REPRODUCTIVE CYCLE AND BIOMETRIC RELATIONS IN A POPULATION OF ACTINOPYGA ECHINITES (ECHINODERMATA : HOLOTHUROIDEA) FROM THE LAGOON OF NEW CALEDONIA, WESTERN TROPICAL PACIFIC

C. Conand
O.R.S.T.O.M., Nouméa, Nouvelle-Calédonie

1 INTRODUCTION

Certain species of holothurians are exploited in the tropical Indo-Pacific region for the preparation of trepang or bêche-de-mer or for consumption of the fresh body wall or internal organs. In New Caledonia approximately ten species are of commercial value ; the reproductive cycles of three large species, Holothuria (Microthele) nobilis, H. (M.) fuscogilva and Thelenota ananas, have already been studied (Conand, 1981). Nevertheless, despite their importance in the benthic fauna, there is little information on tropical holothurians and their biology and ecology remain little known (Bakus, 1973).

Actinopyga echinites (Jaeger, 1833) belonging to the family Holothuriidae is a common species in New Caledonia (Intes and Menou, 1977). It is a brown, medium sized holothurian whose dorsal body wall, wearing numerous papillae, is often covered with sand. There are five beige calcified anal teeth around the anus. It is a commercial species. The reduction of its size parameters during processing has been measured. At the end of the drying, its length was 47 % of the initial length, its weight only 11 % (Conand, 1979). This species is widely distributed in the Indo West Pacific (Clark and Rowe, 1971) and its bathymetric distribution, deeper than Actinopyga mauritiana, is the reason for its english name of deep water redfish (Anonymous, 1979).

2 MATERIAL AND METHODS

Samples were collected from November 1978 to May 1980, in lagoon sites near Noumea (Fig. 1). They were collected at monthly intervals by skin diving generally on the reef slope of Maitre Islet, except in November 1978 at Anse Vata site, February 1979 on Ricaudy Reef flat and a few individuals in May 1980 on Croissant Reef flat.

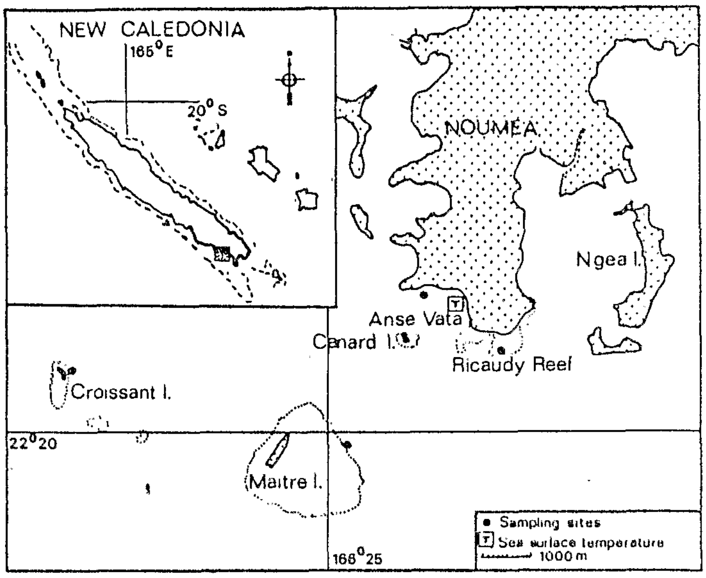
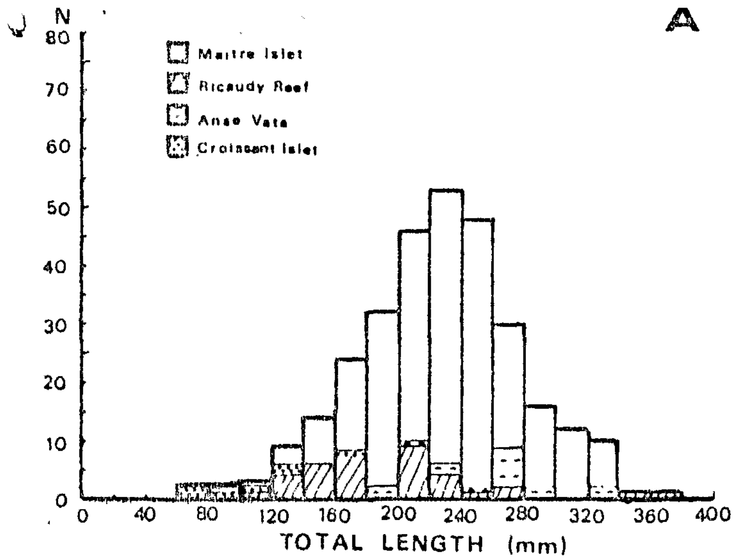


Fig. 1. Sampling sites.

