

DISTRIBUTION AND RELATIVE ABUNDANCE OF PARAPHRONIMIDAE (HYPERIIDAE, AMPHIPODA) IN THE INDIAN OCEAN

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Distribution and relative abundance of two species of amphipods of the family Paraphronimidae, namely *Paraphronima gracilis* and *P. crassipes* are presented in this paper. *P. gracilis* was abundant in the Arabian Sea while *P. crassipes* was abundant in the Bay of Bengal. Latitudinal distribution shows that the maximum is in between latitudes 10° - 20° N irrespective of the seasons.

Statistical analysis of the data reveals that in *P. gracilis* there is no significant difference between the mean number of specimens in the different regions during the period October 16 to April 15, whereas during the period April 16 to October 15 in the Bay of Bengal and in the western Indian Ocean it was found to be significantly different. On comparing the mean length of the specimens it was found that the average length of the specimen is significantly high in the western Indian Ocean during both periods. The coefficient of correlation between the log of number of species and dissolved oxygen was found to be significantly correlated in the eastern Indian Ocean. In the case of *P. crassipes*, the mean length of the specimens in the Bay of Bengal is significantly higher when compared to Arabian Sea during the period October 16 to April 15 and during the same period, the coefficient of correlation between dissolved oxygen and the number of specimens was found to be significant in the Arabian Sea.

INTRODUCTION

The present report on the taxonomy, distribution, ecology and developmental stages of hyperiid amphipods of the IIOE collections is the first to deal with the quantitative and qualitative distribution of the family Paraphronimidae (Hyperiidea, Amphipoda) which is a poorly known group in the Indian Ocean. Description of the species is added in view of the scattered nature of the earlier reports. Paraphronimidae comprises only one genus, *Paraphronima* (Claus, 1879) with three species, *Paraphronima gracilis* (Claus, 1879), *P. crassipes* (Claus, 1879) and *P. clypeata?* (Bovallius, 1885). The first two species are widely distributed, known from the tropical and temperate regions of the world oceans. The third species was originally recorded from the northern temperate regions of the Atlantic and tropical region of the Pacific (Bovallius, 1889).

MATERIAL AND METHODS

1927 zooplankton samples, collected during IIOE, mostly with the Indian Ocean Standard Net, were classified into standard and non-standard and the

Distribution of Paraphronimidae in the Indian Ocean

samples were processed according to a standard procedure (IOBC, 1969). Numerical abundance of each species was calculated and these numbers were used for the preparation of maps. The stations were grouped into two seasons, from 16 April to 15 October and 16 October to 15 April, which coincide respectively with the SW and NE monsoons of the northern Indian Ocean. The day and night grouping of the stations was done taking into account the local time at which the collections were made. For convenience of comparison, the samples are grouped under four regions: Arabian Sea (area north of 5°N and west of 77°E), Bay of Bengal (area north of 5° N and from 77°E to 110°E), western Indian Ocean (area south of 5°N and west of 77°E) and eastern Indian Ocean (area south of 5°N and from 77°E to 110°E).

SYSTEMATICS

- Order: Amphipoda
Suborder: Hyperiidea
Infra order: Physocephala
Superfamily: Viblilioidea
Family: Paraphronimidae (Bovallius, 1887)

Body transparent, slender, head large cubical, eyes large occupying most surface of head. Antennae one, fixed at anterior side of head, flagellum tumid with few segments. Antennae two, reduced, fixed at ventral side of head. Mandibles without palp and molar, adapted for mastication. Maxillipeds inner and outer lobes fused, pereopods one and two much shorter than those following. Pereopod two with a thin hollowed process on either side of the dactyle. Pereopods three to six slender, seventh shorter than sixth. Uropods with exo- and endopods free. Gills on pereonites three to six. Ostegites on pereonites two to five.

Genus: *Paraphronima* (Claus, 1879)

Species: *Paraphronima gracilis* Claus (Fig. 1)

Synonymy: Spandal, 1927, P. 165.

