J. mar. biol. Ass. India, 1972, **14** (1): 115-138

DISTRIBUTION AND ABUNDANCE OF PELAGIC AMPHIPODA IN THE ARABIAN SEA, JAVA SEA, AND INDIAN OCEAN WITH NOTES ON THEIR CONTRIBUTION TO THE TOTAL ZOOPLANKTON*

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Abstract

During a portion (28 June-24 August, 1967) of the global expedition of the U.S. National Oceanic and Atmospheric Administration ship *Oceanographer* quantitative zooplankton samples were collected between Bombay, India and Freemantle, Australia. Five stations were taken between Bombay and the southern tip of Ceylon, five from Ceylon to the northern tip of Sumatra, three in the southeastern Java Sea, and twelve between Java and Freemantle. A total of 36 oblique tows was made in the upper 50 m with the ICITA one-meter plankton net and the Indian Ocean Standard net.

Distribution and abundance of 50 taxa of pelagic amphipods are presented.

The percentage contribution, by numbers, of the amphipods to the total zooplankton averaged less than 1%. This value is believed to be low due to avoidance by the amphipods; also the volume of the individual amphipods was greater than other more numerically abundant zooplankton.

Introduction

Knowledge of the distribution and abundance of the pelagic Amphipoda in the Indian Ocean and adjacent seas is based largely on the results of the following oceanographic expeditions: The voyage of H.M.S. *Challenger* (Stebbing, 1888), the Percy Sladen Trust Expedition (Walker, 1909-1910), the John Murray Expedition (Barnard, 1937), the Carlsberg Foundation's Oceanographical Expedition round the World 1928-1930 and previous 'Dana' Expeditions (Fage, 1960), and the Danish Oceanographical Expeditions 1908-1910 to the Mediterranean and Adjacent Seas (Stephensen, 1918, 1924, and 1925).

During a portion (28 June-24 August, 1967) of the global expedition of the U.S. National Oceanic and Atmospheric Administration (formerly, Coast and Geodetic Survey) ship *Oceanographer* quantitative zooplankton samples were collected between Bombay, India and Freemantle, Australia. Five stations were taken between Bombay and the southern tip of Ceylon, five from Ceylon to the northern tip of Sumatra, three in the southeastern Java Sea, and twelve between Java and Freemantle.

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* Presented at the 'Symposium on Indian Ocean and Adjacent Seas—Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

Contribution No. 221, National Marine Fisheries Service, Tropical Atlantic Biological Laboratory, Miami, Florida 33149. U.S.A.

This report is on the distribution and abundance of 50 taxa of pelagic amphipods collected by the *Oceanographer*, and on their percentage contribution, in terms of numerical abundance, to the total zooplankton.

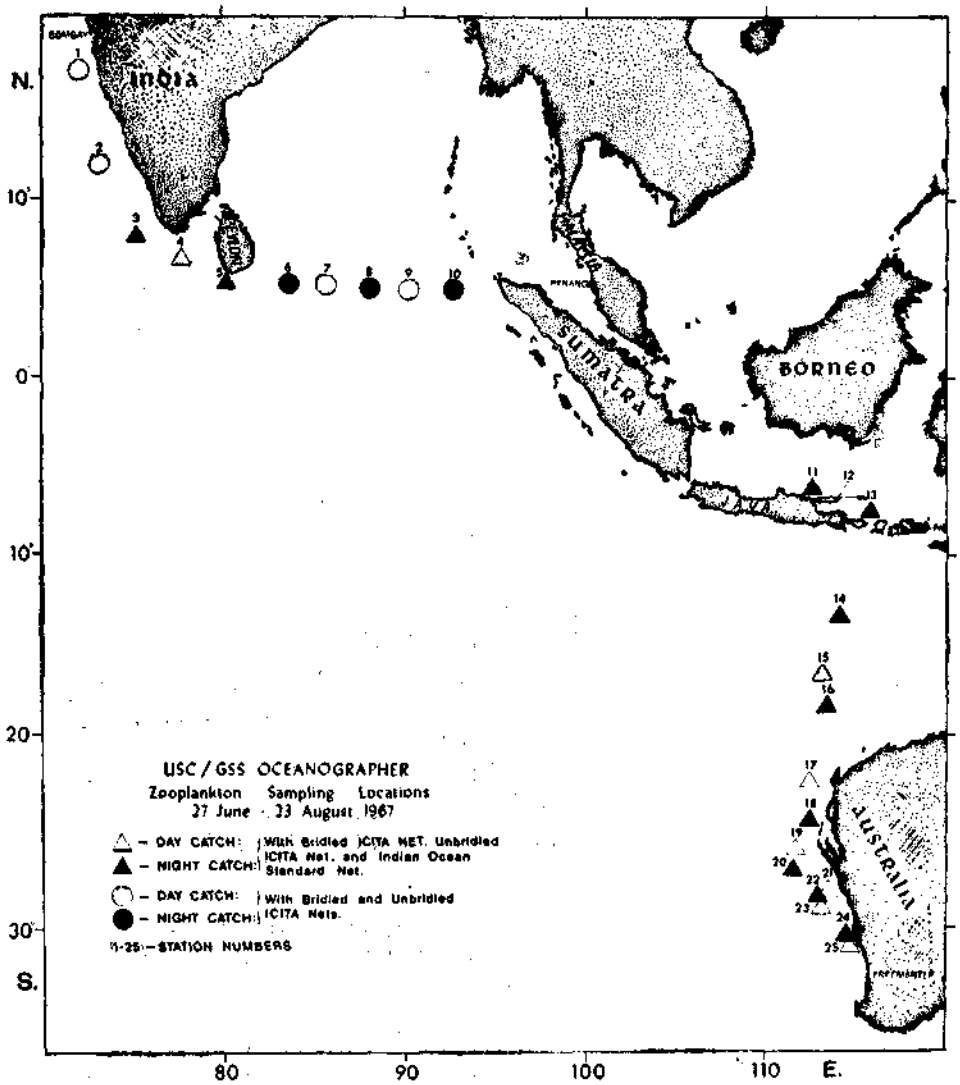

Fig. 1. Locations of zooplankton sampling stations occupied by the U. S. Coast and Geodetic Survey ship *Oceanographer*.

I am deeply grateful to Dr. Robert Burns of the National Oceanic and Atmospheric Administration, Chief Scientist during the cruise, and to the officers and crew of the U.S. National Oceanic and Atmospheric Administration ship *Oceanographer* for their co-operation and assistance in all phases of our field programme.

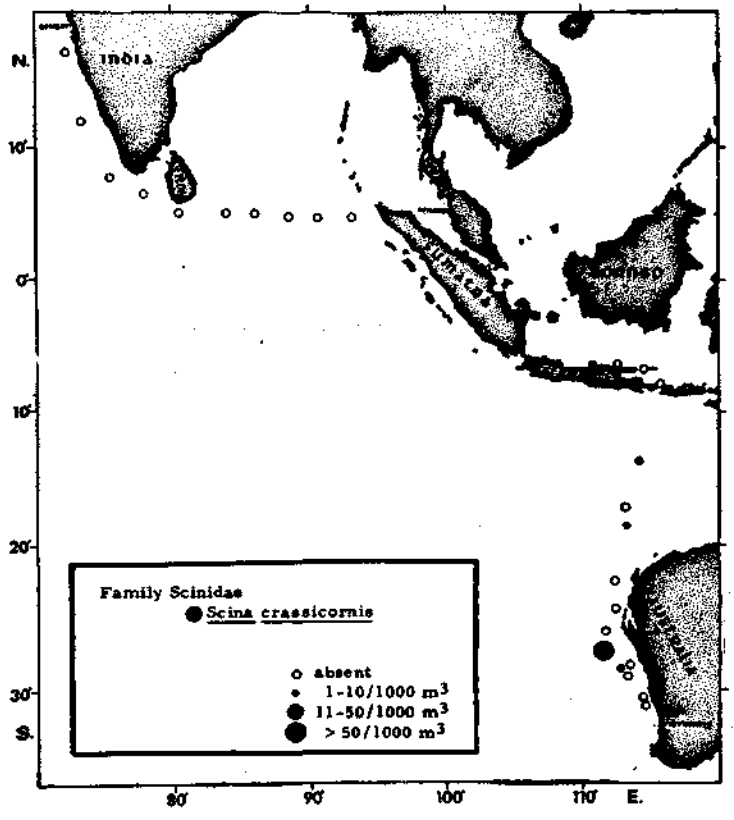

Fig. 2. Distribution and abundance of species of pelagic Amphipoda of the family Scinidae collected during a portion of the global expedition of the U.S. Coast and Geodetic Survey ship *Oceanographer*. 29 June-23 August 1967.

