SPATIAL DISTRIBUTION OF *LITTORINA NERITOIDES* (L. 1758) (MOLLUSCA, GASTROPODA) IN THE SUPRALITTORAL ZONE IN THE BALEARIC ISLANDS

by

M. Bosch and I. Moreno

Department of Zoology and Marine Biology. Science Faculty.
University of the Balearic Islands. Palma of Majorca. Spain.

Résumé

La distribution spatiale de *Littorina neritoides* est étudiée en fonction de l'éloignemcnt de la mer et des limites supérieures de *Chthamalus stellatus* et *C. depressus*. Le littoral des îles Baléares a été analysé selon des transects en six localités de la zone supralittorale et, sur une plus petite échelle, dans deux cuevettes situées respectivement à 1,5 m et 3 m de la mer. On a constaté que dans les transects côtiers et même dans les cuvettes, la distribution offre un « pattern > similaire et qu'il existe une relation avec la distribution des cirripèdes. Les irrégularités de la surface de la roche, l'humectation due à la houle et les radiations solaires sont des facteurs importants pour la distribution de cette espèce dont l'importance change tout au long du transect.

Parallèlement, on observe une migration des individus au cours de leur vie, de telle manière que les plus âgés se trouvent plus éloignés de la mer et les plus jeunes plus proches.

Introduction

The present paper is a study of the spatial distribution of *Littorina neritoides* in the supralittoral zone, of the position of the specimens according to their age, and of their relationship with the situation of the cirripeds *Chthamalus depressus* and *Chthamalus stellatus* that live with *Littorina neritoides* in the supralittoral zone in the coasts of the Balearic Islands. It has been carried out at the end of June and the beginning of July, when these animals are in a quiescent period. The Littorinidae occupy preferently rock crevices and cracks (Foster, 1966; Chow, 1975), the frequency of which may act as a limiting factor for the development of the *Littorina neritoides* population (Emson and Faller-Fritsh, 1976; Raffaeli and Hugues, 1978) because they need them as shelter from the wave impact and dessication. As Fraen el (1961) states that in the Mediterranean this species passes most of its life through a passive stade out of the water and do not have the ame behaviour near the sea that far from it.

On the other hand some authors (Lebour, 1935; Lysaght, 1941; Patane, 1957; Palant and Fsihelson, 1968 and Daguzan, 1976 a andle

CAHIERS DE BIOLOGIE MARINE
Tome XXVII - 1986 - pp. 53-62.

and 1978) have pointed out that these animals carry out an upshore migration throughout their lives. Thus, the different coastal levels show different sizes of *L. neritoides,* increasing in size upshore. In a previous paper (Bosch and Moreno, 1984) it was stated that the greater longevities occured in the most sheltered localities, while in the more exposed ones the population is younger and shows a faster turnower.

Material and methods

In each of the six studied localities a profile perpendicular to the sea was established, in which, according to the width of the supra-littoral zone, six to nine (Table 1) sample areas were marked. IN:

TABLE I
Features of the localities

samples number	Mal Pas d	<	P. de d	Canonge <	Can d	Picafort <	Son d	Bauló 4	C. Sant d	jordi <	Punts d	den Xinx <
1	1.2	30°	0.7	50°	1.9	5°	1.3	40°	0.3	25°	0.5	30°
2	2	20°	1.5	80°	2.4	3°	1.6	40°	1	15°	1	30°
3	3	20°	3	25°	3.4	2°	1.9	40°	2	10°	1.5	25°
4	4	20°	4	20°	4.4	2°	3	1°	4	10°	2.5	15°
5	6	20°	5.5	20°	5.4	0°	4	4°	6	5°	4	5°
6	8	20°	7	20°	7.4	4°	6.4	5°	9	3°	6	5°
7	10	20°			9	2°	9	10°	20	0°	15	2°
8	14	20°			12	2°	10.5	0°	30	0°	30	9°
9					17	2°	14.5	0°			30	1°