Head as deep as long, pereopods slender, elongata with narrow femora. Pereopod seven much shorter than sixth pereopods with fine setae on their marginal parts. Peduncle of the last pair of uropods much narrower than the length of the rami. Telson broad rounded behind.

Length: Male - 2.10 to 8.25 mm; Female - 2.00 to 9.24 mm.

The original description by Claus (1879) agrees well with the specimens obtained from IIOE collections.

DISTRIBUTION

Previous records

Indian Ocean:

Previously the species was recorded from limited areas in the Indian Ocean - from Chagos, Seychelles and Mauritius (Walker, 1909). 9 specimens were collected and the depth of sampling varied from 1375 to 46 m. Males, females and juveniles were recorded and the maximum size reported was 14 mm. Barnard (1937) has collected 10 specimens (3 males and 7 females) from the northern Arabian Sea and the maximum size reported by him was 6 mm.

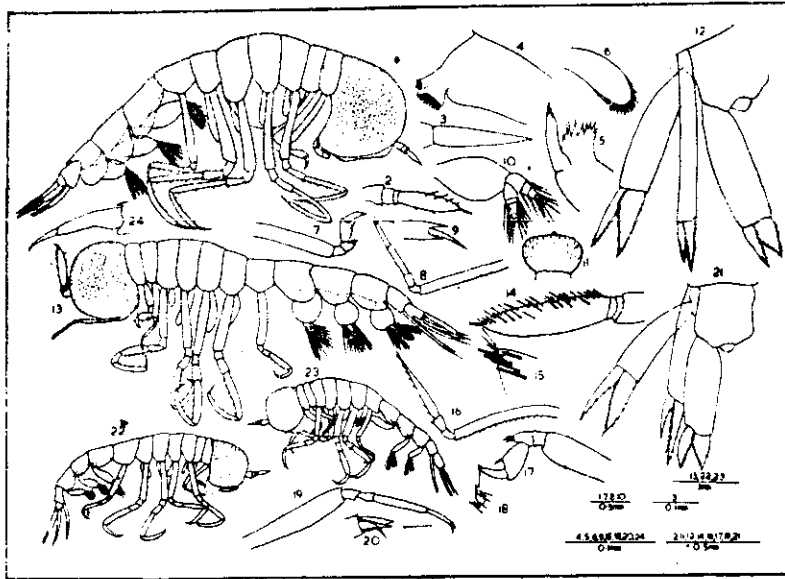


Fig. 1. *Paraphronima gracilis*

1—12: Female. 1—Adult; 2—Antenna 1; 3—Antenna 2; 4—Mandible; 5 and 6—Maxillae; 7—Pereopod 1. 8—Pereopod 2; 9—Pereopod 2 (enlarged dactylus); 10—Pleopod 1; 11—Maxillipeds; 12—Uropods and telson. 13—21: Male. 13—Adult; 14—Antennae 1; 15—Antennae (enlarged tip); 16—Antennae 2; 17—Pereopod 1; 18—Pereopod 1 (dactylus enlarged); 19—Pereopod 2; 20—Pereopod 2 (dactylus enlarged); 21—Uropod and telson; 22—Juvenile male; 23—Juvenile female; 24—dactylus of third pereopod of female.

Atlantic:

The northern limit recorded in Atlantic is 40°N (Stephensen, 1924) and the southern limit recorded is 35° 10'S (Spandal, 1927).

Mediterranean:

Occur during summer, winter and spring and they are found almost exclusively towards the eastern basin (Stephensen, 1924).

Pacific:

Recorded from northwest Pacific to Cape York (Stebbing, 1888), northern temperate and tropical regions of the Pacific (Bovallius, 1889) and the west coast of Pacific (Hurly, 1956).

Results of IIOE: The results of the IIOE indicate that *P. gracilis* is more abundant and widely distributed in the Indian Ocean than in the other world oceans.

