

Distribution, ecology and polymorphic behaviour of the genus *Oxycephalus* (Hyperideae, Oxycephalidae) in the Indian Ocean.

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Abstract - There have been many controversies among various workers on the number of valid species under *Oxycephalus* including the studies made from Indian waters. Previous reports from Indian Ocean were largely dependent on logistics of ship operation which precluded extensive coverage. This is the first comprehensive account on the distribution of this genus covering the entire Indian Ocean through seasons. There exist only three valid species under *Oxycephalus*, *O. clausi*, *O. piscator* and *O. latirostris*, which are mostly circumtropical, in my contention. Hitherto it was believed that females of *O. latirostris* do not show dimorphism, unlike the other two species. Females of *O. latirostris* collected from the Bay of Bengal and south-central Indian Ocean show pronounced dimorphic characters. Polymorphic behaviour is mostly restricted to *O. piscator*, mainly due to post-maturity growth. The geographic variations in length are discussed in detail for the first time.

INTRODUCTION

Oxycephalids are exclusively holoplanktonic animals inhabiting oceanic waters characterised by a high degree of stability of environmental factors such as salinity and temperature; so it is difficult to keep oxycephalids alive under laboratory conditions. This is obviously the reason why very little is known about the biology and ecology of oxycephalids. Some oxycephalids are even parasitic on gelatinous zooplankton (LAVAL, 1980; YOUNG and ANDERSON, 1987).

Oxycephalids have a global distribution, in tropical and subtropical waters. In this family 10 genera are known with 20 species. The validity of 2 species is yet to be established.

There have been many controversies among various workers on the number of valid species under the genus *Oxycephalus* including the studies made from Indian waters. Previous reports from the Indian Ocean were largely dependent on logistics of ship operation which precluded extensive coverage. In recent years the genus was treated rather extensively by FAGE (1960) working on Dana collections. PILLAI (1966a) gave fully illustrated descriptions of species collected off the west coast of India.

The genus *Oxycephalus* exhibits dimorphic and polymorphic characters, first noticed by FAGE (1960). The study described below is the first comprehensive account on this genus covering the entire Indian Ocean through seasons and the second report on confirming the dimorphic and polymorphic behaviour of these curious Peracarid Malacostraca. The geographic variation in length is also discussed in detail for the first time.

MATERIAL AND METHODS

Zooplankton samples (1927) collected during the Indian Ocean Expedition (IOE), mostly with the Indian Ocean standard net, were used for the present study. Out of 1927 samples, oxycephalids were present only in 648 samples. Numerical abundance of each species was calculated and their numbers were used for presentation of distribution

maps (Figs. 1-3). The stations were grouped into 2 seasons, from 16th April to 15th October and from 16th October to 15th April, which coincided with southwest (SW) and northeast (NE) monsoons of the northern Indian Ocean. The day and night groupings of the stations were done taking into account the local time at which the collections were made. For convenience of comparison, the samples were grouped under 4 regions, the Arabian Sea (area north of 5°N and west of 77°E); the Bay of Bengal (area south of 5°N and from 77°E to 110°E); the western Indian Ocean (area south of 5°N and west of 77°E) and the eastern Indian Ocean (area south of 5°N and from 77°E to 110°E).

RESULTS

Geographic distribution

Genus: *Oxycephalus*

Species: *Oxycephalus clausi*

Of the 252 specimens studied, 56 were males, 114 females and 82 juveniles (Table-1). In almost all collections females outnumbered males, males being very rare in the SE Indian Ocean where juveniles and females were found in equal proportions. *O. clausi* is widely distributed in the tropical and sub-tropical areas of the World Oceans. The present study revealed its occurrence in the Indian Ocean from 23°N in the Arabian Sea and 20°N in the Bay of Bengal to 35°S latitude. But for a single sample, the rest of the south central Indian Ocean from 20°S was devoid of this species (Fig-1).

