Temporal variation of a syllid (Syllidae: Polychaeta) taxocoenosis associated with *Stypocaulon scoparium* (Stypocaulaceae: Phaeophyceae) in the western Mediterranean

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Between May of 2000 and July of 2001 a study aiming to determine the seasonal variation of syllid local population abundances was carried out. Samples were taken every second month and consisted of two replicates, each one being a quadrat 20 cm wide. After fixing, the samples were washed and the draining water was passed through a 1 mm sieve; then the syllids were identified and counted. For each replicate a number of ecological indexes were calculated, namely population density, number of species and Shannon's and Simpson's diversity indexes, computing mean values for each sample. In order to identify the most representative species of the taxocoenosis the Ci (constancy index, frequency of the species ranging from 0 to 1) and Di (dominance index, relative abundance ranging from 0 to 100 considering all the collected individuals) were computed for each one.

Analysis of the eight samples yielded 6548 individuals and 48 species belonging to the four subfamilies of Syllidae, of which Exogoninae and Syllinae were the most abundant and diverse. During the study period, the syllid taxocoenosis suffered dramatic changes. The abundance, that in May of 2000 was 33,375 ±775 individuals/m^2, diminished to 2162.5 ±37.5 in September. After this date, the population density slowly increased. The number of present species evolved in a very similar way. Twelve species occurred in all the samples, although just six were abundant enough to yield Ci×Di products exceeding 5, thus being considered as good descriptors of the taxocoenosis. The variation of population density for most of these species more or less paralleled that of the total population of syllids. With regards to relative abundance, the taxocoenosis was always clearly dominated by Exogoninae species, especially by *Salvatoria vieitezi*, whose dominance scores always fluctuated around 45%. *Syllis prolifera* was the only important non-Exogoninae species in terms of dominance, although this parameter showed strong variation in this species.

INTRODUCTION

The family Syllidae is regarded as one of the major taxa in coastal marine assemblages. Virtually every benthic sample from shallow water, irrespective of the substratum, will contain some kind of these annelids (San Martín, 2003). Syllids represent a wide range of feeding habits, from detritivores to carnivores, and are mainly epifaunal on hard bottoms, although many species (especially within subfamilies Exogoninae and Eusyllinae) are infaunal in soft-bottoms (Çinar, 2003a).

In spite of their abundance, a relatively low number of papers dealt with the ecology of Syllidae in the Mediterranean and most of the available data refer to spatial distribution or are included in more general works devoted to Polychaeta (Çinar, 2003a). Prior to this study, little was known about the temporal population dynamics of syllids (or even of polychaetes in general) on rocky shores of the Mediterranean. A possible explanation is that working with samples from this environment requires time-consuming studies in terms of sorting operations (Giangrande et al., 2003); in addition, most syllids are quite difficult species to identify due to their great abundance and small size (San Martín, 2003). Moreover, the

expertise required for the identification of organisms to the species level is becoming rarer in ecological studies (Boero, 2001). The data reported here contribute to fill this void, although further more detailed long-term studies are needed in order to reach a sufficient knowledge of the temporal changes on syllid populations and the factors governing them in the Mediterranean region.

MATERIALS AND METHODS

The sampling site was located in Cala Malpaso, Almería, at 37°17′N 1°43′W on the south-eastern coast of Spain. The coastline is quite abrupt and the area has experienced a low human influence, so the marine communities are well preserved (personal observation). Samples were taken from the southern side of the beach, which is a little rocky point facing the east. Thus the hydrodynamic condition is moderately exposed, since prevailing winds in the region come from the south-east. Apart from the rocky walls the bottom consists of large outcrops of rock on sandy sediment. Both the outcrops and the walls are covered by a dense algal canopy, which below 2 m depth constitutes a good example of a community

Table 1. *Mean values for density (individuals/m⁻²) of polychaete species by samples.*

