On the biology and fishery of *Aristeus antennatus* (Risso, 1816), (Decapoda, Dendrobranchiata) in the Ibiza Channel (Balearic Islands, Spain)*

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SUMMARY: This study presents data on the biology and fishery of *Aristeus antennatus* in the Ibiza Channel, obtained from monthly samples carried out on commercial catches landed in the port of Santa Pola during 1992, 1993 and 1994. The estimations undertaken from the von Bertalanffy Growth Model (VBGF) parameters gave high K values, indicating that the males would reach 23 mm CL in the first year and the females 29 mm CL, which would represent a maximum life expectancy of three and four years, respectively. The reproduction period, based on the percentages of maturation, fecundity and spawning activity, was defined as starting at the end of the spring and lasting through the summer, with greatest intensity in the months of June to September. The sizes at first maturity (L_{50}) of 18.1 mm for males and 21.9 mm for females, indicated that maturation would have to take place within the first year of life. The total annual landings for the whole zone fluctuated around an average of 76 t per year. The mean catch per unit of effort (CPUE), expressed in kilograms of shrimp by boat and fishing day, was 29.12 kg/boat/day. The values of biomass, yields and mortalities obtained by LCA and VPA showed that the stock was slightly overexploited, although the resource was able to cope with variations in the fishing effort with the yields hardly altering. This demonstrated a high rate of biomass production (Turnover), with the mortality vector having a greater effect on the older age classes, especially in the females. This fact could be due to the whole resource not being equally accessible, since exploitation was based on the largest sizes, in which the females predominated.

Key words: Biology, Fisheries, *Aristeus antennatus*, Mediterranean Sea.

INTRODUCTION

The pink shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms of the slopes of the continental shelf, more specifically in zones close to submarine canyons. Its distribution area is very wide, since it is found in the Mediterranean and Atlantic south of the Iberian peninsula, reaching as far as the Portuguese coasts (Arrobas and Ribeiro-Cascalho, 1987). These crustaceans are found on the continental and insular slopes, as in the case of the Balearic Islands, at depths that range from 200 m down to bottoms deeper than 2,000 m. (Cartes, 1994; Cartes and Sardá, 1989, 1992, 1993; Sardá and Cartes 1994), although they mainly concentrate on muddy bottoms between depths of 350 and 800 m. It carries out important migrations of both a diurnal and a seasonal character. It not only moves from depths of 200 m during the night to 800 m during the day, but is also able to change its location during the year (Cartes, 1991).

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It is the object of a very specific fishery, due to its great market value, since, although it does not usually contribute more than 5% of the landings by weight, it can amount to 50% of the landings by value in some ports. Consequently, it can be considered as a monospecific fishery, that does not suffer discards due to its high commercial value. In the Spanish Mediterranean littoral zone it is a species exploited fundamentally in the Ibiza Channel, Catalonia, Levante, Murcia and Almería. In the case of the Ibiza Channel, exploitation is undertaken almost exclusively by vessels from the ports of Alicante, Santa Pola and Villajoyosa, that carry out trips of 4 or 5 days duration.

The total annual volume of landings of the port of Alicante is around 5,000 t, of which some 400 t correspond to trawling. The trawling fleet with a base in the port is composed of six boats, although up to 25 boats can sell daily in the fish market, the majority of which are from other ports of the province and principally the fleet that frequents the fishing grounds of Ibiza.

The Santa Pola trawling fleet is very numerous with 82 boats but with an average of 65 boats selling daily, that land 4,000 t/year. Almost all the fishing activity is carried out in the fishing grounds of the Bahia (Cape San Antonio to Cape Palos), alternating with the fishing grounds of Ibiza.

Villajoyosa is a port with a great fishing tradition; its trawling fleet consists of 50 boats, of which more than half land their catch in other ports, such as Alicante, Jávea, Denia and the ports of Andalucía. The composition of the catches is very similar to that of Santa Pola. Of the 20 boats with a base that habitually sell in Villajoyosa, almost half carry out their activity in the fishing grounds of the Ibiza Channel.

Aristeus antennatus has been the object of numerous studies, which have included biological, (Massuti and Daroca, 1978; Arrobas and Ribeiro-Cascalho, 1987; Sardá and Demestre, 1987; Martinez-Baños *et al.*, 1990; Demestre and Martín, 1993; Demestre and Carbonell, 1994) and reproductive and fecundity aspects (Relini Orsi,1980; Orsi-Relini and Semeria, 1983; Arrobas and Ribeiro-Cascalho, 1987; Demestre and Fortuño, 1992). In addition, analyses of its exploitation have been carried in some zones (Demestre and Lleonart, 1993,: Demestre and Martín, 1993; Demestre *et al*, 1994; Martínez-Baños, 1997). However, despite the existence of these studies, it was considered relevant to carry out this study in order to contribute to the current knowledge on its biology and also, due to the fact that the fishing activity is undertaken in a specific area (Ibiza Channel, Figure 1) which allows a high level of precision to be achieved. The study therefore describes the biology, the fishery and its exploitation pattern, by carrying out an analysis of the exploitation state, which consequently contributes to the knowledge on the current fishing activity of this species.

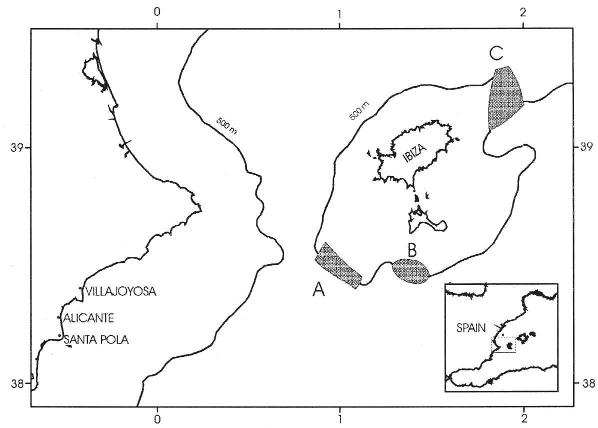


FIG. 1. – Location of the study zone, pointing out the principal fishing grounds in the area (A: El Loco, B: El Clock and C: Tagomago).