The abundance was at first estimated indirectly, by assessing the catch per unit effort (CPUE) or number of specimens counted per diver per hour. Density was later measured on transects where the observer, swimming with a board equiped with a flow meter and a compass, counted all individuals within a width of 2 meters. This method has previouly been used to survey populations of the crown-of-thorns starfish Acanthaster planci (Kenchington and Morton, 1976) and other benthic invertebrates (Pearson, 1980).

During each sampling, roughly twenty A. echinites were collected and brought to the laboratory. Measures of total length (TL), total weight (TW), drained weight (DW) and gutted weight (GW) were recorded on individuals which had been relaxed with magnesium chloride, following the same procedure as already described (Conand, 1981).



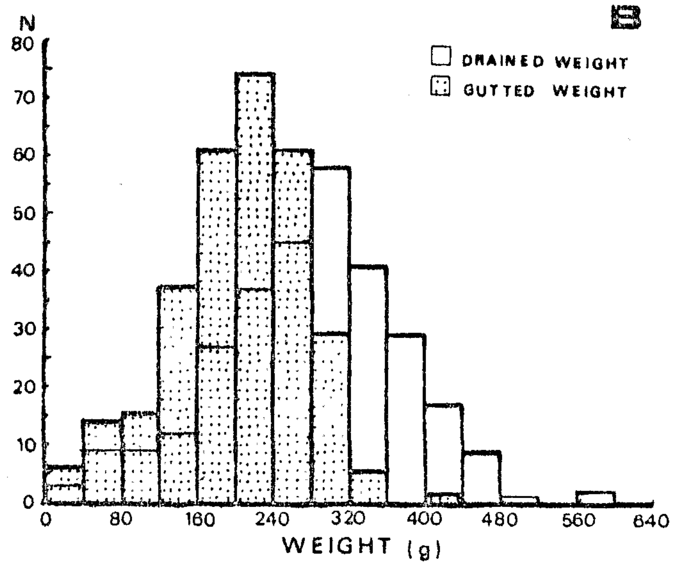


Fig. 2. Frequency distribution : A, total length ; B, weights.

Sexual reproductive biology of aspidochirote holothurians has generally been elucidated by histological examination of the gonads (Tanaka, 1958 ; Harriot, 1980). However, direct microscopic observation of formalin preserved gonads is faster and consequently was used in this study. Sex was determined, diameter and length of the gonadal tubules recorded and oocyte size distribution established. Gonad index (GI) was expressed as a ratio of gonad weight to drained weigth. The monthly mean of the gonad index and confidence limits at a probality level of 0.90 were calculated.

Mean sea water temperatures were calculated from daily measurements at the Noumea-Anse Vata coastal station (Fig. 1).

The size at first sexual maturity was obtained by plotting a graph of the percentage of individuals with developed or developing gonads, in classes of drained weight. The data for the months where the gonads were in the resting phase, were excluded. The size classes, at which 0 % and 100 % of the individuals were mature, determined the interval of first maturity ; the size at which 50 % were mature (DW_{50}) was chosen as an index of first maturity.

3 RESULTS AND DISCUSSION

3.1 Distribution and abundance

At Maitre Islet site, A. echinites was abundant on the windward reef flat and on the detritic reef slope. The catch per unit effort was assessed during five minute surveys. The mean CPUE remained 200 throughout the period of study. The mean density calculated from eight swims of 400 meters length, was 8 individuals per 100 square meters. This density is less than that reported for the same species, from a reef flat in Guam where its density exceeded 1 per square meter (Rowe and Doty, 1977).

3.2 Biometry

Frequency distributions of the total length, drained weigth and gutted weight, established for the entire sample (Fig. 2 A and B), were unimodal. Young individuals were rare. The mean values of these parameters were calculated (Table 1).

Table 1. Biometric study : (n : sample size ; R : range of the values ; $\overline{m}$: mean ; d.f. : degree of freedom ; r : correlation coefficient).

