respect the writer agrees with the opinion expressed by Paulsen (1931), who proposed a new name, *C. gourretii*, for the Schüttian species. This name should be accepted, since the name *jourdanii* must be relegated to the synonymy of *C. horrida*. Klebs (1884) recognized the similarity between Gourret's and Stein's figures, but believed that Gourret, rather than Stein, realized its true relationship, and thus he preferred the name *Dinophysis jourdanii* for Stein's as well as for Gourret's species. In regard to Gourret's figure, the length of the spines, shape of the body, and width of the cingular lists mark it off sharply from *Phalacroma jourdanii* Schütt and reveal its identity with *C. horrida* Stein. It resembles the former species only in having five spines instead of the six characteristic of *C. horrida*. The left antapical spine, however, which is missing in Gourret's figure, often extends laterally so that it is not visible in the view represented in this figure.

The writer agrees further with Paulsen (1931) in the allocation of the figures of Murray and Whitting (1899, pl. 30, figs. 5a, 5b). Figure 5a represents *C. gourretii*, and 5b belongs to *C. horrida*. Kofoid (1910, p. 185) erred in his reference to figure 5a and omitted any reference to figure 5b.

**Distribution.** *Ceratocorys gourretii* is a rare but widespread tropical species. It has been reported from

the Atlantic by Schütt (1895), Murray and Whitting (1899), and Dangeard (1927c). Pavillard (1931) reported it from the collections of the cruise of the Prince of Monaco in the tropical North Atlantic at 78 stations during the years 1887, 1895, 1902-1905, 1908-1910. In the Mediterranean it was reported by Entz (1902, 1905), by Forti (1922), by Paulsen (1931), and from 19 stations by Pavillard (1931). Matzenauer (1933) found it at 2 stations in the Indian Ocean and at 2 stations in the Red Sea. Until the *Carnegie* investigations it had been reported only once from the Pacific, at San Diego (Kofoid, 1910). The *Carnegie* collection has added many new records for the Atlantic and Pacific.

In the *Carnegie* collection this species was found at 41 stations: 5 in the Atlantic and 36 in the Pacific. There are 77 records of occurrence: 68 rare, 8 occasional, and 1 common. The species was found more frequently at the surface than at the lower depths, with 47 records for the surface, 16 for 50 meters, and 19 for 100 meters. There were 33 pump records and 44 net records.

In the Atlantic this species was found at 1 station in the North Atlantic Drift (station 16) and at 4 stations in the North Equatorial Current. In the Pacific it was widely distributed in the tropical regions (fig. 52). In the western Pacific, however, it did not occur north of 19° north. North of the Hawaiian Islands it occurred as far north as 34° north. In the southeastern Pacific it occurred as far south as 32° south. It was not found within a thousand miles of either North or South America in the Pacific.

The surface temperatures at the stations where the species occurred at any depth varied from 22.3 to 28.7 C. The hydrographic conditions *in situ* were as follows: temperature, 11.4 to 28.7 C; salinity, 33.7 to 36.4 ‰; pH, 7.76 to 8.39; phosphate, 3 to 60 mg PO<sub>4</sub>/m<sup>3</sup>.

*Ceratocorys gourretii* is apparently a widespread but rather rare tropical species. The *Carnegie* observations indicate that it is confined to purely tropical water. It was never found at a station where the surface temperature was less than 22.3, so that it is restricted to water warmer than in the case of any other species of the genus. Its geographical distribution is, thus, much more limited than that of *C. horrida*. The species can develop in water poor in nutrients. There were 21 records of its occurrence in water with phosphate content less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

#### Family GONIODOMACEAE Lindemann

**Diagnosis.** "Shape somewhat spherical to polygonal. Apex present. Girdle quite or nearly equatorial. Marine forms, which are distinguished by three antapical plates, three apical plates in typical representatives. Of the antapical plates, two are ventral, one dorsal. Length, as far as known, 40 microns to 94 microns. Only one genus." (Lindemann, 1928, p. 94.)

#### Genus GONIODOMA Stein

**Diagnosis.** See family diagnosis (monogeneric).

**Extent of the genus.** The genus, at present, contains only one well-authenticated species, *G. polyedricum* Pouchet, which is the only one treated in this report. Other species have been reported with very sketchy

drawings, e.g., *G. ostenfeldii* Paulsen (1904), or with no drawings at all, e.g., *G. crassa* and *G. reticulata* Kofoid and Michener (1911). None of these can be included in this genus with full certainty until more adequate descriptions or figures are available.

**Comparisons.** The genus *Goniodoma* is a distinct unit with no close relatives (see p. 8). All regions of the theca except the girdle are distinctive. The tabulation of the epitheca is unique. Although other genera have been reported with ten epithecal plates, none has the combination of three apicals, no intercalaries, and seven precingulars. The hypothecal pattern is almost equally distinctive. It occurs elsewhere only in the genus *Pachydinium* Pavillard.

The ventral area substantiates the distinctness indicated by the larger body plates. The sulcal plates are only five and are comparatively simple and flat. The ventral area is rather flat and there is no well-defined sulcus. The flagellar pore faces ventrally, so that it is completely unobscured in ventral view. The ventral area, thus, must be considered primitive as compared with the highly complex areas of *Peridinium* and *Gonyaulax* with their development of intricate plates, deep sulcus, and elaborate lists.

As indicated on page 8, *Goniodoma* may be considered a primitive genus whose closest relative is *Ceratocorys*, although the two genera are quite widely separated.

*Goniodoma polyedricum* (Pouchet) Jørgensen  
(Figure 60)

*Goniodoma polyedricum* Jørgensen, 1899, p. 33. Paulsen, 1907, p. 8. Paulsen, 1908, p. 33, fig. 42. Paulsen, 1931, p. 37. Lindemann, 1925, pp. 97-98, figs. 2-4. Lebour, 1925, p. 90, fig. 26. Pavillard, 1931, p. 96. Matzenauer, 1933, p. 452.

*Goniodoma polyhedricum*, Forti, 1922, p. 85, pl. 6, fig. 75.

*Peridinium polyedricum* Pouchet, 1883, p. 42, pls. 20, 21, fig. 34.

*Goniodoma acuminatum* Stein, 1883, pl. 7, figs. 1-16, pl. 8, figs. 1, 2. Bütschli, 1885, pl. 52, fig. 5a-c. Schütt, 1887, figs. 13-16. Schütt, 1895, pl. 7, fig. 31, 1-3, pl. 8, fig. 30, 1-10. Schütt, 1896, p. 21, fig. 30. Aurivillius, 1898, p. 98. Cleve, 1900b, p. 245. Entz, 1905, figs. 65, 66. Wang and Nie, 1932, p. 295, figs. 7, 8.

*Gonyaulax polyedra* Okamura, 1907, pl. 5, fig. 35a-c.  
? *Peridinium acuminatum* Ehrenberg, 1838, p. 254, pl. 22, fig. 16.

**Dimensions.** Length of body ( $\bar{l}$ ) 58 (40-93) microns. Diameter ( $\bar{d}$ ) 65 (45-100) microns. Width of girdle 4 to 6 microns. Eighty-two specimens were measured.

**Shape.** Body usually somewhat wider than long. The  $\bar{l}/\bar{d}$  ratio is 0.90 (0.77-1.19). Body almost circular at girdle but otherwise very angular (fig. 60A, B, H). Angles occur at almost all major body plate sutures. Epitheca angular dome-shaped without apical horn although apex is well defined. Hypotheca broadly truncate posteriorly; antapex between one-third and one-half as broad as diameter of body at girdle. Girdle nearly equatorial sinistral; displaced from 1 to 2 girdle widths; slightly concave; no overhang. Girdle continues onto ventral area, where its ends are turned sharply posteriorly. Ventral area short, broad, and angular, with a short projection of the anterior sulcal plate into the epitheca. Flagellar pore ovate, on right side of ventral area at

proximal end of girdle. It is evident in ventral view without dissection. Sulcus only slightly developed.

**Plate pattern.** Formula: 3ap, 7pr, 6g, 5s, 5po, 3ant. The three apical plates are about equal in size and surround the apical platelet, which covers apical pore (fig. 60A). This platelet is oval in shape and is placed at an angle of about 45° to the dorsoventral axis of the body. Precingular plates of approximately equal size except the ventrally placed first and seventh, which are about half the size of the others. The six girdle plates subequal in size with sutures symmetrically placed (fig. 60A). Postcingular plates also approximately equal in size, as are the antapicals (fig. 60B). Second antapical composes most of the truncate antapex. The first and third antapicals are more ventrally placed, and each bounds half of posterior margin of ventral area.

The ventral area composed of five plates: three large posterior plates lying posterior to the girdle, and two anterior ones representing extensions of girdle. Anterior sulcal plate (as, fig. 60F, G, H) forms anterior end and half right edge of flagellar pore and represents the proximal extension of girdle into ventral area. It has a limb extending into epitheca, posterior to pr1. The anterior cingular list is continued across it. The left, posterior, and right sulcal plates are more or less rectangular, of about equal size, and form greater part of area. Left sulcal plate forms left edge of pore, the posterior plate the posterior edge, and the right sulcal plate is not in contact with the pore. Right accessory sulcal plate forms an extension of the distal end of girdle into ventral area. It has a narrow anterior limb which extends to anterior sulcal plate to form the right edge of pore. Thus, all sulcal plates border the pore except the right.

**Surface.** Entire body wall, including that of girdle and sulcal plates, covered with large pits regularly arranged. These have pores in their centers which, in optical cross section, can be seen to extend through body wall. Thickness of body wall extremely variable and depth of pits varies accordingly. Girdle bears two to four rows of pits with pores, although only two rows are ordinarily visible in ventral or lateral view as outer rows are on curved sides of girdle. There is a ventral epithecal pore situated on the anterior margin of pr1 (fig. 60D, H). This pore is peculiar in not being covered by a platelet or surrounded by a ridge or list. Body plates joined by rabbit membranes which are rather narrow compared with those in *Peridinium*.

**Lists.** Cingular lists from 1.5 to 2.5 girdle widths wide, always somewhat ornamented with spines and reticulations, which are quite thick (fig. 60C). Posterior list usually more heavily sculptured than the anterior (fig. 60A, B). Each suture of main body plates marked by a thick triangular list ridge. When these are viewed along edge of body, they appear as thin lists because of their transparency (fig. 60H, I). Along their outer margins they may be clear or bear reticulations. Proximally, however, they almost invariably bear large reticulations or pits (fig. 60A, B, H). Lists surrounding ventral area do not attain a greater development than that of the body lists. No lists occur at sutures between sulcal plates except between the left and posterior sulcal plates.

**Variation.** The size varies considerably. In our material both the length and the width showed a difference of over 100 per cent between the smallest and largest specimens. Shape of body more constant. Most of the material had an  $\bar{l}/\bar{d}$  ratio less than 1.00; in only

2 of the 82 specimens measured was this ratio more than 1.00, viz., 1.03 and 1.19. The broadest specimen, with an  $l/d$  ratio of 0.77, on the other hand, was connected with the mean by a continuous series of intergrades. It was at first thought that the smallest specimens represented a distinct species, but when the frequency of the width of all specimens was plotted, a primary mode was found at 65 microns and a secondary one at 45-50 microns with so many records between that not even a variety was indicated on this basis. The thickness of the body wall and of the associated lists is variable; forms with extremely heavy thecae are common.

**Reproduction.** Stein (1883) figured an individual containing a resting cyst (pl. 7, fig. 2). He also showed an emerging cyst (pl. 7, fig. 9) with the girdle indicated. Other figures by Stein represent cysts with two and four daughter cells (swarm spores?) with girdles (figs. 11, 12). Finally, Stein presented (figs. 13-16) specimens which he interpreted as representing stages intermediate between these young daughters and the mature specimens. His material was from the Baltic and Atlantic. Schütt (1895, pl. 8, fig. 30, 9, 10) shows daughter cells with half-old and half-new thecae, also a "double spore" (fig. 30, 7). No specimens representing reproductive stages were found in the Carnegie material.

**Distribution.** Paulsen (1908) stated that Goniodoma polyedricum is an Atlantic subtropical species. Lebour (1925) also designated it as subtropical. Both authors record the species as rare in the Gulf Stream. It is, however, a widespread tropical species, as shown by the Carnegie and other observations. It was reported from the tropical Atlantic by Schmidt (1901) and Pavillard (1931); from the Baltic by Aurivillins (1896) and Abshagen (1909); from the Mediterranean by Schmidt (1901), Forti (1922), Issel (1928), and Paulsen (1931); from the Pacific by Schmidt (1901); and from the Indian Ocean by Schmidt (1901), and Matzenauer (1933).

In the Carnegie collection G. polyedricum was found at 148 stations: 30 in the Atlantic and 118 in the Pacific. There are 471 records of occurrence: 280 rare, 178 occasional, and 13 common. The species was found less frequently with increase in depth, with 218 records for the surface, 143 for 50 meters, and 110 for 100 meters. There are 190 pump records and 281 net records. It was found in both hemispheres and in all months of the year.

The species was found at practically every station in the tropical and subtropical regions, and it strayed beyond these regions much more than did most of the other tropical forms (fig. 61). Thus, it was found in the North Atlantic Drift as far as the British Isles (station 6c); in the western Pacific north of 40° north; in the eastern Pacific to 37° north; and in the South Pacific to 40° south. There was no particular center of abundance. The records of "common" and "occasional" were scattered throughout the range.

The surface temperatures at the stations where the species occurred at any depth varied from 12.4 to 29.5 C. The ranges of hydrographic conditions in situ were as follows: temperature, 10.6 to 29.6 C; salinity, 29.7 to 37.1 o/oo; pH, 7.17 to 8.47; phosphate, 3 to 198 mg PO<sub>4</sub>/m<sup>3</sup>.

It can be concluded from Carnegie observations that Goniodoma polyedricum is a fairly common, widespread, tropical species. It is similar to Ceratocorys horrida in this respect, but it extends into water of lower temperature. Thus, it was found near the British Isles

where the surface temperature was only 12.4 C; north-east of Japan where the surface temperature was 15.9; off California, in 16.2 water; and in the southeastern Pacific, in 15° water. It occurred at 6 stations where the surface temperature was less than 19°. This species should be an excellent plankton indicator, as it is ubiquitous in the tropics and seems to survive transfer to cooler regions. It should indicate water masses of tropical origin.

The species apparently suffers no decrease in waters of low nutrient content. There were 165 records in water with less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

#### Family GONYAULACACEAE Lindemann

**Diagnosis.** "Shape very variable, spherical, angular, elongate, sometimes with hornlike processes or distinct spines at both ends. Girdle about equatorial, often strongly spiraled. Small posterior intercalary present. Length, 18 microns to 167 microns." (Lindemann, p. 84, 1928.)

#### Genus GONYAULAX Diesing

**Diagnosis.** "Body variously shaped, spheroidal, polyhedral, broadly fusiform, elongated with stout apical and antapical prolongations, or dorso-ventrally flattened. Apex rounded or truncate symmetrically or asymmetrically, never acutely symmetrically pointed. Antapex rounded, flattened, or pointed symmetrically or asymmetrically. Girdle usually equatorial, descending, displaced distally one to seven times its own width, and sometimes with slight overhang. Transverse furrow impressed or not; longitudinal furrow usually slightly indenting the epitheca, often flaring distally, well developed, reaching to or approaching the antapex. Thecal wall consisting of one to six apical plates, none to three anterior intercalaries, six precingulars, six girdle plates, six postcingulars, one posterior intercalary, and one antapical. The longitudinal furrow occupies the whole of the ventral area which slightly indents the epitheca and consists of one anterior, about four intermediate and one posterior plate. The midventral plate of the apical series is usually a narrow plate extending posteriorly to a junction with the anterior plate of the ventral area, thus parting precingulars one and six. When guarded by lateral ridges it simulates an anterior extension of the longitudinal furrow. It bears at its apex a delicate extension, the closing platelet which covers the apical region.

"Surface smooth or rugose with major thickenings along suture lines and minor ones on plates forming a regular or irregular polygonal mesh of varying size, often with vermiculate, longitudinal elements predominating, sometimes spinulate. Furrows with or without lists which in many species are ribbed or spinulate. One or more antapical spines sometimes present, rarely with sheathed spines of the Ceratocorys type. Plates porulate, with pores in centers, angles, or nodes of the mesh. A peculiar large ventral pore occurs to the right of the midventral line usually near the suture between apical one and the plate to its right. Theca divided obliquely in fission. Ecdysis frequently seen. Chromatophores yellow to dark brown, often dense. In fresh, brackish, and marine waters from boreal to tropical

regions." (Kofoid, 1911a, p. 196.)

**Remarks.** The present diagnosis of the genus will undoubtedly be radically revised upon a more intensive study of the morphology of the species now included in the genus. Judging from the results of the careful dissection of the two species included in this report, it can be concluded that many of the specific diagnoses are probably in error. In addition to this, it is likely that the genus as now conceived includes several groups of generic status.

In his first diagnosis of this genus, Kofoid (1907b) gave the plate formula as 6ap, 6pr, 6po, 1ant, 1 longitudinal ventral furrow plate, 1 girdle plate. Apparently this analysis was made without dissection of the plates, and the many ridges and markings of the theca led to an erroneous conclusion as to the plate pattern. Later, Kofoid (1911a) stated that his first interpretation was in error and gave a new diagnosis which agrees much more closely with that found in the two species presented here. His new formula is "3ap, 0a, 6pr, 6g, 6po, 1p, 1ant, ventral area consisting of a narrow anterior plate, large posterior plate, and at least three intermediate plates." In the present investigations complete dissections were made of the entire skeleton of *G. pacifica* and *G. fusiformis*. The plate formula of these two species is as follows: 3ap, 2a, 6pr, 6g, 6-7s, 6po, 1p, 1ant.

Whedon and Kofoid (1936) made an analysis of two new species, *G. catenella* and *G. acatenella*. The formula for each of these is the same, viz., 4ap, 0a, 6pr, 6g, 5s, 6po, 1p, 1ant. This formula is sufficiently different from that of *G. pacifica* and *G. fusiformis* to justify generic separation. *Gonyaulax pacifica* and *G. fusiformis* have one less apical, two (instead of no) anterior intercalaries, and two more sulcal plates. The facies of the ventral part of the epitheca as well as the size and shape of the body generally of Whedon and Kofoid's two species is quite different from those of *G. pacifica* and *G. fusiformis*.

The present work on the genus *Gonyaulax* shows clearly that a complete reclassification of this and related genera is quite necessary. A re-examination of the whole group on the basis of thorough morphological studies is absolutely essential. Quite new conceptions of relationships within the group will undoubtedly result from such a critical analysis of extensive material. As an example of a realigning, resulting from such thorough studies, it may be mentioned that *G. ceratocoroides* Kofoid has been placed in a separate genus.

*Gonyaulax pacifica* Kofoid  
(Figure 62)

*Gonyaulax pacifica* Kofoid, 1907b, p. 308, pl. 30, figs. 37-39. Kofoid, 1911b, p. 235, pl. 15, fig. 35. Pavillard, 1931, p. 51.

*Steiniella cornuta* Karsten, 1907, pp. 348, 420, pl. 53, fig. 7.

**Dimensions.** Length of body, exclusive of antapical spine (1), 155 (131-263) microns. Transdiameter (d'), 80 (52-105) microns. This diameter is the greatest diameter, not the diameter seen in true ventral view (see below). Width of girdle, about 5 microns. Twenty-two specimens were measured.

**Shape.** Body about twice as long as greatest diameter. The 1/d' ratio is 1.98 (1.66-2.65). Body extremely asymmetrical, probably as a result of a differential

growth in which the left side has grown decidedly larger than the right. The short diameter (d) is about 0.6 times the long diameter (d') (see fig. 62D). Epitheca compressed dorsoventrally, very abruptly from the girdle so that the distal half of the epitheca extends as a bladelike horn (fig. 62A, C, I, J). Hypotheca also very strongly compressed dorsoventrally, but here the compression is accompanied by a strong dorsal curvature of the body which results in a concavity on the ventral face and in an extreme approximation of the dorsal and ventral walls of the hypotheca, especially on the right side. Thus, the more posterior part of the hypotheca is concave blade-shaped and the entire hypotheca is "scoop-like" as Kofoid (1911a) described it. Posterior edge of body rounded in ventral view with extension on left side terminated by a spine which is from 1 to 2 girdle widths long. The asymmetrical shape of the body results in quite different contours when the body is viewed from slightly different angles. Figure 62A shows a specimen presenting its widest ventrolateral aspect, and figure 62H, a strictly ventral view, presents a narrower body diameter but shows the broadest view of the ventral area.

Girdle slightly behind the middle; sinistral; ends curved ventrally, particularly the proximal end; displaced 1.5 to 3.0 girdle widths, no overhang; greatly excavated, often as much as 1 girdle width (fig. 62B).

In connection with the unequal development of the two sides of the body, there has been a rotation of the long axis of the sulcus and ventral area so that in ventrolateral view only the right side of the ventral area is visible. Ventral area more or less elliptical in outline, somewhat sigmoid in ventral view but not in the flat ventrolateral view. Anteriorly the area extends into the epitheca about 3 girdle widths. Greatest width of area attained about halfway to antapex. Posteriorly the area tapers to a point about 2 girdle widths from base of antapical spine. Sulcus a deep groove on left side of ventral area. Flagellar pore narrow and long (about 3 girdle widths), sigmoid in outline, following the curvature of the ventral area (fig. 62K), and extending posteriorly from proximal end of girdle.

**Plate pattern.** The three apical plates very unequal in size. First apical very narrow with narrow extension to girdle (fig. 62C). Apical closing platelet present, sometimes loosely attached to anterior end of first apical plate. Kofoid (1911a) stated that the platelet is a definite part of the first apical, but the writer has found that it may be detached quite easily. Second apical plate is large and composes almost all of distal end of apical horn. It has a limb projecting around the apex to right side and fitting into a shoulder of first anterior intercalary (fig. 62D, I). Third apical a long triangular plate with its apex at apex of specimen and its base along margin of second anterior intercalary (fig. 62C, D). This apical was shown in Kofoid's (1907b) earlier drawing, but he later (1911a) rescinded his earlier diagnosis of this species and omitted this plate.

First anterior intercalary, a large plate running almost to apex, where it has a shoulder into which fits the projection of a2. This plate was included in ap3 by Kofoid (1911a), who apparently had not separated it from that plate. The second anterior intercalary has not been reported before for this species, but was easily determined in all specimens examined. It is probably homologous with a1 in *Spiraulax kofoidii*. It frequently bears a double ridge running transversely across its middle

(fig. 62A).

The six precingulars of rather unequal length.

The six girdle plates subequal in size except for g6, which extends from distal end of girdle well around to dorsal side of body (fig. 62F); all U-shaped in cross section (fig. 62B).

First postcingular small; anterior to po1; forms left edge of flagellar pore (fig. 62C, L). It is similar in size and position to po1 in *Ceratocorys*. Second to fourth postcingulars larger; subequal in size; occupy left ventral and left lateral regions of hypotheca (fig. 62G). Fifth and sixth postcingulars large; the fifth is dorsal, the sixth lateral and ventral. The sixth is extremely compressed and forms the lateral keel of hypotheca.

Posterior intercalary plate, a long narrow plate extending from po1 along left edge of sulcus to antapical plate (fig. 62A, C, H, G, L). It bears the wide left sulcal list.

The antapical plate constitutes the compressed ant-apex. A corner of it extends almost halfway to girdle on left side of body (fig. 62J). Other margins of this plate more limited, especially ventrally, where a narrow strip only 1 girdle width wide is visible (fig. 62C). This plate bears the antapical spine at its left ventral corner.

Ventral area composed of seven plates (fig. 62K, L); anterior, posterior, right, left, right accessory, posterior accessory, and intercalary. The anterior sulcal plate consists of two inseparable parts. Posterior part roundish, with semicircular notch posteriorly which represents anterior edge of flagellar pore. Anterior part is a process extending into epitheca between base of first apical and sides of a2 and pr6 (fig. 62C). Posterior sulcal plate large, subtriangular, with oblique base anteriorly where it borders left and intercalary sulcal plates. Remaining five sulcal plates lie between the anterior and the posterior; three on the right side, one on the left side, and one in the middle. Those on the right side, reading posteriorly, are the right accessory, right, and intercalary. Of these, the right accessory and part of the right constitute the right edge of flagellar pore. Posterior edge of pore formed by tip of posterior accessory, which lies between rs, i, and ls, but does not touch ps. Part of left edge of the pore formed by extension of ls; the rest by po1. Thus, all sulcal plates touch the pore except the intercalary and posterior.

**Body wall.** Many prominent narrow lists run longitudinally along body; some run whole length of epitheca, others extend only a short distance from girdle. Most of these "ridges" bear no relation to sutures although they have been so confused in the past. Sutures are often marked by low, narrow ridges; sometimes one on each side of intercalary zones. Second anterior intercalary frequently has a double line, indicating some sort of zone, running transversely through its middle.

A ventral epithelial pore occurs on left anterior corner of second anterior intercalary plate. Apical pore covered by closing platelet. Minute tubercles are scattered over major plates rather irregularly, although they have a tendency to be arranged in rows. Kofoid (1911a) interpreted these as pores. Some of the sulcal plates may have similar tubercles or, sometimes, faint reticulations (fig. 62A). Girdle plates crossed transversely by a varying number of ridges, usually spaced about 0.5 girdle width apart.

**Lists.** Although there are an excessive number of

body lists in this species, the usual list systems are rather poorly developed. Girdle lists small or absent, never over 0.5 girdle width wide. Ribs and other structural differentiations are absent on these lists. The only wide list of the species is the left sulcal list, which in the broad ventrolateral aspect of body covers half of ventral area posterior to distal end of girdle (fig. 62A). It is attached to right and anterior edges of posterior intercalary plate (fig. 62L). Right sulcal list absent on hypothecal part of ventral area, but the anterior right sulcal list is well developed. It occurs on right edge of epithelial extension of ventral area and is attached to pr6. In apical view it is visible as a "spine" at distal end of girdle (ar, fig. 62D). The body list along right keel of hypotheca is well developed and may attain a width greater than 1 girdle width.

Antapical spine often curved to the right. Its length varies considerably, viz., from 0.8 to 2.2 girdle widths. It may bear small lists or large reticulations.

**Variation.** In thin-walled specimens the second anterior intercalary usually is quite hyaline and structureless. This may be the reason why this plate has previously gone unnoticed, for in such cases it may easily be mistaken for a wide intercalary zone if careful dissections are not made.

There is considerable variation in shape of body; for instance, the degree of compression in the girdle region may be low (see fig. 62E), and the antapex may be extended as a slight horn (fig. 62H).

**Distribution.** *Gonyaulax pacifica* is a rare, seldom reported species, although it has a wide distribution over the tropical seas. Pavillard (1931) reported it from the Atlantic and from the Mediterranean (1909, 1931). Previous to the *Carnegie* cruise it had been found in the Pacific only at San Diego (Kofoid, 1907b) and in the Indian Ocean only by Karsten (1907). Böhm (1936) states it had never been found in the western Pacific, and Matzenauer (1933) did not find it in the Indian Ocean.

In contrast with this apparent rarity, the species was found at 77 *Carnegie* stations: 15 in the Atlantic and 62 in the Pacific. There are 163 records of occurrence: 140 rare and 23 occasional. It was never common or abundant. It was found less at the surface than at the lower levels, with 19 records for the surface, 73 for 50 meters, and 71 for 100 meters. There are 107 net records and 56 pump records. It was found in both hemispheres and in practically all months of the year.

*Gonyaulax pacifica* was found rather consistently throughout the tropics, although there are many gaps in its distribution (fig. 61). In the Atlantic it was found at all stations south of station 15, although not at station 24 or in the Caribbean. Although the records are not continuous south of 40° north, it was not found north of that latitude.

In the Pacific the records are even less complete than in the Atlantic. There is no significant geographic grouping of the record stations, however, and it is probable that the species is more uniformly distributed than the present records indicate. It is equally common in the western Pacific and in the eastern Pacific. It was not found north of latitude 35° north nor south of 32° south.

Although the *Carnegie* records do not show a continuous distribution in the tropics, the limits of the distribution of the species show a close correlation with the surface isotherm of 20° C (fig. 61). At the stations where the species was found, the surface temperatures

were above 20° C, except at station 66, where the temperature was 19.4 C.

On the basis of these data, *G. pacifica* must be considered a strictly tropical species which does not endure transfer to colder regions. For this reason it is a good indicator of tropical water masses, although not so good as *Ceratocorys horrida* because of its less frequent occurrence.

Water of low nutrient content is no barrier to the species, as there are 89 records of its occurrence in water with less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

The surface temperatures at the stations where the species occurred at any depth varied from 19.4 to 29.4 C. The ranges of hydrographic conditions *in situ* were as follows: temperature, 1.4 to 29.3 C; salinity, 33.4 to 37.1 o/oo; pH, 7.17 to 8.39; phosphate, 3 to 121 mg PO<sub>4</sub>/m<sup>3</sup>.

*Gonyaulax fusiformis* n.sp.  
(Figure 63)

**Dimensions.** Length of the body ( $\bar{l}$ ), excluding antapical spine, 86 (67-98) microns. Diameter ( $\bar{d}$ ), 47 (35-57) microns. Width of girdle, 4.8 (4-5.5) microns. Length of antapical spine, 17 (12-23) microns. Seven specimens were measured.

**Shape.** Body broadly fusiform. The  $\bar{l}/\bar{d}$  ratio is 1.82 (1.68-1.98); thus body may be almost twice as long as wide. Epitheca extended into a long apical horn equal in length to rest of epitheca. Apex somewhat less than 1 girdle width in diameter. On left side, body tapers gradually from girdle to apex, but on right side there is a prominent shoulder as in *Spiraulax*. Hypotheca tapers uniformly to antapex except for a constriction about 3 girdle widths from base of antapical spine (fig. 63D, E, G). Body circular in girdle section (fig. 63B, F). Girdle approximately equatorial, sinistral, displaced from 1.5 to 2.5 girdle widths, slightly concave; usually with no overhang. Ventral area very narrow, usually almost straight posteriorly, but bends to left anteriorly; sometimes slightly sigmoid. Posteriorly it flares out into an elliptical area, similar to, but not so wide as, that in *Spiraulax*. Anterior sulcal plate has an extension into epitheca (as, fig. 63B). Flagellar pore a long, narrow slit situated at left edge of ventral area between displaced girdle ends and continued posteriorly about 1 girdle width.

**Plate pattern.** The three apical plates quite unequal in size. First apical is long, narrow, and curved, and extends from apex to anterior sulcal plate on ventral side of epitheca (fig. 63E). Second apical extends from first apical around to dorsal side of body (fig. 63B); at apex it has a limb (x, fig. 63B), about 1 girdle width wide which fits into a shoulder formed by the withdrawal from the apex of the first anterior intercalary plate. This process meets a similar process from the third apical (y, fig. 63B, G). Body of third apical linear, extending along right side of distal half of first apical. Therefore it lies between the first and second apicals and between the apex and the two anterior intercalary plates. The two anterior intercalaries make up the greater part of right side of apical horn. The second of them is on ventral face of body touching six different plates, including first and third apicals, sixth precingular, and anterior sulcal plates. The six precingulars are of approximately equal width except the first, which

is somewhat wider.

The six girdle plates approximately equal in length, with sutures as shown by arrows in figure 63A.

The six postcingular plates are about equal in width except the first, which is small and narrow and lies along left edge of flagellar pore (fig. 63E, F). A single antapical plate extends almost halfway up the right side of sulcus. It bears the heavy antapical spine and the "sulcal spine" (fig. 63F, G). The posterior intercalary forms the left edge of ventral area posterior to first postcingular.

Ventral area composed of six plates: anterior, posterior, left, right, right accessory, and intermediate (fig. 63C). Posterior accessory absent. Sulcal plate has a projection into epitheca which meets the first apical plate. A notch in posterior end of this plate represents anterior edge of flagellar pore as in *G. pacifica*. Posterior sulcal plate comprises the expanded elliptical posterior part of ventral area. It extends to within 1 girdle width of distal end of girdle. Left sulcal plate forms posterior edge of flagellar pore and has a process extending anteriorly along left edge of pore to meet first postcingular plate, which also borders pore. Right and right accessory plates form right edge of flagellar pore; the right is opposite distal end of girdle; the right accessory is anterior to this. Intercalary sulcal plate is small, square, posterior to right plate, and removed from flagellar pore.

Thus the flagellar pore is bounded by the first postcingular and four sulcal plates: the anterior, left, right, and posterior accessory. The intercalary and posterior sulcal plates do not touch the pore.

**Thecal wall.** All plates of body except some of sulcal plates covered with a fine areolation which extends completely to edges of plates. Most plates also bear a few large, irregularly scattered pores, which, in optical section, can be seen to pierce the body wall. They occur on the anterior, posterior, and left sulcal plates, but frequently occur only in rows along the edges or ridges of the narrower plates. One row occurs along each edge of girdle plates.

Intercalary zones occur along most of sutures and are marked by a fine areolation and absence of pores. Body ridges usually some distance from sutures, and the intervening space may be considered the intercalary zone, as it is probable that the ridge represents the original suture line.

The ventral epithelial pore so characteristic of *Gonyaulax* is present here at left anterior corner of second anterior intercalary plate. Apical pore closed by a very hyaline apical closing platelet.

**Lists.** Girdle lists about 0.75 girdle width wide, usually strengthened by simple ribs extending from body to the edge of the list, spaced from 0.5 to 1 girdle width apart (fig. 63A). Girdle plates free of ridges. Right and left sulcal lists present. Posterior part of right sulcal list attached to po6 and ant1. A prominent, characteristic spine, the sulcal spine, occurs in the middle of this list at anterior corner of antapical plate. Anteriorly, this list is continuous with posterior girdle list. Posteriorly it terminates at posterior end of ventral area. The anterior (epithelial) part of right sulcal list is attached to pr6 and as and is continuous posteriorly with distal end of anterior girdle list.

Although the boundaries of most of plates are indicated by ridges placed at some distance from the edges, certain sutures are not so marked and extra ridges oc-



cur on many plates. Thus any diagnosis of the plate pattern based on the pattern of ridges would be erroneous. Careful dissection is necessary to insure a correct plate formula. The third apical and the second anterior intercalary are particularly difficult to demonstrate. The second apical bears two ridges removed from the edges; the first anterior intercalary has three (fig. 63A).

The antapical spine is massive, solid, and conical, terminating the hypotheca and borne by the antapical plate. It is 4.1 (2.4-4.5) girdle widths long and from 1 to 2 girdle widths in diameter at base. It is covered with the same fine areolation as that of the body and is marked with ridges running longitudinally.

**Variation.** *Gonyaulax fusiformis* shows considerable variation in size and in length of antapical spine, but other characters are comparatively constant. Length of body varies from 67 to 98 microns; length of antapical spine from 12 to 23 microns or from 2.4 to 4.5 girdle widths. Body shape very constant except that width at girdle shows a tendency to vary; the  $l/d$  ratio varies from 1.68 to 1.98. Sometimes the "sulcal spine" is double, and one specimen was found without this spine. The surface markings show a high degree of constancy, being always a very delicate areolation with scattered large pores. The right sulcal list may end at sulcal spine or may continue beyond to antapical end of sulcus.

**Comparisons.** Although the plate pattern of *G. fusiformis* is fundamentally similar to that of *G. pacifica*, it differs somewhat from that of the latter species. Its major plate pattern is composed of the same number of plates as that in *G. pacifica*, but the arrangement of its plates differs from that in *G. pacifica* in some respects. Its first apical does not reach the girdle as it does in *G. pacifica*, but extends only to the anterior sulcal plate. Its third apical is much smaller, so that its second anterior intercalary touches the first intercalary, which is not the case in *G. pacifica*. The apical process of ap<sub>3</sub> is not represented in *G. pacifica*.

In regard to the ventral area, the arrangement of the plates in *G. fusiformis* is rather similar to that in *G. pacifica*, but there is one less plate in the former species; the posterior accessory is lacking. In *G. pacifica* the intercalary plate is next to the largest of the sulcal complex, whereas in *G. fusiformis* it is the smallest. Its position, however, on the right of the sulcus just anterior to the posterior plate and not touching the flagellar pore, is the same in the two forms. The extra sulcal plate in *G. pacifica*, the posterior accessory, is posterior to the flagellar pore. Its anterior end forms the posterior end of the pore. It has probably been formed by the splitting off from its neighbor to the left, the left sulcal plate. Thus, the left and posterior accessory sulcal plates in *G. pacifica* would be homologous with the left sulcal plate in *G. fusiformis*; this latter plate has an arm extending along the left side of the pore to po<sub>1</sub>, probably homologous with the anterior part of the left sulcal plate in *G. pacifica*.

*Gonyaulax fusiformis* shows some relationship to *Spiraulax kofoidii* and in some respects it is intermediate between *Spiraulax* and *Gonyaulax*. It agrees with *Spiraulax* in that the second anterior intercalary plate touches the first (which in *Spiraulax*, however, is the third apical). It also agrees in the number of the sulcal plates, viz., six. The general arrangement of the sulcal plates in the two species is the same although there are two important differences in the details of the arrangement: First, in *Spiraulax* the left sulcal plate does not

have an arm extending along the side of the flagellar pore, so that the entire left side of the pore is formed by the first postcingular plate; the left sulcal plate marks only the posterior edge of the pore. Secondly, the relative sizes of the plates differ in such a way that in *Spiraulax* the right sulcal plate has been squeezed out from contact with the pore, so that the right side of the pore is formed chiefly by the right accessory sulcal plate and to a small extent by the notch of the anterior plate. So far as the sulcus is concerned, it may be concluded that *G. fusiformis* is more closely related to *G. pacifica* than to *Spiraulax*. The agreement with *Spiraulax* in the number of plates is outweighed by the difference in the pattern of the sulcal plates. Only the splitting of one plate in *G. pacifica* is sufficient to show good agreement with the sulcal plates of *G. fusiformis*, whereas considerable adjustment of plates surrounding the pore would be necessary to show agreement with *Spiraulax*.

Differences in the epithelial plate pattern emphasize the distant relationship of these two forms. In *Spiraulax* the plate which is homologous with the first anterior intercalary in *Gonyaulax fusiformis* is an apical. Thus in *Spiraulax* there are four apicals and only one anterior intercalary, whereas in *G. fusiformis* there are only three apicals and two intercalaries. In *Spiraulax* the first apical does not extend either to the girdle or to the anterior sulcal plate, but terminates at the anterior margin of the first precingular, so that the anterior intercalary extends over and touches the first precingular. Kofoid (1911b) stressed this point in creating the genus *Spiraulax*. The ventral epithelial pore so characteristic of the genus *Gonyaulax* is absent in *Spiraulax*.

There is a superficial resemblance between *G. fusiformis* and *Spiraulax* in general body shape, so that when a specimen of the former species is viewed under the low power of the microscope it may be confused with a species of *Spiraulax*. Under the high power, however, a glance at the surface of the plates is sufficient to distinguish these two forms without any analysis of the plate pattern. *Spiraulax* is coarsely reticulate or with rounded pits, without apparent pores. *Gonyaulax fusiformis* is very finely areolate with a few large pores scattered over the plates. The prominent sulcal spine will distinguish this species from *Spiraulax*, although its absence is not a positive identification of *Spiraulax*.

**Historical.** It is possible that Murray and Whitting's *Gonyaulax jolliffei* (1899, p. 324, pl. 28, fig. 1a, b) was based on an aberrant specimen of *G. fusiformis* (see p. 54). The plate pattern is so poorly figured by these authors that definite identification is not possible. The presence of a left sulcal spine and the general body shape suggest, however, that Murray and Whitting's form is not specifically identical with our material. For this reason and in order to avoid confusion in the literature, it was deemed advisable to give our species a new name and to retain the name *Gonyaulax jolliffei* for Murray and Whitting's species. Kofoid's *Spiraulax* is separate from each of these (see p. 52).

*Gonyaulax fusiformis* was figured by Pavillard (1931, pl. 2, fig. 3) under the caption *Gonyaulax birostris* Stein. Although the plate pattern is not indicated, this form is easily identifiable with the present species by its characteristic body shape and antapical spine. The species differs from *G. birostris* Stein in body shape and plate pattern.

**Distribution.** Pavillard (1931) reported this species from the tropical Atlantic.

In the Carnegie collection *G. fusiformis* was found at 19 stations: 2 in the Atlantic and 17 in the Pacific. There are 33 records of occurrence, all rare. The species occurred about equally at the three depths, with 12 records for the surface, 12 for 50 meters, and 9 for 100 meters. There are 21 pump records and 12 net records.

The species was closely limited to the tropics. In the Atlantic it did not occur north of 30° north. In the Pacific it was not found north of 29° north or south of 16° south. No center of abundance was indicated. The 17 record stations in the Pacific were rather irregularly scattered and showed no correlation with geographic location or with dynamic conditions (fig. 61).

The surface temperatures at the stations where the species occurred at any depth varied from 22.7 to 28.7 C. The hydrographic conditions *in situ* were as follows: temperature, 18.7 to 28.7 C; salinity, 34.2 to 37.0 o/oo; pH, 8.16 to 8.39; phosphate, 3 to 40 mg PO<sub>4</sub>/m<sup>3</sup>.

This is obviously a rare tropical species restricted to warm water. It is remarkable that it was found more often in the nutrient-poor water. Of the 33 records of occurrence, all but 7 were in water with a phosphate content less than 10 mg PO<sub>4</sub>/m<sup>3</sup>. Type locality: Carnegie station 18.

#### Genus ACANTHOGONYAULAX (Kofoid) Graham

**Diagnosis.** Body angular, with prominent lists and brush-formed hypothecal spines simulating *Ceratocorys*. Girdle premedian. Plate pattern: apical platelet, 3ap, 9pr, 6g, 7s, 6po, 1p, 1ant. Ventral epithelial pore on first apical plate. One species. Marine.

**Type species.** *Acanthogonyaulax spinifera* (Murray and Whitting) Graham.

**Historical.** *Acanthogonyaulax* was proposed as a subgenus of *Gonyaulax* by Kofoid (1910) to include Murray and Whitting's (1899) *Ceratocorys spinifera* (see below, pp. 51-52). This subgenus is here raised to the rank of genus.