MATERIAL AND METHODS

Sampling

The data used in this study comes from samplings of the pink shrimp (*Aristeus antennatus*) carried out on landings in the port of Santa Pola from vessels that operated in the Ibiza Channel. The samplings were undertaken monthly from January 1992 to December 1994, following a random stratified scheme for commercial categories present in the catch.

The individuals were sexed and measured by their cephalothoracic length (CL), which was taken from the posterior part of the left orbit to the centre of the posterior edge of the carapace, to the nearest millimetre, and each commercial category was weighed separately. Each sample was carried out on the catches from two different vessels each month, extrapolating the number of individuals, by commercial category, to the total catch from each vessel and finally to the total monthly catch by commercial categories, thereby obtaining a single size composition by month. In total, 72 sampling operations were

TABLE 1. – Yearly and total number of individuals sampled both in size and in biological samplings during the considered period.

YEAR	SIZES	BIOLOGICAL	TOTAL
1992	2 549	2 725	5 274
1993	2 356	2 542	4 898
1994	3 708	2 967	6 675
Total	8 613	8 234	16 847

carried out from January 1992 to December 1994, which led to a total of 16,847 specimens being measured (Table 1). A total of 8,234 individuals were individually weighed (to the nearest 0.1g) and the index of sexual maturity and the presence of spermatophores in females also was recorded. In the samples carried out during the spring and summer of 1992 the gonad weight of the females, to the nearest 0.001g, was also taken.

Growth

From the compiled data, the parameters of the size-weight relationship were determined, with cephalothoracic length (CL)-total weight (W) being adjusted to a potential relationship in the form: $W = a * CL^b$, where W is the weight in grams, CL is the cephalothoracic length in millimetres, a and b are parameters that need to be estimated, with b being the coefficient of allometry.

For the study of the size-age relationship, the Von Bertalanffy growth model (VBGF) was used with the expression: $L_t = L_\infty (1 - e^{-k (t-t0)})$, where L_∞ is the maximum theoretical size, L_t is the size at age t, K is the growth factor and t_0 is the age at which the size is 0. For the estimation of these parameters, the FISAT programme (Gayanilo *et al.*, 1994) was applied to monthly size distributions grouped in size classes of 2 mm, with a running mean of three consecutive classes, taking the "best combination" (Rn) of the parameters (FISAT programme, ELEFAN subprogramme), for each year separately and for the monthly size distributions of the whole period (1992-1994). This was followed by breaking down the frequency histograms into normal components by the Bhattacharya method (FISAT programme), for the size histograms from the same data. These estimations were carried out for males and females separately, adjusting the value of t_0 to the first component identified.

Reproduction

Maturity in females was determined by macroscopic observation, adopting a scale of five maturity stages, modified from Relini-Orsi and Relini (1979) that only recognised the first four of the following: A-virgin, B-developing, C-prespawning, D-spawning and E-resting. Male maturity was determined macroscopically as a function of the shortening of the rostrum (Sardá and Demestre, 1989; Sardá and Cartes, 1997) and the presence or not of petasma fusion (Demestre and Fortuño, 1992), despite the fact that the concurrence of both conditions does not necessarily mean the start of the reproductive status. The sexual ratios were calculated by size class, and the ratio of females in the total number of individuals (Prop. Sex = Nº♀/ [Nº♂ + Nº♀], by carrying out a G test of significance (Sokal and Rohlf, 1969) in order to evaluate the predominance of each sex in each size range.

The percentages of the individuals spawning, active and at rest were determined from the monthly maturity states. These were spawning = stage D, active = stages B+C and at rest = stages A+E. The gonadosomatic index (GSI) was calculated for the various maturity states of the females, with the expression GSI = (GW/TW)*100, where GW is the weight of the gonad and TW the total weight of the individual. Finally, the percentages of maturity by size for each sex were calculated, in order to determine the 50% size at first maturity, which is the size at which 50% of the individuals have reached maturity during the spawning period. This was achieved by carrying out two adjustments of the data, one by a typical sigmoid symmetrical curve (logistic model; $p = 100/(1+exp-(a(t)+b(t)*L))$ and another of an asymmetrical curve (Gompertz model; $p = p_0(t)*exp(G(t)*(1-exp(-g(t)*Ln)$, where p is the percentage of mature individuals by size class (L), comparing the results.

Fishery

In order to obtain an overview of the development of the catches landed in recent decades, data collection from the annual landings of *Aristeus antennatus* was undertaken in the ports of Alicante, Santa Pola and Villajoyosa, thus compiling a historic record of the yearly shrimp catches landed from 1976 to 1994. The data for this section came from the annual returns of the Santa Pola Fishermen's Association. Another of the objectives was to determine the variation in the shrimp landings throughout the year, in order to detect the existence of a seasonal pattern in the catches. For this, the monthly landing data of shrimps in the port of Santa Pola during 1992, 1993 and 1994 was compiled by the Information and Sampling Network of the Instituto Español de Oceanografía.

A series of analyses based on the sampling data was performed to study the exploitation state of the resource. Firstly, the monthly size distributions by sexes were grouped into 2 mm size classes, undertaking a running mean on three consecutive classes, in order to obtain an annual frequency. These annual frequencies were averaged for the three years of sampling and led to the influence of the various annual recruitments being smoothed, which gave a unique distribution of sizes.