d = distance to sea level
◂ = slope

each sample area the number of individuals of *L. neritoides* present in a row perpendicular to the profile of 10 surfaces of 10 cm X 10 cm was counted, during the months of June and July. The proiles were made in: Can Picaforl (CP), Son Bauló (SB), Colonia de Sant Jordi (CJ), Port des Canonge (PDC) and Mal Pas (MP) in the Island of Majorca and Punta den Xinxó (PX) in the Island of Ibiza (Fig. 1). Small scale profiles in two rock pools: pool number 1 and number 2 at 1.5 and 3 m from the sea, were also carried out at the same time when these animals are carrying a passive life. In order to avoid possible overlapping of the effects of the spray and the solar radiation, and to make sure that both came rom perpendicular directions, two pools of Colonia de Sant Jordi were chosen (Fig. 1). To be able to evaluate the possible direct solar radiation in each pool, two profiles: N-S and E-W were carried out in each pool. Each profile was a band of δ cm wide with separations each centimeter. In the pool number 1, in the direction N-S, 89 recounts were made, and 71 in E-W. In the pool number 2, 52 in the direction N-S and 66 in the E-W, with a total of 278. Table 1 summaries the features of the profile localities, from exposed to sheltered, with expression of the sample areas in each one.

For the study of the size gradient of *L. neritoides* along the coastal profiles a total of 1248 specimens were collected and measured from

the aperture base to the shell apex. The different generations correspond to all the animals born in the year and have been separated by means of the probability paper method of Hazen (1913), whose usefulness in biology was pointed out by Harding (1949) and used for this species by Daguzan (1976 *b).* We call last generation to the most recent one.

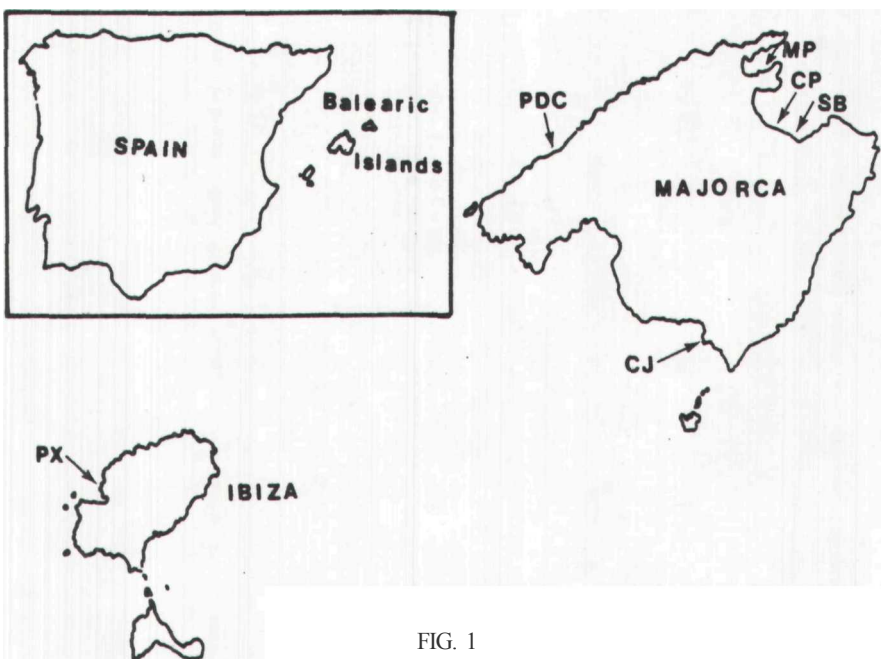

FIG. 1
Situation of the study localities.

RESULTS AND DISCUSSION

Coastal profiles

The figure 2, shows the density of L. *neritoides* in the six localities, in relation with the distance to the sea. In all of them *Littorina neritoides* shows very similar behaviour, with a high density near the sea with a decrease upshore. This descrease is not constant, but two different regions can be observed: the first one nearer the sea with a rapid change (steep slope in the figure) and the second landwards, more attenuated (gentle slope in the figure). Except in Colonia de Sant Jordi the maximum density does not take place in the sample a the very edge of he sea, but very near to it. We think that this is due to the fact that at the edge there are less crevices and cracks. This fact has been already pointed out by some authors (Schneider, 1976) and may ac as a limiting factor for the population of *L. neritoides* (Raffaeli and Hugues, 1978).

