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THE DINOFLAGELLATE GENUS *ORNITHOCERCUS* STEIN FROM NORTH ARABIAN SEA SHELF OF PAKISTAN

S. M. SAIFULLAH, SADAF GUL* AND MAHWISH KHAN

Department of Botany, University of Karachi, Karachi-75270, Pakistan,

Abstract

The present study reports five species of *Ornithocercus* Stein from north Arabian Sea shelf of Pakistan, four of them being new records from the area. The most common and frequent species was *O. magnificus* and the largest species *O. steinii*. Individuals of a given species showed variation in size of their body and also of different parts with greater variations observed in length of sulcal list. The Indus Delta region was found to be richer in species diversity than Balochistan.

Introduction

Ornithocercus is a thecate (armoured) dinoflagellate found commonly in tropical and subtropical waters. It is structurally a complex genus characterized by possession of extensive girdle and sulcal lists which gives the genus an attractive appearance (Licea *et al*., 2004). It has been studied extensively from different parts of the world. Information on this genus form the north Arabian Sea bordering Pakistan is scanty. Kuzmenko (1975) reported three species, two identified and one unidentified, from the North Arabian Sea and Taylor (1976) nine species form the India Ocean. Wood (1963) listed only eight species from the entire Indian Ocean. There does not exist any study on the genus from the continental shelf of Pakistan, except for one localized study in an inshore polluted Karachi Harbour by Hassan & Saifullah (1971). They observed only one speices *Ornithocercus steinii* during one year study. The present paper describes the composition and distribution of five species of *Ornithocercus* from the Pakistan's continental shelf and the deep sea vicinity.

Materials and methods

Samples were collected mostly through horizontal surface net hauls and a few vertical and oblique hauls of mesh size 40 µm from the continental shelf of Pakistan during the Norwegian Fridtjiof Nansen Cruise carried out in 1977. The cruise tracks, method of sampling and the number and locations of stations have already been described in detail earlier (Anonymous, 1978; Saifullah, 1979; Chagtai & Saifullah, 1988; Gul & Saifullah, 2007). A total of 85 samples from different stations were studied which were collected during 19th February to 5th March 1977. Besides phytoplankton samples, simultaneous observations of seawater temperature and salinity were also taken. Morphological studies included also measurement of the body and its parts like hypotheca, epitheca, girdle and sulcal lists.

*Email: sadafgpk@yahoo.com

Observations and Results

Key to the identified species of *Ornithocercus* Stein

1. Left sulcal list quadrate shaped …….. *O. quadratus*
   Left sulcal list not quadrate shaped ……... 2
2. Left sulcal list biangular ……. *O. heteroporus*
   Left sulcal list not biangular ……. 3
3. Left sulcal list with 3 lobes ……... *O. magnificus*
   Left sulcal list with more than 3 lobes …….. 4
4. All ribs ending at lobes ……. *O. steinii*
   All ribs not ending at lobes …….. *O. thumii*

***Ornithocercus heteroporus* Kofoid 1907**
Fig. 1

Kofoid 1907: 206, fig. 70; Kofoid & Skogsberg 1928: 517, figs. 75-76, 1, 3; Schiller 1931: 195, fig. 187a-d; Silva 1956: 56, fig.6; Wood 1954: 207, fig. 58 a-b;-1968:85, fig. 240; Taylor 1976: 48, fig. 83.

Body length 80 µm; body dorsoventrally obliquely subellipsoidal or subcircular; anterior girdle list has 8 radial ribs, distally connected to reticulae, some short marginal ribs are also present; posterior girdle list with 17 complete and simple ribs; theca heavely sculptured; left sulcal list usually ends at or somewhat ventrally to antapex, but may extend somewhat further; with two lobes, 1 lobe is posteroventral, the other is posterior; lobes narrowly rounded; sulcal list widening to R3, dorsal margin straight or gentally convex to concave with 5 radial ribs and submarginal rib behind fission rib.

Local distribution: Pakistan Shelf, Station Nos. 85, 102, 124, 144, 145, 147.

General distribution: Eastern Tropical Pacific (Kofoid, 1907); Indian Ocean (Matzenauer, 1933; Wood, 1963; Taylor, 1976).