Out of a total of 194 samples containing *Paraphronimidae*, *P. gracilis* was found in 185 samples, of which 95 samples (50 day, 45 night) were collected during the SW monsoon period (Fig. 3) and 90 samples (38 day, 52 night) were from the NE monsoon period (Fig. 4). There was a total of 600 specimens belonging to different age groups; 317 specimens were collected during SW monsoon and 283 during NE monsoon (Fig. 7). Of the 600 specimens, 320 were males and the rest were females.

Distribution of Paraphronimidae in the Indian Ocean

80% of the specimens examined were adult males and females and the remaining were juveniles. Some of the females were found to be carrying eggs and a few juveniles were obtained from the brood chamber.

During the April 16 to October 15 period (Fig. 3) and the October 16 to April 15 period (Fig. 4), they were found towards the central part of the Arabian Sea, off Karachi, off Bombay, off Goa, off southeast coast of Africa and in scattered areas in the western Indian Ocean. In the Bay of Bengal, they were found to be absent to the north of 15°N and also in the central part of eastern Indian Ocean. During both the seasons they were fairly represented along the 110°E meridian. The maximum number of specimens (20) were recorded in a night haul from a station to the south of Socotra Island and all the specimens were found to be juveniles. During the NE monsoon their representation in the Bay of Bengal was from two stations on either side of Andaman Islands (Fig. 4).

Latitudinal distribution shows that they are more abundant between 10 and 20°N and 10 and 20°S during both the seasons (Fig. 7). The high values in the above latitude is a result of their high concentrations in the Arabian Sea and along the 110°E meridian respectively. For both seasons in general, night collections always showed more representation and it was quite pronounced in between latitudes 10° and 20°N during SW monsoon.

Paraphronima crassipes Claus, 1879 (Fig. 2)

Synonymy: Shoemaker, 1945, p. 234

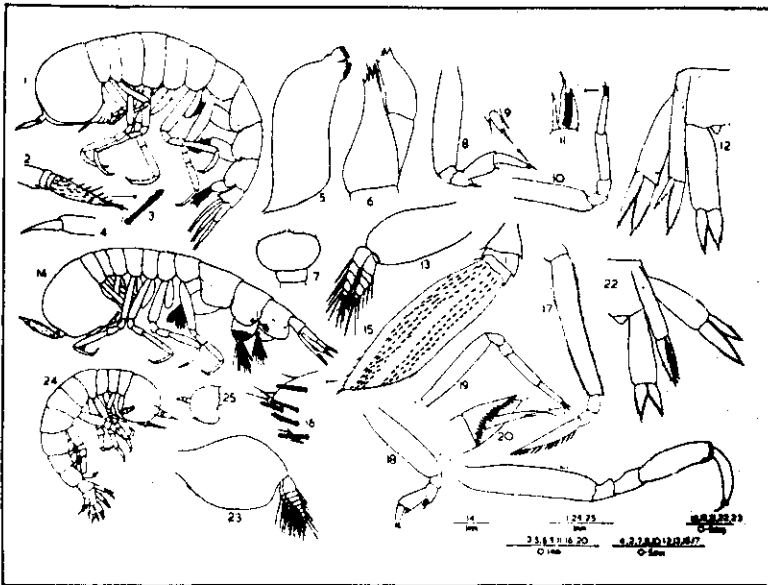


Fig. 2. *Paraphronima crassipes*

1—13: Female. 1—Adult; 2—Antennae 1; 3—Antenna one bristle enlarged; 4—Antennae 2; 5—Mandible; 6—Maxillae; 7—Maxillipeds; 8—Pereopod 1; 9—Pereopod 1 (dactylus enlarged); 10—Pereopod 2; 11—Pereopod 2 enlarged; 12—Uropod and telson; 13—Pleopod 1. 14—23: Male. 14—Adult; 15—Antenna 1; 16—Antenna tip enlarged; 17—Antennae 2; 18—Pereopod 1; 19—Pereopod 2; 20—Pereopod 2 (dactylus enlarged); 21—Seventh pereopoda; 22—Uropods and telson; 23—Pleopod 1; 24—Juvenile male; 25—Head of juvenile female.