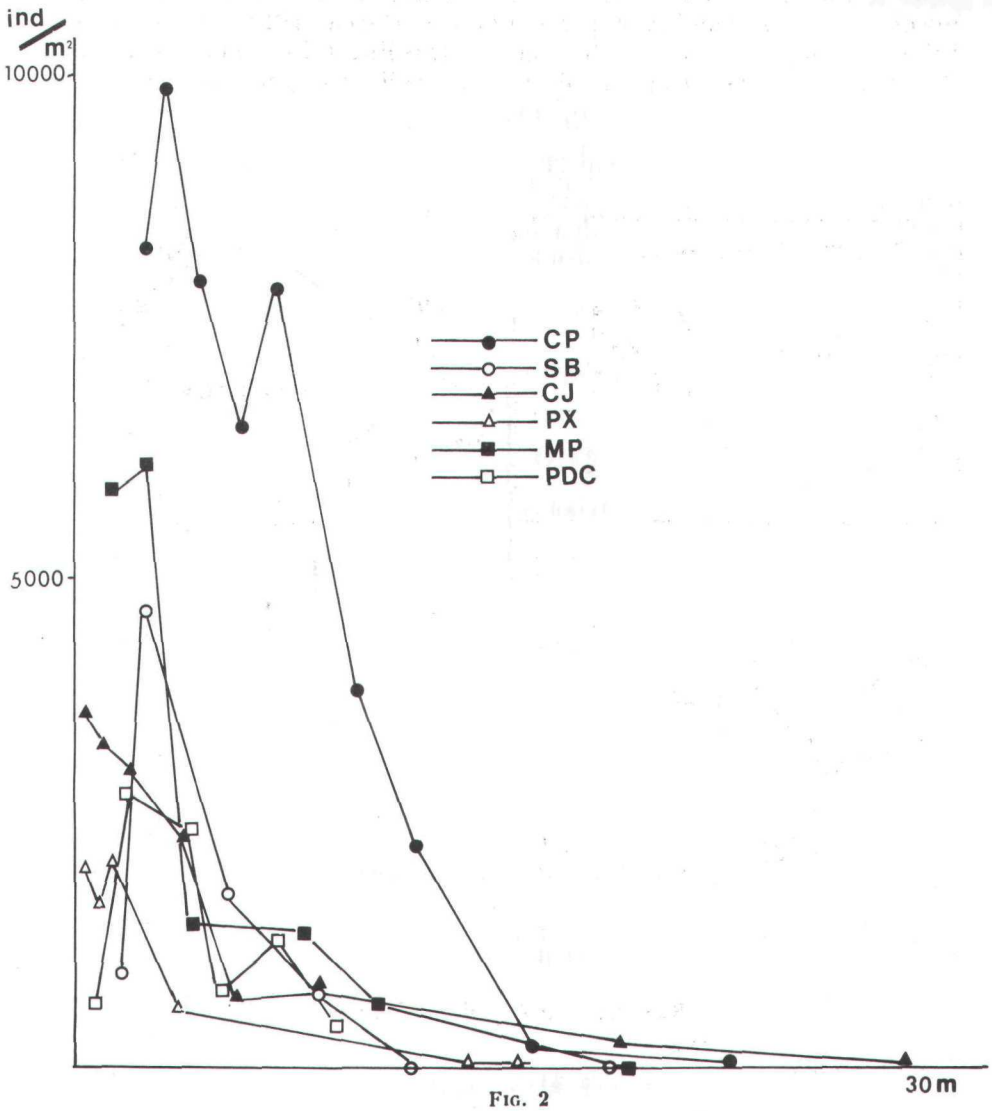

FIG. 2

Density of *L. neritoides* in relation with the distance to the sea in the six studied localities.

In regard to the relations with the uppermost limit of the cirripeds, (Table 2) in the majority of the localities the one of *C. stellatus* is near the maximum density of *L. neritoides,* while the uppermost limit of *C. depressus* is near the point where the density landwards begins to decrease more slowly.

The Table 3 expresses the mean specimen size in each locality, as well as the global mean measurements. As a rule, an increase in size of *L. neritoides* upshore is observed, attenuated in the uppermost areas. Being Mal Pas and Port des Canonge the most exposed of the

studied localities, where the population of *L. neritoides* is younger and with a rapid turnover (Bosch and Moreno, 1985) the attenuation of the attenuation of the size increase is not so evident.

TABLE 2
Uppermost limit in m of *Chthamalus* from the sea level

	C. *stellatus*	C. *depresus*
Ca'n Picafort	3,5	5,7
Colônia S. Jordi	1	5
Punta den Xinxó	3	4,5
Son Bauló	2	3,8
Mal Pas	2	5
Port des Canonge	2,8	6

TABLE 3
Mean size (l) in mm of *L. neritoides* and distance to the sea in the mm (dm) in the six study localities

