

Distribution of *Haloptilus* (Copepoda, Calanoida) in the Indian Ocean

K SARALA DEVI, ROSAMMA STEPHEN & T S S RAO*

National Institute of Oceanography, Regional Centre, Cochin 682018

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Haloptilus specimens, collected during the International Indian Ocean Expedition, from 442 stations are examined. Of the 12 species encountered *H. paralongicirrus*, *H. austini*, *H. bulliceps*, *H. fertilis* and *H. fons* are new to the Indian Ocean. Most of the species are cosmopolitan in distribution, *H. longicornis* being the dominant species. Highest density of most of the species is noticed in the upwelling areas. *H. paralongicirrus* and *H. oxycephalus* show significant difference between day and night collections in southwest Indian Ocean during SW monsoon period. *H. ornatus* shows significant difference between day and night in Bay of Bengal during SW monsoon period. Comparison of number of specimens irrespective of diurnal and seasonal variations in different regions, viz. Arabian Sea, Bay of Bengal, southwest Indian Ocean and southeast Indian Ocean shows significant difference in the case of *H. paralongicirrus* and *H. spiniceps*. Arabian Sea has more number of specimens than Bay of Bengal and southwest and southeast Indian Ocean. *H. ornatus* shows more count in Bay of Bengal. Other species show no significant difference between regions. Comparison of 2 seasons irrespective of diurnal and regional variations shows significant difference only in the case of the dominant species *H. longicornis* for which NE monsoon shows more count than SW monsoon.

The genus *Haloptilus* is widely distributed¹. Occurrence of this genus from scattered and restricted areas of the Indian Ocean has been reported²⁻⁹. Reports on this genus based on the International Indian Ocean Expedition (IIOE) material have also been made¹⁰⁻¹². The present study on *Haloptilus* is from the zooplankton samples collected during IIOE (1960-1965).

Materials and Methods

Arabian Sea and Bay of Bengal received maximum coverage for sampling, the area being of special interest due to the effect of the monsoons. Representative samples from each 5° Marsden square were analysed to get a general idea about the distribution of different species. Altogether 442 standard samples¹³ were examined in the present study. Distribution maps were prepared for common species. For comparison the samples were tentatively arranged into 4 groups according to the regions of collection [226 samples from Arabian Sea (I), 88 samples from Bay of Bengal (II), 97 samples from southwest Indian Ocean (III), and 31 samples from southeast Indian Ocean (IV)]. Comparisons between regions, day and night and periods (16th April-15th October, 16th October-15th April) were made. The data were subjected to statistical analysis using student *t* test and the significance of *t* value established¹⁴. Only

those stations where specimens were available were included in the analysis.

Results and Discussion

Distribution of different species of *Haloptilus* (Figs 1 and 2) is given below.

H. longicornis—This is a very common and most dominant species representing 89.6% of the total samples and 84.3% of the genus. It is widely distributed in all parts of the Indian Ocean with high density along the western and central parts of the ocean. Maximum number (632/st. haul) is found in a station located along the southwest coast of India. It is moderately represented in the Bay of Bengal and southern Indian Ocean. Hydrographic conditions of the stations from where the species was collected show that it can tolerate temperature from 10.3-30.42°C, salinity 31.7-36.6‰ and dissolved oxygen 0.011-6.22 ml/litre.

The type locality of the species is the Mediterranean Sea. This is also recorded in Atlantic Ocean and adjacent seas from 70°N to the Antarctic Sea. The species has been recorded earlier in Indian Ocean from 14°N to 35°S and Pacific from 35°N to 40°S. Near Japan this seems to be present in warm currents.