Head longer than deep, pereopods robust with narrow femora. The seventh pair of pereopoda almost as long as the sixth pair. Pereopods without marginal setae. The peduncle of the last pair of uropoda much narrower than the length of the rami. Telson triangular. First pair of antennae robust, very long in the male, longer than the head. The femer of the first pair of pereopoda somewhat dilated.

Length: Male - 1.58 to 8.91 mm; female - 1.70 to 9.92 mm.

The original description by Claus (1879) agrees fairly well with the present specimens except in the following; The dactyl of the seventh pereopoda with a sharp spine towards the inner margin and at the base of the dactyl of the second pereopoda there are two spines on both sides.

Previous records:

DISTRIBUTION

Indian Ocean: Recorded from central Arabian Sea, Gulf of Aden, south Arabian Sea (Barnard, 1937); southeastern part of Arabian Sea (Tsuruta 1963; Pillai, 1966).

Atlantic: The species is recorded from Florida current, Sargasso Sea, north equatorial current, Guinea current, south equatorial current (Stephensen, 1924), southwest Atlantic, south Atlantic, southeast Atlantic and east mid-Atlantic (Barnard, 1932). The northern limit recorded is 5°27'N and the southern limit is 24°55'S (Spandal, 1927).

Mediterranean: The species is found to occur at all depths between 100 and 3000 m (Stephensen, 1924).

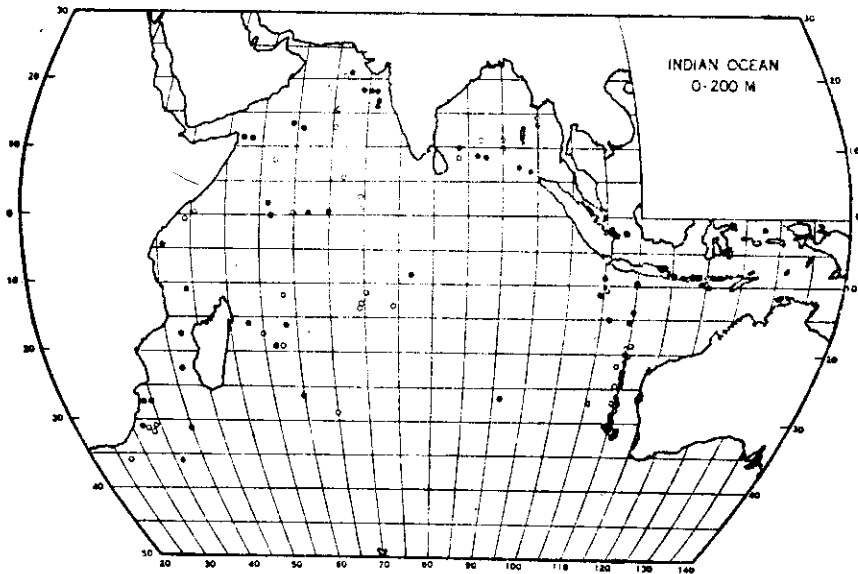


Fig. 3
Stations showing the day and night distribution of *P. gracilis* during the SW monsoon
open circles - day, closed circles - night

