

HARMFUL ALGAL BLOOM (HAB) ORGANISMS OF THE NORTH ARABIAN SEA BORDERING PAKISTAN - I. GONYAULAX DIESING

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Abstract

The taxonomy and distribution along with environmental parameters of seven species of the genus *Gonyaulax* Diesing (Harmful Algal Bloom organisms) including four new records from the Northeastern Arabian Sea have been described from Korangi creek, Manora channel and continental shelf of Pakistan.

Introduction

Nowadays, there is a growing interest in the study of Harmful Algal Blooms (HABs) all over the world, especially in the marine environment. Numerous studies have been carried out on the ecology (White, 1987), biology (Sandra, 1990; Amadi *et al.*, 1992), biochemistry (Boni & Rollo, 1992; Dong-Hee *et al.*, 1993), biotechnology (Salois & Morse, 1996) and toxicology (Todd & Holmes, 1991) of these organisms in different countries with little work reported from Pakistan. Saifullah (1979) and Saifullah & Chaghtai (1990) reported red tides caused by *Noctiluca scintillans* Macartney for the first time from Pakistan's shelf and then Rabbani *et al.*, (1990) observed the same caused by *Prorocentrum minimum* (Pavillard) Schiller in the coastal area of Gawadar. Later Chaghtai & Saifullah (1992) observed a bloom of pennate diatom *Navicula* Bory from Sandspit mangrove swamps. Chaghtai & Saifullah (1997) also documented the occurrence of world famous bloom forming planktonic alga *Pheaeocystis* Legerheim from mangrove creeks of the Karachi coastal area. Saifullah & Hassan (1973) have already described three species of *Gonyaulax* viz., *G. monacantha*, *G. polyedra* (now called *Lingulodinium polyedrum* (Stein) Dodge 1989), and *G. polygramma* Stein from strictly inshore waters of Karachi only. The present work describes the occurrence and distribution of seven species of the genus *Gonyaulax* Diesing from the northeastern Arabian sea bordering Pakistan which is well known to include the red tide organisms.

Materials and Methods

The study is based on 24 phytoplankton net samples collected from inshore waters of Korangi Creek area and 116 samples collected from offshore waters in 1977 during the cruise of research vessel, "Dr Fridtjof Nansen", which lasted for six months from (January-June 1977) covering the entire Pakistan shelf and adjacent waters. The area of study have already been described by Chaghtai & Saifullah (1988, 1997). All the samples were fixed immediately in 5 % formalin and were later examined under the microscope for identification. The specimens were treated chemically following the procedure adopted by Hassan & Saifullah (1971) to clear the thecal plates for the identification of species. Simultaneous measurements of temperature and salinity were also made at each station.

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SYSTEMATIC ACCOUNT

Following is the key for the identification of the species of the genus *Gonyaulax*:

1. Base without spine or projection 2
- Base with spine or projections 3
2. Cells polygonal *Lingulodinium polyedrum*
- Cells ovoid *G. turbynei*
3. Hypotheca with one basal spine 4
- Hypotheca with two or more basal spines 5
4. Large size up to 96 μm *G. kofoidii*
- Small size up to 56 μm *G. monacantha*
5. Having two spines 6
- Having three or more spines *G. polygramma*
6. Body shape ovoid to oval *G. digitale*
- Body shape not so *G. diegensis*

***Gonyaulax diegensis* Kofoid 1911**

Fig. 1b

Rampi, 1943a: 319, Fig.1; Hada, 1967, pl.16, Fig.27b.

=*Gonyaulax spinefera* (Claparede & Lachmann) Diesing, Wood, 1954:263, Fig.174; 1968:

The species can be recognized by its more rotund shape, apical horn short and stout, girdle depressed, little overhang, displaced about two widths, antapicals short and prominent.

Length 125 μm , width 119 μm

Local occurrence: Korangi creek.

***Gonyaulax digitale* (Pouchet 1883) Kofoid 1911**

Fig. 1a

Wood, 1954:259, Fig.165; Steidinger & William 1970:50, Fig. 60a-b

=*Protoperidinium digitale* Pouchet, 1883.

