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COLONIZATION OF WRACK BY BEETLES (INSECTA, COLEOPTERA) ON A SANDY BEACH OF THE ATLANTIC COAST

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COLEOPTERAN ASSEMBLAGES
SUCCESSION
WRACK PATCHES
SANDY BEACHES
ATLANTIC COAST
CONSERVATION

ABSTRACT. – This study deals with the analysis of the coleopteran assemblages in a beach-dune system located on the Galician coast. In particular, we used experimental manipulation of algal wrack, i.e. artificial patches of *Saccorhiza polyschide*s, to test hypotheses about influences on coleopteran assemblages inhabiting the upper shore level along an exposed sandy beach. Specifically, we tested that (1) abundance of colonizing individuals and species vary with the size of wrack patch and time, and (2) as a result, coleopteran assemblages also vary with patch size and time. Furthermore, responses could differ among sites because of their different environmental conditions. A total of 3 980 individuals belonging to 8 families and 18 species were collected. Tenebrionidae was the most abundant family followed by Staphylinidae and Hydrophilidae families, respectively. The tenebrionid *Phaleria cadaverina* (Fabricius, 1792) was the most abundant species within this family, with a total of 1 064 adults and 1 124 larvae. *Phytosus spinifer* Curtis, 1838 was the most abundant staphylinid species represented by 736 adults and 3 larvae. This study showed that coleopterans are very common colonizers in wrack patches on sandy beaches. Patterns of succession differed among species and colonization of patches was rapid, i.e. most species colonised patches on day 3. Coleopteran assemblages changed depending on patch size and time. Wrack may act as islands of food and/or habitat for several coleopteran species on sandy beaches. Cleaning activities on beaches used for recreational purposes might alter the diversity of coleopteran assemblages associated to wrack patches. Thus, for managerial and conservational purposes cleaning activities on beaches should be regulated.

INTRODUCTION

In the last century, sandy beach environments have undergone rapid changes through urbanization, over-exploitation for recreational purposes and landscape homogenization. Beaches are used for recreational purposes and due to an increasing human pressure experience diverse impacts such as cleaning activities, trampling or pollution (Brown & McLachlan 2002). As a consequence, diverse faunal assemblages may be accusing several impacts. A good knowledge of organisms inhabiting beaches is crucial for both scientific and managerial purposes of these areas. Thus, diversity monitoring represents an important tool to assess the state of sandy beaches and gives information on how species react to different environmental impacts (Chelazzi *et al.* 2005). Although marine organisms such as amphipods, isopods or bivalves are very common on beaches, coleopteran insects are also an important component of the fauna (Chelazzi *et al.* 2005) and may be used as indicators of environmental quality (Serrano 1984).

Despite some studies regarding terrestrial macrofauna, i.e. insects, on sandy beaches have been done throughout the world (Backlund 1945, Pichon 1967, Bigot 1970, Chelazzi *et al.* 1983, Ronchetti *et al.* 1986) information on ecological aspects of these organisms is still scarce. For example, most studies conducted in the Iberian Peninsula regarded taxonomical aspects. These works are mainly checklists of different groups of insects such as coleopterans (Cabral & Carvalho 1983, Serrano 1984, Eiroa *et al.* 1988, Novoa *et al.* 1998), orthopterans (Llorente del Moral 1978, Eiroa & Novoa 1987) or hymenopterans (Eiroa & Novoa 1985).

To date few studies have focused on ecological aspects of coleopterans inhabiting sandy beaches on the coasts of the Iberian Peninsula (Serrano 1984, Esteve Selma & Giménez Casalduero 1993, Giménez Casalduero & Esteve Selma 1994). In contrast, several ecological studies on diverse ecological aspects of coleopterans (e.g. zonation patterns, activity rhythm, assemblage structure, feeding strategies, etc.) have been carried out on the East African and Mediterranean coasts. For example, Pichon (1967) and Bigot (1970) reported zonation of coleopteran tenebrionids and staphylinids on the southern Madagascar coast (Tulear Beach). Colombini & Chelazzi (1996) studied the activity of the coleopteran *Eurynebria complanata* (Linnaeus, 1767). Carpaneto & Fattorini (2001) and Chelazzi *et al.* (2005) analyzed different ecological aspects of the assemblages of coleopterans on sandy beaches, i.e. zonation and distribution. Moreover, Colombini *et al.* (1996, 1998, 2000, 2002a, 2002b) have worked on diverse ecological aspects of macrofauna on sandy beaches, finding interesting results on diverse coleopteran species.