H. paralongicirrus—It is present in 38% of the total samples and constitutes 4.27% of the genus. Maximum number (26/st. haul) is observed in a sample collected from a station located at 04°22'S and 67°24'E during SW monsoon. Patches of high distribution are noticed at the mouth of Gulf of Oman, southeastern

*Present address: National Institute of Oceanography, Dona Paula, Goa 403004

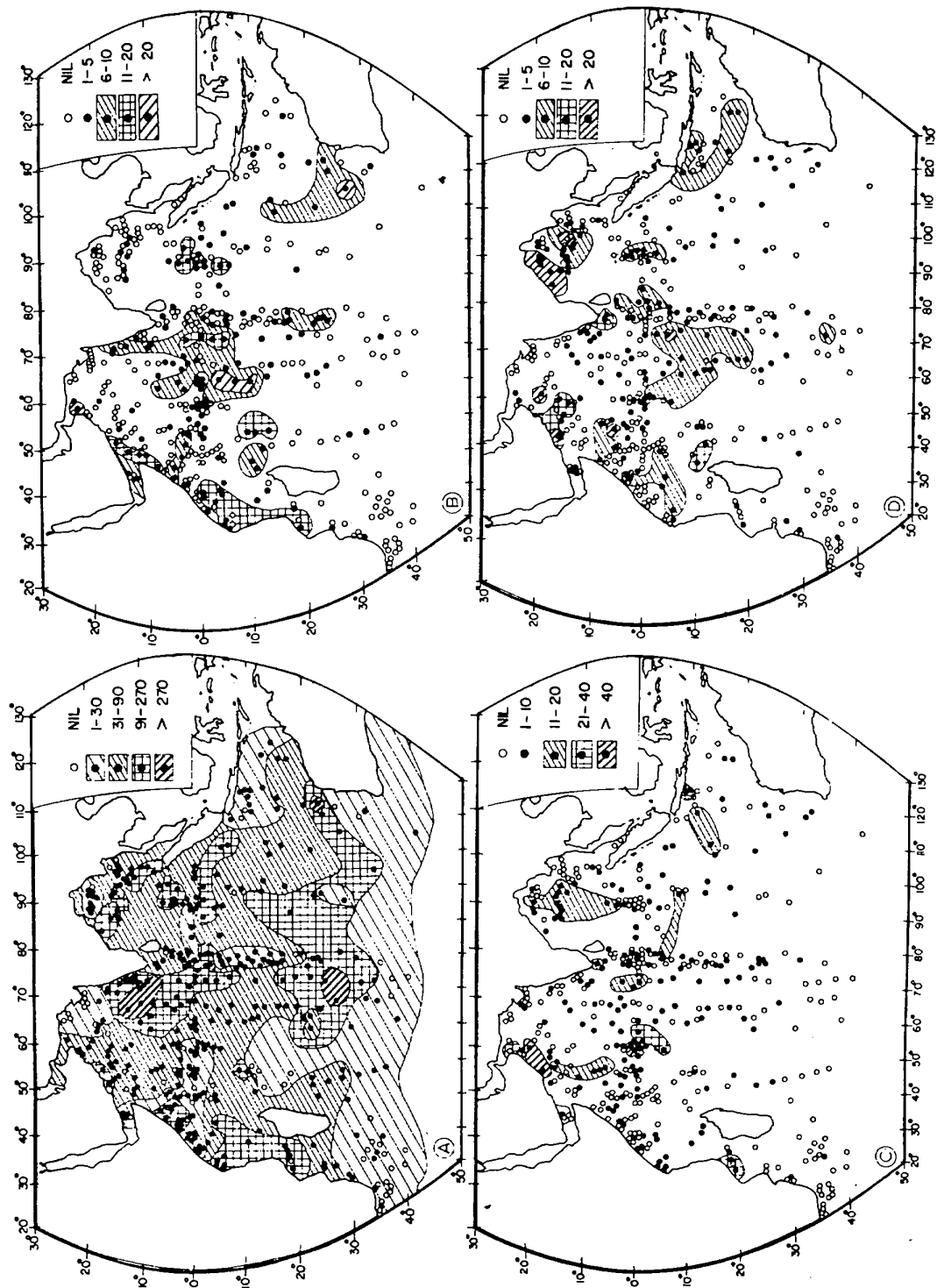


Fig. 1.—Distribution of (A) *H. longicornis*, (B) *H. spiniceps* and (D) *H. ornatus*.

