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Diversity of dung beetles in two Mediterranean habitats (*Coleoptera*: *Scarabaeoidea*)

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Abstract. The spatial and seasonal distribution of dung beetles in a Mediterranean ecosystem of the southeastern part of the Iberian Peninsula were compared. The habitats studied were tall thorny bushes in calcareous soils (*Quercus* brushwood) as wooded area and dwarf shrubs in sandy soils (*Sideritis-Teucrium* shrub) as open area. The most important trophic resource for coprophagous beetles in these areas was sheep dung and rabbit dung pellets. Our results suggest that the distribution of dung beetles depends on habitat, and some species are specially linked to wooded or open areas.

Key words: Scarabaeoidea, spatial distribution, seasonal distribution, Mediterranean ecosystems, Iberian Peninsula.

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I. INTRODUCTION

Dung beetle communities are influenced by environmental characteristics such as vegetation structure, soil composition, temperature, humidity, etc (MATTHEWS 1975; LUMARET 1978; 1980; 1983; LUMARET & KIRK 1987; GALANTE et al. 1991; 1993). The data from the Mediterranean Region do not indicate that there is a dung beetle fauna exclusive to a specific habitat (GALANTE et al. 1995), however, some coprophagous species show preferences for specific vegetational cover (LUMARET 1980; 1983; BAZ 1988; GALANTE et al. 1991; MARTÍN-PIERA et al. 1992). Throughout the year, the distribution of dung beetle fauna is irregular, and these differences in spatial and temporal distribution allow the coexistence of several species (GALANTE 1992).

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II. MATERIALS AND METHODS

Study area

A survey of dung beetles was conducted in a mountainous area, Sierra de Salinas, in Alicante province (southeastern Spain). The climate corresponded to the cool sub-humid meso-Mediterranean type (RIVAS-MARTÍNEZ 1987) and the summer presented severe drought (17.3 mm) with high temperatures (Figs 1-2). Rainfall was concentrated in autumn (34.4 mm) and spring (31.3 mm).

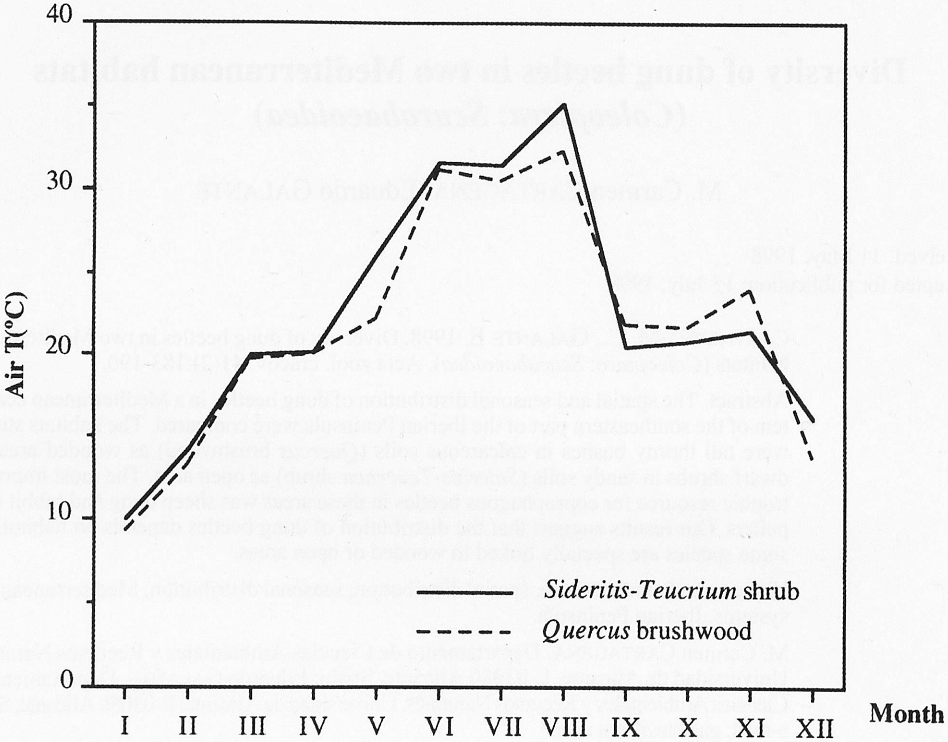

Fig. 1. Average monthly air (1 m height) temperatures in the study area.