**Comparisons.** *Acanthogonyaulax* has a superficial resemblance to *Ceratocorys*, particularly to *C. horrida*. The hypotheca of *Acanthogonyaulax* resembles that of *C. horrida* in the great development of antapical brush spines and in the intervening lists. The epitheca, on the other hand, is prolonged into a short tubular horn, whereas in *Ceratocorys* the epitheca is low dome-shaped.

A more fundamental resemblance between these two genera is expressed by the similar number and pattern of the major hypothecal plates. There is a disparity in the size of some of these plates, however.

The posterior intercalary is much more extensive, and the first postcingular is somewhat larger in *Acanthogonyaulax* than in *Ceratocorys*. The second postcingular, on the other hand, is a small ventral plate in *Ceratocorys*, whereas in *Acanthogonyaulax* it is large, equal in size to the postcingulars of the lateral and dorsal sides.

The epitheca of *Acanthogonyaulax* differs markedly from that of *Ceratocorys*, not only in shape but also in the number and the pattern of the plates. The number of precingular plates in *Ceratocorys* is five; in *Acanthogonyaulax* it is nine. The major part of the epitheca in *Ceratocorys* is composed of four precingular plates, whereas in *Acanthogonyaulax* six of the precingular plates constitute most of the epitheca. The small first

precingular plate in *Ceratocorys* is represented in *Acanthogonyaulax* by three minute precingulars. The apical region in *Ceratocorys* is composed of four plates: two apicals and two intercalaries; in *Acanthogonyaulax* there are three plates in this region, all apicals.

A study of the sulcal complex of these two genera shows even less relationship between them than does a comparison of the epithelial plates. There are seven plates in the ventral area of *Acanthogonyaulax*, and only five in *Ceratocorys*. *Acanthogonyaulax* is unique in that the anterior sulcal plate is removed from the flagellar pore. In *Ceratocorys* the posterior part of the ventral area never flares out into a prominent part of the ventral aspect as it does in *Acanthogonyaulax*. This feature, on the other hand, is characteristic of *Gonyaulax*.

*Acanthogonyaulax* is more closely related to *Gonyaulax* than to *Ceratocorys*. The hypotheca has the same number of plates in the two genera, although the arrangement is somewhat different. In *Gonyaulax* the first postcingular is much smaller and the posterior intercalary is much longer and narrower than in *Acanthogonyaulax*. The antapical plate in *Gonyaulax* is more restricted.

It is more difficult to compare the epithelial and sulcal plates of *Acanthogonyaulax* with those of *Gonyaulax* than with those of *Ceratocorys* because so little critical work has been done on *Gonyaulax*. For that reason the present discussion is based on only two species of *Gonyaulax*; *G. pacifica* and *G. fusiformis*. As stated above (p. 46), the present concept of the genus *Gonyaulax* is probably too broad.

The first apical plate in *Acanthogonyaulax* does not extend to the girdle or to the ventral area; in *Gonyaulax* it extends to the girdle. The number of precingular plates is six in *Gonyaulax*, nine in *Acanthogonyaulax*. The extra three precingulars in the latter genus are the three minute ventral ones, the first, second, and third. It is possible that the first two represent the anterior part of the anterior sulcal plate of *Gonyaulax*, in which case the anterior part not only has separated from the posterior part but also has split longitudinally. The third precingular could, then, represent the lower part of the first antapical of *Gonyaulax*. There is much greater difficulty in homologizing the sulcal plates proper of these two genera, in spite of the fact that the total number of plates may be the same. The flagellar pore does not bear the same relation to the various plates in the two genera (see fig. 1). In *Acanthogonyaulax* the anterior sulcal plate is removed from the pore, whereas in *Gonyaulax* it forms its anterior edge. In *Acanthogonyaulax* the pore is bordered by four plates, two anterior, two posterior; in *Gonyaulax* it is bounded by five plates, only one of which is anterior, one is posterior, the rest lateral. The greatest resemblance in these areas seems to be that the posterior plate in each case is the largest. Their difference in shape, however, is extreme. In *Gonyaulax* it is subelliptical; in *Acanthogonyaulax*, subtriangular with two widespread limbs.

On the basis of the differences in the epithelial and sulcal plate patterns, we are forced to conclude that *Acanthogonyaulax* is only remotely related to the species of *Gonyaulax* included in this report. If further investigations show that other species, now allocated to *Gonyaulax*, are similar in pattern to *G. pacifica* and *G. fusiformis*, then we may conclude that *Acanthogonyaulax* and *Gonyaulax* not only are distinct genera but are separated by a divergent evolutionary development of considerable extent.

*Acanthogonyaulax spinifera*  
(Murray and Whitting) Graham  
(Figures 64, 65)

*Ceratocorys spinifera* Murray and Whitting, 1899, p. 329, pl. 30, fig. 6a, b, e (not fig. 6c, d).

*Gonyaulax ceratocoroides* Kofoid, 1910, p. 182. Kofoid, 1911a, pp. 202, 247. Pavillard, 1931, p. 50, pl. 2, fig. 2.

**Dimensions.** Length (h), measured in ventral view from apex to posterior end of sulcus, 63 (55-75) microns. Diameter (d) 49.5 (42-58) microns. Length of ventral spines 23 (5-31) microns, or about 5 girdle widths for the average. Girdle width 4-5 microns. Thirteen specimens were measured.

**Shape.** Strongly resembles *Ceratocorys* in general appearance because of angularity of body and prominent brushlike spines on hypotheca (figs. 64B and 65). Body, including apical horn, somewhat longer than broad. The h/d ratio is 1.27 (1.19-1.44). Body nearly circular in girdle region (fig. 64C, E) but hypotheca very angular posteriorly (fig. 64B, C). Epitheca rather low but extended as a tubular horn along its distal quarter. Besides the constriction formed by the base of this horn, there is another constriction halfway to girdle, prominent only on the right side. Thus, there are two shoulders on epitheca which are most distinct on the right side of body (fig. 64B). Hypotheca squarish in outline, sometimes with a constriction in the middle, at least on one side, usually the right (fig. 64B); truncated posteriorly. Antapex squarish and sunken in center (fig. 64B, C). A bulge occurs on hypotheca at base of each ventral spine. Girdle sinistral, displaced about 3 girdle widths, not excavated; no overhang.

Ventral area narrow anteriorly but flares out posteriorly to full width of antapex into a bilobed area. Sulcus a deep, narrow groove occupying entire anterior half of ventral area and obscured by various lists associated with it (figs. 64B, 65). Flagellar pore occurs opposite distal end of girdle; almost hidden by overhang of postcingular and right sulcal plates.

**Plate pattern.** The three apical plates are of unequal size. The first is narrow and ventral, and extends only about two-thirds of way to girdle. It bears the ventral epithecal pore. The second and third apicals, only half as long as the first, are broad and compose most of apical horn (fig. 64B, E). Apical closing platelet present. Anterior intercalary plates absent. Of the nine precingular plates, the first three are minute plates just anterior to ventral area. The other six are subequal in size and comprise the larger part of epitheca (fig. 64E). The six girdle plates subequal in size. (Girdle sutures indicated by arrows in fig. 64E.) First postcingular is a small narrow plate overhanging sulcus as in *Gonyaulax* (fig. 64A, B). The other five postcingulars large and subequal in size (fig. 64C). The posterior intercalary plate lies between left side of ventral area, the second and third postcingulars, and the antapical plate. The antapical plate is large and squarish, constituting the truncated antapex. Its four long sides border the third to fifth postcingulars and the posterior sulcal plate, but it also has two relatively short sides bordering the posterior intercalary and the sixth postcingular plates (fig. 64C).

Ventral area composed of seven plates. The posterior sulcal plate is the only large one and forms a major part of the ventral aspect of hypotheca (fig. 64A, D).

Other sulcal plates minute. The anterior sulcal plate is opposite the proximal end of girdle. It has no anterior projection into epitheca. Posterior to this plate and just anterior to flagellar pore are the right accessory and left accessory sulcal plates. Between flagellar pore and posterior sulcal plate are three plates: on the left side of left sulcal plate; on the right side, the right sulcal plate; adjacent to the pore and between the last plate and the posterior sulcal plate there is an intercalary sulcal plate (fig. 64A, D). Right sulcal plate overhangs pore in such a way that it is ventral to left sulcal plate (fig. 65).

**Thecal wall.** Surface of larger body plates covered with deep pits regularly spaced. Pores not demonstrated in these pits. Second and third precingular plates, but not the first, with pores. Girdle plates with two rows of pores. Ventral epithecal pore occurs on right edge of first apical plate.

**Lists and spines.** Lists and spines reach a high development in this species. Girdle lists are usually about 3 girdle widths wide, strengthened by heavy ribs which are connected to numerous heavy listlike cross ribs on girdle plates (figs. 64C, E, 65). Strong lists border all margins of ventral area. Right sulcal list attached to sixth postcingular plate. Left sulcal list attached to first postcingular and posterior intercalary. These two lists extend onto ventral antapical spines. Anterior (epithecal) right sulcal list attached to ninth precingular plate. It borders right margin of epithecal part of ventral area between girdle ends and extends somewhat beyond, anteriorly. Body lists well developed along all sutures of hypotheca and along all sutures of larger precingular plates. Apical plates, however, singularly free of lists (figs. 64B, E, 65). All body lists extending to girdle run out to edge of girdle lists. The body lists often strengthened by irregularly scattered ribs, usually extending out from base of list.

Long spines with "brushes" are a prominent feature of this species. These spines are formed at certain junctions of body lists. The two most prominent spines are at the ventral corners of antapical plate; two other antapical spines occur at the dorsal corners of this plate. The fifth spine is left lateral in position, being located at left corner of the posterior intercalary. The "brushes" consist of secondary thickenings running out from the primary thickening which composes the body of this spine at the list junction.

**Variation.** Size and shape of body fairly constant. The greatest variation occurs in the lists and spines. The variations may represent growth stages. Length of ventral spines, however, constant: from 20 to 31 microns except for one specimen with spines 5 microns long. Displacement of girdle varies more than in most species of Peridinales; a continuous series with displacements from 1.5 to 4 girdle widths was found.

All our specimens had five spines, although in one case one spine was double. Murray and Whitting (1899) stated that the usual number of spines is six and that they found one specimen with only two. Whether the former value should be accepted may be considered doubtful. Since the spines are developed at the junction of lists, however, a maximum number of seven seems possible. The spines may be straight or curved. Curvatures are particularly evident in Murray and Whitting's figures. Outer margins of lists may be straight or very much indented in parts between spines or between spines and girdle list.

**Historical.** Murray and Whitting (1899) described

and figured this species under the name Ceratocorys spinifera. They not only erred in the generic allocation, however, but they also confused the species with two other species of Ceratocorys (Kofoid, 1910). Kofoid (1910) realized the affinity of this species to the genus Gonyaulax and placed it in this genus in his revision of the genus Ceratocorys. No figures were given in this report. Later, Kofoid (1911a) emphasized the differences between this and the other species of Gonyaulax by placing it in a new subgenus, Acanthogonyaulax. Since the specific name spinifera was preoccupied in Gonyaulax, Kofoid proposed the new name ceratocoroides. Kofoid (1911a, p. 202) described Acanthogonyaulax as having six plates in the apical region instead of three. He probably based his judgment on the drawings of Murray and Whitting, in which the plate pattern of this region is very obscure.

On the basis of a detailed study of the skeletal anatomy of this species and of all the species of Ceratocorys as well as of two representatives of the genus Gonyaulax, Acanthogonyaulax is here raised to the rank of an independent genus, related both to Ceratocorys and to Gonyaulax but separated from these genera by wide evolutionary gaps. Since Murray and Whitting's specific name spinifera is not preoccupied in Acanthogonyaulax, it has priority and must be reinstated.

**Distribution.** Acanthogonyaulax spinifera is an extremely rare tropical species. Murray and Whitting's (1899) original material was from the Atlantic. Pavillard (1931) found this species at one station off Spain in 1905. Apparently these are the only records of its occurrence up to the present investigations.

In the Carnegie collections the species was not found in the Atlantic, but was collected at 22 stations in the Pacific. These stations are widely distributed over the tropical Pacific, grouped in the following manner: in the North Pacific, 5 stations northeast of the Hawaiian Islands, 7 stations in the North Equatorial Current north of the Marshall Islands, and 3 stations between Guam and Tokyo; in the South Pacific, 2 stations east of the Samoan Islands, and 5 stations between the Galapagos and Easter Islands (fig. 61). There are 32 records of occurrence: 30 rare and 2 occasional. The species was found about equally at the 3 levels, with 10 records for the surface, 12 for 50 meters, and 10 for 100 meters. There are 24 net records and 8 pump records.

This tropical species reached its greatest distance from the equator in the western Pacific, where it occurred almost to 35° north (station 113). In the eastern Pacific it was found only to 33° north (station 145). In the South Pacific it was not found south of 19° south. The 2 records of "occasional" were in the North Equatorial Current (stations 100 and 101).

The surface temperatures at the stations where the species occurred at any depth varied from 22.4 to 28.5 C. The ranges of hydrographic conditions in situ were as follows: temperature, 16.0 to 28.6 C; salinity, 34.1 to 36.3 o/oo; pH, 8.16 to 8.39; phosphate, 3 to 40 mg PO<sub>4</sub>/m<sup>3</sup>.

It may be concluded from the Carnegie observations that A. spinifera is a very rare but widely distributed tropical species, seldom collected because of its sparse numbers. Water of low nutrient content is no barrier to it, as 18 of the 32 records were from water with less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

#### Genus SPIRAULAX Kofoid

**Diagnosis.** Plate formula: 4ap, 1a, 6pr, 6g, 6s, 6po, 1p, 1ant. First apical does not touch girdle or anterior extension of ventral area. Posterior intercalary wide. Sulcal plates: as, ra, rs, ls, i, ps. Ventral epithecal pore absent.

**Comparisons.** Spiraulax is closely related to Gonyaulax. It has the same number of plates in all regions of the theca, but the arrangement of the plates in the two genera is significantly different. In Spiraulax there are four apicals and only one anterior intercalary. In Gonyaulax pacifica and G. fusiformis there are only three apicals, but there are two, instead of one, intercalaries. The intercalary in Spiraulax is probably homologous with a2 in Gonyaulax, whereas a1 of Gonyaulax is probably homologous with the third apical in Spiraulax. In Gonyaulax the first apical extends either entirely to the girdle or to the anterior end of the ventral area; in Spiraulax this plate lies at the anterior edge of first precingular. The apical limb of ap2 and the ventral epithecal pore found in Gonyaulax are absent in Spiraulax.

The hypothecal plate patterns are the same in the two genera, although p1 is usually narrower in Gonyaulax. The ventral area of Spiraulax is similar to that of G. fusiformis, but G. pacifica has one more sulcal plate.

Spiraulax is less closely related to Acanthogonyaulax than to Gonyaulax. Acanthogonyaulax has nine, instead of six, precingulars; it has no anterior intercalaries; the first apical does not extend to the girdle; and the ventral area is unique (see pp. 5-6).

**Remarks.** The Carnegie material is similar to that described and figured by Kofoid (1911b) from the San Diego region. Our diagnosis of the pattern of the major body plates agrees with that of Kofoid. The pattern of the ventral area has not been reported before.

Kofoid (1911b) identified his material with that of Murray and Whitting (1899) published under the name Gonyaulax jolliffei. He considered this species to be generically distinct from Gonyaulax and established the new genus Spiraulax to include the one species. In our opinion, Kofoid was justified in doing this for his own material, which is specifically the same as ours. Gonyaulax jolliffei Murray and Whitting, however, is probably more closely related to G. fusiformis n.sp. than to Spiraulax (see above). Since it is impossible to determine the plate pattern in this species without dissection, the figures given by Murray and Whitting (1899, pl. 28, fig. 1a, b) probably do not show the correct plate pattern, as these authors apparently did not dissect their specimens. The shape of the body of their species is not that of Spiraulax. Although the first apical is shown not reaching the ventral area or girdle, on the other hand, the accompaniment of this condition in Spiraulax, i.e., the intercalary touching the first precingular, is not shown. In fact, no intercalary plates are shown at all. The ventral epithecal pore and slender first apical are not shown, but these are very easily overlooked in undissected specimens. In G. fusiformis the presence of the slender first apical would never be suspected without dissection.

*Spiraulax kofoidii* new name  
(Figure 66)

*Spiraulax jolliffei* Kofoid, 1911b, pp. 296-298, pl. 19, figs. 1-5. Forti, 1922, p. 82, pl. 6, fig. 71. not *Gonyaulax jolliffei* Murray and Whitting, 1899, p. 324, pl. 28, fig. 1a, b.

**Dimensions.** Length of body (l), excluding antapical spine, 123 (101-160) microns. Diameter at girdle (d) 79 (71-105) microns. Length of antapical spine 10 (0-18) microns. Width of girdle 5 to 6 microns. Twenty-nine specimens were measured.

**Shape.** Body broadly fusiform. The l/d ratio is 1.54 (1.40-1.77). Epitheca prolonged as an apical horn extending 0.75 transdiameter from proximal end of girdle. Hypotheca also extends as a horn but is shorter than epitheca; length 0.46 transdiameter, measured from distal end of girdle. Antapical horn terminates in a stout spine about 2.5 girdle widths long; in strongly sculptured specimens sometimes so heavy that it appears as a continuation of the body proper. Kofoid's (1911b, pl. 19) specimen does not show the spine although he indicates it in his diagnosis. In ventral view (fig. 66G) epitheca usually somewhat concave on left side but with prominent hump on right side, although Kofoid's figure does not show much convexity on right side. Hypotheca has concavity on right side with hump on left side. In apical view body almost circular except for indentation at sulcus, where girdle is depressed about 2 girdle widths (fig. 66D, E). Girdle approximately equatorial, sinistral, displaced from 3 to 4 girdle widths; deep excavation obscured by heavy sculpturing; no overhang.

Ventral area elongate, slightly sigmoid, narrow in middle but expanded at both ends (fig. 66A, G). It extends into epitheca about 2.5 girdle widths. Between girdle ends it is extremely narrow but posteriorly it flares out into an elliptical flat area almost 2.5 girdle widths wide, then narrows somewhat to antapex. Flagellar pore narrow, elongate, extending from posterior margin of proximal end of girdle to anterior margin of distal end.

**Plate pattern.** First and fourth apicals ventral; comparatively small. Second and third apicals large and dorsal (fig. 66C, E, G).

Apical plates separate easily and preserved specimens are usually found with apicals parted. No apical platelet found in our material, but this may be due to its ready loss during the parting of the apicals. First apical does not extend to girdle but terminates at anterior edge of pr1. Anterior intercalary large, lying between ap4 and pr6 and part of pr5. First precingular large, extending a quarter of the way around left side of body. Other precingulars subequal in size, the third and fourth being the smallest.

The six girdle plates subequal in length except the sixth, which is much longer than the rest. Positions of sutures between girdle plates indicated by arrows in figure 66E. The six postcingulars subequal in size except the first, which is small and borders flagellar pore. Posterior intercalary is broad, lies between po1 to po3, and ant1, and borders middle third of left edge of ventral area. Antapical plate large, forming distal part of conical antapical horn. Posterior part of ventral area set into its ventral face.

Ventral area composed of six plates: a large posterior plate, a medium-sized anterior plate, and four

small intermediate plates (fig. 66A, B). Anterior plate forms anterior margin of flagellar pore and extends into epitheca almost halfway up side of anterior intercalary, where it ends in a point. It has an arm which extends posteriorly along anterior part of left edge of the pore. The rest of right edge of the pore is formed by right accessory sulcal plate; the right sulcal plate barely touches the pore. Left sulcal plate forms only posterior edge of pore. Left edge of pore formed by first postcingular plate. Intercalary sulcal plate lies between posterior and right sulcal plates. The posterior sulcal plate forms a large elliptical area on hypotheca. Most of the sulcal plates are rotated on their long axes or are distorted in the formation of the deep sulcus so that their broadest aspects are not seen in ventral view. Figure 66B shows the sulcal plates in their broadest aspects.

**Thecal wall.** All our specimens are thick-walled, but Kofoid (1911b) found thin-walled individuals. Body of thinner individuals covered with a definite reticulation with rounded meshes; but in heavier specimens, this type of differentiation gives way to a very thick wall with fairly regularly spaced pits. Kofoid states that these pits have minute pores in the bottom, but these were not detected among the *Carnegie* specimens under the oil immersion objective. Ventral epithecal pore absent. Surface sculpturing weak or lacking along plate sutures; sometimes there is here a zone of smooth thecal wall more than a girdle width wide. Ridges or lists along body sutures absent except at dorsal sutures of apical plates, where very small lists occur. Girdle plates with two rows of polygons or pits. Posterior sulcal plate reticulate or pitted. Pits and pores occur on anterior and intercalary sulcal plates. Left and right sulcal plates bear only pores; right accessory sulcal plate is entirely smooth.

The anterior part of the first apical plate is bent into a U-shaped trough with concavity facing inward (fig. 66E). In this manner the apex is formed almost entirely by the first apical alone. When a specimen is viewed ventrally, the sides of this trough appear as two dark lines, so that the area between is light by contrast. Kofoid interpreted this as a notch extending from the apex and covered by a thin membrane, and suggested its similarity to a structure in the first apical of *Peridinium*. This is, however, an optical illusion which can be dispelled by examining the separated apical plate in apical view. The structure in *Peridinium*, moreover, is quite different from this. In that genus there is a distinct linear plate, the ventral apical platelet, which lies between the apex and the anterior end of the first apical plate (see p. 16).

All sutures, including those of girdle and ventral area, formed as rabbit joints with underlapping membranes as in *Peridinium* (see p. 10). The membranes of the girdle plates do not underlap the body plates, but lie against the cingular lists, which are attached to the body plates (m, fig. 66F). Striated intercalary zones were not found.

**Lists.** Girdle lists about 1 girdle width wide; very thick in thick-walled individuals, so that it is difficult to distinguish them from body wall. In thinner individuals, lists are strengthened by regularly spaced, stout spines running out from body wall almost to edge of lists. In heavier individuals, these spines may be branched or form a reticulation. Sulcal lists well developed. Right anterior sulcal list occurs along left edge of precingular 6 and joins anterior girdle list. Left

and right posterior sulcal lists 2 girdle widths wide. They do not extend to posterior end of ventral area, but end about halfway down posterior sulcal plate (fig. 66G). Sulcal lists quite evident in lateral view (fig. 66D). Right sulcal list is attached to po6; the left is in two parts, attached posteriorly to p and anteriorly to po1. The portion of the ventral area which is free of lists (the posterior part) is limited to the region bordered by the antapical plate. Left list usually without structural differentiation, but the right has short ribs or reticulations at its base. Antapical spine thick, solid, irregularly furrowed, about 2.5 girdle widths long.

**Historical.** This species was first reported by Kofoid (1911b), who identified his material with *Gonyaulax jolliffei* Murray and Whitting (1899) and assigned it to the new genus *Spiraulax*. Since, in our opinion, Murray and Whitting's specimens do not belong to *Spiraulax* (see p. 52), we are here assigning a new name to Kofoid's species, *Spiraulax kofoidii* new name.

**Distribution.** The references of Schröder (1900) and Karsten (1907) to *Gonyaulax jolliffei* Murray and Whitting for the Mediterranean and Indian oceans, respectively, should not be accepted, since the figures of Murray and Whitting have not yet been positively identified. The records of *Spiraulax jolliffei* Kofoid of Pavillard (1931) and of Matzenauer (1933), however, probably refer to the present species. Pavillard found it in the Atlantic and Mediterranean; Matzenauer in the Indian Ocean. Forti's (1922) records for the Mediterranean are not substantiated by drawings as his drawings are copies.

In the Carnegie collections *Spiraulax kofoidii* was found at most of the tropical stations. It occurred at 80 stations: 12 in the Atlantic and 68 in the Pacific. There are 162 records of occurrence, with 119 rare, 39 occasional, and 4 common. The species was found less commonly with increase in depth, with 66 records for the surface, 51 for 50 meters, and 45 for 100 meters. There are 39 pump records and 123 net records. The species was found in both hemispheres and in all months of the year, except June and July.

The species is widely distributed over tropical and subtropical stations, although the records are not continuous. In the Atlantic it occurred in the Gulf Stream as far north as 38° north (station 1, surface temperature 24° C). Otherwise it was not found north of 24° north in that ocean (station 19, surface temperature 27° C). In the Pacific it was found only to 26° north in the west (station 110, surface temperature 24° C) but to 37° north in the east (station 130, off California, surface temperature 16.2° C). In the South Pacific it did not occur farther south than 35° south (station 62, surface temperature 19° C). It was most abundant north of Easter Island and in the line of stations east and north of the Samoan Islands.

The surface temperatures at the stations where it occurred at any depth varied from 19° to 29.3° C, except for the one record off California (station 130), where the temperature was 16.2°. The hydrographic conditions *in situ* were as follows: temperature, 13.1 to 29.2° C; salinity, 33.4 to 37.1 o/oo; pH, 7.80 to 8.47; phosphate, 2 to 178 mg PO<sub>4</sub>/m<sup>3</sup>.

The species is probably indigenous to the areas with water of low nutrient content as well as to richer tropical waters, as there are 59 records in water containing less than 10 mg PO<sub>4</sub>/m<sup>3</sup>.

#### Family CERATIACEAE Lindemann

Diagnosis. See Lindemann, 1928, p. 91.

#### Genus CERATIUM Schrank

Diagnosis. See Lindemann, 1928, p. 92.

**Remarks.** Although the genus *Ceratium* is one of the commonest and most widespread of the peridinians and is usually the first genus to be reported from expedition collections, its thecal morphology is still as poorly known as that of the rarer genera. In order to contribute something toward the knowledge of the morphology of the genus and to endeavor to find something which might throw light on the relationships of *Ceratium* to other genera, *C. pavillardii* was selected for study and subjected to a morphological analysis.

That this analysis was not so successful as in the case of the other genera is not discouraging. Sufficient knowledge was gained to indicate that such studies within this interesting genus may be quite helpful in solving some of the systematic problems and in arriving at a proper understanding of relationships.

*Ceratium arcticum* was also dissected, but in this species no trace of the ventral area had been preserved, so that only the grosser features could be determined. For this reason it is not reported here except as referred to under "Comparisons" under *C. pavillardii*.

#### *Ceratium pavillardii* Jörgensen (Figure 67)

*Ceratium pavillardii* Jörgensen, 1911a, p. 74, figs. 157A, B, 158. Jörgensen, 1920, p. 92, fig. 83.  
*Ceratium vultur* Pavillard, 1905, p. 54, pl. 1, fig. 2.  
*Ceratium tripos* var. *macroceras* f. *undulata* Schröder, 1900, pl. 1, fig. 17m [not fig. 17K, L].

**Diagnosis.** Diameter (d) 78 (60-90) microns. Apical horn more or less straight. Base of right antapical horn extends laterally from body. Base of left antapical horn bent abruptly anteriorly; sometimes there is a short posterior extension before the turn. Otherwise no posterior extension of antapicals. Antapical horns extend laterally to anteriorly.

**Plate pattern.** First apical with long margin on ventral area; fourth apical with very short margin on area.

Girdle plates four. The functional girdle probably includes only the first three of these. First and fourth girdle plates short, ventral; second and third long, dorsal. Suture g1/g2 in line with sutures pr1/pr2 and po1/po2. First and second plates regular in outline. Third plate with distal end hammer-shaped (fig. 67D, F), probably marking end of girdle proper, as girdle lists end at this point. Fourth girdle plate peculiarly modified at its distal end to form the concave roof of the horn trough (fig. 67E, G).

Fifth postcingular, which forms ventral half of right antapical horn, is molded at its proximal end to form the horn trough (fig. 67G). In chains this trough encloses anterior part of apical horn of adjacent specimen immediately posterior. It is found in all specimens, since all specimens form at least temporary chains at division.

Ventral area composed of a number of extremely

thin, hyaline plates. Most of area anterior to girdle covered by one large plate, the largest of the area (fig. 67I). This plate is bordered along most of its margin with a line of closely spaced minute tubercles. The rest of the plate is covered with fairly regularly spaced tubercles of larger size. At left side of this plate there is a long, narrow, smooth plate. Ventral area posterior to girdle composed for the most part of two smooth plates. On the right side these are shorter than the anterior plate because of the projection of the horn trough into the ventral area. The above four plates were each dissected from the others, so that their occurrence as distinct integral parts is well established. They include all the plates of the right side of the ventral area. There are other plates, however, on the left side. The number and position of these as well as the exact location of the flagellar pore or sulcus could not be determined. The plates in this region are extremely membranaceous and nothing regarding their true shape or orientation could be ascertained.

**Comparisons.** Our analysis of the ventral area of *C. pavillardii* agrees in part with that of Entz (1927) for a number of fresh-water species. Entz also found that most of the area is made up of three large plates. In his species, however, the shapes and relative sizes of these plates varied considerably in different species. It is probable, however, that the presence of these three plates is characteristic of all species of *Ceratium*, both fresh-water and marine.

In regard to the other features of the ventral area, no analysis has been completely satisfactory. Entz shows for most species two small plates at the left side of the area alongside the longitudinal furrow. The nature of this furrow or the position of the flagellar pore, however, must still be considered uncertain.

Entz's analysis of the right side of the ventral area and distal end of girdle is also unsatisfactory, so that no direct comparison can be made with our analysis of that region in *C. pavillardii*.

Our own analysis of *C. arcticum* indicates that there is probably considerable variation among the species in respect to this region, so that the condition of *C. pavillardii* cannot be considered representative of the entire genus. In *C. arcticum* the fourth girdle plate is molded into a cap for the horn trough as in *C. pavillardii*, but

the shape of the distal end of the third girdle plate is regular, not hammer-shaped. Furthermore, there is a continuation of girdle lists, or at least ridges, to the ventral area, so that the distal end of the girdle proper may be said to extend entirely to the ventral area, in marked contrast with the condition in *C. pavillardii*.

**Chain formation.** *Ceratium pavillardii* is often found in chains of several individuals. For this reason the structure of the end of the apical horn and the horn trough of the body is of particular interest. The end of the apical horn is covered by a small platelet, the apical platelet. It is pierced in the center by a large pore. In chain specimens (except in the anterior cell) this platelet, along with the ends of the apical plates, is very much thickened and convoluted, so that a knobby process is formed which holds the end of the horn fast in the socket of the top of the horn trough of the anterior specimen. This socket in the anterior specimen is formed mostly by the fourth girdle plate. Specimens not in chains have neither the knobby apical horn nor the deep socket at the end of the horn trough. Specimens in chains, with the exception of the apical cell, have much shorter apical horns. Perhaps a time factor operates here. It is suggested that, after division, if the cells separate immediately, there is a growth at the end of the apical horn which results in an increase in the length of the horn, whereas, if the specimens remain connected for a short length of time, this growth results, not in increase in the length of the horn, but in formation of a knob at the end of the horn which acts to fasten the two cells together so that by the time cell growth is completed the two cells are firmly secured to each other. Chain formation, on this basis, then, would depend on the formation of the knob during a short critical period while the mother cell undergoes division.

**Distribution.** The genus *Ceratium* is distributed over all the oceans of the world and is one of the most valuable genera of the peridinians for distributional studies. Not only are there cold- and warm-water species, but many species show minor phenotypic variations which are useful in tracing dynamic conditions.

The discussion of the distribution of all the species of *Ceratium* of the *Carnegie* collection constitutes another report. Since the distribution of *C. pavillardii* is included in that work, it is not reported here.





TABLES 3 - 23

TABLES OF DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

(For tables 1 and 2 see page 7)

Abbreviations and Numerical Equivalents used in Tables

For Relative Abundance

a (abundant) indicates over 50 individuals	oc (occasional) from 11 to 25 individuals
c (common) from 25 to 50 individuals	r (rare) from 6 to 10 individuals

For Apparatus

n = sample taken by net	p = sample taken by pump
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Values enclosed in parentheses and marked by asterisk ( )\* are interpolated



Table 3. Distributional and environmental records for *Peridinium depressum* Bailey

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
3	19	100	oc	n	5/21/28	13.65	35.89	8.10	48
6	37	100	r	n	5/31/28	11.30	35.55	8.08	40
6b	45	0	c	n	6/ 2/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
	46	0	oc	n	6/ 2/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
6e	52	0	r	n	7/ 8/28	.....	.....	.....	..
6f	53	0	r	n	7/ 9/28	.....	.....	.....	..
6g	54	0	oc	n	7/10/28	.....	.....	.....	..
7	56	0	r	n	7/13/28	8.92	35.21	8.08	34
	57	50	a	n	7/13/28	8.16	35.25	8.03	47
	58	100	a	n	7/13/28	8.12	35.24	8.04	57
10	68	0	oc	n	7/30/28	10.94	34.95	8.08	28
	69	50	oc	n	7/30/28	9.86	34.94	8.04	34
	70	100	oc	n	7/30/28	6.56	35.02	7.95	52
11	73	0	oc	n	8/ 1/28	10.67	34.91	8.06	27
	75	0	oc	p	8/ 1/28	10.67	34.91	8.06	27
11a	78	0	oc	n	8/ 2/28	(10.67)	(34.91)	(8.06)	(27) <sup>b</sup>
12	79	0	oc	n	8/ 5/28	8.44	33.65	8.10	27
	80	50	c	n	8/ 5/28	3.95	34.74	7.96	78
	81	100	c	n	8/ 5/28	3.46	34.87	7.91	95
	82	0	c	p	8/ 5/28	8.44	33.65	8.10	27
13	83	0	r	n	8/ 7/28	11.27	32.68	8.09	19
	85	50	a	n	8/ 7/28	-1.64	33.40	7.87	59
	86	100	a	n	8/ 7/28	-1.10	33.62	7.87	63
	87	0	oc	p	8/ 7/28	11.27	32.68	8.09	19
14	91	100	r	p	8/ 9/28	14.02	35.59	8.06	34
	94	100	oc	n	8/ 9/28	14.02	35.59	8.06	34
	95	50	oc	n	8/ 9/28	14.95	35.10	8.18	16
15	97	0	r	p	8/11/28	24.81	36.39	8.21	11
	101	50	r	n	8/11/28	20.00	36.48	8.21	8
	102	100	oc	n	8/11/28	18.50	36.45	8.19	15
16	107	50	r	n	8/13/28	23.64	36.41	8.23	8
	108	100	oc	n	8/13/28	19.62	36.48	8.17	13
18	118	50	r	n	8/17/28	22.12	36.82	8.24	5
19	123	50	oc	n	8/20/28	25.31	37.15	8.27	5
20	129	50	r	n	8/22/28	25.72	36.60	8.26	3
	130	100	r	n	8/22/28	22.56	36.73	8.19	5
21	137	100	r	n	8/24/28	20.93	36.75	8.20	7
22	144	100	r	n	8/27/28	17.50	36.10	7.99	123
24	153	100	r	p	8/31/28	15.6	35.6	7.96	99
	155	50	r	n	8/31/28	23.1	36.0	8.14	8
25	162	100	r	n	9/ 3/28	14.6	35.7	7.93	121
28	177	50	r	n	9/11/28	26.7	36.3	8.26	4
Pacific									
111	668	0	oc	n	6/ 3/29	20.1	34.5	8.18	5
	671	0	oc	p	6/ 3/29	20.1	34.5	8.18	5
112	675	50	r	n	6/ 5/29	21.7	34.6	8.23	7
113	680	0	oc	n	6/25/29	24.2	34.5	8.25	5
114	686	0	r	n	6/27/29	19.9	34.3	8.15	7
	688	100	r	n	6/27/29	13.0	34.5	8.00	91
	689	0	r	p	6/27/29	19.9	34.3	8.15	7
115	692	0	r	n	6/29/29	20.6	34.6	8.19	4
	693	50	r	n	6/29/29	17.5	34.6	8.12	17
	694	100	oc	n	6/29/29	15.6	34.6	8.08	27
115a	700	0	c	n	6/30/29	(18.0)	(34.3)	(8.18)	(4)*
	702	0	oc	n	6/30/29	(18.0)	(34.3)	(8.18)	(4)*
116	703	50	c	n	7/ 1/29	10.6	33.8	8.11	23
	706	50	oc	p	7/ 1/29	10.6	33.8	8.11	23
	704	100	oc	n	7/ 1/29	6.7	33.8	.....	..
	707	100	oc	p	7/ 1/29	6.7	33.8	.....	..
117	710	100	r	n	7/ 3/29	8.8	34.1	7.98	84
	713	100	r	p	7/ 3/29	8.8	34.1	7.98	84
118	714	0	oc	p	7/ 5/29	10.2	33.6	8.21	90
	716	100	r	n	7/ 5/29	6.1	33.8	7.94	114
	718	50	r	p	7/ 5/29	8.2	33.7	8.21	92
119	720	0	oc	n	7/ 7/29	6.9	33.0	7.96	142
	723	0	oc	p	7/ 7/29	6.9	33.0	7.96	142
121	732	0	oc	n	7/11/29	7.5	32.9	7.98	141
	735	0	r	p	7/11/29	7.5	32.9	7.98	141
	734	100	r	n	7/11/29	2.1	33.2	7.86	184
122	738	0	r	n	7/13/29	8.2	32.8	7.98	130
	741	0	r	p	7/13/29	8.2	32.8	7.98	130
	739	50	r	n	7/13/29	3.6	33.1	7.94	142
	743	100	r	p	7/13/29	2.4	33.1	7.90	161

<sup>a</sup> Surface values for station 6.<sup>b</sup> Surface values for station 11.

Table 4. Distributional and environmental records for *Peridinium depressum* var. *parallelum* Broch

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
6h	55	0	c	n	7/11/28	.....	.....	...	..
8	59	0	oc	n	7/15/28	10.32	35.23	7.93	13
	60	50	oc	n	7/15/28	9.08	35.25	7.95	27
9	61	100	c	n	7/15/28	8.44	35.25	7.95	54
	64	0	c	n	7/28/28	11.12	35.14	8.08	20
	65	50	oc	n	7/28/28	8.06	35.11	7.96	55
11	66	100	oc	n	7/28/28	7.62	35.11	7.98	56
	73	0	oc	n	8/ 1/28	10.67	34.91	8.06	27
	74	50	c	n	8/ 1/28	7.01	34.97	7.92	63
12	76	50	r	p	8/ 1/28	7.01	34.97	7.92	63
	82	0	oc	p	8/ 5/28	8.44	33.65	8.10	27
13	85	50	c	n	8/ 7/28	-1.64	33.40	7.87	59
	87	0	r	p	8/ 7/28	11.27	32.68	8.09	19
13a	89	0	oc	n	8/ 9/28	(21.18)	(35.23)	(8.18)	(11) <sup>a</sup>
14	94	100	oc	n	8/ 9/28	14.02	35.59	8.06	34
15	102	100	r	n	8/11/28	18.45	36.45	8.19	15
16	108	100	oc	n	8/13/28	19.62	36.48	8.17	13
18	118	50	r	n	8/17/28	22.4	36.8	8.24	5
21	134	100	r	p	8/24/28	21.0	36.8	8.20	7
	137	100	r	n	8/24/28	21.0	36.8	8.20	7
23	149	50	r	n	8/29/28	20.9	36.0	8.14	13
Pacific									
128	773	0	oc	n	7/25/29	16.4	33.0	8.12	29
130	784	0	r	p	9/ 4/29	16.2	33.4	8.34	36
	782	50	c	n	9/ 4/29	11.7	33.4	8.26	83
	785	50	c	p	9/ 4/29	11.7	33.4	8.26	83
	783	100	oc	n	9/ 4/29	8.8	33.7	8.06	176

<sup>a</sup> Surface values for station 14.Table 5. Distributional and environmental records for *Peridinium depressum* var. *convexius* n.var.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
1b	8	100	oc	n	5/16/28	(20.00)	(36.50)	(8.15)	(30)*
14	92	50	r	p	8/ 9/28	14.95	35.10	8.18	16
16	108	100	r	n	8/13/28	19.62	36.48	8.17	13
Pacific									
39	226	50	r	n	11/ 6/28	16.3	34.6	7.92	48
69	424	0	oc	n	1/12/29	21.1	35.2	8.12	62
	425	50	oc	n	1/12/29	17.4	35.1	7.99	151
	426	100	oc	n	1/12/29	14.6	34.8	7.86	198
	427	0	oc	p	1/12/29	21.1	35.2	8.12	62
	428	50	r	p	1/12/29	17.4	35.1	7.99	151
70	429	100	oc	p	1/12/29	14.6	34.8	7.86	198
	431	0	oc	n	1/13/29	21.2	35.1	8.05	103
	432	50	oc	n	1/13/29	15.4	35.0	7.88	178
	433	100	oc	n	1/13/29	12.6	34.8	7.68	233
	434	0	c	p	1/13/29	21.2	35.1	8.05	103
109	435	50	r	p	1/13/29	15.4	35.0	7.88	178
	436	100	r	p	1/13/29	17.6	34.8	7.68	233
	656	100	oc	n	5/29/29	27.4	35.0	8.23	3
110	659	100	r	p	5/29/29	27.4	35.0	8.23	3
	662	50	r	n	5/31/29	18.4	34.8	8.16	7
111	663	100	oc	n	5/31/29	17.9	34.7	8.14	11
	665	50	oc	p	5/31/29	18.4	34.8	8.16	7
	668	0	oc	n	6/ 3/29	20.1	34.5	8.18	5
112	669	50	oc	n	6/ 3/29	19.4	34.6	8.17	5
	670	100	oc	n	6/ 3/29	18.2	34.7	8.13	13
	675	50	oc	n	6/ 5/29	21.7	34.6	8.23	7
116	676	100	oc	n	6/ 5/29	19.8	34.7	8.20	8
	678	50	r	p	6/ 5/29	21.7	34.6	8.23	7
116	704	100	r	n	7/ 1/29	6.7	33.8	...	..