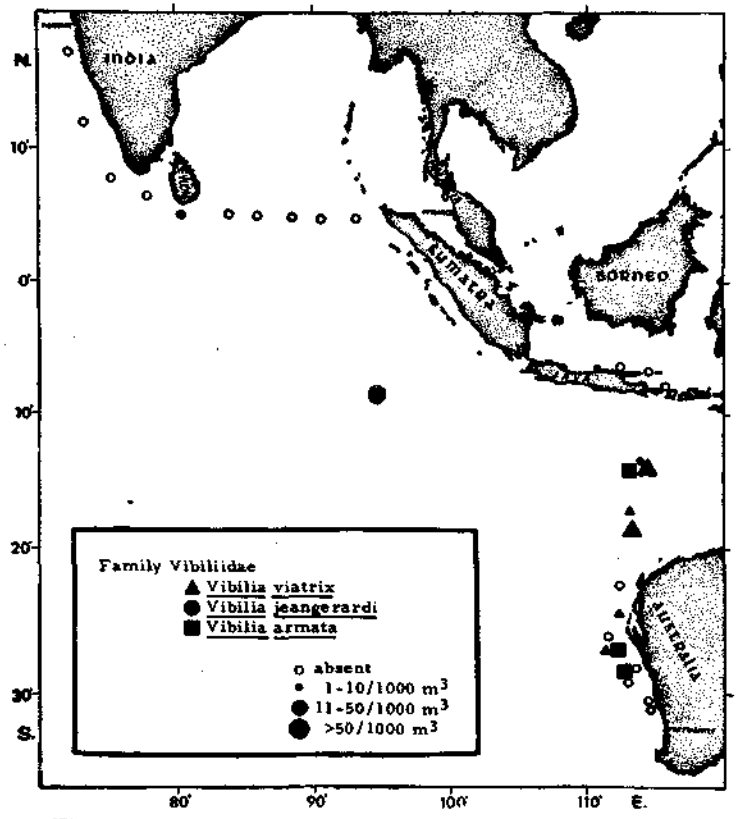

Fig. 3. Distribution and abundance of species of pelagic Amphipoda of the family Vibiliidae.

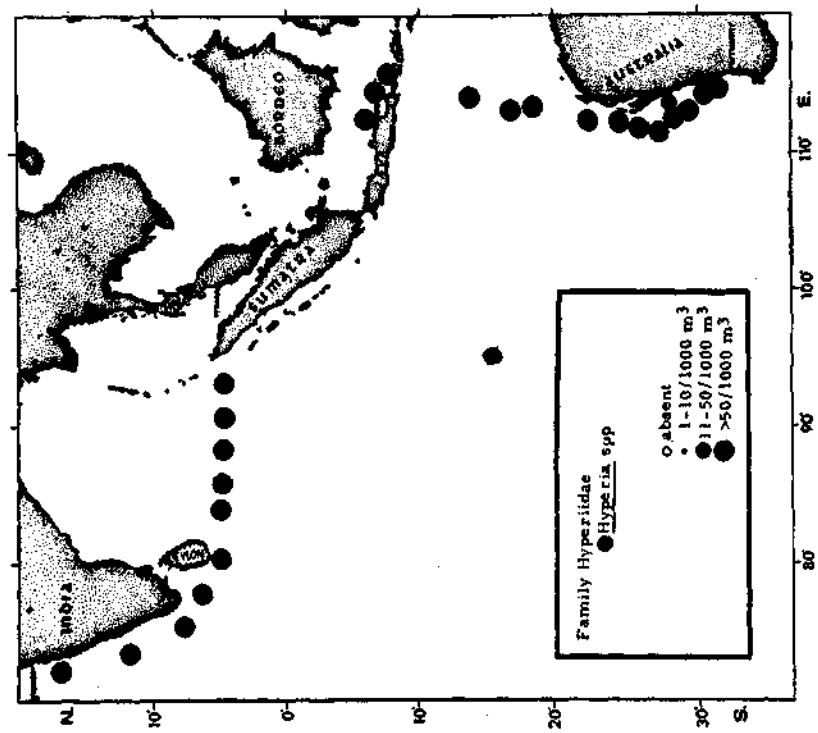

Fig. 5. Distribution and abundance of species of pelagic Amphipoda of the family Hyperiidae.

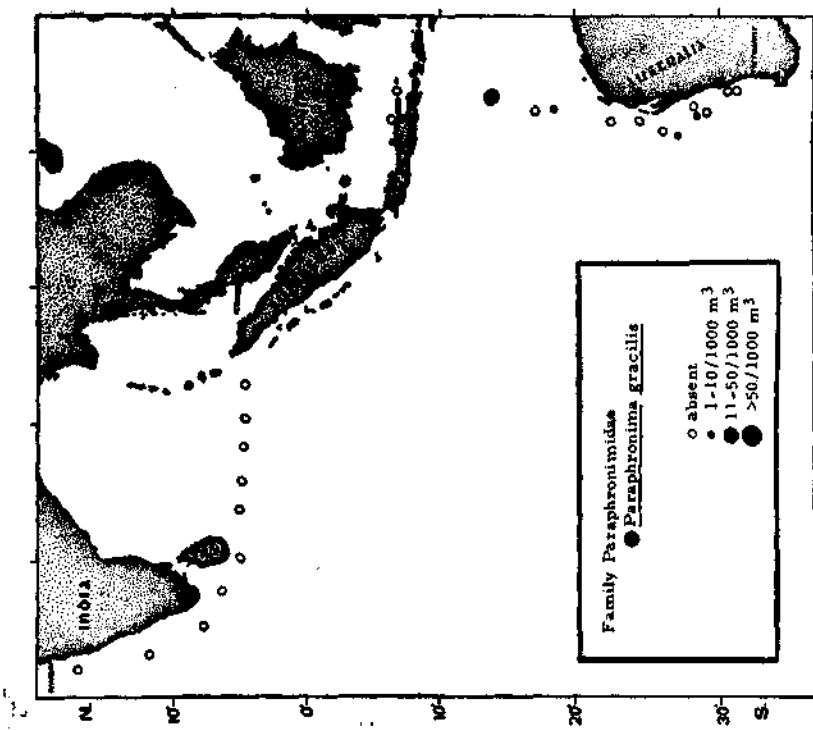

Fig. 4. Distribution and abundance of species of pelagic Amphipoda of the family Paraphronimidae.

[4]

I also wish to thank Mr. Richard E. Pieper, University of British Columbia, for his help in the collection of samples.

List of the Species Identified

Citations within brackets below indicate the source(s) used in identification

Fam. SCINIDAE Stebbing

Scina crassicornis (Fabricius, 1775)
[Stebbing (1904).]

Fam. VIBILIIDAE Claus

Vibilia viatrix Bovallius (1887b)
[Bovallius (1887a).]

Vibilia jeangerardi Lucas (1845)
[Bovallius (1887a).]

Vibilia armata Bovallius (1887b)
[Bovallius (1887a).]

Fam. PARAPHRONIMIDAE Bovallius

Paraphronima gracilis Claus (1879a)
[Bovallius (1889) and Stebbing (1888, described as *Paraphronima cuivis*).]

Fam. HYPERIIDAE Dana

Hyperia spp.
[Members of this genus were not identified to species.]

Fam. PHRONIMIDAE Dana

Phronima sedentaria (Forskål, 1775)
[Shih and Dunbar (1963).]

Phronima atlantica Guérin-Méneville (1836a)
[Shih and Dunbar (1963).]

Phronima atlantica var. *solitaria* Guérin-Méneville (1836b)
[Bovallius (1889, called *Ph. solitaria*) and Stebbing (1888, called *Ph. megalodous*).]

Phronima curvipes Vosseler (1901)
[Vosseler (1901).]

Phronima colletti Bovallius (1887b)
[Bovallius (1889).]

Phronima pacifica Th. Streets (1877)
[Bovallius (1889).]

Phronima stebbingii Vosseler (1901)
[Vosseler (1901).]

Phronimella elongata Claus (1862)
[Bovallius (1889).]

Phronimopsis sarsi Bovallius (1887b)
[Bovallius (1887*b*).]

Phronimopsis spinifera Claus (1879a)
[Bovallius (1889).]

Phronimopsis tenella Stebbing (1888)
[Stebbing (1888).]

Fam. ANCHYLOMERIDAE Bovallius

Anchylomera blossvillei Milne Edwards (1830)
[Bovallius (1889) and Stebbing (1888).]

Phrosina semilunata Risso (1822)
[Bovallius (1889) and Stebbing (1888).]

Phrosina australis Stebbing (1888)
[Stebbing (1888).]

Euprimno macropus (Guérin-Méneville, 1836)
[Bovallius (1889), Vosseler (1901), and Stebbing (1888, described as *Primno macropa*). Guérin-Méneville instituted the new genus *Primno* in 1836. Bovallius corrected this name to *Euprimno*, because *Primno* was previously applied to a genus of Crustacea by Rafinesque Schmaltz in 1814.]

Fam. LYCAEOPSIDAE Chevreux

Lycaeopsis themistoides Claus (1879b)
[Pirlot (1930).]

Lycaeopsis zamboangé (Stebbing, 1888)
[Pirlot (1930) and Stebbing (1888, described as *Phorcorrhaphis zamboange*).]

