Journal of Coastal Development ISSN: 1410-5217
Volume 6, Number 1, October 2002 : 9-21 Accredited: 69/Dikti/Kep/2000

Original paper

THE ROLE OF ZOOPLANKTON PREDATOR, CHAETOGNATHS (*SAGITTA* SPP) IN BAGUALA BAY WATERS, AMBON ISLAND

By: Niette.V. Huliselan *)
Faculty of Fisheries, Pattimura University, Ambon - Indonesia

Received: August 8, 2002 ; Accepted: September 20, 2002

ABSTRACT

Study on the chaetognaths of the Baguala bay waters, Ambon island has been done at approximately monthly intervals during January to March and May to September 1994. Sampling was carried out during the day time by using a 200 µm meshed WP2 zooplankton net at 7 fixed stations. Eleven species of chaetognaths belonging to the genus Sagitta and 2 other species (Pterosagitta draco and Krohnitta pacifica) were recorded. A total of 23,960 individuals of chaetognaths were examined and of these 4,546 individuals contained prey in their guts. The copepods were the dominant prey of Sagitta enflata, accounting for 73.80% of the diet. It was found that the food containing ratio (FCR) of stage 2 of S. enflata was higher than the other stages, while the number prey per chaetognath (NPC) of stage 3 of S. enflata was higher than other stages, and the daily feeding rate (DFR) of S. enflata (all stages) recorded at stations in the mouth of the bay was slightly higher than at stations inside of the bay. The FCRs, NPCs, and DFRs of P. draco were lower than S. enflata, therefore the impact on the copepods community structure would be greatest in this season and the stations in the mouth of the bay.

Key words: Chaetognaths, zooplankton, predators, prey, diet

*) **Correspondence**: Faculty of Fisheries, Pattimura University, Ambon - Indonesia

INTRODUCTION

Chaetognaths or arrow worms are common in the zooplankton of marine waters throughout the world and they are present from coastal waters and estuaries to open oceans, and from shallow depths to deep sea (Pierrot-Bults and Nair, 1991 and Bone *et al.,* 1991). The numerical dominance of chaetognaths over other pelagic predators suggests a potentially important role for chaetognaths (Williams and Collins, 1985; Øresland, 1987). The species diversity of chaetognaths gradually decrease from the lower epipelagic to bathypelagic layers, and the maximum diversity is generally found at a depth of 150 – 250 meter (Pierrot-Bults and Nair, 1991).

There has been a tendency to assume as many of marina fauna consuming plankton are unselective filter feeder, that there is limited scope for predation to structure the community. However, in a number of studies (Terazaki and Marumo, 1982; Øresland, 1986, 1987; Feigenbaum and Maris, 1984; Canino and Grant, 1985; Gibbons, 1992; Steele and Henderson, 1992; Frid *et al.,* 1994) predatory members of the zooplankton

ISSN: 1410-5217
Accredited: 69/Dikti/Kep/2000

have been shown to apply a predation pressure of similar or greater in magnitude than traditional planktivores. Besides the ctenophores, chaetognaths are one of the principle predators of the marine plankton (Terazaki and Marumo, 1982; Kimmerer,1984; Williams and Collins, 1985; Øresland, 1986, 1987; Frid *et al.,* 1994), since all species of chaetognaths are carnivorous and are recognized mainly as ambush predators (Feigenbaum and Reeve, 1977).

Chaetognaths are often abundant, ranking second, after copepods, at certain time of year and as they feed at several trophic level, they potentially play an important role in zooplankton trophodynamics (Huliselan, 1991 and Feigenbaum, 1991). Some of them are more cannibalistic than others (Feigen-baum, 1991). *Sagitta enflata* is the commonest oceanic chaetognath throughout the tropical and subtropical regions of the world, where they are commonly found in coastal waters (Tokioka, 1979). Whilst, Nair (1978) and Rao (1979) stated that *S. robusta*, *S. ferox*, *S. neglecta, S. regularis, S. pacifica, S. bedoti*, and *S.bedoti minor* are the dominant oceanic chaetognaths of the Indo-Pacific region.

The chaetognaths start feeding on small prey and few days after hatching (Feigenbaum, 1984). Their diet includes small copepods such as *Oithona* spp and the copepodites and nauplii of copepods (Kotori, 1979). Cannibalism in chaetognaths is frequently recorded, including preying on their own and other species of chaetognaths (Feigenbaum, 1991). Usually, chaetognaths have one prey in the gut at a time (Feigenbaum, 1979), however, Casper and Reeves (1975) observation of *S. hispida* showed that hungry chaetognaths consumed several items in rapid succession.