Body large, epitheca subconical, shoulders often slightly angled, generally two stout antapical spines.

Length 125-128 μm , width 76-78 μm

Local occurrence: Continental shelf in very shallow waters.

***Gonyaulax kofoidii* Pavillard 1909**

Fig. 1c

Rampi, 1944:320, Fig.4; Taylor, 1976:104, pl.35, Figs.393, 394.

=*G. pacifica* Wood, 1954:261, Fig.170a, b.

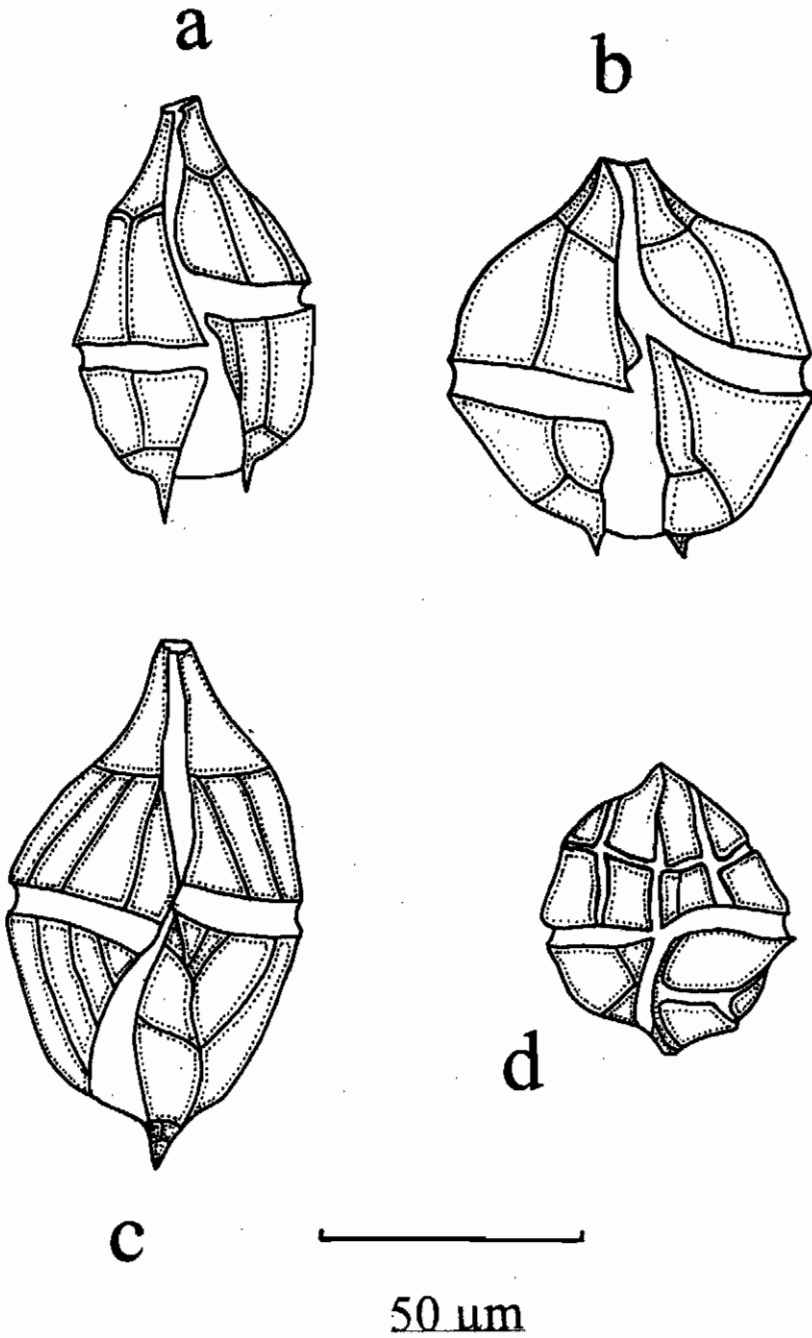


Fig. 1. Morphology of different species of *Gonyaulax*
a) *G. digitale* b) *G. diegensis* c) *G. kofoidii* d) *G. turbyne*

Body elongated and large, epitheca conical, angulate slightly on left side, tapers abruptly into an apical horn with blunt apex. Left antapical with prominent spine. Girdle sub-circular, flattened ventrally, displaced in 2 widths, not overlapping. Hypotheca with almost straight sides, lower than epitheca.