Arabian Sea and near Australian coast around 110°E and 27°S. Moderate values are observed in the equatorial belt between 10°N and 10°S, in the Gulf of Aden and Mozambique coasts. It is sparsely represented in the northern and southern parts of the ocean. This species occurs at temperature 11.85-29.3°C, salinity 31.71-35.87‰ and dissolved oxygen 0.58-6.22 ml/litre. The type locality of the species is Caribbean Sea. This is the second record of the species from world oceans and the first from the Indian Ocean.

H. spiniceps—This species is present in 47% of the total sample and it constitutes 5.33% of the genus. Patches of moderate distribution are seen on the equatorial belt, central Arabian Sea and near Djkartha. Area of highest density is located in the northern Arabian Sea between 17°18'N-61°15'E. Maximum number (125/st. haul) is seen in a station located at 20°44'N and 61°15'E, during NE monsoon.

In the southern Indian Ocean this species is represented in small numbers. It is more abundant north of 10°S. It tolerates temperature between 11.24° and 30°C, salinity 32.22 and 36.6‰ and dissolved oxygen 0.13 and 5.78 ml/litre. *H. spiniceps* is first recorded from Mediterranean Sea. In Atlantic it is reported between 50°N and 28°S and in the Pacific from 38°N to 34°S. In the Indian Ocean it is so far been recorded in the eastern and western sides between the Equator and 35°S. This seems to be the first record of the species from the northern hemisphere in the Indian Ocean.

H. ornatus—This constitutes 24.4% of the total samples and 3.87% of the genus. It is distributed all over the Indian Ocean. Isolated patches of high distribution are observed in the Arabian coast. Maximum number (39/st. haul) is found in a station located between 04°11'S and 75°00'E in the Bay of Bengal. On the whole, Bay of Bengal is highly populated than the Arabian Sea. moderate distribution is noticed between 0 and 20°S. South of this region the species is represented in small numbers. It occurs in a range of temperature 11.33°-29.94°C, salinity 32.7-36.35‰ and dissolved oxygen 0.18-5.78 ml/litre.

First record of this species is from Mediterranean Sea. It is wide spread in the Atlantic between 38°N and 27°S and in the Pacific between 35°N and 20°S. Early records of the species from western Indian Ocean are from 10°N to 30°S and in the eastern Indian Ocean from Malay Archipelago.

H. oxycephalus—This species is present only in 12.4% of total samples and 0.87% of the total genus.

The species is more abundant along the equatorial region. It is sparsely distributed in the central Arabian Sea. Patches of high distribution are noticed in the central part of Bay of Bengal. It is also represented in

the southern Indian Ocean. Maximum number (29/st. haul) is found in a station at 18°S and 70°E. Hydrographic conditions of the station show that *H. oxycephalus* can tolerate temperature from 12.25°-29.64°C, salinity 33.35-36‰ and dissolved oxygen 0.11-5.88 ml/litre.

This species is originally reported from Atlantic Ocean. In the Pacific this species extends to Antarctic region up to 78°S. The species is recorded in the western Indian Ocean from 0-35°S. This is the first record of the species from the eastern Indian Ocean.

H. mucronatus—This species is present only in 5.66% of the samples and constitutes 0.15% of the genus. Better representation of the species is seen in the northern part of the ocean especially in the equatorial region, south of 10°S, it is present only in 3 stations. Patches of high distribution are noticed in the Arabian coast, Gulf of Aden, Somali coast and African coast. It is completely absent in the southern Indian Ocean. Maximum number (25/st. haul) is in a station located at 03°00'S and 53°00'E. This species can tolerate temperature from 12.53°-30.37°C, salinity 32.74-37.36‰ and dissolved oxygen 0.15-5.59 ml/litre.