	Samples								Gi	Di	Ci×Di
	May 2000	July 2000	September 2000	November 2000	January 2001	March 2001	May 2001	July 2001			
Amblyosyllis madeirensis			12.5±12.5						0.13	0.02	0.00
Amblyosyllis formosa								12.5±12.5	0.13	0.02	0.00
Paraehlersia ferrugina	100.0±25.0	12.5±12.5	25.0±0.0		50.0±25.0	37.5±37.5	25.0±25.0	112.5±87.5	1.00	0.61	0.61
Odontosyllis ctenostoma	287.5±87.5	12.5±12.5	12.5±12.5	12.5±12.5	62.5±12.5	425.0±50.0	612.5±87.5	100.0±25.0	1.00	1.86	1.86
Odontosyllis gibba								37.5±37.5	0.13	0.05	0.01
Odontosyllis fulgurans	12.5±12.5		12.5±12.5	12.5±12.5					0.25	0.03	0.01
Pionosyllis lamelligera	125.0±0.0		12.5±12.5	12.5±12.5	50.0±0.0		25.0±25.0		0.75	0.29	0.22
Pionosyllis pulligera	25.0±25.0		12.5±12.5		62.5±12.5	12.5±12.5	75.0±25.0	662.5±362.5	0.75	1.12	0.84
Syllides edentatus	25.0±25.0								0.13	0.03	0.00
Syllides fulvus			12.5±12.5						0.13	0.02	0.00
Brania arminii	562.5±362.5	25.0±25.0	150.0±100.0	237.5±62.5	550.0±500.0	237.5±137.5	87.5±62.5	25.0±25.0	1.00	2.25	2.25
Brania pusilla		12.5±12.5			37.5±37.5	12.5±12.5			0.38	0.12	0.05
Erinaceusyllis cryptica	587.5±62.5		50.0±25.0	25.0±25.0	50.0±25.0	25.0±25.0	37.5±12.5	112.5±112.5	0.38	1.09	0.95
Exogone acerata	75.0±25.0						25.0±25.0		0.25	0.12	0.03
Exogone dispar	75.0±25.0				37.5±12.5		100.0±100.0		0.38	0.26	0.10
Exogone naidina	2987.5±1187.5	75.0±50.0	37.5±12.5	37.5±37.5	437.5±62.5	100.0±25.0	112.5±62.5	387.5±87.5	1.00	5.11	5.11
Exogone verugera	50.0±0.0	12.5±12.5	37.5±37.5	25.0±25.0	25.0±25.0	212.5±62.5			0.75	0.44	0.33
Parapionosyllis brevicirra	12.5±12.5			25.0±25.0					0.13	0.02	0.00
Parapionosyllis labronica	175.0±150.0		12.5±12.5	25.0±0.0				75.0±50.0	0.50	0.32	0.16
Prosphaerosyllis campoyi	50.0±25.0		12.5±12.5						0.38	0.11	0.04
Prosphaerosyllis xarifae	112.5±37.5				12.5±12.5				0.25	0.15	0.04
Salvatoria clavata	4225.0±600.0	362.5±87.5	162.5±12.5	362.5±12.5	812.5±12.5	925.0±200.0	650.0±0.0	1187.5±612.5	1.00	10.62	10.62
Salvatoria limbata	500.0±150.0	75.0±75.0	12.5±12.5	25.0±25.0	37.5±12.5	125.0±50.0	37.5±12.5	525.0±300.0	1.00	1.64	1.64
Salvatoria vieitezi	12000.0±1900.0	4462.5±387.5	937.5±37..5	1100.0±50.0	3712.5±387.5	3612.5±1212.5	3412.5±737.5	4375.0±825.0	1.00	41.10	41.10
Sphaerosyllis austriaca	1562.5±87.5	437.5±37.5	125.0±25.0	337.5±87.5	475.0±125.0	400.0±200.0	300.0±75.0	687.5±337.5	1.00	5.29	5.29

(Continued)

Table 1. (*Continued*).