Coastal waters are typically more variable, in term of salinity, temperature, and turbidity than oceanic waters, and the neritic zooplankton will include those species able to cope with these variable conditions. Generally, the zooplankton from inlet waters (e.g. bays) are much smaller than those from the open coastal waters (Pierrot-Bults and Nair, 1991). *S. ferox* , *S. robusta*, and *S. regularis* are recorded as endemic Indo-Pacific species (Nair, 1978). They also recorded that the most neritic tropical species of chaetognaths occurred in Indo-Pacific waters, however, the chaetognaths are well distributed throughout the world. Pierrot-Bults and Nair (1991) stated that the factors that influenced the distribution patterns of the chaetognaths are water circulation, physico-chemical and ecological parameters (e.g. temperature and prey abundance). It's also found that Chaetognaths are the numerically dominant predatory zooplankton in the coastal water of Ambon Island, Indonesia (Troost *et al*., 1976; Huliselan, 1991). Eight species of *Sagitta* (*S. enflata, S. pulchra, S. pacifica, S. bedoti, S. ferox,S. robusta, S. neglecta,* and *S. S. septata*) and two species from other genera (*Krohnitta pacifica* and *Pterosagitta draco*) have been recorded from Ambon Bay, with *S. enflata* comprising 38% of the total chaetognaths (Troost *et al.,* 1976).

MATERIALS AND METHODS

Baguala Bay, Ambon Island is a semi-enclosed region (Fig. 1). The hydrography of the bay is influenced by monsoons, with southeastern winds prevailing between April and November and northwestern winds between December and March (Zijlstra *et al.,* 1990). During the southeast monsoon the wind pushes the cold waters from the southern Banda Sea into Baguala Bay. While during the northwest monsoon the wind pushes warm waters from the Seram Bay into the Baguala Bay.

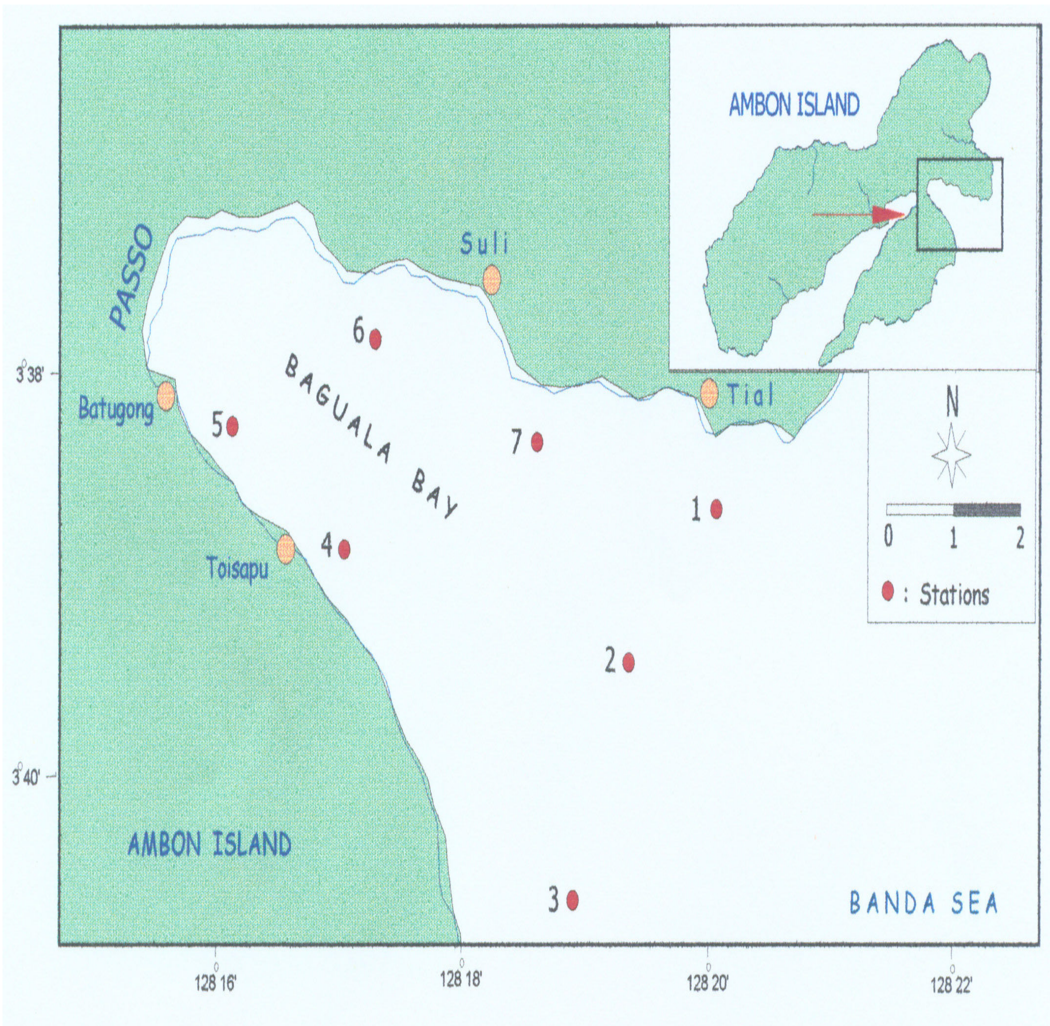

Fig. 1. Position of 7 fixed stations surrounding Baguala Bay, Ambon Island

Samples were collected at approximately monthly intervals during an eight months sampling period, which included both monsoons (January to March and May to September 1994) from 7 stations in Baguala Bay. Sampling was carried out during the daytime and consisted of four vertical hauls of a 200 µm meshed WP2 (UNESCO, 1968) zooplankton net with a mouth area of 0.25 m^2. As the depth of each station varies, therefore the net was hauled from different depths (Tabel 1).