The growth and size-weight relationship parameters used were those calculated in this work. The natural mortalities (M) were calculated as a function of the growth parameters, from the formulae of Pauly (Pauly, 1980) and Djabali (Djabali *et al*, 1994), both on the CL values obtained in mm and by transforming CL to the total length in cm, according to the relationship proposed by Arrobas and Ribeiro-Cascalho (1987), since we considered this transformation had greater biological significance. The peaks of maturity were those calculated in this study, with the terminal mortality from fishing fixed at 1.5 after various tests with other values. Since actual catch data were used, the average annual catch for the species in the period 1992-1994 was taken together from the ports of Alicante, Santa Pola and Villajoyosa. For the single annual distribution of size frequencies mentioned above, a series of Size Cohort (LCA) and Virtual Population (VPA) analyses were carried out according to the catch equation for a pseudocohort and yield per recruit (Y/R). This was performed through the application of the VIT fisheries analysis programme (Lleonart and Salat, 1992), in order to obtain an understanding of the actual exploitation state of the pink shrimp stock in the Ibiza Channel.

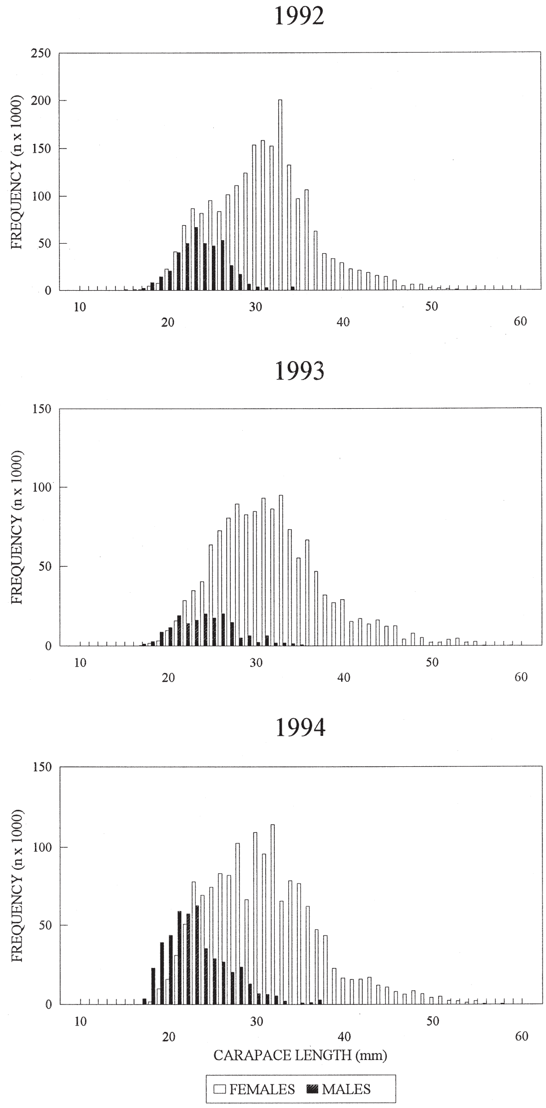
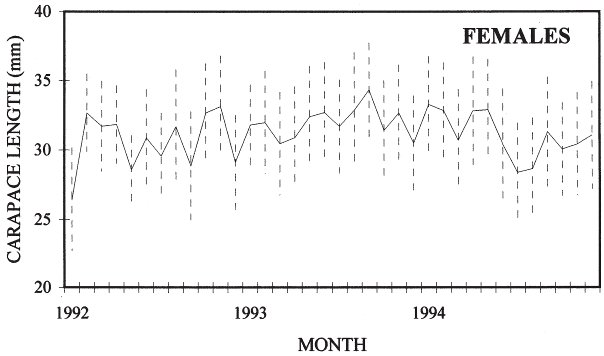


FIG. 2. – Composition (percentage contribution by size class and sex) for the shrimp landings in the port of Santa Pola during 1992, 1993 and 1994.

RESULTS

Size composition

The sizes of the females in the catches varied from a minimum of 15 mm to a maximum of 59 mm CL, with a mean size in the sampling period of 31.21 mm CL. The males varied from a minimum of 15 mm to a maximum of 37 mm CL, with an average of 24.05 mm CL. Figure 2 shows the contributions by size class and sex of the landings in the port of Santa Pola, for 1992, 1993 and 1994 respectively. The males represented 17% of the total number, with the remaining 83% corresponding to the females. The development of the mean monthly size during the sampling period for the males (Fig 3A) and the females (Fig 3B), showed (with greater clarity in the males) that the mean CL decreased progressively from spring until the start of summer (from March to June) with a minimum in July-August, but increased during the autumn and reached the maximum value towards January.



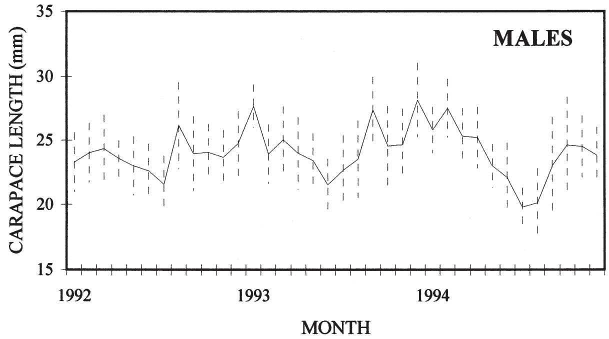


FIG. 3. – Monthly variation of the mean sizes and standard deviation for males and females of *Aristeus antennatus* from landings in the port of Santa Pola during 1992, 1993 and 1994.