CP		CJ		PX		SB		MP		PDC	
dm	l	dm	l	dm	l	dm	l	dm	l	dm	l
1,9	3,01	0,3	3,24	0,5	4,24	1,3	3,76	1,2	2,94	0,7	2,91
2,4	3,27	1	3,39	1,5	4,71	1,6	3,73	2	3,40	1,5	2,96
3,4	3,94	2	3,43	1	4,27	1,9	4,11	3	3,57	3	3,35
4,4	3,53	4	4,34	2,5	5,14	3	4,29	4	3,58	4	3,65
5,4	4,35	6	4,53	4	5,91	4	4,95	6	4,05	5,5	3,50
7,4	4,80	9	6,22	6	6,40	6,4	5,36	8	4,31	7	4,04
9	4,96	20	7,69	15	8,76	9	5,40	10	4,89		
12	4,94	30	7,57	20	9,73			14	5,74		

Studying the uppermost limits of the three most recent generations of *L. neritoides* in respect to the situation of both species of *Cthamalus* (Fig. 3) the uppermost limit of C. *sellatus* is a bit more seawards than the youngest generation of *L. neritoides,* although, exept in Punta den Xinxó, the parallelism of both is evident. Therefore we may assume that the limiting factors of the distribution of *C. stellatus* are analogous of the conditions for the distribution of the youngest individuals of *L. neritoides* (0.5 years old aproximately). On the contrary, the uppermost limit of *C. depressus* does not present a so well marked parallelism with the distribution of *L. neritoides.*

Rock pools

The figures 4 and 5 show the homogenous distribution of *L. neritoides* in the bottom and walls of the pool number 1. Due to its proximity to the sea this pool recieves the splash of the little waves and the conditions of all the surface is very similar. On the contrary, in the pool number 2 in the transect E-W (Fig. 6) the animals are distributed around to well defined lateral nuclei. In the level the water can reach, upwards, a great number of them appear. Near the edge of the pool the number of animals decreases again. The difference

between the density of animals in the eastern and western pool walls is very little, so we think that the wave inluence is not directional and, in this case, only the filling of the rock pool is the fasct that controls