***Ornithocercus magnificus* Stein 1883**
Fig. 2

Stein 1883, 1895 partim., pl. 23, figs. 1-2; Kofoid & Skogsberg 1928: 529, fig. 79/1-9; Schiller 1931: 198, fig. 190a,b; Wood 1954: 203, fig. 60;-1968:86, fig. 241; Steidinger & Williams 1970: 54, fig. 79a, b; Taylor 1976: 49, fig. 67-69.

Body subcircular in lateral outline, body length 77-129 µm; girdle lists large, anterior funnel shaped usually with 6-9 simple and complete ribs, rarely reticulate distally; posterior girdle list is wider at base as compared to anterior girdle list usually with 13-15 complete and simple ribs; ribs of anterior girdle list are thicker than those of posterior girdle list; left sulcal list ends on dorsal side of body, with 3 narrowly rounded lobes, 1 posteroventral, 1 antapical and 1 posterodorsal; typically with 5 ribs behind fission rib: distal ends of these ribs and fission rib connected by submerged rib; a rib extends into posterodorsal lobes; b and c ribs usually end dorsally to vertex of middle lobe, specially the distal termination of c rib is distinctly dorsal to mid lobe, d and e ribs dorsally to posteroventral lobe, central lobe supported typically by 3 ribs, rarely 2 ribs forming a diamond. R1 typically “L” shaped and usually with spur.

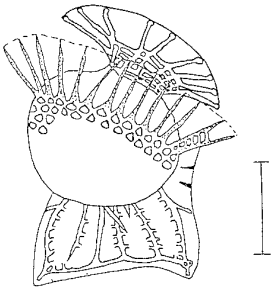


Fig. 1

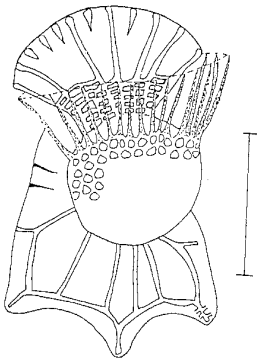
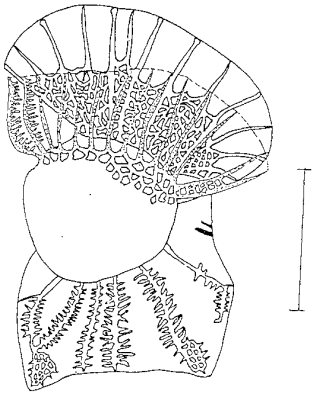


Fig. 2



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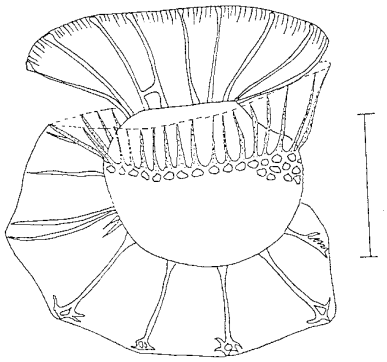

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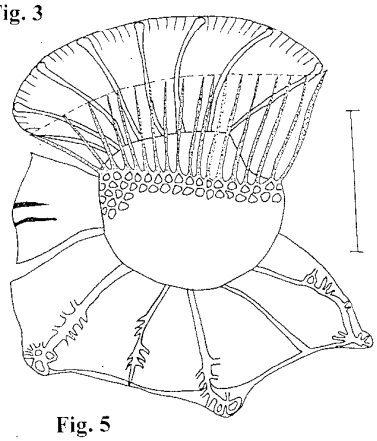

Fig. 5

Fig. 1. *Ornithocercus heteroporus* Lateral view of entire body (scale = 36 µm).
Fig. 2. *Ornithocercus magnificus* Lateral view of entire body (scale = 53 µm).
Fig. 3. *Ornithocercus quadratus* Lateral view of entire body (scale = 33 µm).
Fig. 4. *Ornithocercus steinii* Lateral view of entire body (scale = 64 µm).
Fig. 5. *Ornithocercus thumii* Lateral view of entire body (scale = 41 µm).

Local distribution: Pakistan Shelf, Station Nos. 81, 87, 89, 108, 110, 114, 115, 121, 131, 133, 139, 141, 142, 147.