Growth

The results obtained for the different size-weight relationships of *Aristeus antennatus* carried out in this study on the different groups (males, females and the total) are shown in Table 2. Essentially, they gave values of less than 3 for the allometric coefficients. However, they were significantly different from this value, which showed a negative allometry between the considered parameters.

The different estimations for the Von Bertalanffy growth parameters obtained by the application of the FISAT statistical package (subprogramme ELEFAN), shown in Table 3, gave high growth rate values (K).

TABLE 2. – Parameters of relative growth (size-weight relationship: Weight = a * Size ^{b}) calculated for males and females of *Aristeus antennatus*. Level of significance ***= p<0.001, **= p<0.01, *= p<0.05 and NS= p<0.1 in the Student "t" test.

Group	a	b	err.b	signif.	r2	n
males	0.003156	2.4023	0.017274	***	0.90	2 060
females	0.002425	2.4836	0.005847	***	0.97	5 955
total	0.002526	2.4720	0.004756	***	0.97	8 015

TABLE 3. – Results of the growth parameters (size-age relationship) for the VBGF model obtained using the FISAT (ELEFAN) programme, for males and females of *Aristeus antennatus*, with t_0 being adjusted for a CL_D of 23.05 mm in males and 29.18 mm in females.

Year	Group	L_∞	K	t_0	Rn
1992	males	54	0.330	-0.687	0.378
	females	75	0.398	-0.238	0.203
1993	males	55	0.380	-0.430	0.315
	females	76	0.430	-0.127	0.222
1994	males	58	0.400	-0.266	0.435
	females	77	0.403	-0.182	0.186
92-94	males	55	0.380	-0.430	0.272
	females	73	0.363	-0.406	0.146

Reproduction

The sexual ratio by size class (Fig. 4) showed that, after an initial stage between 15 and 21 mm, the males predominated significantly only at 19 mm. The females started to dominate above 22 mm and were significant from 23 mm throughout the whole range of sizes. The sexual ratio for the whole period of the study was dominated by the females (S_R = 0.80).

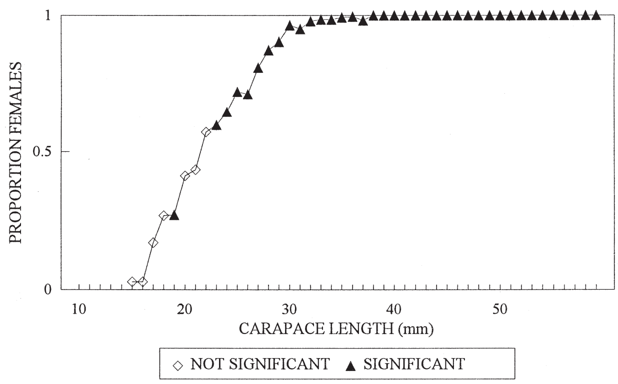


FIG. 4. – Representation of the sexual ratios (proportion of females) by size from shrimps from Santa Pola, showing the significance of the dominance by sex in each size range.

The percentages of maturity (immature-mature) for the males (Fig. 5), showed a high ratio of mature individuals throughout the year, decreasing the immature ratios from March to June and increasing from September to November, coinciding with the observations of Sardá and Demestre (1989). In the case of the females (Fig. 6), the ratios of fertilized females (that showed spermatophora) started to

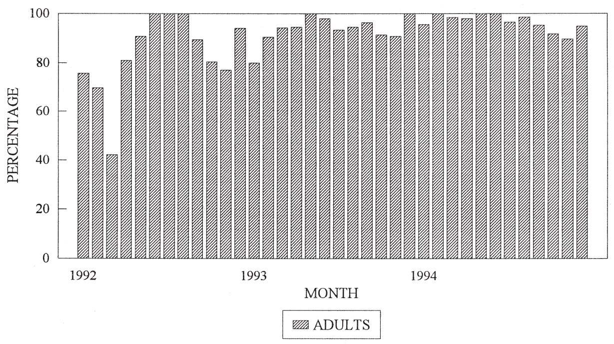


FIG. 5. – Monthly evolution of the percentages of mature males of *Aristeus antennatus*.

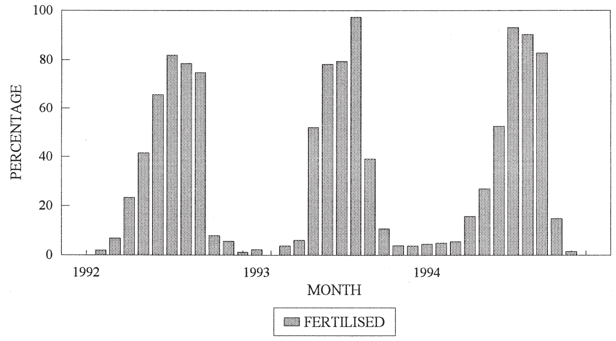


FIG. 6. – Monthly evolution of the percentages of mated (with spermatophora) females of *Aristeus antennatus*.