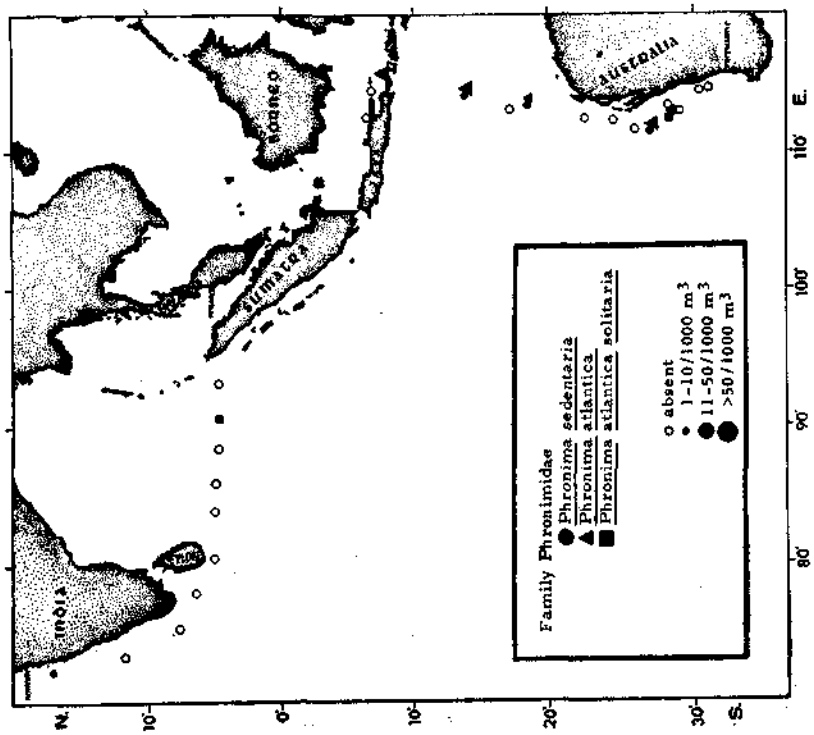

Fig. 7. Distribution and abundance of species of pelagic Amphipoda of the family Phronimidae.

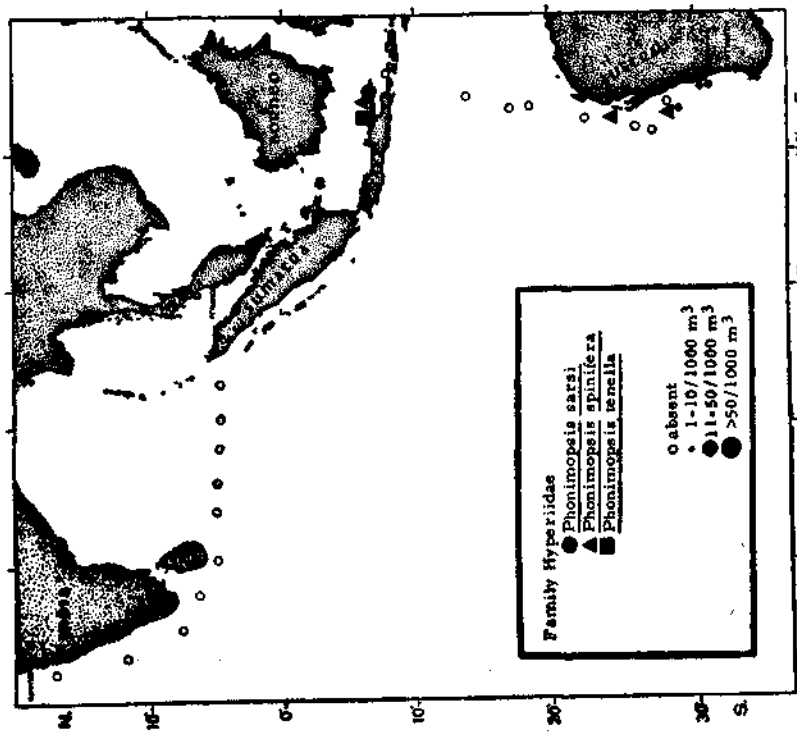

Fig. 6. Distribution and abundance of species of pelagic Amphipoda of the family Hyperiidae.

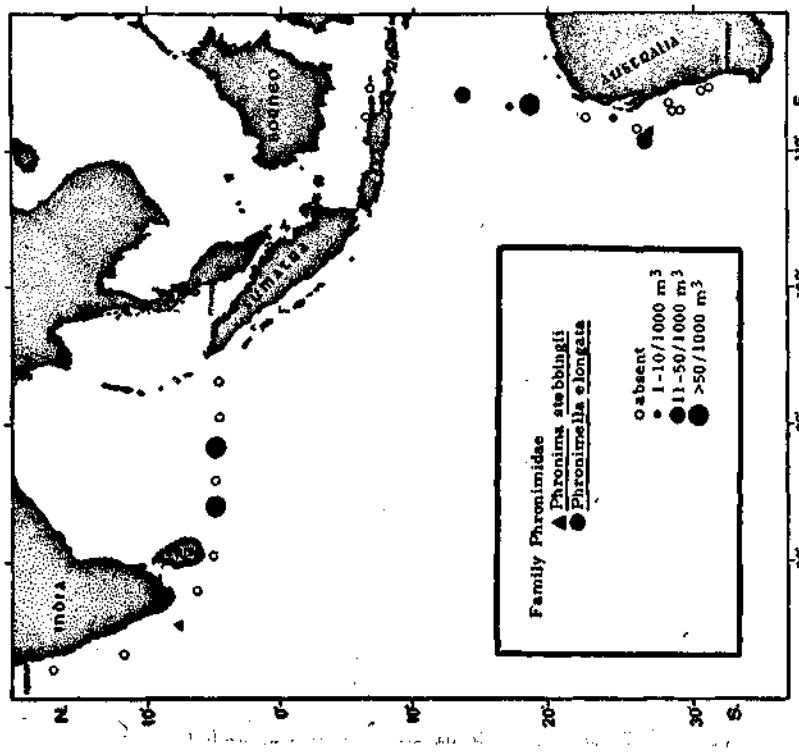

Fig. 9. Distribution and abundance of species of pelagic Amphipoda of the family Phronimidae.

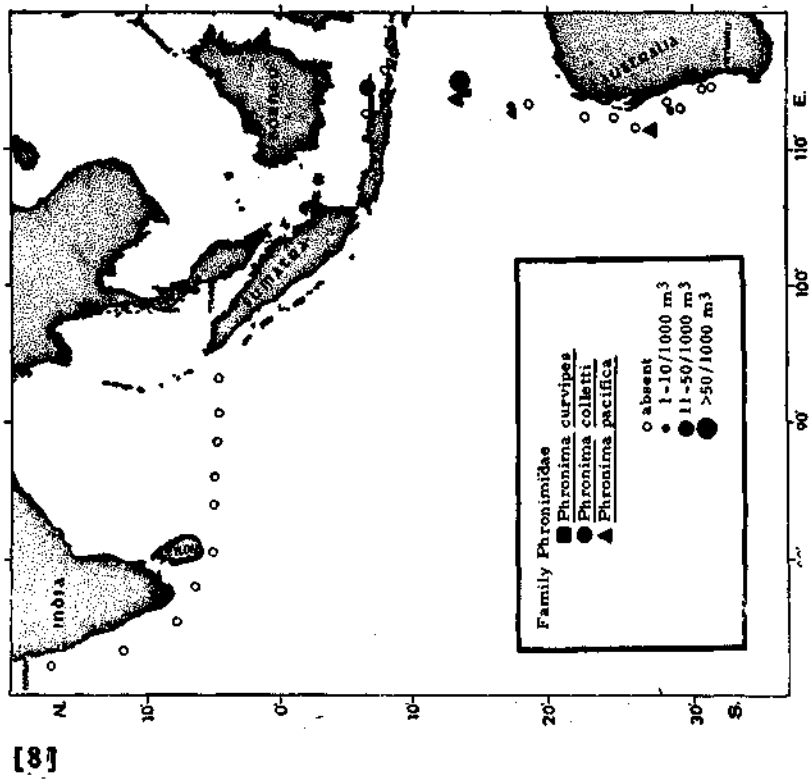

Fig. 8. Distribution and abundance of species of pelagic Amphipoda of the family Phronimidae.

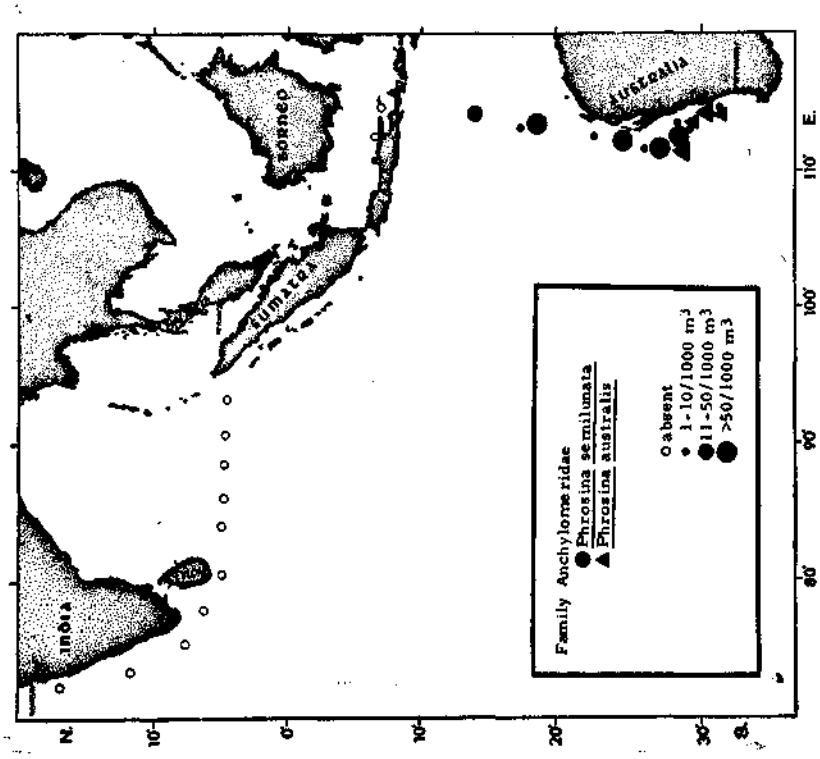

Fig. 11. Distribution and abundance of species of pelagic Amphipoda of the family Anchylomeridae.