	Samples								Ci	Di	Ci×Di
	May 2000	July 2000	September 2000	November 2000	January 2001	March 2001	May 2001	July 2001			
Sphaerosyllis hystrix	3312.5 ±812.5	837.5 ±512.5	87.5 ±12.5	425.0 ±0.0	275.0 ±25.0	300.0 ±75.0	112.5 ±12.5	875.0 ±450	1.00	7.61	7.61
Sphaerosyllis pirifera	375.0 ±100.0	37.5 ±12.5	162.5 ±12.5	262.5 ±162.5	150.0 ±25.0	112.5 ±25.0	137.5 ±62.5	50.0 ±0.0	1.00	1.57	1.57
Sphaerosyllis taylori	1112.5 ±262.5	200.0 ±100.0	25.0 ±25.0		75.0 ±25.0	12.5 ±12.5	62.5 ±12.5	237.5 ±212.5	0.88	2.11	1.85
Sphaerosyllis thomasi	25.0 ±25.0	62.5 ±62.5			12.5 ±12.5				0.38	0.12	0.05
Branchiosyllis exilis	12.5 ±12.5								0.13	0.02	0.00
Eurysyllis tuberculata	62.5 ±37.5	62.5 ±37.5	37.5 ±37.5	37.5 ±12.5	25.0 ±25.0	25.0 ±25.0	12.5 ±12.5	50.0 ±50.0	1.00	0.38	0.38
Haplosyllis spongicola		12.5 ±12.5	25.0 ±25.0						0.25	0.05	0.01
Syllis compacta	12.5 ±12.5		12.5 ±12.5						0.25	0.03	0.01
Syllis columbretensis	25.0 ±25.0	12.5 ±12.5					37.5 ±12.5		0.38	0.09	0.03
Syllis garciai	25.0 ±0.0			12.5 ±12.5					0.25	0.08	0.02
Syllis gerlachi	200.0 ±25.0	50.0 ±50.0		12.5 ±12.5			25.0 ±25.0		0.50	0.34	0.17
Syllis gracilis					12.5 ±12.5	25.0 ±25.0			0.25	0.05	0.01
Syllis hyalina	62.5 ±62.5	112.5 ±37.5							0.25	0.21	0.05
Syllis krohni	62.5 ±62.5	25.0 ±25.0							0.25	0.11	0.03
Syllis pontxioi	12.5 ±12.5								0.13	0.02	0.00
Syllis prolifera	4287.5 ±1862.5	2650.0 ±500.0	175.0 ±125.5	200.0 ±75.0	437.5 ±12.5	575.0 ±225.0	1662.5 ±712.5	1487.5 ±537.5	1.00	14.03	14.03
Syllis variegata	50.0 ±50.0						25.0 ±0.0		0.25	0.09	0.02
Syllis sp.					12.5 ±12.5				0.13	0.02	0.00
Trypanosyllis coeliaca	137.5 ±87.5	12.5 ±12.5	12.5 ±12.5				50.0 ±25.0		0.50	0.26	0.13
Trypanosyllis zebra	12.5 ±12.5	12.5 ±12.5			12.5 ±12.5	25.0 ±0.0	12.5 ±12.5		0.63	0.09	0.06
Xenosyllis scabra	12.5 ±12.5								0.13	0.02	0.00
Myrianida convoluta				12.5 ±12.5					0.13	0.02	0.00
Myrianida edwarsi		12.5 ±12.5						12.5 ±12.5	0.25	0.03	0.01

Ci, constancy index, as frequency ranging from 0 to 1; Di, dominance index (in percentage) considering all the collected individuals and samples; Ci×Di, product of the dominance index by the constancy index.

of photophilic algae in calm water, as described by Meinesz et al. (1983). Most of the community is dominated by areas of *Stypocaulon scoparium* Kützing. In the study area these algae present the characteristic tight, broom shaped fronds, which are quite large throughout the year (maximum length ranging from 15 to 20 cm).

The samples were taken every second month between May of 2000 and July of 2001 and consisted of two replicates, each one being a quadrat 20 cm wide; thus resulted eight samples consisting of 16 replicates. This method was previously used by other authors working on Mediterranean hard bottom communities (Somaschini et al., 1997). Samplings were always performed in the morning between 1000 and 1100 h, and between 3 and 5 m depth. For all the replicates the coverage of *S. scoparium* was 90–100%, the substrate inclination was slight (sub-horizontal) and the substrate orientation was north–north-west. The algae encompassed by the quadrat were introduced in a ZIP lock plastic bag by SCUBA divers. On shore, the whole sample was fixed with formalin in seawater (4%). The algae were washed in the laboratory, and the draining water was passed through a 1 mm sieve (López-Jamar & Mejuto, 1986). The fauna retained in the algae or in the sieve was picked out and preserved in 70% ethanol and the syllids were identified and counted in the laboratory after sorting. The keys and descriptions provided by San Martín (2003) were used for identification and a systematic account; the updatings of generic names and diagnoses proposed by this author and Nygren (2004) have been considered in the present study.

For each replicate, the individuals belonging to each species were established and a number of ecological indexes were calculated, namely population density (as number of individuals/m^2), number of species per sample and Shannon's, based on log 2, and Simpson's indexes for α-diversiy (Krebs, 1989). Mean values were obtained for each sample. In every sample, mean population density in terms of individuals/m^2 was computed for each species. In order to identify the most representative species of the taxocoenosis the Ci (constancy index, frequency of the species ranging from 0 to 1) and Di (dominance index, relative abundance ranging from 0 to 100 considering all the collected individuals) were computed. The product of these indexes yielded the 'order of importance' of the species in the taxocoenosis and more detailed data are given on those species in which Ci×Di was over 5, which can be considered effective descriptors of the taxocoenosis (López de la Rosa et al., 2002). The evolution of population density and relative abundance of these species were dealt with more thoroughly.

RESULTS

Analysis of the eight samples yielded 6548 individuals and 48 species (Table 1) belonging to the four subfamilies of Syllidae. The two most diverse subfamilies were Exogoninae and Syllinae, represented by 19 and 17 species respectively. However, in terms of abundance the former largely went beyond the latter, with 5239 individuals versus 1040. On the contrary, Autolytinae was very poorly represented as just three individuals belonging to two different species were found. Eusyllinae showed discrete values, with 266 individuals belonging to ten species.