Table 1. Position and the depth of hauling at 7 fixed stations throughout Baguala Bay, Maluku Stations in the mouth of the bay (station 1, 2, and 3) and Stations inside the bay (station 4, 5, 6, and 7).

No. Station	Name of Station	Position	Depth of hauling (meter)
1	Tanjung Meriam (Tial)	03º 38' 15" S 128º 21' 10" E	200 – 0
2	Mid (between Tg. Tial and Tg. Hutumuri)	03º 39' 30" S 128º 19' 45" E	35 – 0
3	Tanjung Hutumuri	03º 41' 30" S 128º 19' 00" E	40 – 0
4	Toisapu	03º 38' 45" S 128º 17' 16" E	15 – 0
5	Batu Gong	03º 37' 45" S 128º 16' 16" E	12.5 – 0
6	Natsepa	03º 37' 40" S 128º 17' 30" E	11 – 0
7	Tanjung Suli	03º 38' 20" S 128º 18' 35" E	7 - 0

In the laboratory, the chaetognaths were removed from the samples and identified to species level whenever possible. The gut contents of each individual of *Sagitta* were examined to ensure the smaller items were not overlook. Organisms in the mouth were not included. Many prey can be recognized and often identified to species since some parts of their anatomy resist digestion. Prey found were identified to the lowest taxon possible. Each individual was assigned to a maturity stage based on Dunbar's (1962), McLarens's (1969), and Zo's (1973) and the classification system as follow:

Stage 1. No visible ovary
Stage 2. Developing ovary, some ovary but not mature eggs
Stage 3. One or more mature eggs

The gut contents of each individual of *Sagitt*a were examined microscopically. The whole length of the gut was examined to ensure the smaller items were not overlooked. The food containing ratio (FCR) was obtained from the percentage of chaetognaths with food in their gut, while the number of prey (NPC) was determined by calculating the percentage of chaetognaths feeding on a particular food type (Feigenbaum, 1991). The daily feeding rate, i.e number of prey per *Sagitta* per day was estimated using the Bajkov equation (Bajkov, 1935, cited in Øresland, 1987):

$$FR = \frac{\text{Mean NPC X 24}}{DT}$$

Where:
FR = daily feeding rate (number prey chaetognath^{-1}d^{-1})
NPC = the percentage of *Sagitta* feeding on that particular food type
DT = the digestion time in hours

Only feeding rate of *Sagitta enflata* and *Pterosagitta draco* were determined, since there were no digestion time data available for the other species encountered. While the impact of them was estimated by using the data on the zooplankton community

ISSN: 1410-5217
Accredited: 69/Dikti/Kep/2000

collected at the same hauls and time as the chaetognaths examined. While the estimation of the impact of *S. enflata* and *P. draco* on the copepods population was assessed by determining the daily consumption rate of them upon the prey species.

RESULTS

During the period of study, a total of 98 taxa, mostly species, were recorded. The zooplankton community in Baguala bay waters dominated by copepods, chaetog-naths, cructaceans, appendicularians and medusae. Calanoid copepods of the species *Paracalanus aculeatus, Pseudocalanus* sp, *Acrocalanus gracilis, A. longicornis, Acartia danae, A. amboinensis, A. negligens,* were dominant throughout the period of sampling.

The following copepods taxa were only represented by a small number of specimen at certain months and/or stations: *Eucalanus* spp., *Clausocalanus furcatus, Canthocalanus pauper, Centropages* spp., *Candacia* spp., *Pleuromamma* spp., *Temora* spp., *Euchaeta* spp., and *Tortanus* spp. *Eucalanus* spp. were only recorded at stations in the mouth of the bays (Stations 1, 2, and 3). The upwelling indicator copepod, *Rhincalanus nasutus* was also only recorded at stations in the mouth of the bay and only from March to October.

Probably the most important parameters, which influenced the distribution and occurrence of zooplankton species in Baguala Bay was the monsoon. The monsoonal period (southeast and northwest) occurring in the area coincide with the upwelling and downwelling phases. Therefore, the change in temperature and salinity in the bay was driven by the monsoons. Both temperature and salinity varied significantly between months and stations (two ways ANOVA, months and stations, $F = 24.6$, $p < 0.005$ and $F = 15.83$, $p < 0.005$ respectively for temperature; while $F = 5.81$, $p < 0.005$ and $F = 20.15$, $p < 0.005$ respectively for salinity). Temperature at stations in mouth of the bay (stations 1, 2, and 3) were lower than those at stations inside the bay (stations 4, 5, 6, and 7), which are shallower than stations in the mouth of the bay. While salinity showed the opposite trend to the temperature, as salinity was higher at stations in the mouth of the bay than stations inside the bay.