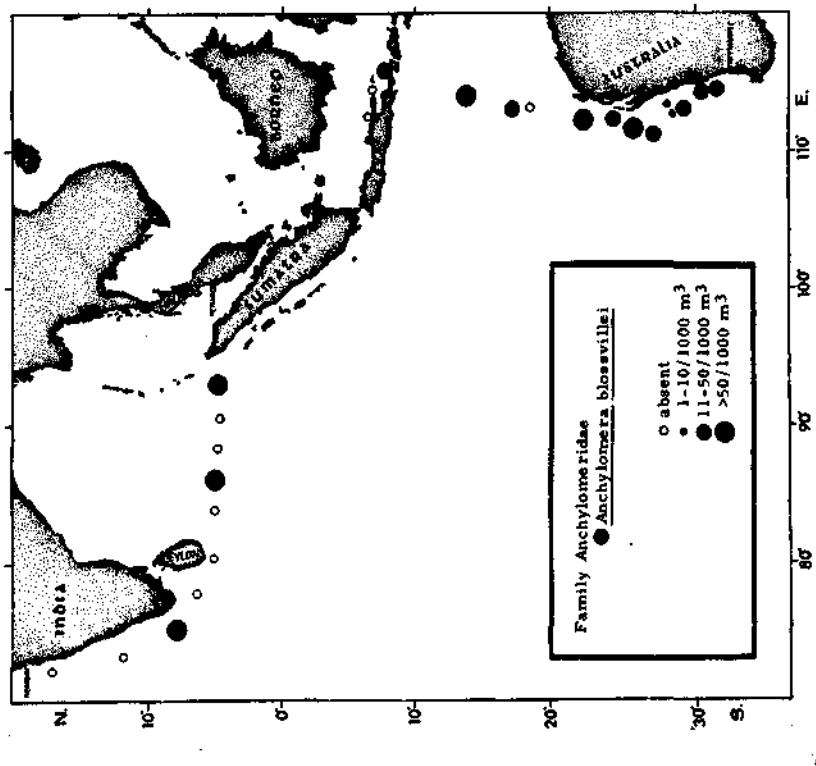

Fig. 10. Distribution and abundance of species of pelagic Amphipoda of the family Anchylomeridae.

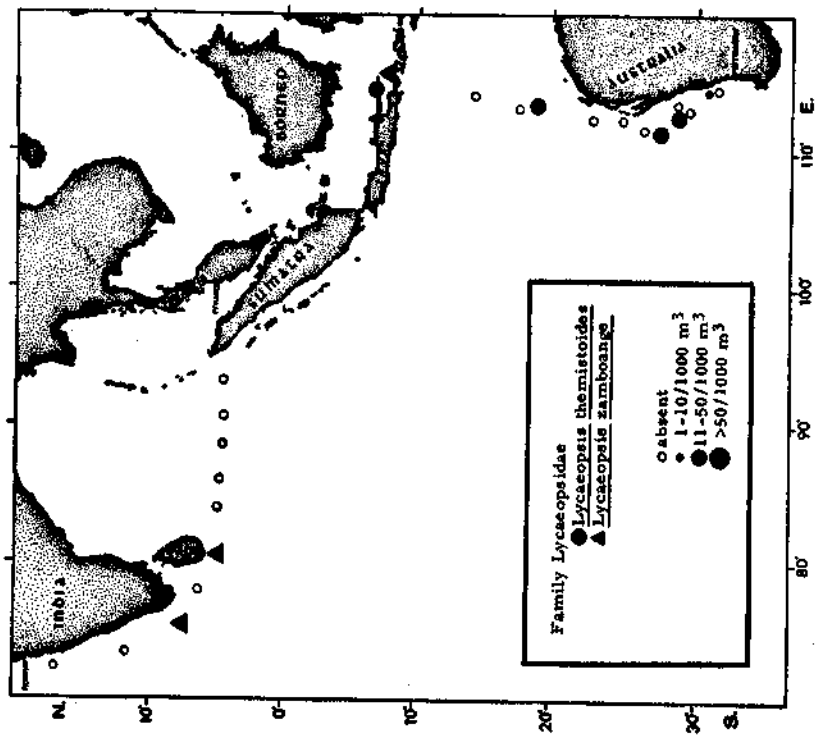

Fig. 13. Distribution and abundance of species of pelagic Amphipoda of the family Lycaeopsidae.

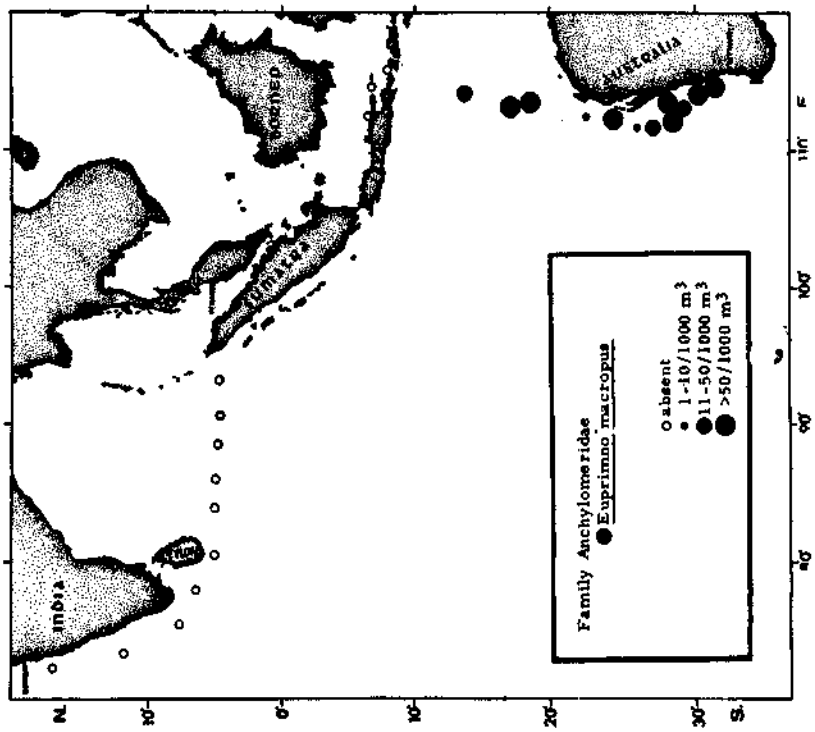

Fig. 12. Distribution and abundance of species of pelagic Amphipoda of the family Anchylomeridae.

Fam. PRONOIDAE Claus

Eupronoe spp.
[Members of this genus were not identified to species.]

Sympronoe parva 7-articulata Stephensen (1925)
[Stephensen (1925).]

Parapronoe crustulum Claus (1879b)
[Claus (1879b).]

Paralycaea spp.
[Members of this genus were not identified to species.]

Fam. LYCAEIDAE Claus

Lycaea pulex Marion (1874)
[Stephensen (1925) and Claus (1879b, described as *Lycaea similis*).]

Fam. BRACHYSCELIDAE Stephensen

Brachyscelus spp.
[Members of this genus were not identified to species.]

Euthamneus platyrrhynchus (Stebbing, 1888)
[Stebbing (1888, described as *Thamneus platyrrhynchus*).]

Fam. OXYCEPHALIDAE Spence Bate

Simorhynchotus antennarius (Claus, 1871)
[Fage (1960), Bovallius (1890), and Stebbing (1888). Claus instituted the new genus *Simorhynchus* in 1871. This was changed by Stebbing in 1888 to *Simorhynchotus* because the former name was found to be preoccupied by a genus of birds.]

Oxycephalus piscator Milne Edwards (1830)
[Bovallius (1890) and Fage (1960).]

Oxycephalus clausi Bovallius (1887b)
[Bovallius (1887b), Fage (1960), and Bovallius (1890).]

Tullbergella cuspidata Bovallius (1887b)
[Bovallius (1887b), Fage (1960), and Bovallius (1890).]

Calamorhynchus pellucidus Streets (1878)
[Fage (1960) and Bovallius (1890).]