Table 6. Distributional and environmental records for *Peridinium claudicanoides* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
1	1	0	oc	n	5/12/28	24.17	36.23	8.16	34
1a	5	0	r	n	5/14/28	.....	.....	.....	..
2	14	0	c	n	5/18/28	20.50	36.40	8.23	58
3	19	100	r	n	5/21/28	13.79	35.91	8.10	50
32	196	100	r	n	10/ 5/28	22.2	36.4	8.10	30
Pacific									
35	204	50	r	n	10/26/28	16.8	34.7	7.92	138
35a	208	0	r	n	10/26/28	(27.0)	(30.0)	(8.25)	(15)*
35b	212	0	r	n	10/28/28	(27.0)	(30.0)	(8.25)	(15)*
40	229	0	r	n	11/ 8/28	22.2	33.7	8.21	24
	230	50	r	n	11/ 8/28	15.3	34.9	7.87	161
	231	100	r	n	11/ 8/28	13.9	35.0	7.85	159
	232	0	r	p	11/ 8/28	22.2	33.7	8.21	24
	233	50	r	p	11/ 8/28	15.3	34.9	7.87	161

Table 7. Distributional and environmental records for *Peridinium oceanicum*

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
9	64	0	c	n	7/28/28	11.12	35.14	8.08	20
	65	50	a	n	7/28/28	8.06	35.11	7.96	55
	66	100	c	n	7/28/28	7.62	35.11	7.98	56
10	68	0	oc	n	7/30/28	10.94	34.95	8.08	28
	69	50	c	n	7/30/28	9.86	34.94	8.04	34
	70	100	oc	n	7/30/28	6.56	35.02	7.95	52
11	73	0	c	n	8/ 1/28	10.67	34.91	8.06	27
	74	50	c	n	8/ 1/28	7.01	34.97	7.92	63
	75	0	oc	p	8/ 1/28	10.67	34.91	8.06	27
	76	50	r	p	8/ 1/28	7.01	34.96	7.92	63
	77	100	r	p	8/ 1/28	6.26	35.05	7.90	67
11a	78	0	r	n	8/ 2/28	(10.67)	(34.91)	(8.06)	(27) <sup>a</sup>
12	80	50	oc	n	8/ 5/28	3.95	34.74	7.96	78
15	102	100	oc	n	8/11/28	18.50	36.45	8.19	15
16	108	100	r	n	8/13/28	19.62	36.48	8.17	13
20a	131	0	r	n	8/23/28	(26.57)	(36.28)	(8.32)	(4) <sup>b</sup>
21	137	100	r	n	8/24/28	21.00	36.75	8.20	7

<sup>a</sup> Surface values for station 11.<sup>b</sup> Surface values for station 21.Table 8. Distributional and environmental records for *Peridinium oceanicum* var. *tenellum*

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
1a	4	0	r	n	5/14/28	.....	.....	.....	..
	5	0	oc	n	5/14/28	.....	.....	.....	..
1b	6	0	oc	n	5/16/28	.....	.....	.....	..
	7	50	oc	n	5/16/28	.....	.....	.....	..
	8	100	r	n	5/16/28	.....	.....	.....	..
2	14	0	oc	n	5/18/28	20.50	36.40	8.23	58
3	20	0	oc	n	5/21/28	15.50	36.06	8.15	99
	18	50	oc	n	5/21/28	14.66	35.96	8.19	30
	19	100	r	n	5/21/28	13.65	35.89	8.10	48
6	36	50	oc	n	5/31/28	11.62	35.51	8.12	32
6a	46	0	oc	n	5/31/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
6b	44	0	oc	n	6/ 2/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
	45	0	c	n	6/ 2/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
6c	49	0	r	n	6/ 4/28	(12.44)	(35.55)	(8.15)	(21) <sup>a</sup>
8	60	50	a	n	7/15/28	9.08	35.25	7.95	27
	61	100	oc	n	7/15/28	8.44	35.25	7.95	54
13a	89	0	r	n	8/ 8/28	(21.18)	(35.23)	(8.18)	(11) <sup>b</sup>
14	91	100	r	p	8/ 9/28	14.02	35.59	8.06	34
	92	50	r	p	8/ 9/28	14.95	35.10	8.18	16
	94	100	r	n	8/ 9/28	14.02	35.59	8.06	34
	95	50	c	n	8/ 9/28	14.95	35.10	8.18	16
15	99	100	r	p	8/11/28	18.45	36.45	8.19	15
16	107	50	oc	n	8/13/28	23.64	36.41	8.23	8
	108	100	r	n	8/13/28	19.62	36.48	8.17	13
31	193	100	oc	n	10/ 3/28	22.56	35.51	8.19	28

Table 8. Distributional and environmental records for *Peridinium oceanicum* var. *tenellum*--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic--Concluded									
32	195	50	r	n	10/ 5/28	27.2	36.0	8.24	2
Pacific									
40	230	50	r	n	11/ 8/28	15.3	34.9	7.87	161
	231	100	r	n	11/ 8/28	13.9	35.0	7.85	159
	232	0	oc	p	11/ 8/28	22.2	33.7	8.21	24
	235	0	r	n	11/ 8/28	22.2	33.7	8.21	24
41	236	50	r	n	11/10/28	14.6	35.0	7.94	58
	238	0	r	p	11/10/28	20.4	34.2	8.11	32
	239	100	r	p	11/10/28	14.5	35.0	7.91	152
41a	240	0	oc	n	11/12/28	(18.7)	(34.7)	(8.06)	(45) <sup>c</sup>
42	241	0	r	n	11/13/28	(18.7)	(34.7)	(8.06)	(45)
	242	50	r	n	11/13/28	17.2	34.9	7.99	68
	243	100	r	n	11/13/28	13.8	35.0	7.91	150
43	246	100	r	n	11/15/28	13.6	35.0	7.90	92
	247	0	r	p	11/15/28	19.6	34.8	8.09	52
44	253	0	r	p	11/17/28	20.7	34.9	8.03	38
45	256	0	r	n	11/19/28	22.4	35.3	8.12	38
	257	50	r	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.00	50
	259	0	oc	p	11/19/28	22.4	35.3	8.12	38
	260	50	r	p	11/19/28	22.4	35.2	8.13	46
46	261	0	oc	n	11/21/28	23.3	35.3	8.16	36
	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	263	100	r	n	11/21/28	22.5	35.4	8.17	40
	264	0	r	p	11/21/28	23.3	35.3	8.16	36
	265	50	r	p	11/21/28	23.2	35.3	8.16	40
47	266	0	r	n	11/23/28	23.9	36.0	8.23	17
	267	50	oc	n	11/23/28	23.8	36.0	8.23	20
	268	100	oc	n	11/23/28	22.7	36.2	8.23	20
	269	0	oc	p	11/23/28	23.9	36.0	8.23	17
48	273	100	oc	n	11/25/28	22.7	36.2	8.23	20
53a	310	0	r	n	12/10/28	...	...	...	...
58	346	100	r	p	12/20/28	14.3	34.4	8.10	40
61	364	50	oc	n	12/28/28	14.0	34.0	8.05	60
	365	100	r	n	12/28/28	10.8	34.0	8.03	80
62	372	50	r	n	12/30/28	16.2	34.3	8.10	28
71	438	0	oc	n	2/ 6/29	23.5	35.2	8.13	58
	439	50	oc	n	2/ 6/29	16.7	35.1	7.90	150
	440	100	r	n	2/ 6/29	13.9	35.0	7.71	220
	441	0	oc	p	2/ 6/29	23.5	35.2	8.13	58
72	445	100	r	n	2/ 6/29	13.9	35.0	7.71	220
73	450	0	oc	n	2/10/29	25.3	35.4	8.21	44
	451	50	r	n	2/10/29	18.7	35.4	8.05	122
	453	100	r	n	2/10/29	14.7	35.0	7.80	178
74	458	100	r	n	2/12/29	15.4	35.1	7.80	175
75	462	0	r	n	2/14/29	22.8	35.8	8.18	44
76	467	0	r	n	2/16/29	23.4	35.9	8.15	50
	471	50	r	p	2/16/29	22.1	35.9	8.14	42
77	472	0	oc	n	2/18/29	23.7	36.0	8.19	16
	473	0	oc	p	2/18/29	23.7	36.0	8.19	16
	474	50	oc	p	2/18/29	23.5	36.0	8.19	16
78	475	0	oc	n	2/20/29	24.6	36.0	8.17	32
	476	50	r	n	2/20/29	23.8	36.1	8.14	32
	477	100	oc	n	2/20/29	21.9	36.2	8.14	34
	478	0	r	p	2/20/29	24.6	36.0	8.17	32
79	481	0	oc	n	2/22/29	25.2	36.0	8.17	34
	482	0	oc	n	2/22/29	25.2	36.0	8.17	34
	483	100	oc	n	2/22/29	21.8	36.2	8.13	45
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
	485	50	r	p	2/22/29	24.5	36.1	8.17	34
80	486	0	oc	n	2/24/29	26.0	35.9	8.20	36
	488	0	oc	p	2/24/29	26.0	35.9	8.20	36
81	491	0	oc	n	2/26/29	26.5	35.8	8.19	38
	492	50	r	n	2/26/29	26.4	35.9	8.19	38
	493	0	r	p	2/26/29	26.5	35.8	8.19	38
	494	50	r	p	2/26/29	26.4	35.9	8.19	38
	495	100	r	p	2/26/29	23.6	36.2	8.18	36
82	497	50	oc	n	2/28/29	27.2	36.3	8.21	34
97	574	0	oc	n	4/28/29	28.3	35.2	8.16	24
	575	50	r	n	4/28/29	28.0	35.4	8.16	21
	576	100	r	n	4/28/29	27.6	35.6	8.15	25
98	581	0	r	n	4/30/29	27.0	35.3	8.16	24
	583	100	r	n	4/30/29	26.7	35.4	8.14	32

Table 8. Distributional and environmental records for *Peridinium oceanicum* var. *tenellum*--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific --Concluded									
98	584	0	r	p	4/30/29	27.0	35.3	8.16	24
	588	100	r	p	4/30/29	26.7	35.4	8.14	32
99	589	0	r	n	5/ 2/29	27.9	34.9	8.21	12
	590	50	r	n	5/ 2/29	27.8	34.9	8.22	12
	592	0	r	p	5/ 2/29	27.9	34.9	8.21	12
	594	100	r	p	5/ 2/29	27.8	35.0	8.22	17
	595	0	r	n	5/ 2/29	27.9	34.9	8.21	12
100	596	50	c	n	5/ 4/29	27.6	34.7	8.21	10
	597	100	oc	n	5/ 4/29	27.6	34.7	8.22	12
115	693	50	oc	n	6/29/29	17.5	34.6	8.12	17
	697	50	r	p	6/29/29	17.5	34.6	8.12	17
115a	700	0	r	n	6/30/29	(18.0)	(34.3)	(8.18)	(4)*
116	704	100	oc	n	7/ 1/29	6.7	33.8	...	..
117	709	50	oc	n	7/ 3/29	12.5	34.2	8.06	51
	712	50	oc	p	7/ 3/29	12.5	34.2	8.06	51
127	767	0	oc	n	7/23/29	13.4	32.7	8.12	43
	768	50	r	n	7/23/29	10.5	32.8	8.09	56
	771	50	r	p	7/23/29	10.5	32.8	8.09	56
	769	100	r	n	7/23/29	8.2	32.8	8.00	72
128	773	0	oc	n	7/25/29	16.4	33.0	8.12	29
	776	0	oc	p	7/25/29	16.4	33.0	8.12	29
	775	100	oc	n	7/25/29	10.2	33.2	8.06	46
130	783	100	r	n	9/ 4/29	8.8	33.7	8.06	176
	792	0	r	p	9/ 4/29	16.2	33.4	8.34	36
131	788	0	r	n	9/ 6/29	19.3	33.4	8.34	..
	793	0	r	p	9/ 6/29	19.3	33.4	8.34	..
151	938	50	r	n	9/ 6/29	18.3	34.4	...	..
152	945	50	r	n	10/27/29	14.2	34.5	7.87	53
	946	100	r	n	10/27/29	11.4	34.7	7.76	75
155	973	50	r	p	11/ 2/29	27.7	34.9	8.30	30
156	974	100	r	n	11/ 4/29	26.4	35.1	8.30	48
157	978	0	oc	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	r	n	11/ 6/29	27.1	35.2	8.32	60
	980	100	r	n	11/ 6/29	26.8	35.5	8.30	64
158	983	0	r	n	11/ 8/29	28.2	35.6	8.34	36
	984	50	r	n	11/ 8/29	28.2	35.6	8.39	50
	985	100	r	n	11/ 8/29	27.6	35.9	8.39	48
159	990	0	r	n	11/11/29	28.6	35.7	8.37	15
	991	50	r	n	11/11/29	28.5	35.7	8.39	15
	992	100	r	n	11/11/29	28.0	35.7	8.37	23

<sup>a</sup> Surface values for station 6.    <sup>b</sup> Surface values for station 14.    <sup>c</sup> Values of station 42.

Table 9. Distributional and environmental records for *Peridinium crassipes* Kofoid

Station	Sample	Depth	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific									
35	204	50	r	n	10/26/28	16.8	34.7	7.92	138
36	213	0	r	n	10/30/28	26.5	31.6	8.23	16
37	218	50	r	n	11/ 1/28	18.8	34.5	8.00	121
	221	50	r	p	11/ 1/28	18.8	34.5	8.00	121
40	234	100	r	p	11/ 8/28	13.9	35.0	7.85	159
41	237	100	oc	n	11/10/28	14.5	35.0	7.91	152
44	254	50	r	p	11/17/28	20.4	34.9	8.04	34
45	256	0	r	n	11/19/28	22.4	35.3	8.12	38
	257	50	r	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.00	50
48	271	0	oc	n	11/25/28	23.6	36.4	8.23	13
	272	50	r	n	11/25/28	23.6	36.4	8.24	16
	273	100	r	n	11/25/28	22.7	36.3	8.26	16
49	277	0	r	n	11/27/28	23.4	36.2	8.27	13
49a	283	0	r	n	11/28/28	(23.2)	(36.0)	(8.23)	(13)*
58	346	100	r	p	12/22/28	12.3	34.1	8.05	40
60	359	....	r	p	12/22/28	12.3	34.1	8.05	40
61	364	50	r	n	12/28/28	14.0	34.0	8.05	60
	365	100	r	n	12/28/28	10.8	34.0	8.03	80
62	372	50	r	n	12/30/28	16.2	34.3	8.10	28
	373	100	r	n	12/30/28	13.1	34.2	8.06	48
69	424	0	r	n	1/12/29	21.1	35.2	8.12	62
	425	50	oc	n	1/12/29	17.4	35.1	7.99	151
	426	100	oc	n	1/12/29	14.6	34.8	7.86	198

Table 9. Distributional and environmental records for *Peridinium crassipes* Kofoid--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n t i n u e d									
77	472	0	oc	n	2/18/29	23.7	36.0	8.19	16
78	477	100	r	n	2/20/29	21.9	36.2	8.14	34
84	506	50	r	n	3/ 4/29	27.5	36.4	8.21	24
86	517	50	r	n	3/ 9/29	27.4	36.2	8.29	17
97	574	0	oc	n	4/28/29	28.3	35.2	8.16	24
	575	50	oc	n	4/28/29	28.0	35.4	8.16	21
	576	100	oc	n	4/28/29	27.6	35.6	8.15	25
	578	50	r	p	4/28/29	28.0	35.4	8.16	21
	579	100	r	p	4/28/29	27.6	35.6	8.15	25
98	583	100	oc	n	4/30/29	26.7	35.4	8.14	32
	584	0	oc	p	4/30/29	27.0	35.3	8.16	24
99	589	0	r	n	5/ 2/29	27.9	34.9	8.21	12
	590	50	oc	n	5/ 2/29	27.8	34.9	8.22	12
	591	100	oc	n	5/ 2/29	27.8	35.0	8.22	17
	595	0	oc	n	5/ 2/29	27.9	34.9	8.21	12
100	596	50	oc	n	5/ 4/29	27.6	34.7	8.21	10
	597	100	oc	n	5/ 4/29	27.6	34.7	8.22	12
	602	100	r	p	5/ 4/29	27.6	34.7	8.22	12
101	603	0	oc	n	5/ 7/29	26.3	34.7	8.24	8
	604	50	oc	n	5/ 7/29	26.2	34.7	8.24	8
	605	100	oc	n	5/ 7/29	25.2	35.1	8.25	8
102	609	0	oc	n	5/ 9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/ 9/29	25.8	35.0	8.24	8
103	615	0	oc	n	5/11/29	26.0	35.0	8.25	5
	616	50	oc	n	5/11/29	25.8	35.2	8.25	5
	617	100	r	n	5/11/29	24.8	35.2	8.25	5
	620	100	r	p	5/11/29	24.8	35.2	8.25	5
104	621	0	oc	n	5/13/29	26.1	35.2	8.24	7
	623	100	oc	n	5/13/29	25.3	35.3	8.21	7
105	627	50	oc	n	5/15/29	26.9	34.9	8.23	5
	628	50	r	n	5/15/29	26.9	34.9	8.23	5
	629	100	oc	n	5/15/29	25.2	35.1	8.23	5
106	633	0	r	n	5/17/29	27.2	35.0	8.23	5
	634	50	oc	n	5/17/29	27.0	35.0	8.23	5
	635	100	oc	n	5/17/29	25.6	35.1	8.23	5
107	639	0	oc	n	5/19/29	28.0	34.4	8.23	5
	640	0	oc	n	5/19/29	28.0	34.4	8.23	5
	641	0	r	n	5/19/29	28.0	34.4	8.23	5
132	789	50	oc	n	9/ 8/29	17.6	33.9	8.33	19
	799	100	oc	n	9/ 8/29	14.3	33.4	8.30	16
133	805	50	r	n	9/10/29	20.8	34.7	8.37	7
134	809	50	r	n	9/12/29	19.8	34.6	8.34	6
	810	100	r	n	9/12/29	18.1	34.6	8.34	6
	817	100	r	p	9/12/29	18.1	34.6	8.34	6
135	821	50	r	n	9/14/29	21.5	35.0	8.37	5
	822	100	r	n	9/14/29	18.7	34.8	8.34	5
136	827	0	r	n	9/16/29	24.6	35.4	8.37	3
	828	50	oc	n	9/16/29	21.4	35.1	8.39	3
	829	100	oc	n	9/16/29	18.6	35.0	8.39	3
139	850	50	oc	n	9/22/29	25.8	34.9	8.31	6
140	857	50	r	n	10/ 3/29	26.9	35.0	8.39	7
	862	100	r	p	10/ 3/29	25.5	35.0	8.34	7
141	864	0	r	n	10/ 5/29	25.9	35.2	8.34	5
	865	50	oc	n	10/ 5/29	24.8	35.3	8.34	5
142	874	100	oc	n	10/ 7/29	16.6	34.4	8.27	7
149	921	50	r	n	10/21/29	23.3	35.0	8.37	6
150	929	0	oc	n	10/25/29	25.6	34.7	8.39	7
	930	50	r	n	10/25/29	22.8	34.8	8.35	10
	931	100	r	n	10/25/29	19.6	34.6	8.32	11
151	937	0	r	n	10/26/29	26.0	34.0	...	..
	938	50	r	n	10/26/29	18.3	34.4	...	..
	939	100	r	n	10/26/29	12.5	34.6	...	..
	942	50	r	p	10/26/29	18.3	34.4	...	..
	944	0	r	n	10/27/29	27.4	33.7	8.35	20
152	946	100	r	n	10/27/29	11.4	34.7	7.76	75
153	951	0	r	n	10/29/29	28.1	34.2	8.47	7
	955	0	r	p	10/29/29	28.1	34.2	8.47	7
	952	50	r	n	10/29/29	28.2	34.2	8.40	7
	953	100	r	n	10/29/29	25.3	34.8	7.93	21
154	959	50	r	n	10/31/29	28.2	34.2	8.40	7
	960	100	r	n	10/31/29	25.3	34.8	7.93	21
155	965	0	oc	n	11/ 2/29	27.8	34.9	8.29	29
	966	50	oc	n	11/ 2/29	27.7	34.9	8.30	30
	967	100	r	n	11/ 2/29	27.2	35.0	8.30	35
156	973	50	oc	n	11/ 4/29	27.0	35.1	8.37	46
	974	100	r	n	11/ 4/29	26.4	35.1	8.30	48



DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

Table 9. Distributional and environmental records for *Peridinium crassipes* Kofoid--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific --Concluded									
157	978	0	oc	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	oc	n	11/ 6/29	27.1	35.2	8.32	60
	980	100	oc	n	11/ 6/29	26.8	35.5	8.30	64
158	983	0	r	n	11/ 8/29	28.2	35.6	8.34	36
	985	100	oc	n	11/ 8/29	27.6	35.9	8.39	48
160	1002	50	r	n	11/13/29	28.6	35.6	8.39	15

Table 10. Distributional and environmental records for *Peridinium truncatum* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific									
35	203	0	oc	n	10/26/28	27.4	29.7	8.31	15
	204	50	r	n	10/26/28	16.8	34.7	7.92	138
	205	100	r	n	10/26/28	14.4	34.9	7.88	189
	206	0	oc	p	10/26/28	27.4	29.7	8.31	15
35a	208	0	oc	n	10/26/28	(27.0)	(30.0)	(8.26)	(15)*
	211	0	c	n	10/26/28	(27.0)	(30.0)	(8.26)	(15)*
	212	0	oc	n	10/26/28	(27.0)	(30.0)	(8.26)	(15)*
36	213	0	oc	n	10/30/28	26.5	31.6	8.23	16
	214	50	r	n	10/30/28	18.5	34.5	8.03	122
	215	100	r	n	10/30/28	14.4	34.9	7.85	149
37	217	0	oc	n	11/ 1/28	27.1	31.7	8.28	15
	218	50	r	n	11/ 1/28	18.8	34.5	8.00	121
	219	100	r	n	11/ 1/28	15.1	34.9	7.82	153
42	241	0	r	n	11/13/28	18.7	34.7	8.06	45
80	486	0	r	n	2/24/29	26.0	35.9	8.20	36
91	541	50	r	n	3/27/29	28.4	35.4	8.29	28
92	546	50	oc	n	3/29/29	28.4	35.4	8.29	28
95	564	100	r	n	4/24/29	28.5	35.4	8.22	21
96	569	50	r	n	4/26/29	29.2	35.3	8.23	12
97	575	50	oc	n	4/28/29	28.0	35.4	8.16	21
	578	50	r	p	4/28/29	28.0	35.4	8.16	21
99	589	0	r	n	5/ 2/29	27.9	34.9	8.21	12
	590	50	r	n	5/ 2/29	27.8	34.9	8.22	12
	592	0	r	p	5/ 2/29	27.9	34.9	8.21	12
	593	50	r	p	5/ 2/29	27.8	34.9	8.22	12
	595	0	oc	n	5/ 2/29	27.9	34.9	8.21	12
100	596	50	oc	n	5/ 4/29	27.6	34.7	8.21	10
104	623	100	r	n	5/13/29	25.3	35.3	8.21	7
105	629	100	r	n	5/15/29	25.2	35.1	8.23	5
112	675	50	r	n	6/ 5/29	21.7	34.6	8.23	7
137	837	50	r	n	9/18/29	24.4	35.1	8.34	4
141	865	50	oc	n	10/ 5/29	24.8	35.3	8.34	5
151	942	50	r	p	10/26/29	18.3	34.4	...	...
155	965	0	oc	n	11/ 2/29	27.8	34.9	8.29	29
	966	50	oc	n	11/ 2/29	27.7	34.9	8.30	30
	967	100	oc	n	11/ 2/29	27.2	35.0	8.30	35
156	972	0	oc	n	11/ 4/29	27.6	35.0	8.34	28
	973	50	oc	n	11/ 4/29	27.0	35.1	8.37	46
157	978	0	c	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	c	n	11/ 6/29	27.1	35.2	8.32	60
	980	100	r	n	11/ 6/29	26.8	35.5	8.30	64
158	984	50	r	n	11/ 8/29	28.2	35.6	8.39	50
	985	100	r	n	11/ 8/29	27.6	35.9	8.39	48
159	990	0	r	n	11/11/29	28.6	35.7	8.37	15
	991	50	r	n	11/11/29	28.5	35.7	8.39	15
	992	100	r	n	11/11/29	28.0	35.7	8.37	23

Table 11. Distributional and environmental records for *Peridinium pallidum* Ostenfeld

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
3	18	50	r	n	5/21/28	15.0	36.1	8.15	99
	20	0	oc	n	5/21/28	15.5	36.1	8.15	99
6b	45	0	r	n	6/ 2/28	10.2	35.4	8.11	28
	46	0	r	n	6/ 2/28	10.2	35.4	8.11	28

Table 11. Distributional and environmental records for *Peridinium pallidum* Ostenfeld--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic --Concluded									
6e	52	0	r	n	7/ 8/28	10.2	35.4	8.11	28
6g	54	0	r	n	7/10/28	10.2	35.4	8.11	28
6h	55	0	oc	n	7/11/28	10.2	35.4	8.11	28
7	56	0	oc	n	7/13/28	8.9	35.2	8.08	34
	57	50	oc	n	7/13/28	8.2	35.2	8.03	47
8	58	100	c	n	7/13/28	8.1	35.2	8.04	57
	60	50	oc	n	7/15/28	9.1	35.2	7.95	27
9	61	100	r	n	7/15/28	8.4	35.3	7.95	54
	64	0	oc	n	7/28/28	11.2	35.1	8.08	20
10	65	50	oc	n	7/28/28	8.4	35.1	7.96	55
	66	100	oc	n	7/28/28	7.6	35.1	7.98	56
	68	0	r	n	7/30/28	10.9	34.9	8.08	28
11a	69	50	r	n	7/30/28	10.0	34.9	8.04	39
	78	0	oc	n	8/ 2/28	9.1	34.2	8.08	27
12	79	0	r	n	8/ 5/28	8.4	33.6	8.10	27
	80	50	oc	n	8/ 5/28	3.9	34.7	7.91	95
	81	100	oc	n	8/ 5/28	3.4	34.9	7.89	82
13	82	0	oc	p	8/ 5/28	8.4	33.6	8.10	27
	85	50	c	n	8/ 7/28	-1.6	33.4	7.87	59
	86	100	oc	n	8/ 7/28	-1.2	33.6	7.87	60
14	95	50	r	n	8/ 9/28	15.0	35.1	8.18	16
16	103	0	r	p	8/13/28	25.9	36.2	8.24	8
	104	50	r	p	8/13/28	24.4	36.4	8.25	8
17	111	0	r	n	8/15/28	26.2	36.6	8.29	9
Pacific									
97	575	50	oc	n	4/28/29	28.0	35.4	8.16	21
	576	100	r	n	4/28/29	27.6	35.6	8.15	25
98	577	0	oc	p	4/28/29	28.3	35.2	8.16	24
	583	100	r	n	4/30/29	26.7	35.4	8.14	32
101	584	0	oc	p	4/30/29	27.0	35.3	8.16	24
	604	50	oc	n	5/ 7/29	26.2	34.7	8.24	8
102	605	100	oc	n	5/ 7/29	25.2	35.1	8.23	8
	609	0	oc	n	5/ 9/29	25.8	35.0	8.24	8
113	610	50	r	n	5/ 9/29	25.8	35.0	8.24	8
	611	100	oc	n	5/ 9/29	25.6	35.0	8.23	8
	612	0	r	p	5/ 9/29	25.6	35.0	8.23	8
114	682	100	oc	n	6/25/29	21.5	34.7	8.23	8
	686	0	r	n	6/27/29	19.9	34.3	8.15	7
116	688	100	r	p	6/27/29	13.0	34.5	8.00	91
	703	50	oc	n	7/ 1/29	10.6	33.8	8.11	23
117	706	50	r	p	7/ 1/29	10.6	33.8	8.11	23
	711	0	r	p	7/ 3/29	15.9	34.3	8.17	3
	709	50	oc	n	7/ 3/29	12.5	34.2	8.06	51
133	712	50	oc	p	7/ 3/29	12.5	34.2	8.06	51
	710	100	oc	n	7/ 3/29	8.8	34.1	7.98	84
	806	100	r	n	9/10/29	18.4	34.8	8.31	7
134	813	50	r	p	9/10/29	20.8	34.7	8.37	7
	808	0	r	n	9/10/29	22.7	34.7	8.47	7
135	810	100	r	n	9/12/29	18.1	34.6	8.34	6
136	821	50	oc	n	9/14/29	21.5	35.0	8.37	5
137	828	50	r	n	9/16/29	21.4	35.1	8.39	3
	833	50	r	p	9/16/29	21.4	35.1	8.39	3
	834	100	oc	p	9/16/29	18.6	35.0	8.39	3
	836	0	oc	n	9/16/29	25.5	35.0	8.39	4

Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
1	1	0	oc	n	5/12/28	24.0	36.2	8.16	34
	2	70	r	n	5/12/28	22.1	36.5	8.17	39
1a	4	0	r	4'n	5/14/28	(22.0)	(36.3)	(8.20)	(45)*
1b	7	50	c	n	5/16/28	(22.0)	(36.3)	(8.20)	(45)*
	8	100	oc	n	5/16/28	(22.0)	(36.3)	(8.20)	(45)*
2	13	100	r	n	5/18/28	19.8	36.4	8.21	33
	14	0	oc	n	5/18/28	20.5	36.4	8.23	58
15	102	100	oc	n	8/11/28	18.4	36.4	8.20	19
16	103	0	r	p	8/13/28	25.9	36.2	8.24	8
	104	50	r	p	8/13/28	24.4	36.4	8.23	8
	106	0	oc	n	8/13/28	25.9	36.2	8.24	8
	107	50	oc	n	8/13/28	24.4	36.4	8.23	8

Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic --Concluded									
	108	100	r	n	8/13/28	19.9	36.5	8.17	13
17	109	0	r	p	8/15/28	26.2	36.6	8.29	9
	110	50	r	p	8/15/28	21.9	36.6	8.28	12
	112	50	oc	n	8/15/28	21.9	36.6	8.28	12
	113	100	oc	n	8/15/28	19.3	36.5	8.23	9
19	122	0	r	n	8/20/28	26.6	37.0	8.34	5
20	128	0	oc	n	8/22/28	26.1	36.6	8.37	5
	129	50	r	n	8/22/28	25.8	36.6	8.26	3
	130	100	oc	n	8/22/28	22.6	36.7	8.19	5
21	132	0	r	p	8/25/28	26.6	36.3	8.32	4
	134	100	r	p	8/25/28	21.0	36.8	8.25	4
	135	0	oc	n	8/25/28	26.6	36.3	8.32	4
	137	100	r	n	8/25/28	21.0	36.8	8.25	4
22	139	0	r	p	8/27/28	26.7	36.0	8.26	8
	143	50	oc	n	8/27/28	24.5	36.2	8.21	9
23	145	0	r	p	8/29/28	27.2	35.9	8.25	4
	148	0	r	n	8/29/28	27.2	35.9	8.25	4
	149	50	oc	n	8/29/28	20.9	36.0	8.27	4
24	151	0	r	p	8/31/28	27.2	35.2	8.32	4
	152	50	r	p	8/31/28	23.1	36.0	8.28	4
	155	50	r	n	8/31/28	23.1	36.0	8.28	4
25	157	0	oc	p	9/ 3/28	27.5	35.6	8.31	5
	158	50	r	p	9/ 3/28	21.5	36.0	8.30	4
	161	50	oc	n	9/ 3/28	21.5	36.0	8.30	4
	162	100	r	n	9/ 3/28	14.6	35.7	8.22	12
31	191	0	r	n	10/ 3/28	28.5	34.4	8.27	2
	192	50	oc	n	10/ 3/28	28.2	35.4	8.25	2
	193	100	oc	n	10/ 3/28	23.5	36.5	8.22	2
32	194	0	c	n	10/ 5/28	28.0	36.0	8.23	2
	194a	0	oc	p	10/ 5/28	28.0	36.0	8.23	2
	195	50	c	n	10/ 5/28	27.2	35.9	8.24	2
	196	100	oc	n	10/ 5/28	22.2	36.4	8.20	4
33	197a	0	oc	p	10/ 8/28	28.5	35.6	8.23	4
	198	50	r	n	10/ 8/28	28.2	36.2	8.24	4
	198a	50	oc	p	10/ 8/28	28.2	36.2	8.24	4
34	200	0	oc	n	10/ 9/28	28.5	35.9	8.28	2
	200a	0	oc	p	10/ 9/28	28.5	35.9	8.28	2
	201	100	r	n	10/ 9/28	20.5	36.6	8.16	16
	202	50	oc	n	10/ 9/28	25.0	36.5	8.21	3
Pacific									
35	205	100	r	n	10/26/28	14.4	34.9	7.88	189
	206	0	oc	p	10/26/28	27.4	29.7	8.31	15
35a	208	0	c	n	10/26/28	(27.0)	(30.5)	(8.26)	(16)*
	209	0	c	n	10/27/28	(27.0)	(30.5)	(8.26)	(16)*
	211	0	oc	n	10/28/28	(27.0)	(30.5)	(8.26)	(16)*
	212	0	c	n	10/28/28	(27.0)	(30.5)	(8.26)	(16)*
36	213	0	oc	n	10/20/28	26.5	31.6	8.23	16
	216	0	r	p	10/20/28	26.5	31.6	8.23	16
37	217	0	oc	n	11/ 1/28	27.1	31.7	8.28	15
	218	50	oc	n	11/ 1/28	19.8	34.5	8.00	121
	219	100	oc	n	11/ 1/28	15.1	34.9	7.92	153
	220	0	oc	p	11/ 1/28	27.1	31.7	8.28	15
38	222	0	r	n	11/ 3/28	26.5	32.9	8.33	20
39	226	50	r	n	11/ 6/28	16.3	34.6	7.92	48
	227	100	r	n	11/ 6/28	14.0	35.0	7.88	181
41a	240	0	oc	n	11/12/28	(21.0)	(34.0)	(8.15)	(28)*
42	241	0	r	n	11/13/28	18.7	34.7	8.10	45
	243	100	r	n	11/13/28	13.6	35.0	7.91	150
44	250	0	r	n	11/17/28	20.7	34.9	8.03	38
45	256	0	oc	n	11/19/28	22.4	35.3	8.12	38
	257	50	oc	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.12	46
	259	0	r	p	11/19/28	22.4	35.3	8.12	38
	260	50-0	r	p	11/19/28	22.4	35.3	8.12	38
	261	0	oc	n	11/21/28	23.3	35.3	8.16	36
	262	50	oc	n	11/21/28	23.2	35.3	8.16	40
	263	100	r	n	11/21/28	22.6	35.4	8.17	40
	264	0	r	p	11/21/28	23.3	35.3	8.16	36
47	266	0	r	n	11/23/28	23.9	36.0	8.23	17
	267	50	oc	n	11/23/28	23.8	36.0	8.23	20
	268	100	r	n	11/23/28	22.7	36.2	8.23	20
	270	50	r	p	11/23/28	23.8	36.0	8.23	20
48	271	0	oc	n	11/25/28	23.6	36.4	8.23	13
	272	50	oc	n	11/25/28	23.6	36.4	8.24	16
	273	100	oc	n	11/25/28	22.7	36.3	8.26	16

Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n t i n u e d									
48	274	0	oc	p	11/25/28	23.6	36.4	8.23	13
49	277	0	oc	n	11/27/28	23.4	36.2	8.27	13
	278	50	oc	n	11/27/28	22.6	36.1	8.26	13
	279	100	oc	n	11/27/28	21.6	35.9	8.26	13
	281	50	r	p	11/27/28	22.6	36.1	8.26	13
49a	283	0	oc	n	11/28/28	(23.3)	(36.1)	(8.25)	(13)*
50	284	0	oc	n	11/29/28	23.2	36.0	8.23	13
	285	50	oc	n	11/29/28	22.0	36.0	8.23	13
	288	50	r	p	11/29/28	22.0	36.0	8.23	13
50a	290	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
	291	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
	292	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
51	293	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	294	50	oc	n	12/ 1/28	20.5	35.6	8.22	16
	295	100	oc	n	12/ 1/28	20.0	35.6	8.22	17
52	299	0	r	n	12/ 3/28	22.5	35.4	8.21	8
	300	50	oc	n	12/ 3/28	20.2	35.6	8.20	8
	301	100	oc	n	12/ 3/28	18.2	35.2	8.17	8
53	303	0	r	n	12/ 5/28	22.6	35.7	8.22	13
	304	50	oc	n	12/ 5/28	21.2	35.8	8.20	13
	305	100	c	n	12/ 5/28	19.9	35.6	8.20	13
	306	0	oc	p	12/ 5/28	22.6	35.7	8.22	13
53a	307	0	oc	n	12/ 6/28	(23.0)	(35.6)	(8.22)	(11)*
	308	0	oc	n	12/ 6/28	(23.0)	(35.6)	(8.22)	(11)*
	310	0	c	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	311	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	312	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	313	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	316	0	r	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
	317	0	oc	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
54	320	50	oc	n	12/14/28	19.8	35.4	8.18	17
	321	100	oc	n	12/14/28	18.7	35.4	8.16	20
	322	0	oc	p	12/14/28	23.4	35.5	8.22	9
55	323	0	r	n	12/16/28	20.4	34.9	8.19	12
	324	50	oc	n	12/16/28	18.7	35.0	8.18	12
	325	100	oc	n	12/16/28	16.7	34.9	7.17	12
	327	50	r	p	12/16/28	18.7	35.0	8.18	12
56	328	0	oc	n	12/18/28	20.8	34.9	8.13	9
	329	50	oc	n	12/18/28	18.5	35.1	8.14	9
	330	100	r	n	12/18/28	16.6	34.8	8.11	12
	331	0	r	p	12/18/28	20.8	34.9	8.13	9
	332	50	r	p	12/18/28	18.5	35.1	8.14	9
	333	100	r	p	12/18/28	16.6	34.8	8.11	12
56a	334	0	r	n	12/19/28	(20.0)	(34.9)	(8.13)	(15)*
57	335	0	oc	n	12/20/28	19.0	34.5	8.14	20
	336	50	oc	n	12/20/28	15.6	34.3	8.14	21
	337	100	r	n	12/20/28	14.3	34.4	8.13	25
	338	0	r	p	12/20/28	19.0	34.5	8.14	20
61a	369	0	r	n	12/28/28	(17.5)	(34.1)	(8.07)	(39)*
75	462	0	r	n	2/14/29	22.8	35.8	8.18	44
	465	0	r	p	2/14/29	22.8	35.8	8.18	44
76	467	0	c	n	2/16/29	23.4	35.9	8.15	50
	469	100	r	n	2/16/29	21.2	35.8	8.12	50
	470	0	r	p	2/16/29	23.4	35.9	8.15	50
77	472	0	oc	n	2/18/29	23.7	36.0	8.19	16
	473	0	r	p	2/18/29	23.7	36.0	8.19	16
	474	50	oc	p	2/18/29	23.5	36.0	8.19	16
78	475	0	r	n	2/20/29	24.6	36.0	8.2	32
	477	100	oc	n	2/20/29	21.9	36.2	8.1	34
	478	0	r	p	2/20/29	24.6	36.0	8.2	32
79	481	0	oc	n	2/22/29	25.2	36.0	8.17	34
	482	0	r	n	2/22/29	25.2	36.0	8.17	34
	483	100	oc	n	2/22/29	21.8	36.2	8.13	45
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
80	486	0	r	n	2/24/29	26.0	35.9	8.20	36
	487	50	r	n	2/24/29	25.9	36.0	8.19	29
	488	0	r	p	2/24/29	26.0	35.9	8.20	36
	489	50	r	p	2/24/29	25.9	36.0	8.19	29
81	491	0	oc	n	2/26/29	26.5	35.8	8.19	38
	492	50	r	n	2/26/29	26.4	35.9	8.19	38
	495	100	r	p	2/26/29	23.7	36.2	8.18	36
82	496	0	oc	n	2/28/29	27.2	36.3	8.21	34
	497	50	r	n	2/28/29	27.2	36.3	8.21	34
83	501	0	oc	n	3/ 2/29	27.5	36.3	8.24	29
	502	50	oc	n	3/ 2/29	27.5	36.5	8.24	25
	504	50	r	p	3/ 2/29	27.5	36.5	8.24	25

## DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

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Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
84	505	0	r	n	3/4/29	27.8	36.2	8.23	24
	506	50	r	n	3/4/29	27.5	36.4	8.21	24
85	510	0	r	n	3/6/29	27.9	36.2	8.22	40
	511	50	r	n	3/6/29	27.9	36.2	8.22	40
86	515	0	oc	n	3/9/29	28.2	36.2	8.29	20
	516	0	c	n	3/9/29	28.2	36.2	8.29	20
	517	50	oc	n	3/9/29	27.5	36.2	8.29	17
	518	0	r	p	3/9/29	28.2	36.2	8.29	20
87	521	0	c	n	3/11/29	27.9	36.1	8.28	17
	522	50	oc	n	3/11/29	26.5	36.1	8.26	20
	523	0	r	p	3/11/29	27.9	36.1	8.28	17
	524	50	r	p	3/11/29	26.5	36.1	8.26	20
88	526	0	oc	n	3/21/29	28.5	35.9	8.23	16
	527	50	oc	n	3/21/29	28.5	35.9	8.25	13
89	528	0	oc	n	3/23/29	28.4	35.6	8.25	21
	529	50	r	n	3/23/29	28.6	35.8	8.27	12
	530	0	r	p	3/23/29	28.4	35.6	8.25	21
	532	0	oc	n	3/23/29	28.4	35.6	8.25	21
90	533	0	c	n	3/25/29	28.5	35.5	8.27	21
	534	50	oc	n	3/25/29	28.6	35.6	8.26	21
91	540	0	oc	n	3/27/29	28.7	35.1	8.30	21
	541	50	oc	n	3/27/29	28.5	35.2	8.30	24
	542	0	r	p	3/27/29	28.7	35.1	8.30	21
	544	100	r	p	3/27/29	25.8	36.0	8.25	30
92	545	0	c	n	3/29/29	28.5	35.3	8.29	28
	546	50	oc	n	3/29/29	28.4	35.4	8.29	28
93	550	0	c	n	3/31/29	28.7	34.7	8.30	28
	551	50	oc	n	3/31/29	28.5	34.8	8.30	28
	552	0	r	p	3/31/29	28.7	34.7	8.30	28
	553	100	r	p	3/31/29	27.6	35.9	8.27	29
94	557	0	r	n	4/22/29	29.5	34.7	8.25	14
	558	50	oc	n	4/22/29	29.3	34.7	8.25	14
	559	100	r	n	4/22/29	28.5	35.6	8.21	25
95	563	50	c	n	4/25/29	29.3	34.9	8.24	16
	564	100	oc	n	4/25/29	28.5	35.4	8.22	21
	565	0	r	p	4/25/29	29.4	34.7	8.26	14
	567	100	r	p	4/25/29	28.5	35.4	8.22	21
	568a	0	r	n	4/25/29	28.5	35.4	8.26	21
96	568	0	oc	n	4/26/29	29.3	35.3	8.23	12
	569	50	oc	n	4/26/29	29.2	35.3	8.23	12
	570	100	oc	n	4/26/29	28.3	35.7	8.19	25
	572	50	r	p	4/26/29	29.2	35.3	8.23	12
97	574	0	c	n	4/28/29	28.3	35.2	8.16	24
	575	50	c	n	4/28/29	28.0	35.4	8.16	21
	576	100	r	n	4/28/29	27.6	35.6	8.15	25
	578	50	r	p	4/28/29	28.0	35.4	8.16	21
99	589	0	oc	n	5/2/29	27.9	34.9	8.21	12
	590	50	oc	n	5/2/29	27.9	34.9	8.22	12
	591	100	oc	n	5/2/29	27.8	35.0	8.22	17
	595	0	r	n	5/2/29	27.9	34.9	8.21	12
100	596	50	c	n	5/4/29	27.6	34.7	8.21	10
	597	100	r	n	5/4/29	27.6	34.7	8.22	12
	599	50	oc	p	5/4/29	27.6	34.7	8.21	10
101	603	0	c	n	5/7/29	26.3	34.7	8.24	8
	604	50	c	n	5/7/29	26.2	34.7	8.24	8
	605	100	c	n	5/7/29	25.2	35.1	8.23	8
	607	50	r	p	5/7/29	26.2	34.7	8.24	8
	608	100	r	p	5/7/29	25.2	35.1	8.23	8
102	609	0	oc	n	5/9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/9/29	25.8	35.0	8.24	8
	611	100	oc	n	5/9/29	25.6	35.0	8.23	8
103	615	0	c	n	5/11/29	26.0	35.0	8.25	5
	616	50	c	n	5/11/29	25.8	35.2	8.25	5
	617	100	oc	n	5/11/29	24.8	35.2	8.25	5
	620	100	r	p	5/11/29	24.8	35.2	8.25	5
104	621	0	c	n	5/13/29	26.1	35.2	8.24	7
	622	50	c	n	5/13/29	25.8	35.2	8.24	7
	623	100	c	n	5/13/29	25.3	35.3	8.21	7
	624	0	oc	p	5/13/29	26.1	35.2	8.24	7
105	627	50	c	n	5/15/29	26.8	34.9	8.23	5
	628	50	c	n	5/15/29	26.8	34.9	8.23	5
	629	100	c	n	5/15/29	25.2	35.1	8.23	5
	630	0	r	p	5/15/29	26.9	34.9	8.23	5
106	633	0	oc	n	5/17/29	27.2	35.0	8.23	5
	634	50	oc	n	5/17/29	27.0	35.0	8.23	5
	635	100	oc	n	5/17/29	25.6	35.1	8.23	5

Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
107	639	0	c	n	5/19/29	28.0	34.4	8.23	5
	640	50	oc	n	5/19/29	27.9	34.4	8.23	4
108	646	0	c	n	5/27/29	28.4	35.0	8.25	4
	647	50	oc	n	5/27/29	26.8	35.0	8.24	4
	648	100	c	n	5/27/29	25.2	35.0	8.23	4
Guam	652	0	r	n	May 1929				
109	654	0	c	n	5/29/29	27.4	35.0	8.23	3
	655	50	oc	n	5/29/29	23.1	35.0	8.22	3
	656	100	oc	n	5/29/29	19.4	34.8	8.18	5
	658	50	oc	p	5/29/29	23.1	35.0	8.22	3
	659	100	oc	p	5/29/29	19.4	34.8	8.18	5
	660	0	oc	p	5/29/29	27.4	35.0	8.23	3
110	661	0	oc	n	5/31/29	23.9	34.7	8.18	5
	662	50	oc	n	5/31/29	18.4	34.8	8.16	5
	663	100	r	n	5/31/29	17.9	34.7	8.14	11
111	668	0	r	n	6/ 3/29	20.1	34.5	8.18	5
	672	50	r	p	6/ 3/29	19.4	34.6	8.17	5
112	674	0	r	n	6/ 5/29	23.2	34.6	8.22	7
	675	50	r	n	6/ 5/29	21.7	34.6	8.23	7
	676	100	r	n	6/ 5/29	19.8	34.7	8.20	8
113	680	0	oc	n	6/25/29	24.2	34.5	8.25	5
	681	50	r	n	6/25/29	23.8	34.6	8.25	5
	682	100	r	n	6/25/29	21.5	34.7	8.23	8
	685	100	r	p	6/25/29	21.5	34.7	8.23	8
131	787	0	r	n	9/ 6/29	19.3	33.4	8.34	...
	789	100	r	n	9/ 6/29	12.1	33.4	8.32	...
132	797	0	oc	n	9/ 8/29	21.0	33.9	8.34	15
	798	50	oc	n	9/ 8/29	17.6	33.9	8.33	19
	799	100	oc	n	9/ 8/29	14.3	33.4	8.30	16
	802	50	r	p	9/ 8/29	17.6	33.9	8.33	19
	803	100	r	p	9/ 8/29	14.3	33.4	8.30	16
133	804	0	oc	n	9/10/29	22.7	34.7	8.47	7
	805	50	r	n	9/10/29	20.8	34.7	8.37	7
	806	100	oc	n	9/10/29	18.4	34.8	8.31	7
	813	50	r	p	9/10/29	20.8	34.7	8.37	7
	814	100	r	p	9/10/29	18.4	34.8	8.31	7
134	808	0	oc	n	9/12/29	22.9	34.7	8.34	6
	809	50	oc	n	9/12/29	19.8	34.6	8.34	6
	810	100	r	n	9/12/29	18.1	34.6	8.34	6
	815	0	r	p	9/12/29	22.9	34.7	8.34	6
	816	50	r	p	9/12/29	19.8	34.6	8.34	6
	817	100	r	p	9/12/29	18.1	34.6	8.34	6
135	820	0	r	n	9/14/29	23.8	35.1	8.37	7
	821	50	r	n	9/14/29	21.5	35.0	8.4	5
	822	100	r	n	9/14/29	18.7	34.8	8.37	5
136	827	0	oc	n	9/16/29	24.6	35.4	8.37	3
	828	50	oc	n	9/16/29	21.4	35.1	8.39	3
	829	100	oc	n	9/16/29	18.6	35.0	8.39	3
	832	0	r	p	9/16/29	24.6	35.4	8.37	3
	834	100	r	p	9/16/29	18.6	35.0	8.39	3
137	836	0	c	n	9/18/29	25.5	35.0	8.39	4
	838	100	r	n	9/18/29	21.5	35.1	8.30	5
138	843	0	oc	n	9/20/29	26.1	34.8	8.35	5
	844	50	oc	n	9/20/29	25.6	34.7	8.30	3
	847	0	r	p	9/20/29	26.1	34.8	8.35	5
139	849	0	r	n	9/22/29	26.7	34.8	8.34	6
	850	50	oc	n	9/22/29	25.8	34.9	8.31	6
	851	100	oc	n	9/22/29	22.4	35.2	8.28	6
	853	0	r	p	9/22/29	26.1	34.9	8.4	5
	854	50	r	p	9/22/29	25.8	34.9	8.3	6
140	856	0	oc	n	10/ 3/29	26.9	35.0	8.42	7
	857	50	oc	n	10/ 3/29	26.9	35.0	8.39	7
858	858	100	oc	n	10/ 3/29	25.5	35.0	8.34	7
	860	0	r	p	10/ 3/29	26.9	35.0	8.42	7
141	864	0	c	n	10/ 5/29	25.9	35.2	8.34	5
	865	50	c	n	10/ 5/29	24.8	35.3	8.34	5
	868	0	r	p	10/ 5/29	26.9	35.2	8.34	5
	869	50	r	p	10/ 5/29	24.8	35.3	8.34	5
	870	50	r	p	10/ 5/29	24.8	35.3	8.34	5
142	872	0	c	n	10/ 7/29	24.1	34.8	8.33	5
	873	50	oc	n	10/ 7/29	21.8	34.8	8.30	5
	874	100	c	n	10/ 7/29	16.6	34.4	8.27	7
	876	0	r	p	10/ 7/29	24.1	34.8	8.33	5
	877	50	r	p	10/ 7/29	21.8	34.8	8.30	5
	879	100	r	p	10/ 7/29	16.6	34.4	8.27	7
143	883	100	r	n	10/ 9/29	13.8	34.1	8.30	10

Table 12. Distributional and environmental records for *Ceratocorys horrida* Stein--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c --Concluded									
144	886	0	oc	n	10/11/29	23.3	35.0	8.37	6
145	890	0	oc	n	10/13/29	22.3	34.6	8.29	6
	891	50	oc	n	10/13/29	18.7	34.3	8.34	6
	892	100	oc	n	10/13/29	16.0	34.1	8.31	6
146	896	0	oc	n	10/15/29	22.4	34.9	8.37	6
	897	50	oc	n	10/15/29	22.4	34.9	8.30	6
	898	100	oc	n	10/15/29	19.7	34.3	8.26	7
147	904	50	r	n	10/17/29	23.1	35.3	8.29	5
	905	100	oc	n	10/17/29	19.2	35.0	8.29	5
148	910	0	oc	n	10/19/29	23.4	35.2	...	...
	912	100	r	n	10/19/29	20.0	35.0	...	...
149	920	0	oc	n	10/21/29	23.5	35.0	8.34	6
	921	50	oc	n	10/21/29	23.3	35.0	8.37	6
	922	100	oc	n	10/21/29	20.3	34.9	8.38	6
150	929	0	oc	n	10/23/29	25.6	34.7	8.39	7
	930	50	oc	n	10/23/29	22.8	34.8	8.35	10
	931	100	r	n	10/23/29	19.6	34.6	8.32	11
	936	100	r	p	10/23/29	19.6	34.6	8.32	11
151	937	0	r	n	10/25/29	26.0	34.0	...	...
	938	50	r	n	10/25/29	18.3	34.4	...	...
	939	100	r	n	10/25/29	12.5	34.6	...	...
152	944	0	r	n	10/27/29	27.4	33.7	8.35	20
	946	100	r	n	10/27/29	11.4	34.7	7.76	75
153	951	0	oc	n	10/29/29	28.1	34.2	8.47	7
	952	50	oc	n	10/29/29	28.1	34.4	8.39	7
	953	100	r	n	10/29/29	20.5	34.7	8.28	31
	955	0	r	p	10/29/29	28.1	34.2	8.47	7
154	958	0	oc	n	10/31/29	28.3	34.2	8.39	7
	959	50	oc	n	10/31/29	28.2	34.2	8.40	7
155	965	0	c	n	11/ 2/29	27.8	34.9	8.29	29
	966	50	oc	n	11/ 2/29	27.7	34.9	8.30	30
	967	100	oc	n	11/ 2/29	27.2	35.0	8.30	35
156	972	0	oc	n	11/ 4/29	27.6	35.0	8.34	28
	973	50	r	n	11/ 4/29	27.0	35.1	8.37	46
	974	100	oc	n	11/ 4/29	26.4	35.1	8.30	48
157	978	0	c	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	c	n	11/ 6/29	27.1	35.2	8.32	60
	980	100	oc	n	11/ 6/29	26.9	35.5	8.30	64
158	983	0	c	n	11/ 8/29	28.2	35.6	8.34	36
	984	50	c	n	11/ 8/29	28.2	35.6	8.39	50
	985	100	c	n	11/ 8/29	27.6	35.9	8.39	48
159	990	0	oc	n	11/11/29	28.6	35.7	8.37	15
	991	50	oc	n	11/11/29	28.5	35.7	8.39	15
	992	100	r	n	11/11/29	28.0	35.7	8.37	23
160	1000	0	r	n	11/13/29	28.6	35.6	8.37	12
	1002	50	r	n	11/13/29	28.6	35.6	8.39	15

Table 13. Distributional and environmental records for *Ceratocorys armata* (Schütt) Kofoid

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
A t l a n t i c									
2	13	100	r	n	5/18/28	19.8	36.4	8.21	33
	14	0	r	n	5/18/28	20.5	36.4	8.23	58
15	99	100	r	p	8/11/28	18.4	36.4	8.20	19
16	103	0	r	p	8/13/28	25.9	36.2	8.24	8
	104	50	r	p	8/13/28	24.4	36.4	8.23	8
	106	0	oc	n	8/13/28	25.9	36.2	8.24	8
18	114	0	r	p	8/17/28	27.0	37.0	8.23	5
	115	50	r	p	8/17/28	22.4	36.8	8.24	5
	117	0	c	n	8/17/28	27.0	37.0	8.23	5
	118	50	r	n	8/17/28	22.4	36.8	8.24	5
	119	100	oc	n	8/17/28	20.4	36.8	8.24	5
21	134	100	oc	p	8/25/28	21.0	36.8	8.25	4
	135	0	oc	n	8/25/28	26.6	36.3	8.32	4
22	139	0	r	p	8/27/28	26.7	36.0	8.26	8
	140	50	r	p	8/27/28	24.5	36.2	8.21	9
24	151	0	r	p	8/31/28	27.2	35.2	8.32	4
25	157	0	r	p	9/ 3/28	27.5	35.6	8.31	5
28	178	100	r	n	9/11/28	22.8	36.6	8.23	4
29	184	100	r	n	9/13/28	23.1	36.6	8.26	8
31	191	0	r	n	10/ 3/28	28.5	34.4	8.27	2
34	200	0	r	n	10/ 9/28	28.5	35.9	8.28	2
	200a	0	oc	p	10/ 9/28	28.5	35.9	8.28	2

Table 13. Distributional and environmental records for *Ceratocorys armata* (Schütt) Kofoid--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c									
35a	209	0	r	n	10/27/28	(27.0)	(30.0)	(8.26)	(15)*
36	213	0	r	n	10/20/28	26.5	31.6	8.23	16
	215	100	r	n	10/20/28	14.4	34.9	7.8	149
41	237	100	r	n	11/10/28	14.5	35.0	7.92	151
	238	0	r	p	11/10/28	20.4	34.2	8.11	32
	239	100	r	p	11/10/28	14.5	35.0	7.92	151
48	272	50	oc	n	11/25/28	23.6	36.4	8.24	16
	273	100	oc	n	11/25/28	22.7	36.3	8.26	16
	274	0	r	p	11/25/28	23.6	36.4	8.23	13
	275	50	r	p	11/25/28	23.6	36.4	8.24	16
49	277	0	oc	n	11/27/28	23.4	36.2	8.27	13
	279	100	oc	n	11/27/28	21.6	35.9	8.26	13
	280	0	r	p	11/27/28	23.4	36.2	8.27	13
49a	283	0	oc	n	11/28/28	(23.3)	(36.1)	(8.25)	(13)*
50	284	0	c	n	11/29/28	23.2	36.0	8.23	13
	285	50	oc	n	11/29/28	22.0	36.0	8.23	13
	286	100	oc	n	11/29/28	20.5	35.7	8.22	13
	287	0	oc	p	11/29/28	23.2	36.0	8.23	13
50a	290	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
	291	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
	292	0	oc	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
51	294	50	oc	n	12/ 1/28	20.5	35.6	8.22	16
	295	100	oc	n	12/ 1/28	20.0	35.6	8.22	17
	296	0	r	p	12/ 1/28	22.8	35.6	8.22	16
52	300	50	oc	n	12/ 3/28	20.2	35.6	8.20	8
	301	100	oc	n	12/ 3/28	18.2	35.2	8.17	8
	302	0	oc	p	12/ 3/28	22.5	35.4	8.21	8
53	304	50	c	n	12/ 5/28	21.2	35.8	8.20	13
	305	100	oc	n	12/ 5/28	19.9	35.6	8.20	13
	306	0	r	p	12/ 5/28	22.6	35.7	8.22	13
53a	308	0	r	n	12/ 6/28	(23.0)	(35.6)	(8.22)	(11)*
	310	0	c	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	311	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	312	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	313	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	316	0	r	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
	317	0	oc	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
54	320	50	r	n	12/14/28	19.8	35.4	8.18	17
	322	0	oc	p	12/14/28	23.4	35.5	8.22	9
55	323	0	r	n	12/16/28	20.4	34.9	8.19	12
	324	50	oc	n	12/16/28	18.7	35.0	8.18	12
	325	50	oc	n	12/16/28	18.7	35.0	8.18	12
56	328	0	oc	n	12/18/28	20.8	34.9	8.13	9
	329	50	oc	n	12/18/28	18.5	35.1	8.14	9
	330	100	oc	n	12/18/28	16.6	34.8	8.11	12
	331	0	oc	p	12/18/28	20.8	34.9	8.13	9
	332	50	r	p	12/18/28	18.5	35.1	8.14	9
56a	334	0	oc	n	12/19/28	(20.0)	(34.9)	(8.13)	(15)*
57	336	50	oc	n	12/20/28	15.6	34.3	8.14	21
	338	0	r	p	12/20/28	19.0	34.5	8.14	20
	339	50	r	p	12/20/28	15.6	34.3	8.14	21
	340	100	r	p	12/20/28	14.3	34.4	8.13	25
62	373	100	r	n	12/30/28	13.2	34.2	8.06	48
63	380	50	r	n	1/ 1/29	17.0	34.6	8.08	25
	382	0	r	p	1/ 1/29	20.5	34.6	8.07	21
64a	401	0	r	n	1/ 3/29	(20.4)	(34.6)	(8.11)	(22)*
78	478	0	r	p	2/20/29	24.6	36.0	8.17	32
83	503	0	r	p	3/ 2/29	27.5	36.3	8.24	29
84	506	50	r	n	3/ 4/29	27.5	36.4	8.21	24
85	510	0	r	n	3/ 6/29	28.0	36.3	8.22	40
86	515	0	r	n	3/ 9/29	28.2	36.2	8.29	20
	516	0	oc	n	3/ 9/29	28.2	36.2	8.29	20
	517	50	r	n	3/ 9/29	27.5	36.2	8.29	17
	518	0	r	p	3/ 9/29	28.2	36.2	8.29	20
87	521	0	r	n	3/11/29	27.9	36.1	8.28	17
88	526	0	oc	n	3/21/29	28.5	35.9	8.23	16
89	528	0	r	n	3/23/29	28.4	35.6	8.25	21
	532	0	r	n	3/23/29	28.4	35.6	8.25	21
90	533	0	oc	n	3/25/29	28.5	35.5	8.27	21
	534	50	oc	n	3/25/29	28.6	35.6	8.26	21
	535	0	r	p	3/25/29	28.5	35.5	8.27	21
91	540	0	oc	n	3/27/29	28.7	35.1	8.30	21
	541	50	oc	n	3/27/29	28.5	35.2	8.30	24
	542	0	r	p	3/27/29	28.7	35.1	8.30	21
92	545	0	oc	n	3/29/29	28.5	35.3	8.29	28
93	550	0	r	n	3/31/29	28.7	34.7	8.30	28
	551	50	oc	n	3/31/29	28.5	34.8	8.30	28



Table 13. Distributional and environmental records for *Ceratocorys armata* (Schütt) Kofoid--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Concluded									
95	568a	0	r	n	4/24/29	29.4	34.7	8.26	14
99	595	0	r	n	5/ 2/29	27.9	34.9	8.21	12
101	603	0	c	n	5/ 7/29	26.3	34.7	8.24	8
	604	50	c	n	5/ 7/29	26.3	34.7	8.24	8
	605	100	c	n	5/ 7/29	25.3	35.1	8.23	8
	608	100	r	p	5/ 7/29	25.3	35.1	8.23	8
102	609	0	r	n	5/ 9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/ 9/29	25.8	35.0	8.24	8
	611	100	oc	n	5/ 9/29	25.6	35.0	8.23	8
	612	0	r	p	5/ 9/29	25.8	35.0	8.24	8
	613	50	r	p	5/ 9/29	25.8	35.0	8.24	8
103	615	0	c	n	5/11/29	26.0	35.0	8.25	5
	616	50	oc	n	5/11/29	25.9	35.2	8.25	5
	617	100	r	n	5/11/29	24.8	35.2	8.25	5
	620	100	r	p	5/11/29	24.8	35.2	8.25	5
104	621	0	c	n	5/13/29	26.1	35.2	8.24	7
	622	50	oc	n	5/13/29	25.9	35.2	...	...
	623	100	oc	n	5/13/29	26.3	35.3	8.21	7
	624	0	r	p	5/13/29	26.1	35.2	8.24	7
105	627	50	c	n	5/13/29	25.9	35.2	8.24	7
	629	100	oc	n	5/13/29	26.3	35.3	8.21	7
106	633	0	oc	n	5/17/29	27.2	35.0	8.23	5
	634	50	oc	n	5/17/29	27.0	35.0	...	...
	635	100	oc	n	5/17/29	25.6	35.1	8.23	5
107	639	0	oc	n	5/19/29	28.0	34.4	8.23	5
	641	100	r	n	5/19/29	26.8	34.9	8.23	5
109	654	0	oc	n	5/29/29	27.4	35.0	8.23	3
	655	50	r	n	5/29/29	23.1	35.0	...	...
	658	50	r	p	5/29/29	23.1	35.0	...	...
	660	0	r	p	5/29/29	27.4	35.0	8.23	3
110	661	0	r	n	5/31/29	23.9	34.7	8.18	5
113	680	0	r	n	6/25/29	24.2	34.5	8.25	5
134	810	100	r	n	9/12/29	18.1	34.6	8.34	6
135	818	0	r	n	9/14/29	23.8	35.1	8.37	7
	824	0	r	p	9/14/29	23.8	35.1	8.37	7
136	827	0	r	n	9/16/29	24.6	35.4	8.37	3
	829	100	r	n	9/16/29	18.7	35.0	8.39	3
	832	0	r	p	9/16/29	24.6	35.4	8.37	3
137	836	0	r	n	9/18/29	25.5	35.0	8.39	4
	838	100	r	n	9/18/29	21.5	35.1	8.30	5
	840	0	r	p	9/18/29	25.5	35.0	8.39	4
	842	100	r	p	9/18/29	21.5	35.1	8.30	5
138	844	50	r	n	9/20/29	25.6	34.7	8.30	3
	845	100	r	n	9/20/29	22.2	34.8	8.31	3
139	850	50	r	n	9/22/29	25.8	34.9	8.31	6
141	864	0	r	n	10/ 5/29	25.9	35.2	8.34	5
	870	50	r	p	10/ 5/29	24.8	35.3	8.34	5
142	872	0	r	n	10/ 7/29	24.1	34.9	8.33	5
	873	50	r	n	10/ 7/29	21.8	34.8	8.30	5
	874	100	r	n	10/ 7/29	16.6	34.5	8.27	7
144	886	0	r	n	10/11/29	23.27	35.0	8.37	6
	887	0	r	p	10/11/29	23.27	35.0	8.37	6
145	890	0	oc	n	10/13/29	22.3	34.6	8.29	6
	891	50	oc	n	10/13/29	18.7	34.3	8.34	6
	892	100	r	n	10/13/29	16.0	34.1	8.31	6
	893	0	r	p	10/13/29	22.3	34.6	8.29	6
146	896	0	r	n	10/15/29	22.4	34.9	8.37	6
149	921	50	r	n	10/21/29	23.3	35.0	8.36	6
	922	100	r	n	10/21/29	20.3	34.9	8.36	6
	927	0	r	p	10/21/29	23.5	35.0	8.34	6
	928	50	r	n	10/21/29	23.3	35.0	8.36	6
150	930	50	oc	n	10/23/29	22.9	34.8	8.34	10
	931	100	r	n	10/23/29	19.6	34.6	8.32	11
154	959	50	r	n	10/31/29	28.2	34.2	8.40	7

Table 14. Distributional and environmental records for *Ceratocorys reticulata* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
28	177	50	r	n	Atlantic 9/11/28	26.7	36.3	8.26	4
35b	211	0	r	n	Pacific 10/28/28	(27.0)	(30.0)	(8.27)	(15)*
41	235	0	r	n	11/10/28	20.4	34.2	8.11	32
41a	240	0	r	n	11/12/28	(19.5)	(34.4)	(8.09)	(38)*
76	468	50	r	n	2/16/29	22.1	35.9	8.14	42
78	478	0	r	p	2/20/29	24.6	36.0	8.17	32
89	529	50	r	n	3/23/29	28.6	35.8	8.27	12
90	533	0	oc	n	3/25/29	28.5	35.5	8.27	21
	534	50	r	n	3/25/29	28.6	35.6	8.26	21
91	541	50	r	n	3/27/29	28.5	35.2	8.30	24
92	546	50	r	n	3/29/29	28.4	35.4	8.29	28
94	558	50	r	n	4/22/29	29.3	34.7	8.25	14
95	564	100	r	n	4/24/29	28.5	35.4	8.22	21
96	570	100	r	n	4/26/29	28.3	35.7	8.19	25
100	597	100	r	n	5/4/29	27.6	34.7	8.22	12
101	604	50	oc	n	5/7/29	26.3	34.7	8.24	8
	605	100	oc	n	5/7/29	25.3	35.1	8.23	8
	607	50	r	p	5/7/29	26.3	34.7	8.24	8
102	609	0	r	n	5/9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/9/29	25.8	35.0	8.24	8
	611	100	r	n	5/9/29	25.6	35.0	8.23	8
104	623	100	r	n	5/13/29	25.3	35.3	8.21	7
106	635	100	r	n	5/17/29	25.6	35.1	8.23	5
137	837	50	r	n	9/18/29	24.5	35.1	8.34	4
	842	100	r	p	9/18/29	21.5	35.1	8.30	5
138	844	50	r	n	9/20/29	25.6	34.7	8.30	3
139	850	50	oc	n	9/22/29	25.8	34.9	8.31	6
	851	100	r	n	9/22/29	22.4	35.2	8.28	6
140	856	0	r	n	10/3/29	26.9	35.0	8.42	7
	857	50	r	n	10/3/29	26.9	35.0	8.39	7
	858	100	r	n	10/3/29	25.5	35.2	8.34	7
141	865	50	r	n	10/5/29	24.8	35.3	8.34	5
153	952	50	r	n	10/29/29	28.1	34.4	8.39	7
	953	100	r	n	10/29/29	20.5	34.7	8.28	31
154	958	0	r	n	10/31/29	28.3	34.2	8.39	7
156	973	50	r	p	11/4/29	27.0	35.1	8.37	46
157	979	50	r	n	11/6/29	27.1	35.2	8.32	60
158	983	0	r	n	11/8/29	28.2	35.6	8.34	36
	985	100	r	n	11/8/29	27.7	35.9	8.39	48
159	991	50	r	n	11/11/29	28.5	35.7	8.38	19
160	1002	50	r	n	11/13/29	28.6	35.6	8.39	14

Table 15. Distributional and environmental records for *Ceratocorys aultii* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
57	337	100	r	n	Pacific 12/20/28	14.3	34.4	8.10	40
62	371	0	r	n	12/30/28	16.9	34.0	8.05	46
65	406	50	r	n	1/5/29	16.5	34.5	8.10	25
	408	0	r	p	1/5/29	20.2	34.5	8.10	24
	409	50	r	p	1/5/29	16.5	34.5	8.10	25
83	501	0	r	n	3/2/29	27.5	36.3	8.24	29
	503	0	r	p	3/2/29	27.5	36.3	8.24	29
92	549	100	r	p	3/29/29	26.2	36.0	8.28	28
93	551	50	r	n	3/31/29	28.5	34.8	8.30	28
94	558	50	r	n	4/22/29	29.3	34.7	8.25	14
	559	100	r	n	4/22/29	28.5	35.6	8.21	25
95	564	100	r	n	4/24/29	28.5	35.4	8.22	21
104	623	100	r	n	5/13/29	25.3	35.3	8.21	7
105	629	100	r	n	5/15/29	25.2	35.1	8.23	5
107	640	50	r	n	5/19/29	27.9	34.4	8.23	4
	642	0	r	p	5/19/29	28.0	34.4	8.23	5
132	803	100	r	p	9/8/29	14.3	33.4	8.30	16
133	814	100	r	p	9/10/29	18.4	34.8	8.31	7
136	828	50	r	n	9/16/29	21.4	35.1	8.39	3
	829	100	r	n	9/16/29	18.6	35.0	8.39	3
146	898	100	r	n	10/15/29	19.7	34.3	8.26	7

Table 16. Distributional and environmental records for *Ceratocorys bipes* (Cleve) Kofoid

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
2	14	0	r	n	5/18/28	25.7	36.4	8.23	58
Pacific									
45	257	50	r	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.12	46
	260	50-0	r	p	11/19/28				
46	261	0	r	n	11/21/28	23.3	35.3	8.16	36
	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	265	50	r	p	11/21/28	23.2	35.3	8.16	40
47	268	100	r	n	11/23/28	22.7	36.2	8.23	20
48	273	100	r	n	11/25/28	22.7	36.3	8.26	16
	276	100	r	p	11/25/28	22.7	36.3	8.26	16
52	301	100	r	n	12/ 3/28	18.2	35.2	8.17	8
53	305	100	r	n	12/ 5/28	19.9	35.6	8.20	13
56	330	100	r	n	12/18/28	16.6	34.8	8.11	12
77	474	50	oc	p	2/18/29	23.5	36.0	8.19	16
79	483	100	r	n	2/22/29	21.8	36.2	8.13	45
95	563	50	r	n	4/24/29	29.3	35	8.24	16
98	582	50	r	n	4/30/29	26.9	35.3	8.16	28
	583	100	r	n	4/30/29	26.7	35.4	8.14	32
	584	0	r	p	4/30/29	27.0	35.3	8.16	24
100	597	100	r	n	5/ 4/29	27.6	34.7	8.22	12
	602	100	r	p	5/ 4/29	27.6	34.7	8.22	12
101	605	100	r	n	5/ 7/29	25.3	35.0	8.23	8
109	656	100	oc	n	5/29/29	19.5	34.8	8.18	5
	659	100	r	p					
112	676	100	r	n	6/ 5/29	19.9	34.7	8.20	8
137	841	50	r	p	9/18/29	24.5	35.1	8.34	4
140	863	100	r	p	10/ 3/29	25.5	35.0	8.34	7
151	938	50	r	n	10/25/29	18.3	34.4	...	...
154	960	100	r	n	10/31/29	25.3	34.8	7.93	21
156	973	50	r	p	11/ 4/29	27.0	35.1	8.37	46
	974	100	r	n	11/ 4/29	26.4	35.1	8.30	48
157	979	50	r	n	11/ 6/29	27.1	35.2	8.32	60

Table 17. Distributional and environmental records for *Ceratocorys skogsbergii* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific									
49a	283	0	r	n	11/28/28	(23.2)	(36.0)	(8.23)	(13)*
50a	291	0	r	n	11/30/28	(22.8)	(35.6)	(8.22)	(16)*
53a	317	0	r	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
85	513	50	r	p	3/ 6/29	27.8	36.2	8.22	40
89	529	50	r	n	3/23/29	28.6	35.8	8.27	12
91	540	0	r	n	3/27/29	28.7	35.1	8.30	21
	542	0	r	p	3/27/29	28.7	35.1	8.30	21
100	597	100	r	n	5/ 4/29	27.6	34.7	8.22	12
102	610	50	r	n	5/ 9/29	25.8	35.0	8.24	8
113	682	100	r	n	6/25/29	21.5	34.7	8.23	8
160	1002	50	r	n	11/13/29	28.6	35.6	8.39	15

Table 18. Distributional and environmental records for *Ceratocorys gourretii* Paulsen

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
16	103	0	r	p	8/13/28	25.9	36.2	8.24	8
23	145	0	oc	p	8/29/28	27.2	35.9	8.25	4
25	157	0	oc	p	9/ 3/28	27.5	35.6	8.31	5
26	163	0	r	p	9/ 5/28	27.6	36.0	8.30	5
29	179	0	r	p	9/13/28	27.6	36.2	8.31	3
	181	100	r	p	9/13/28	23.1	36.6	8.26	8 (frag- ment)
Pacific									
45	256	0	r	n	11/19/28	22.4	35.3	8.12	38
	257	50	r	n	11/19/28	22.4	35.2	8.13	46

Table 18. Distributional and environmental records for *Ceratocorys gurrettii* Paulsen--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature - (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n c l u d e d									
	258	100	oc	n	11/19/28	18.6	35.1	8.12	46
	259	0	r	p	11/19/28	22.4	35.3	8.12	38
	260	50-0	r	p	11/19/28				
46	263	100	oc	n	11/21/28	22.6	35.4	8.17	40
	264	0	r	p	11/21/28	23.3	35.3	8.16	36
	265	50	r	p	11/21/28	23.2	35.3	8.16	40
48	274	0	r	p	11/25/28	23.6	36.4	8.23	13
49a	283	0	r	n	11/28/28	(23.3)	(36.1)	(8.25)	(13)*
50	284	0	r	n	11/29/28	23.2	36.0	8.23	13
	287	0	oc	p	11/29/28	23.2	36.0	8.23	13
	288	50	r	p	11/29/28	22.0	36.0	8.23	13
50a	290	0	r	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
	292	0	r	n	11/30/28	(23.0)	(35.8)	(8.22)	(13)*
51	295	100	r	n	12/ 1/28	20.0	35.6	8.22	17
	297	50	r	p	12/ 1/28	20.5	35.6	8.22	16
53	304	50	r	n	12/ 5/28	21.2	35.8	8.20	13
	306	0	r	p	12/ 5/28	22.6	35.7	8.22	13
53a	310	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	311	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	313	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
54	320	50	r	n	12/14/28	19.8	35.4	8.18	17
	322	0	r	p	12/14/28	23.4	35.5	8.22	9
63a	385	0	r	n	1/ 1/29	(20.6)	(34.6)	(8.10)	(21)*
	388	0	r	n	1/ 2/29	(20.6)	(34.6)	(8.10)	(21)*
	393	0	r	n	1/ 3/29	(20.6)	(34.6)	(8.10)	(21)*
64a	401	0	r	n	1/ 3/29	(20.4)	(34.6)	(8.11)	(22)*
	403	0	r	n	1/ 4/29	(20.4)	(34.6)	(8.11)	(22)*
	404	0	oc	n	1/ 4/29	(20.4)	(34.6)	(8.11)	(22)*
65	408	0	oc	p	1/ 5/29	20.2	34.5	8.10	24
79	481	0	r	n	2/22/29	25.2	36.0	8.17	34
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
82	496	0	r	n	2/28/29	27.2	36.3	8.21	34
	497	50	r	n	2/28/29	27.2	36.3	8.21	34
	498	0	r	p	2/28/29	27.2	36.3	8.21	34
86	518	0	r	p	3/ 9/29	28.2	36.2	8.29	20
91	542	0	r	p	3/27/29	28.7	35.1	8.30	21
93	550	0	r	n	3/31/29	28.7	34.7	8.30	28
	551	50	r	n	3/31/29	28.5	34.8	8.30	28
	552	0	r	p	3/31/29	28.7	34.7	8.30	28
	553	100	r	p	3/31/29	27.6	35.9	8.27	29
97	574	0	oc	n	4/28/29	28.3	35.2	8.16	24
	576	100	r	n	4/28/29	27.6	35.6	8.15	25
	577	0	r	p	4/28/29	28.3	35.2	8.16	24
100	597	100	r	n	5/ 4/29	27.6	34.7	8.22	12
101	605	100	r	n	5/ 7/29	25.3	35.0	8.23	8
103	616	50	r	n	5/11/29	25.9	35.2	8.25	5
	618	0	r	p	5/11/29	26.0	35.0	8.25	5
105	630	0	c	p	5/15/29	26.9	34.9	8.23	5
108	648	100	r	n	5/27/29	25.3	35.0	8.23	4
139	854	50	r	p	9/22/29	25.8	34.9	8.31	6
142	878	100	r	p	10/ 7/29	16.6	34.5	8.27	7
144	887	0	r	p	10/11/29	23.3	35.0	8.37	6
145	893	0	r	p	10/13/29	22.3	34.6	8.29	6
	892	0	r	n	10/13/29	22.3	34.6	8.29	6
146	901	50	r	p	10/15/29	22.4	34.9	8.37	6
149	927	0	r	p	10/21/29	23.5	35.0	8.34	6
150	929	0	r	n	10/23/29	25.6	34.7	8.39	7
	930	50	r	n	10/23/29	25.9	34.8	...	...
	931	100	r	n	10/23/29	19.6	34.7	8.32	11
151	938	50	r	n	10/25/29	18.3	34.4	...	...
	941	0	r	p	10/25/29	26.0	34.0	...	...
152	944	0	r	n	10/27/29	27.5	33.7	8.35	20
	945	50	r	n	10/27/29	14.2	34.5	7.87	53
	946	100	r	n	10/27/29	11.4	34.7	7.76	...
157	978	0	r	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	r	n	11/ 6/29	27.1	35.2	8.32	60
158	983	0	r	n	11/ 8/29	28.2	35.6	8.34	36
	985	100	r	n	11/ 8/29	27.2	35.9	8.39	48
159	992	100	r	n	11/12/29	28.0	35.8	8.37	23

## DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

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Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
1	1	0	oc	n	5/12/28	24.0	36.2	8.16	34
1b	7	50	r	n	5/16/28	(22.2)	(36.3)	(8.25)	(38)*
	8	100	oc	n	5/16/28	(20.3)	(36.5)	(8.18)	(36)*
2	14	0	r	n	5/18/28	20.5	36.4	8.23	58
3	20	0	r	n	5/21/28	15.5	36.1	8.15	99
5a	33	0	oc	n	5/30/28	(13.7)	(35.8)	(8.17)	(19)*
	34	0	r	n	5/30/28	(13.7)	(35.8)	(8.17)	(19)*
6	36	50	oc	n	5/31/28	11.6	35.6	8.12	32
	37	100	oc	n	5/31/28	11.3	35.6	8.08	41
6b	44	0	r	n	6/ 2/28	(10.6)	(35.4)	(8.12)	(28)*
	45	0	oc	n	6/ 2/28	(10.6)	(35.4)	(8.12)	(28)*
	46	0	oc	n	6/ 2/28	(10.6)	(35.4)	(8.12)	(28)*
6c	48	0	r	n	6/ 3/28	(10.6)	(35.4)	(8.12)	(28)*
13a	89	0	r	n	8/ 8/28	(16.3)	(34.0)	(8.13)	(15)*
15	97	0	oc	p	8/11/28	24.8	36.4	8.21	11
	98	50	r	p	8/11/28	19.8	36.5	8.21	8
	101	50	r	n	8/11/28	19.8	36.5	8.21	8
	102	100	r	n	8/11/28	18.4	36.4	8.20	19
16	103	0	r	p	8/13/28	25.9	36.2	8.24	8
	104	50	r	p	8/13/28	24.4	36.4	8.23	8
	107	50	r	n	8/13/28	24.4	36.4	8.23	8
	108	100	oc	n	8/13/28	19.9	36.5	8.17	13
17	110	50	r	p	8/15/28	21.9	36.6	8.28	12
	111	0	r	n	8/15/28	26.2	36.6	8.29	9
	112	50	oc	n	8/15/28	21.9	36.6	8.28	12
	113	100	r	n	8/15/28	19.3	35.5	8.23	9
18	114	0	oc	p	8/17/28	27.0	37.0	8.23	5
	115	50	r	p	8/17/28	22.4	36.8	8.24	5
	118	50	oc	n	8/17/28	22.4	36.8	8.24	5
19	121	50	r	p	8/20/28	25.2	37.1	8.27	5
	122	0	r	n	8/20/28	26.6	37.0	8.34	5
	123	50	oc	n	8/20/28	25.2	37.1	8.27	5
	124	100	r	n	8/20/28	22.4	37.0	8.25	5
20	125	0	r	p	8/22/28	26.0	36.6	8.37	5
	126	50	r	p	8/22/28	25.8	36.6	8.26	3
	127	100	r	p	8/22/28	22.6	36.7	8.19	5
	128	0	r	n	8/22/28	26.0	36.6	8.37	5
	130	100	r	n	8/22/28	22.6	36.7	8.19	5
20a	131	0	r	n	8/23/28	(26.6)	(36.3)	(8.32)	(4)*
21	135	0	oc	n	8/24/28	(26.6)	(36.3)	(8.32)	(4)*
	136	50	r	n	8/24/28	24.4	36.2	8.26	4
22	139	0	r	p	8/27/28	26.7	36.0	8.26	8
	144	100	r	n	8/27/28	17.5	36.1	7.99	123
23	145	0	r	p	8/29/28	27.2	35.9	8.25	4
	150	100	r	n	8/29/28	16.6	36.0	8.18	75
24	151	0	r	p	8/31/28	27.2	35.2	8.32	4
	155	50	r	n	8/31/28	23.1	36.0	8.14	8
25	157	0	oc	p	9/ 3/28	27.5	35.6	8.31	5
	158	50	r	p	9/13/28	21.5	36.0	8.22	12
	161	50	r	n	9/13/28	21.5	36.0	8.22	12
26	163	0	r	p	9/ 5/28	27.6	36.0	8.30	5
28	177	50	r	n	9/11/28	26.7	36.3	8.26	4
	178	100	r	n	9/11/28	22.8	36.6	8.22	7
29	183	50	r	n	9/13/28	27.2	36.2	8.29	3
	184	100	r	n	9/13/28	23.1	36.6	8.21	8
30	186	50	r	p	9/15/28	27.8	36.1	8.29	3
31	191	0	r	n	10/ 3/28	28.5	34.4	8.27	2
32	194	0	c	n	10/ 5/28	28.0	36.0	8.23	2
	194a	0	oc	p	10/ 5/28	28.0	36.0	8.23	2
	195	50	r	n	10/ 5/28	27.2	36.0	8.24	2
	196	100	oc	n	10/ 5/28	22.2	36.4	8.10	30
33	197a	0	oc	p	10/ 8/28	28.5	35.6	8.23	4
	199a	100	r	p	10/ 8/28	22.3	36.5	8.18	23
34	200	0	oc	n	10/ 9/28	28.5	35.9	8.28	2
Pacific									
35	204	50	r	n	10/26/28	16.8	34.7	7.92	138
	205	100	r	n	10/26/28	14.4	34.9	7.88	189
	206	0	oc	p	10/26/28	27.4	29.7	8.31	15
35a	208	0	oc	n	10/26/28	(27.0)	(30.7)	(8.27)	(16)*
	209	0	c	n	10/27/28	(27.0)	(30.7)	(8.27)	(16)*
35b	212	0	c	n	10/28/28	(27.0)	(30.7)	(8.27)	(16)*
36	213	0	oc	n	10/30/28	26.5	31.6	8.23	16
	214	50	r	n	10/30/28	18.5	34.5	8.03	122
	215	100	r	n	10/30/28	14.4	34.9	7.85	149
	216	0	r	p	10/30/28	26.5	31.6	8.23	16

Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n t i n u e d									
37	217	0	oc	n	11/ 1/28	27.1	31.7	8.28	15
	218	50	r	n	11/ 1/28	18.8	34.5	8.00	121
	219	100	r	n	11/ 1/28	15.1	34.9	7.82	153
	220	0	r	p	11/ 1/28	27.1	31.7	8.28	15
38	222	0	r	n	11/ 3/28	26.5	32.9	8.33	20
	223	50	r	n	11/ 3/28	21.3	34.4	8.14	35
	224	100	r	n	11/ 3/28	15.6	34.9	7.91	166
40	229	0	r	n	11/ 8/28	22.2	33.7	8.21	24
	231	100	r	n	11/ 8/28	13.9	35.0	7.85	159
	232	0	c	p	11/ 8/28	22.2	33.7	8.21	24
	233	50	r	p	11/ 8/28	15.3	34.9	7.87	161
	234	100	r	p	11/ 8/28	13.9	35.0	7.85	159
41	238	0	r	p	11/10/28	20.4	34.2	8.11	32
	239	100	r	p	11/10/28	14.5	35.0	7.91	152
41a	240	0	oc	n	11/12/28	(19.6)	(34.5)	(8.09)	(39)*
42	241	0	r	n	11/13/28	18.7	34.7	8.06	45
	242	50	r	n	11/13/28	17.2	34.9	7.99	68
	243	100	r	n	11/13/28	13.8	35.0	7.91	150
43	248	50	r	p	11/15/28	17.0	34.9	7.93	80
44	253	0	r	p	11/17/28	20.7	34.9	8.03	38
	254	50	r	p	11/17/28	20.4	34.9	8.04	34
	255	100	r	p	11/17/28	13.8	35.0	7.85	70
45	257	50	r	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.00	50
	259	0	oc	p	11/19/28	22.4	35.3	8.12	38
	260	50	r	p	11/19/28	22.4	35.2	8.13	46
46	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	263	100	r	n	11/21/28	22.5	35.4	8.17	40
	264	0	r	p	11/21/28	23.3	35.3	8.16	36
47	266	0	r	n	11/23/28	23.9	36.0	8.23	17
	267	50	r	n	11/23/28	23.8	36.0	8.23	20
	268	100	r	n	11/23/28	22.7	36.2	8.23	20
	269	0	r	p	11/23/28	23.9	36.0	8.23	17
	270	50	r	p	11/23/28	23.8	36.0	8.23	20
48	271	0	oc	n	11/25/28	23.6	36.4	8.24	16
	272	50	oc	n	11/25/28	23.6	36.4	8.24	16
	273	100	oc	n	11/25/28	22.7	36.3	8.26	16
	274	0	oc	p	11/25/28	23.6	36.4	8.23	13
	275	50	oc	p	11/25/28	23.6	36.4	8.24	16
49	277	0	oc	n	11/27/28	23.4	36.2	8.27	13
	278	50	r	n	11/27/28	22.6	36.1	8.26	13
	279	100	oc	n	11/27/28	21.6	35.9	8.26	13
	280	0	oc	p	11/27/28	23.4	36.2	8.27	13
	281	50	oc	p	11/27/28	22.6	36.1	8.26	13
	282	100	oc	p	11/27/28	21.6	35.9	8.26	13
49a	283	0	oc	n	11/28/28	(23.2)	(36.0)	(8.23)	(13)*
50	284	0	oc	n	11/29/28	(23.2)	(36.0)	(8.23)	(13)*
	285	50	oc	n	11/29/28	22.0	35.9	8.23	13
	286	100	oc	n	11/29/28	20.5	35.7	8.22	13
	287	0	oc	p	11/29/28	23.2	36.0	8.23	13
	288	50	r	p	11/29/28	22.0	35.9	8.23	13
	289	100	oc	p	11/29/28	20.5	35.7	8.22	13
51	290	0	c	n	12/ 1/28	22.8	35.6	8.22	16
	291	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	292	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	294	50	oc	n	12/ 1/28	20.5	35.6	8.22	17
	295	100	oc	n	12/ 1/28	20.0	35.6	8.22	17
	296	0	r	p	12/ 1/28	22.8	35.6	8.22	16
	297	50	r	p	12/ 1/28	20.5	35.6	8.22	17
	298	100	r	p	12/ 1/28	20.0	35.6	8.22	17
52	300	50	r	n	12/ 3/28	20.2	35.6	8.20	8
	301	100	oc	n	12/ 3/28	18.2	35.2	8.17	8
	302	0	oc	p	12/ 3/28	22.5	35.4	8.21	8
53	304	50	c	n	12/ 5/28	21.2	35.8	8.20	13
	305	100	oc	n	12/ 5/28	19.9	35.6	8.19	13
	306	0	oc	p	12/ 5/28	22.6	35.7	8.22	13
53a	307	0	r	n	12/ 6/28	(23.0)	(35.6)	(8.22)	(11)*
	308	0	oc	n	12/ 6/28	(23.0)	(35.6)	(8.22)	(11)*
	310	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	311	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	312	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	313	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	316	0	r	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
53b	317	0	oc	n	12/12/28	(23.0)	(35.6)	(8.22)	(11)*
54	320	50	oc	n	12/14/28	19.8	35.4	8.18	17
	321	100	oc	n	12/14/28	18.7	35.4	8.16	20

## DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

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Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
54	322	0	oc	p	12/14/28	23.4	35.5	8.22	9
55	324	50	oc	n	12/16/28	18.7	35.0	8.18	12
	325	100	r	n	12/16/28	16.7	34.9	7.17	12
56	328	0	oc	n	12/18/28	20.8	34.9	8.13	9
	329	50	r	n	12/18/28	18.5	35.1	8.14	9
	330	100	r	n	12/18/28	16.6	34.8	8.11	12
	331	0	r	p	12/18/28	20.8	34.9	8.13	9
	332	50	oc	p	12/18/28	18.5	35.1	8.14	9
	333	100	r	p	12/18/28	16.6	34.8	8.11	12
57	334	0	oc	n	12/20/28	19.0	34.5	8.14	20
	335	0	r	n	12/20/28	19.0	34.5	8.14	20
	336	50	r	n	12/20/28	15.6	34.3	8.14	21
	338	0	r	p	12/20/28	19.0	34.5	8.14	20
60	361	0	r	n	12/26/28	15.0	34.0	8.07	50
61a	369	0	r	n	12/23/28	(18.1)	(34.1)	(8.09)	(39)*
62	373	100	r	n	12/30/28	13.1	34.2	8.06	48
	374	0	r	p	12/30/28	19.2	34.2	8.12	32
	376	100	r	p	12/30/28	13.1	34.2	8.06	48
63	377	0	r	n	12/31/28	20.5	34.6	8.07	21
	378	0	r	n	12/31/28	20.5	34.6	8.07	21
	379	0	r	n	1/ 1/29	20.5	34.6	8.07	21
	380	50	r	n	1/ 1/29	17.0	34.6	8.08	25
	381	100	r	n	1/ 1/29	15.6	34.6	8.08	24
	382	0	r	p	1/ 1/29	20.5	34.6	8.07	21
	385	0	r	n	1/ 1/29	20.5	34.6	8.07	21
	386	0	oc	n	1/ 1/29	20.5	34.6	8.07	21
	389	0	r	n	1/ 2/29	20.5	34.6	8.07	21
	391	0	r	n	1/ 3/29	20.5	34.6	8.07	21
	392	0	r	n	1/ 3/29	20.5	34.6	8.07	21
	393	0	r	n	1/ 3/29	20.5	34.6	8.07	21
64	394	0	r	n	1/ 3/29	20.6	34.6	8.12	21
	398	0	r	p	1/ 3/29	20.6	34.6	8.12	21
	400	100	r	p	1/ 3/29	15.8	34.5	8.10	32
	402	0	r	n	1/ 4/29	20.6	34.6	8.12	21
	403	0	r	n	1/ 4/29	20.6	34.6	8.12	21
	404	0	r	n	1/ 4/29	20.6	34.6	8.12	21
65	405	0	r	n	1/ 5/29	20.2	34.5	8.10	24
	406	50	r	n	1/ 5/29	16.5	34.5	8.10	25
	408	0	r	p	1/ 5/29	20.2	34.5	8.10	24
	409	50	r	p	1/ 5/29	16.5	34.5	8.10	25
66	412	100	r	n	1/ 7/29	17.8	34.9	8.12	21
	413	0	r	p	1/ 7/29	19.4	34.7	8.10	29
	415	100	r	p	1/ 7/29	17.8	34.9	8.12	21
67	416	0	oc	n	1/ 8/29	19.3	34.9	8.11	21
	417	50	r	n	1/ 8/29	17.4	34.7	8.11	20
	418	100	oc	n	1/ 8/29	16.2	34.6	8.05	40
68	422	0	r	p	1/10/29	19.2	35.1	8.14	29
	423	50	r	p	1/10/29	18.2	35.0	8.14	29
69	424	0	oc	n	1/12/29	21.1	35.2	8.12	62
	425	50	oc	n	1/12/29	17.4	35.1	7.99	151
	426	100	oc	n	1/12/29	14.6	34.8	7.86	198
	427	0	oc	p	1/12/29	12.1	35.2	8.12	62
	428	50	oc	p	1/12/29	17.4	35.1	7.99	151
	429	100	r	p	1/12/29	14.6	34.8	7.86	198
70	434	0	oc	p	1/13/29	21.2	35.1	8.05	103
71	438	0	oc	n	2/ 6/29	23.5	35.2	8.13	58
	439	50	r	n	2/ 6/29	16.7	35.1	7.90	150
	440	100	r	n	2/ 6/29	13.9	35.0	7.71	220
	441	0	oc	p	2/ 6/29	23.5	35.2	8.13	58
72	446	0	r	p	2/ 8/29	24.9	35.3	8.16	50
	447	50	oc	p	2/ 8/29	18.7	35.4	8.12	60
73	449	0	oc	n	2/10/29	25.3	35.4	8.21	44
	451	50	r	n	2/10/29	18.7	35.4	8.05	122
	452	100	oc	n	2/10/29	14.7	35.0	7.80	178
	453	0	r	p	2/10/29	25.3	35.4	8.21	44
	455	100	r	p	2/10/29	14.7	35.0	7.80	178
74	459	0	r	p	2/12/29	24.2	35.6	8.17	68
75	462	0	oc	n	2/14/29	22.8	35.8	8.18	44
	465	0	r	p	2/14/29	22.8	35.8	8.18	44
76	467	0	oc	n	2/16/29	23.4	35.9	8.15	50
	470	0	r	p	2/16/29	23.4	35.9	8.15	50
77	473	0	r	p	2/18/29	23.7	36.0	8.19	16
	474	50	oc	p	2/18/29	23.5	36.0	8.19	16
78	475	0	r	n	2/20/29	24.6	36.0	8.17	32
	477	100	oc	n	2/20/29	21.9	36.2	8.14	34
79	481	0	r	n	2/22/29	25.2	36.0	8.17	34

Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
79	483	100	oc	n	2/22/29	21.8	36.2	8.13	45
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
	485	50	r	p	2/22/29	24.5	36.1	8.17	34
80	486	0	r	n	2/24/29	26.0	35.9	8.20	36
	487	50	r	n	2/24/29	25.9	36.0	8.19	29
	488	0	oc	p	2/24/29	26.0	35.9	8.20	36
	489	50	r	p	2/24/29	25.9	36.0	8.19	29
81	491	0	oc	n	2/26/29	26.5	35.8	8.19	38
	492	50	r	n	2/26/29	26.4	35.9	8.19	38
	493	0	r	p	2/26/29	26.5	35.8	8.19	38
	494	50	r	p	2/26/29	26.4	35.9	8.19	38
82	497	50	r	n	2/28/29	27.2	36.3	8.21	34
	498	0	r	p	2/28/29	27.2	36.3	8.21	34
83	501	0	oc	n	3/ 2/29	27.5	36.3	8.24	29
	502	50	oc	n	3/ 2/29	27.4	36.5	8.24	25
	503	0	r	p	3/ 2/29	27.5	36.3	8.24	29
84	505	0	r	n	3/ 4/29	27.8	36.2	8.23	24
	506	50	r	n	3/ 4/29	27.5	36.4	8.21	24
	507	0	r	p	3/ 4/29	27.8	36.2	8.23	24
85	510	0	r	n	3/ 6/29	27.9	36.2	8.22	40
	511	50	r	n	3/ 6/29	27.8	36.2	8.22	40
	512	0	r	p	3/ 6/29	27.9	36.2	8.22	40
	513	50	r	p	3/ 6/29	27.8	36.2	8.22	40
86	515	0	oc	n	3/ 9/29	28.3	36.2	8.29	20
	516	0	oc	n	3/ 9/29	28.3	36.2	8.29	20
	518	0	oc	p	3/ 9/29	28.3	36.2	8.29	20
	519	50	r	p	3/ 9/29	27.4	36.2	8.29	17
87	521	0	r	n	3/11/29	27.8	36.1	8.28	17
	522	50	r	n	3/11/29	26.5	36.1	8.26	20
	523	0	r	p	3/11/29	27.8	36.1	8.28	17
	524	50	oc	p	3/11/29	26.5	36.1	8.26	20
88	526	0	oc	n	3/21/29	28.5	35.9	8.23	16
	527	50	r	n	3/21/29	28.4	35.9	8.25	13
89	528	0	r	n	3/23/29	28.4	35.6	8.25	21
	529	50	r	n	3/23/29	28.6	35.8	8.27	12
	530	0	oc	p	3/23/29	28.4	35.6	8.25	21
	531	100	r	p	3/23/29	26.4	36.0	8.24	12
	532	0	r	n	3/23/29	28.4	35.6	8.25	21
90	533	0	oc	n	3/25/29	28.5	35.5	8.27	21
	534	50	oc	n	3/25/29	28.6	35.6	8.26	21
	535	0	oc	p	3/25/29	28.5	35.5	8.27	21
	536	50	r	p	3/25/29	28.6	35.6	8.26	21
91	540	0	oc	n	3/27/29	28.7	35.1	8.30	21
	541	50	oc	n	3/27/29	28.5	35.2	8.30	24
	542	0	r	p	3/27/29	28.7	35.1	8.30	21
	543	50	r	p	3/27/29	28.5	35.2	8.30	24
	544	100	r	p	3/27/29	25.8	36.0	8.25	30
92	545	0	oc	n	3/29/29	28.5	35.3	8.29	28
93	550	0	c	n	3/31/29	28.7	34.7	8.30	28
	551	50	oc	n	3/31/29	28.5	34.8	8.30	28
	552	0	oc	p	3/31/29	28.7	34.7	8.30	28
94	557	0	r	n	4/22/29	29.5	34.7	8.25	14
	559	100	r	n	4/22/29	28.5	35.6	8.21	25
	562	100	r	p	4/22/29	28.5	35.6	8.21	25
95	563	50	oc	n	4/24/29	29.3	34.9	8.24	16
	564	100	oc	n	4/24/29	28.5	35.4	8.22	21
	565	0	r	p	4/24/29	29.4	34.7	8.26	14
	566	50	r	p	4/24/29	29.3	34.9	8.24	16
	567	100	r	p	4/24/29	28.5	35.4	8.22	21
	568a	0	r	n	4/24/29	29.4	34.7	8.26	14
96	568	0	oc	n	4/26/29	29.3	35.3	8.23	12
	569	50	oc	n	4/26/29	29.2	35.3	8.23	12
	570	100	oc	n	4/26/29	28.2	35.7	8.19	25
97	574	0	c	n	4/28/29	28.3	35.2	8.16	24
	575	50	oc	n	4/28/29	28.0	35.4	8.16	21
	577	0	r	p	4/28/29	28.3	35.2	8.16	24
98	584	0	oc	p	4/30/29	27.0	35.3	8.16	24
	588	100	oc	p	4/30/29	26.7	35.4	8.14	32
99	589	0	oc	n	5/ 2/29	27.9	34.9	8.21	12
	590	50	oc	n	5/ 2/29	27.8	34.9	8.22	12
	591	100	oc	n	5/ 2/29	27.8	35.0	8.22	17
	592	0	oc	p	5/ 2/29	27.9	34.9	8.21	12
	594	100	r	p	5/ 2/29	27.8	35.0	8.22	17
	595	0	r	n	5/ 2/29	27.9	34.9	8.21	12
100	596	50	oc	n	5/ 4/29	27.6	34.7	8.21	10
	597	100	oc	n	5/ 4/29	27.6	34.7	8.22	12



Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
100	598	0	c	p	5/4/29	27.7	34.7	8.21	10
	599	50	oc	p	5/4/29	27.6	34.7	8.21	10
	602	100	oc	p	5/4/29	27.6	34.7	8.22	12
101	603	0	c	n	5/7/29	26.3	34.7	8.24	8
	604	50	c	n	5/7/29	26.2	34.7	8.24	8
	606	0	r	p	5/7/29	26.3	34.7	8.24	8
102	609	0	oc	n	5/9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/9/29	25.8	35.0	8.24	8
	611	100	oc	n	5/9/29	25.6	35.0	8.23	8
	612	0	oc	p	5/9/29	25.8	35.0	8.24	8
	613	50	r	p	5/9/29	25.8	35.0	8.24	8
103	615	0	oc	n	5/11/29	26.0	35.0	8.25	5
	616	50	oc	n	5/11/29	25.8	35.2	8.25	5
	617	100	oc	n	5/11/29	24.8	35.2	8.25	5
	618	0	r	p	5/11/29	26.0	35.0	8.25	5
	619	50	r	p	5/11/29	25.8	35.2	8.25	5
104	621	0	oc	n	5/13/29	26.1	35.2	8.24	7
	622	50	oc	n	5/13/29	25.8	35.2	8.24	7
	624	0	oc	p	5/13/29	26.1	35.2	8.24	7
	625	50	oc	p	5/13/29	25.8	35.2	8.24	7
105	627	50	c	n	5/15/29	26.8	34.9	8.23	5
	628	50	r	n	5/15/29	26.8	34.9	8.23	5
	629	100	oc	n	5/15/29	25.2	35.1	8.23	5
	630	0	oc	p	5/15/29	26.9	34.9	8.23	5
	631	50	oc	p	5/15/29	26.8	34.9	8.23	5
106	633	0	oc	n	5/17/29	27.2	35.0	8.23	5
	635	100	oc	n	5/17/29	25.6	35.1	8.23	5
	637	50	r	p	5/17/29	27.0	35.0	8.23	5
	638	100	r	p	5/17/29	25.6	35.1	8.23	5
107	640	50	oc	n	5/19/29	27.9	34.4	8.23	4
	641	100	oc	n	5/19/29	26.8	34.9	8.23	11
	642	0	r	p	5/19/29	28.0	34.4	8.23	5
	644	100	oc	p	5/19/29	26.8	34.9	8.23	11
	645	50	r	p	5/19/29	27.9	34.4	8.23	4
108	646	0	r	n	5/27/29	28.4	35.0	8.25	4
	647	50	oc	n	5/27/29	26.8	35.0	8.25	4
	648	100	oc	n	5/27/29	25.2	35.0	8.23	4
	650	50	r	p	5/27/29	26.8	35.0	8.24	4
Guam	652	0	oc	n	5/--/29	...	...	...	..
109	654	0	oc	n	5/29/29	27.4	35.0	8.23	3
	657	...	r	...	5/29/29	27.4	35.0	8.23	3
	658	50	oc	p	5/29/29	23.1	35.0	8.22	3
	659	100	oc	p	5/29/29	19.4	34.8	8.18	5
	660	0	r	p	5/29/29	27.4	35.0	8.23	3
110	661	0	r	n	5/31/29	23.9	34.7	8.18	5
	662	50	r	n	5/31/29	18.4	34.8	8.16	7
	663	100	oc	n	5/31/29	17.9	34.7	8.14	11
	664	0	oc	p	5/31/29	23.9	34.7	8.18	5
	665	50	r	p	5/31/29	18.4	34.8	8.16	7
	666	100	r	p	5/31/29	17.9	34.7	8.14	11
	667	...	..	..	...	...	...	...	..
111	668	0	oc	n	6/3/29	20.1	34.5	8.18	5
	669	50	r	n	6/3/29	19.4	34.6	8.17	5
	671	0	oc	p	6/3/29	20.1	34.5	8.18	5
	672	50	r	p	6/3/29	19.4	34.6	8.17	5
112	674	0	r	n	6/5/29	23.2	34.6	8.22	7
	675	50	oc	n	6/5/29	21.7	34.6	8.23	7
	676	100	oc	n	6/5/29	19.8	34.7	8.20	8
	677	0	oc	p	6/5/29	23.2	34.6	8.22	7
	678	50	r	p	6/5/29	21.7	34.6	8.23	7
	679	100	r	p	6/5/29	19.8	34.7	8.20	8
113	681	50	oc	n	6/25/29	23.8	34.6	8.25	5
	682	100	oc	n	6/25/29	21.5	34.7	8.23	8
	683	0	oc	p	6/25/29	24.2	34.5	8.25	5
	685	100	r	p	6/25/29	21.5	34.7	8.23	8
115	695	0	r	p	6/29/29	20.6	34.6	8.19	4
117	710	100	r	n	7/3/29	8.8	34.1	7.98	84
130	792	0	r	p	9/4/29	16.2	33.4	8.34	36
131	794	0	r	p	9/6/29	19.3	33.4	8.34	...
132	797	0	oc	n	9/8/29	21.0	33.9	8.34	15
	801	0	r	p	9/8/29	21.0	33.9	8.34	15
	798	50	r	n	9/8/29	17.6	33.9	8.33	19
	802	50	r	p	9/8/29	17.6	33.9	8.33	19
	803	100	r	p	9/8/29	14.3	33.4	8.30	16
133	804	0	r	n	9/10/29	22.7	34.7	8.47	7
	806	100	r	n	9/10/29	18.4	34.8	8.31	7

Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> <sup>3</sup> mg/m <sup>3</sup>
Pacific--Continued									
133	814	100	r	p	9/10/29	18.4	34.8	8.31	7
134	809	50	r	n	9/12/29	19.8	34.6	8.34	6
	817	100	r	p	9/12/29	18.1	34.6	8.34	6
135	820	0	r	n	9/14/29	23.8	35.1	8.37	7
	821	50	r	n	9/14/29	21.5	35.0	8.37	5
	825	50	r	p	9/14/29	21.5	35.0	8.37	5
	826	100	r	p	9/14/29	18.7	34.8	8.34	5
136	827	0	r	n	9/16/29	24.6	35.4	8.37	3
	829	100	oc	n	9/16/29	18.6	35.0	8.39	3
	833	50	r	p	9/16/29	21.4	35.1	8.39	3
	834	100	r	p	9/16/29	18.6	35.0	8.39	3
137	837	50	r	p	9/18/29	24.4	35.1	8.34	4
138	843	0	oc	n	9/26/29	26.1	34.8	8.35	5
	847	0	r	p	9/26/29	26.1	34.8	8.35	5
	844	50	r	n	9/26/29	25.6	34.7	8.30	3
	845	100	oc	n	9/26/29	22.2	34.8	8.31	3
139	853	0	r	p	9/22/29	26.7	34.8	8.34	6
	850	50	oc	n	9/22/29	25.8	34.9	8.31	6
	854	50	r	p	9/22/29	25.8	34.9	8.31	6
140	860	0	r	p	10/ 3/29	26.9	35.0	8.42	7
	957	50	oc	n	10/ 3/29	26.9	35.0	8.39	7
	861	50	r	p	10/ 3/29	26.9	35.0	8.39	7
	858	100	oc	n	10/ 3/29	25.5	35.0	8.34	7
	863	100	r	p	10/ 3/29	25.5	35.0	8.34	7
141	864	0	r	n	10/ 5/29	25.9	35.2	8.34	5
	868	0	r	p	10/ 5/29	25.9	35.2	8.34	5
	865	50	oc	n	10/ 5/29	24.8	35.3	8.34	5
	869	50	r	p	10/ 5/29	24.8	35.3	8.34	5
	871	100	r	p	10/ 5/29	20.0	35.0	8.33	5
142	872	0	oc	n	10/ 7/29	24.1	34.8	8.33	5
	874	100	oc	n	10/ 7/29	16.6	34.4	8.27	7
	876	0	oc	p	10/ 7/29	24.1	34.8	8.33	5
	877	50	oc	p	10/ 7/29	21.8	34.8	8.30	5
	878	100	oc	p	10/ 7/29	16.6	34.4	8.27	7
	879	100	oc	p	10/ 7/29	16.6	34.4	8.27	7
143	881	0	oc	n	10/ 9/29	22.4	34.4	8.30	6
	884	0	r	p	10/ 9/29	22.4	34.4	8.30	6
	882	50	oc	n	10/ 9/29	19.0	34.2	8.34	6
	885	50	r	p	10/ 9/29	19.0	34.2	8.34	6
	883	100	r	n	10/ 9/29	13.8	34.1	8.30	10
144	886	0	r	n	10/11/29	23.3	35.0	8.37	6
	889	100	r	p	10/11/29	16.6	34.5	8.37	6
145	890	0	c	n	10/13/29	22.3	34.6	8.29	6
	893	0	r	p	10/13/29	22.3	34.6	8.29	6
	891	50	oc	n	10/13/29	18.7	34.3	8.34	6
	894	50	r	p	10/13/29	18.7	34.3	8.34	6
	892	100	r	n	10/13/29	16.0	34.1	8.31	6
	895	100	r	p	10/13/29	16.0	34.1	8.31	6
146	896	0	r	n	10/15/29	22.4	34.9	8.37	6
	897	50	r	n	10/15/29	22.4	34.9	8.30	6
147	903	0	r	n	10/17/29	23.3	35.3	8.26	8
	907	0	r	p	10/17/29	23.3	35.3	8.26	8
	904	50	r	n	10/17/29	23.1	35.3	8.29	5
	909	100	r	p	10/17/29	19.2	35.0	8.29	5
148	910	0	r	n	10/19/29	23.4	35.2	...	..
	917	0	r	p	10/19/29	23.4	35.2	...	..
	912	100	r	n	10/19/29	20.0	35.0	...	..
149	920	0	r	n	10/21/29	23.5	35.0	8.34	6
	927	0	r	p	10/21/29	23.5	35.0	8.34	6
	928	50	r	p	10/21/29	23.3	35.0	8.37	6
150	929	0	oc	n	10/23/29	25.6	34.7	8.39	7
	930	50	oc	n	10/23/29	22.8	34.8	8.35	10
	934	50	r	p	10/23/29	22.8	34.8	8.35	10
	931	100	oc	n	10/23/29	19.6	34.6	8.32	11
	936	100	r	p	10/23/29	19.6	34.6	8.32	11
151	937	0	r	n	10/26/29	26.0	34.0	...	..
	941	0	r	p	10/26/29	26.0	34.0	...	..
	938	50	r	n	10/26/29	18.3	34.4	...	..
	942	50	r	p	10/26/29	18.3	34.4	...	..
	939	100	r	n	10/26/29	12.5	34.6	...	..
152	944	0	r	n	10/27/29	27.4	33.7	8.35	20
	948	0	r	p	10/27/29	27.4	33.7	8.35	20
	945	50	oc	n	10/27/29	14.2	34.5	7.87	53
	946	100	r	n	10/27/29	11.4	34.7	7.76	75
153	951	0	oc	n	10/29/29	28.1	34.2	8.47	7
	955	0	r	p	10/29/29	28.1	34.2	8.47	7

Table 19. Distributional and environmental records for *Goniodoma polyedricum* Pouchet--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific --Concluded									
153	952	50	oc	n	10/29/29	28.1	34.4	8.39	7
	956	50	r	p	10/29/29	28.1	34.4	8.39	7
	953	100	r	n	10/29/29	20.5	34.7	8.28	31
	957	100	r	p	10/29/29	20.5	34.7	8.28	31
154	959	50	r	n	10/31/29	28.2	34.2	8.40	7
155	965	0	oc	n	11/ 2/29	27.8	34.9	8.29	29
	966	50	r	p	11/ 2/29	27.7	34.9	8.30	30
	967	100	oc	n	11/ 2/29	27.2	35.0	8.30	35
156	972	0	oc	n	11/ 4/29	27.6	35.0	8.34	28
	974	100	oc	n	11/ 4/29	26.4	35.1	8.30	48
157	978	0	r	n	11/ 6/29	27.1	35.3	8.27	47
	979	50	r	n	11/ 6/29	27.1	35.2	8.32	60
	980	100	r	n	11/ 6/29	26.8	35.5	8.30	64
158	983	0	oc	n	11/ 8/29	28.2	35.6	8.34	36
	984	50	oc	n	11/ 8/29	28.2	35.6	8.39	50
	985	100	r	n	11/ 8/29	27.6	35.9	8.39	48
159	990	0	r	n	11/11/29	28.6	35.7	8.37	15
	991	50	r	n	11/11/29	28.5	35.7	8.39	15
	992	100	r	n	11/11/29	28.0	35.7	8.37	23
160	1000	0	r	n	11/13/29	28.6	35.6	8.37	12

Table 20. Distributional and environmental records for *Gonyaulax pacifica* Kofoid

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
15	98	50	oc	p	8/11/28	19.8	36.5	8.21	8
	99	100	oc	p	8/11/28	18.4	36.4	8.20	19
	101	50	r	n	8/11/28	19.8	36.5	8.21	8
	102	100	oc	n	8/11/28	18.4	36.4	8.20	19
16	104	50	r	p	8/13/28	24.4	36.4	8.23	8
	108	100	r	n	8/13/28	19.9	36.5	8.17	13
17	110	50	r	p	8/15/28	21.9	36.6	8.28	12
	111	0	r	n	8/15/28	26.2	36.6	8.29	9
18	114	0	r	p	8/17/28	27.0	37.0	8.23	5
	118	50	r	n	8/17/28	22.4	36.8	8.24	5
	115	50	r	p	8/17/28	22.4	36.8	8.24	5
	119	100	oc	n	8/17/28	20.4	36.8	8.21	5
19	121	50	r	p	8/20/28	25.2	37.1	8.27	5
	123	50	r	n	8/20/28	25.2	37.1	8.27	5
20	126	50	r	p	8/22/28	25.8	36.6	8.26	3
	129	50	r	n	8/22/28	25.8	36.6	8.26	3
	130	100	r	n	8/22/28	22.6	36.7	8.19	5
21	136	50	r	n	8/24/28	24.4	36.2	8.26	4
	137	100	r	n	8/24/28	21.0	36.8	8.20	7
22	143	50	r	n	8/27/28	24.5	36.2	8.21	9
23	149	50	r	n	8/29/28	20.9	36.0	8.14	13
25	158	50	r	p	9/ 3/28	21.5	36.0	8.22	12
	161	50	oc	n	9/ 3/28	21.5	36.0	8.22	12
	162	100	r	n	9/ 3/28	14.6	35.7	7.93	121
26	164	50	r	p	9/ 5/28	24.1	36.1	8.21	5
	165	100	r	p	9/ 5/28	14.9	35.6	8.11	40
27	167	0	r	p	9/ 7/28	27.5	36.3	8.31	4
	171	50	r	n	9/ 7/28	26.0	36.2	8.30	4
28	178	100	r	n	9/11/28	22.8	36.6	8.22	7
29	180	50	r	p	9/13/28	27.2	36.2	8.29	3
30	189	50	r	n	9/15/28	27.8	36.1	8.29	3
Pacific									
36	215	100	r	n	10/30/28	14.4	34.9	7.85	149
45	257	50	r	n	11/19/28	22.4	35.2	8.13	46
	258	100	r	n	11/19/28	18.6	35.1	8.00	50
	259	0	r	p	11/19/28	22.4	35.3	8.12	38
46	261	0	r	n	11/21/28	23.3	35.3	8.16	36
	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	263	100	oc	n	11/21/28	22.5	35.4	8.17	40
	264	0	r	p	11/21/28	23.3	35.3	8.16	36
	265	50	r	p	11/21/28	23.2	35.3	8.16	40
47	266	0	r	n	11/23/28	23.9	36.0	8.23	17
	267	50	r	n	11/23/28	23.8	36.0	8.23	20
	268	100	oc	n	11/23/28	22.7	36.2	8.23	20
	270	50	oc	p	11/23/28	23.8	36.0	8.23	20
49	279	100	oc	n	11/27/28	21.6	35.9	8.26	13

Table 20. Distributional and environmental records for *Gonyaulax pacifica* Kofoid--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific--Continued									
49	281	50	r	p	11/27/28	22.6	36.1	8.26	13
50	288	50	r	p	11/29/28	22.0	35.9	8.23	13
	289	100	r	p	11/29/28	20.5	35.7	8.22	13
51	295	100	r	n	12/ 1/28	20.0	35.6	8.22	17
	297	50	r	p	12/ 1/28	20.5	35.6	8.22	17
52	300	50	r	n	12/ 3/28	20.2	35.6	8.20	8
53	304	50	oc	n	12/ 5/28	21.2	35.8	8.20	13
	305	100	r	n	12/ 5/28	19.9	35.6	8.19	13
54	320	50	r	n	12/14/28	19.8	35.4	8.18	17
55	324	50	r	n	12/16/28	18.7	35.0	8.18	12
	325	100	r	n	12/16/28	16.7	34.9	7.17	12
56	329	50	r	n	12/18/28	18.5	35.1	8.14	9
	330	100	r	n	12/18/28	16.6	34.8	8.11	12
64	396	100	r	n	1/ 3/29	15.8	34.5	8.10	32
65	409	50	r	p	1/ 5/29	16.5	34.5	8.10	25
	410	100	r	p	1/ 5/29	14.8	34.3	8.10	34
66	412	100	r	n	1/ 7/29	17.8	34.9	8.12	21
	415	100	r	p	1/ 7/29	17.8	34.9	8.12	21
76	469	100	r	n	2/16/29	21.2	35.8	8.12	45
77	474	50	r	p	2/18/29	23.5	36.0	8.19	16
78	475	0	r	n	2/20/29	24.6	36.0	8.17	32
	476	50	r	n	2/20/29	23.8	36.1	8.14	32
	477	100	oc	n	2/20/29	21.9	36.2	8.14	34
79	483	100	r	n	2/22/29	21.8	36.2	8.13	45
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
84	506	50	r	n	3/ 4/29	27.5	36.4	8.21	24
86	517	50	r	n	3/ 9/29	27.4	36.2	8.29	17
87	522	50	r	n	3/11/29	26.5	36.1	8.26	20
88	527	50	r	n	3/21/29	28.4	35.9	8.25	13
91	544	100	r	p	3/27/29	25.8	36.0	8.25	30
93	550	0	r	n	3/31/29	28.7	34.7	8.30	28
95	563	50	r	n	4/24/29	29.3	34.9	8.24	16
96	573	100	r	p	4/26/29	28.2	35.7	8.19	25
97	576	100	r	n	4/28/29	27.6	35.6	8.15	25
100	597	100	r	n	5/ 4/29	27.6	34.7	8.22	12
101	604	50	r	n	5/ 7/29	26.2	34.7	8.24	8
	605	100	oc	n	5/ 7/29	25.2	35.1	8.23	8
102	609	0	r	n	5/ 9/29	25.8	35.0	8.24	8
	610	50	r	n	5/ 9/29	25.8	35.0	8.24	8
	611	100	r	n	5/ 9/29	25.6	35.0	8.23	8
	612	0	r	p	5/ 9/29	25.8	35.0	8.24	8
	614	100	r	p	5/ 9/29	25.6	35.0	8.23	8
	613	50	r	p	5/ 9/29	25.8	35.0	8.24	8
103	616	50	oc	n	5/11/29	25.8	35.2	8.25	5
	617	100	oc	n	5/11/29	24.8	35.2	8.25	5
104	622	50	r	n	5/13/29	25.8	35.2	8.24	7
	623	100	oc	n	5/13/29	25.3	35.3	8.21	7
	626	100	r	p	5/13/29	25.3	35.3	8.21	7
105	628	50	r	n	5/15/29	26.8	34.9	8.23	5
	629	100	r	n	5/15/29	25.2	35.1	8.23	5
106	633	0	r	n	5/17/29	27.2	35.0	8.23	5
	635	100	r	n	5/17/29	27.2	35.0	8.23	5
	634	50	r	n	5/17/29	27.0	35.0	8.23	5
	637	50	r	p	5/17/29	27.0	35.0	8.23	5
	638	100	r	p	5/17/29	25.6	35.1	8.23	5
107	641	100	oc	n	5/19/29	26.8	34.9	8.23	11
108	647	50	oc	n	5/27/29	26.8	35.0	8.24	4
	648	100	r	n	5/27/29	25.2	36.0	8.23	4
109	656	100	r	n	5/29/29	19.4	34.8	8.18	5
	658	50	r	p	5/29/29	23.1	35.0	8.22	3
	659	100	oc	p	5/29/29	19.4	34.8	8.18	5
110	663	100	r	n	5/31/29	17.9	34.7	8.14	11
	665	50	r	p	5/31/29	18.4	34.8	8.16	7
	666	100	r	p	5/31/29	17.9	34.7	8.14	11
113	681	50	r	n	6/25/29	23.8	34.6	8.25	5
	682	100	r	n	6/25/29	21.5	34.7	8.23	8
	684	50	r	p	6/25/29	23.8	34.6	8.25	5
132	798	50	r	n	9/ 8/29	17.6	33.9	8.33	13
	801	0	r	p	9/ 8/29	21.0	33.9	8.34	15
	799	100	r	n	9/ 8/29	14.3	33.4	8.30	16
	802	100	oc	p	9/ 8/29	14.3	33.4	8.30	16
	804	0	r	n	9/ 8/29	21.0	33.9	8.34	15
133	805	50	r	n	9/10/29	20.8	34.7	8.37	7
134	810	100	r	n	9/12/29	18.1	34.6	8.34	6
135	821	50	r	n	9/14/29	21.5	35.0	8.37	5
	822	100	r	n	9/14/29	18.7	34.8	8.34	5

Table 20. Distributional and environmental records for *Gonyaulax pacifica* Kofoid--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Pacific --Concluded									
135	825	50	r	p	9/14/29	21.5	35.0	8.37	5
	826	100	r	p	9/14/29	18.7	34.8	8.34	5
136	828	50	oc	n	9/16/29	21.4	35.1	8.39	3
	829	100	oc	n	9/16/29	18.6	35.0	8.39	3
	833	50	r	p	9/16/29	21.4	35.1	8.39	3
	834	100	r	p	9/16/29	18.6	35.0	8.39	3
137	837	50	r	n	9/18/29	24.4	35.1	8.34	4
	838	100	r	n	9/18/29	21.5	35.1	8.30	5
138	844	50	r	n	9/20/29	25.6	34.7	8.30	3
	845	100	r	n	9/20/29	22.2	34.8	8.31	3
	848	50	r	p	9/20/29	25.6	34.7	8.30	3
139	854	50	r	p	9/22/29	25.8	34.9	8.31	6
	855	100	r	p	9/22/29	22.4	35.2	8.28	6
140	857	50	r	n	10/ 3/29	26.9	35.0	8.39	7
	858	100	r	n	10/ 3/29	25.5	35.0	8.34	7
141	864	0	r	n	10/ 5/29	25.9	35.2	8.34	5
	865	50	r	n	10/ 5/29	24.8	35.3	8.34	5
	870	50	r	p	10/ 5/29	24.8	35.3	8.34	5
	871	100	r	p	10/ 5/29	20.0	35.0	8.33	5
142	874	100	r	n	10/ 7/29	16.6	34.4	8.27	7
	879	100	r	p	10/ 7/29	16.6	34.4	8.27	7
143	883	100	r	n	10/ 9/29	13.8	34.1	8.30	10
145	890	0	r	n	10/13/29	22.3	34.6	8.29	6
	891	50	r	n	10/13/29	18.7	34.3	8.34	6
	892	100	r	n	10/13/29	16.0	34.1	8.31	6
	893	0	r	p	10/13/29	22.3	34.6	8.29	6
146	896	0	r	n	10/15/29	22.4	34.9	8.37	6
	897	50	r	n	10/15/29	22.4	34.9	8.30	6
	898	100	r	n	10/15/29	19.7	34.3	8.26	7
	901	50	r	p	10/15/29	22.4	34.9	8.30	6
	902	100	r	p	10/15/29	19.7	34.3	8.26	7
147	904	50	r	n	10/17/29	23.1	35.3	8.29	5
	905	100	r	n	10/17/29	19.2	35.0	8.29	5
	909	100	r	p	10/17/29	19.2	35.0	8.29	5
149	922	100	oc	n	10/21/29	20.3	34.9	8.38	6
150	930	50	oc	n	10/23/29	22.8	34.8	8.35	10
	936	100	r	p	10/23/29	19.6	34.6	8.32	11
151	938	50	r	n	10/26/29	18.3	34.4	...	..
	939	100	r	n	10/26/29	12.5	34.6	...	..
	942	50	r	p	10/26/29	18.3	34.4	...	..
152	945	50	r	n	10/27/29	14.2	34.5	7.87	53
	946	100	r	n	10/27/29	11.4	34.7	7.76	75
158	985	100	r	n	11/ 8/29	27.6	35.9	8.39	48
159	992	100	r	n	11/11/29	28.0	35.7	8.37	23

Table 21. Distributional and environmental records for *Gonyaulax fusiformis* n.sp.

