

ICES Identification Leaflets for Plankton

Fiches d'Identification du Plancton

LEAFLET NO. 180

Potentially Toxic Phytoplankton 2. Genus *Dinophysis* (Dinophyceae)

by

JACOB LARSEN and ØJVIND MOESTRUP

Institut for Sporeplanter

University of Copenhagen

Øster Farimagsgade 2D, DK-1353 Copenhagen K, Denmark

Editor

J. A. LINDLEY

Natural Environment Research Council

Plymouth Marine Laboratory

Prospect Place, West Hoe, Plymouth PL1 3DH, England

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

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Dinophysis Ehrenberg, 1839

Introduction

Diarrhetic¹ shellfish poisoning (DSP) has been associated with phytoplankton only for the last few decades. Incidents of seafood poisoning described as DSP were reported from Japan by Yasumoto *et al.* (1978), and the causative organism was later identified as *Dinophysis fortii* (Yasumoto *et al.*, 1980). Similar incidents from the 1960s and 1970s in the Netherlands have been described with *D. acuminata* as the most likely toxin producer (Kat, 1983). Subsequently, several species belonging to the genus *Dinophysis* have been shown to cause DSP, now reported from several parts of the world and posing increasing problems for the seafood industry, especially mussel farming (see, for example, Anderson *et al.*, 1985; Granéli *et al.*, 1990; Shumway, 1990).

Incidents of intoxication are characterized by gastrointestinal disturbances; hence the designation diarrhetic shellfish poisoning. The most characteristic symptoms of DSP intoxication are diarrhoea, nausea, vomiting, abdominal pain, and chill. The symptoms usually appear from 30 minutes to several hours after consumption of contaminated shellfish, and they may last for several days; see also WHO (1984). No one has ever died from DSP. However, some of the DSP toxins may promote stomach tumours and thus produce chronic problems in shellfish consumers (Suganuma *et al.*, 1988).

The DSP toxins: Twelve toxic compounds have been isolated from shellfish so far, nine of which have been characterized chemically. The toxins can be classified

into three groups: okadaic acid (OA) and its derivatives, the dinophysistoxins (dinophysistoxin-1, DTX1; dinophysistoxin-3, DTX3); polyether lactones named pectenotoxins (PTXs); and the yessotoxins (YTXs). Not all the toxins have been isolated from the dinoflagellates (Lee *et al.*, 1989) and it is presumed that a series of chemical changes take place after ingestion by the shellfish. For an overview, see Yasumoto (1990).

To detect DSP contamination in shellfish, bioassays are usually applied. Assays include rat tests, where shellfish are incorporated in the diet of the animals (Lammers, 1961; Kat, 1983); tests of liver cell cultures (Aune, 1989); and, most commonly, mouse tests, where extracts of the shellfish hepatopancreas are injected directly into the animals (Yasumoto *et al.*, 1980). The result of a mouse test is expressed in mouse units, with one unit being the amount of toxin contained in one gram of hepatopancreas that kills a 20-g mouse in 24 hours (MU/g), see Yasumoto *et al.* (1980).

For routine toxicity tests of seafood products, the application of chemical methods would be more satisfactory than bioassays. The mouse tests require large numbers of test animals, and the assay is susceptible to producing false positive results due to contamination, for example by free fatty acids (Lee *et al.*, 1987). This led Lee *et al.* (1987) to develop alternative chemical methods, and they found that OA and DTX-1 can be quantified by high-performance liquid chromatography (HPLC) after treatment with 9-anthryldiazomethane (ADAM). However, this method is apparently still not sufficiently reliable, although it does represent an important step towards a routine chemical technique (Stabell and Cembella, 1990). An immunoassay kit for quick detection of OA and DTX1 has been developed by UBE Industries, Japan (UBE, 1988). The development of new techniques is hampered by the paucity of

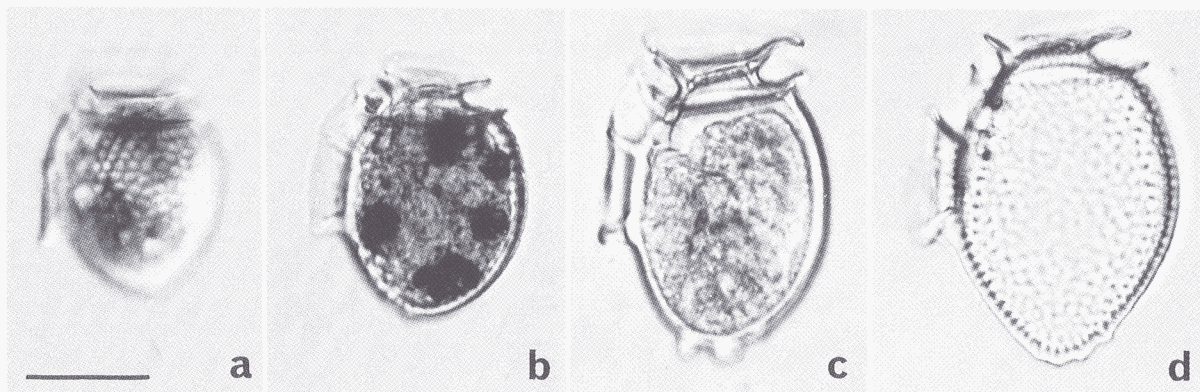


Figure 1a–d: *Dinophysis acuminata*. 1a: live cell; 1b: lugol preserved cell; 1c–d: formaldehyde preserved cells. Material from the Kattegat, Denmark. Scale bar: 20 μ m.

reference standards, and by the failure of the individual methods to detect the full range of toxins. Toxicity levels considerably higher than could be accounted for by OA were thus found by Marcaillou-le Baut and Masselin (1990) in mussels from the French coast.