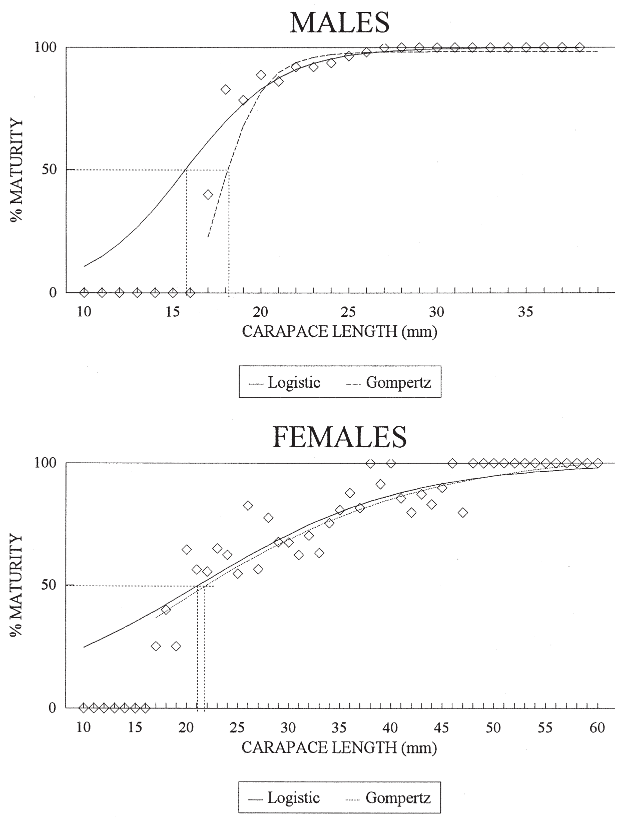


FIG. 8. – Curves of sexual maturity (Logistic and Gompertz models) for *Aristeus antennatus*. Males have the 50% size at first maturity at 15.9 and 18.1 mm respectively, whereas for females they are 21.1 and 21.9 mm of carapace length.

increase in spring, reached the maximum during the summer (July-September) and decreased in the autumn. The spawning period was clearly shown by the percentages of spawning, active or inactive females throughout the period studied. This occurred between the months of May to October, but was especially intense in July and August (Fig. 7).

The percentages of maturity by size class, for determination of the 50% size at first maturity, showed different, although very similar, results according to the method of adjustment used. These were 15.9 mm for males and 21.1 mm for females according to the logistic model and 18.1 mm for males and 21.9 mm for females according to the Gompertz model (Fig. 8). The mean values for the gonadosomatic indices (GSI) calculated for each maturity state for the females were A= 0.005187; B= 0.039822; C= 0.042696; D= 0.0530576 and E= 0.007467. Figure 9 shows these mean values, as well as the deviation of the GSI by size class and the maturation state for *Aristeus antennatus* females.

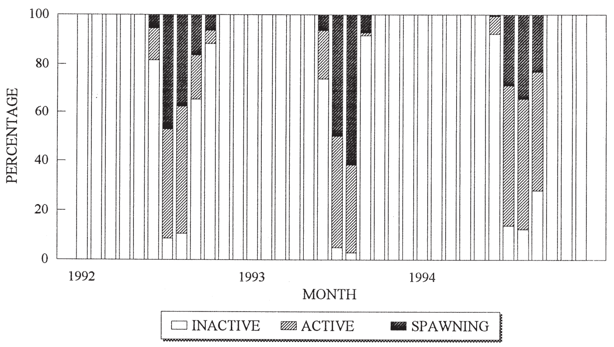


FIG. 7. – Monthly evolution of the percentages of individuals in the different maturity stages (at rest(A+E), active (B+C) and spawning (D)) for females of *Aristeus antennatus*.

Catches

A total of 50 vessels had fishing activities directed towards the pink shrimp in the Ibiza Channel fishing ground during 1993. They carried out their sales in the ports of Alicante, Villajoyosa and Santa Pola, although, in addition, they also had their base in various other ports of the zone (Altea, Jávea, Calpe, Denia...).