During the study period, the syllid taxocoenosis suffered dramatic changes in terms of abundance and, to a lesser extent, of species richness (Figure 1A,B). The abundance, that in May of 2000 was 33,375.0 ±775.0 individuals/m^2, diminished to 9700.0 ±175.0 in July and reached its minimum in September (2162.5 ±37.5). After this date, the population density slowly increased and in January of 2001 reached 7437.5 ±162.5. It remained near this value for the rest of the study period (7300.0 ±1725.0 in March and 7637.5 ±1112.5 in May) in a quite steady fashion, but in the last sample it went to 11,012.5 ±4112.5. The number of species per sample index evolved in a very similar way and after the first sampling (30.0 ±3.0) it clearly diminished to a minimum of 15.5 ±1.5, which in the case of this parameter occurred in November. Species richness differed from abundance in that it increased slightly in the samples of January (20.5 ±1.5) and May (19.5 ±1.5) of 2001 but for the remainder of the samples it stayed quite low.

However, such a trend could not be observed in other indexes that describe the complexity of the system. Shannon's diversity index (Figure 1C) suffered a sudden reduction from May (3.08 ±0.12) to July (2.32 ±0.22) of 2000, but subsequently it rose to a level similar to that at the starting point (2.97 ±0.04 and 2.98 ±0.06 in September and November, respectively). In January it showed again a low value (2.65 ±0.27) and continued around 2.6 until July of 2001, when the value of this index increased a little (2.77 ±0.32). Simpson's index (Figure 1D) showed a similar pattern and after the first reduction (from 0.81 ±0.02 in May to 0.70 ±0.04 in July), values of this index increased and in November even went beyond initial ones (0.83 ±0.01). Then it fell to a value similar to that of July of 2000 (0.71 ±0.06 in January of 2001), and for the rest of the study this index showed a gradual increase (0.76 ±0.06 in July of 2001).