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic									
18	114	0	r	p	8/17/28	27.0	37.0	8.23	5
	115	50	r	p	8/17/28	22.4	36.8	8.24	5
	117	0	r	n	8/17/28	27.0	37.0	8.23	5
	119	100	r	n	8/17/28	20.4	36.8	8.21	5
20	126	50	r	p	8/22/28	25.8	36.6	8.26	3
	127	100	r	p	8/22/28	22.6	36.7	8.19	5
	128	0	r	n	8/22/28	26.0	36.6	8.37	5
	129	50	r	n	8/22/28	25.8	36.6	8.26	3
	130	100	r	n	8/22/28	22.6	36.7	8.19	5
Pacific									
46	265	50	r	p	11/21/28	23.2	35.3	8.16	40
	267	50	r	n	11/21/28	23.2	35.3	8.16	40
47	269	0	r	p	11/23/28	23.9	36.0	8.23	17
89	530	0	r	p	3/23/29	28.4	35.6	8.25	21
91	542	0	r	p	3/27/29	28.7	35.1	8.30	21
	544	100	r	p	3/27/29	25.8	36.0	8.25	30
92	548	50	r	p	3/29/29	28.4	35.4	8.29	28
99	589	0	r	n	5/ 2/29	27.9	34.9	8.21	12
105	630	0	r	p	5/15/29	26.9	34.9	8.23	5
	631	50	r	p	5/15/29	26.8	34.9	8.23	5
107	642	0	r	p	5/19/29	28.0	34.4	8.23	5
109	656	100	r	n	5/29/29	19.4	34.8	8.18	5

Table 21. Distributional and environmental records for *Gonyaulax fusiformis* n.sp.--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n c l u d e d									
133	805	50	r	n	9/10/29	20.8	34.7	8.37	7
	813	50	r	p	9/10/29	20.8	34.7	8.37	7
135	822	100	r	n	9/14/29	18.7	34.8	8.34	5
	825	50	r	p	9/14/29	21.5	35.0	8.37	5
	826	100	r	p	9/14/29	18.7	34.8	8.34	5
136	832	0	r	p	9/16/29	24.6	35.4	8.37	3
	834	100	r	p	9/16/29	18.6	35.0	8.39	3
137	840	0	r	p	9/18/29	25.5	35.0	8.39	4
138	845	100	r	n	9/20/29	22.2	34.8	8.31	3
139	854	50	r	p	9/22/29	25.8	34.9	8.31	6
149	927	0	r	p	10/21/29	23.5	35.0	8.34	6
154	959	50	r	n	10/31/29	28.2	34.2	8.40	7

Table 22. Distributional and environmental records for *Acanthogonyaulax spinifera* (Murr. and Whitt.) Graham

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c									
46	261	0	r	n	11/21/28	23.3	35.3	8.16	36
	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	263	100	r	n	11/21/28	22.5	35.4	8.17	40
48	273	100	r	n	11/25/28	22.7	36.3	8.26	16
79	481	0	r	n	2/22/29	25.2	36.0	8.17	34
	484	0	r	p	2/22/29	25.2	36.0	8.17	34
80	488	0	r	p	2/24/29	26.0	35.9	8.20	36
81	491	0	r	n	2/26/29	26.5	35.8	8.19	38
	493	0	r	p	2/26/29	26.5	35.8	8.19	38
90	534	50	r	n	3/25/29	28.6	35.6	8.26	21
100	596	50	r	n	5/ 4/29	27.6	34.7	8.21	10
	597	100	oc	n	5/ 4/29	27.6	34.7	8.22	12
	599	50	r	p	5/ 4/29	27.6	34.7	8.21	10
101	604	50	r	n	5/ 7/29	26.2	34.7	8.24	8
	605	100	oc	n	5/ 7/29	25.2	35.1	8.23	8
102	609	0	r	n	5/ 9/29	25.8	35.0	8.24	8
	610	50	r	n	5/ 9/29	25.8	35.0	8.24	8
103	617	100	r	n	5/11/29	24.8	35.2	8.25	5
	620	100	r	p	5/11/29	24.8	35.2	8.25	5
104	622	50	r	n	5/13/29	25.8	35.2	8.24	7
105	628	50	r	n	5/15/29	26.8	34.9	8.23	5
107	639	0	r	n	5/19/29	28.0	34.4	8.23	5
109	658	50	r	p	5/29/29	23.1	35.0	8.22	3
112	677	0	r	p	6/ 5/29	23.2	34.6	8.22	7
113	681	50	r	n	6/25/29	23.8	34.6	8.25	5
136	829	100	r	n	9/16/29	18.6	35.0	8.39	3
139	851	100	r	n	9/22/29	22.4	35.2	8.28	6
145	892	100	r	n	10/13/29	16.0	34.1	8.31	6
146	898	100	r	n	10/15/29	19.7	34.3	8.26	7
149	921	50	r	n	10/21/29	23.3	35.0	8.37	7
	927	0	r	p	10/21/29	23.5	35.0	8.34	7
159	991	50	r	n	11/11/29	28.5	35.7	8.39	15

Table 23. Distributional and environmental records for *Spiraulax kofoidii* new name

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
A t l a n t i c									
1	1	0	r	n	5/12/28	24.0	36.2	8.16	34
19	122	0	oc	n	8/20/28	26.6	37.0	8.34	5
	123	50	r	n	8/20/28	25.2	37.1	8.27	5
	124	100	r	n	8/20/28	22.4	37.0	8.25	5
21	134	100	r	p	8/24/28	21.0	36.8	8.20	7
	137	100	r	n	8/24/28	21.0	36.8	8.20	7
22	139	0	oc	p	8/27/28	26.7	36.0	8.26	8
	143	50	r	n	8/27/28	24.5	36.2	8.21	9
	144	100	r	n	8/27/28	17.5	36.1	7.99	123
23	145	0	r	p	8/29/28	27.2	35.9	8.25	4
	149	50	oc	n	8/29/28	20.9	36.0	8.14	13
	150	100	r	n	8/29/28	16.6	36.0	8.18	75
24	152	50	r	p	8/31/28	23.1	36.0	8.14	8

DISTRIBUTIONAL AND ENVIRONMENTAL RECORDS

Table 23. Distributional and environmental records for *Spiraulax kofoidii* new name--Continued

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
Atlantic --Concluded									
24	155	50	r	n	8/31/28	23.1	36.0	8.14	8
25	157	0	oc	p	9/ 3/28	27.5	35.6	8.31	5
	158	50	oc	p	9/ 3/28	21.5	36.0	8.22	12
26	164	50	r	p	9/ 5/28	24.1	36.1	8.21	5
27	172	100	r	n	9/ 7/28	17.7	36.0	8.09	46
29	184	100	r	n	9/13/28	23.1	36.6	8.21	8
31	191	0	r	n	10/ 3/28	28.5	34.4	8.27	2
32	194	0	r	n	10/ 5/28	28.0	36.0	8.23	2
	195	50	r	n	10/ 5/28	27.2	36.0	8.24	2
Pacific									
44	253	0	r	p	11/17/28	20.7	34.9	8.03	38
45	259	0	r	p	11/19/28	22.4	35.3	8.12	38
	260	50	r	p	11/19/28	22.4	35.2	8.13	46
46	262	50	r	n	11/21/28	23.2	35.3	8.16	40
	263	100	r	n	11/21/28	22.5	35.4	8.17	40
47	266	0	r	n	11/23/28	23.9	36.0	8.23	17
	267	50	r	n	11/23/28	23.8	36.0	8.23	20
	269	0	r	p	11/23/28	23.9	36.0	8.23	17
48	271	0	oc	n	11/25/28	23.6	36.4	8.23	13
	273	100	r	n	11/25/28	22.7	36.3	8.26	16
	274	0	oc	p	11/25/28	23.6	36.4	8.23	13
49	277	0	r	n	11/27/28	23.4	36.2	8.27	13
	279	100	r	n	11/27/28	21.6	35.9	8.26	13
	280	0	r	p	11/27/28	23.4	36.2	8.27	13
	281	50	r	p	11/27/28	22.6	36.1	8.26	13
	282	100	r	p	11/27/28	21.6	35.9	8.26	13
49a	283	0	oc	n	11/28/28	(23.2)	(36.0)	(8.23)	(13)*
50	284	0	c	n	11/29/28	(23.2)	(36.0)	(8.23)	(13)*
	285	50	oc	n	11/29/28	22.0	35.9	8.23	13
	286	100	oc	n	11/29/28	20.5	35.7	8.22	13
	287	0	oc	p	11/29/28	23.2	36.0	8.23	13
	289	100	r	p	11/29/28	20.5	35.7	8.22	13
51	290	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	291	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	292	0	oc	n	12/ 1/28	22.8	35.6	8.22	16
	294	50	oc	n	12/ 1/28	20.5	35.6	8.22	17
	295	100	oc	n	12/ 1/28	20.0	35.6	8.22	17
	297	50	r	p	12/ 1/28	20.5	35.6	8.22	17
	298	100	r	p	12/ 1/28	20.0	35.6	8.22	17
52	300	50	r	n	12/ 3/28	20.2	35.6	8.20	8
	301	100	oc	n	12/ 3/28	18.2	35.2	8.17	8
53	303	0	oc	n	12/ 5/28	22.6	35.7	8.22	13
	304	50	oc	n	12/ 5/28	21.2	35.8	8.20	13
	305	100	oc	n	12/ 5/28	19.9	35.6	8.19	13
	306	0	r	p	12/ 5/28	22.6	35.7	8.22	13
53a	310	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	311	0	oc	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	313	0	r	n	12/10/28	(23.0)	(35.6)	(8.22)	(11)*
	322	0	r	p	12/14/28	23.4	35.5	8.22	9
55	324	50	oc	n	12/16/28	18.7	35.0	8.18	12
56	329	50	r	n	12/18/28	18.5	35.1	8.14	9
	330	100	oc	n	12/18/28	16.6	34.8	8.11	12
62	373	100	r	n	12/18/28	13.1	34.2	8.06	48
63	380	50	r	n	1/ 1/29	17.0	34.6	8.08	25
	388	0	r	n	1/ 1/29	20.5	34.6	8.07	21
64	396	100	r	n	1/ 3/29	15.8	34.5	8.10	32
	402	0	r	n	1/ 3/29	20.6	34.6	8.12	21
	403	0	r	n	1/ 3/29	20.6	34.6	8.12	21
	404	0	r	n	1/ 3/29	20.6	34.6	8.12	21
65	406	50	r	n	1/ 5/29	16.5	34.5	8.10	25
66	412	100	r	n	1/ 7/29	17.8	34.9	8.12	21
	414	50	r	p	1/ 7/29	17.8	34.8	8.10	29
67	416	0	r	n	1/ 8/29	19.3	34.9	8.11	21
	418	100	oc	n	1/ 8/29	16.2	34.6	8.05	40
69	425	50	r	n	1/12/29	17.4	35.1	7.99	151
	427	0	r	p	1/12/29	21.1	35.2	8.12	62
73	452	100	r	n	2/10/29	14.7	35.0	7.80	178
80	486	0	r	n	2/24/29	26.0	35.9	8.20	36
	488	0	r	p	2/24/29	26.0	35.9	8.20	36
81	491	0	c	n	2/26/29	26.5	35.8	8.19	38
	492	50	r	n	2/26/29	26.4	35.9	8.19	38
	493	0	r	p	2/26/29	26.5	35.8	8.19	38
83	502	50	r	n	3/ 2/29	27.4	36.5	8.24	25
85	510	0	r	n	3/ 6/29	27.9	36.2	8.22	40
87	522	50	r	n	3/11/29	26.5	36.1	8.26	20

Table 23. Distributional and environmental records for *Spiraulax kofoidii* new name--Concluded

Station	Sample	Depth (m)	Relative abundance	Apparatus	Date	Temperature (°C)	Salinity (o/oo)	pH	PO <sub>4</sub> mg/m <sup>3</sup>
P a c i f i c -- C o n c l u d e d									
88	526	0	r	n	3/21/29	28.5	35.9	8.23	16
	527	50	r	n	3/21/29	28.4	35.9	8.25	13
89	532	0	r	n	3/23/29	28.4	35.6	8.25	21
90	533	0	oc	n	3/25/29	28.5	35.5	8.27	21
91	540	0	oc	n	3/27/29	28.7	35.1	8.30	21
	542	0	r	p	3/27/29	28.7	35.1	8.30	21
92	545	0	c	n	3/29/29	28.5	35.3	8.29	28
93	550	0	c	n	3/31/29	28.7	34.7	8.30	28
	551	50	oc	n	3/31/29	28.5	34.8	8.30	28
96	569	50	r	n	4/26/29	29.2	35.3	8.23	12
97	575	50	oc	n	4/28/29	28.0	35.4	8.16	21
98	585	50	r	p	4/30/29	26.9	35.3	8.16	28
	588	100	r	p	4/30/29	26.7	35.4	8.14	32
99	589	0	r	n	5/ 2/29	27.9	34.9	8.21	12
	590	50	r	n	5/ 2/29	27.8	34.9	8.22	12
	591	100	oc	n	5/ 2/29	27.8	35.0	8.22	17
	593	50	r	p	5/ 2/29	27.8	34.9	8.22	12
	595	0	r	n	5/ 2/29	27.9	34.9	8.21	12
100	596	50	r	n	5/ 4/29	27.6	34.7	8.21	10
	597	100	oc	n	5/ 4/29	27.6	34.7	8.22	12
101	603	0	oc	n	5/ 7/29	26.3	34.7	8.24	8
	604	50	oc	n	5/ 7/29	26.2	34.7	8.24	8
	605	100	oc	n	5/ 7/29	25.2	35.1	8.23	8
102	609	0	r	n	5/ 9/29	25.8	35.0	8.24	8
	610	50	oc	n	5/ 9/29	25.8	35.0	8.24	8
	611	100	oc	n	5/ 9/29	25.6	35.0	8.23	8
103	615	0	oc	n	5/11/29	26.0	35.0	8.25	5
	616	50	r	n	5/11/29	25.8	35.2	8.25	5
104	621	0	r	n	5/13/29	26.1	35.2	8.24	7
	623	100	oc	n	5/13/29	25.3	35.3	8.21	7
105	628	50	r	n	5/15/29	26.8	34.9	8.23	5
106	638	100	r	p	5/17/29	25.6	35.1	8.23	5
107	639	0	r	n	5/19/29	28.0	34.4	8.23	5
	640	50	r	n	5/19/29	27.9	34.4	8.23	4
108	648	100	r	n	5/27/29	25.2	35.0	8.23	4
109	654	0	r	n	5/29/29	27.4	35.0	8.23	3
	656	100	r	n	5/29/29	19.4	34.8	8.18	5
110	663	100	r	n	5/31/29	17.9	34.7	8.14	11
130	787	0	oc	n	9/ 4/29	16.2	33.4	8.34	36
132	792	0	r	n	9/ 9/29	21.0	33.9	8.34	15
	798	50	r	n	9/ 9/29	17.6	33.9	8.33	19
	799	100	r	n	9/ 9/29	14.3	33.4	8.30	16
	803	100	r	p	9/ 9/29	14.3	33.4	8.30	16
138	843	0	r	n	9/20/29	26.1	34.8	8.35	5
	845	100	r	n	9/20/29	22.2	34.8	8.31	3
139	851	100	r	n	9/22/29	22.4	35.2	8.28	6
140	860	0	r	p	10/ 3/29	26.9	35.0	8.42	7
	857	50	r	n	10/ 3/29	26.9	35.0	8.39	7
	858	100	r	n	10/ 3/29	25.5	35.0	8.34	7
	861	50	r	p	10/ 3/29	26.9	35.0	8.39	7
	863	100	r	p	10/ 3/29	25.5	35.0	8.34	7
141	864	0	r	n	10/ 5/29	25.9	35.2	8.34	5
	868	0	r	p	10/ 5/29	25.9	35.2	8.34	5
142	873	50	r	n	10/ 7/29	21.8	34.8	8.30	5
	874	100	r	n	10/ 7/29	16.6	34.4	8.27	7
	877	50	r	p	10/ 7/29	21.8	34.8	8.30	5
143	882	50	r	n	10/ 9/29	19.0	34.2	8.34	6
145	891	50	oc	n	10/13/29	18.7	34.3	8.34	6
	892	100	r	n	10/13/29	16.0	34.1	8.31	6
146	901	50	r	p	10/15/29	22.4	34.9	8.30	6
149	921	50	r	n	10/21/29	23.3	35.0	8.37	6
150	929	0	r	n	10/23/29	25.6	34.7	8.39	7
	931	100	oc	n	10/23/29	19.6	34.6	8.32	11
	933	0	r	p	10/23/29	25.6	34.7	8.39	7
	936	100	r	p	10/23/29	19.6	34.6	8.32	11
152	944	0	r	n	10/27/29	27.4	33.7	8.35	20
153	951	0	r	n	10/29/29	28.1	34.2	8.47	7
154	959	50	r	n	10/31/29	28.2	34.2	8.40	7
155	965	0	r	n	11/ 2/29	27.8	34.9	8.29	29
157	978	0	r	n	11/ 6/29	27.1	35.3	8.27	47
158	983	0	r	n	11/ 8/29	28.2	35.6	8.34	36
	984	50	r	n	11/ 8/29	28.2	35.6	8.39	50
	985	100	r	n	11/ 8/29	27.6	35.9	8.39	48
159	992	100	r	n	11/11/29	28.0	35.7	8.37	23
160	1002	50	r	n	11/13/29	28.6	35.6	8.39	15



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FIGURES 1 - 67

PLATE I

FIGURES 1 - 9

Fig. 1. Comparison of tabulations of ventral areas of various genera of the Peridinales. A, primitive area; B, Ceratocorys horrida; C, Goniodoma polyedricum; D, Gonyaulax pacifica; E, Gonyaulax fusiformis; F, Acanthogonyaulax spinifera; G, Spiraulax kofoidii; H, Peridinium crassipes. (For explanation, see pp. 7-8.)

Fig. 2. Diagram illustrating concepts of relationships of genera treated in this report.

Fig. 3. A, diagram of cross section of thecal wall of Peridinium in region of suture, simple suture without intercalary zone; B, hypothetical diagram of same following development of intercalary zone. External intercalary zone observed; internal intercalary zone not yet demonstrated.

Fig. 4. Examples of the three types of first apical plates. A, Orthoperidinium; B, Metaperidinium; C, Paraperidinium.

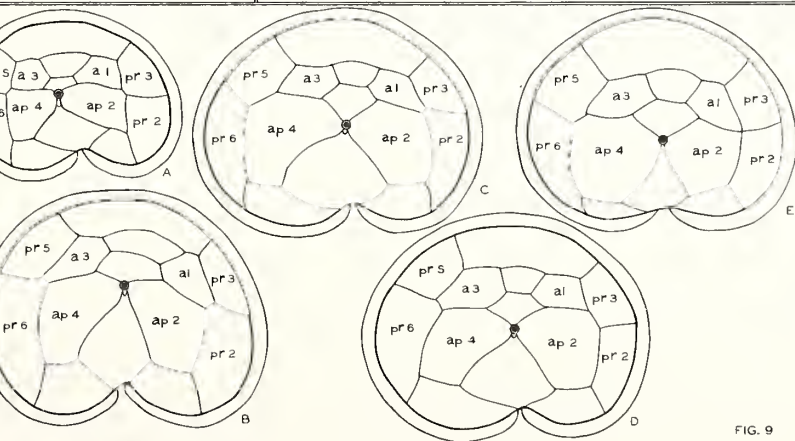
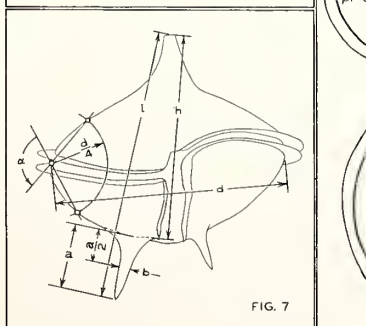
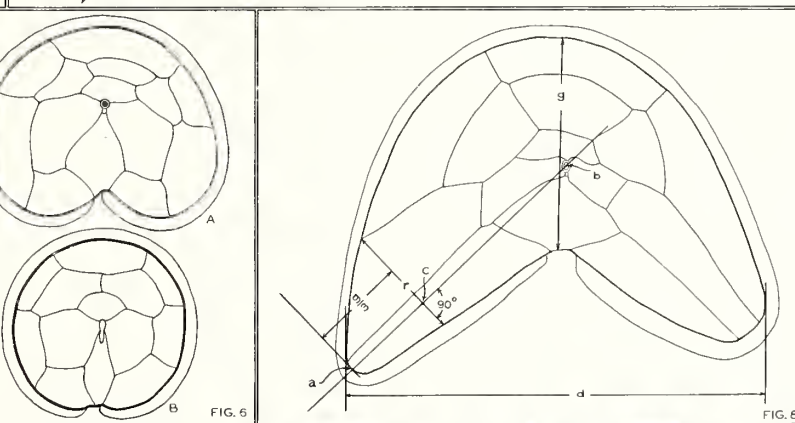
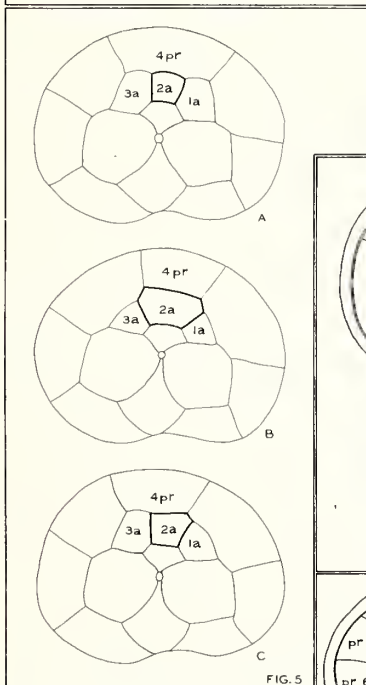
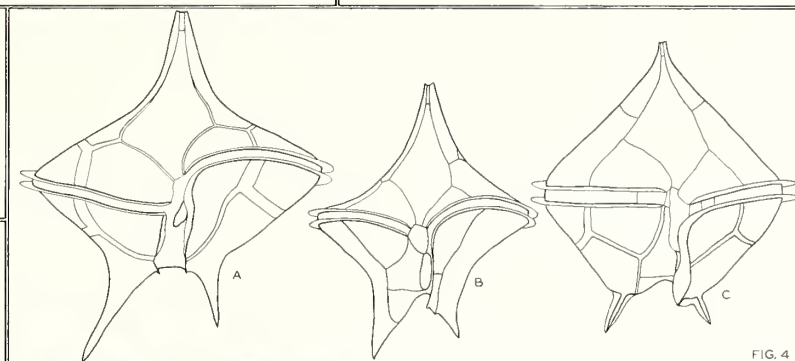
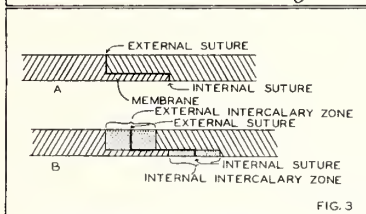
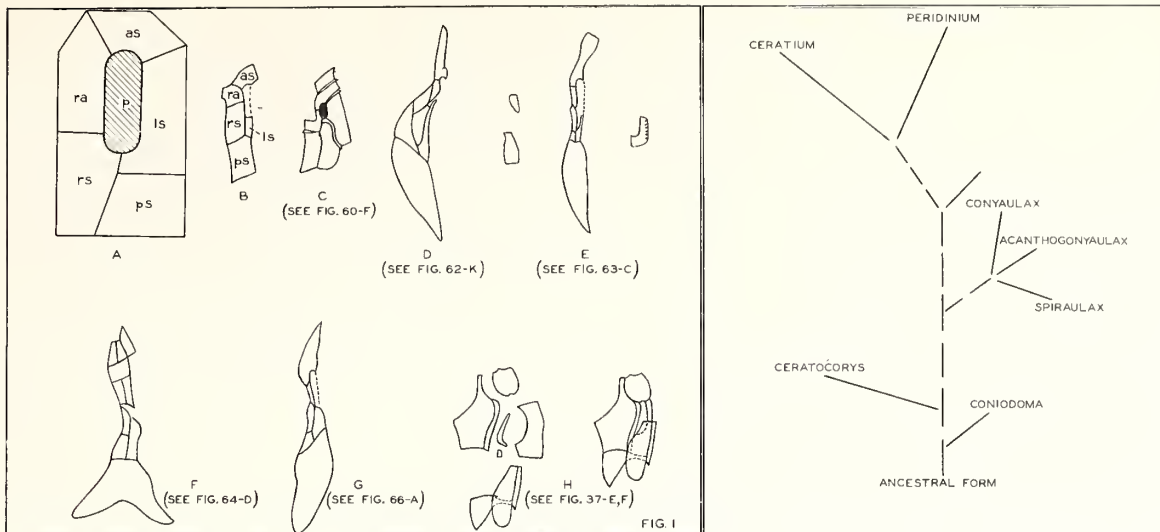
Fig. 5. Examples of the three types of dorsal epithecal tabulation used by Jørgensen, Paulsen, et al. in subdividing the subgenera of Peridinium. (See text for explanation.)

Fig. 6. Epithecal tabulation. A, with three intercalary plates; B, with only two intercalary plates.

Fig. 7. Diagram showing the dimensions used in the study of body proportions in Peridinium. Ventral view.

Fig. 8. Diagram showing the dimensions used in the study of body proportions in Peridinium. Apical view.

Fig. 9. Epithecal plate patterns in the section Oceanica. A, first symmetrical; B, second symmetrical; C, first asymmetrical; D, second asymmetrical; E, intergrade between first symmetrical and first asymmetrical.



FIGURES 10 - 18

Fig. 10. Frequency distribution of the x-ratios in 144 random specimens related to P. depressum Bailey. ○, P. depressum; ×, P. oceanicum; ●, var. parallelum; ■, var. tenellum.

Fig. 11. Frequency distribution of length classes in 170 random specimens related to P. depressum.

Fig. 12. Frequency distribution of the diameter classes in 170 random specimens related to P. depressum.

Fig. 13. Frequency distribution of the  $h/d$  classes in 170 random specimens related to P. depressum.

Fig. 14. Peridinium depressum Bailey. A, in "resting" position in bottom of drop of mounting medium; B, ventral view; C, left side view; D, apical view; E, dorsal view; F, antapical view. Magnification: × 170.

Fig. 15. Apex of P. depressum Bailey. A, intact; B, plates separated. Symbols: ap, apical pore; app, apical pore platelet; ap1-ap4, first to fourth apical plates; dl, dorsal segment of apical list; lal, left segment of apical list; ll1, left lateral list; ral, right segment of apical list; rll, right lateral list; vap, ventral apical platelet. Magnification: × 670.

Fig. 16. Girdle of P. depressum Bailey. A, intact. Symbols: iz, intercalary zone; s, sulcus; lg-4g, first to fourth girdle plates. B, section showing strengthening ridges. C, cross section showing attachment to adjacent plate and cingular list. Symbols: bp, body plate; cl, cingular list; g, girdle plate. Magnification: A, × 230; B and C, × 470.

Fig. 17. Ventral area of P. depressum Bailey. A, ventral view intact; B, left ventral view intact, membranes not shown; C, ventral view showing plates separated. Magnification: × 400. Symbols: acl, anterior cingular list; ag, anterior flagellar groove; agl, anterior groove list; ant1, first antapical plate; ant2, second antapical plate; ap1, first apical plate; app, anterior pore process; arl, anterior right sulcal list; as, anterior sulcal plate; iz, intercalary zone; ll, left sulcal list; ls, left sulcal plate; m, membrane; p, flagellar pore; pas, posterior accessory sulcal plate; pcl, posterior cingular list; pg, posterior flagellar groove; pgl, posterior groove list; pl, posterior sulcal list; po1, first postcingular plate; po5, fifth postcingular plate; ppp, posterior pore process; pr1, first precingular plate; pr7, seventh precingular plate; prl, posterior right sulcal list; ps, posterior sulcal plate; ras, right accessory sulcal list; ris, right internal sulcal plate; rs, right sulcal plate; 1g, 2g, 4g, first, second, and fourth girdle plates.

Fig. 18. Details of ventral area. A, left side view with left sulcal plate removed; B, same with plates separated; C, posterior view of cross section of posterior end of sulcus; D, anterior view of cross section of right sulcal plate. Magnification: A and B, × 730; C and D, × 400. (Symbols as in fig. 17.)

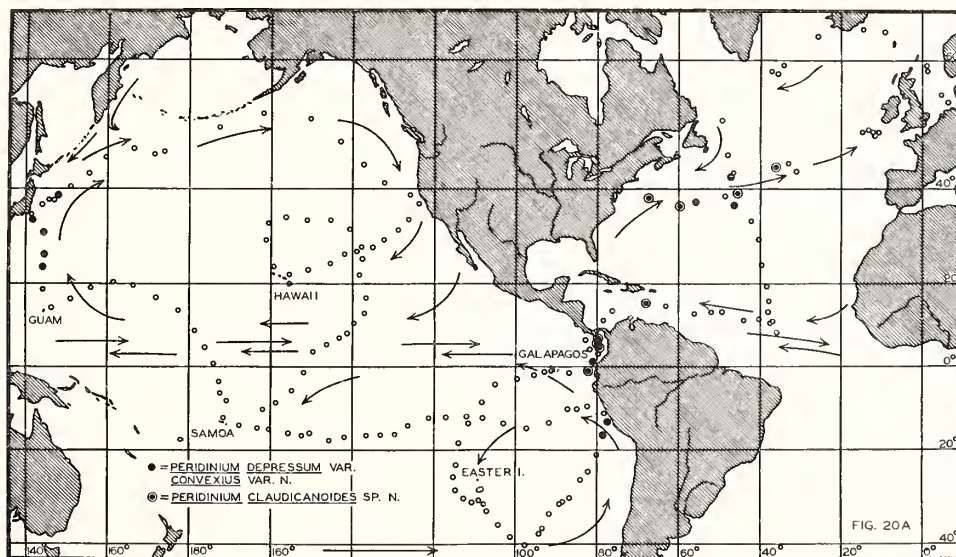
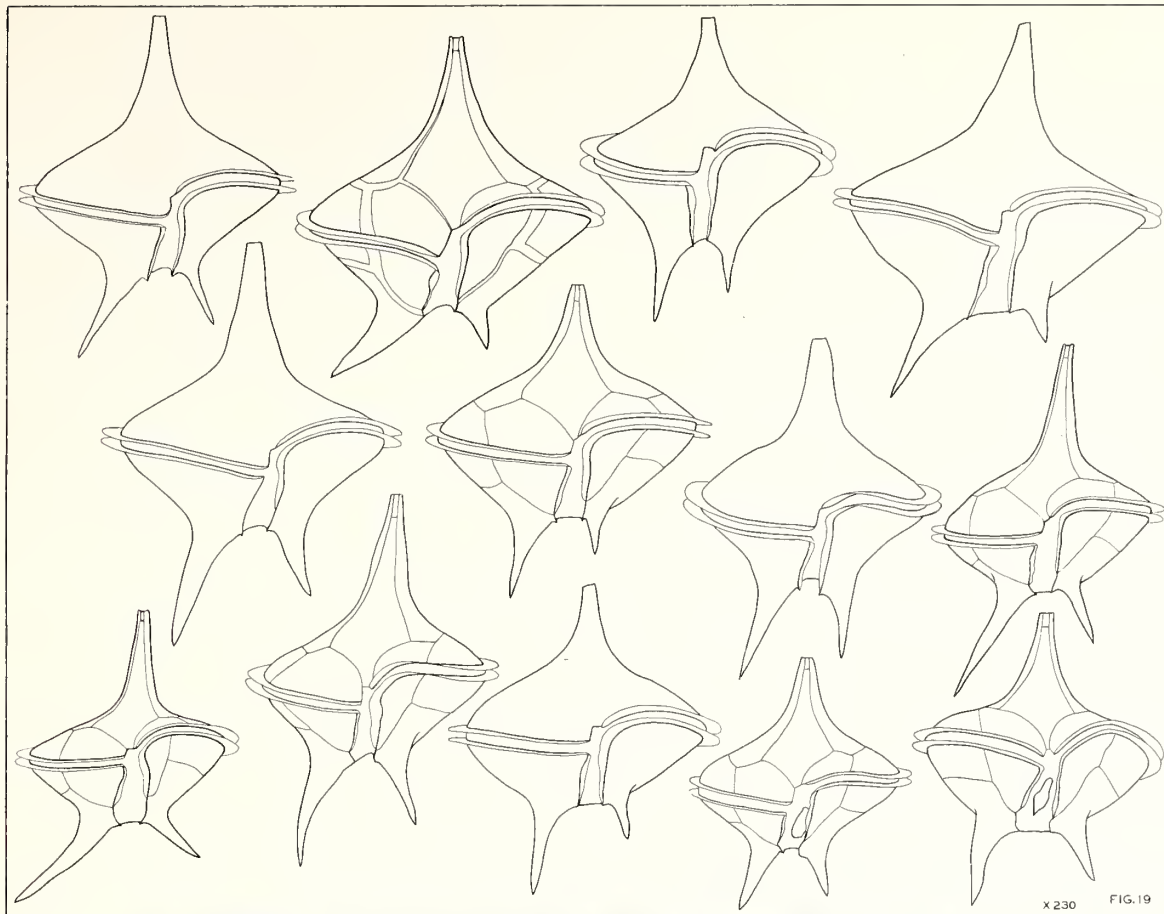




FIGURES 19 and 20-A

Fig. 19. Variations in body form in P. depressum Bailey. Magnification:  $\times 230$ .

Fig. 20-A. Distribution of species of Peridinium at Carnegie stations.

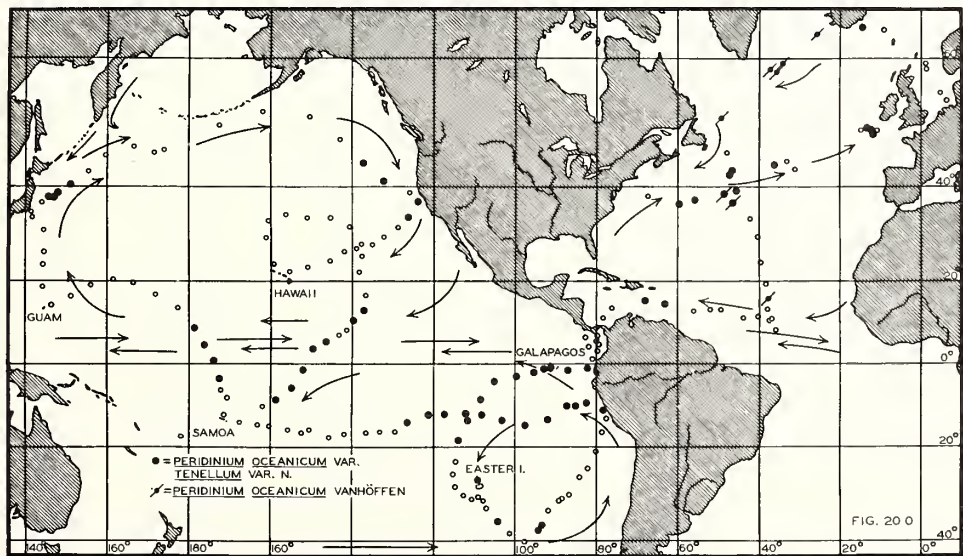
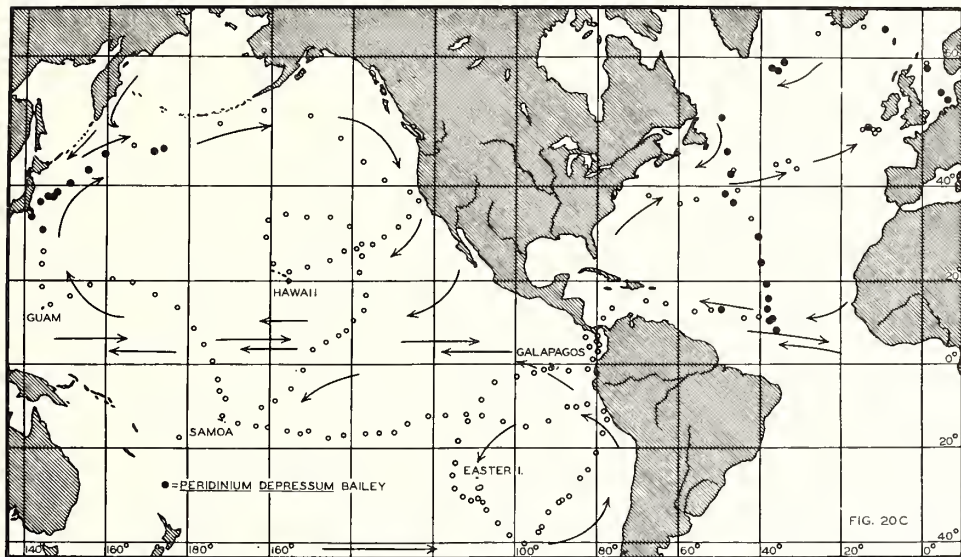
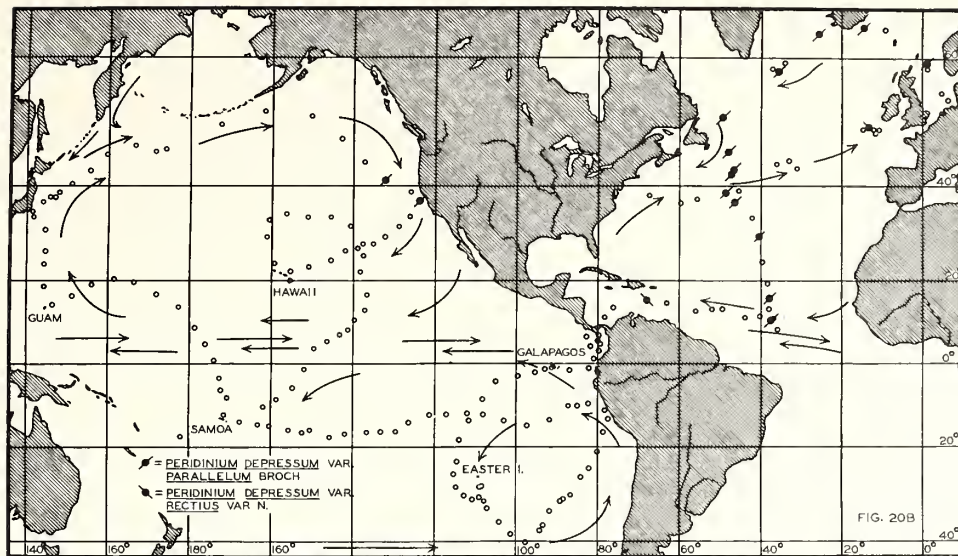


FIGURES 20-B, 20-C, and 20-D

Fig. 20-B. Distribution of species of Peridinium at Carnegie stations.

Fig. 20-C. Distribution of species of Peridinium at Carnegie stations.

Fig. 20-D. Distribution of species of Peridinium at Carnegie stations.



FIGURES 21 - 29

Fig. 21. Peridinium depressum var. parallelum Broch. A, "resting" position; B, ventral view; C, right side view; D, apical view. Magnification:  $\times 230$ .

Fig. 22. Ventral views of four specimens of P. depressum var. parallelum Broch. Magnification:  $\times 230$ .

Fig. 23. Frequency distribution of  $\alpha$  classes in 108 random specimens of P. depressum Bailey and var. parallelum Broch.

Fig. 24. Frequency distribution of  $a/d$  classes in 108 random specimens of P. depressum Bailey and var. parallelum Broch.