In spite of all these studies there is very little information on processes driving zonation patterns of insects, particularly coleopteran species, on sandy beaches. For example, patterns of succession on wrack deposits are considered to affect the distribution of different species including terrestrial insects on sandy beaches (Colombini & Chelazzi 2003). In fact, wrack patches provide food and habitat to a diverse and abundant component of the macrofaunal assemblages, mainly terrestrial arthropods (Inglis 1989, Polis & Hurd 1996, Dugan 1999, Colombini *et al*. 2000, Jedrzejczak 2000a, 2000b, Dugan *et al*. 2003). Changes in the mean zonation of certain species may be due to variations in the zonation of wrack deposits (Colombini & Chelazzi 2003). Different dimensions and compactness of patches may also create different microclimatic evolutions that influence the type and number of colonizers (Colombini *et al*. 2000). Patch size has been shown to influence the number of taxa present in terrestrial and marine habitats (e.g. Simberloff 1976, Irlandi *et al*. 1995). The mosaic of patches on sandy beaches might influence the structure and function of animal assemblages and determine the taxonomic composition and diversity of species as shown in other marine coastal systems (e.g. Norkko & Bonsdorff 1996, Bowden *et al*. 2001).

This study deals with the analysis of the coleopteran assemblages in a beach-dune system located on the Galician coast. In particular, we used experimental manipulation of algal wrack, i.e. artificial patches of *Saccorhiza polyschide*s (Lightf.), to test hypotheses about influences on coleopteran assemblages inhabiting the upper shore level along an exposed sandy beach. Specifically, we tested that (1) abundance of colonizing individuals and species vary with the size of wrack patch and time, and (2) as a result, coleopteran assemblages also vary with patch size and time. Furthermore, responses could differ among sites because of their different environmental conditions.

MATERIAL AND METHODS

Area of study: The study site of O Vilar (42° 34' 50''N, 9° 08' 45''W) is an exposed sandy beach located in the Corrubedo beach-lagoon complex. This complex, declared a Natural Park in 1992, is situated in an embayment on the northwestern coast of Spain. The area presents a humid oceanic climate with a mean annual temperature of 13-14°C and heavy rainfalls during the year.

O Vilar beach is an exposed beach, about 10 km long and 140 m width (in low tides of spring tide), backed by a large and active dune system, 9 km long and 16 m high (Calvo *et al*. 1999). On this beach the composition of the macrophyte wrack is very variable over the year. During summer, heterogeneous patches of algal wrack commonly range from 0.07 to 0.60 m^2, and are spread along the upper shore of the beach (personal observations).

Experimental design and sampling: The experiment started on 16 June 2004 and lasted for 21 days. The experiment was carried out in three different sites separated by about 150 m. A day prior to the experiment fresh seaweed, *Saccorhiza polyschides*, was collected by hand from surrounding intertidal areas, taken to the laboratory, where it was washed with sea water to clean any organisms, and then, weighed. A previous observational study in the area showed that patches of natural stranded seaweed ranged from 0.07 to 0.60 m^2 and were mainly composed of brown algae such as *Sacchoriza polyschides*, *Sargassum muticum* (Yendo), *Fucus* spp., and *Laminaria saccharina* (Linnaeus). Based on this observational study, small (0.09 m^2; 1 kg ± 50 g wet weight), medium (0.25 m^2; 3 kg ± 50 g wet weight) and large (0.49 m^2; 5 kg ± 50 g wet weight) squared-patches of seaweed fronds and thalli were randomly placed at each site on the upper shore level of the beach parallel to the shoreline, i.e. 27 patches per site (N = 81). Patches were placed 2 m apart and their positions were marked with aluminium sticks stuck into the sand and located on the upper left corner of each patch. Patches remained on the sand by day 7 and were partially buried by day 21.

On days 3, 7 and 21 of the experiment three randomly chosen replicate patches of each size were collected at each site. The associated fauna was retained by enclosing each patch within a 70 x 70 cm sieve of 1 mm mesh size. Insecticide was then sprayed, and after 5 minutes, the seaweed and any visible fauna transferred to a plastic bag. Individuals underneath each patch were also taken using a 10 cm diameter stainless-steel corer that was pushed into the sediment to a depth of 20 cm (n = 4). To measure control abundances of invertebrates in natural bare sediment, three replicates (4 cores per replicate) 50 cm apart from the wrack patches and separated by 2 m were taken at each site.

In the laboratory, samples of seaweed were gently washed, sieved through a 0.5 mm mesh, and fixed in borax-buffered 4 % formaldehyde in seawater. Then retained fauna was separated and stored in 70 % ethanol.

Data analyses: Changes in number of individuals and number of species were investigated using a 3-factor orthogonal analysis of variance. The factors were Patch size (3 levels), Sites (3 levels) and Time (3 levels). Patch size and Time were fixed and Site was random. Before analysis, the homogeneity of variances was evaluated by using Cochran's test (Winer *et al*. 1991) and data log (x+1)-transformed when necessary. *A posteriori* multiple comparisons were done using SNK tests. In addition, three factor orthogonal non-parametric multivariate analyses of variance (PERMANOVA) were used to test the hypothesis that coleopteran assemblages varied depending on patch size, time and site (see Anderson 2001).

