COMPARATIVE STUDY ON THE EFFICIENCY OF TWO PLANKTON NETS FOR THE QUANTITATIVE ESTIMATION OF APPENDICULARIANS (CHORDATA, TUNICATA)

Graciela Beatriz ESNAL[*]
Cheruparambil SANKARANKUTTY[**]
Beatriz Nora GONZALEZ[*]
Fabiana Lía CAPITANIO[*]

INTRODUCTION

The quantitative estimation of zooplankton depends on the choice of plankton net and mesh size. When comparing abundance and composition of several zooplanktonic groups, it is strongly recommended to use the appropriate net for each group, and to express the results according to the volume of water filtered by the different nets (Fenaux, 1986). These considerations also apply to the different species in the same group, and several examples exist in Appendicularia, which are very well documented in that respect (Wyatt, 1973; Paffenhöfer, 1975; Fenaux *et al.*, 1979; Fenaux & Palazzoli, 1979; Fenaux, 1986). Frequently, samples are not representative of the real population size, because juvenile stages of many species may be underestimated when nets with a large mesh size are employed. Comparing the capture of appendicularians by 53 µm and 200 µm mesh nets in the Mediterranean Sea, Fenaux *et al.* (1979) noticed that the larger mesh size determined not only an underestimation of densities, but also an important underestimation of biomass (see also Fenaux & Palazzoli, 1979). In the present paper the efficiency of two plankton nets with similar characteristics to those used by Fenaux *et al.* (1979) is comparatively analyzed for the quantitative estimation

* Departamento de Ciências Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina.

** Departamento de Oceanografia e Limnologia, Universidade Federal do Rio Grande do Norte, Praia de Mãe Luiza s/n, Natal-Rn 59014-100, Brazil.

of four species of the genus *Oikopleura*. We test the hypothesis that immature animals are captured in a greater proportion by the 53 μm mesh net. In addition, their abundance at a coastal station located in the northeast of Brazil is discussed.

MATERIALS AND METHODS

Sampling was performed from the oil platform PUB 3, Guamaré, Rio Grande do Norte (5°S - 36°W) between 17 and 21 October 1989. Eight diurnal and eight nocturnal samples were taken using two plankton nets (53 μm and 200 μm pore size) hauled vertically and simultaneously from a depth of 10 m to the surface. The number of organisms per cubic meter was estimated by the cylinder formula, taking into account mouth diameter of nets and sample depth.

Appendicularians were classified into three maturity stages: immature, intermediate, and mature, following the characterizations proposed by Fenaux (1976), Esnal & Castro (1977), Esnal & Castro (1985), Esnal *et al.* (1985), and Simone *et al.* (1989).

Net efficiencies were compared through a randomized complete blocks ANOVA design (Steel & Torrie, 1980). Sixteen samples as the blocks, four species, three maturity stages, and two nets were considered (N=384). Densities (d) were transformed to d'=log (d+0.5) (Sokal & Rohlf, 1996) to test the assumption for the ANOVA. Double interactions were analyzed by simple effect tests (Winer, 1971).

RESULTS

Table 1 shows the density of appendicularians collected by the 53 μm and 200 μm mesh nets; temperature and salinity are also included. *Oikopleura cornutogastra* Aïda 1907, *O. dioica* Fol 1872, *O. longicauda* (Vogt 1854), and *O. rufescens* Fol 1872 were the main appendicularians present in the samples. A single specimen of *Fritillaria formica* Fol 1872 was capture by the 53μm mesh net, at midnight, on 18 October, and another one of *Megalocercus abyssorum* Chun 1888, by the 200 μm mesh net, at 3:00 AM, the same day. *Oikopleura longicauda* was the dominant species in samples from both nets, followed by *O. dioica. O. cornutogastra* and *O. rufescens* appeared frequently but their densities were low. A high proportion of immature animals was recorded, indicating an active reproduction of all the species. However, between the two most abundant species an alternation of abundances seems to occur, since immature *O. longicauda* were abundant during the last sampling days, whereas immature *O. dioica* were predominant at the beginning of the sampling period. Captures were higher during the night, especially for *O. longicauda* and *O. cornutogastra* (Table 2).