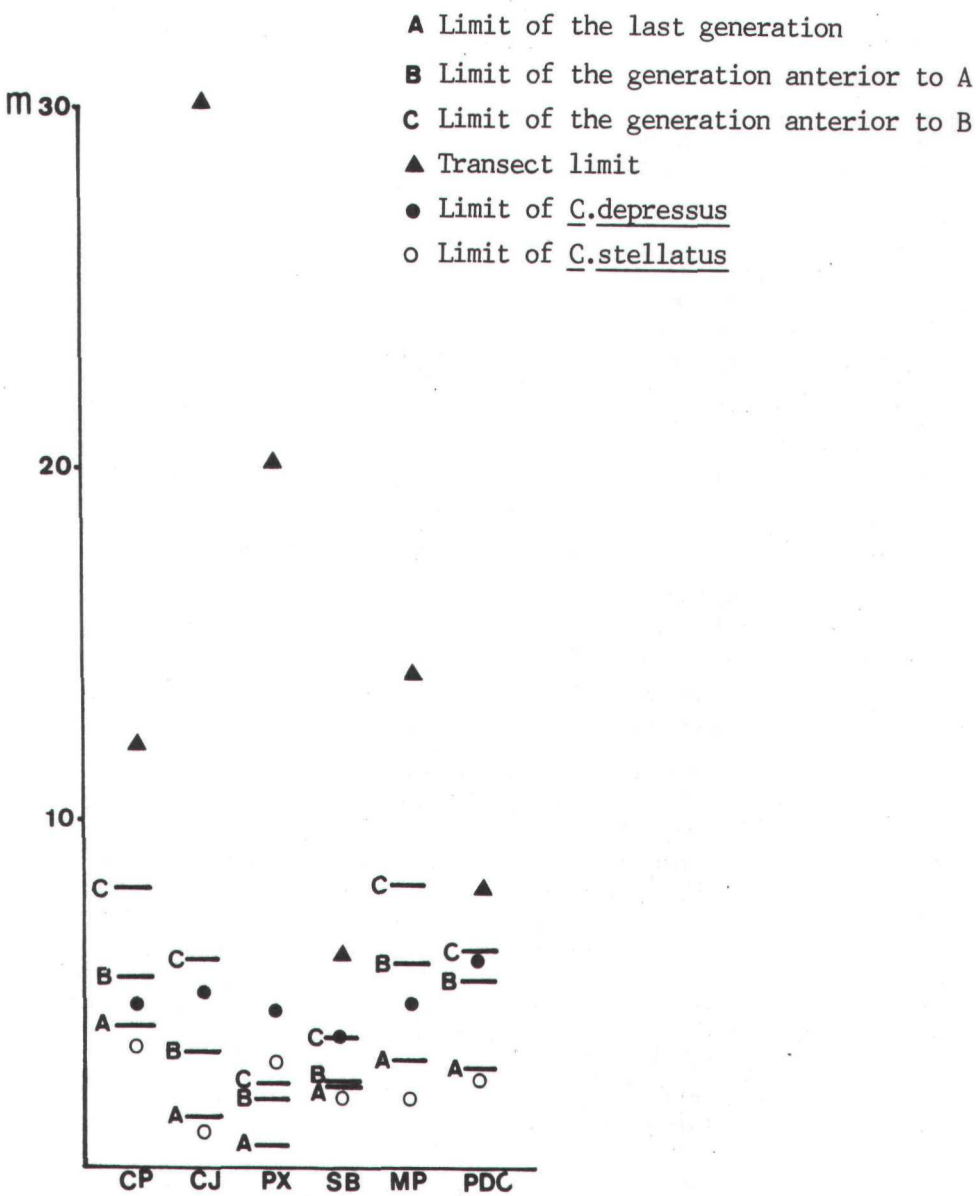

FIG. 3

Uppermost limit of the three last generations of *L. necritoidcs* and *Chthamalus stellatus* and *C. depressus.*

the distribution of *L. neritoides* in it. The transect N-S (Fig. 7) is very different from the former, although in the southern wall there is an

accumulation of individuals similar to the one described in the previous proile, there is not anything of the kind in the northern wall. Here there is only a few specimens tending to group in the margin of

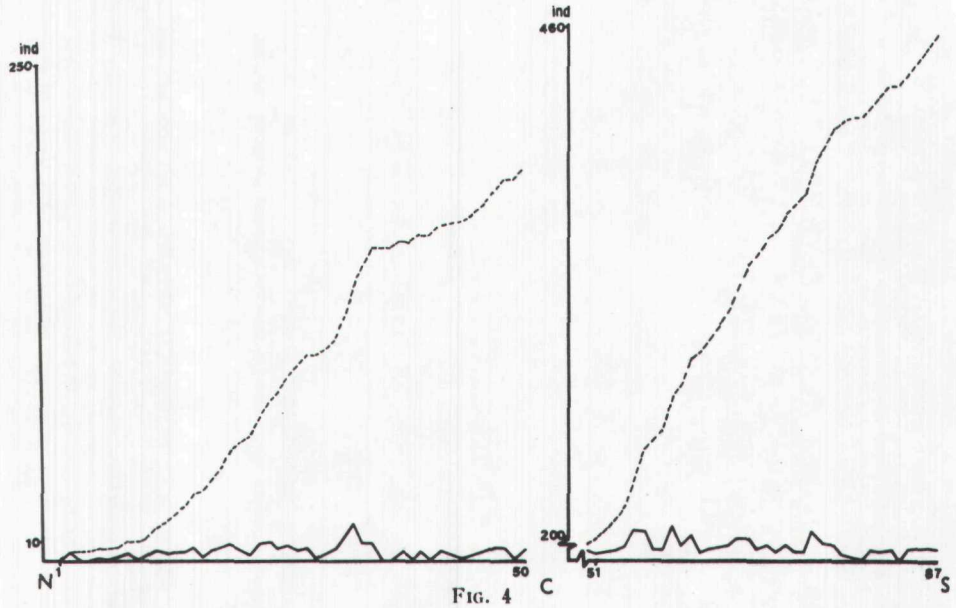

FIG. 4

Absolute and **cumulative** frequencies of specimens of *L. neritoides* in the N-S profile in the pool number 1.

the maximum height of the water within the pool. Consequently a marked directionality of the factors affecting the small scale distribution within the rock pool in the N-S profile can be assumed.