Description of the genus

The genus *Dinophysis* was described by Ehrenberg (1839) with *D. acuta* as the only, and therefore type, species. Since then more than 200 species of *Dinophysis* and *Phalacroma* (now considered synonyms) have been described (Sournia, 1986). Major taxonomic and floristic accounts include Jörgensen (1923), Kofoed and Skogsberg (1928), Schiller (1933), Tai and Skogsberg (1934), Abé (1967), Balech (1976), Dodge (1982), and Hallegraeff and Lucas (1988).

Species belonging to *Dinophysis* have a cingulum and a sulcus giving the cell a dorso-ventral orientation. The cingulum is located close to the apical end of the cell, and in many species the epicone is not readily visible. Lists (sails) line both furrows with the list on the left side of the sulcus being especially well developed; it is supported by three ribs. Most species are strongly compressed, and the cells are therefore usually seen in lateral view.

The possible taxonomic importance of thecal plate pattern in *Dinophysis* has until recently received little attention. Details were first described by Tai and Skogsberg (1934), and subsequently plate details of a number of species have been added (e.g., Norris and Berner, 1970; Balech, 1976). It appears that species of *Dinophysis* typically possess 18 plates with the following general plate pattern: four epithecal plates, four hypothecal plates, four cingular plates, four sulcal plates which surround the flagellar pore, and two platelets surrounding an apical pore (Norris and Berner, 1970; Balech, 1976; Hallegraeff and Lucas, 1988). In species taxonomy, the posterior sulcal plate has attracted particular attention, thus *D. odiosa* and *D. hastata* are distinguished mainly by the presence of a spine on the posterior sulcal plate of *D. odiosa*. In assessing the importance of plate patterns in *Dinophysis*, it should not be overlooked, however, that the type species, *D. acuta*, apparently possesses only 17 plates, lacking an anterior pore platelet (Balech, 1976). Given the relatively small number of species in which the plate pattern has been scrutinized, and with almost nothing known about clonal or intra-specific variation, it seems premature to separate species on the basis of minor variations in some platelets. With more than 200 species described, many of which cannot be clearly distinguished from the type descriptions, the genus is badly in need of

revision, and plate pattern or perhaps especially thecal ornamentation (Hallegraeff and Lucas, 1988) may prove useful taxonomic characters. The current lack of success in culturing species of *Dinophysis* is, however, a major obstacle to a thorough taxonomic revision.

The most important diagnostic features in *Dinophysis* are size and shape of the cells, morphology of the left sulcal list, presence or absence of chloroplasts, and presumably plate pattern and thecal ornamentation.

Species of *Dinophysis* are widely distributed, but they rarely form red tides. It has been reported that *D. fortii*, at concentrations as low as 200 cells/litre, may lead mussels and scallops to become sufficiently toxic to cause DSP outbreaks (Yasumoto *et al.*, 1980).

The following species which have been shown to be toxin producers (Lee *et al.*, 1989) are described below: *Dinophysis acuminata*, *D. acuta*, *D. fortii*, *D. mitra*, *D. norvegica*, *D. rotundata*, and *D. tripos*. The suspected toxin producers *Dinophysis caudata*, *D. hastata*, and *D. sacculus* are also included. Synonyms are indicated in some cases, but more extensive lists of possible synonyms must await a revision of the genus. It is noteworthy that a heterotrophic species (*D. rotundata*, see below) has now been shown to be toxic. The number of toxic *Dinophysis* species will most likely increase in the future.

Recent ultrastructural studies (Hallegraeff and Lucas, 1988; Schnepf and Elbrächter, 1988; Lucas and Vesik 1990) have revealed unusual cryptophycean-like chloroplasts in several species.

Description of the species

Dinophysis acuminata Claparède & Lachmann, 1859

Fig. 1a-d

Synonyms: *D. lachmannii* Paulsen, 1949; *D. borealis* Paulsen, 1949; *D. boehmii* Paulsen, 1949

Description: The cells are more or less oval, varying from almost rotund to rather elongate, 38–58 µm long, 30–38 µm wide (dorso-ventrally), occasionally with small protrusions on the hypocone. Epicone not visible in lateral view. Theca areolated. Chloroplasts present. This species is best identified by its small size and the usually regular oval outline.

Taxonomic notes: *Dinophysis acuminata* varies considerably in size and shape, and Kofoed and Skogsberg (1928) considered it a collective species. Paulsen (1949) gave specific status to some of the varieties, and his views were partly followed by Solum (1963). Lassus and Bardouil (1991) carried out morphometric measurements on the “*Dinophysis acuminata* complex” (*D. cf. acuminata*, *D. cf. sacculus*, and *D. sp.*), but concluded

that this was not sufficient for precise definition of the species involved. The detailed plate pattern of *D. acuminata* was studied by Balech (1976), who concluded that splitting seems unjustified and that Paulsen's species were best accommodated in *D. acuminata*. This view is followed here. Dodge (1982) indicates that *D. skagii* Paulsen, 1949 may be an aberrant form of *D. acuminata*, see also Balech (1976). The cells encountered in Japanese coastal waters seem to be more rounded and usually without antapical knobs (Fukuyo *et al.*, 1990).