Character	n	R	$\overline{m}$
TL (mm)	303	65 - 365	222
TW (g)	301	16 - 1380	435
DW (g)	299	11 - 580	274
GW (g)	303	9 - 405	200
Relation		**d.f.**	**r**
TW = 4.38 TL - 537.72		296	0.84
DW = 1.91 TL - 149.38		297	0.79
DW = 0.49 TW + 64.14		289	0.78
GW = 0.70 DW + 7.80		295	0.96

The biometric relations established between pairs of characters are presented in Table 1. Examination of the correlation coefficients revealed that drained weight and gutted weight are the least variable characters (Fig. 3B). Drained weight was therefore used to calculate gonad-index.

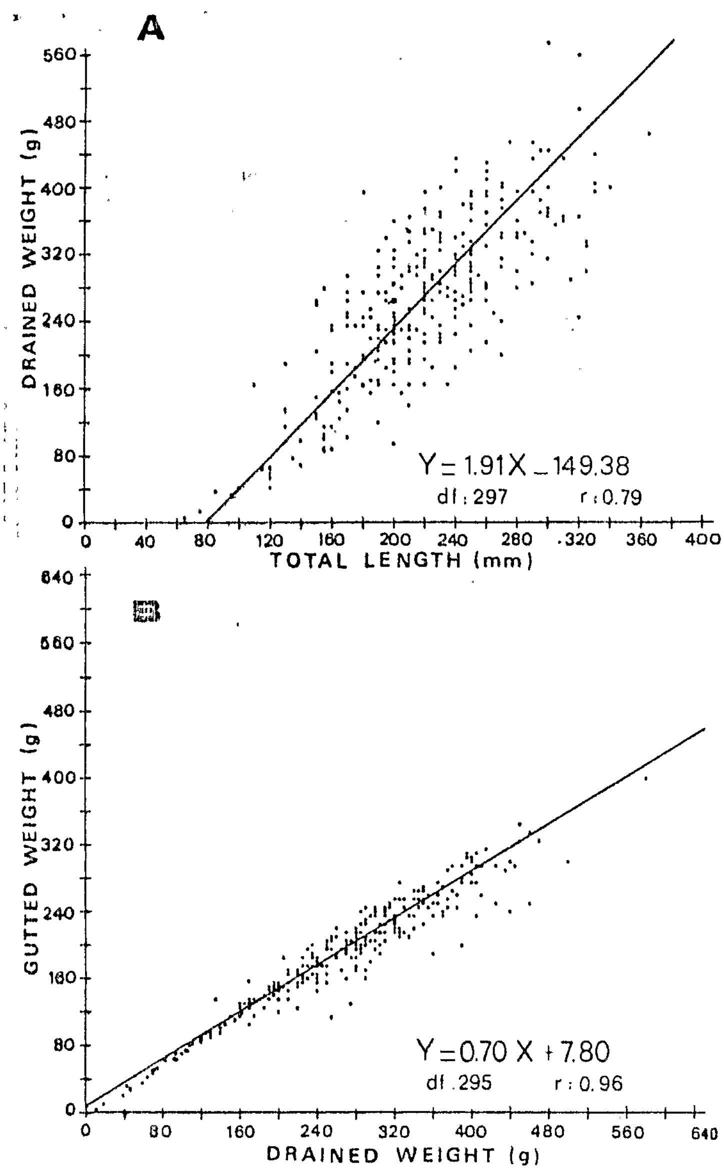


Fig. 3. Biometric relations : A, length - drained weight ; B, drained weight-gutted weight.

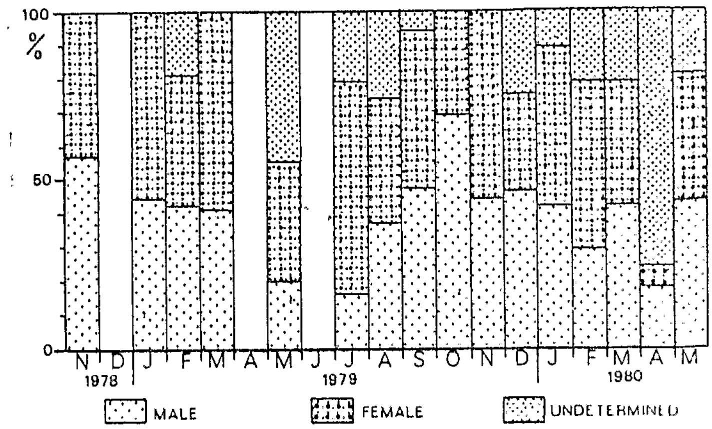


Fig. 4. Monthly percentages of males, females and undetermined individuals.

Despite the variability in length (Fig. 3A), it will be necessary to use this character for a future study of growth by tagging.