Eleven species of chaetognaths belonging to the genus *Sagitta* were *S. enflata, S. hexaptera, S. ferox, S. robusta, S. pulchra, S. regularis, S. neglecta, S. zetesios, S. bipunctata, S. pacifica, S. bedoti.,* and two species from other genera, *Krohnitta subtilis* and *Pterosagitta draco.* Amongst these species, *S. enflata, S. ferox,* and *S. regularis* were the only species which were present at all stations during the entire period of study. While *S. zetesios* and *K. subtilis* were the only meso-and bathypelagic chaetognaths found and were recorded only when the upwelling occurred.

The density of individuals/m^3 of the chaetognaths species encountered at the stations inside the bay was greater than at the stations in the mouth of the bay, and the young stage of them occurred in high abundance at the stations inside the bay. Table 2 showed that the total number of individuals of the chaetognaths were the highest at station 7 in September (12,595 induviduals/100m^3). This study found that *S. enflata* dominated the chaetognath community followed by *S. pulchra* and *S. ferox* (62.19%, 12.65%, and 12.25% respectively).

Table 2. Numbers of chaetognaths (*Sagitta* spp)/ 100 m^3 encountered at stations throughout Baguala bay from January to March and May to September 1994.

Month	Stations						
	1	2	3	4	5	6	7
January	290	260	251	411	60	851	5,876
February	815	763	902	270	2,539	2,484	7,134
March	916	2,443	1,922	2,144	1,065	3,672	5,936
May	606	2,192	1,036	1,579	1,706	2,093	2,701
June	574	5,126	1,366	1,294	780	2,408	2,256
July	2,955	2,395	1,067	404	749	503	4,648
August	692	1,352	1,198	489	1,529	132	3,288
September	3,302	3,682	1,461	284	246	443	12,595

The largest individuals found were 26 mm (in length) belonging to *S. hexaptera* and *S. zetesios*. Whilst the smallest individuals were ± 3 mm (in length) belonging to *S. enflata, S. pulchra, S. ferox, S. robusta, S. regularis, S. neglecta, S. bipunctata, S. pacifica, S. bedoti, K. subtilis,* and *P. draco*. Stages 2 and 3 of the *Sagitta* spp. were more abundant at the stations in the mouth of the bay, while the juveniles of *S. enflata, S. pulchra, S. feros,* and *S. robusta* and the adult individuals of the smallest species, *S. regularis* were more abundant at the stations inside the bay. This implies that the juveniles of the large *Sagitta* spp. preferred the waters with high temperature and low salinity.

From a total of 23,960 chaetognaths belonging to thirteen species of *Sagiita* were examined, of these, 4,546 individuals contained prey in their guts. However, since only digestion time estimates were available for *S. enflata* and *P. draco* , only these two species feeding behaviour were examined in detail.

At total of 13,620 individuals of *S. enflata* were examined. The food containing ratio was 0.23% (3,156 individuals). Of the 3,156 individuals with prey in their guts, the total of 346 individuals (all stages) had consumed two items, 13 individuals (all stages 3) had consumed three items and 1 individual (stages 3) had consumed four items. The copepods were the dominant prey of *S. enflata,* accounting for 73.80% of the diet by number of individuals. The rest 26.20% was the other prey.

The food containing ratio (FCR) of stage 2 of *S. enflata* was higher than stage 1 and stage 3 (Tabel 3). The FCR of individuals at stations in the mouth of the bay did not vary between months but varied significantly between stages (two way ANOVA, months and stages, F = 1.05, $p > 0.05$ and F = 16.03, $p < 0.005$ respectively). While the FCRs of the individuals at stations inside the bay varied significantly between months but did not vary between stages (two way ANOVA, months and stages, F = 10.14, $p < 0.005$ and F = 1.92, $p > 0.05$ respectively). It appeared that individuals contained food in the guts more frequently from January to March (i.e. the northwest monsoon), when the water temperature was higher.

Table 3. Food Containing Ratio (FCR) and Daily Feeding Rate (DFR) of stage 1, 2, and 3 of *S. enflata*.