General distribution: Red Sea, Arabian Sea, Indian Ocean (Cleve, 1900, 1901, 1903); Indian Ocean (Karsten, 1907); Eastern Tropical Pacific (Kofoid, 1907), Vitiaz Strait (Kofoid & Skogsberg, 1928), Indian Ocean, Caribbean Sea (Wood, 1963, 1968); Indian Ocean (Taylor, 1976).

Ornithocercus quadratus Schütt 1900
Fig. 3

Schütt 1900, figs. 1-4, 12-13; Kofoid & Skogsberg 1928: 561, fig. 85/5, 86/1-14, 87/1-20; Schiller 1931: 204, fig. 194a-f, 195 a-d; Wood 1954: 209, fig. 63 a-e;-1968:86, fig. 242; Taylor 1976: 50, fig. 77-82, 499-501.

Body length 100-138 µm, lateral outline subcircular; anterior girdle list large in size than posterior one, usually with 8-18 ribs, distally with very much reticulations; posterior girdle list with 12-15 simple and sometime reticulated ribs; girdle wider on dorsal side; left sulcal list end on dorsal side of body and is biangular and quadrate shaped, finishing parallel with dorsal plane; usually with a submarginal rib; one lobe is posteroventral, the other posterodorsal, usually with 5-6 ribs behind fission rib, these ribs have reticulation; some times the margins of the left sulcal list, when fully developed, bears numerous reticulae to the exterior of the marginal rib; the list ribs are relatively smooth; anterior girdle list with numerous complete and incomplete ribs.

Local distribution: Pakistan Shelf, Station Nos. 81, 87, 97, 131, 147.

General distribution: Red Sea, Gulf of Aden (Ostenfeld & Schmidt, 1901); Red Sea, Arabian Sea (Cleve, 1903); Indian Ocean, Arabian Sea (Schröeder, 1906; Karsten, 1907), Southern & Indian Ocean, Caribbean Sea (Wood 1963, 1968); Indian Ocean (Taylor, 1976).

Ornithocercus Steinii Schütt 1900
Fig. 4

Schütt 1900; Kofoid & Skogsberg 1928: 551, figs. 83/1-12; Schiller 1931: 202, fig. 192a; Wood 1954: 203, fig. 62;-1968:86, fig. 244; ; Steidinger & Williams 1970: 54, fig. 80; Hassan & Saifullah 1972a:68, fig. 6; Taylor 1976: 52, fig.72-73.

Body length 100-160 µm, subcircular in lateral outline; anterior girdle list has greater number of primary ribs (8-10) supporting the upper girdle list; numerous short marginal ribs, sometimes submarginal rib with reticulation; posterior girdle list with 14-16 ribs, mostly simple and complete, rarely reticulate; sulcal list ends on dorsal side of body, margins rounded, almost parallel with body; rib a + near posterior girdle list with four nearly equidistant lobes, postventral, mid-ventral, mid-dorsal and posterodorsal, with reticulam in each lobe; typically with five ribs behind fission rib, evenly spaced, last rib sometimes reaching margin of ventral side of wing; submarginal rib may or may not be present; a rib ends near the middle of dorsal margin of list, each of b-d ribs end at the vertex of 1 of each 4 lobes.

Local distribution: Pakistan Shelf, Station Nos. 83, 110, 115, 118, 142, 143, 144.

General distribution: Boeton Str (Ostenfeld, 1915); Indian Ocean (Matzenauer, 1933); Southern Indian Ocean, Caribbean Sea (Wood, 1963, 1968); Indian Ocean (Taylor, 1976).

Ornithocercus thumii (Schmidt) Kofoid *et* Skogsberg 1928
Fig. 5

Kofoid & Skogsberg 1928: 540, fig. 81/1-11, 4-6 (sub thurni-lapsus oculi); Schiller 1931: 200, fig. 191a-h; Wood 1954: 209, fig. 63 a-e;-1968:86, fig. 242; Ballantine 1961: 218, fig. 14; Steidinger & Williams 1970: 54, fig. 81; Taylor 1976: 53, fig. 71, 72, 74.