The result of the ANOVA on transformed densities (Table 3) shows the significance of the interactions: a) net x stage x species (F=2.099, 6 and 345 degrees of

freedom, P=0.052), b) stage x species (F=10.538, 6 and 345 degrees of freedom, P=0), c) net x species (F=10.928, 3 and 345 degrees of freedom, P=0) and d) net x stage (F=12.489, 2 and 345 degrees of freedom, P=0). The degrees of freedom of the interactions were calculated by multiplying the degrees of freedom of each one of the involved factors. The degrees of freedom of the error were calculated by subtracting 38 degrees of freedom to the total degrees of freedom (N-1=383). Simple effect tests were used, beginning with the net x stage interaction. The 53 μm mesh net captured more immature specimens than the 200 μm mesh net (F=27.123, 1 and 345 degrees of freedom, P=0), whereas intermediate and mature animals were equally captured by both nets (P=0.213 and P=0.075) (Table 4, Figure 1). As the highest difference between the numbers of organisms captured by both nets was restricted to immature stages, a simple effect test was used for this stage on the net x species interaction (Table 5). Immature *O. dioica* were captured in a greater proportion by the 53 μm mesh net (F=55.63, 1 and 345 degrees of freedom, P=0), whereas the remaining species were equally captured by both nets (P>0.05).

Table1: Sampling data from a coastal station off Brazil (5°S, 36°W).

Sample	Temperature (C°)	Salinity (‰)	Appendicularians total density (specimens/m^3)	
			53 μm net	200 μm net
1	29.0	36.0	71.0	38.2
2	29.0	36.0	83.0	56.43
3	29.0	36.0	98.0	87.1
4	29.0	36.0	51.1	63.1
5	29.0	36.0	58.0	65.8
6	29.0	36.0	62.3	28.4
7	29.0	36.0	27.4	55.8
8	29.0	36.0	46.0	29.9
9	29.0	36.1	115.0	53.4
10	29.0	36.1	108.6	69.5
11	29.0	36.1	54.9	39.9
12	29.0	36.1	66.8	72.2
13	29.0	36.1	21.4	10.9
14	29.0	36.1	7.1	2.1
15	29.0	36.1	3.4	3.1
16	29.0	36.1	19.1	7.9

Table 2: Mean densities (specimens/m^3) of the four species pooled for the 53 μm and 200 μm mesh nets in diurnal and nocturnal samples.

Species	Diurnal density		Nocturnal density	
	53 μm	200 μm	53 μm	200 μm
O. longicauda	64.1	57.1	105.8	58.6
O. dioica	56.6	16.2	60.1	22.3
O. rufescens	29.4	20.5	31.3	26.1
O. cornutogastra	31.2	22.6	47.6	37.8

Table 3: ANOVA. DF: degrees of freedom; F: statistic; P: probality.

Source of variation	DF	F	P
Sample	15	11.829	0.000
Net	1	8.124	0.005
Stage	2	111.677	0.000
Species	3	89.251	0.000
Net x stage	2	12.489	0.000
Net x species	3	10.928	0.000
Stage x species	6	10.538	0.000
Net x stage x species	6	2.099	0.052
Error	345		

Table 4: Mean densities and simple efefct test for the net x stage interaction. (1) stage in nets; (2) net in maturity stages. F: statistic; P: probability.

	Immature (2)	Intermediate (2)	Mature (2)	F	P
53 μm net (1)	9.533	3.838	0.438	97.670	0
200 μm net (1)	6.359	3.778	0.448	26.498	0
F	27.123	1.540	3.099		
P	0	0.213	0.075		

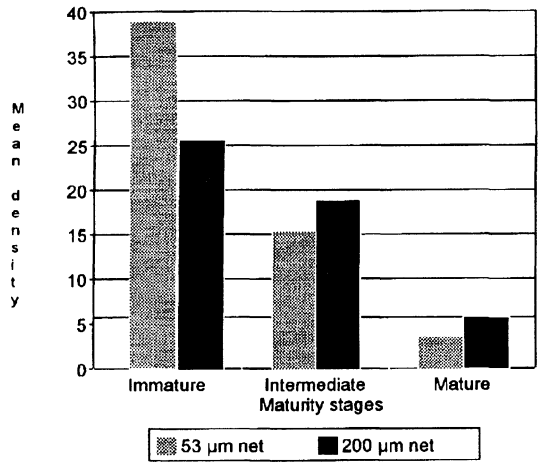

Fig. 1
Mean density (specimens/m^3), of each maturity stage of the four appendicularian species captured simultaneously with 53 µm and 200 µm mesh nets.