Twelve species occurred in all the samples (Table 1), although just six were abundant enough to yield Ci×Di products exceeding 5, namely *Salvatoria vieitezi* (San Martín, 1984), *Syllis prolifera* Krohn, 1852, *Salvatoria clavata* (Claparède, 1868), *Sphaerosyllis hystrix* Claparède, 1865, *Sphaerosyllis austriaca* Banse, 1959, and *Exogone naidina* Örsted, 1845. The variation of population density for most of these species more or less paralleled that of the total population of syllids, especially in the cases of *Salvatoria vieitezi*, *Sphaerosyllis hystrix* and *S. austriaca* (Figure 2A,D,E). In the latter two species the only differences compared with the general plot were that after the sampling of January of 2001 populations slightly decreased instead of remaining stable and that the increase of population densities between May and July of 2001 were distinctly more abrupt. *Salvatoria clavata* (Figure 2C) and *E. naidina* (Figure 2F) also showed a similar trend, although the very dramatic decline of these two species is noteworthy. Their population densities also reached their minima in September, but values were also extremely low in the sample of July. As for the total taxocoenosis, the population density of *Salvatoria clavata* (which had fallen from 4225.0 ±600.0 individuals/m^2 in May of 2000 to 162.5 ±12.5 in September) slowly increased after this sampling, but never reached the figures of the first
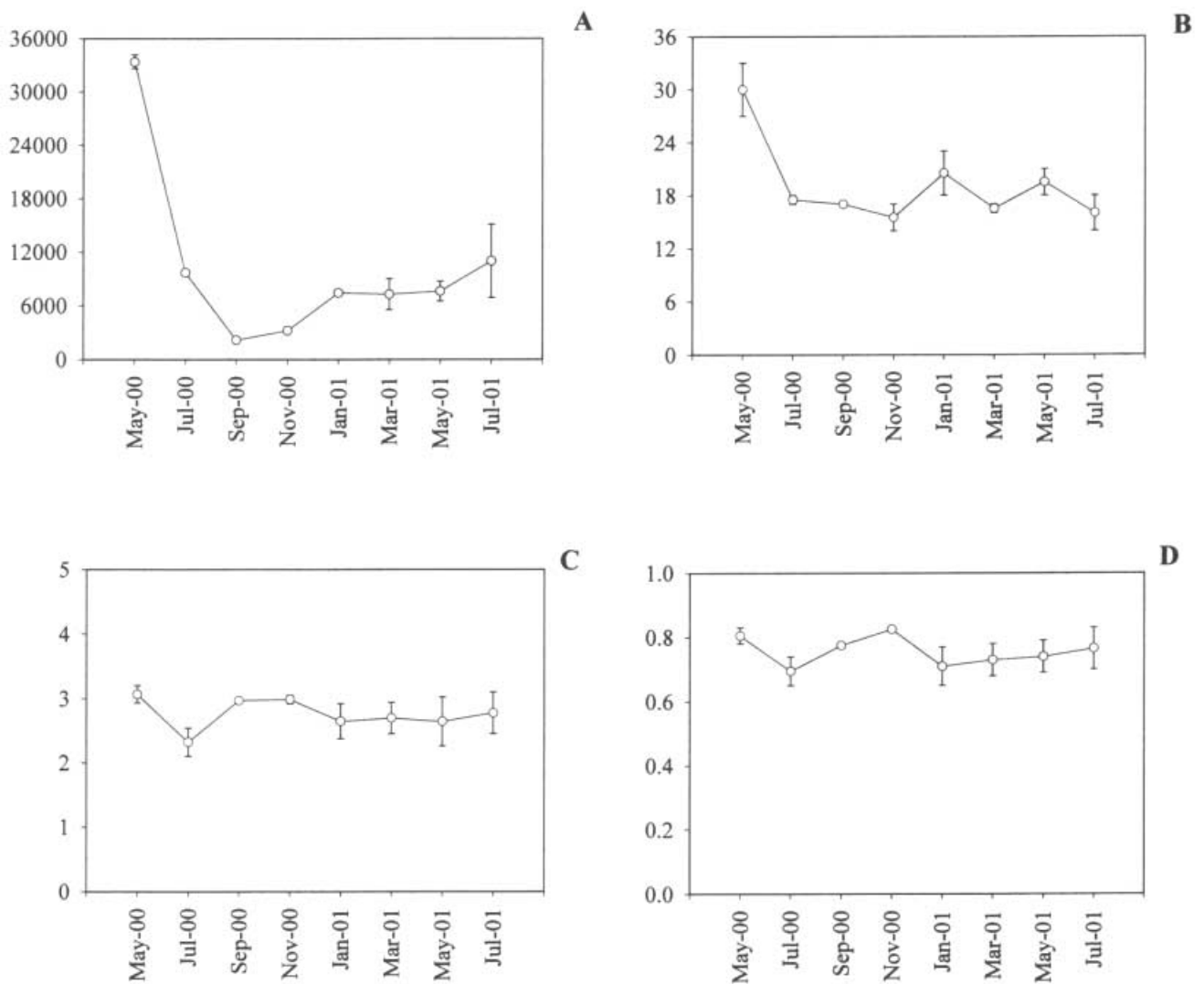
Figure 1. (A) Population density as individuals/m² of the whole syllid taxocoenosis during the study; (B) evolution of the number of species per sample during the study period; (C) evolution of Shannon's diversity index during the study period; and (D) evolution of the Simpson's diversity index during the study period.

sample, showing a second peak in July of 2001 (1187.5 ±612.5). The decrease of population in *E. naidina* was the most severe of the studied species and population densities fell from 2987.5 ±1187.5 individuals/m² to 75.0 ±50.0 in July and to a mere 37.5 in the following two samples. A discrete increase was found in January of 2001 (437.5 ±62.5), but population density fell again in the subsequent samples and kept around 100 individuals/m² until July (387.5 ±87.5). A different behaviour can be described for *Syllis prolifera* (Figure 2B), in which population variation was somewhat different from that of the taxocoenosis as a whole. In the case of this species, the population decrease was more gradual and the subsequent growth was very slow. Moreover, population density suffered a slight reduction in July of 2001 (from 1662.5 ±712.5 in May to 1487.5 ±537.5), in contrast to the rest of the dominant species. Thus the evolution of the population density of this species yielded a plot clearly distinct from that of the total syllid population.