Distribution of Paraphronimidae in the Indian Ocean

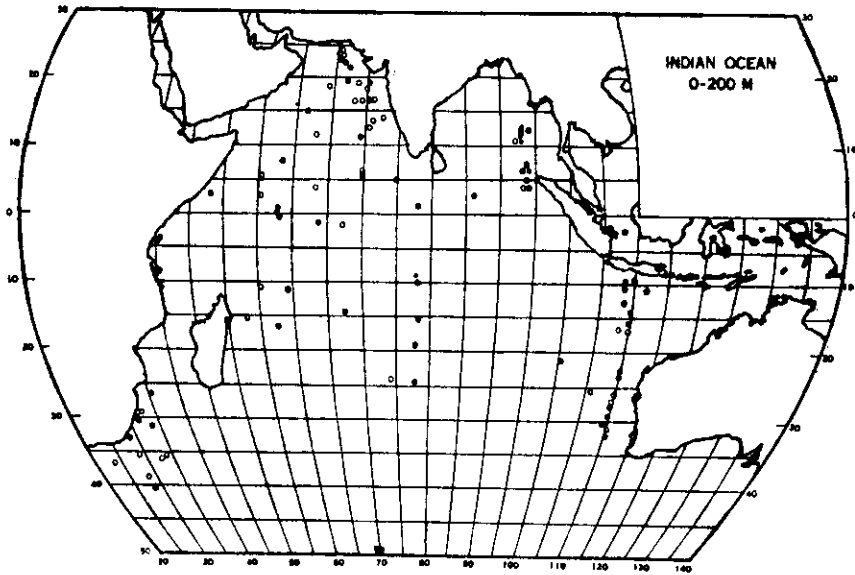


Fig. 4. Stations showing the day and night distribution of *P. gracilis* during NE monsoon
Open circle - day, closed circle - night.

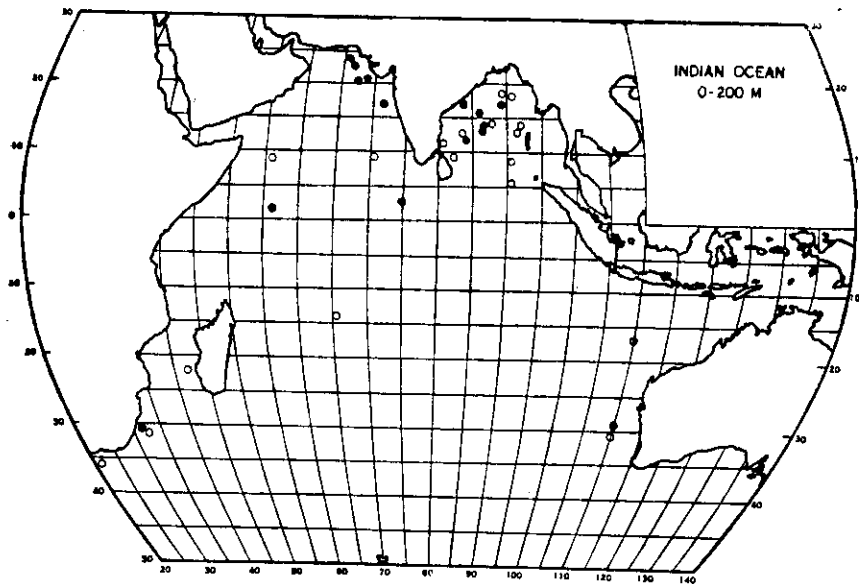


Fig. 5. Stations showing the day and night distribution of *P. crassipes* during the SW monsoon
Open circle - day, closed circle - night.

Pacific: Distribution all over the tropical region of the Pacific (Bovallius, 1988).

Results of IIOE:

The IIOE results indicate that they are less abundant in the Indian Ocean when compared to *P. gracilis*.

P. crassipes was recorded from 70 stations out of which 33 stations (18 day and 15 night) were in SW monsoon season (Fig. 5) and 37 stations (28 day and 9 night) in NE monsoon period (Fig. 6). There was a total number of 200 specimens out of which 86 were males and the remaining females. Females carrying eggs and juveniles were also found.

This is a widely distributed species known from the tropical and temperate regions of the world oceans.

In the Arabian Sea, during the period April 16 to October 15, they were recorded only from seven stations, mostly from night hauls off Karachi, off Bombay and from 2 day stations along 11°N (Fig. 5). From the western Indian Ocean, they were recorded only from seven stations scattered all over, out of which three collections were from nearshore waters off South Africa. In the central Indian Ocean and eastern Indian Ocean, their representation was almost nil except from three stations along 110°E. In Bay of Bengal, they were distributed all over and the maximum number of specimens (20 juveniles) were collected from a day haul (05°06' N and 91°33' E).