RESULTS

Natural abundances of coleopterans in bare sand

Very few individuals and species were found in the controls. A total of 22 individuals belonging to 2 species, *Cercyon littoralis* (Gyllenhal, 1808) and *Phaleria cadav-*

Table I. – Total number of coleopterans found in wrack patches. a) Numbers are the pooled samples over all algal wrack patches and sites at each sampling time; b) numbers are the pooled samples over all sites and sampling times at each wrack patch size.

	a				**b**		
	3 days	**7 days**	**21 days**	**Total**	**Small**	**Medium**	**Large**
Adults							
HYDROPHILIDAE							
Cercyon (C.) *littoralis* (Gyllenhal, 1808)	□	░	░	108	6	23	79
HISTERIDAE							
Hypocacculus (Nessus) rubripes (Erichson, 1834)	░			4			4
Hypocaccus (Hypocaccus) crassipes (Erichson, 1834)	░			1		1	
Hypocaccus (Baeckmanniolus) dimidiatus maritimus (Stephens, 1830)	░	□	░	119	19	41	59
STAPHYLINIDAE							
Cafius (Cafius) xantholoma (Gravenhorst, 1806)	█	░		358	10	92	256
Aleochara (Emplenota) grisea (Kraatz, 1856)	█	▒		406	28	118	260
Phytosus (Actosus) balticus Kraatz, 1859	░	░	░	3	1	1	1
Phytosus (Phytosus) spinifer Curtis, 1838	█	□	░	736	16	197	523
Leptacinus faunus Coiffait, 1956	░			4		2	2
MELOLONTHIDAE							
Anoxia (Anoxia) villosa (Fabricius, 1781)			░	1	1		
LATRIDIIDAE							
Enicmus transversus (Olivier, 1790)	░			2			2
TENEBRIONIDAE							
Phylan gibbus (Fabricius, 1775)		░		1	1		
Phaleria cadaverina (Fabricius, 1792)	█	█	█	1062	204	376	482
Tentyria curculionoides interrupta Latreille, 1807	░			1		1	
ANTHICIDAE							
Anthicus floralis (Linnaeus, 1758)	░	░		17	9	5	3
CHRYSOMELIDAE							
Leptinotarsa decemlineata (Say, 1824)			░	1		1	
Phyllotreta undulata Kutschera, 1860	░	░		6	2	1	3
Psylliodes marcidus (Illiger, 1807)		░		2		2	
Larvae							
HYDROPHILIDAE							
Cercyon (C.) littoralis (Gyllenhal, 1808)	░	░	░	21	3	11	7
STAPHYLINIDAE							
Phytosus (Phytosus) spinifer Curtis, 1838			░	3			3
TENEBRIONIDAE							
Phaleria cadaverina (Fabricius, 1792)	▒	█	█	1124	235	394	495

░	< 50 individuals	▒	100 - 200 individuals
□	50 - 100 individuals	█	> 200 individuals

erina (Fabricius, 1792) were collected. The most abundant species in bare sediment, which also showed the largest abundances on the experimental patches, was a coleopteran species, *Phaleria cadaverina* (82% of total individuals in bare sand).