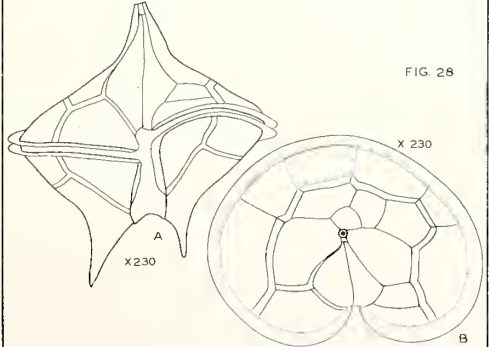
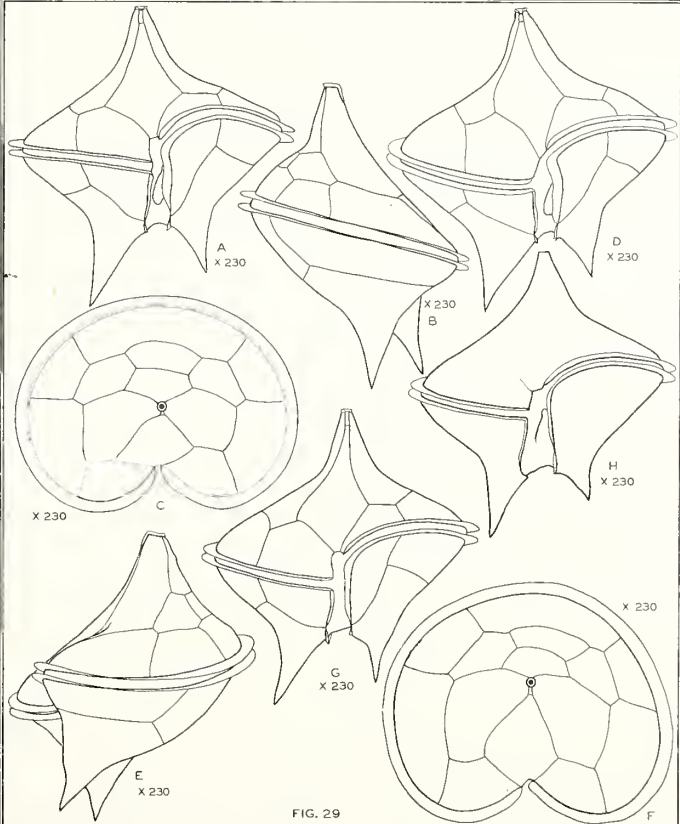
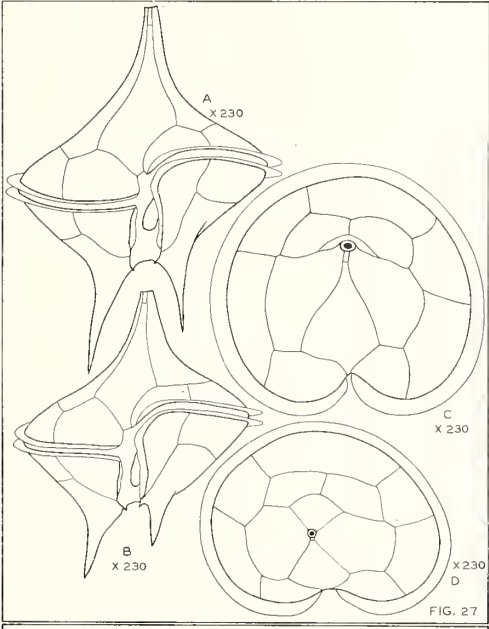
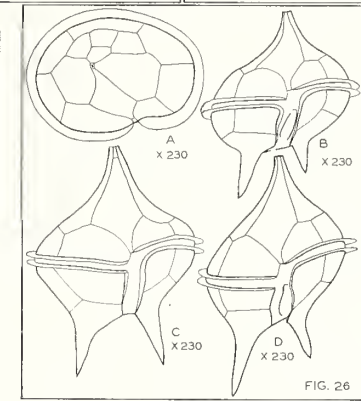
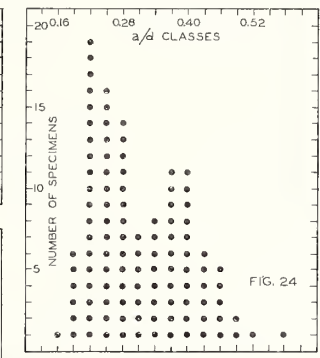
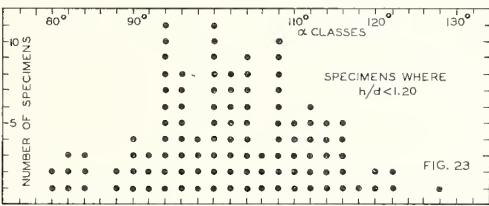
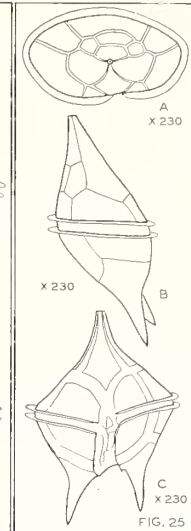
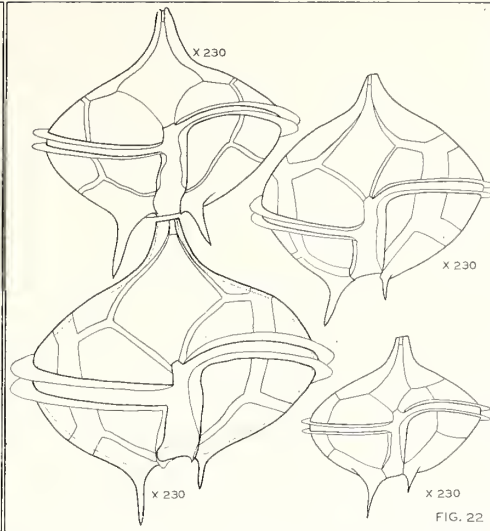
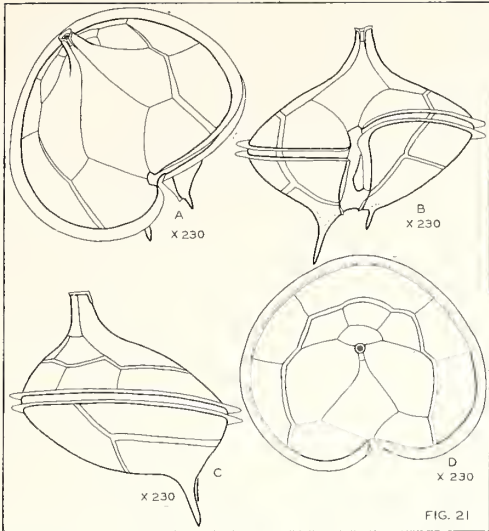
Fig. 25. Peridinium depressum var. rectius n.var. A, apical view; B, right side view; C, ventral view. Magnification:  $\times 230$ . Type specimen from station 32.

Fig. 26. Peridinium depressum var. convexius n.var. A, C, apical and ventral views of type specimen from station 14; B, ventral view of specimen from station 16; D, ventral view of specimen from station 1b. Magnification:  $\times 230$ .

Fig. 27. Peridinium depressum f. bisintercalares n.f. A, B, ventral views of two specimens; C, apical view of A; D, apical view of B. Magnification:  $\times 230$ . A, C, type specimen from station 13.

Fig. 28. Peridinium depressum f. multitabulatum n.f. A, ventral view; B, apical view. Magnification:  $\times 230$ . Type specimen.

Fig. 29. Peridinium claudicanoides n.sp. A-C, ventral, right side, and apical views of same specimen; D-F, ventral, left side, and apical views of a second specimen; G, H, ventral views of two other specimens. Magnification:  $\times 230$ . A-C, type specimen from station 2 (S. 14); D-F, from station 3 (S.19); H, from station 2 (S. 14); G, from station 1-A (S. 5).



FIGURES 30 - 36

Fig. 30. Peridinium oceanicum Vanhöffen. A, in "resting" position in bottom of drop of mounting medium; B, apical view; C, ventral view; D, right side view. Magnification:  $\times 230$ .

Fig. 31. Frequency distribution of length classes in 82 random specimens of P. oceanicum and its variants.

Fig. 32. Peridinium oceanicum var. tenellum n.var. A, apical view; B, right side view; C, ventral view. Magnification:  $\times 230$ . Type specimen.

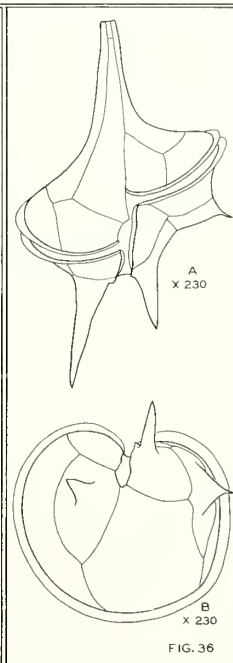
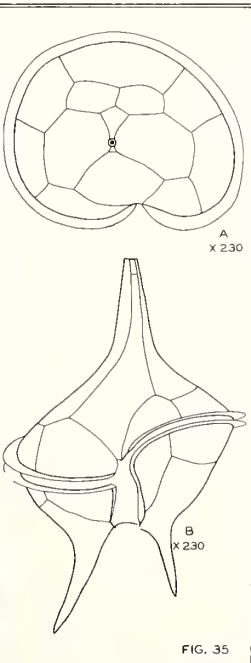
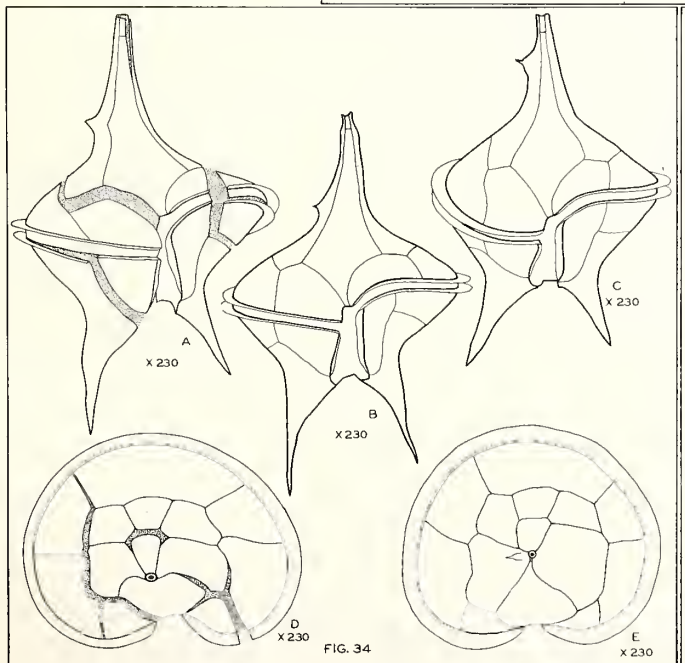
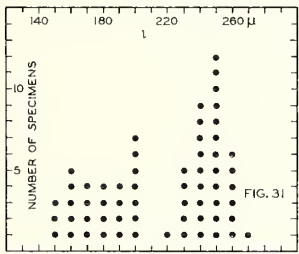
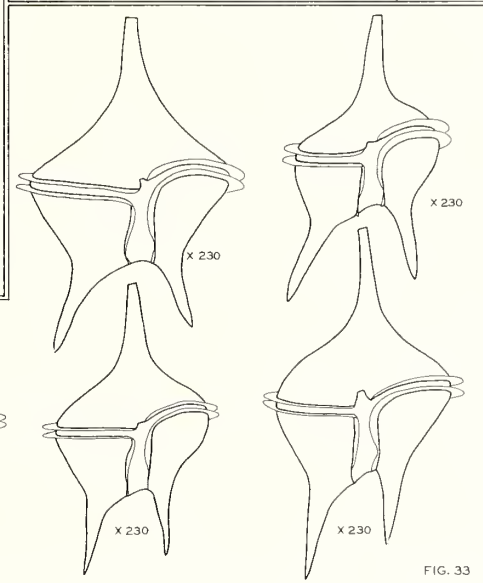
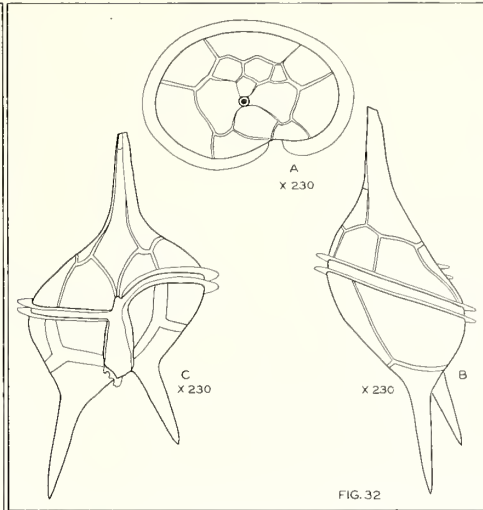
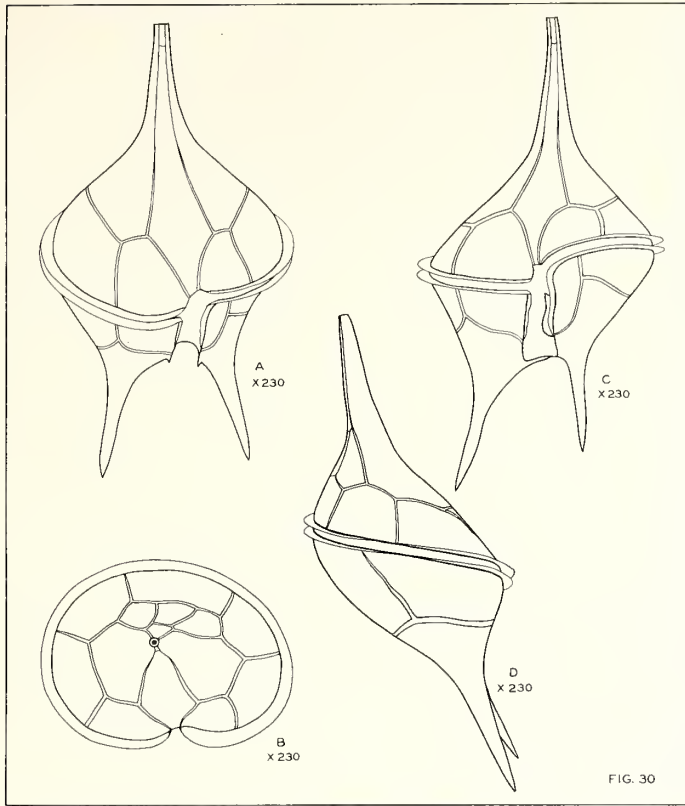
Fig. 33. Variations in body shape in P. oceanicum var. tenellum n.var. Magnification:  $\times 230$ .

Fig. 34. A, B, C, ventral views of three specimens of P. oceanicum f. spiniferum n.f.; D, apical view of A; E, apical view of C. Magnification:  $\times 230$ . A, D, from station 13 (S. 85); B, from station 13 (S. 86); C, E, from station 13 (S. 85).

Fig. 35. Peridinium oceanicum f. bisintercalares n.f. A, apical view; B, ventral view. Magnification:  $\times 230$ . Type specimen.

Fig. 36. Peridinium oceanicum f. tricornutum n.f. A, ventral view; B, antapical view. Magnification:  $\times 230$ .



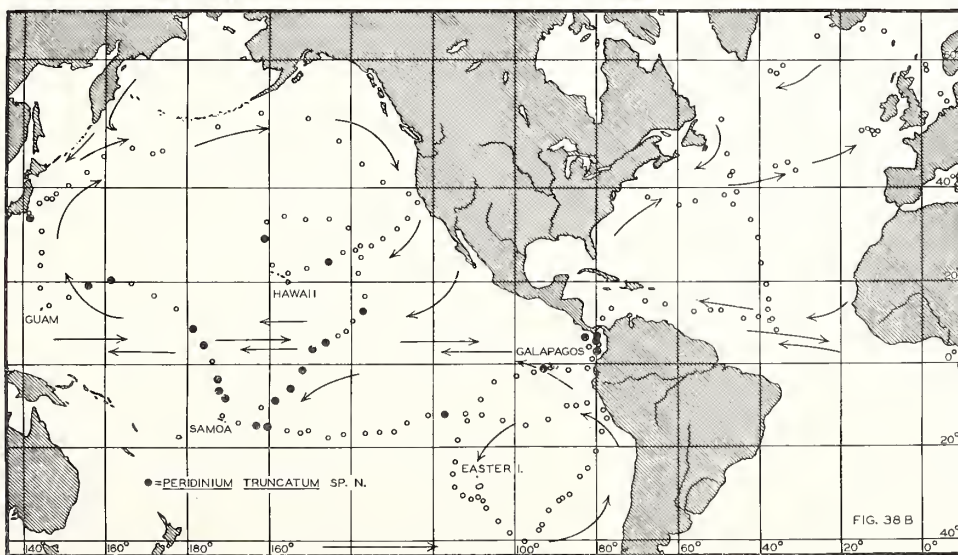
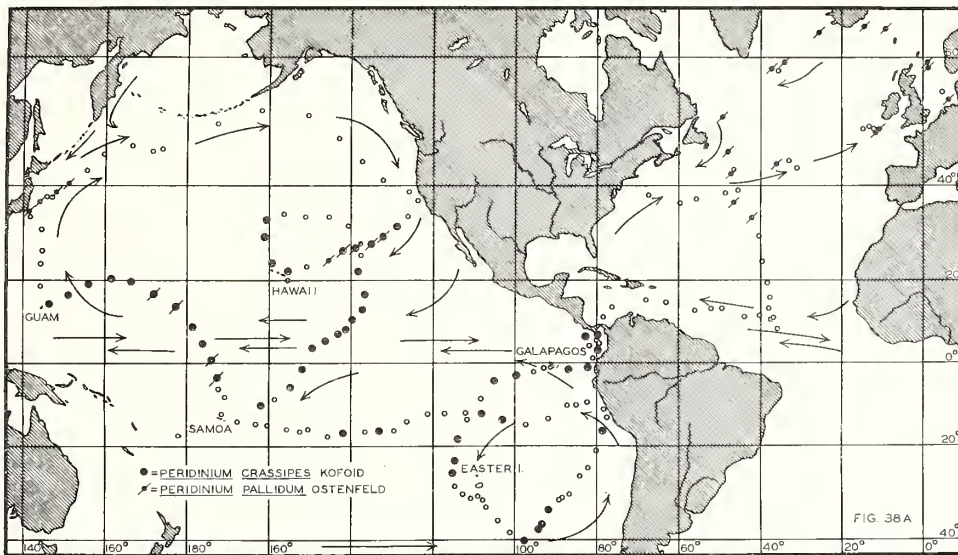
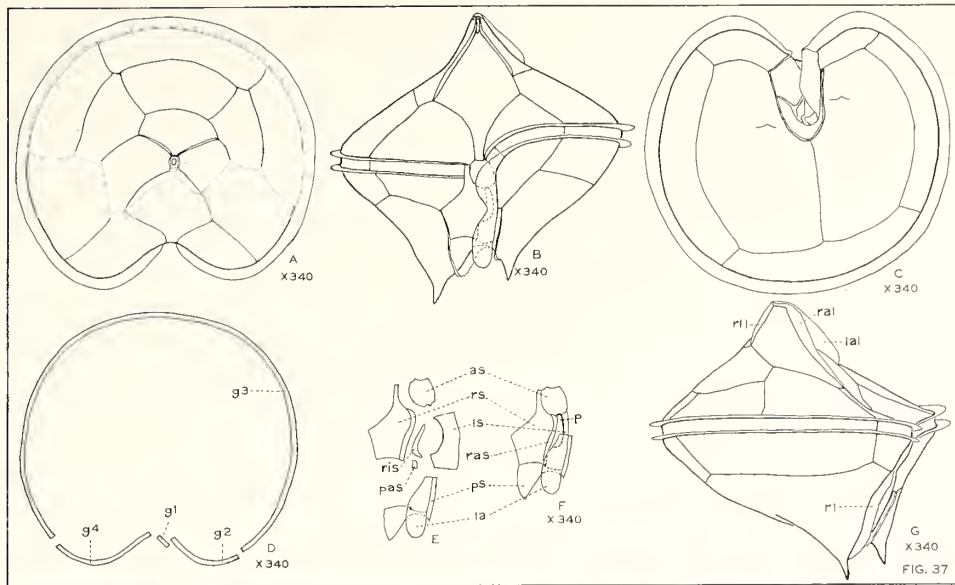


FIGURES 37, 38-A, and 38-B

Fig. 37. Peridinium crassipes Kofoid from station 99 (sample 590). A, apical view; B, ventral view; C, antapical view; D, apical view of separated girdle plates; E, ventral view of separated sulcal plates; F, ventral view of undissected sulcal complex; rabbit membranes not shown; G, right lateral view. Magnification:  $\times 340$ . Symbols: as, anterior sulcal plate; g1-g4, first to fourth girdle plates; la, left accessory sulcal list; lal, left segment of apical list; ls, left sulcal plate; p, flagellar pore; pas, posterior accessory sulcal plate; ps, posterior sulcal plate; ral, right segment of apical list; ras, right accessory sulcal list; ris, right internal sulcal plate; rl, right sulcal list; rll, right lateral list; rs, right sulcal plate.

Fig. 38-A. Distribution of Peridinium crassipes and Peridinium pallidum at Carnegie stations.

Fig. 38-B. Distribution of Peridinium truncatum at Carnegie stations.



FIGURES 39 - 42

Fig. 39. Peridinium truncatum n.sp. A, apical view of specimen from station 35 showing epithelial plate pattern and cross ribs in anterior cingular list; B, antapical view of same with sulcal elements labeled; C, dissection of apex; D, dissection of ventral area and adjacent plates; E, ventral view of specimen shown in A; F, left lateral view of separated right sulcal plate showing internal processes and right accessory sulcal list; G, separated girdle plates; cross ribs on outer surface of girdle plates indicated for only small part of one plate; H, right lateral view of specimen shown in A. Magnification:  $\times 340$ . Symbols: a, anterior internal sulcal process; ant1, ant2, first and second antapical plates; ap1-ap4, first to fourth apical plates; as, anterior sulcal plate; dl, dorsal segment of apical list; g1-g4, first to fourth girdle plates; lal, left segment of apical list; la, left accessory sulcal list; ll, left sulcal list; ls, left sulcal plate; p, posterior internal sulcal process; pas, posterior accessory sulcal plate; pal, posterior accessory sulcal list; pl, posterior sulcal list; po1, po5, first and fifth postcingular plates; pp, apical pore platelet; pr1, pr7, first and seventh precingular plates; ps, posterior sulcal plate; ral, right segment of apical list; ras, right accessory sulcal list; rs, right sulcal plate; vp, ventral apical platelet. Type specimen.

Fig. 40. A, B, Peridinium truncatum n.sp. A, apical view of specimen with intercalary zones from station 91; B, ventral view of same. C, D, Peridinium truncatum forma acutum, n.f.; C, ventral view; D, apical view of same. Magnification:  $\times 230$ . C, D, type specimen, from station 104.

Fig. 41. Ventral area and adjacent regions in P. truncatum n.sp. Magnification:  $\times 270$ . (Cf. figs. 39D, E.)

Fig. 42. Peridinium pallidum Ost. A, ventral view of specimen from station 13; B, apical view of same; C, antapical view of same; D, dorsal view of same; E, right lateral view of same; F, apical view of separated girdle plates; G, detail of distal end of girdle; H, dissection of ventral area and adjacent plates. Magnification: A-F,  $\times 340$ ; G, H,  $\times 770$ . Symbols: all, anterior segment of left sulcal list; ant1, ant2, first and second antapical plates; ap1, first apical plate; arl, anterior segment of right sulcal list; app, apical pore platelet; as, anterior sulcal plate; dl, dorsal segment of apical list; g1-g4, first to fourth girdle plates; i, intercalary zone; lal, left segment of apical list; ll, left lateral list; ls, left sulcal plate; pas, posterior accessory sulcal plate; pl, posterior sulcal list; pll, posterior segment of left sulcal list; po1, po5, first and fifth postcingular plates; prl, posterior segment of right sulcal list; pr1, pr7, first and seventh precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; ral, right segment of apical list; ras, right accessory sulcal list; rll, right lateral list; rs, right sulcal plate; vap, ventral apical platelet; 1'-4', first to fourth apical plates; 1a, 3a, first and third anterior intercalary plates; 1'', 6'', first and sixth precingular plates.

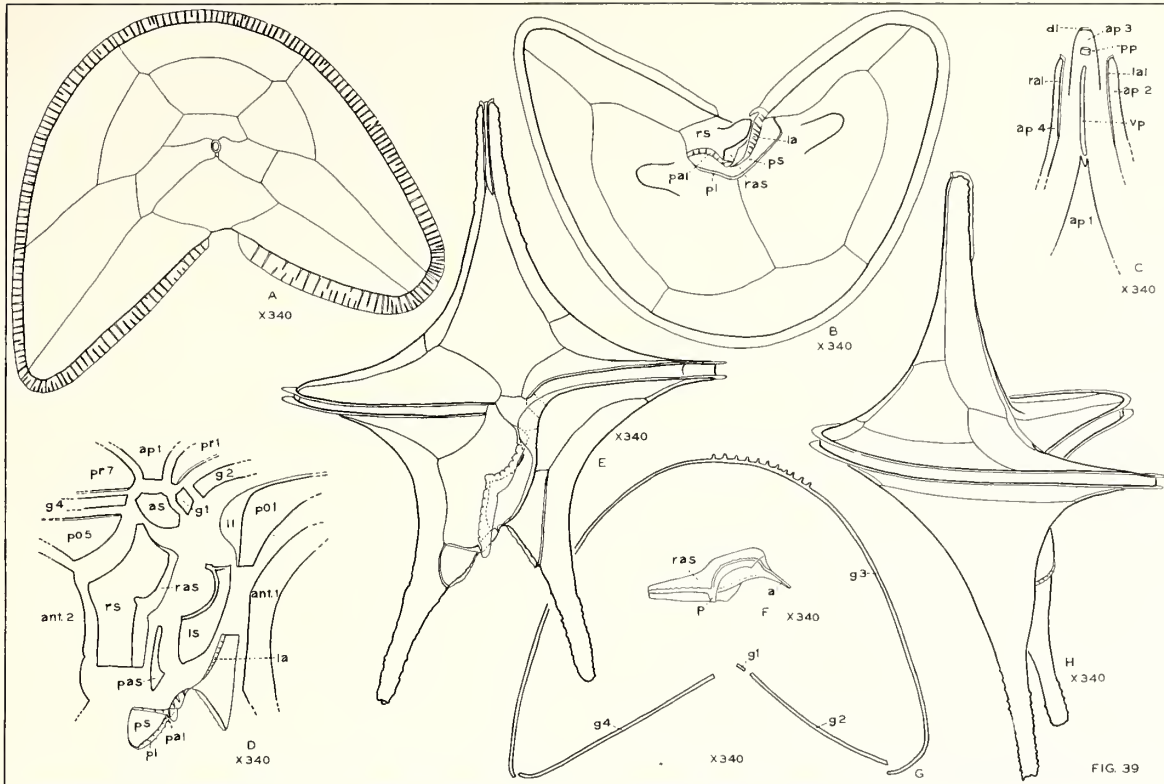


FIG. 39

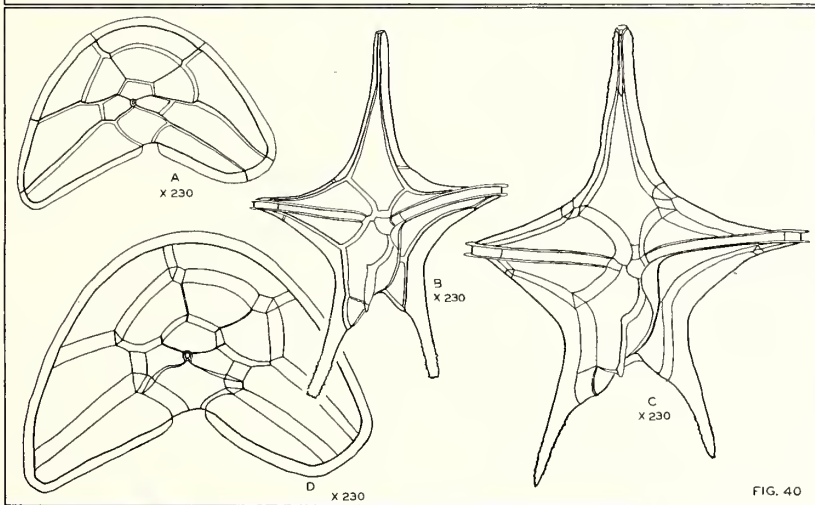


FIG. 40

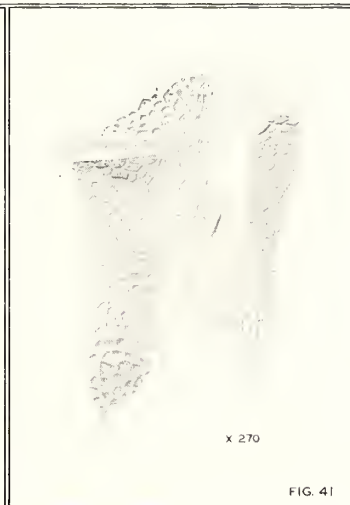


FIG. 41

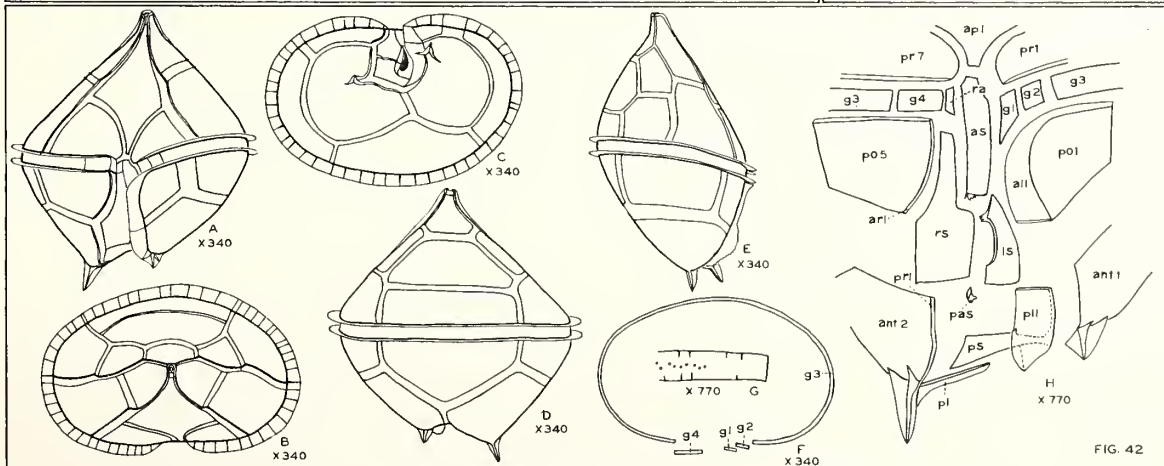


FIG. 42

FIGURES 43 - 46

Fig. 43. Peridinium pallidum Ost. A, anteroventral view of apex; B, latero-posteroventral view of ventral area and adjacent regions; C, diagram of same; D, diagram of A. Magnification: A, D,  $\times 810$ ; B, C,  $\times 660$ . (For symbols, see fig. 42.)

Fig. 44. Skeletal dissection of Ceratocorys horrida Stein. A, in ventral view; B, in apical view. Symbols: a1, a2, first and second anterior intercalary plate; ac, anterior cingular list; ant, antapical plate; ap1, ap2, first and second apical plate; as, anterior sulcal plate; ep, ventral epithecal pore; g1, g2, g5, g6, first, second, fifth, and sixth girdle plates; ls, left sulcal plate; pc, posterior cingular plate; pi, posterior intercalary plate; pl, apical pore platelet; po1-po3, po6, first to third, and sixth postcingular plates; pr1-pr5, first to fifth precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; rs, right sulcal plate; vb, ventral body list; vs, ventral spine.

Fig. 45. Diagram of the dimensions used in the study of body proportions in Ceratocorys. (See p. 36 for explanation.)

Fig. 46. Graphical representation of the relationships of the species of Ceratocorys.

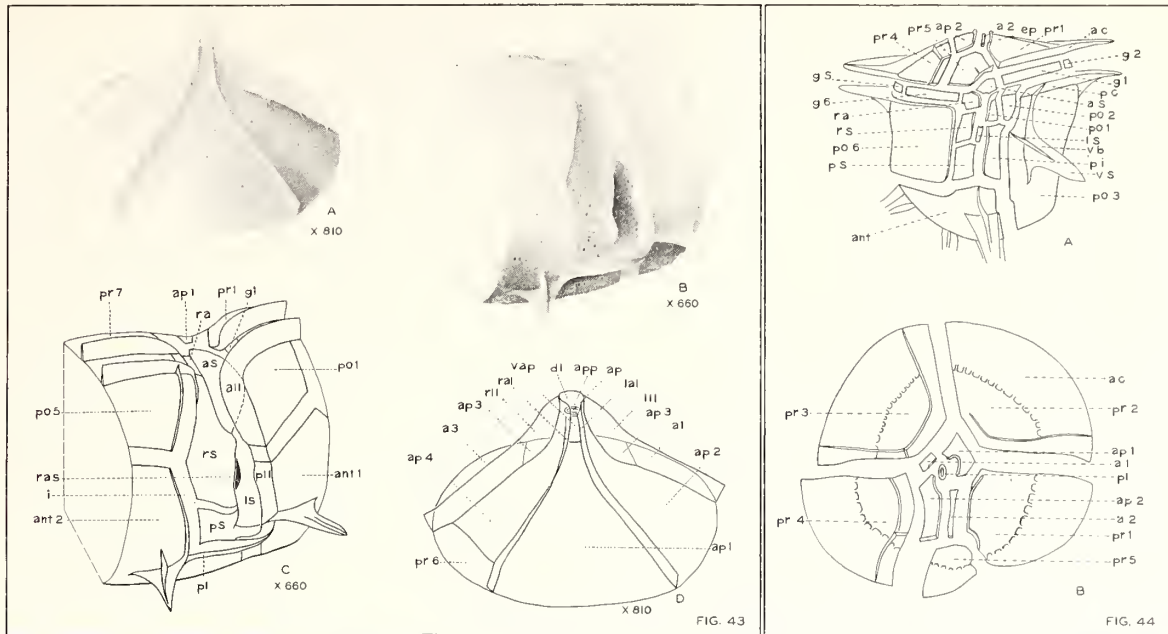


FIG. 43

FIG. 44

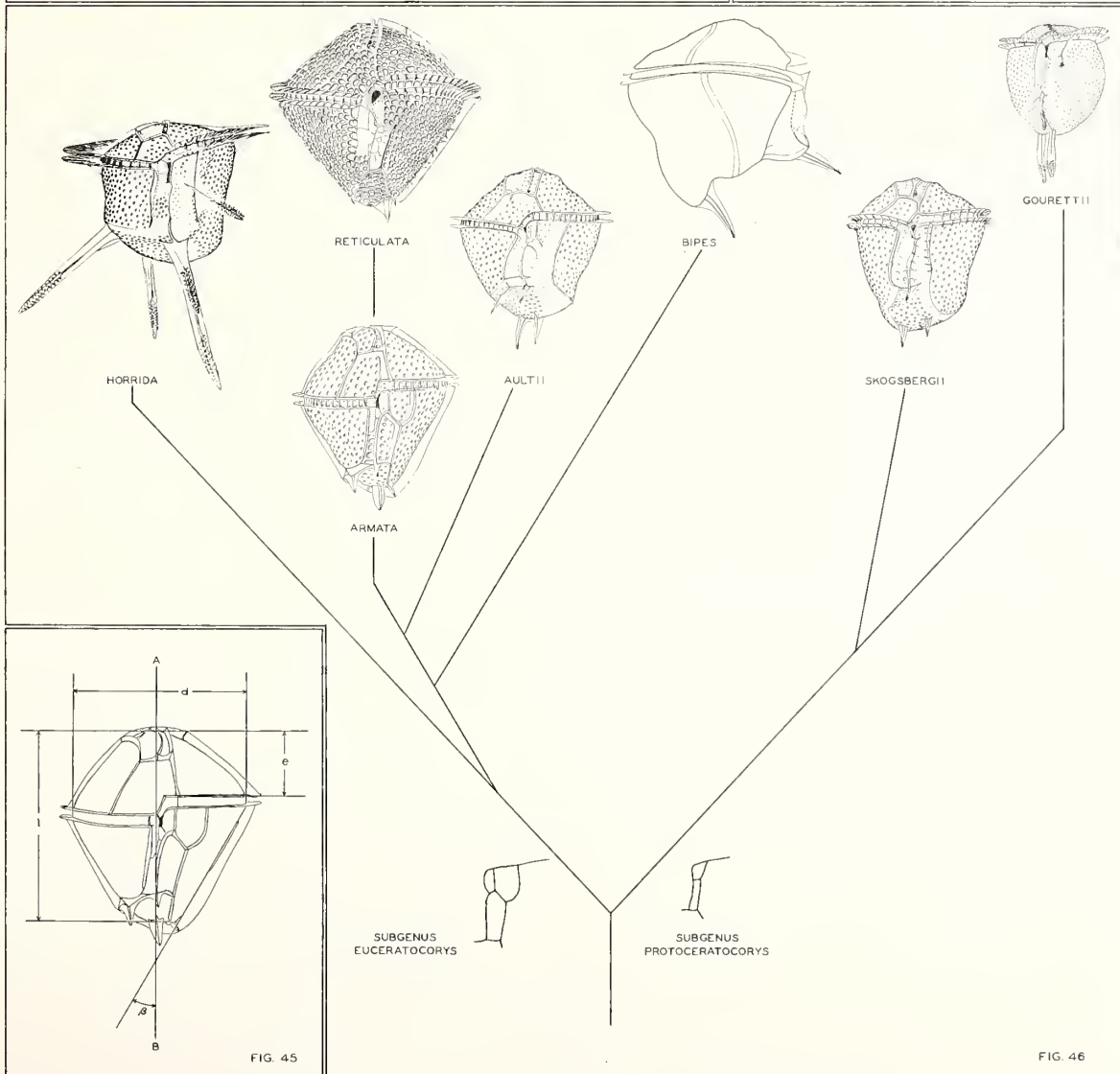


FIG. 45

FIG. 46

FIGURES 47 - 51

Fig. 47. Typical mature Ceratocorys horrida Stein, from station 57. A, antapical view; B, ventral view; C, apical view; D, left lateral view; E, right lateral view. Magnification:  $\times 340$ .

Fig. 48. Daughter cells of Ceratocorys horrida Stein. A, B, C, D, apical, antapical, left lateral, and ventral views, respectively, of left (two-spined) daughter cell with old left moiety and new right moiety, from sample 192; E, F, G, apical, right lateral, and ventral views, respectively, of right (four-spined) daughter cell with old right moiety and new left moiety, from sample 335; H, left daughter cell with directly opposed spines, from sample 256; I, left daughter cell with rather dependent spines, from sample 284. Magnification:  $\times 230$ .

Fig. 49. Ceratocorys horrida Stein. A, long-spined form from sample 278; B, thick-walled, heavily sculptured form from sample 161; C, long-spined form with double dorsal and ventral spines, from sample 272; D, short-spined form with dorsal spine absent, from sample 161; E, anterior view of sixth girdle plate showing the partitioning lists on the girdle; F, short-spined form (hypotheca only) with double dorsal and ventral spines, from sample 240; G, long-spined form, from sample 1; H, short-spined form showing autotomy of the spines; three of the antapical spines have been cast off; the other spines are fracturing; I, J, K, cross sections of bases of dorsal, right, and ventral spines, respectively. Magnification:  $\times 230$ ; except B,  $\times 340$ .

Fig. 50. Thin-walled, spineless specimen of Ceratocorys horrida Stein from sample 284. A, ventral view; B, apical view; surface of pr2-pr4 not shown; C, right lateral view, surface not shown. Magnification:  $\times 340$ .

Fig. 51. Frequency distribution of length of spine in C. horrida.