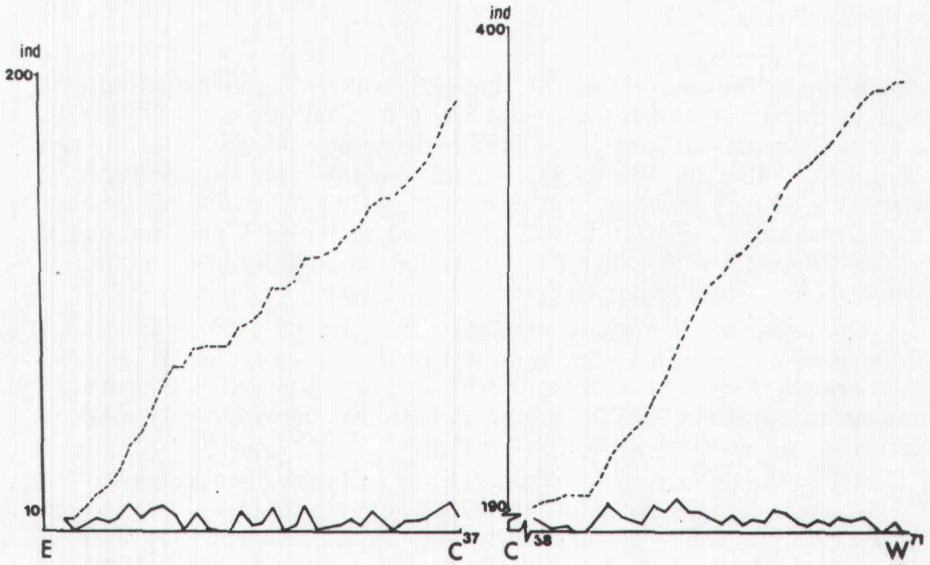

FIG. 5

Absolute and cummulativc frequencies of specimens of *L. neritoides* in the E-W profile in the pool number 1.

Discarding the effect of wave exposure, as in the former case, density control must be atributed to the direct solar radiation. Specially considering that the collecting took place near the autumn equinox.

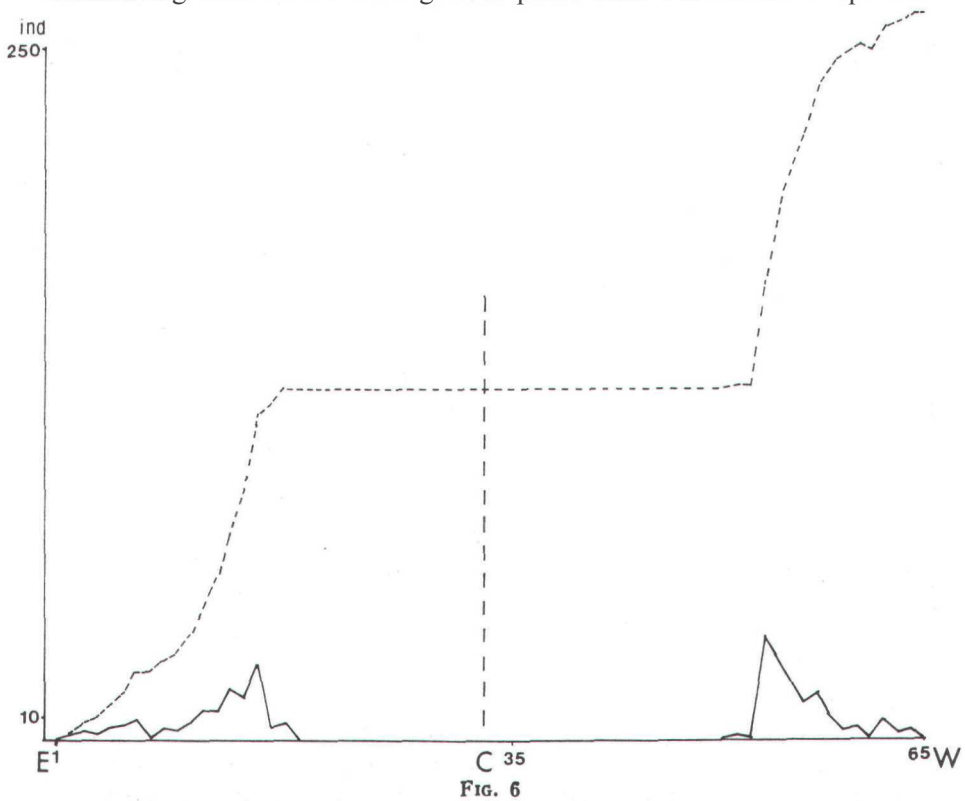

FIG. 6

Absolute and cummulative frequencies of specimens of *L. neritoides* in the E-W profile in the pool number 2.

According to Guijarro (1981) the theoretical direct solar radiation respect to the horizontal for the pool walls in a latiude of 39.5° N with a slope between 60° and 70° would be between 0.68 and 0.60 for the E and W walls, for the northern wall that obviously is facing S, it would be of 0.84 and the southern wall, facing N, would not recieve any direct solar radiation but *L. neritoides* in the rock pool number 2 is conditioned by the direct solar radiation and by the maximum height of the water inside the pool.