The climax vegetation of Sierra de Salinas was the Mediterranean holm oak association (*Quercus rotundifolia* LAMARCK), with some individuals of *Q. faginea* LAMARCK growing in deep humid soil on north facing slopes. Serial vegetation in calcareous soils was constituted by tall thorny bushes ("coscojar") with *Q. coccifera* LINNAEUS and *Rhamnus lycioides* LINNAEUS. In sandy soil, the vegetation was dominated by dwarf shrubs of *Teucrium dunense* SENNEN, *Sideritis chamaedryfolia* CAVANILLES, *Ononis natrix* LINNAEUS subsp. *hispanica* (LINNAEUS fil.) COUTINHO, *Silene otites* (LINNAEUS) WIBEL, or *Launaea fragilis* (ASSO) PAU. Many of these plant species are endemic to the eastern Iberian Peninsula. Low shrublands with *Ulex parviflorus* POURRET, *Rosmarinus officinalis* LINNAEUS, *Helianthemum* sp. pl., *Cistus* sp. pl., or *Teucrium* sp. pl., dominated the landscape in calcareous soil, after fires or strong human pressure (e.g. grazing, agriculture, etc). Grasslands were dominated by *Stipa tenacissima* LINNAEUS in deep sunny soil, or by *Brachypodium retusum* (PERSOON) BEAUVERD, in rocky calcareous areas, forming a mosaic with the woody vegetation (ALCARAZ 1984).

Air (1 m height) and soil (5 cm depth) temperatures were registered fortnightly with a digital thermohygrometer (Hygratest 6200/6250) and the monthly average was calculated (Figs 1-2).

Collection of beetles

Four plots were selected: two in *Quercus* brushwood (calcareous soils) as wooded area, and two others in *Sideritis-Teucrium* shrub (sandy soils) as open area. Two pitfall traps (1 trap + 1 replica) were placed at each plot. The trap (CSR type according to LOBO et al. 1988) consisted of a plastic

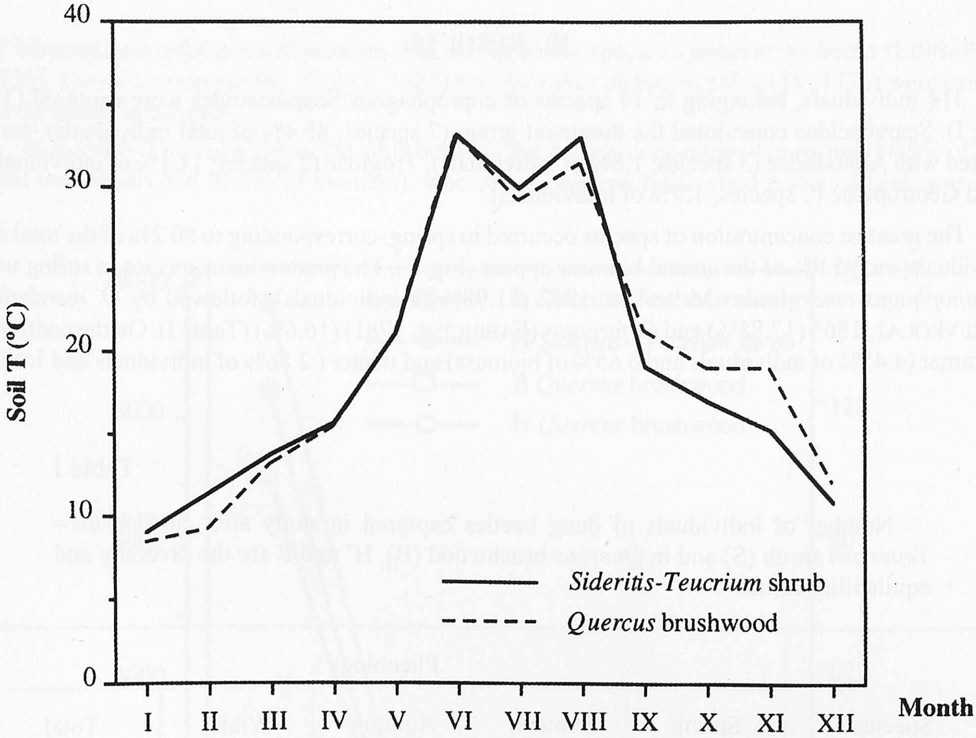

Fig. 2. Average monthly soil (5 cm depth) temperatures in the study area.