H. mucronatus is first reported from the Mediterranean Sea. In Atlantic it occurs between 37°N and 25°S. In Pacific between 30°N and 34°S and in the Indian Ocean it has been so far recorded only from the western side of the ocean up to 27°S. The present record extends up to 30°S in the western Indian Ocean. This is the first record of the species from Bay of Bengal and from the eastern Indian Ocean.

H. austini—This species is represented in 11.5% of the total sample and 0.43% of the genus. In the Arabian Sea *H. austini* is observed off the Arabian coast, at the mouth of Gulf of Oman, in the Gulf of Aden and off the southwest coast of India. It is completely absent along the east coast of Africa in the northern and central part of Bay of Bengal. South of Equator up to 35°S this species shows a scattered distribution. Maximum number (13/st. haul) is observed in a station located off Arabian coast.

H. austini is originally reported from the equatorial and subtropical regions of east central Pacific Ocean. Earlier records are from the northern hemisphere, from the central and western Atlantic between 0 and 40°N and from the central Pacific between 0 and 28°N. This is reported here for the first time from the Indian Ocean, occurring between 24°N and 35°S. This species occurs at a temperature range of 11.2-30.0°C, salinity 34.09-36.25‰ and dissolved oxygen 0.25-6.22 ml/litre.

H. acutifrons—It's presence is noticed in 9.3% of the total samples and 0.34% of the genus. Maximum representation is in the northern Indian Ocean than in