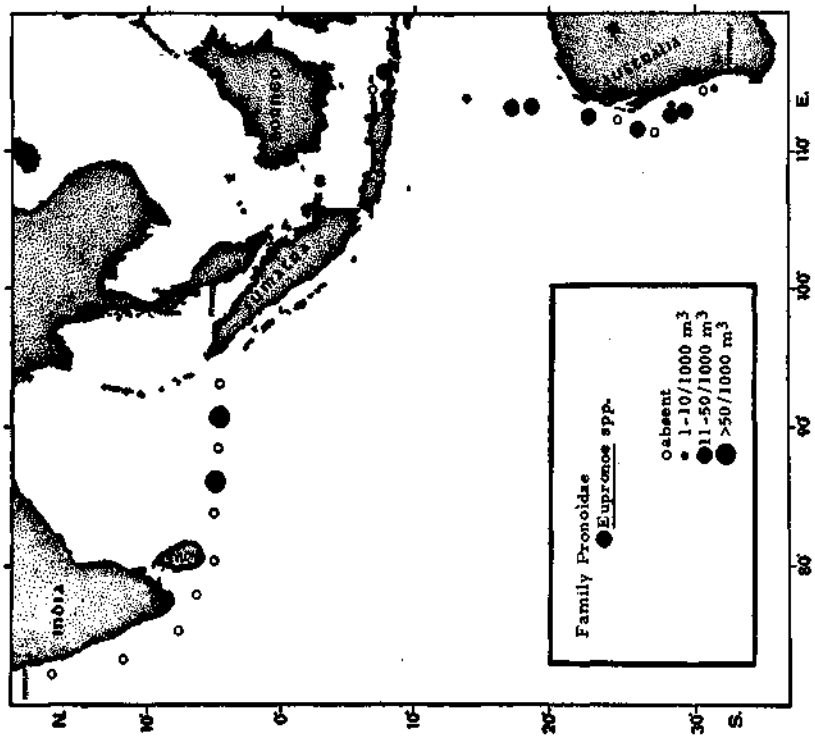

Fig. 15. Distribution and abundance of species of pelagic Amphipoda of the family Pronoidae.

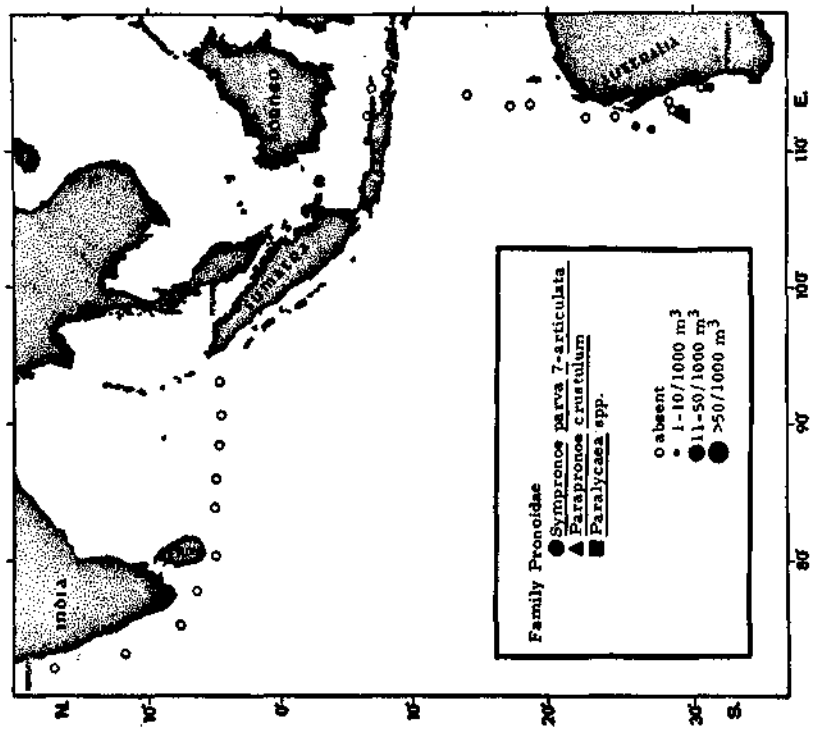

Fig. 14. Distribution and abundance of species of pelagic Amphipoda of the family Pronoidae.

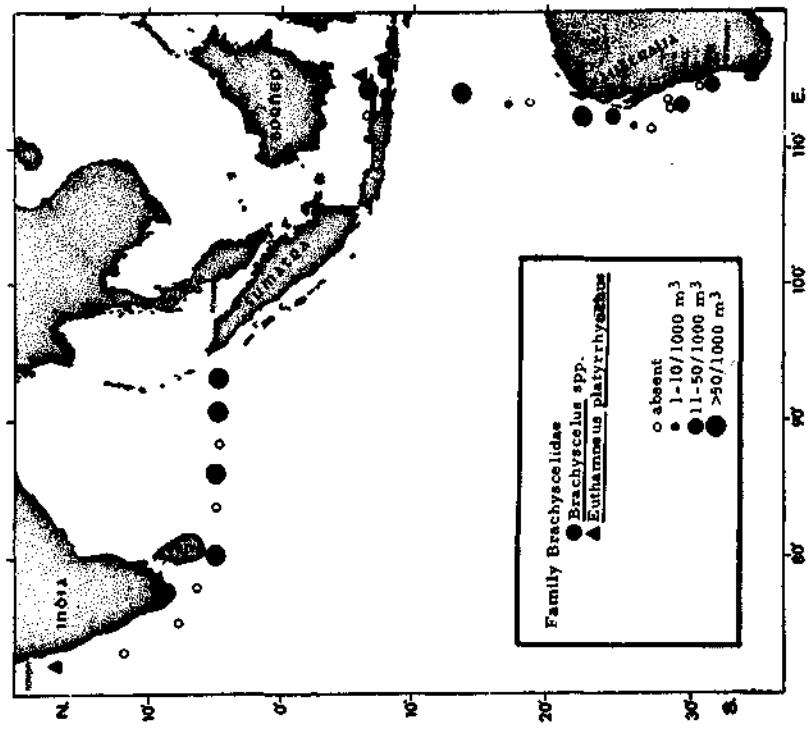

Fig. 17. Distribution and abundance of species of pelagic Amphipoda of the family Brachyscelidae.

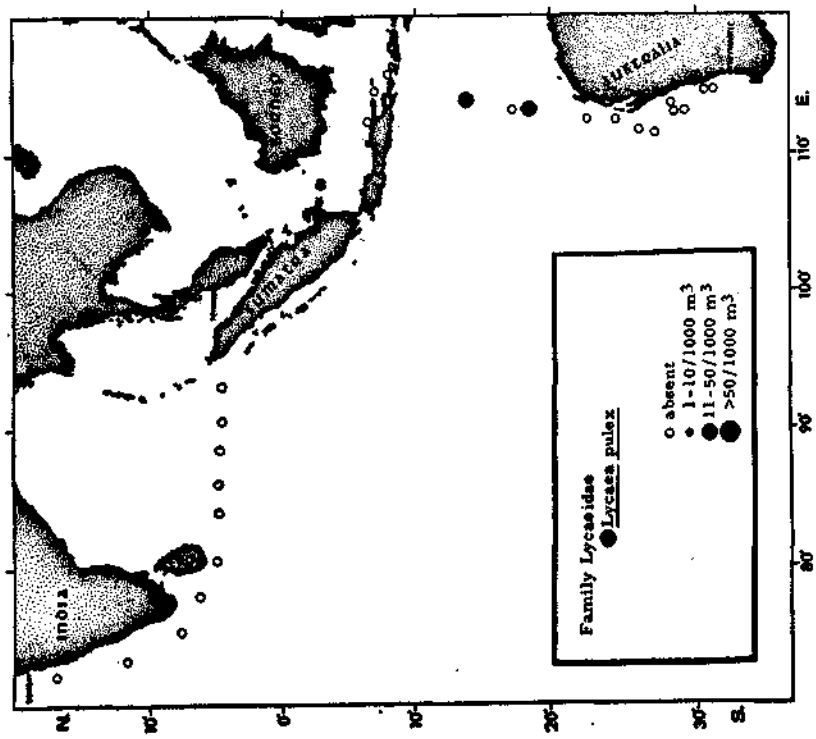

Fig. 16. Distribution and abundance of species of pelagic Amphipoda of the family Lycaeidae.

Leptocotis tenuirostris Claus (1871)
[Fage (1960), Bovallius (1890), and Stephensen (1925).]

Streetsia steenstrupi (Bovallius, 1887b)
[Bovallius (1887b, described as *Oxycephalus steenstrupi*), Fage (1960), and Bovallius (1890).]

Streetsia mindanaonis (Stebbing, 1888)
[Stebbing (1888, described as *Leptocotis mindanaonis*), and Fage (1960).]

Streetsia challengeri Stebbing (1888)
[Stebbing (1888) and Fage (1960).]

Streetsia porcella (Claus, 1879b)
[Claus (1879b, described as *Oxycephalus porcellus*), Fage (1960), and Bovallius (1890).]

Rhabdosoma whitei Spence Bate (1862)
[Fage (1960) and Bovallius (1890).]

Fam. PARASCELIDAE Bovallius

Parascelus similis Stephensen (1925)
[Stephensen (1925).]