With regards to relative abundance, the taxocoenosis was clearly dominated in all the samples by small Exogoninae species, especially by *Salvatoria vieitezi*. The dominance of this species (Figure 3A) was always very high and fluctuated around 45%. Except for the sample of November of 2000 (34.12 ±0.3%), it was always over the initial value (35.84 ±4.88%) and in the sample of January of 2001 it peaked up to 50.05 ±6.3%. *Syllis prolifera* was the only important non-Exogoninae species in terms of relative abundance, although this parameter showed strong variation in this species (Figure 3B). Its relative abundance was below the initial value of 12.98 ±5.88% for most of the study but it showed two clearly higher peaks, in July of 2000 (27.23 ±4.66%) and in May of 2001 (20.85 ±6.29%). In the last sample it fell to 13.58 ±0.19, being the only dominant species that did not increase its population density in this sample. *Salvatoria clavata* (Figure 3C) showed a high dominance in the first sample (12.62 ±1.50%), similar to that of *Syllis prolifera*.
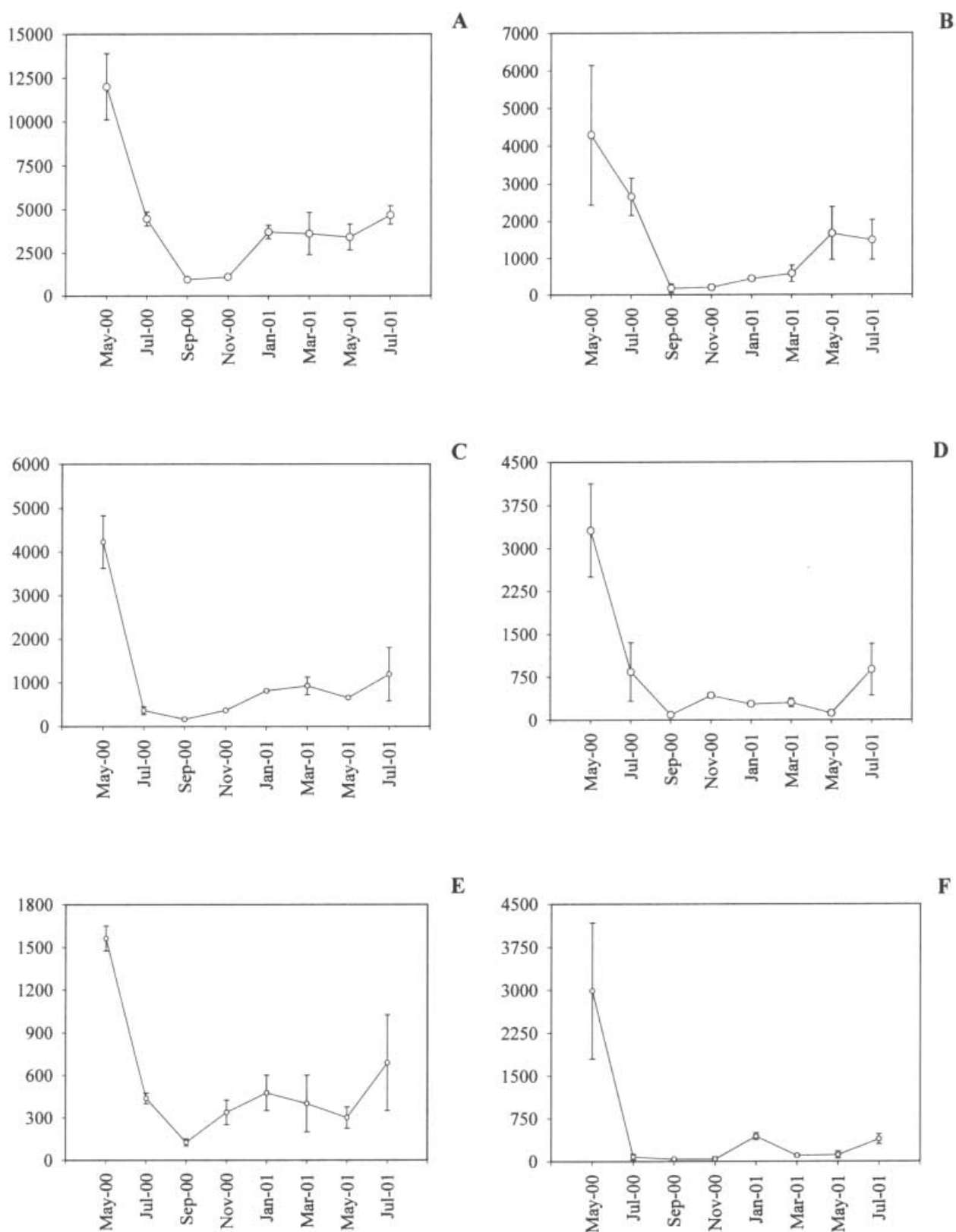
Figure 2. Evolution of the population density, as individuals/m² of the six most characteristic species studied. (A) *Salvatoria vieitezi* (San Martín, 1984); (B) *Syllis prolifera* Krohn, 1852; (C) *Salvatoria clavata* (Claparède, 1868); (D) *Sphaerosyllis hystrix* Claparède, 1865; (E) *Sphaerosyllis austriaca* Banse, 1959; and (F) *Exogone naidina* Örsted, 1845.
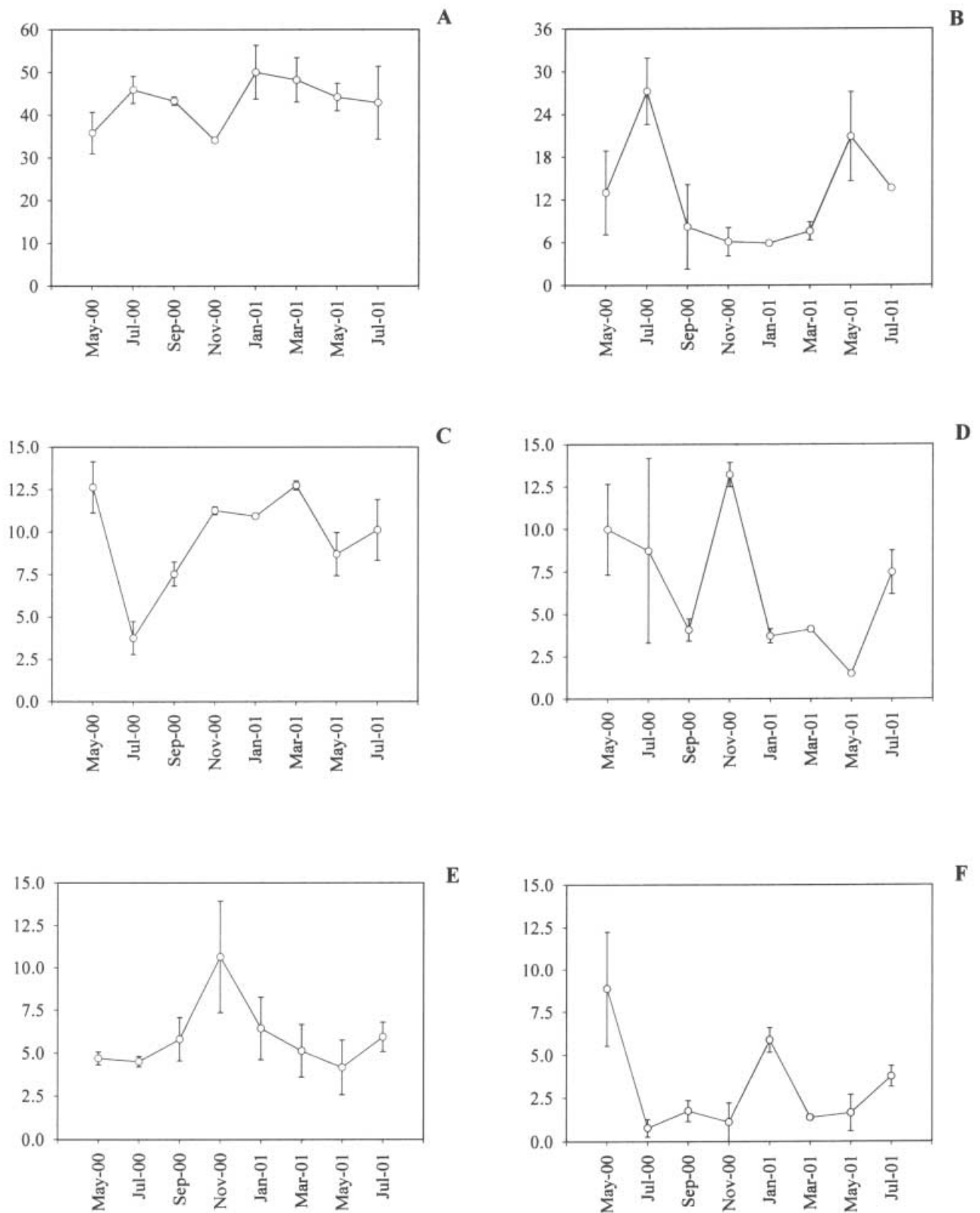
Figure 3. Evolution of the relative abundance (dominance) of the six most characteristic species studied. (A) *Salvatoria vieitezi* (San Martín, 1984); (B) *Syllis prolifera* Krohn, 1852; (C) *Salvatoria clavata* (Claparède, 1868); (D) *Sphaerosyllis hystrix* Claparède, 1865; (E) *Sphaerosyllis austriaca* Banse, 1959; and (F) *Exogone naidina* Örsted, 1845.