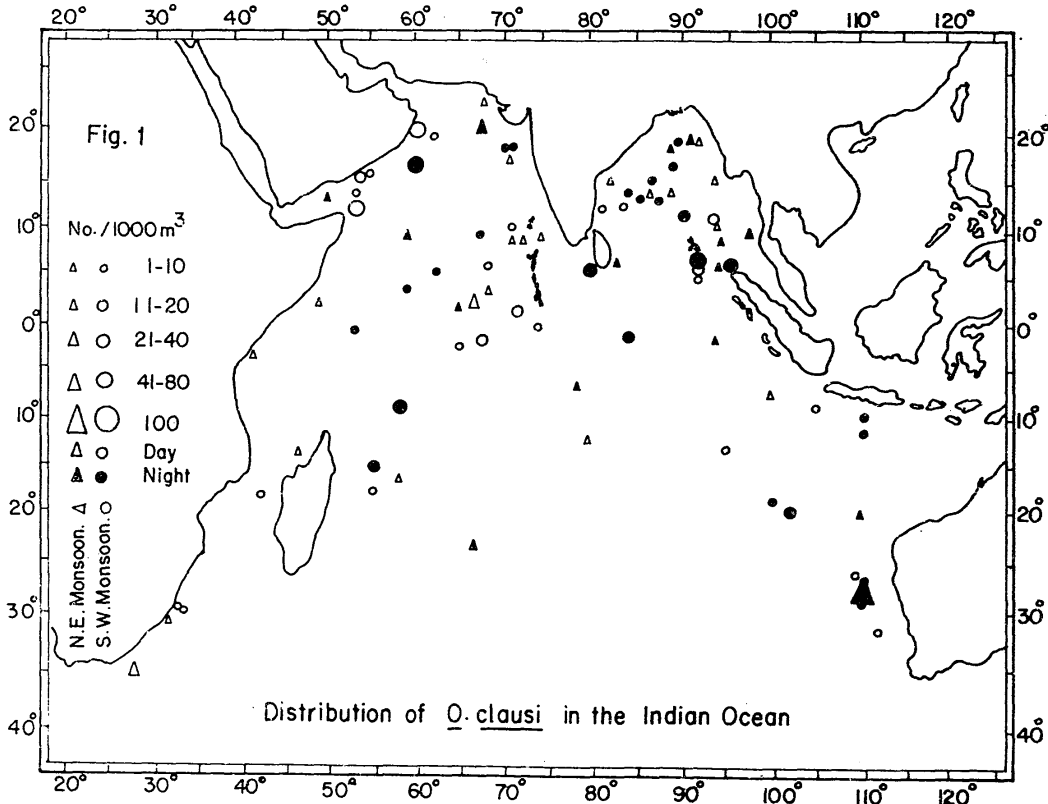


Fig. 1. The distribution of *O. clausi* in the Indian Ocean.

Table 1. Percentage occurrence and total number of each species in four geographical areas, in two seasons, day & night.

Species -	<i>O. clausi</i>	<i>O. piscator</i>	<i>O. latirostris</i>
Numerical abundance (%)	9.8	10.4	2.2
Occurrence (%)	13.9	13.6	2.8
Arabian Sea	71 M. F. J. (15-40-16)	49 M. F. J. (3-34-12)	9 M. F. J. (5-4- -)
Bay of Bengal	75 M. F. J. (21-32-22)	80 M. F. J. (15-34-31)	8 M. F. J. (2-6- -)
S.W. Indian Ocean	47 M. F. J. (13-16-18)	40 M. F. J. (3-18-19)	18 M. F. J. (12-5-1)
S.E. Indian Ocean	59 M. F. J. (7-26-26)	99 M. F. J. (14-40-45)	23 M. F. J. (6-3-14)
S.W. Monsoon	150 Nc (50)	146 Nc (47)	42 Nc (13)
N.E. Monsoon	102 Nc (40)	132 Nc (41)	16 Nc (5)
Day	91 Nc (44)	130 Nc (48)	35 Nc (11)
Night	161 Nc (46)	138 Nc (40)	23 Nc (7)

M = Males; F = Female; J = Juveniles; Nc = Number of collections;
S.W = South West; S.E = South East; N.E = North East.

O. clausi was present in 13.9% of stations from where oxycephalids were identified and their numerical abundance was about 9.79%. Their numerical abundance remained more or less the same both in the Arabian Sea and Bay of Bengal whereas the NE and SW Indian Ocean showed slight variation (Table-1).

The peak abundance (100/1000m³) of *O. clausi* was observed in a night station off the west coast of Australia (Fig.1). Areas of high density (41-81/1000m³) were located to the south of the Andaman Islands, to the west of Sacotra Island and off the coast of Muscat and Oman. Areas of moderate density (21- 40/1000m³) were found at three widely separated areas off the southeast coast of South Africa, off Gujarat and off the north- west coast of Sumatra. Low density areas (11-20/1000m³) as well as areas of poor concentration (1-10/1000m³) were found to be scattered all over the Indian Ocean, more so in the Bay of Bengal and to the west of Laccadive and Maldiv Islands. It was totally absent in the Red Sea, Persian Gulf, head of the Arabian Sea and Bay of Bengal, in the central Arabian Sea and south central Indian Ocean.

O. clausi showed its dominance during the SW monsoon period with 150 specimens from 50 stations compared to 102 specimens from 40 stations during NE monsoon. Areawise coverage during the seasons is given in Table 1.

Previous records from the Indian Ocean

Earlier reports included those by BOVALLIUS (1887) from the southern Indian Ocean; WALKER (1909b) from the Maldiv Archipelago; CECCHINI (1929) from the Red Sea; BARNARD (1937) from the central and southern Arabian Sea and also from Zanzibar area; FAGE (1960) along the route of Dana between 6° 36'N to 40°06'S; PILLAI (1957 & 1966a) from the central and south-west coast of India and JOSSI (1972) between Sumatra and Sri Lanka and between Java and Australia.