The thecal surface of *D. acuminata* carries a prominent circular areolation (Hallegraeff and Lucas, 1988: fig. 1a). It was studied recently by electron microscopy (Lucas and Vesik, 1990).

Ecology and distribution: The most extensive blooms of *D. acuminata* seem to occur during summer and autumn (Kat, 1989), but attempts to correlate the occurrence of these blooms with environmental factors (temperature, salinity, nutrients) have been unsuccessful (Lassus *et*

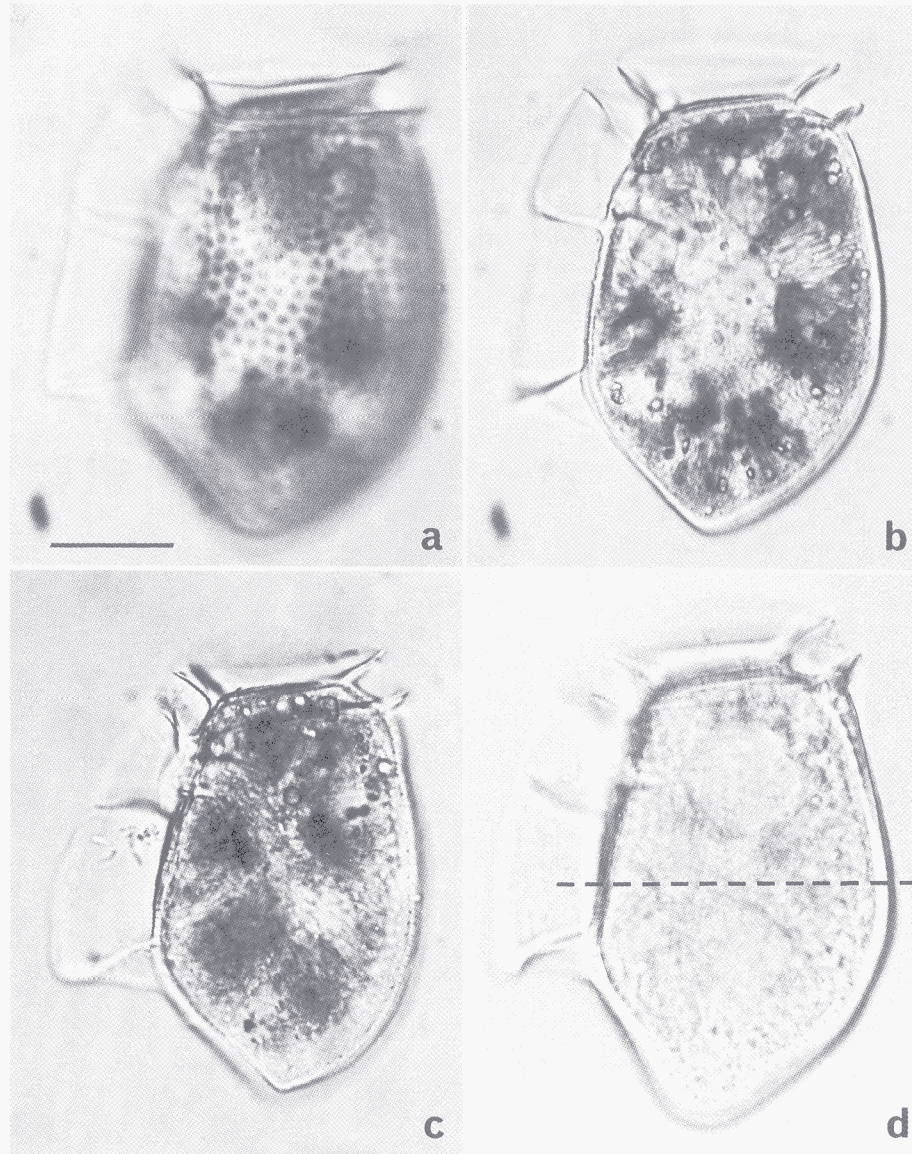


Figure 2a-d. *Dinophysis acuta*. 2a-c: live cells; 2d: formaldehyde-preserved cell; in this species the cells are widest below the middle which has been indicated in the figure. Figure 2a-c, material from the Kattegat; Figure 2d, from the North Sea, Denmark. Scale bar: 20 μ m.

al., 1985; Menesguen *et al.*, 1990). Durand Clement *et al.* (1988) reported on diurnal vertical migration, and pointed out that this should be taken into consideration when conducting monitoring programmes.

Dinophysis acuminata blooms are particularly severe along the coasts of Western Europe. Yearly recurring blooms are now reported from the Netherlands with densities exceeding 40 000 cells per litre (Kat, 1985; 1989). Blooms have also been reported from Australia (Hallegraeff, 1987), Denmark (Bjergskov *et al.*, 1990), France (Lassus *et al.*, 1985), Ireland (Doyle and Dunne; Jowett, cited in Kat, 1985), Japan (Fukuyo *et al.*, 1990), Norway (Dahl and Yndestad, 1985), Spain (see Kat, 1985), Sweden (Krogh *et al.*, 1985), and the USA (Freudenthal and Jijina, 1985).