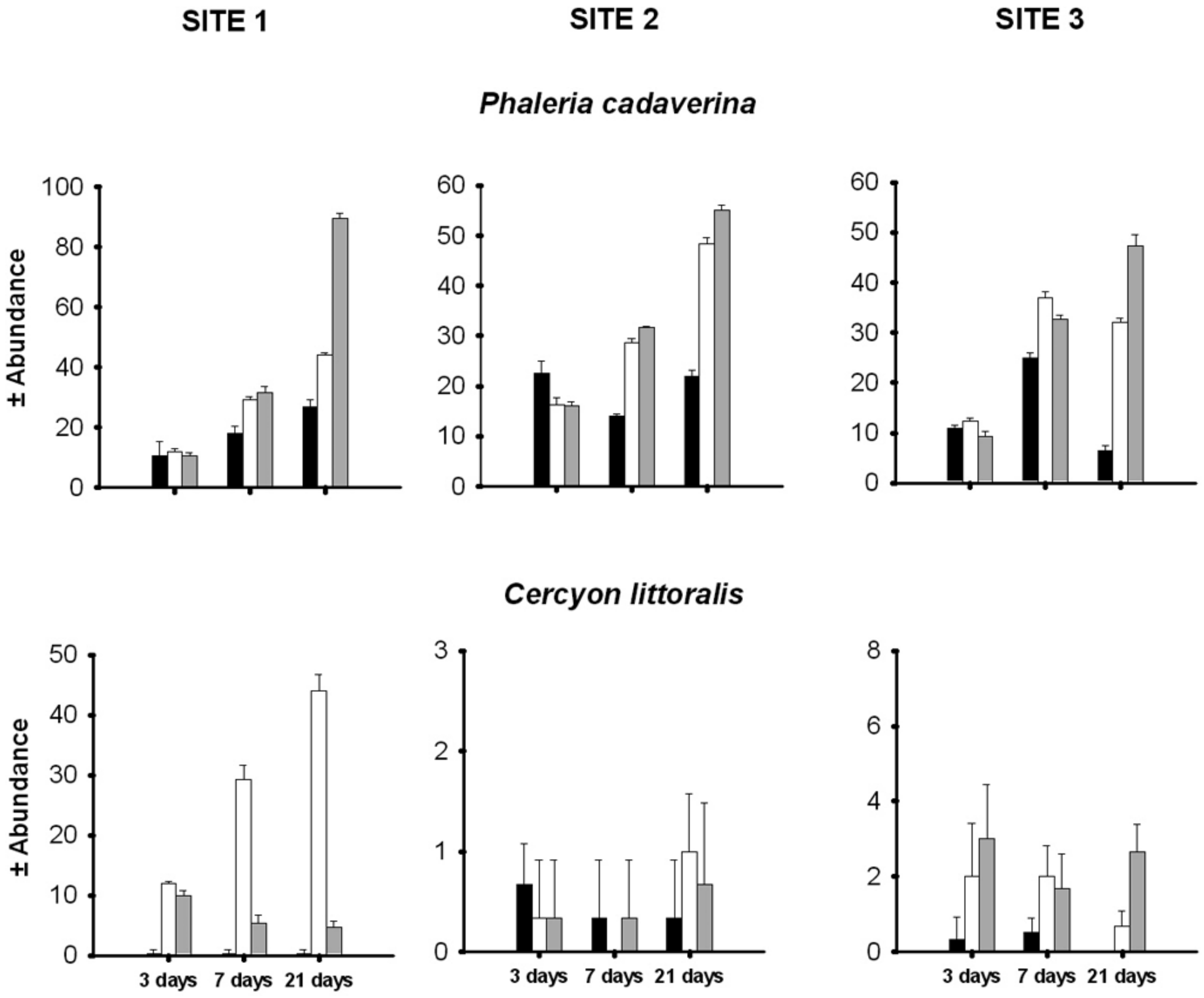

Fig. 1. – The influence of patch size and site on the mean number (± SE) of individuals ($n = 3$) through time of *P. cadaverina* and *C. littoralis*. Black, white and grey bars indicate small, medium and large patches, respectively.

Composition and abundance of coleopterans in wrack patches

A total of 3 980 individuals belonging to 8 families and 18 species were collected. Tenebrionidae was the most abundant family, followed by Staphylinidae and Hydrophilidae, respectively. The tenebrionid *Phaleria cadaverina* was the most abundant species within this family with a total of 1 064 adults and 1 124 larvae. *Phytosus (P.) spinifer* Curtis, 1838 was the most abundant staphylinid represented by 736 adults and 3 larvae. The rest of species from this family were only represented by adults. *Cercyon littoralis* was the only species within the Hydrophilidae and was represented by 108 adults and 21 larvae. The other families were only represented by adults. The histerids represented 3.11% of the total abundance, with *Hypocaccus (B.) dimidiatus maritimus* (Stephens, 1830) as the most abundant species within this family. The rest of the families, Anthicidae, Chrysomellidae, Lathrididae and Melolonthidae, counted very few species and individuals, and their occurrence seemed to be stochastic. For example, the family Anthicidae was represented by the species *Anthicus floralis* (Linnaeus, 1758) (7 adults) or the family Lathrididae was represented by one species, *Enicmus transversus* (Olivier, 1790) (2 adults).

Phaleria cadaverina accounted for 55% of the total individuals, followed by *P. spinifer* with 18.56%. Other two staphilinid species, *Cafius (C.) xantholoma* (Gravenhorst, 1806) and *Aleochara (E.) grisea* (Kraatz, 1856) accounted for 9% and 10% of the total abundance, respectively. The histerid *H. dimidiatus maritimus* represented 3% of the total abundance. The other species only represented 1% of the total abundance and their occurrence was sporadic. Only *P. cadaverina* and *C. littoralis* occurred in bare sand, although they appeared in small numbers, 26 and 8 individuals, respectively.

Adults and larvae of species showed different trends over time. For example, adults and larvae of *P. cadaveri-*

na presented their maximum abundance on day 21. Adults of *C. littoralis* and *P. spinifer* showed the maximum abundance on day 3, whereas larvae of both species reached maximum abundances on day 21.