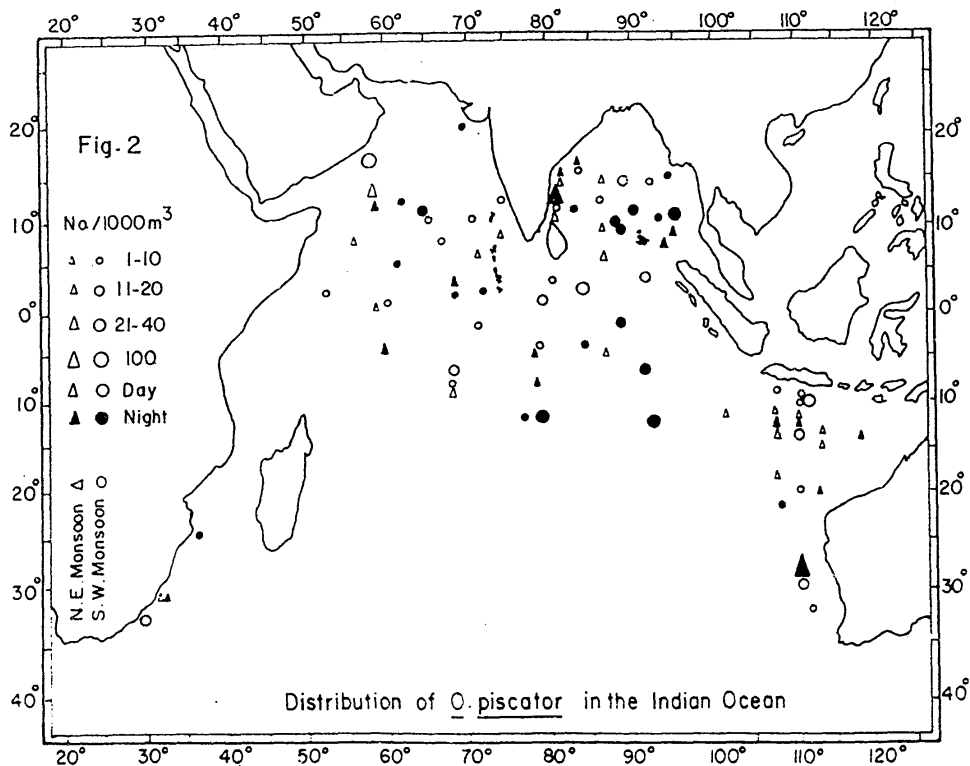


Fig. 2. The distribution of *O. piscator* in the Indian Ocean.

World distribution

A very widely distributed species with a geographical limit from 43°N to 41°71'S including the Mediterranean Sea and the Red Sea.

Oxycephalus piscator

In all, 268 specimens comprised of 35 males, 126 females and 107 juveniles were obtained. Males were very few especially in the Arabian Sea and the SW Indian Ocean (Table - 1). Gravid females and juveniles were more in the SE Indian Ocean and the Bay of Bengal. This widely distributed species inhabiting the tropical zones of all the Oceans, was found distributed from 20°N in the Arabian Sea and 16°N in the Bay of Bengal upto 35°S during the present study (Fig.2).

These 268 specimens comprising 10.41% of oxycephalids were identified from 88 (13.6%) out of 648 collections. The regional distribution pattern (Table - 1) showed that it was more (66.7%) in the eastern half of the Indian Ocean when compared to the western half where the number of positive stations also remained low (Fig. 2).

Distribution and abundance of *O. piscator* (Fig. 2) in the Indian Ocean showed its peak (100/1000m³) off Muscat, off Madras and off the central west coast of Australia. Areas of moderate density (21-40/1000m³) were found to the east of Socotra Island, off Mergui Archipelago and two isolated patches south of 10°S between 75° and 95°E. Low density areas (11- 20/1000m³) and areas of poor concentration (1-10/1000m³) were found off the coast of South Africa, areas between 12°N and 12°S latitude on

either side of the equator which extend upto 16°N in the Bay of Bengal, along and on either side of 110°E meridian. It was almost totally absent along the east coast of Africa, along Saudi Arabian coast, northern and central Arabian sea along the central and northern areas of the west coast of India, northern areas of the Bay of Bengal and south central Indian Ocean. Surprisingly, gregariousness and swarming of this species reported by FAGE (1960) was not observed in the IIOE studies.

O. piscator was relatively more abundant (146 specimens in 47 collections) during the SW monsoon period when compared to NE monsoon (122 specimens from 44 collections). Their frequency of occurrence was more in the SE Indian Ocean (Table-1).

Previous records form the Indian Ocean

O. piscator was reported from the Bay of Bengal by MILNE EDWARDS (1830/1840), from areas around Scycheles, Madagascar and Mozambique Channel by FAGE (1960); off the south west coast of India by PILLAI (1966a) and from areas between Java and Australia by JOSSI (1972).

World distribution

This circumglobal species was found in the Atlantic, Pacific and Indian Oceans as well as in the Mediterranean Sea. The form *O. bulbosus* was more specific to areas of high temperature. It was absent in the Mediterranean where the typical form was common. The geographical limit of this species appear to be 41°21'N to 41°47'S.

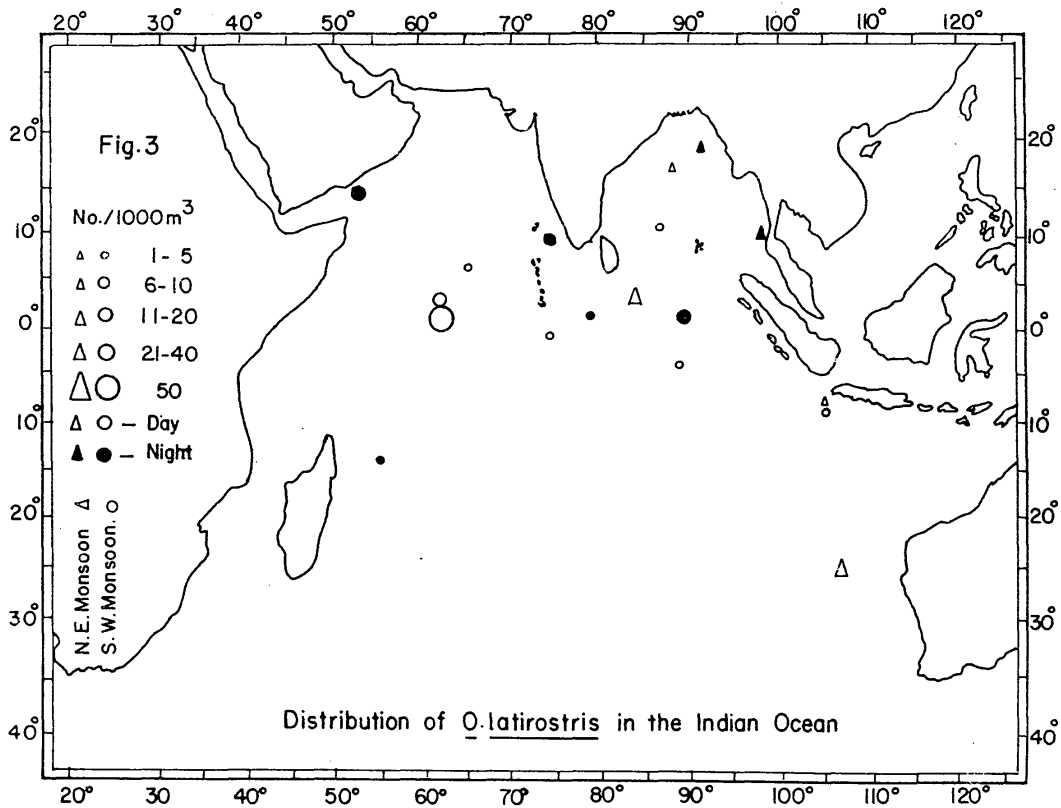


Fig. 3. The distribution of *O. latirostris* in the Indian Ocean.