Toxicology: Lee *et al.* (1989) investigated the toxic potential of *D. acuminata* and found it to be an OA producer. See also Marcaillou-le Baut *et al.* (1985), and Yasumoto (1990).

Dinophysis acuta Ehrenberg, 1839 Fig. 2a–d

Description: The cells are 54–94 µm long, 43–60 µm wide (dorso-ventrally), and among the largest species of

Dinophysis. Hypocone blunt posteriorly. Epitheca not visible in lateral view. The major plates carry a strong areolation. This species is best identified by being widest below the middle. Chloroplasts present.

Taxonomic notes: *Dinophysis acuta* may be confused with *D. norvegica*, see below, but the variation in shape seems less pronounced in *D. acuta* (Balech, 1976). The two species differ in size and shape; *D. norvegica* is widest in the middle region of the cell (compare Figure 2d and 7f).

Several authors (Schiller, 1933; Balech, 1976; Burns and Mitchell, 1982) have noted the close similarity between the warm-water species *D. schroederi* Pavillard, 1909, and *D. acuta*.

Dinophysis acuta from Norwegian waters was investigated in detail by Balech (1976), who described the plate pattern. While many species possess 18 plates, *D. acuta*, the type species, apparently possesses only 17, with the apical platelet reported as missing. Some of the circular plates display considerable variation with regard to the presence of spines. These observations suggest that variation may be expected in the plate pattern both within the genus and within the individual species, but the taxonomic importance of this cannot be assessed at present.

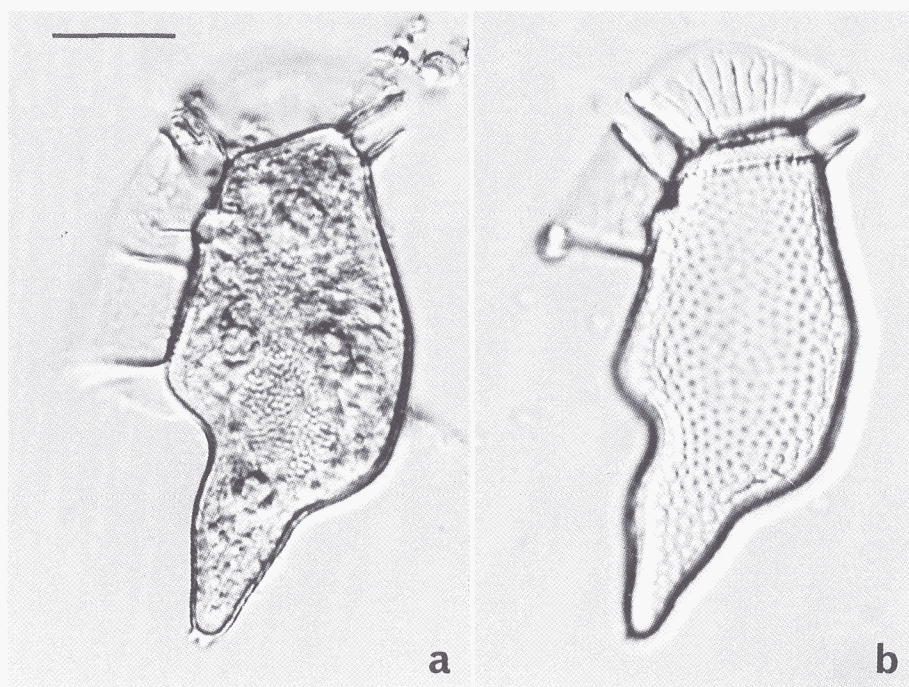


Figure 3a–b. *Dinophysis caudata*. Formaldehyde-preserved cells. Sample from the Adriatic Sea, Italy, kindly provided by Dr G. Socal, Trieste. Scale bar: 20 µm.

Dimorphic cells, with one half resembling *D. acuta* and the other half *D. dens*-like, have occasionally been observed (G. Hansen, pers. comm.; see also Reguera *et al.*, 1990).

Ecology and distribution: *Dinophysis acuta* has been associated with DSP outbreaks in Chile (Hallegraeff, pers. comm.), Portugal (Alvito *et al.*, 1990, Sampayo *et al.*, 1990), Scandinavia (Dahl and Yndestad, 1985; Krogh *et al.*, 1985; Underdal *et al.*, 1985; Edler and Hageltorn, 1990), and the USA (Freudenthal and Jijina, 1985).

Toxicology: The toxic potential of *D. acuta* has been investigated by Lee *et al.*, (1989). It produces OA as well as DTX1. See also Yasumoto (1990).

been reported to form blooms associated with fish mortality in Japan (see Fukuyo *et al.*, 1990).

Toxicology: The toxic potential needs further examination.

Dinophysis fortii Pavillard, 1923 Fig. 4a–c

Description: Cell outline long ovate, 60–70 μm long, 45–55 μm wide (dorso-ventrally). The dorsal side and the antapical end smoothly convex, the ventral side straight. The hypocone with a marked areolation. A distinct reticulation occurs occasionally on the left sulcal list. Chloroplasts present.