3.3 Sexual stages and reproductive cycle

In A. echinites the sexes are separate. No hermaphrodite individuals nor any individual undergoing fission were observed. Only one specimen had two posterior ends with two anus, only one of which was connected with the intestine. This abnormality was probably simply regeneration following a wound.

The ovaries and the testes each consist of a single tuft of tubules. A maturity scale of five stages was defined. The macroscopic and microscopic gonadal features of Holothuria (M.) nobilis can also be used for A. echinites (Conand, 1981). The mean values of the length and diameter of the tubules, of the gonad weight and of the

Table 2. Maturity stages ($\overline{m}$: mean ; n : number of specimens ; SD : standard deviation ; L : length of tubules ; Ø : diameter).

Maturity stage		Gonad tubules L(mm)	Gonad tubules Ø(mm.10^{-1})	Gonad weight (g.10^{-1})	GI	Gonad tubules L(mm)	Gonad tubules Ø(mm.10^{-1})	Gonad weight (g.10^{-1})	GI
		Undetermined							
Stage I Immature	$\overline{m}$	10.0	2.3	1.7	0.12				
Stage II Resting	n	49	37	54	54				
	SD	9.7	1.4	1.3	0.14				
		Males				Females			
Stage III Growing	$\overline{m}$	65.5	5.0	28.4	1.08	47.9	6.7	30.2	0.99
	n	22	22	22	22	30	30	30	29
	SD	27.7	2.0	26.9	0.88	26.2	2.7	40.9	1.30
Stage IV Mature	$\overline{m}$	114.6	8.0	196.1	6.07	106.8	11.1	251.1	7.84
	n	42	42	44	42	38	38	39	39
	SD	29.0	3.1	136.7	3.19	25.8	3.9	189.3	5.29
Stage V Post spawning	$\overline{m}$	52.1	4.4	23.1	0.77	44.1	5.3	28.7	0.94
	n	53	41	53	53	52	38	53	52
	SD	30.9	1.6	25.3	0.72	27.1	3.9	44.9	1.40

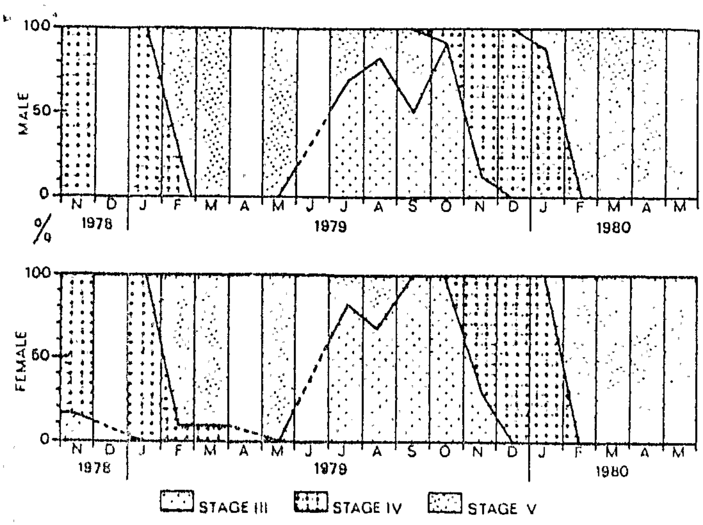


Fig. 5. Monthly percentages of maturity stages.

gonad index were calculated for each stage of maturity for both sexes (Table 2.). Stages I and II respectively correspond to immature and resting individuals. During these stages sex can not be determined even microscopically. Furthermore, it is impossible or very difficult to distinguish resting gonads from immature gonads.

There is a certain sexual dimorphism, testis tubules are slightly longer and narrower than ovarian ones and the mature ovaries are pink and heavier than the whitish testes.

At stage IV, the gonad index values were 6.1 for the males and 7.8 for the females. The ripe oocytes measured approximately 175 µm. The coefficient of fecundity, estimated by dividing the mean weight of ovaries in stage IV by the cube of the diameter, equals 4700. A. echinites is therefore characterized by the relatively large size of oocytes and a low fecundity.

At stage V of post-spawning, spicules were apparent in the gonadal wall.