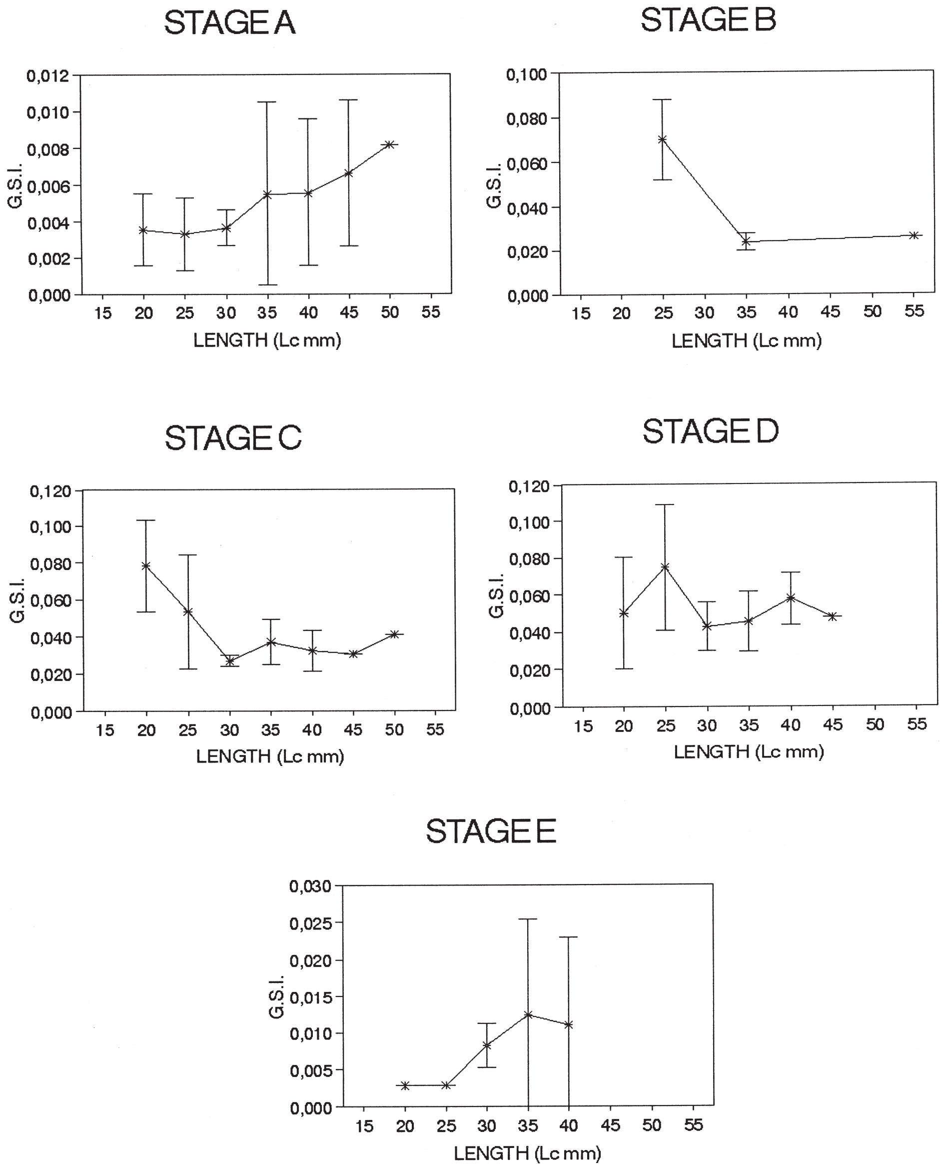


FIG. 9. – Values of the gonadosomatic index (GSI) based on the maturity state and the size of the *Aristeus antennatus* females.

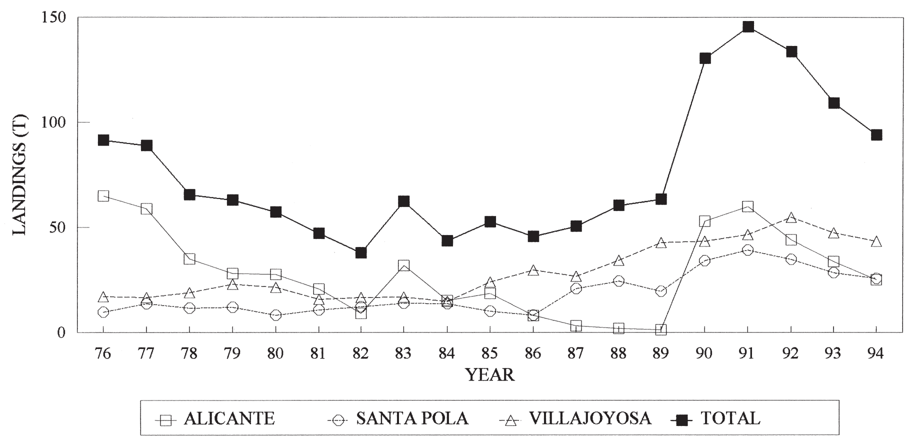


FIG. 10. – Historical series of annual landings for *Aristeus antennatus* in the ports of Alicante, Villajoyosa and Santa Pola between 1976 and 1994. Data from the Fishermen's Associations.

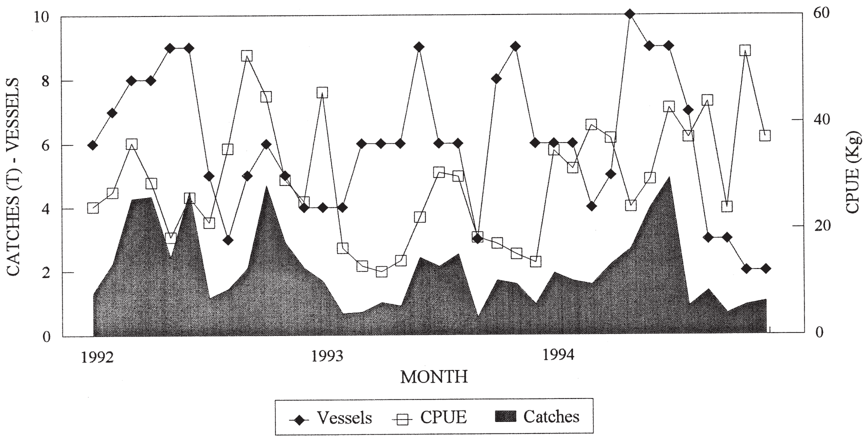


FIG. 11. – Monthly landings of *Aristeus antennatus* in the port of Santa Pola during 1992-1994. Data from RIM-IEO for the trawl fleet.

As shown in Figure 10, the total annual landings for the historic series from these ports considered together fluctuated around an annual average of 76 t until 1989, although it started to decline in 1992. The maximum volume of landings was reached in 1991 with 145 t, and the minimum in 1982 with 38 t. The catches by port showed a good relationship between Santa Pola and Villajoyosa, which increased slightly until 1992, when both reached their maxima (35 t in Santa Pola and 55 t in Villajoyosa), before decreasing slightly after this year.

The minimum landings were reached in 1980 (8 t in Santa Pola) and in 1984 (15 t in Villajoyosa), with an average of 18.5 t and 29.2 t respectively. The pink shrimp landings in the port of Alicante showed a very irregular pattern that had a minimum of 1.1 t in 1989, but which increased in subsequent years. Nevertheless, the maximum value of 65 t was in 1976 and the average was 28.4 t. These fluctuations were attributed to the fact that, for several years, the landings of pink shrimp were considered together with other commercial categories.

The monthly values for the development of the shrimp landings compiled during the 1992-1994 period for the Santa Pola trawling fleet (Fig. 11) showed large fluctuations, but did not indicate any seasonality in the landings. The mean monthly catch was 2.06 t, whereas the catch by unit of effort (CPUE) was 29.12 kg/boat/day, based on the data compiled throughout the period considered. However, the relationships between catches and CPUE are not particularly good, mainly due to the monthly variations of the total number of boats that operated in the area.

TABLE 4- Results of the natural mortality rate (M) calculated for males and females as a function of distinct values of L_∞, according to two different authors and methodologies.