Summarizing, it may be concluded that the global distribution of *L. neritoides* presents a maximum not in the very edge of the sea but very near it. From this point two decreases are observed, one seawards and another upshore which, in turn, two parts : one with a very marked decrease and another with a gentle slope.

Thus, the pattern of *L. neritoides* can be understood as controlled *by* two basic factors according to the distance to he sea. In the areas nearer the sea (not the very edge, that as we have already seen it depends on the rock surface) the control seems to be carried out by the wave impact and the splash, while in the latter areas it seems to be controlled by the negative tropism to the direct solar radiation

of the animal itself. The more homogenous distribution near the sea and the more heteregenous far from it, can be explained saying that in the first case the animals recieve enough splash but in the second group only receive splash in rare occasions and the animals distribute according to the rock crevices and cracks as in the very edge, but in order to protect themselves from dessication and heat and not from wave impact as in the edge.

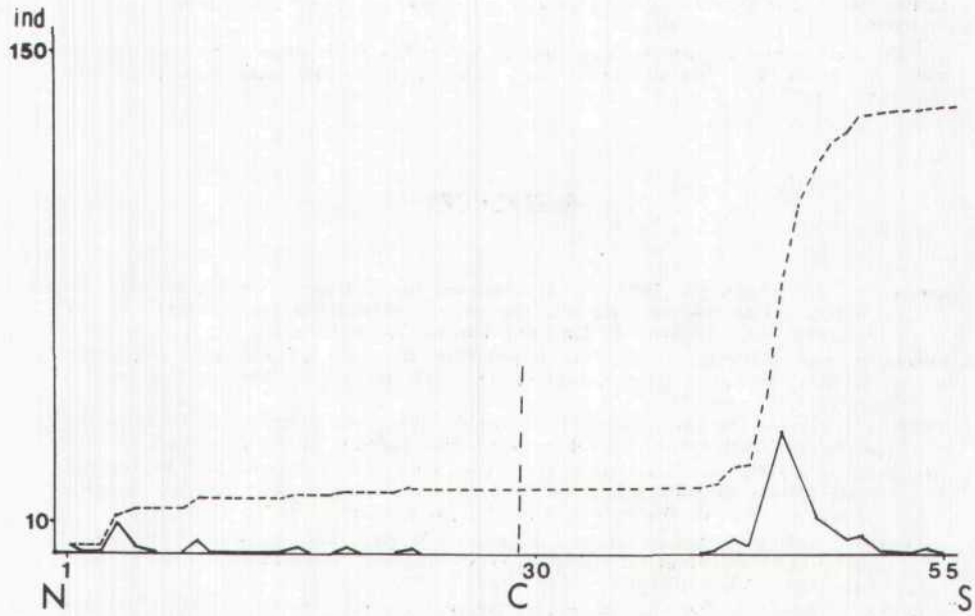

FIG. 7

Absolute and cummulative frequencies of specimens of *L. neritoides* in the N-S profile in the pool.

Parallel to this density gradient a progressive size increase of the specimens upshore is observed. This size/age gradient is the consequence of the tendency, already mentioned, of this species to migrate upshore as it grows. The total animal length is allometric with respect to the aperture size (Bosch and Moreno, 1985) therefore the aperture is proportionally smaller in larger specimens, leading to an increase in resistance to dessication and high temperature but a decrease in the capacity of adhearance to the rock and therefore in resistance to wave action.

Summary

The spatial distribution of *Littorina neritoides* in relation to the distance to the sea and to the upper limit of *Chthamalus stellatus* and *C. depressus* has been studied in six transects in six different stations of the Balearic, supralittoral zone and in two rock pools 1.5 and 3 m from the sea. In the transects, as well as in the pools, the distribution has a very similar pattern and there is a relationship with the behaviour of the cirripeds. The rock surface, the humectation and the direct radiation are important factors affecting the distribution of *L. neritoides* but their importante is not the same in the whole transect.

A migration upshore of the animals through their life is also observed, being the elder ones farer from the sea than the younger ones.

Resumen

Se ha estudiado la distribución espacial de *L. neritoides* en relación con la distancia al mar y con los limites superiores de *Chthamalus stellatus* y *C. depressas* en sés transectos de la zona supralitoral de otras tantas estaciones del litoral Balear y, a menor escala, dentro de dos cubetas situadas a 1,5 y 3 m del mar respectivamente. Se ha observado que tanto cn los transectos costeros como en las cuhctas la distribución ofrece un « pattern » similar y que hay una rclación con Ia distribución de los cirripcclos. Las irrcgularidades de la superficie de la roca, la humcctaclón recibida por efecto del oleaje y la radiación solar, son factores importantes en la distribución de esta espécie, variando su importância a lo largo del transecto.