Body length 95-120 µm, lateral outline subcircular, anterior girdle list with simple complete and numerous short marginal ribs; complete ribs 7-9 in number with no reticulation distally; posterior girdle list also with simple and complete 18-22 ribs, more in number as compared to anterior girdle list; hypotheca sometimes short, sometime large; left sulcal list ends on dorsal side of body and with 3 narrowly to fairly broadly rounded lobes, forming a "V" shaped sulcal list compared to quadradentate sulcal list of *O. steinii*; 1 lobe posterodorsal, 1 antapical, 1 posteroventral, typically with five ribs behind fission rib and with or without submarginal rib connecting them; a rib extends into posterodorsal lobe, b rib ends ventrally to this lobe, c and e ribs end at vertices of antapical and posteroventral lobes respectively; sometime with disorganization of the supportive ribs of the left sulcal list into a reticular network; d rib does not end into vertex of any lobe.

Local distribution: Pakistan Shelf, Station Nos. 85, 87, 97, 102, 118, 124, 133, 134, 147.

General distribution: California Current, Mexican Current, Panamic Area, Peruvian Current Galapagos Eddy (Kofoid & Skogsberg, 1928); Indian Ocean (Matzenauer, 1933); Southern Indian Ocean, Caribbean Sea (Wood, 1963, 1968); Indian Ocean (Taylor, 1976).

Discussion

In all five species have been identified from the area of study. The number of species may appear small, but in view of the size of the area it is not. Kuzmenko (1975) reported only three species from the entire northern Arabian Sea and Taylor (1976) nine from the Indian Ocean which are several times larger in area than the Pakistan's Shelf. Overall, the genus *Ornithocercus* is not as diverse as *Peridinium*, *Ceratium*, *Dinophysis* and other genera comprising many species, but is represented only by 15 species in the entire world (Gomez, 2005).

Earlier study by Saifullah & Hassan (1971) revealed only one species *O. steinii* in polluted harbour of Karachi, and Kuzmenko (1975) identified only two species *O. thumii* and *O. magnificus* from the north Arabian Sea, excluding Pakistan's shelf. Taylor (1976) reported nine species and Wood (1963) eight from the Indian Ocean. All the five species observed in the present study have already been reported earlier from Indian Ocean (Subrahmanyan, 1958; Wood, 1963; Taylor, 1976) but only two, i.e. *O. magnificus* and *O. thumii* form the northern Arabian Sea. Saifullah & Hassan (1971) described only *O. steinii* from Karachi Harbour, therefore, four species *O. quadratus*, *O. heteroporus*, *O. magnificus* and *O. thumii* are new records form the northwest Arabian Sea shelf of Pakistan.

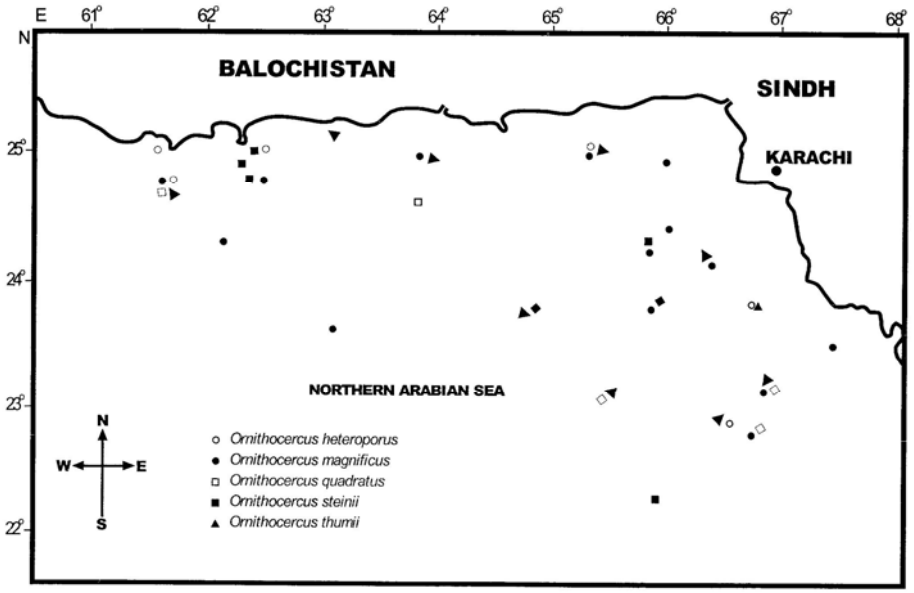

Fig. 6. Distribution of *Ornithocercus* Stein species at different stations in Sindh and Balochistan shelf.