Patterns of succession

Patterns of succession differed among species. Species responded differently across patches and time causing no consistent patterns of colonization. Most species colonized patches on day 3 (14 species), and only 2 species colonized on day 7 and 21 (Table I). *Phylloides marcidus* (Illiger, 1807) and *Phylan gibbus* (Fabricius, 1775) colonized wrack patches on day 7, whereas *Anoxia (A.) villosa* (Fabricius, 1781) and *Leptinotarsa decemlineata* (Say, 1824) colonized wrack patches on day 21. At the end of the experiment, only two species *P. cadaverina* and *C. littoralis* were quite abundant. Time and patch size influenced the total number of species and individuals, respectively. Total number of species varied significantly over time ($F_{2,4}$: 25.73; $P < 0.01$; SNK tests 3 days < 7 days < 21 days, $P < 0.05$), whereas total number of individuals varied across patches ($F_{2,4}$: 27.84; $P < 0.01$; small < medium = large; SNK tests, $P < 0.05$).

Most abundant species such as *P. cadaverina*, *P. spinifer*, *A. grisea*, *C. xantholoma* and *C. littoralis* showed different trends in patterns of abundance across patches and time. Both adults and larvae of *P. cadaverina* colonized wrack patches on day 3. Abundance of this species in small patches did not vary over time, whereas abundances in medium and large patches showed significant variation over time (medium patch: day 3 < day 7 = day 21; large patch: day 3 < day 7 < day 21; SNK tests, $P < 0.05$) (Fig. 1). *Cercyon littoralis* colonized all wrack patches quickly, and its abundance did not vary over time (Fig. 1). Larvae of this species showed different patterns across sites and wrack patches. For example, adults were more abundant in large patches than medium or small patches at Site 1.

The three staphylinid species *C. xantholoma*, *A. grisea* and *P. spinifer* followed a similar trend at the three sites (Fig. 2). They colonized all wrack patches, but patterns of colonization were not constant over time. They colonized all patches on day 3, but their abundances decreased on day 7, disappearing on day 21. Nevertheless, each species showed slightly different responses. For example, abundances of *C. xantholoma* in small and medium patches were significantly larger on day 3 (day 21 = day 7 < day 3, SNK tests, $P < 0.05$), whereas abundances in large patches decreased over time (day 3 > day 7 > day 21; SNK tests, $P < 0.05$). Number of individuals of *A. grisea* increased with increasing patch size (SNK tests, $P < 0.05$) up to day 7, to disappear on day 21. Abundances of *P. spinifer* in small patches did not vary over time whereas its abundances in medium and large patches decreased over time (day 21 < day 7 < day 21, SNK tests, $P < 0.05$).

Hypocaccus dimidiatus maritimus, the most abundant species within Histeridae family, followed a completely different pattern (Fig. 3). It reached its maximum abundance on day 7 in medium and large patches, whereas abundances on days 3 and 21 were very small and similar in all wrack patch sizes.

Assemblages

In general, a similar species composition was found in bare sand at all sites and times of sampling. Assemblages in bare sand were similar among sites at all times of sampling, i.e. no significant interaction (Site x Time, $P > 0.05$).

Coleopteran assemblages in wrack patches differed through time, but this response was not consistent among patches (i.e. significant interaction Patch x Time, see Table II). Assemblages from medium and large patches differed over time (3 days ≠ 7 days ≠ 21 days, SNK tests, $P < 0.05$), whereas assemblages from small patches were similar over time except for day 3 (3 days ≠ 7 days = 21 days, SNK tests, $P < 0.05$). Furthermore, assemblages did not vary across sites.

DISCUSSION

Species composition and abundance

Species richness, abundance, composition and distribution of terrestrial arthropod assemblages in sandy beaches are limited by ecological factors such as beach-cast algae, tidal inundation, humidity, salinity, organic matter contents, and behavior (Colombini *et al.* 2002a). The number of individuals and species found in this study was relatively large and disagrees with previous studies on wrack deposits on sandy beaches (see Colombini & Chelazzi 2003). The presence of wrack patches could attract a conspicuous variety of phytophagous and scavenger species that might have successively attracted diverse predators. The fauna of O Vilar beach associated to wrack patches was dominated by tenebrionids and staphylinids (~ 93 % of total individuals). These findings contrast with earlier reports on coleopteran species on the Galician sandy beaches (Eiroa *et al.* 1988, Novoa *et al.* 1998). For example, Eiroa *et al.* (1988) found 6 coleopteran families represented by 12 species (Carabidae, Oedemeridae, Anthicidae, Tenebrionidae, Melolonthidae and Cetoniidae) on an exposed sandy beach. It is worth mentioning that Novoa *et al.* (1998) reported contrasting results in our area of study (O Vilar beach). These authors only found two coleopteran families, Carabidae (4 species) and Chrysomelidae (22 species). In addition, we found a larger number of species and individuals of Tenebrionidae and Staphylinidae than those reported in other studies done elsewhere (e.g. Inglis 1989, Shibata 1993, Colombini *et al.* 2000, Colombini *et al.* 2002b, Jaramillo