Oxycephalus latirostris

Altogether 58 specimens consisting of 25 males, 18 females and 15 juveniles were collected. Males were rare in the Bay of Bengal with 2 specimens, whereas the SW Indian Ocean had 12. Females did not show much of a variation in their occurrence in all the 4 geographical areas (Table-1). Juveniles were totally absent in the Arabian Sea and Bay of Bengal, whereas 14 of them were present in the SE Indian Ocean.

O. latirostris was present only in 18 samples out of 648 (2.8%) and their numerical abundance also remained low (2.25%). The geographical distribution showed its peak abundance ($50/1000\text{m}^3$) in a day haul along the equator from 63°E meridian (Fig-3). Next range of $24-40/1000\text{m}^3$ was noticed off Yemen, off the SE coast of Sri Lanka and off the west coast of Australia. Moderate densities ($11-20/1000\text{m}^3$) were found off the SW coast of Burma and along the equator at 80°E meridian. Low ($6-10/1000\text{m}^3$) and poor ($1-5/1000\text{m}^3$) densities were observed in isolated patches off the north-east coast of Madagascar, in the northern Bay of Bengal, off the SW coast of Java and from a few hauls on either side of the equator. While maximum concentration occurred between the equator and the 10°N latitude, it was almost absent south of 5°S and north of 10°N in the western half of the Indian Ocean except for 2 isolated occurrences off Yemen & Madagascar.

As in the case of the 2 preceding species, *O. latirostris* also showed a dominance during the SW monsoon with 42 specimens from 13 samples. During the NE monsoon period only 16 specimens were found in 5 samples. While 55% (32 Nos) were collected from the SW and SE Indian Ocean during SW monsoon, during NE monsoon none was recorded from the SW Indian Ocean and the Arabian Sea (Table-1)

Previous records from the Indian Ocean

O. latirostris has been recorded near Cocos Islands in the east, up to Cape of Good Hope in the west (FAGE, 1960); off the SW coast of India (PILAI, 1966a) and in the Red Sea (SPANDL, 1924 and 1927).

World distribution

In contrast to the other species of the genus, *O. latirostris* was found to be unevenly distributed in the tropical waters of the Atlantic, Pacific and Indian Ocean with an extended distribution into the Red Sea and Mediterranean waters. In the Atlantic it was rare compared to other oceans.

This species was generally not known to extend beyond 10°N and 40°S . The southernmost extension in the Indian Ocean as was reported by FAGE (1960) is 38°S . However during the IIOE it was found to extend only up to 25°S .

Latitudinal distribution

Latitudinal distribution of *O. clausi* and *O. piscator* showed maximum number of stations and numerical abundance between 10°N and 20°N . From 10°N to south, there was a gradual decrease both in the number of stations and numerical abundance reaching the lowest between 30° and 40°S . But between 20°S and 30°S latitude the numerical density remained relatively high due to the presence of peak density stations off the west coast of Australia. The high numerical abundance of *O. piscator* between 10° and 20°S was mainly due to the high number of positive stations in that area. The peak abundance of *O. latirostris* was found shifted to 0° and 10°N . To the south of equator *O. latirostris* was almost absent except in 4 scattered stations. *O. piscator* and *O. latirostris* were totally absent between $20^\circ - 25^\circ\text{N}$ latitude (Fig -4).

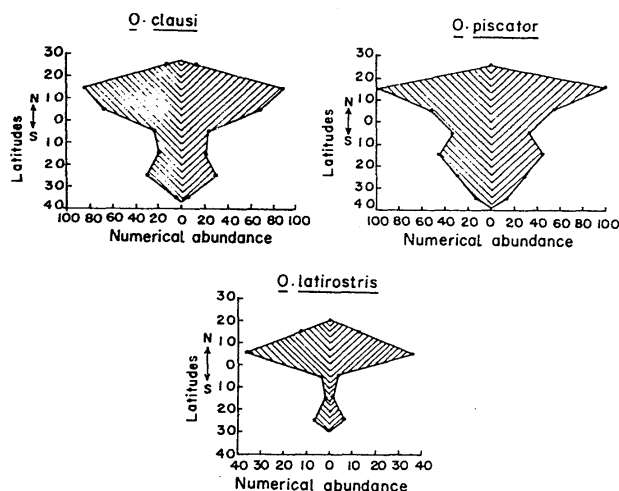


Fig. 4. Latitudinal distribution of *O. clausi*, *O. piscator* and *O. latirostris* in the Indian Ocean.

Day and night variation

Out of 252 specimens of *O. clausi* collected from 90 stations, 91 specimens were recorded during the day at 44 stations and 161 specimens appeared during the night at 46 stations. In general nocturnal abundance was more in almost all areas except for a marginal increase during day in the Arabian Sea (Table-1). Maximum number of specimens was found in the Bay of Bengal (57) and in the SE Indian Ocean (51) during night.