Length 90-96 μm , width 55-60 μm

Local occurrence: Continental shelf.

***Gonyaulax monacantha* Pavillard 1916**

Saifullah & Hassan 1973:144, Fig.1a, b.

Theca with coarse pores arranged in rows. Epitheca irregularly conical, longer than hypotheca. Sulcus starts from the lower side of the girdle.

Length 45-58 μm , width 31-40 μm

Local occurrence: Continental shelf and Manora channel.

***Gonyaulax polygramma* Stein 1883**

Saifullah & Hassan, 1973:145, Fig.3a, b.

Large armoured species, the sulcus is slightly excavated and the girdle is displaced left handedly about 1.5 times the girdle width.

Length 42-60 μm , width 41-50 μm

Local occurrence: Manora channel.

***Gonyaulax turbynei* Murray & Whitting 1899**

Fig.1d

Wood, 1954:263, Fig.175; 1968:6, Fig.161; Balech, 1971:164, t.35, Fig.689-691, t. 36, Fig.692-694. Taylor, 1976:108, pl.35, Fig.399.

=*G. scripsa* Kofoid, 1911.

A small ovoid species, with no apical horn. Epitheca and hypotheca sub-equal with convex sides. Girdle equatorial without ridges. Middle part of the sulcus is very narrow and posterior is elliptical.

Length, 95 μm , width 80 μm

Local occurrence: Continental shelf.

***Lingulodinlum polyedrum* (Stein) Dodge, 1989**

Dodge, 1989:291, figs 1H, I, 34-38.

=*Gonyaulax polyedra* Stein 1883, Saifullah & Hassan, 1973:144, Fig.2a, b.

Small angular body with polyhedral ridges along sutures. Girdle equatorial, displaced 1-2 widths. Surface regularly pitted.
Length 50-52 μ m, width 50-52 μ m

Local occurrence: Continental shelf and Manora channel.

Results and Discussion

Of the seven species of *Gonyaulax* described, *G. diegensis*, *G. digitale*, *G. kofoidii* and *G. turbynei* are new records from northeastern Arabian Sea bordering Pakistan, whereas *G. monacantha*, *G. polyedra* (now called *Lingulodinium polyedrum*) and *G. polygramma* have already been reported from inshore waters of Manora Channel, Karachi (Saifullah & Hassan, 1973). *G. digitale*, *G. polygramma* and *L. polyedrum* have been reported to be bloom forming and also toxic causing mortality to fish and other marine organisms (Okaichi, 1989; Cannon, 1990; Lam & Yip, 1990; Todd & Holmes, 1991) including human beings as well (Medcof *et al.*, 1947). *G. digitale*, caused red tide in Bedford basin in Canadian waters (Amadi *et al.*, 1992), while *G. polygramma* and *L. polyedrum* are highly toxic and cause Paralytic Shellfish Poisoning (PSP). *Gonyaulax polygramma* have been reported to produce toxicity in *Perna perna* in the gulf of Cariaco Venezuela (Ferraz - Rayes *et al.*, 1985), and also caused a three months long red tide in Hong Kong (Lam & Yip, 1990).

Gonyaulax kofoidii, *G. monacantha* and *L. polyedrum* showed wide distribution and occurred in both shallow and deep waters, whereas *G. diegensis*, *G. digitale* and *G. polygramma* occurred strictly in shallow waters near the shore (Table 1). *G. monacantha* was found to be eurythermal and euryhaline as well because it occurred in a wide range of temperature and salinity (Table 1) and therefore recorded very frequently both in inshore and offshore waters. It is also considered to be very common in the Arabian Sea region (Wood, 1954, 1963, 1968). *Gonyaulax polygramma* and *L. polyedrum* preferred warmer temperatures, whereas *G. diegensis*, *G. digitale* and *G. turbynei* cold temperatures (Table 1) and therefore occurred in winter (northeast monsoon season) only. The presence of toxic or red tide species *G. digitale*, *G. polygramma* and *L. polyedrum* in our waters is alarming and indicates possible occurrence of red tides which may cause mass mortality of fish (Lam & Yip, 1990; Amadi *et al.*, 1992).