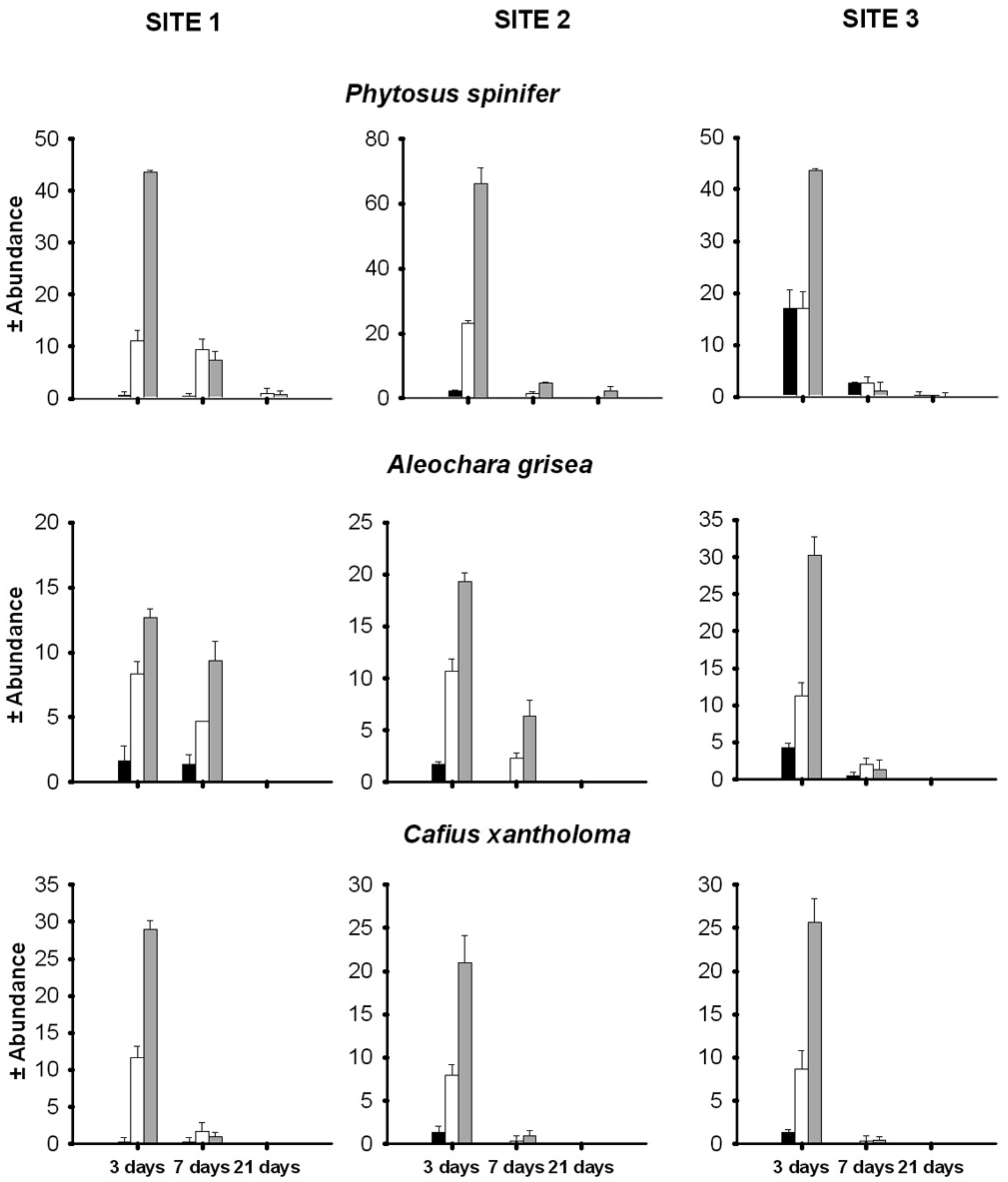

Fig. 2. – The influence of patch size and site on the mean number (± SE) of individuals ($n = 3$) through time of *P. spinifer, A. grisea* and *C. xantholoma*. Black, white and grey bars indicate small, medium and large patches, respectively.

et al. 2003) or slightly lower (Jedrzejczak 2002b). Although most studies have also reported the dominance of Tenebrionidae and Staphilinidae families over other families (e.g. Fallaci *et al*. 1999, Colombini & Chelazzi 2003, Chelazzi *et al*. 2005), few studies have found different patterns (Colombini *et al*. 2002b, Jedrzejczak 2002b). Nevertheless, it is important to highlight that the methodology used in all these works was completely different from that used in this study. Apart from Inglis (1989) and Jedrzejczak (2002a, b) who used litterbags as