Taxonomic notes: *Dinophysis fortii* is best identified by the rounded shape and the reticulations on the sulcal list. It was recently studied electron microscopically by Hallegraeff and Lucas (1988) and Lucas and Veski (1990).

Ecology and distribution: *Dinophysis fortii* was the first species to be associated with DSP (Yasumoto *et al.*, 1980). Yasumoto *et al.* (1980) reported that concentrations of only 200 cells per litre can induce human intoxication. It seems to be most abundant in early summer (Yasumoto *et al.*, 1980; Osaka and Takabayashi, 1985; Igarashi, 1986). Diurnal migration was not observed (Osaka and Takabayashi, 1985; Igarashi, 1986).

In addition to Japan, *Dinophysis fortii* blooms have also been reported from Australia (Hallegraeff, 1987).

Dinophysis caudata Kent, 1881 Fig. 3a–b

Description: Cells 70–110 μm long, typically with a long ventral projection on the hypocone which is usually widest at the basis of the left sulcal list. Thecal plates areolated. The anterior cingular list is supported by ribs and forms a funnel thus hiding the epicone in lateral view. Chloroplasts present.

Taxonomic notes: This species varies considerably and several forms have been described; see Schiller (1933). Some of these have a short dorsal protrusion giving some resemblance to *D. tripos*, see below.

Ecology and distribution: *Dinophysis caudata* is widely distributed in subtropical and tropical waters. It has

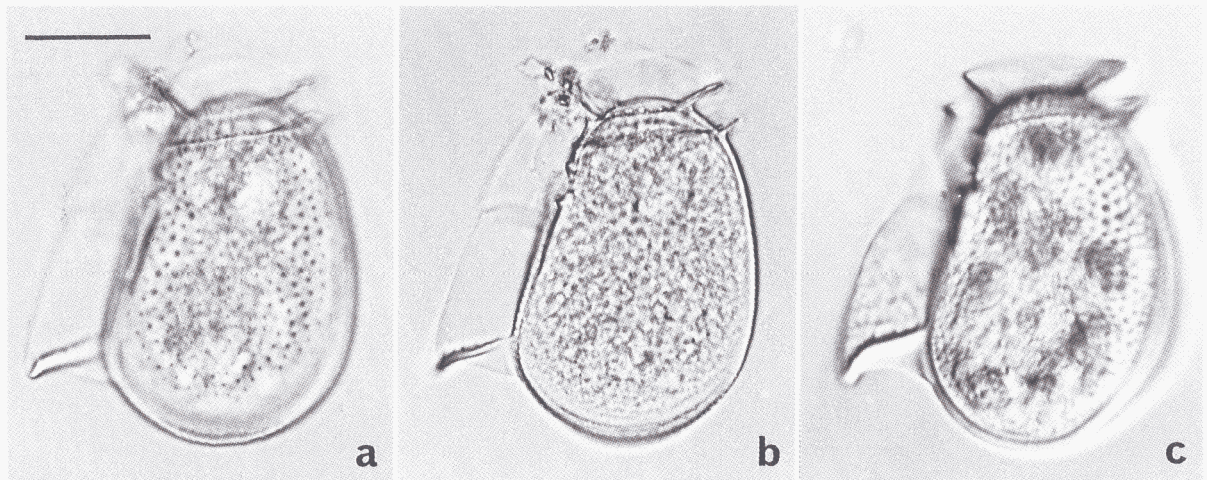


Figure 4a–c. *Dinophysis fortii*. Formaldehyde preserved cells; the chloroplasts and the reticulation on the left sulcal list are visible in Fig. 4c. Sample from the Adriatic Sea, Italy, kindly provided by Dr G. Socal, Trieste. Scale bar: 20 μm .

Toxicology: *Dinophysis fortii* is the most noxious cause of DSP in Japanese waters. It produces DTX1, PTX2, and OA (Lee *et al.*, 1989; Yasumoto, 1990).

Dinophysis hastata Stein, 1883

Fig. 5a–b

Description: Cell outline asymmetrically oval with a conspicuous antapical spine sometimes supported by a central rib, 42–90 μm long, 37–64 μm wide (dorso-ventrally). Epicone not visible in lateral view. The anterior cingular list supported by several ribs. The left sulcal list is prominent, about two-thirds the length of the hypocone and with its maximum width at the posterior supporting rib which usually curves posteriorly. The sulcal list has an irregular reticulation. Chloroplasts absent.

Taxonomic notes: *Dinophysis hastata* was considered a collective species by Kofoid and Skogsberg (1928), and subsequent studies (Abé, 1967; Norris and Berner, 1970) have not clarified the situation. It is thus still questionable whether *D. odiosa* (Pavillard) Tai and Skogsberg, 1934, is synonymous with *D. hastata*. Schiller (1933) included Pavillard's species in *D. hastata* (as *Phalacroma hastatum* Pavillard, 1909, later changed by its author to *P. odiosum* Pavillard, 1930), but Norris and Berner (1970) and Balech (1976) retained the two separate species based on differences in cell shape and morphological details in the structure of sulcal and cingular plates.

Ecology and distribution: According to Schiller (1933), *D. hastata* is widely distributed, especially in tropical and subtropical waters. There are no reports of blooms.