Table 1. Environmental parameters relating to the occurrence of *Gonyaulax* species.

Name of species	Frequency %	Temp. (°C)	Salinity (ppt)	Depth of stations (m)
<i>Gonyaulax diegensis</i>	11.5	19-21	36.00-37.55	10
<i>G. digitale</i>	12.24	19-21	36.22-36.28	15
<i>G. kofoidii</i>	26.56	20-24	35.83-36.60	10-1050
<i>G. monacantha</i>	42.85	19-30	29.40-38.70	10-3000
<i>G. polygramma</i>	12.24	24.9-29.1	36.00-36.50	10
<i>G. turbynei</i>	6.12	21.1-21.8	36.04-36.05	10-520
<i>Lingulodinium polyedrum</i>	14.82	22.8-29.1	36.00-36.50	10-3000

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References

- Amadi, I., D.V.S. Rao and Y. Pan. 1992. A *Gonyaulax digitale* red water bloom in the Bedford Basin, Nova Scotia, Canada. *Bot. Mar.*, 35: 451-455.
- Balech, E. 1971. Microplankton del Atlantic ecuatorial oeste (equalent I). *Publ. Serv. hydrogr. nvl. B. Aires*, 654: 1-103.
- Boni, L and F. Rollo. 1992. Molecular detection and characterization of marine dinoflagellates and their symbionts: Potentials and pitfalls. In: *Marine coastal eutrophication*. (Eds.): R.A. Vollenweider, R. Marchetti and R. Viviani. *Sci. Total. Environ. Suppl.* pp., 945-956.
- Cannon, J.A. 1990. Developments and dispersal of red tide in Port River, South Australia. In: *Toxic Marine Phytoplankton* (Eds.): E. Graneli, B. Sundstörn, L. Edler and D.M. Anderson. Elsevier, N.Y. pp.110-115.
- Chaghtai, F. and S.M. Saifullah. 1988. An illustrated account of species of *Ceratium* Schrank found in North Arabian Sea bordering Pakistan. *Pub 5: CEMB*, University of Karachi. Shamim Printing Press, Karachi. pp.50.
- Chaghtai, F. and S.M. Saifullah. 1992. First recorded bloom of *Navicula* Bory in a Mangrove habitat of Karachi. *Pak. J. Mar. Sci.*, 1: 139-140.
- Chaghtai, F. and S.M. Saifullah. 1997. Occurrence of *Phaeocystis* in Mangroves creeks near Karachi, Pakistan. *Pak. J. Mar. Sci.*, 6: 105-106.
- Dodge, J.D. 1989. Some revisions of the family Gonyaulacaceae (Dinophyceae) based on a scanning electron microscope study. *Bot. Mar.*, 32: 275-298
- Dong-Hee, Lee., M. Mittag, S. Sczekan, D. Morse, J.W. Hastings. 1993. Molecular cloning and genomic organization of a gene for luciferin-binding protein from the dinoflagellate *Gonyaulax polyedra*. *Jour. Biol. Chem.*, 268: 8842-8850.
- Ferraz-Reyes, E., G. Reyes-Vasques and A.L. Oliveros. 1985. Dinoflagellates of the genera *Gonyaulax* and *Protogonyaulax* in the gulf of Cariaco Venezuela. In: *Toxic dinoflagellates*. (Eds.): D.M. Anderson, A.W. White and D. Baden Elsevier, N.Y. pp. 69-72.
- Hada, Y. 1967. Protozoan plankton of the Inland Sea, Setonakai. I. The Mastigophora. *Bull. Suzugamine Women's Coll., Nat. Sci.*, 13: 1-26.
- Hassan, D. and S.M. Saifullah. 1971. Some thecate dinophyceae from inshore waters of Karachi. *Pak. Jour. Bot.*, 3: 61-70.
- Kofoed, C.A. 1911. Dinoflagellates of the San Diego region. IV. The genus *Gonyaulax* with notes on its skeletal morphology and discussion of its generic and specific characteristics. *Uni. Cal. Pub. Zool.*, 8: 187-287.
- Lam, C.W.Y. and S.S.Y. Yip. 1990. A three month red tide event in Hong Kong. In: *Toxic Marine Phytoplankton*. (Eds.): E. Graneli, B. Sundstörn, L. Edler and D.M. Anderson. Elsevier Science Publishing Co., New York. pp.481-486.
- Medcof, J.C., A.H. Leim, B. Alfreda, B. Needler, A.W.H. Needler, J. Gibbard and J. Naubert. 1947. Paralytic shellfish poisoning on the Canadian Atlantic coast. *Bull. Fish. Res. Bd. Can.*, 125: 1-32.
- Okaichi, T. 1989. Red tide problems in the Seto inland Sea, Japan. In: *Red tides: Biology, Environmental Science and Toxicology*. (Eds.): T. Okaichi, D.M. Anderson and T. Nemoto. pp. 137-142. Elsevier Science Publishing Co., New York.
- Rabbani, M.M., A. Rehman and C.E. Harms. 1990. Mass mortality of fishes caused by dinoflagellate bloom in Gwadar Bay, southwestern, Pakistan. In: *Toxic Marine Phytoplankton* (Eds.): E. Graneli, B. Sundstörn, L. Edler and D.M. Anderson. Elsevier Science Publishing Co., New York. pp.209-214.
- Saifullah, S.M. 1979. Occurrence of Dinoflagellates and distribution of chlorophyll "a" on the Pakistan shelf. In: *Toxic Dinoflagellate Blooms*. (Eds.): D.L. Taylor and H.H. Saliger. Elsevier, N.Y. pp. 203-208.
- Saifullah, S.M. and F. Chaghtai. 1990. Incidence of *Noctiluca scintillance* (Macartney) Ehrenb., blooms along Pakistan's shelf. *Pak. J. Bot.*, 22: 94-99.
- Saifullah, S.M. and D. Hassan. 1973. Planktonic dinoflagellates from inshore waters of Karachi. I. *Gonyaulax* Diesing. *Pak. J. Zool.*, 5: 143-147.