In *O. piscator* there was not much of an appreciable difference between the number of specimens collected during day and night where 48 day collections contained 130 specimens and 40 night collections yielded 138 individuals. Nocturnal abundance was noticed in the Bay of Bengal and the SE Indian Ocean samples (Table-1).

Table 2. Size ranges of *O. clausi* in the Indian Ocean and some previous length records (Length in mm). (M - Male; F - Female; J - Juvenile).

	Indian Ocean			
	Arabian Sea	Bay of Bengal	SW Indian Ocean	SE Indian Ocean
(M)	11.20-18.00 (mode-14.00)	8.28-15.36 (mode-11.00)	8.96-30.10 (mode-15.00)	10.04-34.00 (mode-17.00)
(F)	8.90-18.00 (mode-15.00)	7.04-24.00 (mode-14.00)	11.86-36.80 (mode-19.00)	16.42-34.00 (mode-21.00)
(J)	5.76-6.70 (mode-5.80)	3.20-6.40 (mode-4.20)	3.84-7.6 (mode-7.00)	1.98-5.44 (mode-5.14)
Previous records				
20.00-35.00 - from all subtropical regions, BOVALLIUS (1890).				
16.00 - Mediterranean, STEPHENSEN (1925)				
6.50-14.00 - Pacific, BARNARD (1931)				
36.00 - East and mid Atlantic, BARNARD (1932)				
15.00-30.00 - Indian Ocean (Arabian Sea), BARNARD (1937)				
30.00 - Atlantic (Bermuda), SHOEMAKER (1945)				
6.00-18.00 - South Africa, REID (1955)				
27.00-38.50 - South African coast, FAGE (1960)				
21.40 - Indian Ocean (Arabian Sea), PILLAI (1966a)				

Table 3. Size ranges of *O. piscator* in the Indian Ocean and some previous records (Length in mm).

Indian Ocean				
	Arabian Sea	Bay of Bengal	SW Indian Ocean	SE Indian Ocean
(M)	12.80-16.00 (mode-14.50)	7.04-15.04 (mode-15.00)	8.85-11.25 (mode-9.50)	8.00-23.00 (mode-13.00)
(F)	7.80-12.00 (mode-10.00)	7.40-16.00 (mode-9.00)	7.44-18.80 (mode-12.50)	8.00-19.00 (mode-14.00)
(J)	3.64-6.90 (mode-6.40)	1.92-5.44 (mode-3.50)	1.38-4.46 (mode-4.00)	2.56-5.78 (mode-4.20)

Previous records

- 14.00-20.00 - Temperate subtropical & tropical Atlantic, BOVALIUS (1890).
 25.00 - Mediterranean, STEPHENSEN (1925).
 27.00 - Pacific (New Zealand), BARNARD (1930).
 19.00 - East Mid Atlantic, BARNARD (1932).
 17.00 - Atlantic (Bermuda), SHOEMAKER (1945).
 15.00 - South Africa, REID (1955).
 27.00-30.50 - North & South Atlantic, FAGE (1960).
 15.60 - Indian Ocean (Arabian sea), PILLAI (1966a).

(M - Male; F - Female; J - Juvenile).

Table 4. Size ranges of *O. latirostris* in the Indian Ocean and some previous records (Length in mm)

Indian Ocean				
	Arabian Sea	Bay of Bengal	SW Indian Ocean	SE Indian Ocean
(M)	12.80-13.00 (mode-13.00)	14.40-15.00 (mode-14.50)	11.20-12.60 (mode-12.20)	15.46-15.48 (mode-15.00)
(F)	11.49-14.46 (mode-11.50)	7.36-19.00 (mode-7.40)	12.20-14.40 (mode-12.80)	13.50-19.40 (mode-15.50)
(J)	nil	nil	6.36	9.60-11.46 (mode-11.00)

Previous records

- 16.00-22.00 - Subtropical regions of Atlantic and Indian Ocean, BOVALLIUS (1890).
 11.00-20.50 - Tropical and subtropical Atlantic, Pacific and Indian Ocean, FAGE (1960).
 13.90 - Indian Ocean (Arabiab Sea), PILLAI (1966a).

(M - Male; F - Female; J - Juvenile)

On the contrary, *O. latirostris*. was more abundant during the day when compared to night samples and its peak abundance also was noticed in a day sample along the equator from 63°E meridian.

Length variation

In *O. clausi*, generally the adult females reach a greater length than the adult males. The smallest mature males were collected from the Bay of Bengal (Table-2). The 36.30 mm long female collected from the SW Indian Ocean appears to be the second longest female on record (Table-2).

Unlike *O. clausi*, the males of *O. piscator* grow to a greater length. This was observed in most of the collections from the Arabian Sea and the Bay of Bengal (Table-3). On the other hand in collections from SW and SE Indian Ocean, most of the adult males were smaller than the females. A predominance of small females was observed in the Bay of Bengal collections.

In *O. latirostris*, the usual size of the adults varied between 12-15 mm, FAGE (1960). But ovigerous females of 7.36 mm long were found during the present study from the Bay of Bengal (Table-4). At the same time, in the SE Indian Ocean females of 9.6 mm long were found to be sub-adults.

Polymorphic and dimorphic behaviour

O. clausi and *O. piscator* were reported to exhibit polymorphic and dimorphic tendencies by FAGE (1960). From the present study, it is established that *O. clausi* and *O. piscator* show polymorphic and dimorphic behaviour as the case may be. *O. latirostris*, according to Fage did not show any dimorphic character. But during the present study, though rare, dimorphic tendency of *O. latirostris* has been observed and discussed in detail.