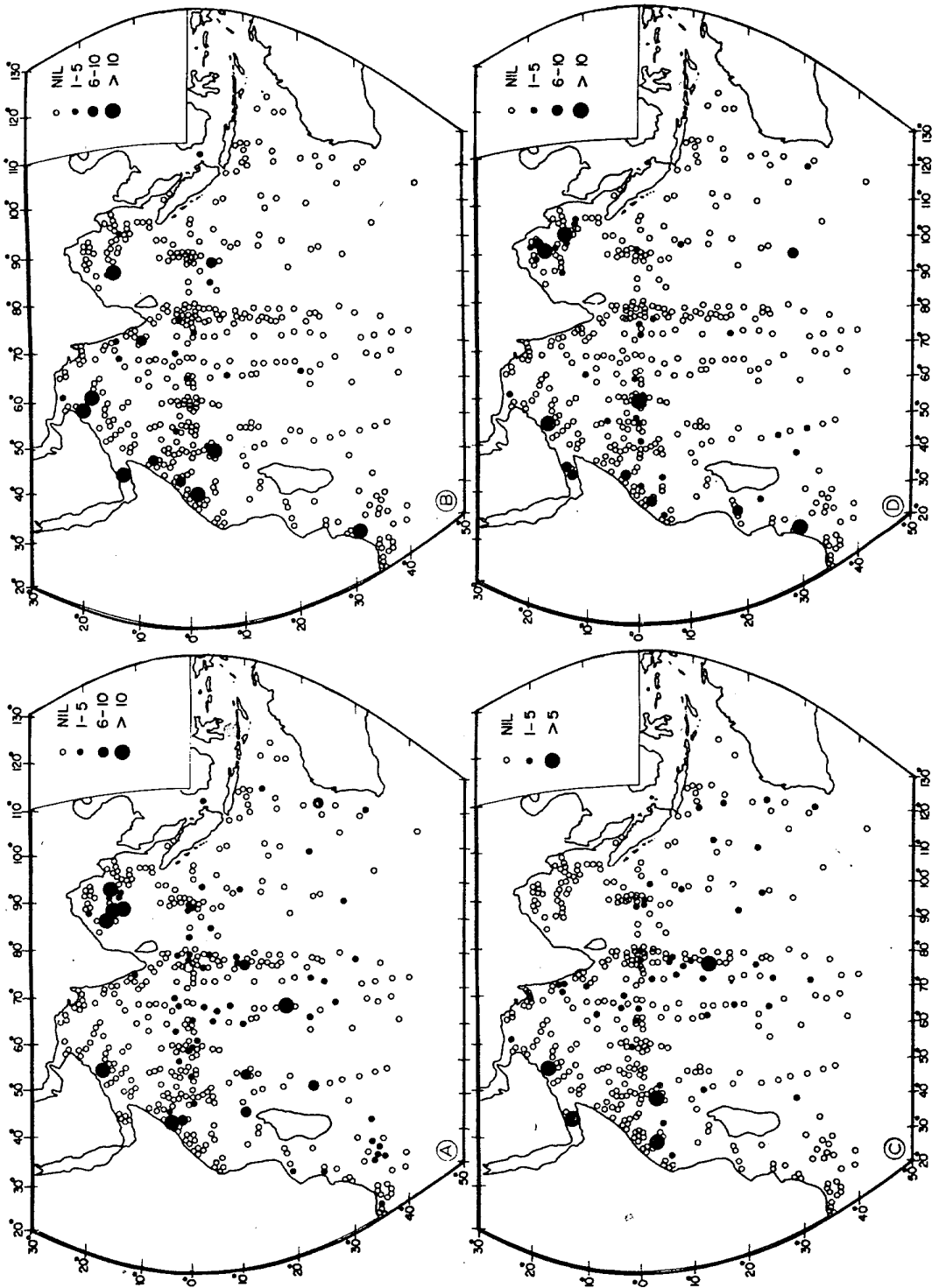


Fig. 2—Distribution of (A) *H. oxycephalus*, (B) *H. mucronatus*, (C) *H. ausini*, and (D) *H. acutifrons*

the southern region where its representation is scattered. High values are seen off the coast of Arabia, Bay of Bengal and in the equatorial region between 65 and 70°E. Maximum number (14/st. haul) is found in a station located in the southwest Indian Ocean, along African coast. The range of tolerance of temperature salinity and dissolved oxygen is between 11.24-29.76°C, 31.7 and 36.25‰ and 0.14 and 5.86 ml/litre respectively.

First record of the species is from Mediterranean Sea. It is wide spread in the Atlantic and Pacific. Earlier records of the species from the Indian Ocean extends from 24-35°S.

H. chierchiaie—This species is found at 2 stations, one in the Gulf of Oman and another in the central part of Arabian Sea. Temperature, salinity and oxygen of the 2 stations range from 14.66-29.44°C, 34.8-36.25‰, 0.13-5.57 ml/litre respectively.

Type locality of the species is northern Atlantic. It occurs in southeast Pacific from the Equator to 17°S. Former records of the species from the Indian Ocean are between 6°N and 18°N. Present record also is from the northern Indian Ocean.

H. bulliceps—Six specimens, stage IV female, are obtained from 4 collections taken from 3 regions, viz. Bay of Bengal, southern Indian Ocean and southeastern Indian Ocean. Three specimens are observed in a sample collected from off the coast of Australia. This species tolerates temperature between 11.54 and 29.30°C, salinity 32.71 and 35.87‰ and oxygen 0.58 and 6.22 ml/litre.

The original record of the species is based on stage IV female from Atlantic Ocean. This is the first record of the species from the Indian Ocean.

H. fertilis—One male specimen of *H. fertilis* is obtained from sample collected by the ship *Vitiaz* from the area between 28°18'S and 62°33'E. The first record of the species is from Atlantic between 25°N and 28°N. In the Pacific it is reported only in the northern hemisphere. The present record is the first one from Indian Ocean.

H. fons—Two stage V and 1 stage IV female specimens are obtained from 3 stations along 110°E meridian at 15°30'S, 18°30'S and 27°30'S latitude respectively. This forms the first record of the species from the Indian Ocean. The Atlantic and Pacific records were based on adult specimens.