bucket, 21 cm in diameter, buried to its rim in the soil. 1000 cm^3 (± 200) of fresh cattle dung as bait for each trap was supported on a wire grill on the top of the bucket. As a preserving fluid, 300 ml of 50% ethylene glycol were used. The traps were baited fortnightly for a year and the dung used as bait and the preserving fluid containing trapped beetles was removed at the end of each period. A total of 200 samples was examined. After collection, fresh dung and preserving fluid were replaced. Thus, the sequence of the annual and spatial distribution of coprophagous Scarabaeoidea beetles was studied.

Data analysis

The biomass per species was obtained by calculating the mean dry weight of 20 specimens (10 males and 10 females) of each species. These were dehydrated at 40°C for 48 hours and subsequently weighed on a precision balance. The total dry weight of beetles of each species was calculated from the number of beetles trapped.

Diversity was expressed using Shannon (H') and Equitability (E) indices to evaluate specific abundance (MAGURRAN 1988).

Data were compared using analysis of X^2 to test the *a priori* hypotheses that there would be differences in (1) dung beetle biomass; and (2) in dung beetle individuals in fresh cattle dung. Results were considered significant at α= 0.001 level.

III. RESULTS

314 individuals, belonging to 14 species of coprophagous Scarabaeoidea were captured (Table I). Scarabaeidae constituted the dominant group (7 species; 85.4% of total individuals), compared with Aphodiidae (3 species; 1.6% of individuals), Trogidae (2 species; 11.1% of individuals) and Geotrupidae (2 species; 1.9% of individuals).

The greatest concentration of species occurred in spring, corresponding to 80.2% of the total individuals and 85.9% of the annual biomass appear (Fig. 3). The predominant species in spring was *Onthophagus emarginatus* MULSANT, 1842 (51.98% of individuals), followed by *O. merdarius* CHEVROLAT, 1865 (17.85%) and *O. furcatus* (FABRICIUS, 1781) (16.6%) (Table I). On the contrary, summer (4.45% of individuals and 0.65% of biomass) and winter (2.86% of individuals and 1.68%

Table I

Number of individuals of dung beetles captured in study area, in *Sideritis*--*Teucrium* shrub (S) and in *Quercus* brushwood (B). H' and E are the diversity and equitability values

Species	Phenology									
	Spring		Summer		Autumn		Winter		Total	
	S	B	S	B	S	B	S	B	S	Q
S. sacer	8	–	–	–	–	–	–	–	8	–
O. furcatus	40	2	13	–	–	–	–	–	53	2
O. lemur	1	1	–	–	–	–	–	–	1	1
O. maki	1	–	–	–	–	–	–	–	1	–
O. merdarius	44	1	–	–	–	–	1	–	45	1
O. emarginatus	48	83	–	–	2	19	–	1	50	103
O. taurus	–	2	–	1	–	–	–	–	–	3
T. hispidus	1	–	–	–	–	–	–	–	1	–
T. perlatus hispanicus	3	16	–	–	–	10	3	2	6	28
Th. intermedius	–	–	–	–	–	2	–	–	–	2
T. typhoeus	–	–	–	–	–	4	–	–	–	4
A. distinctus	–	–	–	–	1	–	1	–	2	–
A. granarius	–	1	–	–	–	–	–	–	–	1
A. lusitanicus	–	–	–	–	–	1	1	–	1	1
Total individuals	146	106	13	1	3	36	6	3	168	146
Total biomass	8434.7	1157.9	50.05	23.5	14.6	1295.8	116.8	71.3	14647.7	4768.2
Total species	8	7	1	1	2	5	4	2	10	10
H	2.043	1.091	0	0	0.90	1.715	1.780	0.90	2.18	1.42
E	0.681	0.388	–	–	0.90	0.73	0.89	0.90	0.65	0.42

of biomass) were the poorest seasons (Fig. 3). Only the species *Typhaeus typhoeus* (LINNAEUS, 1758), *Thorectes intermedius* (COSTA, 1827) and *Aphodius distinctus* (MÜLLER, 1776) were exclusively active in autumn.