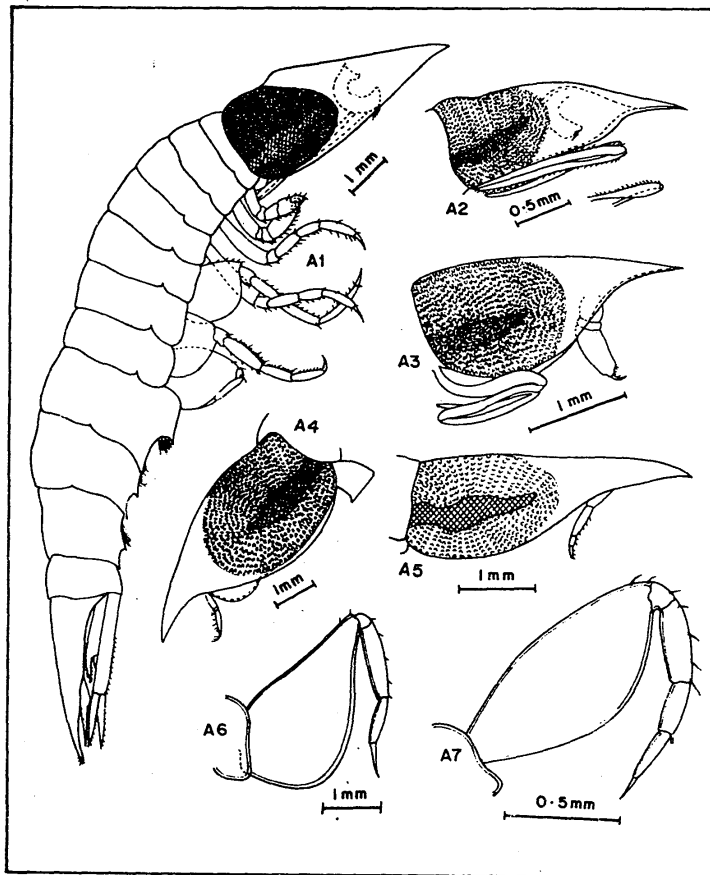


Plate 1. Illustrations of *O. clausi*, A-1 - *Oxycephalus clausi* (Adult male), A-2 - Cephalon (Adult male), A-3 - Cephalon (Juvenile male), A-4 - Cephalon (Adult female) - *bulbosus* form, A-5 - Cephalon (Adult female) - typical form, A-6 - Seventh pereopod (Adult female), A-7 - Seventh pereopod (Adult male).

DISCUSSION

The general pattern of distribution of *O. clausi* was similar to that of *O. piscator* except that *O. clausi* extended further up in the Arabia Sea. Their absence in the Red Sea, Persian Gulf and at the head of the Arabian Sea might indicate their avoidance of high saline waters while their absence at the head of the Bay of Bengal might suggest a similar avoidance of very low saline waters as well. Contrary to the above finding, the record of *O. clausi* from the Red Sea waters by CECCHINI (1929) is surprising. *O. latirostris* also does not seem to prefer waters of high salinity even though it was recorded from the southern areas of the Red Sea by SPANDL (1924 & 1927). Other than salinity, temperature also can be one of the factors controlling the distribution of all the three species.

The dominance of *O. piscator* in the SE Indian Ocean and westward spreading along the south equatorial current and counter current also indicated its preference to waters of moderate salinity. The general distribution pattern showed that it is mainly confined to the Indo-Pacific. Its absence along the cooler west wind drift and sub-tropical areas could not possibly be attributed to low temperature, as FAGE (1960) had reported *O. piscator* in good numbers from adjacent areas during Dana Expedition at temperatures varying between 27.59° to 19.76°C.

From the present study, it appears that *O. latirostris* is a tropical species with extended distribution in the sub-tropical areas as well. Presence of good number of juveniles together with berried females suggested the possibility of SE Indian Ocean being a favourable breeding ground for this species. Even though the Dana Expedition collected this species in good numbers (577) from the Indian Ocean, they were encountered only in small numbers during the IIOE. This might be due to the fact that the IIOE collections were vertical hauls of much shorter duration, unlike Dana's oblique tows of longer duration.

Females of *O. clausi* show dimorphism showing distinct difference in size and morphology. Typical females has an elongated cephalon (Pl-1, A-5) and small ones a more globular cephalon (Pl-1, A-4). In the IIOE collections the length of female specimens varied between 7.04 to 34.00 mm. Those exceeding 13.5 mm in length never had globular head. FAGE (1960), who also had observed this dimorphism, stated that 15 mm is the limit of the length of females with globular head.

As in the case of *O. piscator*, in the equatorial areas, the premature forms of *O. clausi* with globular heads were more numerous compared to the rest of the areas. Females of premature forms were found to extend into the Arabian Sea and Bay of Bengal but their southern limit was found to be 10°S in the Indian Ocean. FAGE (1960) had given 7°N as the northern limit and the tropic of capricorn as the southern limit of premature forms except a single record which he had made off Madagascar. It is interesting to note that this dimorphism is not found among the males.

Studies by FAGE (1960) on the Dana material confirmed that the distribution of the premature forms of *O. clausi* is temperature dependent. From the area of study in the Indian Ocean, Fage had reported a temperature of 25.4°C extending up to 30m depth; while from 50 m onwards the fall was rapid reaching a mean of 18.5°C at 125m depth below which premature females were absent.

A significant sexually dimorphic character that is unusual is the shape of the base of the seventh pereopod. STEBBING (1888), PILLAI (1966a) and VINOGRADOV *et al* (1982) who all have illustrated the female leg show the basis as regularly narrowing distalwards (Pl-1, A-6), In male the basis is elongate ovate (Pl-1, A-7).