	Stations in the mouth of the Bay	Stations inside the Bay

Month	Stage	NE	NF	FCR (%)	NP C	DFR 1	DFR 2	NE	NF	FCR (%)	NPC	DFR 1	DFR 2
Jan.	1	91	16	18	0.21	5.04	6.46	57	12	21	0.26	6.24	8.00
	2	93	26	28	0.30	7.20	9.23	29	8	28	0.28	6.72	8.62
	3	136	32	24	0.24	5.76	7.38	12	4	33	0.33	7.92	10.15
Feb.	1	390	72	18	0.20	4.80	6.15	172	28	16	0.20	4.80	6.15
	2	294	80	27	0.27	6.48	8.31	104	26	25	0.25	6.00	7.69
	3	327	86	26	0.27	6.48	8.31	98	29	30	0.30	7.20	9.23
March	1	398	80	20	0.21	5.04	6.46	223	44	20	0.22	5.28	6.77
	2	290	82	28	0.28	6.72	8.62	96	24	25	0.25	6.00	7.69
	3	478	138	29	0.29	6.96	8.92	54	14	26	0.26	6.24	8.00
May	1	355	76	21	0.22	5.28	6.77	187	37	20	0.22	5.28	6.77
	2	377	108	29	0.29	6.96	8.92	63	13	21	0.21	5.04	6.46
	3	356	100	28	0.28	6.72	8.62	62	14	23	0.23	5.52	7.08
June	1	686	127	19	0.19	4.56	5.85	181	32	18	0.19	4.56	5.85
	2	774	226	29	0.29	6.96	8.92	101	19	19	0.19	4.56	5.85
	3	715	232	32	0.32	7.68	9.85	103	28	27	0.27	6.48	8.31
July	1	595	110	18	0.19	4.56	5.85	163	29	18	0.21	5.04	6.46
	2	414	107	26	0.26	6.24	8.00	10	2	20	0.20	4.80	6.15
	3	425	130	31	0.31	7.44	9.54	5	1	20	0.20	4.80	6.15
Aug.	1	523	130	25	0.25	6.00	7.69	228	57	25	0.29	6.96	8.92
	2	148	37	25	0.25	6.00	7.69	16	3	19	0.25	6.00	7.69
	3	137	37	27	0.27	6.48	8.31	3	1	33	0.33	7.92	10.15
Sept.	1	2061	362	18	0.19	4.56	5.85	95	14	15	0.17	4.08	5.23
	2	835	176	21	0.21	5.04	6.46	6	1	17	0.17	4.08	5.23
	3	654	170	26	0.26	6.24	8.00	3	1	33	0.33	7.92	10.15

Note: NE: Number of individuals examined, NF: Number of individuals with food in the gut, FCR: Food Containing Ratio (%), NPC: Number Prey per Chaetognaths, DFR1: Daily Feeding Rate/Ind/day (Digestion time 60 mins based on Szyper, 1978), DFR2: Daily Feeding Rate/Ind/day (Digestion time with in-situ temperature).

The number prey per chaetognath (NPC) of stage 3 of *S. enflata* was higher than other stages (Table 3). However, the NPCs of the individuals at stations in the mouth of the bay varied significantly between months but did not vary between stages (two way ANOVA, months and stages, F = 9.82, $p < 0.005$ and F = 1.80, $p > 0.05$ respectively). The NPCs of individuals at stations inside the bay showed a similar pattern (two way ANOVA, months and stages, F = 9.80, $p < 0.005$ and F = 1.65, $p > 0.05$ respectively). The NPCs during the northwest monsoon were higher than the NPCs during the southeast monsoon months (Table 3).

While the daily feeding rate (DFR) of *S. enflata* (all stages combined) recorded at stations in the mouth of the bay, was slightly higher than the DFRs of the individuals at stations inside of the bay (Table 3), However, the DFRs of stage 1 and 3 individuals did not vary between months and stations (two way ANOVA, months and stations, F = 2.10, $p > 0.05$, and F = 2.40, $p > 0.05$ for stage 1: and F = 1.12, $p > 0.05$ and F = 0.18, $p > 0.05$ for stage 3).

On the other hands, the food containing ratio (FCR) of *P. draco* was higher at stations in the mouth of the bay than at stations inside the bay (Table 4). The FCRs, NPCs and DFRs of *P. draco* were lower than *S. enflata*. It was found that the FCRs, NPCs, and DFRs did not vary between months but did vary between stations (two way ANOVA, months and stations, F = 0.39, $p > 0.05$ and F = 6.12, $p < 0.05$ respectively for FCRs: and F = 0.47, $p > 0.05$ and F = 6.74, $p < 0.05$

respectively for NPCs; while F = 0.047, $p > 0.05$ and F = 6.75, $p < 0.05$ respectively for DFRs).

Table 4. Food Containing Ratio (FCR) and Daily Feeding Rate (DFR) of *Pterosagitta draco.*

	Stations in the mouth of the Bay					**Stations inside the Bay**				
Month	**NE**	**NF**	**FCR (%)**	**NPC**	**DFR**	**NE**	**NF**	**FCR (%)**	**NPC**	**DFR**
Jan.	274	30	11	0.13	1.13	60	10	17	0.17	1.48
Feb.	611	151	25	0.25	2.18	0	0	0	0	0
March	455	76	17	0.17	1.48	20	2	10	0.10	0.87
May	76	11	14	0.15	1.31	358	58	16	0.16	1.40
June	25	3	12	0.12	1.05	50	4	8	0.10	0.87
July	196	38	19	0.19	1.66	0	0	0	0	0
August	596	98	16	0.16	1.40	0	0	0	0	0
Sept.	98	11	11	0.11	0.96	0	0	0	0	0

Note: NE: Number of individuals examined, NF: Number of individuals with food in the gut, FCR: Food Containing Ratio (%), NPC: Number Prey per Chaetognaths, DFR: Daily Feeding Rate/Ind/day (Digestion time 165 mins based on Terazaki, 1972).