Table 1 gives the comparison of day and night collections, in different region for 8 species for SW and NE monsoons. For *H. longicornis*, there is no significant difference between day and night collections in different regions in both seasons. For *H. paralongicirrus* southwest Indian Ocean shows a significant difference between day and night collections at 5% level in SW monsoon period and the

Table 1—Comparison of Day and Night in Different Regions for 8 Species of *Haloptilus* for the Two Seasons

[Values represent No./st. haul]

	SW monsoon		NE monsoon	
	Night mean	Day mean	Night mean	Day mean
<i>H. longicornis</i>				
Region I	1.5137	1.6766	1.6339	1.7983
Region II	1.2628	1.8068	1.4673	1.5689
Region III	1.4452	1.3862	1.7525	1.6343
Region IV	1.5030	1.6520	1.4861	1.4813
<i>H. paralongicirrus</i>				
Region I	0.8500	0.8380	0.8469	0.8197
Region II	—	—	—	—
Region III	0.8333	0.2719	0.7265	0.7059
Region IV	0.6330	0.6618	—	—
<i>H. spiniceps</i>				
Region I	0.8747	0.7776	0.8749	0.8164
Region II	—	—	0.4454	0.7860
Region III	0.8579	0.4781	0.5238	0.6512
Region IV	0.7238	0.8374	0.7138	0.6439
<i>H. ornatus</i>				
Region I	0.7091	0.6437	0.6806	0.7266
Region II	—	—	0.4602	0.5123
Region III	0.5599	0.4601	0.7230	0.7474
Region IV	0.6475	0.9264	0.7224	0.9211
<i>H. oxycephalus</i>				
Region I	0.5178	0.3399	—	—
Region II	—	—	—	—
Region III	0.6515	0.2223	—	—
Region IV	0.6780	0.5410	—	—
<i>H. acutifrons</i>				
Region I	0.7046	0.5539	0.5264	0.7144
Region II	—	—	—	—
Region III	—	—	—	—
Region IV	—	—	0.9065	0.7553
<i>H. austini</i>				
Region I	0.6363	0.5113	0.3750	0.5689
Region II	—	—	—	—
Region III	—	—	0.6277	0.2698
Region IV	0.5000	0.3597	—	—
<i>H. mucronatus</i>				
Region I	0.9375	0.4337	0.7095	0.9658
Region II	—	—	—	—
Region III	—	—	—	—
Region IV	—	—	—	—

Region: I, Arabian Sea; II, Bay of Bengal; III, SW Indian Ocean; IV, SE Indian Ocean.

number of specimens in night collections are more compared to day collections. For *H. spiniceps* there is no significant difference between day and night collections in both seasons. *H. ornatus* shows a significant difference between day and night collections in Bay of Bengal in SW monsoon at 5%

level. Number of specimens in day collections are more compared to the night collections. In *H. oxycephalus* a significant difference can be noticed between day and night in southwest Indian Ocean in SW monsoon at 5% level. Number of specimens are more in night than in day. There is no significant difference for species *H. acutifrons*, *H. austini* and *H. mucronatus*.

Comparisons of regions irrespective of seasonal and diurnal variations for each species indicate that *H. longicornis* shows no significant result. In *H. paralongicirrus* significant difference is noticed between Arabian Sea and southwest Indian Ocean and Arabian Sea and Bay of Bengal ($P < 0.01$, $P < 0.05$). Arabian Sea is having more number of specimens than southwest Indian Ocean and Bay of Bengal. *H. spiniceps* shows a significant difference ($P < 0.001$) between Arabian Sea and southwest Indian Ocean. *H. ornatus* shows a significant difference between Arabian Sea and Bay of Bengal; southeast Indian Ocean and

Bay of Bengal, and southwest Indian Ocean and Bay of Bengal ($p < 0.05$, $P < 0.05$, $P < 0.01$). In all 3 cases Bay of Bengal shows more count. *H. oxycephalus*, *H. acutifrons*, *H. austini* and *H. mucronatus* show no significant difference between the regions.