However, it fell to 3.75 ±0.97% in July and remained low (7.53 ±0.71%) in the next sampling. Since the sample of November of 2000 until that of March of 2001, values of relative abundance were similar or slightly lower than the initial one and, then, this parameter decreased again (8.69 ±1.26% in May and 10.12 ±1.78 in July). The relative abundance of *Sphaerosyllis hystrix* (Figure 3D) showed a very irregular pattern of variation, with very strong fluctuations. It seemed to decrease steadily from the initial value (9.99 ±2.67%), but in the sample of November of 2000 this parameter rose dramatically to 13.22 ±0.72% from 4.06 ±0.65% in the previous sample; similarly, from May to July of 2001 it went from 1.48 ±0.05% (the lowest value for the study period) to 7.46 ±1.30%. Another species of the same genus, *S. austriaca* (Figure 3E), had a similar but smoother plot with a peak in the sample of November (10.65 ±3.29%) and a slight increase from May (1.48 ±0.06%) to July (7.46 ±1.30%) of 2001. *Exogone naidina* (Figure 3F) suffered a dramatic decrease of its relative abundance after the first sampling, falling from 8.87 ±3.35% to values below 2%, although a peak (5.87 ±0.71%) took place in the sampling of January of 2001 and there was a second increase at the end of the study (3.74 ±0.60% in July of 2001).