During the period October 16 to April 15, they were found only from 7 stations in the Arabian Sea; 4 day hauls off the west coast of India, 2 hauls

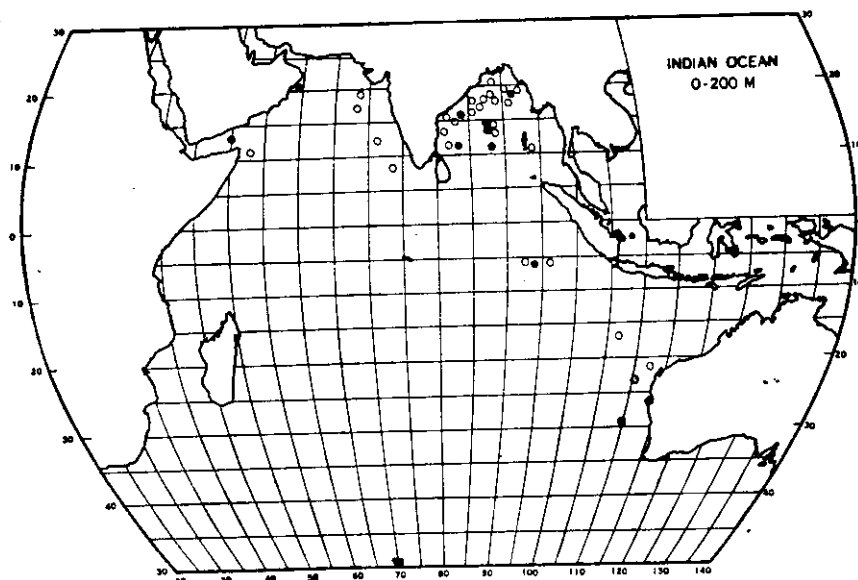


Fig. 6. Stations showing the day and night distribution of *P. crassipes* during the NE monsoon
Open circle - day, closed circle - night.

Distribution of Paraphronimidae in the Indian Ocean

from the Gulf of Aden and one from the northeast coast of Saudi Arabia. During this season to the south of 8°N and to the west of 82°E they were absent (Fig. 6). As in the case of the SW monsoon season, Bay of Bengal showed fair representation during NE monsoon season also but they were present more frequently in day samples rather than night samples.

Latitudinal distribution shows that they are found in maximum in between latitudes 10-20°N during both the seasons as in the case of *P. gracilis* (Fig. 7). The high values in these latitudes are the result of their high concentration in the Bay of Bengal unlike *P. gracilis* which was found more in the Arabian Sea.

VERTICAL MIGRATION

Pronounced vertical migration was found in both *P. gracilis* and *P. crassipes*. In the case of *P. gracilis*, during SW monsoon, night collections were found to contain more number of specimens and the numbers were remarkably high in between 10-20°N and 20-30°S (Fig. 7). *P. gracilis* was found to be more in numbers towards the surface waters during night when compared to day.

In the case of *P. crassipes*, more number of animals were collected during the day than in the night. Even the juveniles were found in high numbers in day collections unlike *P. gracilis* where most of the day collections were dominated by adult males.