- Salois, P. and D. Morse. 1996. Do Dinoflagellate contain a Cdc² - like protein kinase? *Mol. Mar. Biol. Biotech.*, 5: 52-61.
- Sandra, E. Shumway. 1990. A review of the effects on Algal blooms on shellfish and Aquaculture. *Journal of the world Aquaculture Society*, 21: 65-104.
- Steidinger, K.A. and J. William. 1970. Dinoflagellates. *Mems Hourglass Cruises (Florida Dept nat. Resources, St. Petersburg)*, 2: 1-251.
- Taylor, F.J.R. 1976. Dinoflagellates from the International Indian Ocean Expedition. A report on material collected by the R.V. Anton Bruun 1963-1964. *Bibliotheca bot.*, 132: 1-234.
- Todd, E.C.D. and C.E.B. Holmes. 1991. Recent illness from seafood toxins in Canada: doses related to fish poisoning. In: *Toxic phytoplankton blooms in the sea*. (Eds.): Smayda T.J, Shimizuy. *Dev. Mar. Biol.*, Elsevier 3: pp. 341-346.
- White, A.W. 1987. The effect of toxic dinoflagellate bloom on shellfish and finfish in eastern Canada. In: *Problems of toxic dinoflagellate bloom in aquaculture*. (Eds.): B. Dale, D.G. Baden, B. Mck. Bary, L. Edler, S. Fraga, I.R. Jaenkinson, G.M. Hallegraeff, T. Ochaichi: pp. 56-57.
- Wood, E.J.F. 1954. Dinoflagellates in the Australian Region. *Aust. J. Mar. Fres. Wat. Res.*, 5: 171-351.
- Wood, E.J.F. 1963. Dinoflagellates in the Australian Region. II. Recent Collection. *Div. Fish. Oceanogr. CSIRO, Techn. Pap.* 14:1-55.
- Wood, E.J.F. 1968. Dinoflagellates in the Carribean Sea and adjacent areas. *Univ. of. Miami Press*. 1-145.

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