Monthly percentages were calculated for males, females and individuals of undetermined sex (Fig. 4). The overall sex ratio was 1.0 : 1.0. Undetermined individuals represented 19 % of the total. The percentage of these individuals was low from September to January and higher from April

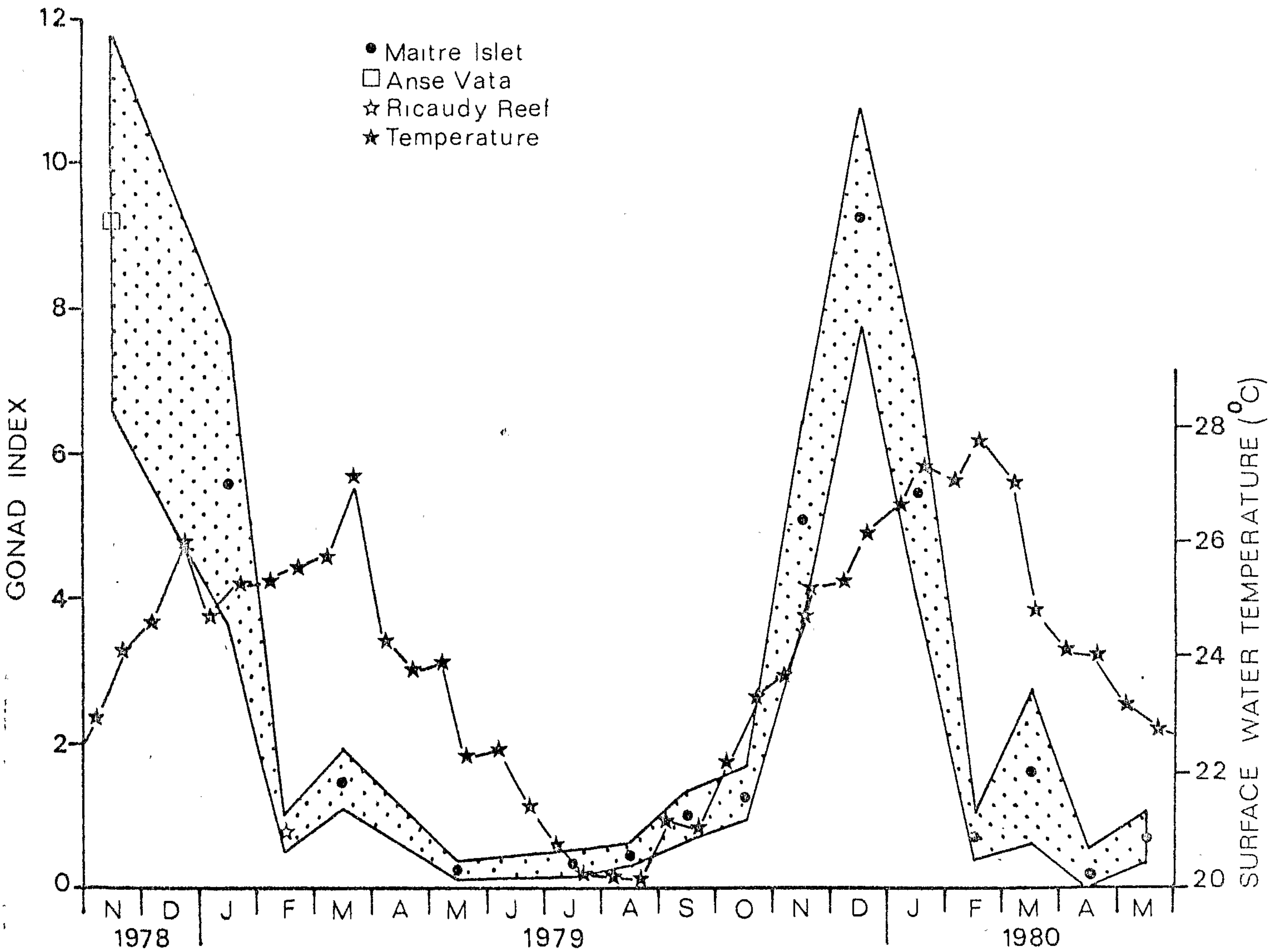


Fig. 6. Monthly changes of gonad index and surface water temperature. The dotted area represents the confidence interval (0.90 probability level) of the mean gonad index.

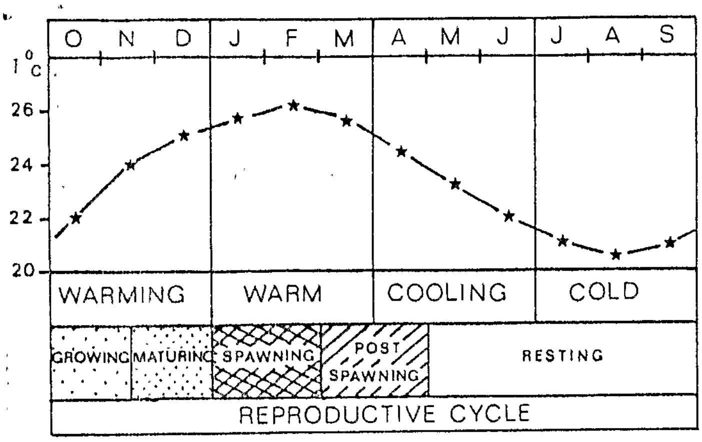


Fig. 7. Phases of the reproductive cycle in relation to sea water seasons.