Table 5. Number of prey removed by *Sagitta enflata* (stages 1, 2, dan 3) and *Pterosagitta draco* (ind/day/m^3) at stations in the mouth of the bay and stations in the mouth of the bay.

Stations in the mouth of bay	**Jan.**	**Feb.**	**March**	**May**	**June**	**July**	**August**	**Sept.**
Sagitta enflata	14.05	31.30	24.16	20.07	41.51	69.59	52.39	183.84
Stage 1	47.97	26.41	23.17	28.77	53.34	2340	8	60.82
Stage 2	27.16	31.91	31.87	22.07	52.06	23.71	5.24	49.40
Stage 3								
P. draco	0.77	3.34	1.68	0.25	0.07	0.81	2.09	0.23
T o t a l	89.95	92.96	80.88	71.16	148.98	107.51	67.69	294.29
Stations inside the bay	Jan.	Feb.	March	May	June	July	August	Sept.

Sagitta enflata	12.61	30.89	39.69	33.74	30.97	28.23	53.82	14.82
Stage 1	8.82	23.38	21.53	11.28	17.65	1.72	3.13	0.75
Stage 2	4.16	28.86	13.17	12.31	25.10	0.34	0.98	0.91
Stage 3								
P. draco	0.30	0	0.06	1.67	0.15	0	0	0
T o t a l	25.98	83.13	4.45	59.00	73.87	30.29	57.93	16.48

The number of prey (copepods) eaten by *S. enflata* /day/m^3 was higher at stations in the mouth of the bay (Table 5). The highest number of prey removed by *S. enflata* /day/m^3 from stations at the mouth of the bay was in September and the lowest was in August. While the proportion of the prey standing stock removed at stations in the mouth of the bay was higher in January (Table 6). This was because in January the number of prey was low and the abundance of stage 2 and 3 individuals of *S. enflata* were high and some of the stage individuals contained multiple prey. Therefore, the NPC was high. While the number of prey removed by *S. enflata* (stage 2) at stations inside the bay was never high, always less than 23 individuals (Table 5).

Table 6. Mean abundance of Copepods (ind/m^3) at stations in the mouth of the bay and stations inside the bay, and the percentages of Copepods removed from population standing stock (ind./day/m^3) by *S. enflata* and *P. draco*.

	Stations in the mouth of the bay		**Stations inside of the bay**	
Month	**No. Ind/m^3 of Copepods**	**Prey Removed (%)**	**No. Ind/m^3 of Copepods**	**Prey Removed (%)**
January	1,104	8.15	1,029	2.52
February	2,820	3.30	3,753	2.22
March	2,320	3.49	4,315	1.73
May	3,055	2.33	6,287	0.94
June	3,921	3.75	2,501	2.95
July	3,999	2.69	3,576	0.85
August	1,683	4.02	3,605	1.61
September	4,740	6.22	4,051	0.40

Table 7. The abundance of Copepods (ind/m^3) at 7 stations throughout Baguala bay, Ambon island (January to March and May to September 1994)

Month	**Station**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
January	560	1,477	1,195	1,220	503	1,364	1,182
February	815	3,766	2,779	3,535	4,788	2,936	3,921
March	1,359	1,457	2,461	2,785	5,845	4,769	4,002
May	1,374	2,892	3,904	4,050	4,096	10,716	4,049
June	1,847	7,537	2,201	4,057	1,115	2,332	4,097
July	1,497	2,316	2,106	1,598	4,307	4,822	10,075
August	470	2,350	1,081	5,148	1,092	4,575	2,830
September	2,435	3,421	2,788	5,204	3,869	3,081	10,275

At stations inside of the bay predation was high in February, March, and June (Table 4) and the highest was in June. In this month the number of *S.*

enflata (all stages) was high, while the number of prey was low (Table 2, 6, and 7). The proportion of the prey removed from the standing stock by *S. enflata* and *P. draco* at stations in the mouth of the bay was high in January. While at stations inside the bay was in June (Table 6). The large proportion of the standing stock removed by these 2 species in January and September at the stations in the mouth of the bay (Table 6) raises the possibility of significant impact on prey population at certain time of year.

DISCUSSION

A total of 13 species of chaetognaths were recorded from Baguala bay, but the dominant, numerically species was *Sagitta enflata,* which is generally regarded as the commonest oceanic chaetognath from tropical and sub-tropical waters (Nair, 1986; Tokioka, 1979; Pierrot-Bults and Nair, 1991) but it is also common and often abundant in neritic waters (Tokioka, 1979). *S. robusta, S. ferox, S. bedoti, S. pacifica, S. bipunctata,* and *Pterosagitta draco* which were also recorded are generally characterized as oceanic, Indo-Pacific, species. While *S. regularis,* and *S. neglecta* are usually considered as neritic species (Pierrot-Bults and Nair, 1991). All these species are epipelagic in their distribution but *S. zetesios,*and *Krohnitta subtilis* which are regarded as mesopelagic species (Pierrot-Bults and Nair, 1991 and Terazaki, 1991) were also recorded during this study. This mix of neritic and oceanic, epipelagic and mesopelagic species highlight the complex, and seasonally varying hydrography of Baguala bay and hence the seasonal changes in the ecology of the zooplankton.