	CL (mm)		Lt (cm)	
Author	males	females	males	females
Pauly (1980)	0.56	0.54	0.79	0.78
Djabali *et al.*, (1994)	0.41	0.40	0.47	0.47

TABLE 5. – Results of the VPA for males and females of *Aristeus antennatus* for values of M (¬& ,%) = 0.47; F= 1.5).

	males	females
Mean no. of individuals (n*1000)	2326.3	4535.2
Mean annual biomass (MT)	10.5	35.4
SSB (gr/recruit)	1.9	2.9
Recruitment (n*1000)	272.9	289.4
Mean age (years)	0.78	0.62
Critical age (year)	0.76	0.68
Mean size (cm)	20.1	24.4
Critical size (cm)	20.0	26.0
Virgin biomass (Mt)	51.3	270.5
Balance biomass (D)	23.9	73.7
INPUTS		
Recruitment (%)	36.8	18.8
Growth (%)	63.2	81.2
OUTPUTS		
Natural mortality (%)	20.5	22.6
Biomass caught (%)	79.5	77.4
Renovation rate (Turnover)	228.9	207.9

Exploitation scheme

As this study progressed it was considered interesting to carry out an analysis of the degree of exploitation of the resource, although due to certain limitations in the design of the study itself, related to the geographical scale and the season chosen, the results should be considered as approximations. The natural mortality rate was calculated, both for the CL in mm and for its transformation into Lt in cm, according to Pauly (Pauly, 1980) and Djabali (Djabali *et al.*, 1994) (Table 4), and it varied from 0.40 to 0.78 for females and from 0.41 to 0.79 in males. The Pauly model gave a result that was more sensitive to the variations of L_∞ than that of Djabali, therefore it was decided to use the values obtained according to this last author, transformed to the total length in cm, since it was considered that these values corresponded better to the biology of the species. The results of the Length Cohort Analysis (LCA) for both options are shown in Table 5.

The mean age, both for males and females, was very similar to the critical age, although it was slightly higher for the males. In the case of the sizes we found the same situation, with the mean size slightly below the critical in the females, which can be interpreted as the exploitation pattern being close to the optimum. In the case of the sizes we found the same situation, with the mean size close to the critical in both sexes. The percentage biomass caught by fishing was 79.5% and 77.4%, compared to a range of natural mortality between 20.5% and 22.6%, for males and females, respectively. All the results obtained showed a difference between sexes, with the biomass of the females being much greater than that of the males.

In Table 6 the data for yield by recruit (Y/R) is shown, both for the level of actual effort and the optimum for males and females. The graph of yield by recruit for each sex is shown in Figure 12. There was a greater yield for the females, which was almost double compared to the males, and this was close to the maximum sustainable yield (MSY), especially so in the case of the males. Although the females had a value of 0.4, despite the slope of the curve being very smooth in both cases, similar yields were maintained with large variations of the effort, and they showed an exploitation rate greater than in the case of the males.

Table 7 shows the incidence of the mortality by

TABLE 6. – Results of the Yield by Recruit analysis (Y/R) for the different groups (males, females and total population) of *Aristeus antennatus* for the actual level of exploitation. (M (♀ ,♂) = 0.47; F= 1.5).

Group	Y/R	MSY	F(opt)
Males	4.56 g	4.69 g	0.70
Females	8.33 g	9.72 g	0.40

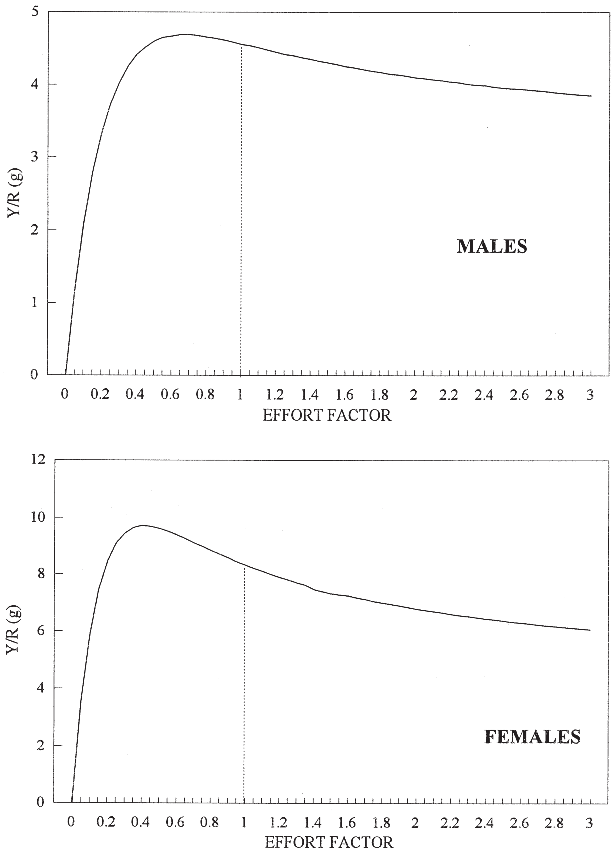


FIG. 12. – Curve of Yield by Recruit (Y/R) as a function of the fishing effort, for (M = 0.47; F= 1.5) males and females of *Aristeus antennatus*; actual value of F. = 1.

fishing (F) and the initial number of each age class and of each sex from the Virtual Population Analysis (VPA). A maximum of three age classes were observed for males and four for females, with the fishing pressure centred on age class 2 in males and 2 and 3 in females, whereas age classes 0 maintained low levels of exploitation, that were more pronounced in the females. The effect of the mortality vector by fishing on the individuals by size classes is shown in Figure 13. It was observed that the

TABLE 7. – Results of the VPA, demonstrating the incidence of the fishing mortality (F) and the initial number, for each age class and sex of *Aristeus antennatus*.