Paralelamente se observa una migración de los indivíduos α lo largo de su vida, de modo que los mayores están más alojados del mar y los jóvenes más próximos.

REFERENCES

BOSCH, M y MORENO, ι., 1984. — Crecimiento de *Littorina neritoides* (L.1758) (Molusco, Oastcrópodo) en rclación con la exposition en Baleares. Act IV Simpósio Hier, do Benthos Marinho. Lisboa. 2, *pp·* 197-207.

BOSCH, M and MORENO, I., 1985. — Population structure of *Littorina neritoides* (L.1758) (Mollusca Gastropoda) in the Balearic Coast. *Marine Ecology* (in press).

CHOW, v., 1975. — The importance of size in the Intertidal distribution of *Liltorina scutulala* (Gastropoda, Prosobranchia), *The Veliger,* 18 (1), *pp.* 69-78.

DAGUZAN, J., 197βα. — Contribution à l'écologie des Littorinidac (Mollusques gastéropodes prosobranches). II *Littorina neritoides* (L) et *Litlorina saxatilis* (Olivi). *Cahiers de Biologie Marine,* 17, *pp.* 213-236.

DAGUZAN, *i.,* 1976 I). — Contribution ii l'étude de la croissance et de la longévité de quelques Littorinidae (Mollusques, Gastéropodes, Prosobranches). *Arch. Zool. Exp. Gen.,* 117, *pp.* 57-80.

DAGUZAN, J., 1978. — Principales caractéristiques biologiques et écophysiologiqucs des Littor nidae Armoricaines (Mollusques, Gastéropodes, Prosobranches). *Haliotis.* 9, *pp.* 55-64.

EMSON, R.H. and FALLER-FRITSCH, R.J., 1976. — An experimental investigation into the effect of crevice on abundance and size-structure in a population of *Littorina rudis* (Maton) : Gastropoda prosobranchia. *J. exp. mar. Biol. Ecol.* 23, pp. 285-297.

FOSTER, H.A., 1966. — The effects of wave exposure and aspect on the vertical shore distribution and population composition of *Melarhaphe olivieri. Tone,* 12, *pp.* 37-44.

FRAENKEL., G., 1961. — Resistance to high temperatures in the Mediterranean snail, *Littorina neriloidex. Ecology,* 42 (3), *pp.* 604-606.

GUIJARRO, J.A., 1981. — Primeras medidas de irradiación solar en Palma de Mallorca. Relación con la isolación. *Bol. Soc. Hist. Nat. Baleares,* 25, *pp.* 31-38.

HARDING, J., 1949. — The use of probability paper for the graphical analysis of polymodal frequency distributions. *J. Mar. Biol. Ass. U.K.,* 28, *pp.* 141-153.

HAZEN, A., 1913 — Storage to be provided in impounding reservoirs for munucipal water supply. *Proc. Amer. Soc. Civil Eng.,* 49, *pp.* 1943-2044.

LEBOUR, M.V., 1935. — The breeding of *Littorina neritoides. J. Mar. Biol. Ass. U.K.,* 20, *pp.* 373-378.

LYSACHT, A.M., 1941. — The biology and trematode parasites of the Gastropod *Littorina neritoides. J. Mar. Biol. Ass. U.K.,* 25, pp. 41-67.

PALANT, B. and FISHELSON, L., 1968. — *Littorina punctata* (Gmelin) and *Littorina neritoides* L. (Mollusca Gastropoda) from Israel : Ecology and anual cycle of genital system. *Isr. Jour. Zool,* 17, *pp.* 145-160.

PANESE, L., 1957. — Cinese e tropismi anidre e anaerobiosi in *Littorina neritoides* L. *Bull. Accad. Ginesia.* 32, *pp.* 65-73.

RAFFABLI, D.G. and HUGUES, R.N., 1978. — The effects of crevice size and availability on populations of *Littorina rudis* and *Littorina neritoides. Jour, of Animal Ecology.* 47, *pp.* 71-83.

SCHNEIDER, 1976. — Biological and Inorganic Factors in the destruction of limestone coasts. *Contr. Sedimento!,* 6, *pp.* 1-112.