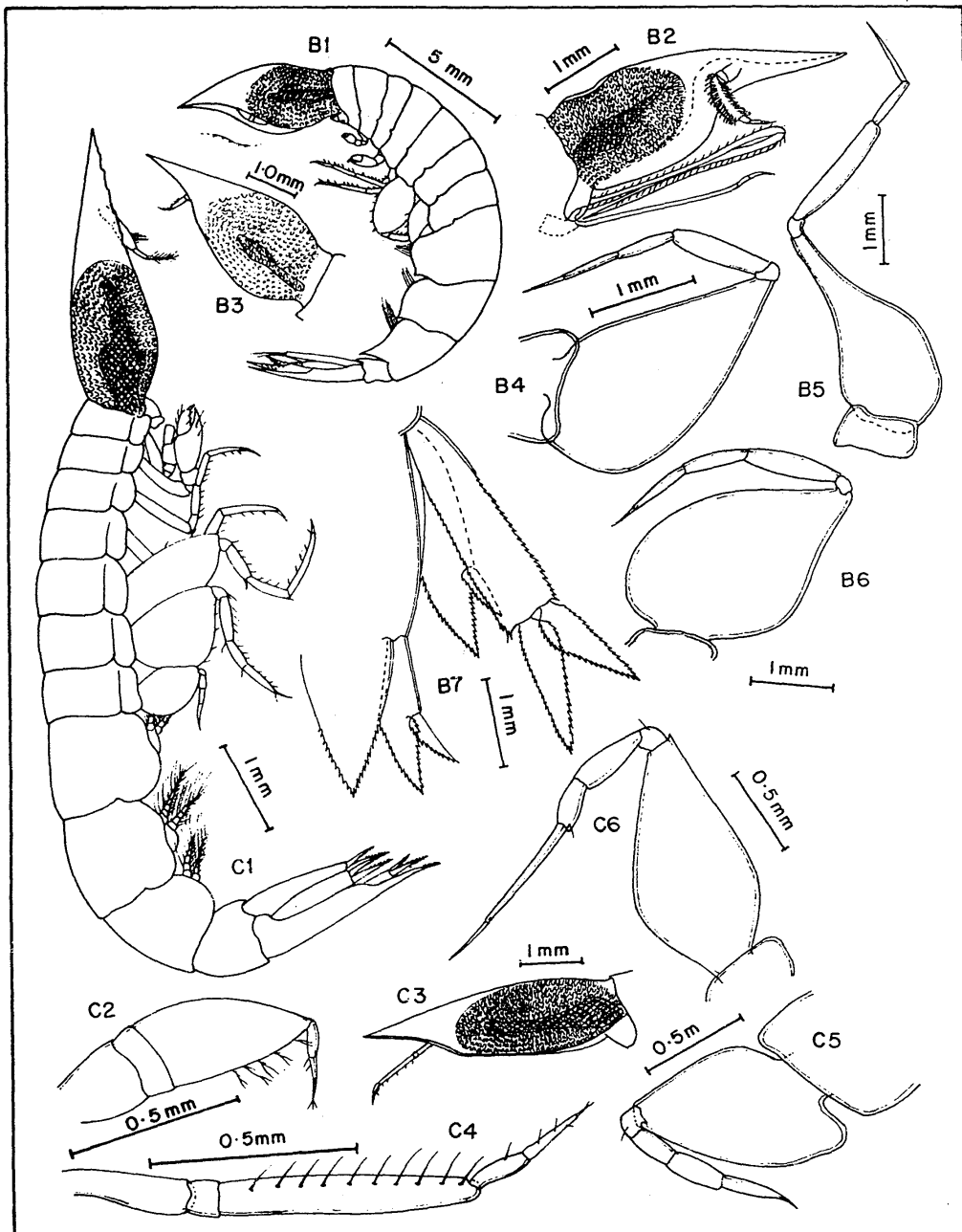


Plate 2. Illustrations of *O. piscator* and *O. latirostris*. B-1 - *Oxycephalus piscator* (Adult female), *bulbosus* type, B-2 - Cephalon (sub-adult male), B-3 - Cephalon (Adult female) typical form, B-4 - Seventh pereopod (Adult female), B-5 - Seventh pereopod (Adult female) - After SHOEMAKER (1945), B-6 - Seventh Pereopod (Adult male), B-7 - Uropods with telson (Adult female), C-1 - *Oxycephalus latirostris* (Adult female) - typical form, C-2 - First antenna (Adult female) - typical form, C-3 - Cephalon (Adult female) - dimorphic form, C-4 - First antenna (Adult female) dimorphic form, C-5 - Seventh pereopod (Adult female) typical form, C-6 - Seventh pereopod (Adult female) - dimorphic form.

FAGE (1960) described polymorphism in the female of *O. Piscator*. The IIOE collections lend support to Fage's conclusion. There were females of 8-14 mm long with swollen highly elevated cephalon with a short rostrum (P1-2, B-1). It would appear that STREETS (1878) described such a specimen as *O. bulbosus*. In other types of females the cephalon was elongated, with the dorsal profile gradually continued on to the rostrum (P1-2, B-3). *O. similis* CLAUS (1879) apparently represented such a female.

IN the IIOE collection, the males appeared only in two forms corresponding to the two female groups. In one group the females were 7.04 to 19 mm and the corresponding males 7.04 to 23 mm. Though the minimum length of the male was 7.04, the same as that of the female, a vast majority of the males collected from the Arabian Sea, Bay of Bengal and SW and NE Indian Ocean were 14.50, 15.00, 9.50 and 13 mm respectively corresponding to females 10.00, 9.00, 12.50 and 14.00 mm. Evidently in the Arabian Sea and Bay of Bengal females attained sexual maturity at a smaller size and the males were clearly longer. Within this group the *bulbosus* form predominated.