Parascelus typhoides Claus (1879b)
[Claus (1879b).]

Parascelus edwardsii Claus (1879b)
[Claus (1879b).]

Fam. PLATYSCELIDAE Stebbing

Platyscelus armatus (Claus, 1879b)
[Claus (1879b, described as *Eutyphis armatus*).]

Platyscelus serratulus (Claus, 1879b)
[Claus (1879b, described as *Eutyphis serratus*).]

Paratyphis clausii Stephensen (1925)
[Stephensen (1925).]

Tetrathyrus forcipatus Claus (1879b)
[Claus (1879b).]

Amphithyrus bispinosus Claus (1879b)
[Claus (1879b).]

Amphithyrus sculpturatus Claus (1879b)
[Claus (1879b).]

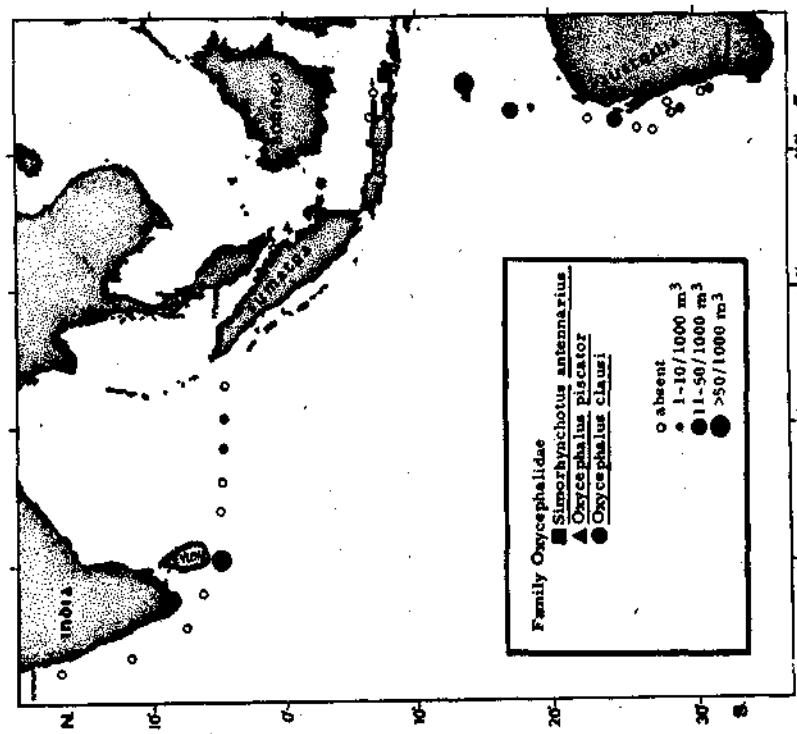

Fig. 19. Distribution and abundance of species of pelagic Amphipoda of the family Oxycephalidae.

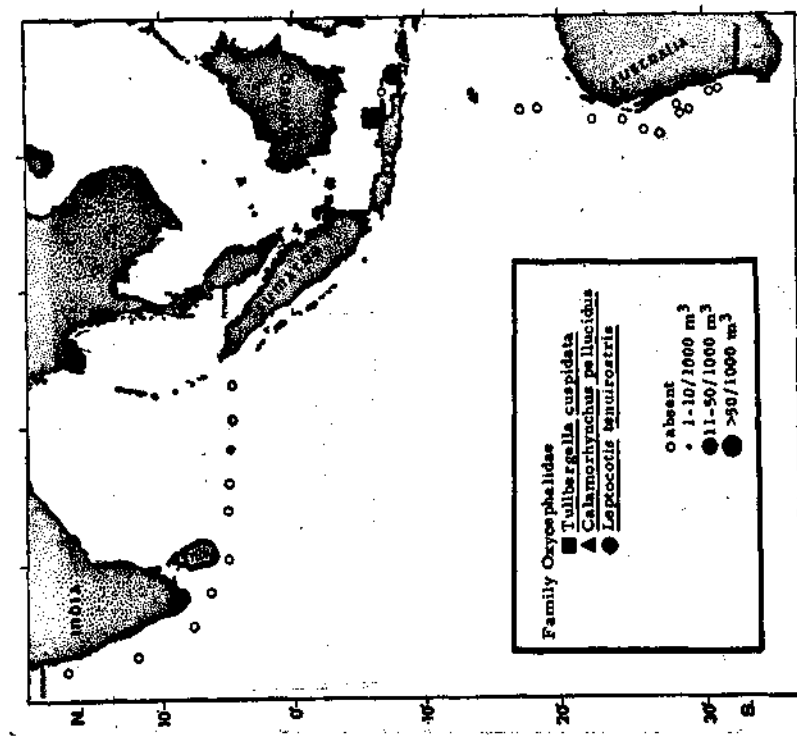

Fig. 18. Distribution and abundance of species of pelagic Amphipoda of the family Oxycephalidae.

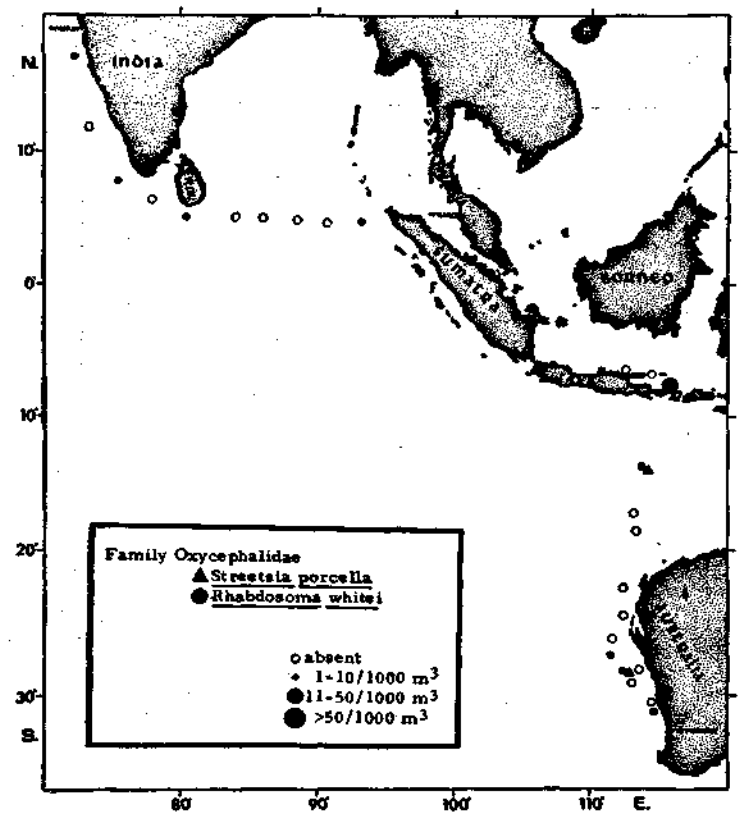

Fig. 20. Distribution and abundance of species of pelagic Amphipoda of the family Oxycephalidae.

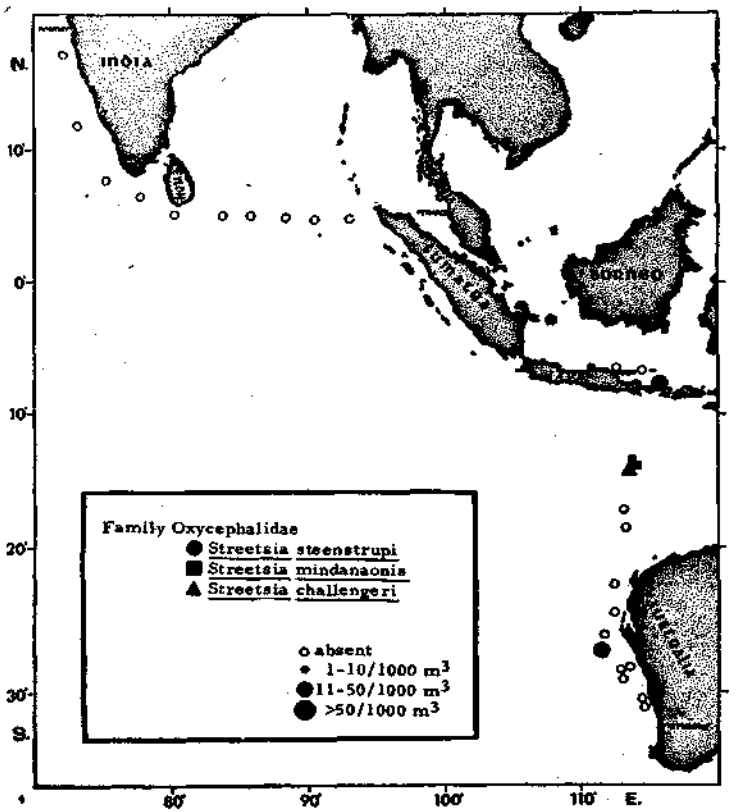

Fig. 21. Distribution and abundance of species of pelagic Amphipoda of the family Oxycephalidae.