S. enflata were distributed throughout Baguala bay but were more abundant at stations in the mouth of the bay. This confirms *S. enflata* as essentially an oceanic species. However, it appears that the young stage (new hatched and stage 1) of this species were more common at stations inside of the bay, which were characterized by high temperature and low salinity. This study also found the abundance of copepods increased from March to September. Copepods dominated the zooplankton community, accounting for 89.58% of the individuals at stations in the mouth of the bay and 85.27% at stations inside of the bay (average of 8 months). This means that the food available for the growth of immature chaetognaths and the reproduction in the adult (Nagasawa, 1984).

The chaetognaths can feed on larger prey when available and large chaetognaths eat small individuals of the same species (Feigenbaum, 1979, 1982; Nagasawa, and Marumo, 1984; Øresland, 1987). This study also found that large chaetognaths (*S. zetesios, S. hexaptera,* and *S. enflata*) feed on larger size prey. The small chaetognaths (*S. regularis,* and *P. draco*) and the young stage of the large species feed on small prey, such as *Pseudocalanus, Oithona, Acartia,* and *Corycaeus*. *S. enflata* and it was frequently found with multiple prey in their guts. This implies that *S. enflat*a are able to make maximum use of food when the distribution of food were patchy. It was also found that the number of prey (copepods) eaten by *S. enflata* was higher at certain stations and months. The guts contained food more frequently from January to March, when the water temperature were high, therefore, it could be suggested that temperature influences the feeding habit of *S. enflata*. This result is supported by Reeve (1966) who found that feeding in *S. hispida* also increased when temperatures were high.

Furthermore, the highest percentage of copepods removed by *S. enflata* and *P. draco* was at stations in the mouth of the bay in January (8.15% of the population stock) and the lowest in May

ISSN: 1410-5217
Accredited: 69/Dikti/Kep/2000

(2,33%). While from the stations inside of the bay was highest in June (2.95%) and the lowest in September (0.40%), when *P. draco* was absent. This clearly shows that the occurrence and distribution of *S. enflata* and *P. draco* can impact on the prey communities. This impact though is highly variable in time and probably has most effect during northwest monsoon when the copepods abundance was low.

CONCLUSSION

It could be concluded that since the mature *Sagitta* were more abundant at stations in the mouth of the bay during the northwest monsoon and the abundance of the copepods were low, the impact on the copepods community structure would be greatest in this season and at the stations in the mouth of the bay. This implies that a seasonal effect within this community, may vary between years dependent on the degree of oceanic influence induced in a particular year.

REFERENCES

Bone, Q., H. Kapp and A.C. Pierrot-Bults, 1991. Introduction and relationship of the group. In: *The Biology of Chaetognaths.* Edited by Q. Bone, H. Kapp and A.C. Pierrot-Bults. Oxford Science Publication. pp. 1-4.

Canino, M F. and G.C. Grant, 1985. The feeding and diet of *Sagitta tenuis* (Chaetognatha) in the lower Chesapeake Bay. *J. Plank. Res.,* 7 : 175-188.

Casper, T.C. and M.R. Reeve, 1975. Digestive efficiency of the Chaetognath *Sagitta hispida* Conant. *J. Exp. Mar. Biol. Ecol.*, 17 : 33-38.

Dunbar, M.J., 1962. The life cycle of *Sagitta elegans* in arctic and subarctic seas, and the modifying effects of hydrographic differences in the environment. *J. Mar. Res.,* 20 : 76-91.

Feigenbaum, D.L., 1979. Daily ration of the Chaetognath *Sagitta enflata. Mar. Biol.,*54 : 78-82.

Feigenbaum, D.L., 1991. Food and feeding behaviour. In: *The Biology of Chaetognaths.* Edited by Q. Bone, H. Kapp and A.C. Pierrot-Bults. Oxford Science Publication. pp. 45-54.

Feigenbaum, D.L., and M.R. Reeve, 1977. Prey detection in the Chaetognatha: Response to a vibrating probe and experimental determination of attack distance in large aquaria. *Limnol. Oceanogr.,* 22 : 1052-1058.

Feigenbaum, D.L., and R.C. Maris, 1984. Feeding in the Chaetognatha. *Oceanogr. Mar. Biol. Ann. Rev.,* 22 : 343-392.

Frid, C.L.J., L.C. Newton, and J.A. Williams, 1994. The feeding rate of *Pleurobrachia* (Ctenophora) and *Sagitta* (Chaetognatha), with notes on the potential seasonal role of planktonic predators in the dynamic of North Sea zooplankton communities. *Neth. J. Aqua. Ecol.,* 28 (2) : 181-191.