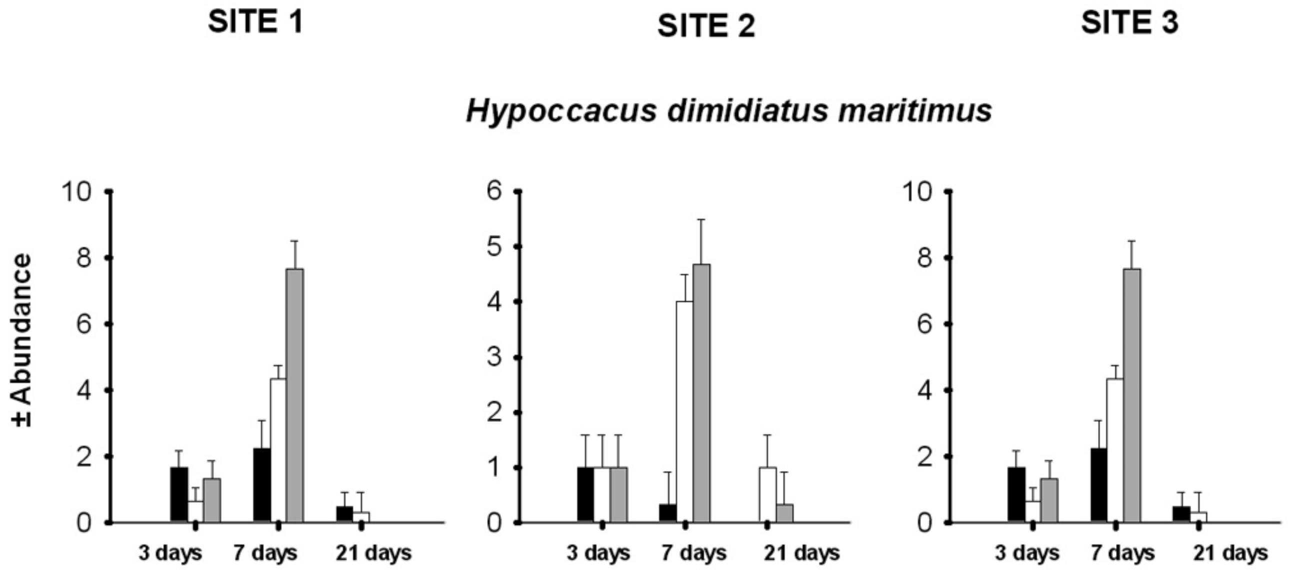

Fig. 3. – The influence of patch size and site on the mean number (± SE) of individuals (*n* = 3) through time of *H. dimidiatus maritimus*. Black, white and grey bars indicate small, medium and large patches, respectively.

Table II. – Summary of PERMANOVA for coleopteran assemblage. *F*-ratios and level of significance are shown (*n* = 3). Site (three levels: site1, site2 and site 3) is a random factor, Patch size (three levels: small, medium and large) and Time (three levels: 3, 7 and 21 days) are fixed factors.

Source	df	MS	F	P
Site	2	1007.75	1.77	0.1021
Patch	2	6888.34	11.54	0.0004
Time	2	18419.34	28.20	0.0002
Site x Patch	4	597.28	1.05	0.4016
Site x Time	4	653.24	1.15	0.3098
Patch x Time	4	2073.27	4.19	0.0018
Site x Patch x Time	8	494.73	0.87	0.6324
Residual	54	569.10		

sampling methods the other authors used different traps, i.e. pitfall traps, wall traps, tube traps and mobile cages, and hand picking techniques. The use of artificial wrack patches could favour the presence of certain species. For example, the reduction of the elytrae, typical of the Staphylinoidea, can induce dehydration and this may be in part the reason why specimens appear in larger number in wrack patches than in pitfall traps.

Succession

Bare sediment was characterized by species-poor assemblages and low abundances of individuals. Only two species, *P. cadaverina* and *C. littoralis* occurred in bare sand (small number of adults). It is evident that wrack provided refuge and/or food for many species and, therefore, it might play an important role in determining the population abundances of upper shore assemblages on this exposed beach. The patterns of succession observed in this study contrast with those reported by Colombini *et al*. (2000) and Jedrzejczak (2002b), that showed that Tenebrionidae and Hydrophilidae families were absent or occurred in very low abundances. In our study, tenebrionids appeared on day 3 and lasted till the end of the experiment. A striking result was the high abundance of adults and larvae of *P. cadaverina* (55 % of the total individuals) and its increasing abundance through time. Tenebrionids are very often associated with beached algae or dead fish (Español 1969, Serrano 1984). Wrack might offer a refuge for larvae of these species, i.e. adults and larvae increased constantly over time, and food for adults.