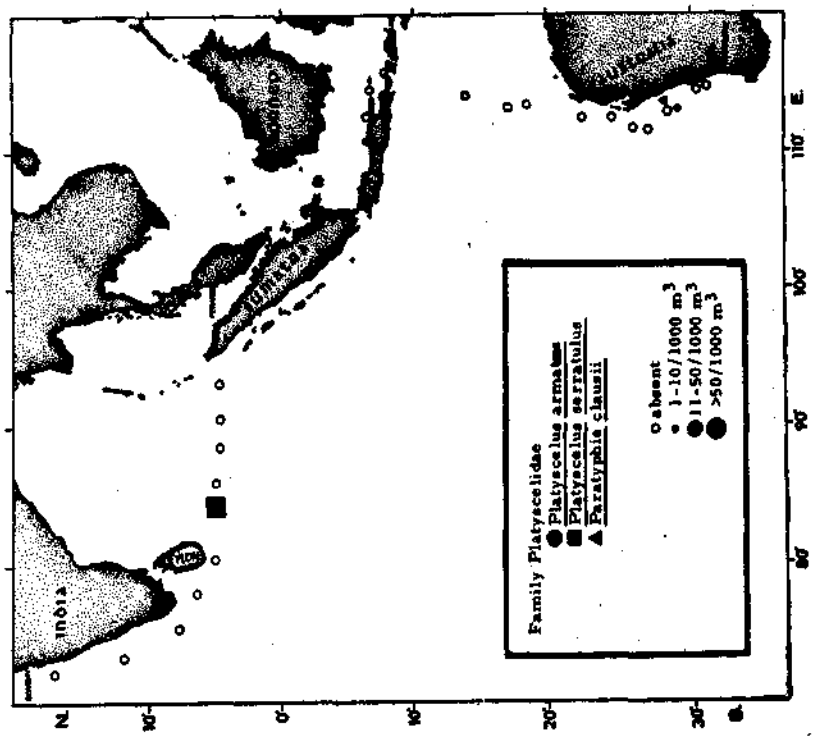

Fig. 23. Distribution and abundance of species of pelagic Amphipoda of the family Platyscelidae.

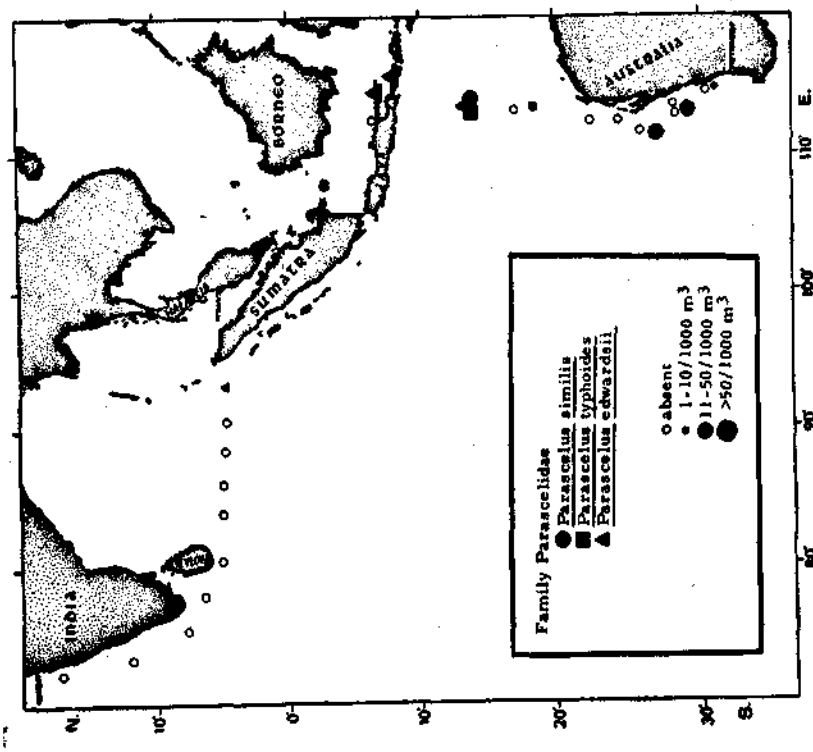

Fig. 22. Distribution and abundance of species of pelagic Amphipoda of the family Parascelidae.

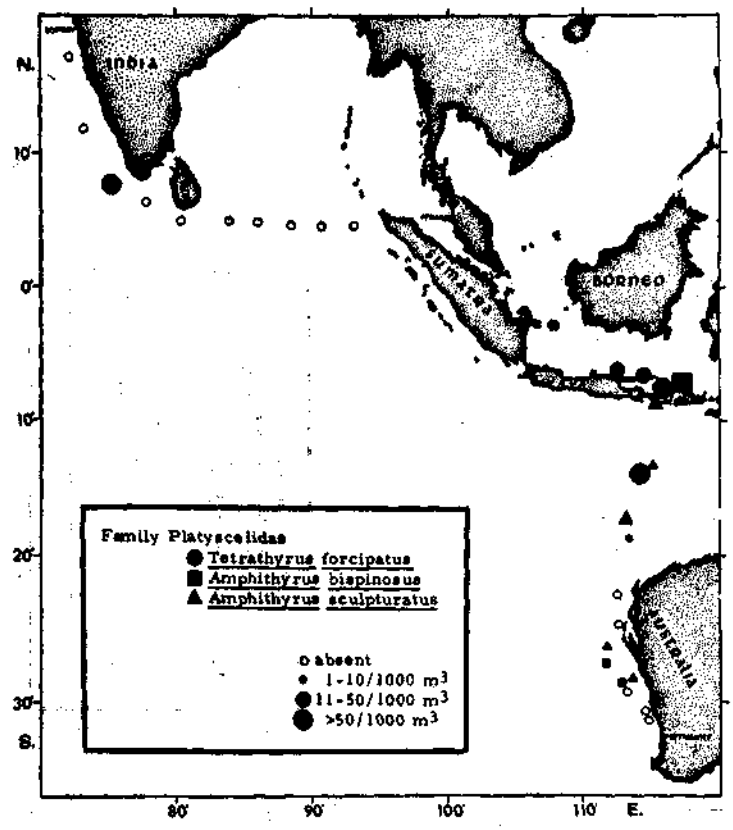

Fig. 24. Distribution and abundance of species of pelagic Amphipoda of the family Platyscelidae.

METHODS

The samples were taken primarily to provide comparisons of zooplankton sampling gear and were limited to stations on the predetermined cruise track of the *Oceanographer*. Their locations and spacing were, as a result, not ideal for providing information about the distribution of amphipods over the large area travelled.

Details of the sampling procedure are available in Aron, Jossi, and Pieper (1970). Briefly the samples were obtained as follows: Simultaneous tows of a bridled and an unbridled ICITA net (Jossi, 1966) were made at each station. The bridled ICITA net fished 2-meters above the unbridled ICITA net. All tows were oblique with a desired depth of 50 metres. This depth was chosen to avoid sampling below the surface mixed layer where vertical patchiness might have interfered with the net comparisons. Tows were approximately 30 minutes duration and the net speed was approximately 103 cm/sec (2 knots). The tows were made during presumed non-migratory periods of the zooplankton. The volume of water

filtered was calculated from flow meter readings. An Indian Ocean standard net (Currie, 1963) was towed immediately after making the tow with the ICITA nets. It was towed obliquely and at the same speed and to the same depth as the ICITA nets.

Samples were removed from the nets and preserved in 5 per cent sea water formalin (buffered with an excess of sodium borate; colour preserved with ionol). The Smithsonian Oceanographic Sorting Center, Washington, D. C., determined the zooplankton displacement volumes and sorted the samples into 84 possible taxa. The amphipods were identified to species, with the exception of immature specimens of species which exhibit ontogenetic changes. Unfortunately, this included three genera (*Hyperia*, *Eupronoe*, and *Brachyscelus*) which were present in a majority of the catches; because of their relative importance the distribution and abundance of members of these three genera are reported.

The location and type of zooplankton sampling stations occupied by the *Oceanographer* are shown in Figure 1 and detailed data on the sampling stations are given in Appendix I.

Results and Discussion

The distributions and abundances of 50 taxa from this collection are shown in Figures 2 to 24. Each family is represented by an individual figure with a maximum of three species per figure. All abundances are expressed as the number of organisms per $1000m^3$ of water filtered and are the mean values from the collections of the two or three nets. Although the catching ability of the three nets was significantly different, this difference was not sufficiently large to affect the abundance categories (1-10; 11-50; $>$ 50) used here. These categories were based on natural breaks in the abundance frequency distribution for all amphipod species.

Only general features of the distribution and abundance of the amphipods will be discussed here. At stations 1 to 10 there was a conspicuous absence of a majority (34 of 50) of taxa. *Hyperia* spp. was captured at all ten stations while the remaining 33 taxa were present only at four stations or less. Abundances of the taxa present at one or more of the first ten stations, were not significantly less than at the remaining stations. No satisfactory correlations could be established with environmental features that could explain these anomalies in distribution, although the presence of relatively low salinity water for this oceanic area (stations 1-10) during June-August may have been responsible. Distributions and abundances of amphipods as well as other planktonic groups from other cruises, e.g., the International Indian Ocean Expeditions, may provide an explanation.