Gibbons, M.J., 1992. Diel feeding and vertical migration of *Sagitta*

ISSN: 1410-5217
Accredited: 69/Dikti/Kep/2000

serratodentata Krohn *tasmanica* Thomson (chaetognatha) in the southern Benguela. *J. Plank. Res*., 11.2. : 249-259.

Huliselan, N.V., 1991. An ecological study of horizontal spatial distribution, composition and abundance of zooplankton in Ambon Bay, Indonesia. M.Sc. Thesis. Department of Marine Sciences and Coastal Management, University of Newcastle upon Tyne, U.K.

Kimmerer, W.J., 1984. Selective predation and its impact on prey of *Sagitta enflata* (Chaetognatha). *Mar. Ecol. Prog. Ser.,* 15 : 55-62.

Kotori, M., 1979. Reproduction and life history of *Sagitta elegans* Verill (review). *Bull. Plank. Soc. Jpn.,* 26: 25-39.

McLaren, L.A., 1969. Population and Production Ecology of zooplankton in Ogac Lake, a landlocked fjord on Baffin Island. *J. Fish. Res. Bd. Can.,* 26 : 1485-1559.

Nagasawa, S., 1984. Laboratory feeding and egg production in the Chaetognath *Sagitta crassa* Tokioka. *J. Exp. Mar. Biol. And Ecol.,* 76 : 51-65.

Nagasawa, S., 1985. The digestive efficiency of the Chaetognath *Sagitta crassa* Tokioka, with observation on the feeding process. *J. Exp. Mar. Biol. And Ecol.,*87 : 271-282.

Nagasawa, S., and R. Marumo, 1984. Feeding habits and copulation of the Chaetognath *Sagitta crassa*. *La Mer,* 22 : 8-14.

Nair, V.R., 1978. Bathymetric distribution of Chaetognaths in the Indian Ocean. *Ind. J. Mar. Sci.,* 7 : 276-282.

Øresland, V., 1986. Temporal distribution of size and maturity stages of the chaetognath *Sagitta setosa* in the western English Channel. *Mar. Ecol. Prog. Ser.,* 29 : 55-60.

Øresland, V., 1987. Feeding of the Chaetognaths *Sagitta elegans* and *S. setosa* at different seasons in Gullmarsfjorden, Sweden. *Mar. Ecol. Prog. Ser.,* 39 : 67 76.

Pierrot-Bults, A.C. and V.R. Nair, 1991. Distribution patterns in Chaetognatha. In: *The Biology of Chaetognaths.* Edited by Q. Bone, H. Kapp and A.C. Pierrot-Bults. Oxford Science Publication. pp. 86-116.

Rao, T.S.S., 1979. Zoogeography of the Indian Ocean. In: *Zoogeography and diversity of plankton.* Edited by S. van der Spoel and A.C. Pierrot-Bults, Bunge. Utrecht. pp. 254-292.

Reeve, M.R., 1966. Observation on the biology of a chaetognath. In: *Some contemporary studies in marine science.* Edited by H. Barnesh, George Allen and Unwin Ltd. London. pp. 613-630.

Stelle, J.H. and E.W. Henderson, 1992. A simple model for plankton patchiness. *J. Plank. Res.,* 14 : 1397-1403.

Terazaki, M., 1991. Deep sea Chaetognaths. In: *The biology of Chaetognaths.* Edited by Q. Bone, H. Kapp and A.C. Pierrot-bults, Oxford Sciences Publication. pp. 117-121.

Terazaki, M., and R. Marumo, 1982. Feeding habits of meso and bathypelagic chaetognath *Sagitta zetesios* Fowler. *Oceanologica Acta.* 5 : 461-464.

Tokioka, T., 1979. Neritic and oceanic zooplankton. In: *Zoogeography and diversity of plankton.* Edited by S. van der Spoel and A.C. Pierrot-Bults, Bunge. Utrecht. pp. 126-143.

Troost, D.G., A.B. Sutomo and L.F. Wenno. 1976. Distribution and abundance of major zooplankton groups in Ambon bay (Maluku, Indonesia) during a Salp swarming with notes on chaetognatha ans Pteropoda species. *Mar. Res. Indonesia,* 16 : 31-44.

Unesco, 1968. *Smaller mesozooplankton.* Report of working party No. 2, Monographs on Oceanographic. 2 : 153-159.

Williams, R. and N.R. Collins. 1985. Chaetognaths and Ctenophores in the holoplankton of the Bristol Channel. *Mar. Biol*., 85 *:* 97-107.

Zijlstra, J.J., M.A. Baars, S.B. Tijssen, F.J. Wetsteyn, J.I.J. Witte, A.G. Ilahude, and Hadikusuma, 1990. Monsoonal effect on the hydrography of the upper waters (<300m) of the eastern Banda Sea and northern Arafura Sea, with special reference to vertical transport processes. *Neth. J. Sea Res.,* 25 : (4) : 431-447.

Zo, Z., 1973. Breeding and growth of the chaetognath *Sagitta elegans* in Bedford Basin. *Limnol. Oceanogr.,* 18 : 750-756.