It cannot be determined from the original description whether this species possesses chloroplasts, but their absence has been shown by Hallegraeff and Lucas (1988). Hansen (1991) showed it to be phagotrophic, feeding on ciliates which are ingested through a peduncle.

Toxicology: Toxic potential unknown.

Dinophysis mitra (Schütt) Abé vel Balech, 1967

Fig. 6a

Description: Cell broad wedge-shaped 70–95 μm long, 58–70 μm wide (dorso-ventrally). Dorsal side convex, ventral side more or less straight in the sulcus region, becoming distinctly concave at the posterior end of the left sulcal list towards the antapical end. The epicone is visible as a small, slightly convex “cap” above the cingulum. Theca reticulated.

Taxonomic notes: Schiller (1933) indicates that *D. mitra* is probably synonymous with *D. rapa* (Stein) Balech, 1967. The difference between the two species seems to be the degree of concavity of the ventral side. Hallegraeff and Lucas (1988) studied *D. rapa* by epifluorescence microscopy and sometimes found red chloroplast fluorescence.



Figure 5a–b. *Dinophysis hastata*. Live cells from the Kattegat, Denmark. Scale bar: 20 μm .



Figure 6a. *Dinophysis mitra*. Redrawn from Schiller (1933). Scale bar: 20 μ m.

Ecology and distribution: *Dinophysis mitra* is widely distributed in warmer waters. There are no reports of blooms.

Toxicology: The toxicity of this species has been confirmed by Lee *et al.* (1989). It is a DTX1 producer.

Dinophysis norvegica Claparède & Lachmann, 1859
Fig. 7a-f
Synonym: *D. debilior* Paulsen, 1949

Description: Cells are 48–80 μ m long, 39–70 μ m wide (dorso-ventrally). The dorsal side is usually smoothly convex; the posterior part of the ventral side varies from almost straight to distinctly concave. The hypocone ta-

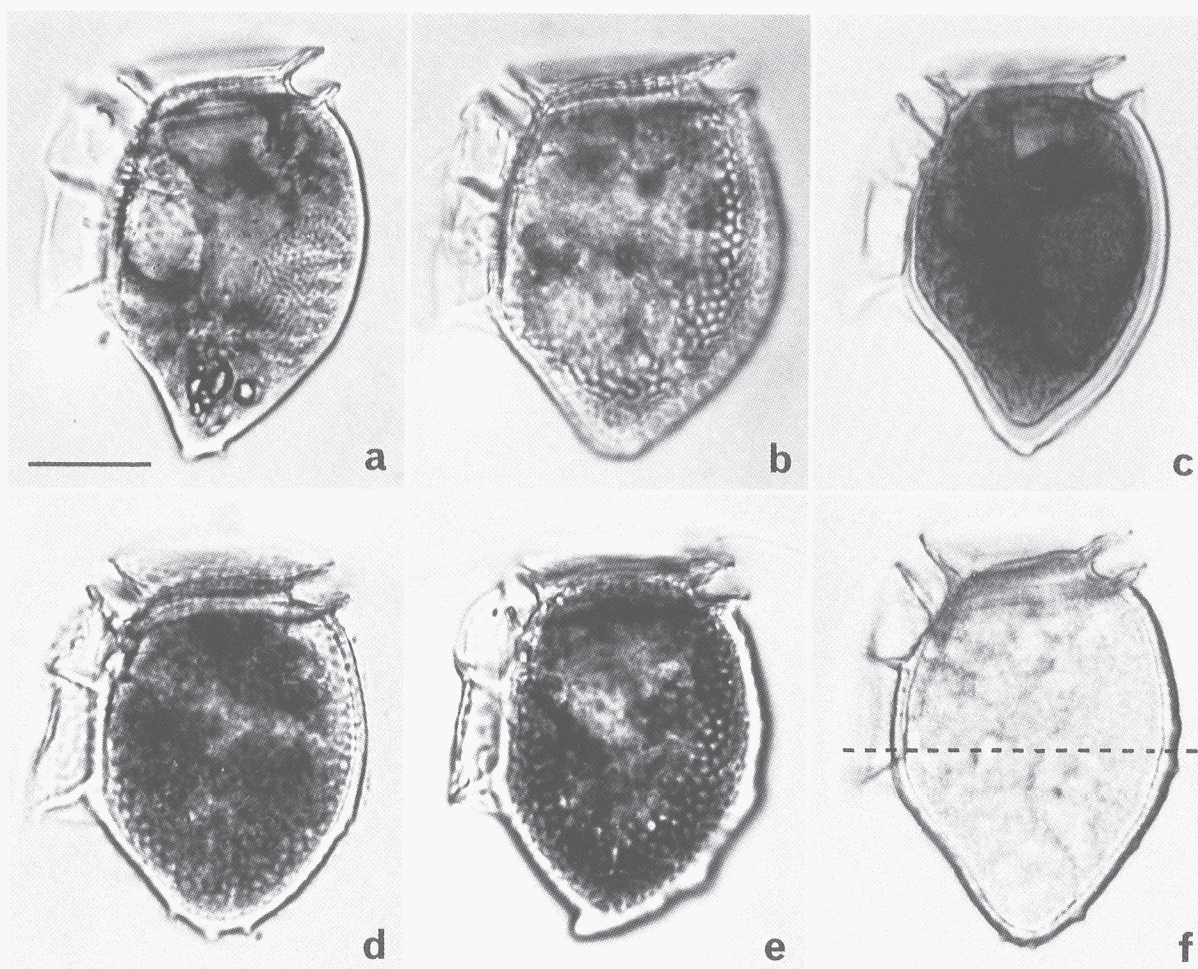


Figure 7a–f. *Dinophysis norvegica*. 7a–b, d–e: live cells; 7c: lugol-preserved cell; 7f: formaldehyde-preserved cell; cells of this species are widest near the middle of the cell which has been indicated in Figure 7f. Figure 7a–e: material from the Kattegat; Figure 7f: from the Baltic. Scale bar: 20 μ m.

pers posteriorly, occasionally with small protrusions; cell widest at or slightly above the level of the mid dorso-ventral line; see Figure 7f.