Twelve of the twenty-five stations were occupied during the day and the remainder at night, as indicated in Figure 1. Total occurrences of the 50 taxa were compared from catches during day (81 occurrences) and night (147 occurrences) time-periods. The probability of there being no difference between the number of day stations and the number of night stations at which the 50 taxa were captured is less than 1 per cent according to the Wilcoxon Matched-Pairs Signed-Ranks Test (Siegel, 1956). Vertical migration of zooplankton might account for this difference, but the increased avoidance of these organisms during the day (Aron, Jossi, and Pieper, 1970) must also be considered as a possible cause.

APPENDIX I

Summary of station information for the USC & GS ship OCEANOGRAPHER, 29 June - 23 August, 1967.

Station	Date			Position		Net Type	Tow Midtime (local)	Tow Duration (mins.)	Tow Depth (m.)	Water Filtered (m^3)	Remarks
	Day	Month	Year	Latitude	Longitude						
1	29	June	1967	17°18′N	072°08′E	ICITA B	1420	31	48.0	1282	
				17°18′N	072°08′E	ICITA U	1420	31	50.0	1758	
				—	—	—	—	—	—	—	
2	30	June	1967	12°19′N	073°14′E	ICITA B	1352	19	32.0	807	
				12°19′N	073°14′E	ICITA U	1352	17	34.0	826	
				—	—	—	—	—	—	—	
3	1	July	1967	08°12′N	075°13′E	ICITA B	2428	17	34.0	932	
				08°12′N	075°13′E	ICITA U	2428	18	36.0	923	
				08°12′N	075°13′E	IOSN	2455	20	34.0	1390	
4	3	July	1967	06°52′N	077°43′E	ICITA B	1234	26	40.0	1306	
				06°52′N	077°43′E	ICITA U	1234	28	42.0	1223	
				06°52′N	077°43′E	IOSN	1305	21	47.0	1547	
5	3	July	1967	05°56′N	080°08′E	ICITA B	2354	33	32.0	1330	
				05°56′N	080°08′E	ICITA U	2353	34	34.0	1206	
				05°56′N	080°08′E	IOSN	—	—	—	—	Net Lost
6	5	July	1967	05°34′N	083°39′E	ICITA B	0038	20	32.0	1251	
				05°34′N	083°39′E	ICITA U	0038	21	34.0	1255	
				—	—	—	—	—	—	—	
7	5	July	1967	05°26′N	085°38′E	ICITA B	1058	17	29.0	1110	
				05°26′N	085°38′E	ICITA U	1058	19	31.0	1018	
				—	—	—	—	—	—	—	
8	5	July	1967	05°12′N	088°07′E	ICITA B	2334	19	40.0	1056	
				05°12′N	088°07′E	ICITA U	2334	21	42.0	1015	
				—	—	—	—	—	—	—	
9	6	July	1967	05°05′N	090°23′E	ICITA B	1110	20	35.0	1223	
				05°05′N	090°23′E	ICITA U	1111	21	37.0	1114	
				—	—	—	—	—	—	—	
10	6	July	1967	05°08′N	092°45′E	ICITA B	2323	22	37.0	853	
				05°08′N	092°45′E	ICITA U	2323	23	39.0	759	
				—	—	—	—	—	—	—	
11	11	August	1967	06°23′S	112°35′E	ICITA B	0300	28	—	1574	Winch's Meter-Wheel Failed.
				06°23′S	112°35′E	ICITA U	0301	31	—	1475	
				06°23′S	112°35′E	IOSN	0401	31	—	—	Flow Meter Failed

12	12	August 1967	06°43′S	114°26′E	ICITA B	1421	31	45.0	1003
			06°43′S	114°26′E	ICITA U	1420	32	47.0	889
			06°44′S	114°25′E	IOSN	1456	17	30.0*	1015
13	12	August 1967	07°44′S	115°38′E	ICITA B	2254	18	28.5*	826
			07°44′S	115°38′E	ICITA U	2254	18	30.5*	899
			07°44′S	115°38′E	IOSN	2321	18	34.0*	1781
14	16	August 1967	13°31′S	114°01′E	ICITA B	2328	21	22.5*	1174
			13°31′S	114°01′E	ICITA U	2327	22	24.5*	1188
			13°32′S	114°02′E	IOSN	2400	23	24.0*	1822
15	17	August 1967	16°38′S	113°04′E	ICITA B	1326	20	38.0*	1028
			16°38′S	113°04′E	ICITA U	1325	22	40.0*	1126
			16°39′S	113°04′E	IOSN	1354	19	29.5*	1345
16	17	August 1967	18°24′S	113°23′E	ICITA B	2336	20	13.0*	1324
			18°24′S	113°23′E	ICITA U	2336	20	15.0*	1432
			18°24′S	113°23′E	IOSN	2409	23	22.0*	1921
17	19	August 1967	22°21′S	112°26′E	ICITA B	1416	19	11.5*	1180
			22°21′S	112°26′E	ICITA U	1416	20	13.5*	1295
			22°21′S	112°26′E	IOSN	1448	20	25.0*	1484
18	19	August 1967	24°31′S	112°32′E	ICITA B	2323	20	22.0*	889
			24°31′S	112°32′E	ICITA U	2324	21	24.0*	928
			24°33′S	112°31′E	ISON	2350	20	29.5*	1542
19	20	August 1967	26°06′S	111°36′E	ICITA B	1321	18	16.0*	1116
			26°06′S	111°36′E	ICITA U	1322	19	18.0*	1150
			26°05′S	111°34′E	IOSN	1349	22	23.0*	1725
20	20	August 1967	26°56′S	111°34′E	ICITA B	2326	18	13.0*	1294
			26°56′S	111°34′E	ICITA U	2327	19	15.0*	1428
			26°56′S	111°34′E	IOSN	2356	24	23.0*	1929
21	21	August 1967	28°14′S	113°17′E	ICITA B	1346	15	23.0*	1289
			28°14′S	113°17′E	ICITA U	1345	18	25.0*	1244
			28°14′S	113°17′E	IOSN	1414	26	34.5*	1881
22	21	August 1967	28°22′S	112°59′E	ICITA B	2346	18	32.0*	1061
			28°22′S	112°59′E	ICITA U	2347	19	34.0*	1058
			28°23′S	112°59′E	IOSN	2416	23	18.5*	2024
23	22	August 1967	28°57′S	113°06′E	ICITA B	1327	18	19.0*	1275
			28°57′S	113°06′E	ICITA U	1328	19	21.0*	1175
			28°58′S	113°06′E	IOSN	1355	24	22.0*	1966
24	23	August 1967	30°26′S	114°38′E	ICITA B	0110	19	13.0*	1250
			30°26′S	114°38′E	ICITA U	0111	19	15.0*	1228
			30°30′S	114°39′E	IOSN	0137	22	28.5*	1531
25	23	August 1967	30°42′S	114°41′E	ICITA B	1301	22	24.0*	1096
			30°42′S	114°41′E	ICITA U	1301	26	26.0*	1241
			30°42′S	114°41′E	IOSN	1330	22	31.5*	1679

* Depths determined by bathykymograph. (All other depths determined from wire angle at max. depth.)

[21]

Table 1 shows the percentage contribution, in terms of numerical abundance, of the amphipods to the total zooplankton. In terms of numerical abundance, the median contribution of the 50 taxa of amphipods to the total zooplankton was 0.65 per cent. The wide range (0.10 to 6.07 per cent) of this contribution is attributed to both the type of net used and to capture of swarms of single species in certain samples.

TABLE 1. *Percentage of amphipods in the total Zooplankton* $\left(\frac{\text{No. amphipods}}{\text{No. zooplankton}}\right) \times 100$ *captured by three different nets in the Indian Ocean and adjacent seas.*

	Bridled ICITA Net	Unbridled ICITA Net	Indian Ocean Standard Net	All Nets
Range	0.10-1.50	0.10-1.66	0.43-6.04	0.10-6.04
Median	0.46	0.51	0.72	0.65

The contribution of the amphipods to the zooplankton community is more important than is indicated by the low numbers given above. First, the importance of any zooplankton group in the economy of the sea should be based on biomass rather than numerical abundance. The latter estimation gives undue weight to small organisms, e.g., copepods, which, per individual, contribute less organic matter than do individuals larger in size, e.g., the amphipods. Estimation of volume contribution (biomass) of the amphipods, presently underway, will more clearly define their contribution to the food chain. Secondly, avoidance of towed net samplers by amphipods has been demonstrated through gear comparisons (Aron, Jossi, and Pieper, 1970). Also, studies of stomach contents of pelagic fishes taken in the same location as the towed net samples show that for many of the species reported here larger specimens are found in the stomach contents than are captured by these three nets (Dragovich, personal communication).

Taxonomy:

Since the preparation of this manuscript, a contribution by Laval (1970) has come to my attention. From a morphological study of *Phronima colletti*, he has concluded that there are two distinct species, *P. colletti* from the Atlantic and *P. bucephala* from the Indo-W. Pacific; *Phronima bucephala* being erroneously included in the synonymy of *P. colletti*. The reader is, therefore, referred to Laval's paper when examining the distributions and abundances of *P. colletti* in this paper.

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