Among five species observed *O. magnificus* was comparatively the most common and frequent (Fig. 6, Table 1) and *O. quadratus* being rare (Table 1). Most of the species were tropical, subtropical and warm temperate, which may be due to the fact that area under study is characterized by tropical waters. The species occurred more frequently on the Indus Delta shelf than on the Balochistan shelf because the former area is more heterogenous in physical oceanographic parameters than the latter (Fig. 6).

Temperature and salinity ranges of different species are mentioned in Table 1 and it is evident that the species occurred in a wide range of temperature and narrow range of salinity during the period of study.

Size variation among individuals of a given species and also among different species is a common phenomenon in dinoflagellates (Dowidar, 1972; Taylor, 1995). The largest species was *O. steinii* (100-160 µm) and the smallest *O. heteroporus* (80 µm). Among different parts of the body, length of sulcal list showed greater variation than any other part (Table 2).

Our specimen of *O. heteroporus* agreed well with already defined specimen by Wood (1954, 1968) and Taylor (1976) but is larger in size as compared to earlier described small sized individuals.

O. magnificus agrees well with that described by Wood (1954, 1968) and Taylor (1976) with the exception of body size. It is a small to moderately sized species which superficially resembles *O. thumii* in the manner in which the left sulcal list is lobed. Size of the specimen showed great variability and was larger in size as compared to the specimen described by Wood (1968). Another character which was also different from the specimen by Wood (1968) was the pattern of ribs of anterior girdle list. Two types of specimens were observed, one with anterior girdle list having ribs reticulated distally. There were also specimens which showed some reticulation in ribs of sulcal list similar to that described by Taylor (1976) while others did not show any reticulation at all.

Table 1. Frequency of occurrence, temperature and salinity ranges of different species of *Ornithocercus*.

S. No.	Name of species	Frequency of occurrence (%)	Temperature ranges C°	Salinity ranges PSU
1.	*Ornithocercus heteroporus*	7.05	23.04-25.10	36.481-36.644
2.	*Ornithocercus magnificus*	16.47	23.04-28.20	36.367-36.571
3.	*Ornithocercus quadratus*	5.88	23.04-26.80	36.481-36.717
4.	*Ornithocercus steinii*	8.23	23.04-27.80	36.481-36.717
5.	*Ornithocercus thumii*	11.76	21.04-24.12	36.481-36.602

Table 2. Measurement of different parts of the species of *Ornithocercus* Stein in µm.

S.No	Species	Length of body	Width of body	Length of epitheca	Width of epitheca	Length of hypotheca	Width of hypotheca	Length of anterior girdle list	Width of anterior girdle list	Length of posterior girdle list	Width of posterior girdle list	Length of sulcal list	Width of sulcal list
1.	*O. heteroporus*	80	50	6	30	19	35	20	32	9	38	28	40
2.	*O. magnificus*	77-129	40-75	7-12	24-35	24-26	28-40	12-18	35-55	9-18	40-60	25-55	40-55
3.	*O. quadratus*	100-138	55-90	6-10	30-40	25-35	25-40	18-30	40-55	12-18	55-65	40-45	50-75
4.	*O. steinii*	100-160	55-80	7-13	35-45	30-40	30-47	20-28	35-45	13-22	30-47	30-57	40-55
5.	*O. thumii*	95-120	65-80	7-10	35-47	20-25	45-55	15-17	40-60	11-18	50-65	45-50	40-50

Ornithocercus quadratus occurred in following three forms: 1) Large size individuals with anterior girdle list having branched ribs but not reticulated distally. Sulcal list with ribs relatively smooth but profusely reticulated to the exterior of marginal rib similar to that defined by Taylor (1976). 2) Individuals with anterior girdle list having ribs heavily reticulated distally and ribs of sulcal list also with numerous delicate side branches but do not have marginal rib connecting them. 3) Individuals invariably smaller in size but do have marginal rib. All three taxa agree well with those described by Taylor (1976).

Ornithocercus thumii has been perviously reported as *O. thurni* by Wood (1963, 1968) Kofoid & Skogsberg (1928), but Taylor (1976) and Gomez (2005) maintained the present name. The presently observed *O. thumii* is larger in size as described by earlier workers. Ribs of anterior girdle list were not reticulated distally as described by Wood (1968). Ribs of sulcal list may be heavily reticulated, moderately reticulated or may have reticulum only at the vertex of lobe.

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