Taxonomic notes: *Dinophysis norvegica* varies considerably in size and shape (Schiller, 1933; Solum, 1963; Balech 1976). It is generally smaller than *D. acuta* although they overlap in size. They are distinguished by differences in the shape of the hypocone; compare Figures 2d and 7f; see also comments on *D. acuta*. Balech (1976) found that the plate patterns of the two species are very similar, but more variable in *D. norvegica*.

D. norvegica may occasionally produce dimorphic individuals (G. Hansen, pers. comm.).

Ecology and distribution: According to Schiller (1933), this species is widely distributed, but mostly restricted to coastal waters. Blooms are reported from the British Isles (Dodge, 1977), Scandinavia (Dahl and Yndestad, 1985; Krogh *et al.*, 1985); and the USA (Freudenthal and Jijina, 1985). Cell numbers of about 80 000 cells per litre have been reported from Denmark (H. Munk Sørensen, unpubl. obs.).

Toxicology: *Dinophysis norvegica* is a DTX1 and OA producer (Lee *et al.*, 1989; Yasumoto, 1990).

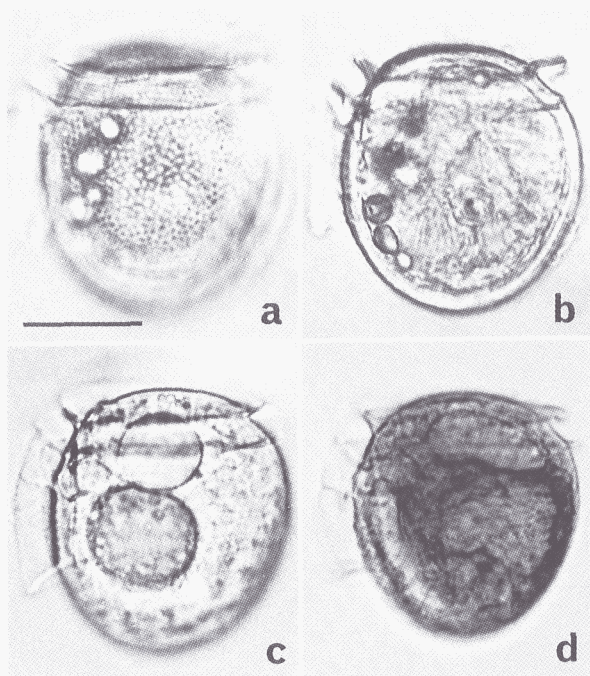


Figure 8a–d. *Dinophysis rotundata*. Figure 8a–c: live cells; 8d: lugol-preserved cell. Material from the Kattegat. Scale bar: 20 μ m.

Dinophysis rotundata Claparède & Lachmann, 1859 Fig. 8a–d
Synonym: *D. whittingae* Balech, 1971

Description: Cells are 36–56 μ m long, regularly round-oval in lateral view. The epicone is visible as a small convex “cap” above the cingulum; see Figure 8b. Cingular lists usually smooth. Chloroplasts absent.

Taxonomic notes: *Dinophysis rotundata* is distinguished from the other species included here by its roundish outline, the lack of chloroplasts, and the epicone which appears as a tiny cap above the cingulum. Plate details of this species have been studied by Balech (1976).

Ecology and distribution: There are no reports of blooms of *D. rotundata*. The feeding habits of this heterotrophic species have been investigated by Hansen (1991) who found it to feed on ciliates which are ingested through a peduncle.

Toxicology: This is the first heterotrophic dinoflagellate in which toxin production has been demonstrated (Lee *et al.*, 1989). It produces DTX1. However, toxins have been found only in Japanese strains so far; North American strains were non-toxic (Cembella, 1989).

Dinophysis sacculus Stein, 1883 Fig. 9a–b

Description: Cell outline irregular oval, rounded; the dorsal side is straight or more or less concave, 48–60 μ m long, 25–35 μ m wide. Occasionally with small blunt protrusions posteriorly near the ventral side. The ribs supporting the left sulcal list are strong. Chloroplasts are probably present, see Figure 9a.



Figure 9a–b: *Dinophysis sacculus*. Formaldehyde-preserved cells; the chloroplasts are visible in Figure 9a. Sample from the Adriatic Sea, Italy, kindly provided by Dr G. Socal, Trieste. Scale bar: 20 μ m.