Table 5: Simple effect test for the net x species interaction. Comparison of densities of immature individuals of each species between both nets. DF: degrees of freedom; F: statistic; P: probability

Species	DF	F	P
O. longicauda	1	1.135	0.288
O. rufescens	1	0.327	1.000
O. cornutogastra	1	2.134	0.149
O. dioica	1	55.631	0.000
Error	345		

DISCUSSION

When comparative studies on the efficiency of plankton nets are discussed, all authors agree that the 200 µm mesh net is not the most appropriate net for the quantitative estimation of appendicularians, recommending the use of a smaller pore net. Paffenhöfer (1975) mentions, for the case of *Oikopleura dioica* from the North Sea, that specimens with trunk length under 400-500 µm are not quantitatively estimated if a 200 µm mesh net is employed. In the case of *O. longicauda* from the Mediterranean Sea, Fenaux & Palazzoli (1979) affirm that those animals with trunk lengths under 300 µm are underestimated if sampled using a 200 µm mesh net. These authors propose the use of correction coefficients when a representative sampling of the population density is required. For the appendicularians of the family Oikopleuridae the proposed coeffi-

cient is 2.9, while for those of the family Fritillaridae, which are generally smaller, the proposed factor is 4.6. Wyatt (1973), also estimated correction factors for *O. dioica* smaller than 300 μm in trunk length, collected by a multiple high speed plankton sampler net (78 meshes/cm). For the Mediterranean appendicularians, Fenaux (1986) mentions that qualitative composition does not seem to be influenced by net choice (53 μm vs. 200 μm mesh), as opposed to what happens with quantitative estimations.

The results obtained in the present study agree with the above mentioned authors since the 53 μm net seems to be the most efficient mesh size to study the overall species assemblage. However, when the densities of immature stages of each species were analyzed separately, differences in captures were due exclusively to *O. dioica* (P=0), which was the only species underestimated by the 200 μm net. All individuals of the remaining species were equally captured by both nets (P>0.05).

No differences in the faunistic composition of the captures were found between both plankton nets, with the single exception of a specimen of *Fritillaria formica* captured by the 53 μm net, and another one of *Megalocercus abyssorum* captured by the 200 μm net. Although the latter species is very large, the presence of a single specimen can be interpreted as a random effect and not as plankton net selectivity.

The highest density of animals was observed during night samplings. Appendicularians show small scale vertical migrations due to diverse environmental factors such as thermal and saline gradients, concentrations of chlorophyll and suspended particles. On some occasions, a differential stratification of different populations has been observed (Acuña & Anadón, 1992; Shiga, 1993; Acuña, 1994). The sampling design herein used does not permit to detect vertical migration of the studied species, since only surface samplings (0-10 m layer) were performed. However, the differences observed between diurnal and nocturnal samplings would suggest night migration to the surface, a well-known distribution pattern among zooplankton organisms.

ACKNOWLEDGEMENTS

We are grateful to the staff of the oil platform PUB 3 of PETROBRAS for their cooperation and assistance in collecting the samples. This research was supported by grants from CONICET and UBACYT to G. B. Esnal.

ABSTRACT

Appendicularians collected from a coastal station located at 5°S and 36°W, northeast Brazil, were studied. Eight daytime and eight night samples were collected from the 0-10 m layer. Two samples were taken simultaneously using 53 μm and 200 μm mesh plankton nets. *Oikopleura cornutogastra, O. dioica, O. longicauda,* and *O. rufescens* were the main species present in the samples. The efficiency of both nets was compared for the quantitative estimation of these species. All the appendicularians were classified into three maturity stages: immature, intermediate, and mature. Their densities were compared using a randomized complete blocks ANOVA design with net level as the main plot. Only immature *O. dioica* were underestimated when a 200 μm mesh net was used (P=0). Immature individuals of the remaining species were equally captured by both nets (P>0.05). *O. longicauda* and, to a lesser extent. *O. dioica,* were the dominant species. All samples showed a high proportion of immature animals, indicating an active reproduction of all the species.

Key-words: zooplankton, Appendicularia, nets, sampling methodology.