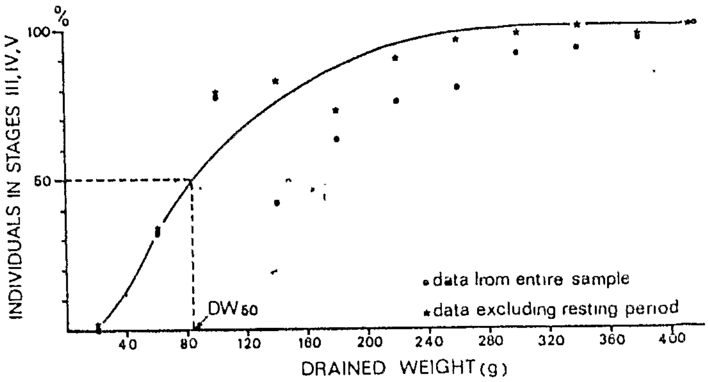


Fig. 8. Weight at first sexual maturity.

to August. This variation was related to the reproductive cycle.

Monthly percentages of maturity stages (Fig. 5) were similar in both males and females. Stage III was preponderant from July to October, stage IV from November to January. The post-spawning stage V lasted from February to July.

The gonad index cycle (Fig. 6) clearly showed a growing phase from September to November-December, where the values were at their maximum. A rapid decline occured in 1979 as well as in 1980, in January and February, followed by a phase of low values. The high percentage of undetermined individuals from April to August therefore corresponded to resting individuals.

By considering the gonad index cycle, the variations of maturity stages and the percentages of undetermined individuals alltogether, it was possible to define more precisely the different phases of the reproductive cycle as described by Boolootian (1966). A close relationship existed between these phases and the surface sea water temperature (Fig. 7). The period of increasing temperatures corresponded to the activation followed by the growing and maturation phases. Spawning occured during the warm period in January-February. Post-spawning or recession took place during the decreasing temperature period and was followed by the resting phase during the cold season.

This cycle, characterized by a warm season spawning is comparable to the cycle encountered in other tropical holothurians of New Caledonia, T. ananas and M. fuscogilva (Conand, 1981), of the Great Barrier Reef in Australia, H. impatiens (Harriot, 1980) and H. leucospilota (Franklin, 1980) and of Florida, H. mexicana and H. floridana (Engstrom, 1980). Other species therefore exhibit different modalities varying from an annual reproductive cycle with a different seasonality as. H. nobilis (Conand, 1981), to a bi-annual reproduction as H. scabra (Krishnawany and Krishnan, 1967), H.atra (Harriot, 1980) and Stichopus chloronotus (Franklin, 1980), or a continuous reproduction as H. edulis (Harriot, 1980). These two latter reproductive patterns seem apparently more frequent in species for which asexual reproduction by fission is important. The increasing attention being shown to the relationship between the reproduction of holothurians and tropical environmental parameters should result in a better understanding of the adaptative significance of reproductive seasonality.

3.4 Size at first sexual maturity

Few data are available on aspidochirote holothurian size at first sexual maturity. Some authors give the size of the smallest mature specimen (Choe, 1963 ; Engstrom, 1980) ; others give the size over which individuals are generally mature (Harriot, 1980 ; Franklin, 1980). The method used here, widely employed in fish population studies, gives a more precise estimate of this parameter and also facilitates inter-species comparisons.

Figure 8 emphasizes the increasing percentage of mature individuals between 20 g and 340 g. DW_{50}, the weight at first maturity is 85 g. Using the relations of the Table 1, the total length and the gutted weight at first maturity are calculated ; TL_{50} equals 120 mm, GW_{50} equals 67 g.

The ratio between the weight at first maturity and the overall mean weight of the population ($DW_{50}/\overline{DW}$) was 0.31. This value is lower than the observed values for other species.

A. echinites is a medium sized holothurian reproducing annually during the warm season, it has a relatively low fecundity and its first sexual maturity occurs at a small size.

4 ACKNOWLEDGEMENT

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