In *Sideritis-Teucrium* shrub, the adult activity was mainly concentrated in spring (86.9% of annual individuals and 97.9% of biomass), whereas in *Quercus* brushwood a second peak was observed in autumn (24.7% of annual individuals and 50.9% of biomass) (Fig. 3).

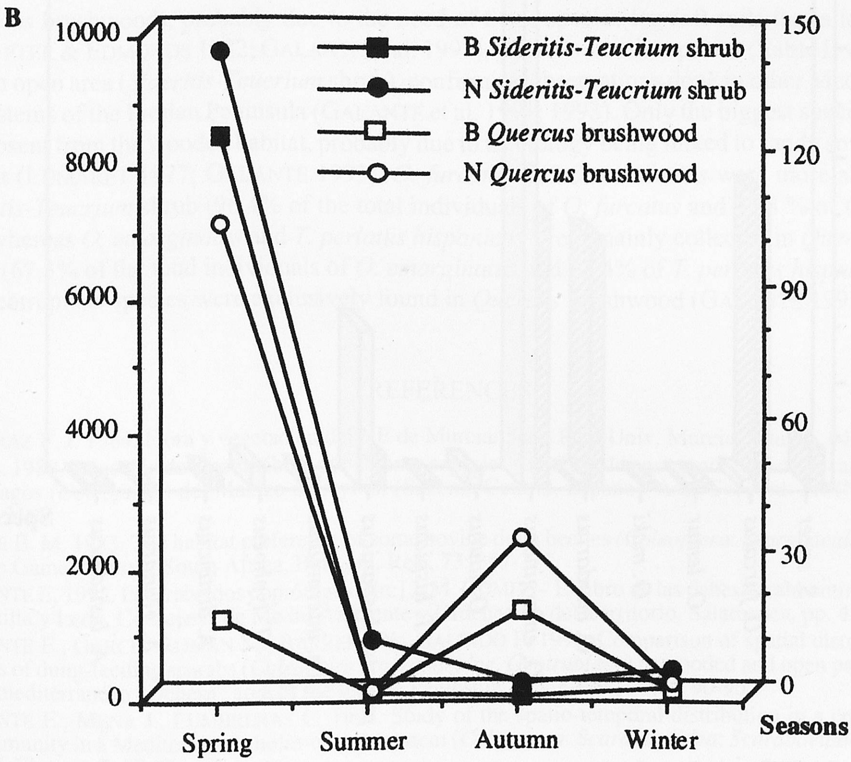

Fig. 3. Seasonal variation of dung beetle biomass (B) and individuals (N).

Differences in number of species and individuals present in each habitat were also registered. *Scarabaeus sacer* (LINNAEUS, 1758) was only captured in *Sideritis-Teucrium* shrub habitat, whereas *O. furcatus* and *O. merdarius* were more abundant in sandy soil. On the contrary, *T. typhoeus* and *Th. intermedius* were found exclusively in *Quercus* brushwood, and *O. emarginatus* and *Trox perlatus hispanicus* HAROLD, 1872 were more abundant in calcareous soil (Fig. 4).

The differences observed between the dung beetle communities of *Quercus* brushwood and *Sideritis-Teucrium* shrub were highly significant ($X^2 = 44.23$, df= 7, P<0.0001). Significant differences were also found between dung beetle biomass of both communities ($X^2 = 4961.00$, df= 7, P<0.0001).