RESUMO

Apendiculárias coletadas em uma estação costeira localizada a 5° S e 36°W, no nordeste do Brasil, foram estudadas. Foram coletadas oito amostras noturnas e oito amostras diurnas na camada entre 0 e 10 m. Duas amostras foram coletadas simultaneamente usando redes de plâncton com abertura de malha de 53 μm e 200 μm. *Oikopleura cornutogastra, O. dioica, O. longicauda* e *O. rufescens* foram as espécies registradas. Ambas as redes foram comparadas com relação à sua eficiência para estimar a densidade das espécies. Todos os organismos foram classificados em três estágios de maturidade: imaturo, intermediário e maduro. Suas densidades foram comparadas usando um desenho experimental de ANOVA em bloco completo aleatorizado, com o tipo de rede como a plotagem principal. Somente *O. dioica* imaturos foram subestimados quando uma rede de 200 μm de abertura de malha foi usada (P=0). Organismos imaturos das espécies remanescentes foram igualmente capturados com ambas as redes (P>0.05). *O. longicauda* e em seguida *O. dioica* foram as espécies dominantes. Todas as amostras analisadas apresentaram uma alta porcentagem de animais imaturos, como evidência da reprodução ativa das espécies.

Palavras-chave: zooplâncton, Appendicularia, redes, metodologia de amostragem.

REFERENCES

ACUÑA, J. L. 1994. Summer vertical distribution of appendicularians in the Central Cantabrian Sea (Bay of Biscay). *J. Mar. Biol. Ass., U.K.,* 74: 585-601.

ACUÑA, J. L. & ANADON, R. 1992. Appendicularian assemblages in a shelf area and their relationship with temperature. *J. Plankton Res.,* 14 (9): 1233-1250.

ESNAL, G. B. & CASTRO, R. J. 1977. Distributional and biometrical study of appendicularians from the West Atlantic Ocean. *Hydrobiol.,* 56 (3): 241-246.

ESNAL, G. B. & CASTRO, R. J. 1985. Caracterización de estadios de madurez y variaciones intraspecíficas en *Oikopleura longicauda* (Vogt,1854), (Tunicata, Appendicularia). *Physis, Buenos Aires,* 43 (104): 19-24.

ESNAL, G. B.; SANKARANKUTTY, C. & CASTRO, R. J. 1985. Diurnal and seasonal fluctuations of *Oikopleura dioica* Fol, 1872 (Tunicata, Appendicularia) in the mouth of the River Potengi (North Brazil). *Physis, Buenos Aires,* 43 (105): 65-71.

FENAUX, R. 1976. Cycle vital d un appendiculaire *Oikopleura dioica* Fol, 1872. Description et chronologie. *Ann. Instit. Oceanogr., Paris,* 52 (1): 89-101.

FENAUX, R. 1986. Influence de la maille du filet sur l estimation des populations d' appendiculaires in situ. *Rapp. Comm. Int. Mer. Medit.*, 30, 2, p. 203.

FENAUX, R.; GORSKY, G. & ESNAL, G.B. 1979. Comparaison et variation de la biomasse du plancton récolté pendant 24 heures en baie de Villefranche-sur-Mer, à l'aide de 2 filets de maille différente: 53 µ et 200 µ. *Rapp. Comm. Int. Mer. Int. Mer. Medit., 25/26,* 8: 81-82.

FENAUX, R. & PALAZZOLI, I. 1979. Estimation in situ d'une population d'*Oikopleura longicauda* (Appendicularia) à l'aide de deux filets de maille différente. *Mar. Biol.,* 55: 197-200.

PAFFENHÖFER, G. A. 1975. On the biology of Appendicularia of the Southeastern North Sea. *10th European Symposium on Marine Biology, Ostend, Belgium*, 2: 437-455.

SHIGA, N. 1993. Regional and vertical distributions of *Oikopleura vanhoeffeni* on the northern Bering Sea shelf in summer. *Bull. Plankton Soc. Japan,* 39: 117-126.

SIMONE, L.; CASTRO, R. J. & ESNAL, G. B. 1989. Characterization of maturity stages in *Oikopleura rufescens* Fol, 1872 (Tunicata, Appendicularia) by means of a multivariate analysis. *Physis, Buenos Aires,* 47 (112): 35-41.

SOKAL, R. & ROHLF, J. 1996. *Biometry.* W.H. Freeman & Co., Ed., 1-860.

STEEL, R. & TORRIE, J. 1980. *Principles and procedures of statistics. A biometrical approach.* Mc. Graw-Hill Inc., Ed., 1-622.

WINER, B. J. 1971. *Statistical principles in experimental design.* Mc. Graw- Hill Inc., Ed., 1-907.

WYATT, T. 1973. The biology of *Oikopleura dioica* and *Fritillaria borealis* in the Southern Bight. *Mar. Biol.,* 22: 137-158.