	AGE	F	Nº (x 1 000)
♀	1	0.540	4646.5
	2	3.383	1692.8
	3	1.500	35.9
♂	1	0.765	6893.3
	2	2.437	2003.6
	3	2.441	109.5
	4	1.500	5.9

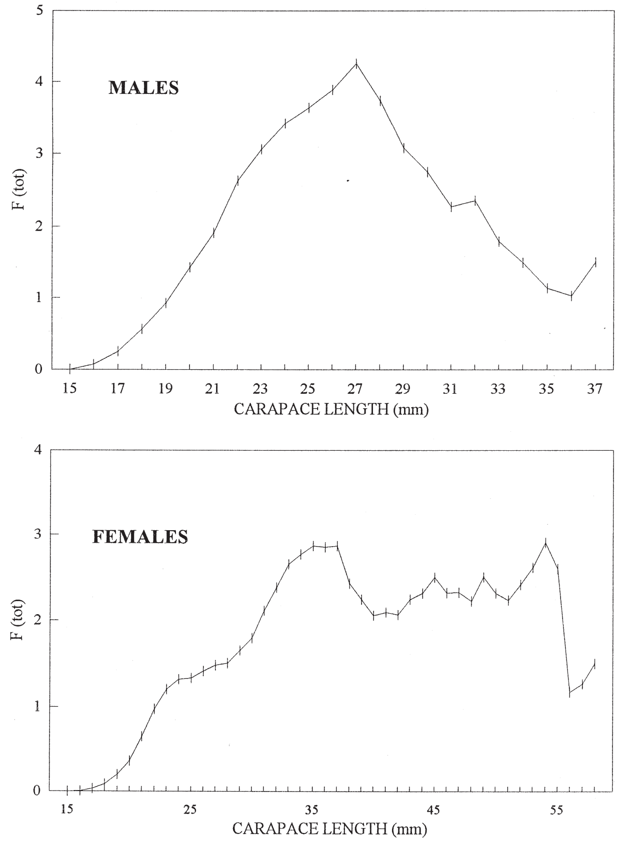


FIG. 13. – Vector of fishing mortality for each size class (M = 0.47; F= 1.5) for males and females of *Aristeus antennatus*.

mortality vector acted with greater intensity on the 23-30 mm size classes in males and from 33 mm in females .

DISCUSSION

The sizes of the catches, resulting in lower values for the males in all cases, show very similar ranges to those found in other studies (Demestre and Martín, 1993; Martinez-Baños *et al.*, 1990), which further indicates the size dimorphism of the species. The decreases observed in the monthly evolution of the average sizes could be attributed to the incorporation of a larger number of small sized individuals to the fishery, from March to June and with a greater intensity in July-August, perhaps related to the start of reproduction. This is the contrary to that observed by Tobar and Sardá (1987) who reported this decrease of average sizes from September to March. This phenomenon has also been pointed out by Arrobas and Ribeiro-Cascalho (1987) but for southern Portugal in September-December.

The parameters of the size-weight relationship estimated in this study are similar to those calculated by other authors (Arrobas and Ribeiro-Cascalho, 1987; Martinez-Baños *et al.*, 1990), since the values of the allometry coefficient b were lower than 3, mainly in the males. This indicates a negative allometry in the growth of the Mediterranean pink shrimp throughout its development, which results in the females being slightly bigger than the males.

With respect to the estimations carried out for the VBGF parameters, although the L_∞ values were similar, the values for the growth rate calculated in this study are higher than those presented by other authors (Sardá and Demestre, 1987; Martinez Baños, 1997). However, the modes related to age classes were similar to those proposed by Sardá and Demestre (1987), suggesting that the males would reach 23 mm CL in the first year and the females 29 mm CL, which could represent a life expectancy of three or four years for males and females respectively.

The reproduction period was defined based on the maturity percentages, and on the fecundity and spawning activity. They show that spawning clearly occurred at the end of the spring and summer, with the greatest intensity in the months of June to September, which is similar to that pointed out by other studies (Arrobas and Ribeiro-Cascalho, 1987; Martinez-Baños, *et al.*, 1990; Demestre and Martín, 1993). The decrease of the male immature ratios from March to June and the increase from September to November, coincides with the observations of Sardá and Demestre (1989), and we can conclude that maturation in males take place in Spring, whereas recruitment takes place in Autumn, but in a number that does not affect the mean sizes. The sizes at first maturity (L_{50}) of 18.1 mm for males and 21.9 mm for females (Gompertz model) differ slightly, being smaller from those found in areas close to the Spanish Mediterranean, such as reported by Sardá and Demestre (1987) (L_{50} ♂ = 23-25 mm; ♀ = 27 mm), Demestre and Martín (1993) for Catalonia (L_{50} ♂ = 21 mm; ♀ = 26 mm), and Martinez-Baños *et al.* (1990) for Murcia (L_{50} ♂ = 21-22 mm; ♀ = 27-28 mm). This could be attributed to a greater presence of small sized males, which sampling in this part of the population would intensify, thereby affecting the results. In any case the maturation stage, both for males and females, would have to take place within the first year of life.

The values obtained for biomass and yields showed an exploitation that was slightly towards overexploitation, but not as close to the optimum as has been reported in other studies from nearby areas (Demestre and Lleonart, 1993; Demestre and Martín, 1993; Demestre *et al.*, 1994; Martínez Baños, 1997). However, the resource is able to cope with variations of the fishing effort with the yields hardly altering, demonstrating a high biomass production rate (Turnover), although the mortality vector has a greater effect on the older age classes, especially in the females. This could be due to the fact that not all the resource is equally accessible, with exploitation based on the largest sizes, in which the females predominate, leaving an important part of the population, mainly constituted by males, in deeper areas.

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