Two more families represented by quite large numbers of individuals, Staphilinidae and Hydrophilidae, colonized the wrack patches from the beginning of the experiment. The pattern of succession observed in this study may be related to different factors (e.g. Inglis 1989, Scapini *et al*. 1992, Colombini & Chelazzi 2003). For example, successional change of species has been found to be associated with different qualitative stages of decomposition and ageing of wrack (Colombini & Chelazzi 2003).

For example, Staphilinids were very abundant on day 3 (Table I). Species from this family are very sensitive to dehydration so they could colonise wrack patches when they still presented a high water content, i.e. days 3 and 7 (see Colombini *et al.* 1998). Histerids predate on insects, mainly dipteran larvae, and they also can feed on organic matter (Yelamos 2002). They have a very strong sense of smell being able to detect food sources from long distance. The decomposition of the wrack patches together with the presence of dipteran larvae on day 7 could attract individuals of this species. The presence of the species *A. floralis* from the family Anthicidae on days 3 and 7 might be also related with its preference for organic matter with high water content (Bucciarelli 1980).

Trophic habits and physiological needs of different species have been reported to be important factors causing different patterns of abundance in other studies (e.g. Inglis 1989, Marsden 1991, Colombini *et al.* 2000, Colombini & Chelazzi 2003). Most species in the assemblages (72 %) are predators, carrion-feeders and detritivores, whereas few species, i.e. families Chrysomelidae, Anthicidae and Melolonthidae, are flower-growing species. First colonizers such as *C. littoralis* and *P. spinifer* are phytophagous, whereas *P. cadaverina* and *C. xantholoma* are scavengers (Serrano 1984, Ponel 1993). Large abundances of *P. cadaverina* during the study could be related to the abundance of food resources (dead animals, decomposed algae, etc.).

The size of the wrack patch had an effect on some species (e.g. *P. cadaverina*, *A. grisea*, *C. littoralis*, *H. dimidiatus maritimus*). Moreover, *C. littoralis* presented a different behavior in the distribution along the shore, i.e. differences among sites. These patchy distributions could be associated with differences in decomposition of wrack patches or sand characteristics (e.g. Aloia *et al.* 1999, Colombini *et al.* 2002b). A patchy distribution of some invertebrates such as wolf spiders in dunes has been reported to be related to size of the habitat patches (Bonte *et al.* 2003). Because rates of mortality of this species are very high, the viability of subpopulations is largely dependent on population size which relates to patch size. Although life histories of coleopterans inhabiting sandy beaches are poorly understood it is very likely that rates of mortality of certain species might be related to patch size. Moreover, several studies have indicated the importance of patch size in immigration and emigration rates of several invertebrates (e.g. Simberloff 1976, Irlandi *et al.* 1995). Strong variation in patch quality, such as documented for size, structure and connectivity, may give rise to source-sink dynamics. Thus, occupancy of sinks could be expected to depend directly on their dispersal abilities and immigration rates (see Bonte *et al.* 2003). Life-history attributes and mobility of different taxa, such as their colonizing and competitive abilities, might play an important role in determining different distributions of coleopterans among wrack patches.

In addition, our results showed that coleopteran assemblages changed in response to patch size and time. Species-specific strategies for exploiting the algal wrack (as refuges and/or as a feeding site), that vary in space and in time, and interactions between and within species may also lead to inconsistent changes in assemblages associated with different sizes of algal wrack patches over time.

This study showed that coleopterans are very common colonizers in wrack patches on sandy beaches. It is evident that wrack patches provided food and/or habitat for many of these organisms and have beneficial effects on invertebrates assemblages, increasing diversity and population densities (i.e. bare sand *vs* wrack patches). Due to their abundance on sandy beaches coleopterans could be considered important bio-indicators of the health of beach ecosystems as they are extremely sensible to environmental changes (Serrano 1984). Beach-cast macroalgae supporting prey resources are also commonly exploited by a number of shorebirds and secondary consumers such as spiders, scorpions, lizards, rodents and coyotes. Apart from providing food and shelter, wrack deposits act as important links between habitats (Brown & McLachlan 2002, Dugan *et al.* 2003). Most studies have generally demonstrated that beach-cast macroalgae have beneficial effects on assemblages inhabiting sandy beaches. Unfortunately, rapid social changes associated with the need to exploit beaches for tourism or through harvesting of wrack deposits have produced environmental impacts all over the world (see Colombini & Chelazzi 2003). Therefore, attention should be paid to beach cleaning activities since they may alter diversity and composition of assemblages on sandy beaches. There is a hope that different policies will be adopted in the removal of wrack deposits from beaches or in prevention at the source.

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