DISCUSSION

From a quantitative point of view, the studied syllid taxocoenosis suffered a dramatic decline after the first sampling period. The cause of this phenomenon could not be certainly assessed, but a decrease in the amount of sediment retained among the fronds might be involved. This decline distinctly affected both the population density and the absolute number of species but the complexity of the taxocoenosis was not so strongly affected, as can be learned from the relative stability of values for Shannon's and Simpson's indexes. For instance, the sample of September of 2000, when the number of syllid individuals was at its minimum, yielded quite high values for α-diversity indexes. These results are consistent with those found by Giangrande (1990) in similar environments from the Italian coast. It must be also noted that none of the five species that were not collected again after the first sampling numbered more than two individuals, indicating that the reduction of number of species was due chiefly to disappearance or rarefaction of accidental ones. Thus, it can be stated that the drop in the number of individuals and species did not affect the taxocoenosis from the point of view of the relative complexity.

The pattern of this population fluctuation did not seem seasonal, since this variation was not cyclic (after population density reduction no subsequent recovery of the population occurred). Some authors have suggested that most Mediterranean polychaete populations are sharply seasonal, with very different summer and winter assemblages (Fresi et al., 1984; Giangrande, 1990; San Martín & Aguirre, 1991). However, Fraschetti et al. (2002) described a more complex scenario. In their investigation on polychaete assemblages associated with photophilic algae from Italian coasts, they noticed that seasonal fluctuation did not affect the population density or number of species necessarily. In most sampling sites no significant variation of these parameters could be detected, although

differences in the taxocoenosis deep structure could be assessed by means of multidimensional scaling analyses; the Syllidae populations inhabiting our studied area might follow the same pattern. Seasonal fluctuations do not always happen at the same time every year when present and may be delayed or brought forward from one year to the next (Rueda & Salas, 2003). This could be an alternative explanation for the lack of a second spring peak in population densities and/or number of species, but since the study period was longer than 12 months it is unlikely that such variation passed undetected.

Most of the syllid species considered here as effective descriptors of the taxocoenosis are well known dominant species in shallow water photophilic algae from the Mediterranean Sea (Giangrande, 1990; Sardà, 1991; López & Viéitez, 1999; Tena et al., 2000; Çinar, 2003a,b), although *Salvatoria vieitezi* was recorded as a dominant species only in some of the studies on western Mediterranean communities. It is remarkable that the high dominance scores of *Sphaerosyllis austriaca* in the present study, were previously recorded by Giangrande (1990) only. This species seemed to replace *Sphaerosyllis pirifera* Claparède, 1868, a usually dominant species on photophilic environments (López & Viéitez, 1999; Çinar, 2003b). The latter author found that in *Halopteris* sp. (an alga very similar to *Stypocaulon scoparium*) the small exogonins prevailed, probably due to the relatively simple structure of the fronds that did not permit larger predatory species to settle. This could explain why the smaller species of *Sphaerosyllis* (*Sphaerosyllis hystrix* and *S. austriaca*) were so abundant whereas the large one (*S. pirifera*) was quite scarce.

Another remarkable fact was that the population of *Syllis prolifera* behaved in a way different from the remainder of the dominant species. As they suffered severe reductions in their population density after the first sampling, the former species did not decrease in number so much, leading to a noticeable increase of its dominance score. Since the reduction of populations may be due to an increase of mortality rates or to a decrease in recruitment of juveniles, two alternative explanations for this fact exist. On the one hand, the well known plasticity of the species (Giangrande, 1990) might allow many individuals to endure for some time the would-be environmental changes that caused the rarefaction of the Exogoninae species, in such a way that the decrease of the population was more gradual. On the other hand, its longer lifespan (Franke, 1985) that might cause a severe drop in recruitment rates of this species, was not so noticeable in the short term.

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