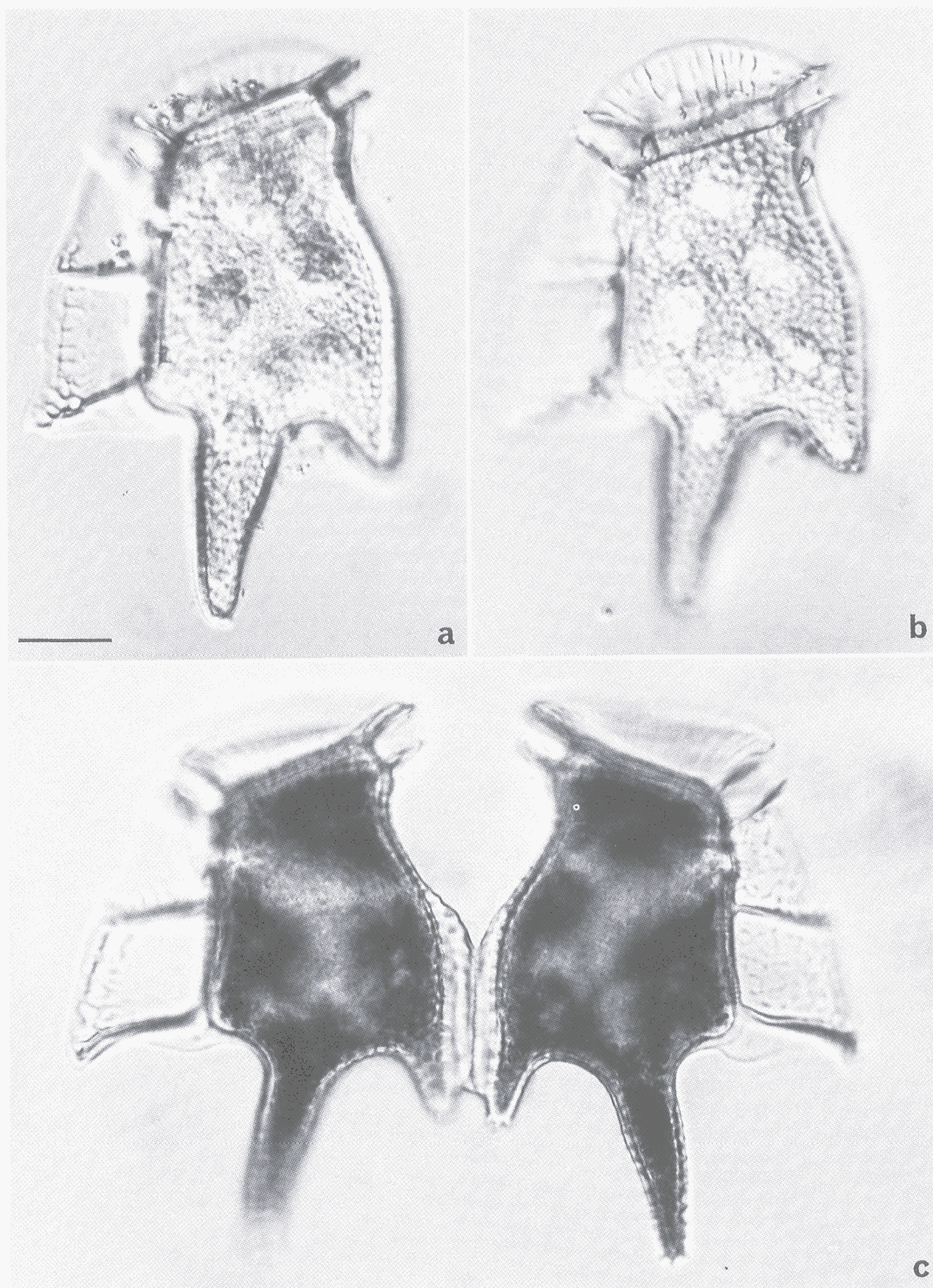


Figure 10a–c. *Dinophysis tripos*. 10a–b. Formaldehyde-preserved cells, the chloroplasts and the reticulation on the left sulcal list are visible in 10b. Sample from the Adriatic Sea kindly provided by Dr G. Socal, Trieste; 10c: recently divided cell, material from the Kattegat, Denmark. Scale bar: 20 μ m.

Taxonomic notes: This species varies considerably (see Schiller, 1933). It is best identified by its long oval shape and straight or slightly concave dorsal side.

Ecology and distribution: Blooms of *D. sacculus* have been reported from Portugal (Alvito *et al.*, 1990; Sampayo *et al.*, 1990).

Toxicology: The toxic potential is unknown.

Dinophysis tripos Gouret, 1883 Fig. 10a–c

Description: Cell elongated, asymmetrical, 95–120 µm long, 50–60 µm wide. The hypocone has two posteriorly directed horns, the ventral one being the longer. The anterior cingular list is supported by ribs; the sulcal list is well developed and often reticulated. The posterior part of the dorsal horn is straight, sometimes with a narrow list which connects with the daughter cell during cell division. Chloroplasts present.

Taxonomic notes: This species belongs in the *caudata* group *sensu* Kofoid and Skogsberg (1928), and is best identified by its size and the shape of the posterior horns.

Ecology and distribution: *D. tripos* is widely distributed in subtropical and tropical waters, and occasionally found also in colder regions. There are no reports of blooms.

Toxicology: Toxin production, DTX1, has been demonstrated by Lee *et al.* (1989).

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