Comparison of 2 seasons irrespective of diurnal and regional variations indicates that *H. longicornis* shows a significant difference between the 2 seasons ($P < 0.01$). NE monsoon shows more count compared to SW monsoon. For other species the seasonal differences are not significant.

Comparisons between seasons, regions and day and night variations for all species taken together have been made. The differences between (i) seasonal means in different regions, (ii) day and night variations in regions and seasons, (iii) day and night of all regions taken together and (iv) NE and SW monsoons collections irrespective of regional and diurnal variations are not significant.

Table 2—Station Data for Rare Species

Ship	Cruise No.	St. No.	Lat.	Long.	Date	Time (hrs)	Depth	Species	No./st. haul
Anton Bruun	4A	189	24°00'N	62°04'E	1-11-63	0311	200-0	<i>H. chierchia</i>	2
Discovery	3	5385	11°19'N	64°32'E	22-5-64	2247	"	(f. st. IV)	
Anton Bruun	1	26	10°39'N	93°49'E	26-3-63	1530	"	do	2
do	5	312	31°26'S	74°57'E	12-4-64	1229	"	<i>H. bulliceps</i>	1
Koyomaru	14	23	19°58'S	94°02'E	1-1-63	1955	261-40	(f. st. IV)	
Umitakamaru	24	6312	21°04'S	112°50'E	11-12-63	1102	239-33	do	3
Diamentina	1/63	7	27°30'S	110°00'E	31-3-63	2115	220-25	<i>H. fons</i>	1
do	2/63	78	15°30'S	110°00'E	28-5-63	1045	210-18	(f. st. IV)	
do	2/63	80	18°30'S	110°00'E	29-5-63	1030	200-0	<i>H. fons</i>	1
Vitiaz	36	5223	28°18'S	62°33'E	26-12-64	0910	200-0	(f. st. V)	
								do	1
								<i>H. fertilis</i>	1
								(m. adult)	

Table 3—Numerical Abundance and Maximum Density of Different Species of *Haloptilus* during SW and NE Monsoons

Species	SW monsoon		NE monsoon		Maximum observed density			
	Total	Av. No./st. haul	Total	Av. No./st. haul	SW monsoon		NE monsoon	
					Station No.	No./st. haul	Station No.	No./st. haul
<i>H. longicornis</i>	14601	69	12140	72	AB. 109	342 D	Va. 2007	632 D
<i>H. paralongicirrus</i>	768	8	573	8	Di. 5458B	26 D	AB. 191	25 N
<i>H. spiniceps</i>	943	8	730	8	Di. 5038	50 N	AB. 196	125 N
<i>H. ornatus</i>	676	7	513	7	AB. 323	25 D	AB. 67	39 D
<i>H. oxycephalus</i>	193	4	79	4	AB. 78	24 D	Me. 135	19 N
<i>H. acutifrons</i>	104	5	98	5	AB. 358	14 D	AB. 51	10 D
<i>H. austini</i>	69	3	66	3	Di. 5038	13 N	Me. 151 & Me. 93B	8 D
<i>H. mucronatus</i>	57	7	103	7	Ar. Lu. 43	25 N	Me. 95B	19 D

D=Day and N= Night

A total of 11 species of *Haloptilus* are recorded earlier from the Indian Ocean and 12 species from different parts of the ocean are encountered during the present study. Data concerning the stations and number of specimens for rare species are presented in Table 2. Numerical abundance and maximum density of various species during the 2 seasons are given in Table 3. Highest density of most of the species are noticed in the upwelling areas of the ocean. On the basis of the spatial distribution the species can be grouped into (1) widely distributed species—*H. longicornis*; (2) species showing preference to equatorial waters—*H. paralongicirrus* and *H. oxycephalus*; (3) species showing patchy distribution—*H. spiniceps* and *H. ornatus*; (4) species showing scattered distribution—*H. mucronatus*, *H. acutifrons* and *H. austini* and (5) rare species—*H. bulliceus*, *H. chierchiaie*, *H. fertilis* and *H. fons*.

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