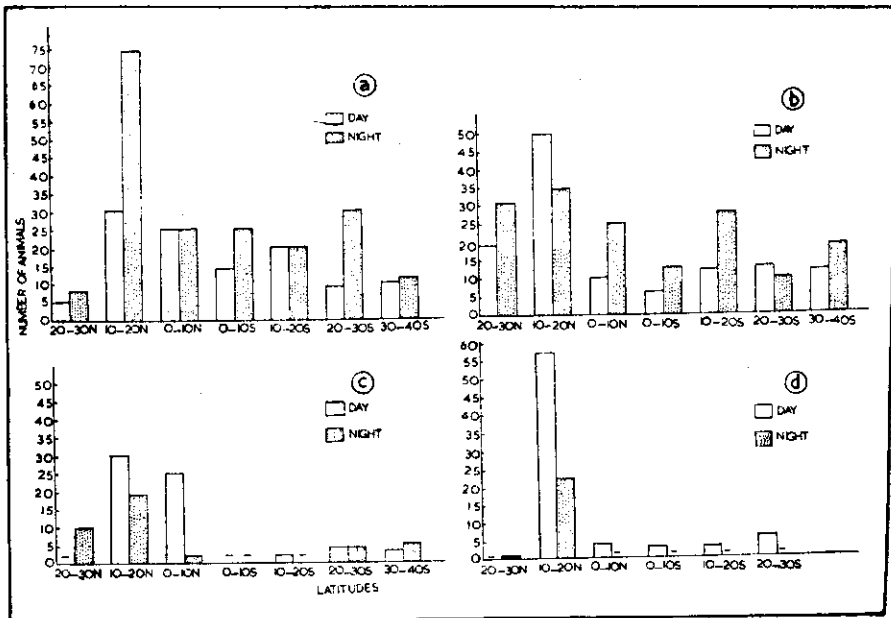


Fig. 7. a - Latitudinal distribution of *P. gracilis* during SW monsoon. b - Latitudinal distribution of *P. gracilis* during NE monsoon. c - Latitudinal distribution of *P. crassipes* during SW monsoon. d - Latitudinal distribution of *P. crassipes* during NE monsoon

ENVIRONMENTAL RELATIONSHIPS

In the case of *P. gracilis* there is no significant difference between the mean number of specimens observed in the NE monsoon in the different regions. But during the SW monsoon in the Bay of Bengal and the western Indian Ocean, the mean number of specimens in day and night were found to be significantly different (Table 1).

Table 2 gives the mean lengths of the specimens of *P. gracilis* and *P. crassipes* collected from different regions of the Indian Ocean during the two seasons. Statistical comparison of the mean lengths shows that it varies significantly between several regions during both monsoons.

Correlation estimates between the number of specimens with the environmental parameters *i. e.*, temperature, salinity and dissolved oxygen in different regions showed that in the case of *P. gracilis*, during NE monsoon, dissolved oxygen correlated significantly with the number of specimens in eastern Indian Ocean. In the case of *P. crassipes*, during NE monsoon, again dissolved oxygen correlated significantly with the number of specimens in the Arabian Sea.

DISCUSSION

Out of a total of 1927 IIOE plankton samples examined, only 194 samples contained the representatives of the family Paraphronomidae. A total number of 1012 specimens were collected and their percentage composition in the total collections was found to be 0.81% (Nair *et al.*, 1973a).

Paraphronima gracilis is widely distributed all over Indian Ocean, more towards the Arabian Sea throughout the year. They were absent in the Bay of Bengal except in a few stations on either side of the 10°N latitude during April 16 to October 15. During the October 16 to April 15 they were pushed further down to 5°N except from 2 stations on either side of the Andamans. Their high concentration in the Arabian Sea and poor representation in the Bay of Bengal might be due to the highly varying salinity and associated hydrographical characters of the Bay of Bengal. The northwest Australian Sea was found to be always rich throughout the year which might be due to the highly complicated circulation patterns and periodic replenishment of the highly productive waters (Nair *et al.*, 1973 b). Regarding their vertical migrations, in most of the cases, night samples showed high values when compared to day indicating diurnal vertical migration.

The largest size of the specimen recorded from the Indian Ocean during IIOE is 9.24 mm whereas Walker (1909) has recorded the maximum size as 14 mm from Indian Ocean which is equal to the size reported from the high latitudes by Barnard (1930).

The breeding period also differs from ocean to ocean; in the Atlantic, females with ova or embryos are found from March to October (Stephensen, 1924), November to February (Siegfried, 1963); in the Mediterranean, around November (Stephensen, 1924) whereas in northern Indian Ocean, females with eggs and ova are found frequently during the months June to August.