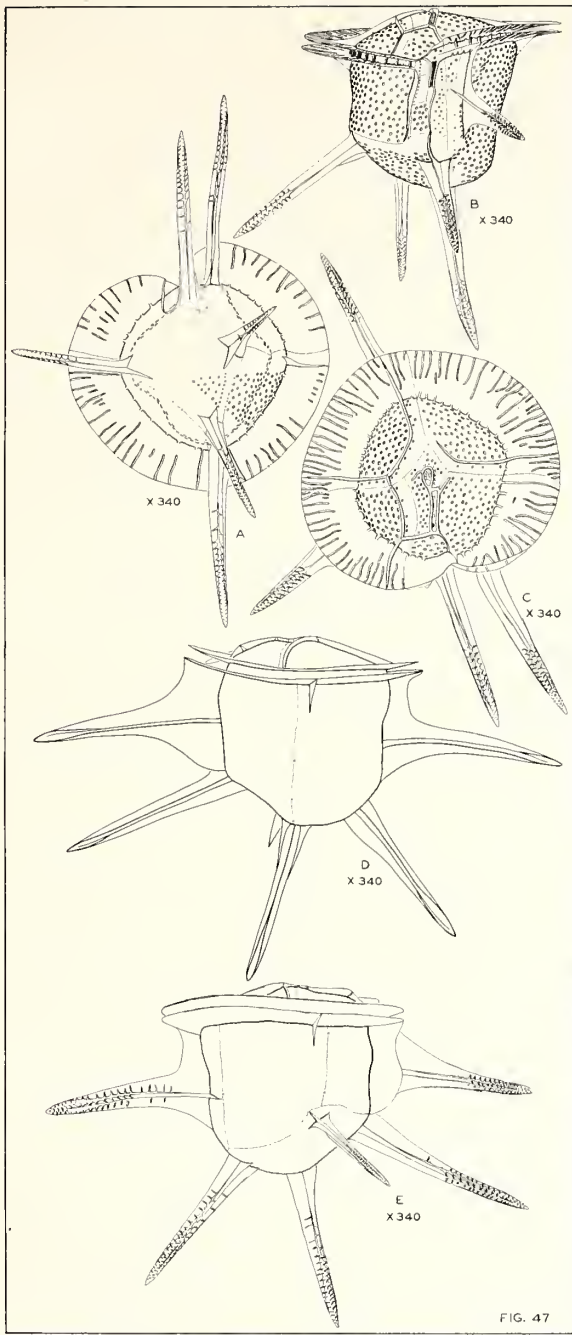


FIG. 47

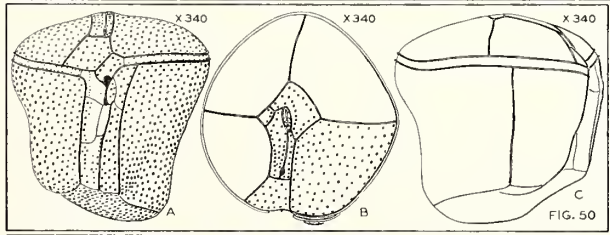


FIG. 50

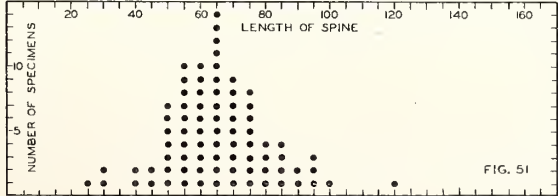


FIG. 51

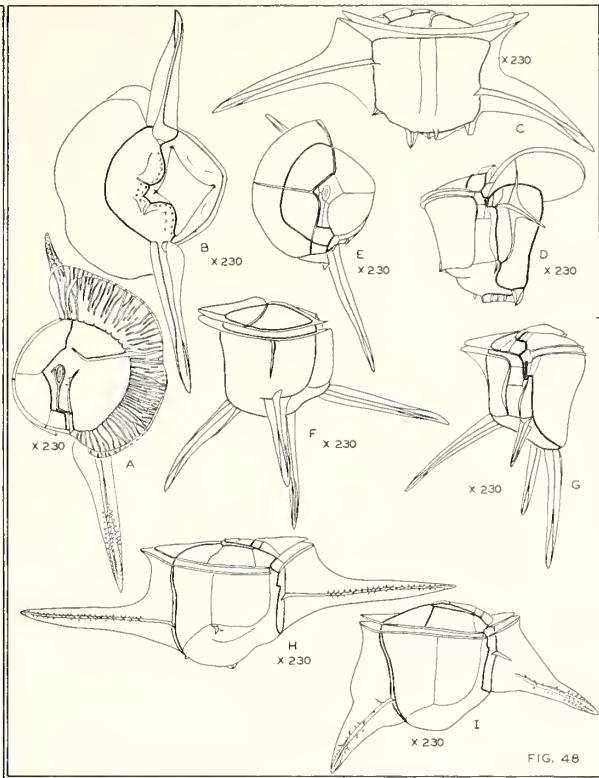


FIG. 48

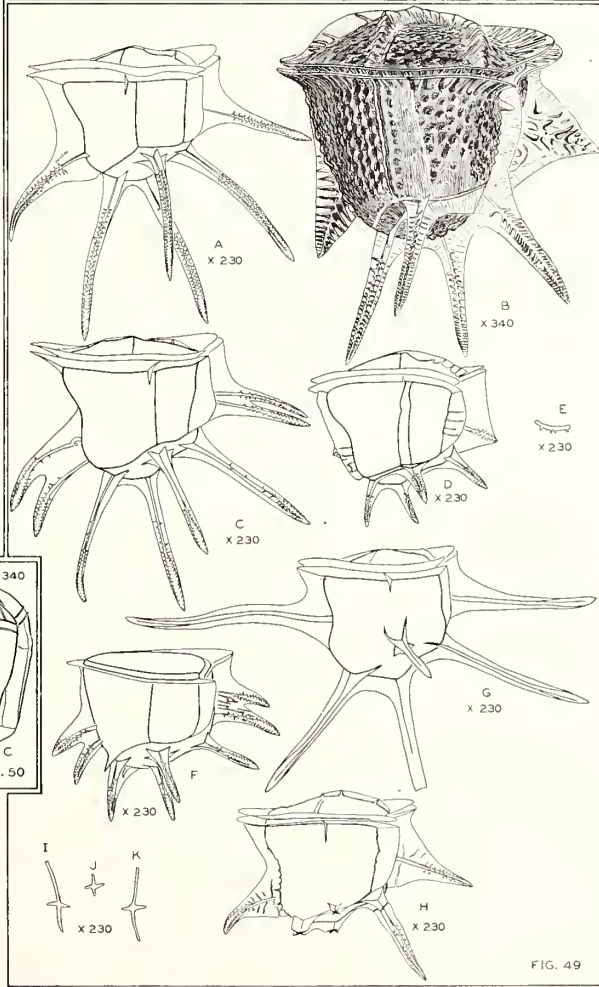


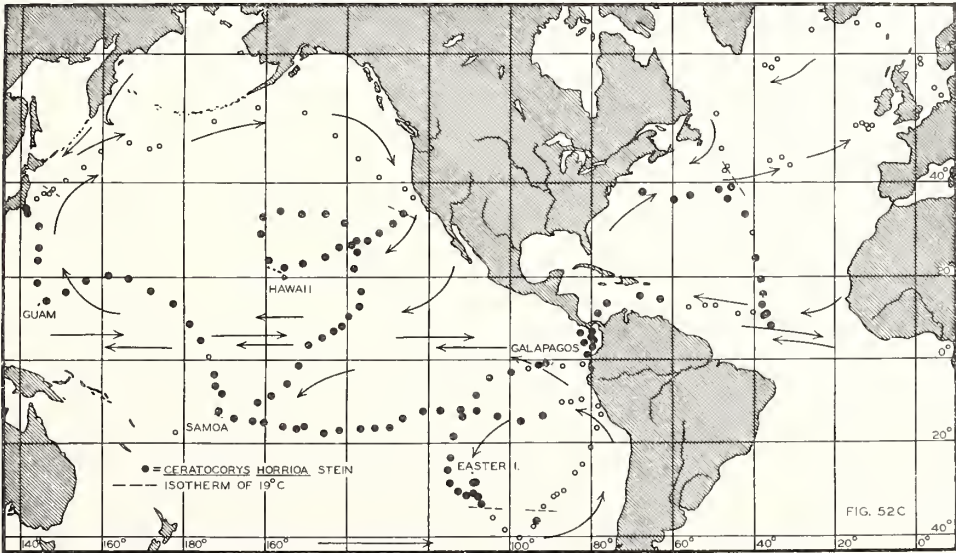
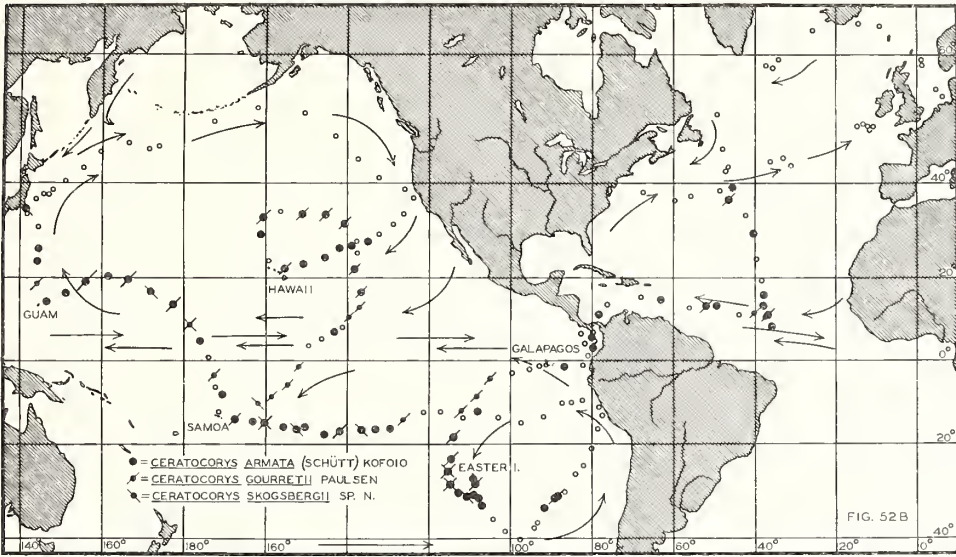
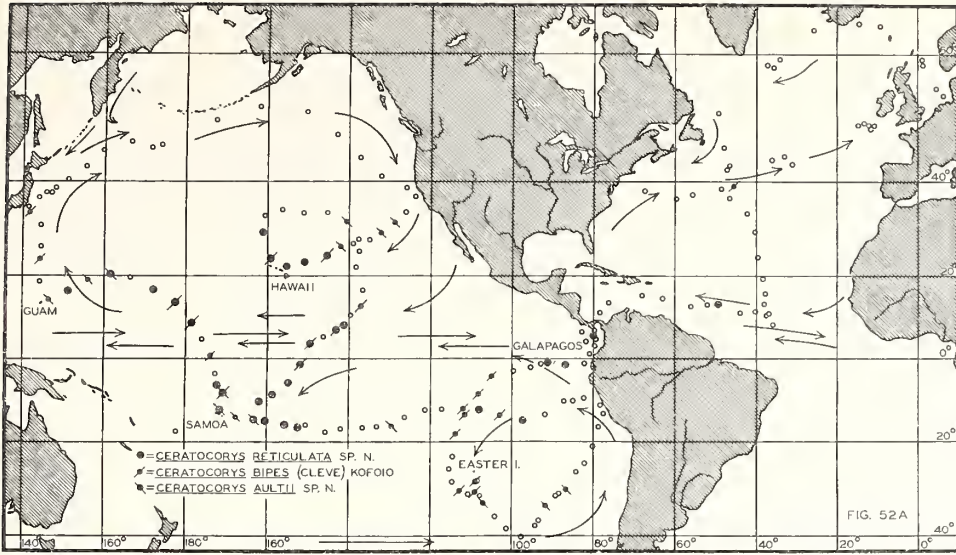
FIG. 49

FIGURES 52-A, 52-B, and 52-C

Fig. 52-A. Distribution of species of Ceratocorys at Carnegie stations.

Fig. 52-B. Distribution of species of Ceratocorys at Carnegie stations.

Fig. 52-C. Distribution of species of Ceratocorys at Carnegie stations.



FIGURES 53 - 56, and 58

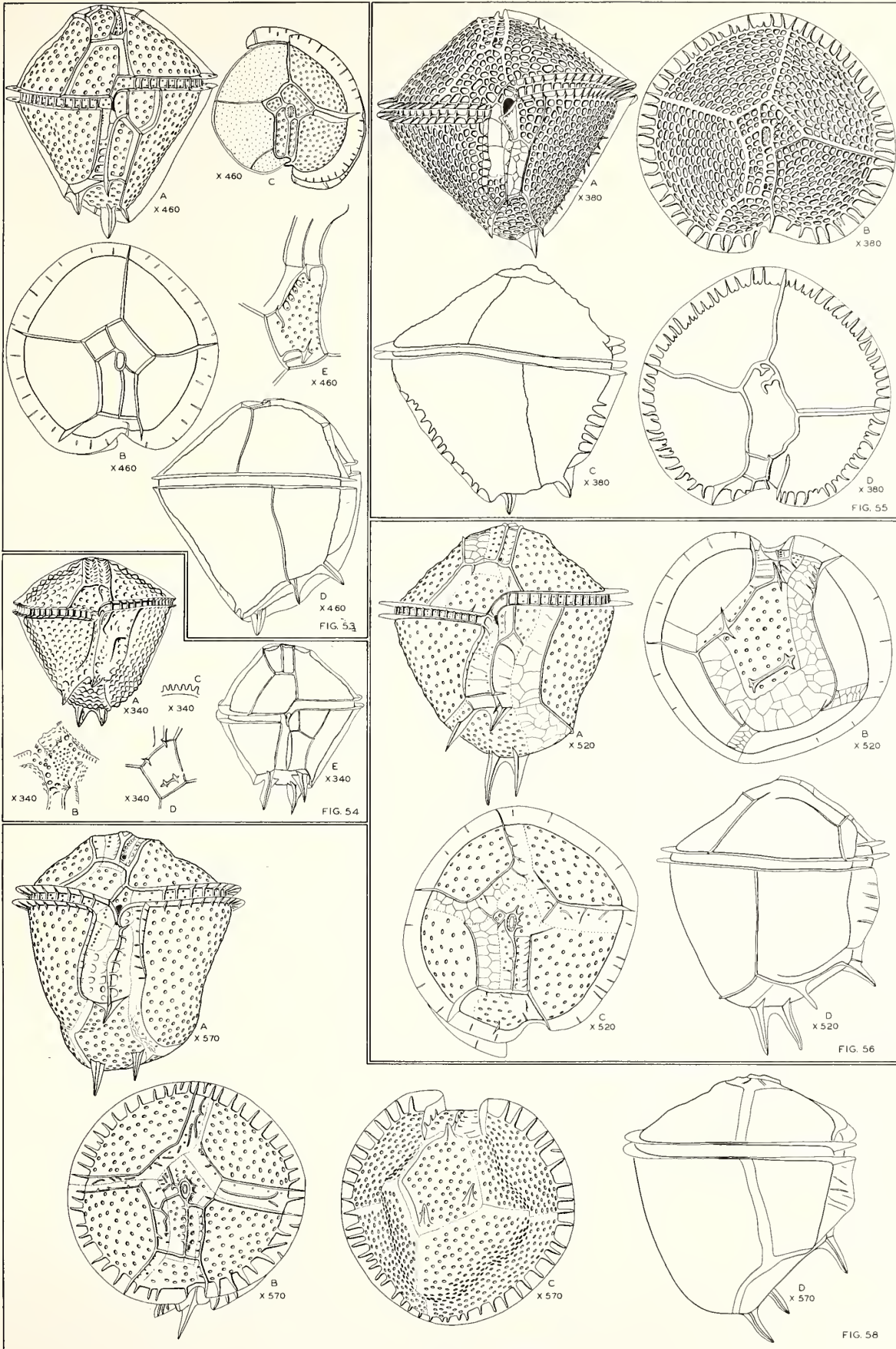
Fig. 53. *Ceratocorys armata* (Schütt) Kofoid. A, ventral view of specimen from sample 271; B, apical view of same; C, apical view of left daughter cell from sample 287; D, right lateral view of specimen in A; E, antapex of same. Magnification:  $\times 460$ .

Fig. 54. *Ceratocorys armata* (Schütt) Kofoid. A, heavy-walled specimen from sample 13, ventral view; B, antapex of same; C, anterior view of a girdle plate showing the heavy, well-developed transverse lists or ridges of the girdle; D, antapex of specimen from sample 99 showing approximation of the left and dorsal antapical spines; E, specimen from sample 290 with unusually long spines; left antapical spine absent. Magnification:  $\times 340$ .

Fig. 55. *Ceratocorys reticulata* n.sp. A, ventral view; B, apical view; C, right lateral view; D, antapical view. Magnification:  $\times 380$ . Type specimen, from sample 177.

Fig. 56. *Ceratocorys aultii* n.sp. A, ventral view; B, antapical view; C, apical view; D, right lateral view. Sutures indicated by dotted lines. Magnification:  $\times 520$ . Type specimen, from sample 337.

Fig. 58. *Ceratocorys skogsbergii* n.sp. A, ventral view; B, apical view; C, antapical view; D, right lateral view. Magnification:  $\times 570$ . Type specimen, from sample 291.



FIGURES 57, 59, and 60

Fig. 57. Ceratocorys bipes (Cleve) Kofoid. A, ventral view of specimen from sample 273; B, apical view of same; C, right lateral view of specimen with abortive spines from sample 257; D, right lateral view of specimen shown in A; E, antapical view of same; F, right lateral view of specimen from sample 330. Magnification:  $\times 520$ .

Fig. 59. Ceratocorys gourretii Paulsen. A, ventral view of specimen from sample 157; B, apical view of same; C, antapical view of same; D, right lateral view of same showing autotomy of dorsal spine; E, left daughter cell from sample 265; F, left lateral view of specimen from sample 402 showing double ventral spine; G, left daughter cell from sample 287; H, fourth postcingular plate from old moiety of specimen shown in E, showing large intercalary zone with scattered pits. Magnification: A-D,  $\times 470$ ; E, G, H,  $\times 340$ ; F,  $\times 290$ .

Fig. 60. Goniodoma polyedricum Pouchet. A, apical view of specimen from station 45; arrows indicate position of girdle sutures; heavy lines indicate position of epithecal sutures; B, antapical view of same; optical section of girdle is shown at fourth postcingular plate only; C, separated precingular plate of heavily sculptured specimen; rabbit membranes indicated; D, separated first precingular showing ventral epithecal pore; E, section of girdle to show excavation; F, undissected sulcal complex; G, separated sulcal elements; H, ventral view of specimen shown in A; I, right view of same. Magnification:  $\times 340$ . Symbols: as, anterior sulcal plate; ls, left sulcal plate; m, rabbit membrane; ps, posterior sulcal plate; ra, right accessory sulcal plate; rs, right sulcal plate.

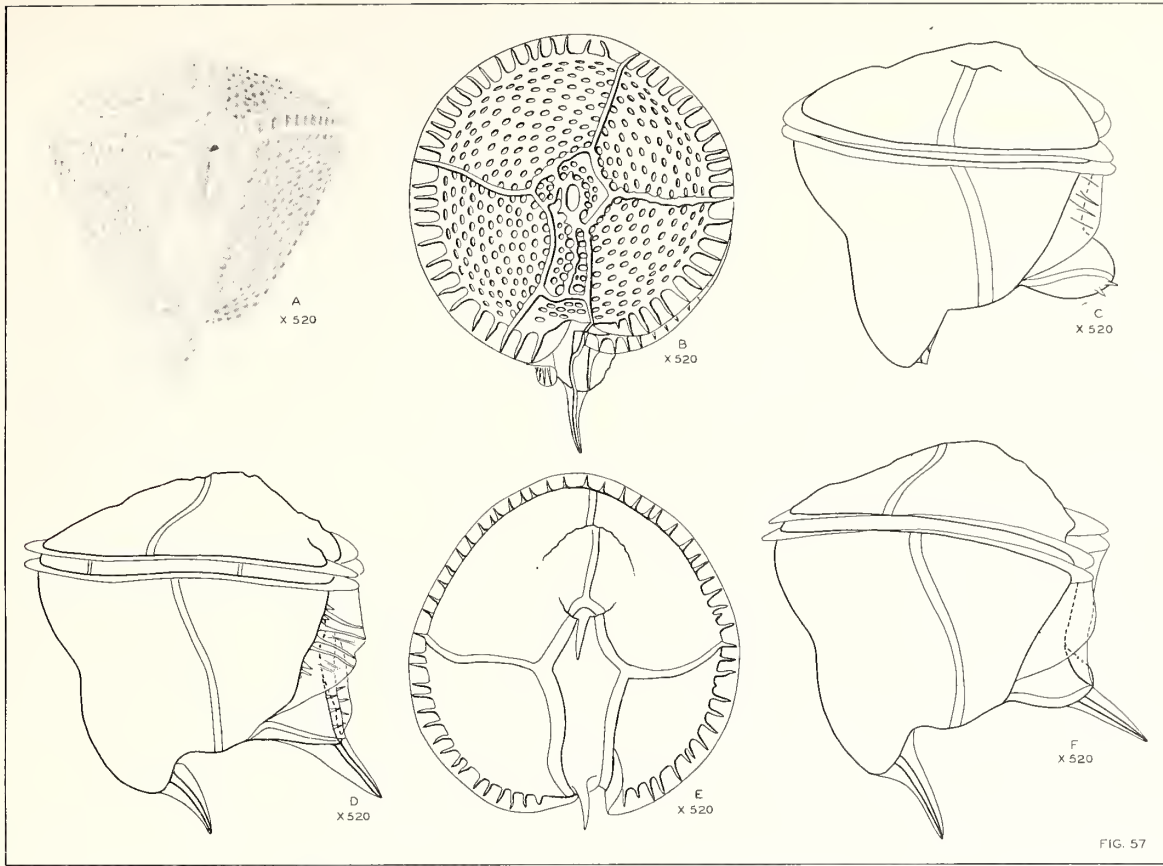


FIG. 57

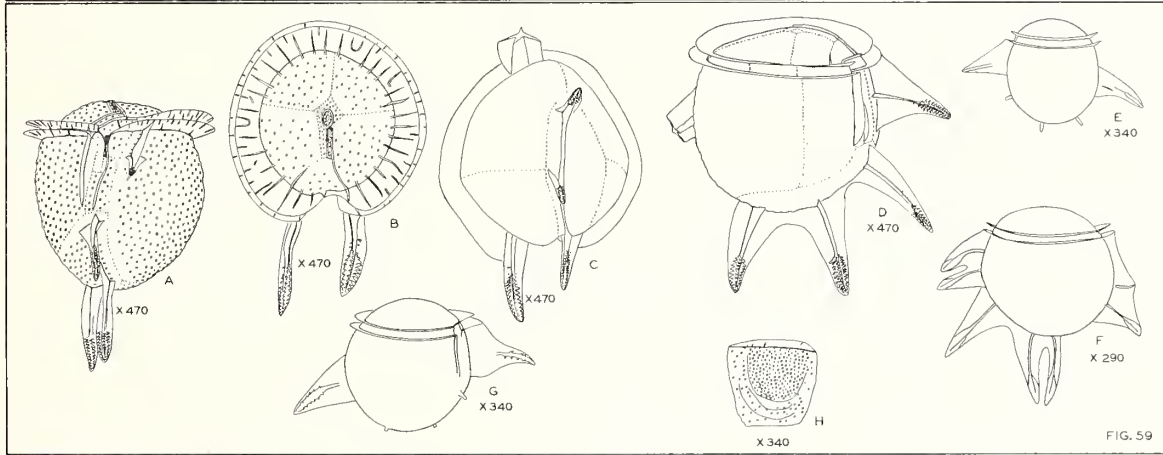


FIG. 59

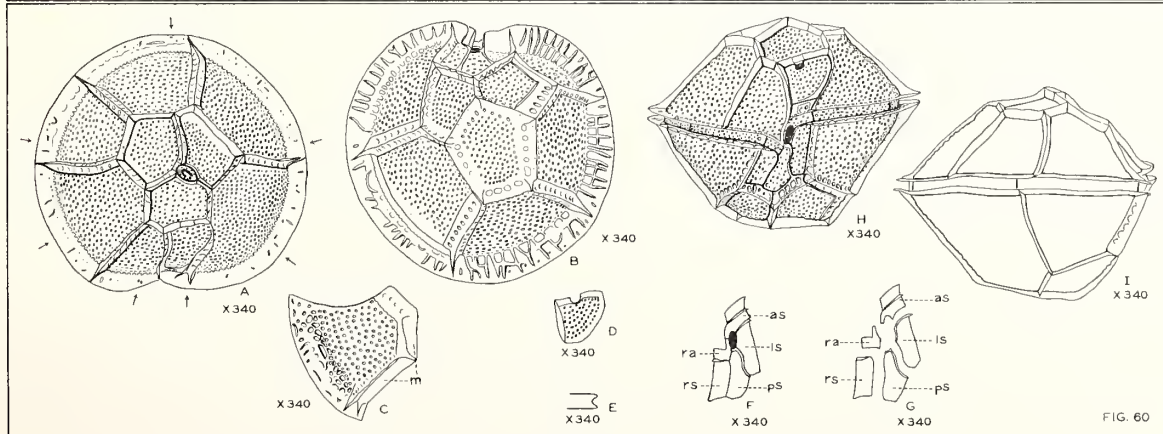


FIG. 60

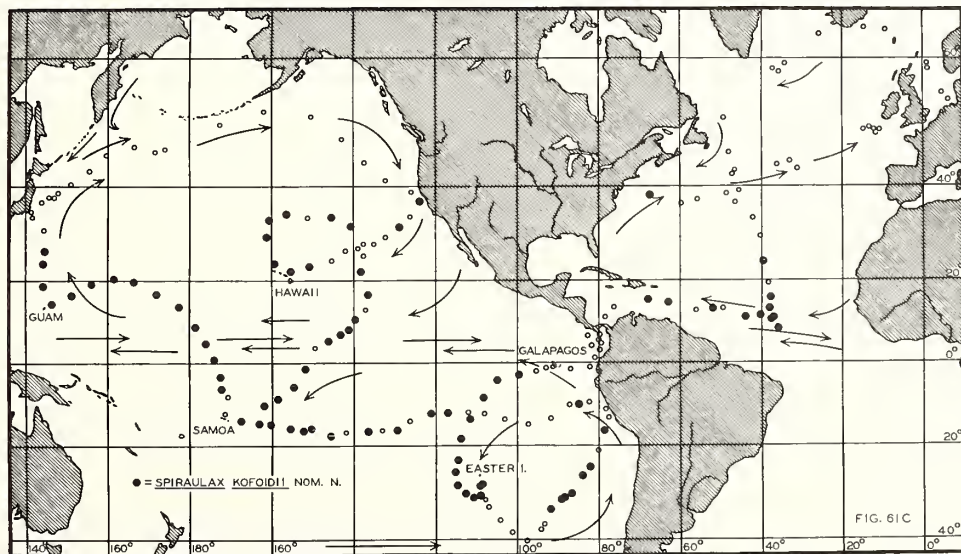
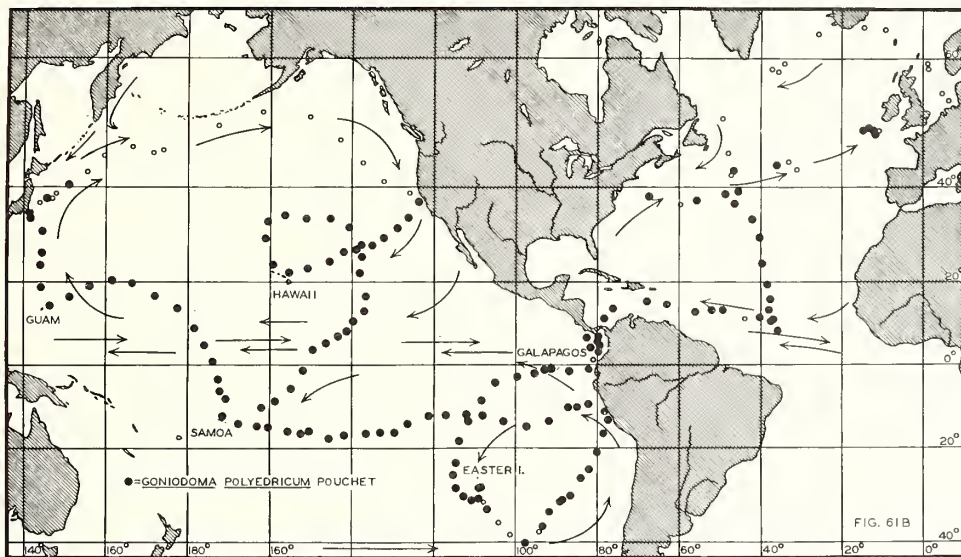
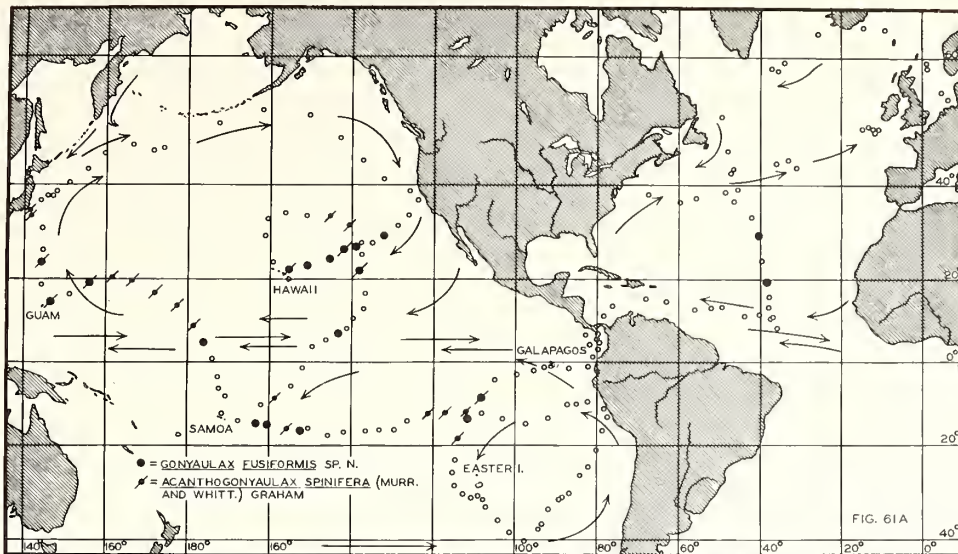
FIGURES 61-A, 61-B, and 61-C

Fig. 61-A. Distribution of species of Gonyaulax and Acanthogonyaulax at Carnegie stations.

Fig. 61-B. Distribution of species of Goniodoma at Carnegie stations.

Fig. 61-C. Distribution of species of Spiraulax at Carnegie stations.



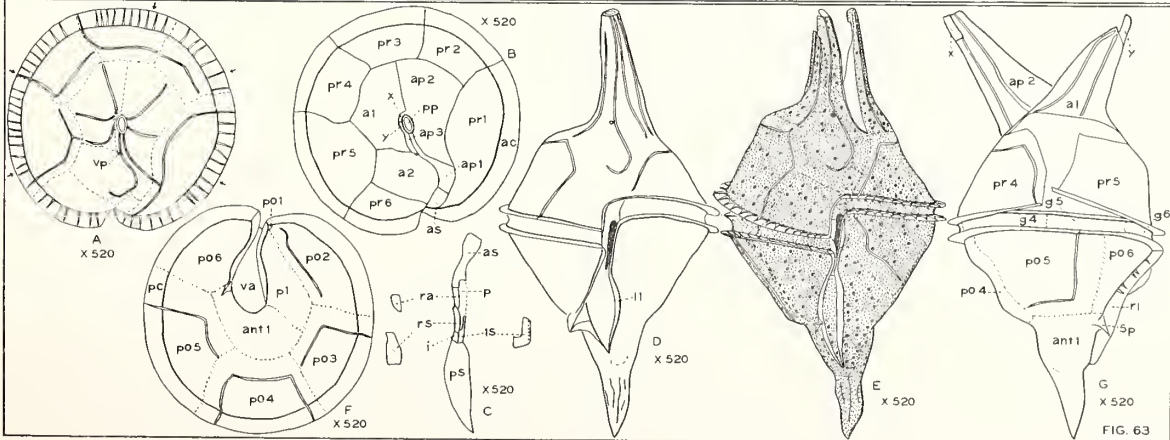
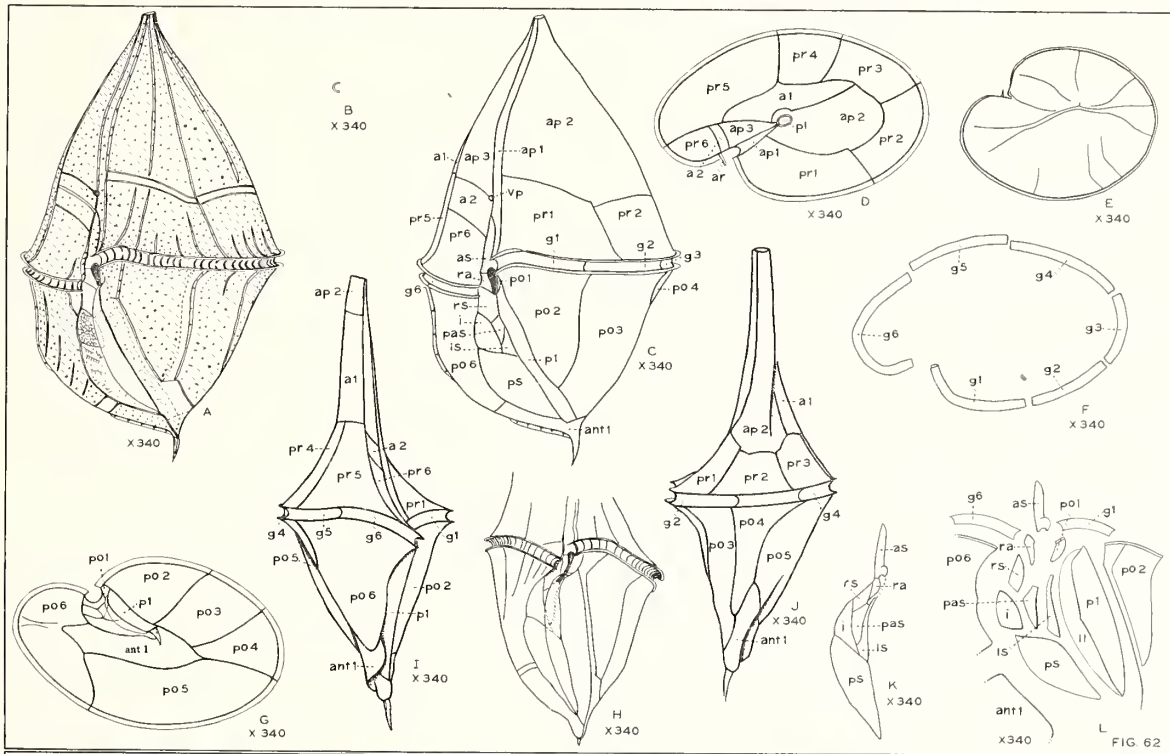
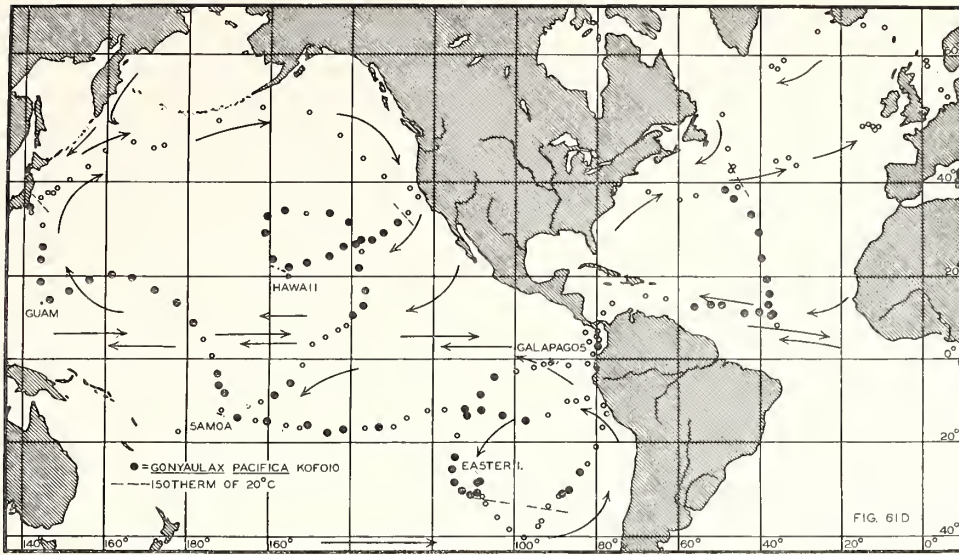


FIGURES 61-D, 62, and 63

Fig. 61-D. Distribution of species of Gonyaulax at Carnegie stations.

Fig. 62. Gonyaulax pacifica Kofoid. A, ventrolateral view of specimen, from station 45; B, cross section of girdle; C, ventrolateral view showing sutures only; D, apical view of same; E, antapical view of specimen from station 22; F, apical view of separated girdle plates; G, antapical view of specimen shown in A; H, true ventral view of specimen from station 49; I, right lateral view of specimen shown in A; J, left lateral view of same; K, ventral view of undissected ventral area; L, ventral view of separated sulcal and adjacent plates. Magnification:  $\times 340$ . Symbols: a1, a2, first and second anterior intercalary plates; ant, antapical plate; ap1-ap3, first to third apical plates; ar, anterior segment of right sulcal list; as, anterior sulcal plate; g1-g6, first to sixth girdle plates; i, intercalary sulcal plate; ll, left sulcal list; ls, left sulcal plate; pas, posterior accessory sulcal plate; po1-po6, first to sixth postcingular plates; pr1-pr6, first to sixth precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; rs, right sulcal plate; vp, ventral epithecal pore.

Fig. 63. Gonyaulax fusiformis n.sp. A, reconstruction of apical view, arrows indicate position of girdle sutures; B, diagram of plate pattern in apical view; C, diagram of the ventral area undissected; three plates also shown separately in their broadest aspect; D, ventral view of specimen from station 18; E, ventral view of another specimen from the same sample; F, antapical view of same specimen; G, right lateral view of same specimen partially dissected, showing inside surface of the second apical plate. Magnification:  $\times 520$ . Symbols: a1, a2, first and second anterior intercalary plates; ac, anterior cingular list; ant, antapical plate; ap1-ap3, first to third apical plates; as, anterior sulcal plate; g4-g6, fourth to sixth girdle plates; i, intercalary sulcal plate; ll, left sulcal list; ls, left sulcal plate; p, flagellar pore; pc, posterior cingular list; p1, posterior intercalary plate; po1-po6, first to sixth postcingular plates; pp, anterior pore platelet; pr1-pr6, first to sixth precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; rl, right sulcal list; rs, right sulcal plate; sp, sulcal spine; va, ventral area; vp, ventral epithecal pore; x, limb of second apical plate; y, limb of third apical plate. E, F, G, type specimen.



FIGURES 64 - 67, and PLATES I-A, I-B, and I-C

Fig. 64. Acanthogonyaulax spinifera (Murray and Whitting) Graham. A, separated plates of the ventral area and adjacent regions; B, ventral view of specimen from station 48; C, antapical view of specimen from station 46; D, diagram of undissected ventral area and first three precingular plates; E, apical view of specimen shown in C; arrows indicate positions of girdle sutures. Magnification:  $\times 470$ . Symbols: ap1-ap3, first to third apical plates; as, anterior sulcal plate; i, intercalary sulcal plate; la, left accessory sulcal plate; ls, left sulcal plate; p, flagellar pore; pl, posterior intercalary plate; po1, po2, po6, first, second and sixth postcingular plates; pr1-pr4, pr8, pr9, first to fourth, eighth, and ninth precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; rs, right sulcal plate; vp, ventral epithelial pore.

Fig. 65. Acanthogonyaulax spinifera (Murray and Whitting) Graham. Ventral view of specimen from station 48. Magnification:  $\times 470$ .

Fig. 66. Spiraulax kofoidii new name. A, diagram of ventral area undissected; B, separated sulcal plates presenting their broadest aspects; sculpturing not shown on ps; C, right lateral view of entire specimen from station 48; D, antapical view of same; E, apical view of same; arrows indicate position of girdle sutures; F, antapical view of sixth girdle plate showing the membrane which lies against the cingular list; G, ventral view of specimen shown in C. Magnification:  $\times 340$ . Symbols: a, anterior intercalary plate; ant, antapical plate; ap1-ap4, first to fourth apical plates; as, anterior sulcal plate; g1-g6, first to sixth girdle plates; i, intercalary sulcal plate; ll, left sulcal list; ls, left sulcal plate; p, flagellar pore; pl, posterior intercalary plate; m, rabbit membrane; pc, posterior cingular list; po1-po6, first to sixth postcingular plates; pr1-pr6, first to sixth precingular plates; ps, posterior sulcal plate; ra, right accessory sulcal plate; rl, right sulcal list; rs, right sulcal plate; va, ventral area.

Fig. 67. Ceratium pavillardii Jørgensen from station 67. A, apical view of right side of body at level of girdle showing end of posterior girdle list, curvature of body at lateral margin, and curvature of horn trough; B, apical platelet; C, ventral view of entire specimen; D, third girdle plate in apical view; E, antapical view of fourth girdle plate; F, distal end of third girdle plate; G, ventral view of body; plates of ventral area not indicated; body pores shown on only part of body; H, dorsal view of body; only few body pores shown; I, four plates of ventral area. Magnification: C,  $\times 50$ ; other figures  $\times 340$ .

Plate I-A. Details of skeletal structure of P. depressum. Ventral area and adjacent regions. Magnification:  $\times 400$ . (Cf. fig. 17.)

Plate I-B. Details of skeletal structure of P. depressum. Detail of ventral area. Magnification:  $\times 730$ . (Cf. fig. 18.)

Plate I-C. Details of skeletal structure of P. depressum. Detail of apex. Magnification:  $\times 670$ . (Cf. fig. 15.)

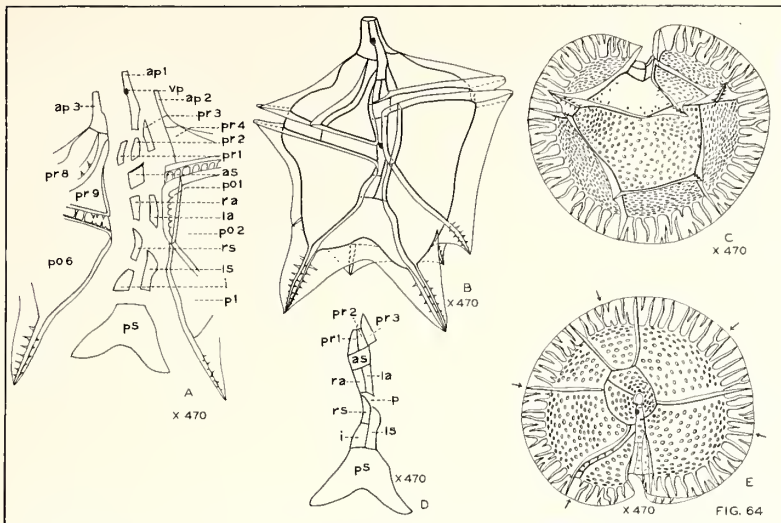


FIG. 64



FIG. 65

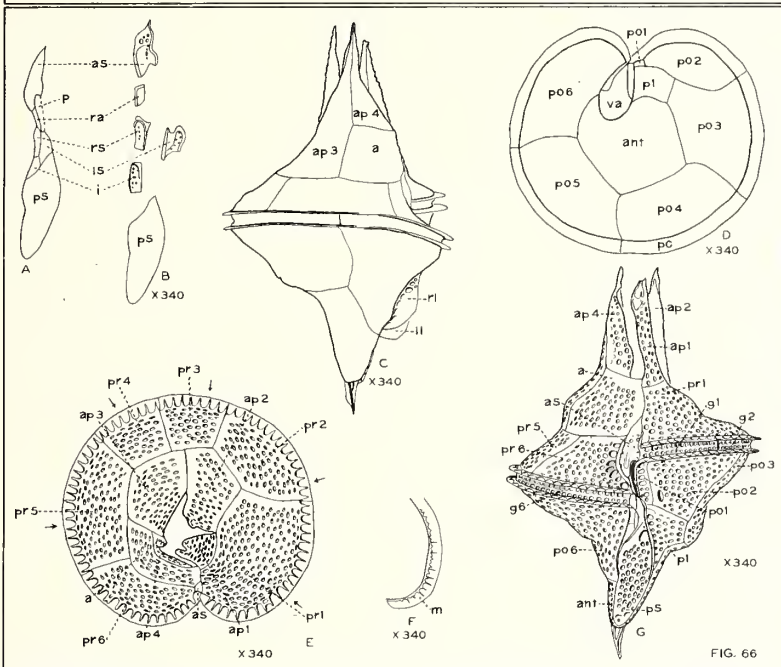


FIG. 66



FIG. 67

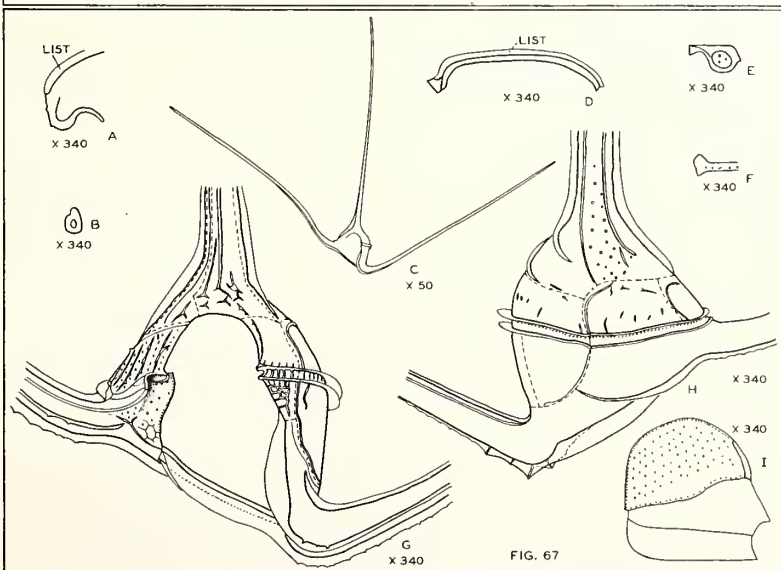


FIG. 67



PLATE I



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