This variation in length of the adults indicates that there was much postmaturity growth. Males 14-17mm long were sub-adults with first antenna not yet fully grown. From the SE Indian Ocean such a sub-adult male of 23 mm long was captured (P1-2, B-2). In the same geographical area *bulbosus* and *similis* populations of *O. piscator* were mingled.

The proportion of the division of the body do not vary with the difference in the size or sex of the individuals. The cephalon forms one quarter of the total length, the pereon is nearly equal to the metasome and the urosome is one fifth of the total length in the male but slightly shorter in the female.

The double urosome segment is one and a half times the length of the telson. The telson of the female of the *bulbosus* type is shorter than in the *similis* type and the first uropod reaches or over-reaches the telson (P1-2, B-7).

The seventh pereopod shows dimorphic differences. In the male the basis is broader and suddenly narrowed at the tip (P1-2, B-6) as illustrated by BOVALLIUS (1890). But in some specimens it steadily narrows distalwards (P1-2, B-4) and yet in some others, the elongation is pronounced as illustrated by SHOEMAKER (1945) (P1-2, B-5). This difference is however not visible in sub-adult males.

The IIOE collections showed that the *bulbosus* form occurs both north and south of the equator extending up to the central Arabian Sea and the Andaman and Nicobar Islands in the north and down to 20°S latitude. During the present study about 43% of the females collected from the above areas were of the *bulbosus* type, while 56% of females collected from the Indian Ocean and the Indo-Malaysian areas by FAGE (1960) belongs to the *bulbosus* type. He had observed a maximum of 60% of them from the Atlantic whereas the south Pacific areas had only a maximum of 45%. The 'Thor' and 'Dana' Expeditions showed that the *bulbosus* form was absent in the Mediterranean and the north Pacific at high salinities and low temperature. Fage recorded the *bulbosus* form from the waters around Fiji Islands where the temperature was 28.44°C, whereas at the same depth in the vicinity of New Zealand where the temperature dropped to 13°C, only the typical form was present. These conclusions, however, could not be scrutinised during the present study owing to the lack of stratified samples.

FAGE(1960) from his rich collection of *O. latirostris* (577) from all over the tropical waters concluded that *O. latirostris* do not show dimorphism unlike the other two species. It should be pointed out that 453 of his specimens were from the Indian Ocean, mostly from the east coast of Africa and equatorial waters. From the IIOE material two adult females showing dimorphism were identified one from the Bay of Bengal and

the other form the SE Indian Ocean. Both specimens were 19.50 mm long. In the dimorphic female the head is long as long as the pereon and parallel sided for more than two-thirds of its length (Pl-2, C-3). In typical female the cephalon steadily narrows towards the tip of the rostrum (Pl-2, C-1). The first antenna is six segmented (Pl-2, C-4) against five-segmented in the typical form (Pl-2, C-2). The most significant difference is in the seventh pereopod. In the typical form the lower proximal part is expanded into a rounded lobe making the segment proximally broadest (Pl-2, C-5). The rest of the appendage is as long as or shorter than the basis. In the dimorphic species the basis is broadest at one-third distance from the base and further on steadily narrows (Pl-2, C-6). The rest of the appendage, unlike in the typical form is longer than the basis.

The length of *O. clausi* according to BOVALLIUS (1890) varies between 20 and 35 mm (Table-2). According to FAGE (1960) the longest male measure 27 mm while the female reached 38.50 mm though the usual length was only 32 mm. FAGE (1960) observed males and females reaching maturity at 11 and 12 mm respectively. Table (2) indicates that though this species varies considerably in length, a vast majority of individuals attain maturity at a moderate length indicating perhaps post maturity growth. The geographical variation in length of *O. piscator* is quite pronounced. Such variations are mostly dependent on the stage of growth of the individual and the physiological conditions. Bovallius gives the length variation as 14 to 20 mm (Table-3). But STEPHENSEN (1925) records a female of 25 mm long and BARNARD (1930) a male of 27 mm. The largest specimen Fage got from the north Atlantic was 27 mm and the one from the south Atlantic measured 30.50mm. The maximum size for the male and female in IIOE material was 23 and 19 mm respectively. The length of *O. latirostris* according to Bovallius varies from 16 to 22 mm (Table-4). The largest male FAGE (1960) obtained was 20 mm long and female 20.50 mm collected from the north Pacific and central Pacific respectively. In IIOE samples the maximum length of the male and female was 15.48 mm and 19.40 mm respectively.

Nocturnal abundance in *O. clausi* was more pronounced when compared to *O. piscator*. The marginal increase of *O. piscator* in night samples might indicate their preference for surface/sub-surface waters. STEPHENSEN (1925) had noticed a nocturnal abundance of *O. piscator* especially from 10 to 35 m depth. During the Dana Expedition, FAGE (1960) had observed the occurrence of *O. piscator* even at a depth of 4000m, with maximum frequency between 50 and 300 m depth. Fage, while studying the vertical distribution of the two forms (the *bulbosus* and the typical one) in the Indian Ocean observed that up to 50 m depth, both the forms occurred in almost equal proportion. However, in Dana collections, from 50 to 100 m depth the *bulbosus* form was found scarce and was totally absent below 300 m. *O. latirostris*, on the whole, though showed dominance during day, in the Arabian Sea and Bay of Bengal they were more during night. PIRLOT (1938) qualified this species as bathy pelagic. But studies on Dana material by FAGE (1960) showed dense concentration between 20 and 30 m depth becoming rare progressively below 100 m.

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