P. crassipes is more dominant in the Bay of Bengal during both the seasons suggesting their low salinity preference associated with other inter-related hydrographic parameters. In the Arabian Sea they are found to be distributed towards the coastal waters whereas in the Bay of Bengal they are

Distribution of Paraphronimidae in the Indian Ocean

TABLE 1. DAY AND NIGHT COMPARISON USING 't' TEST (THE NUMBERS ARE REPRESENTED BY THEIR LOG VALUES)

Area	NE Monsoon				SW Monsoon				d.f.
	Day (mean)	Night (mean)	t	d. f.	Day (mean)	Night (mean)	t	d.f.	
<i>P. gracilis</i>									
Arabian Sea (A.S.)	0.44247	0.52157	0.83659	35	0.64014	0.35842	1.40389	21	
Bay of Bengal (B.B.)	0.30907	0.42255	0.10247	4	0.64260*	0.36735	2.50452 *	10	
Western Indian									
Ocean (W.I.O.)	0.22562	0.23320	0.09309	33	0.39855	0.19419	2.36939*	32	
Eastern Indian									
Ocean (E.I.O.)	0.30101	0.34013	0.47396	24	0.31737	0.18061	1.37392	26	
<i>P. crasstipes</i>									
A. S.	0.4005	0.5010	0.4278	7	0.3010	0.3010	0	5	
B. B.	0.1003	0.2256	0.0571	26	0.3578	0.4151	0.3640	17	
W. I. O.	0.3010	0.3010	0	4	0.1505	0.1806	0.1586	7	
E. I. O.	—	—	—	—	—	—	—	—	—

*=p < 0.05

TABLE 2. COMPARISON OF MEAN LENGTHS (mm)

Area	<i>P. gracilis</i>		<i>P. crassipes</i>	
	NE Monsoon	SW Monsoon	NE Monsoon	SW Monsoon
A. S.	4.3995	3.8847	4.6696	3.6886
B. B.	4.2370	5.0562	5.3211	3.7220
W. I. O.	5.0890	5.3091	—	5.9842
E. I. O.	4.4801	4.3920	5.2921	7.3528

COMPARISON OF MEAN LENGTH USING 't'									
	<i>P. gracilis</i>			<i>P. crassipes</i>					
	NE Monsoon	SW Monsoon	d.f.	NE Monsoon	SW Monsoon	d.f.			
A. S. Vs. B. B.	0.6445	5.3763***	139	3.0064***	0.0690	81			
A. S. Vs. W. I. O.	4.2335***	7.1685***	190	—	2.9072**	27			
A. S. Vs. E. I. O.	0.4735	2.7196**	171	1.1459	4.4495***	20			
B. B. Vs. W. I. O.	10.1067	1.1834	89	—	4.181***	80			
B. B. Vs. E. I. O.	0.9000	2.9440***	79	0.0912	5.3331***	73			
W. I. O. Vs. E. I. O.	3.0384***	4.5044***	121	—	1.2651	19			

** =P < 0.01, *** =P < 0.001

Distribution of Paraphronimidae in the Indian Ocean

found throughout the area. To the south of the equator, irrespective of the seasons, they are very seldom observed. As mentioned by Tsurata (1963) in the southeastern part of Arabian Sea *P. crassipes* was found to be totally absent.

Regarding the vertical migration there is a marked difference between day and night. Unlike many other species, of planktonic animals *P. crassipes* was found to dominate in many of the day collections especially in the Bay of Bengal during NE monsoon. This does not agree with the findings of Stephensen (1924).

Females with eggs and ova are found in the Atlantic during October and February (Stephensen, 1924) and in the Pacific in July and August (Hurly, 1956). In the Indian Ocean, females with matured eggs and juveniles in the brood pouches are frequently found from September to November.

The largest size reported for *P. crassipes* is 17 mm from the Atlantic by Barnard (1932) whereas from the Indian Ocean Pillal (1966) has reported the maximum size as 6.6 mm from the west coast of India. The largest size found from IIOE material is 9.92 mm.

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