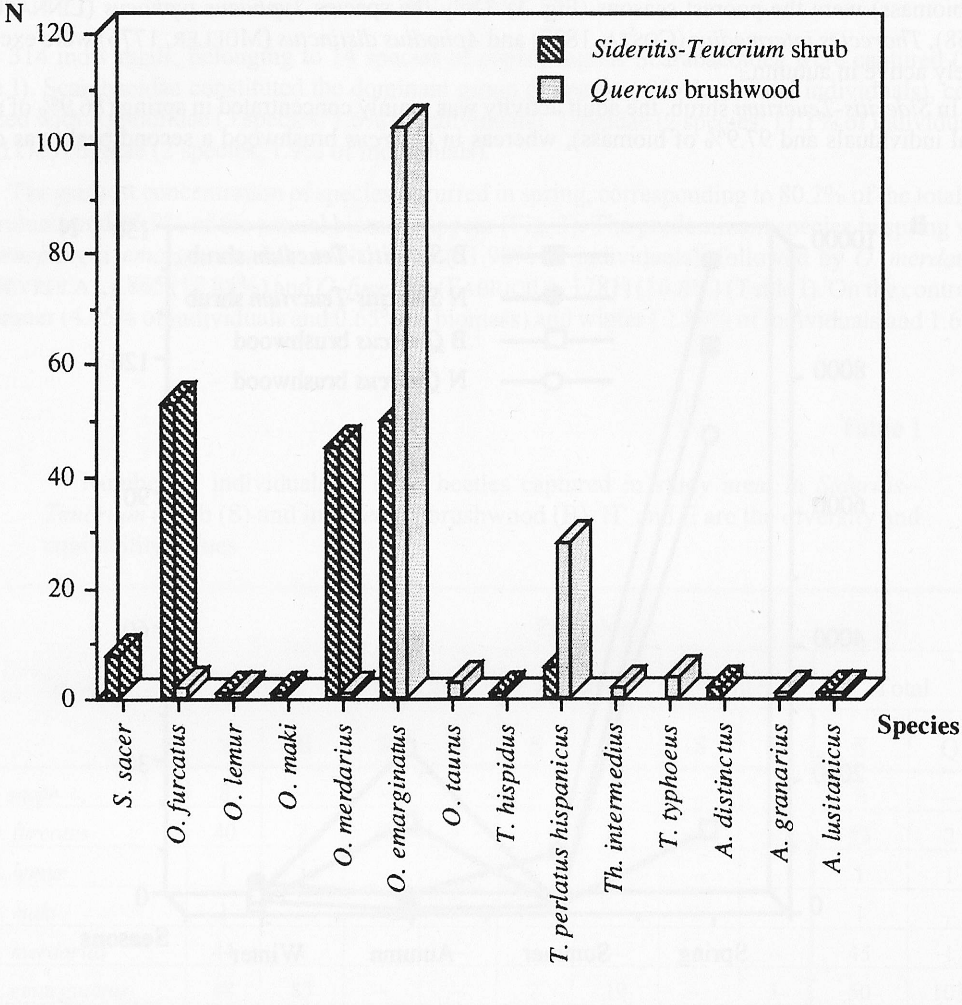

Fig. 4. Comparison of distribution of different dung beetle species captured.

IV. DISCUSSION

Sideritis-Teucrium shrub and *Quercus* brushwood dung beetle communities showed the same specific richness (10 species), but only six species were in common to both ecosystems (Table I). Our results showed that throughout the study period the H' and E indices (Table I) were lower than observed in other Mediterranean areas of the Iberian Peninsula (GALANTE et al. 1995), and of south-eastern France (LUMARET & IBORRA 1996), probably due to the progressive decrease in XX's century of sheep grazing (LÓPEZ & ROSSELLÓ 1978). Moreover, the highest H' and E values were registered in *Sideritis-Teucrium* shrub, except in autumn when the *Quercus* brushwood registered a second peak of activity (Fig. 3) constituted by species with a greater preference for wooded areas, such as *T. typhoeus* (GALANTE et al. 1991), *Th. intermedius* (LUMARET 1990) or *T. perlatus hispanicus* (LUMARET & KIRK 1987). Once more the increase of temperature in summer (Figs 1-2) was the reason for the fall in dung beetle activity and the decrease in diversity in both ecosystems.

Vegetation ground cover is an important factor in local distribution of coprophagous fauna (DOUBE 1983; LUMARET & KIRK 1987; GALANTE et al. 1991), having an effect on the soil temperature and dung humidity (MATTHEWS 1975) that affect the structure of the dung beetle community (LUMARET 1983). Our results suggest that coprophagous communities of the Eastern Iberian Peninsula are influenced by vegetation cover as indicated by many authors (LUMARET 1980; 1983; BAZ 1988; GALANTE et al. 1991; 1993; MARTÍN-PIERA et al. 1992; KADIRI et al. 1997) (Figs 3-4). Larger species, such as *Th. intermedius* and *T. typhoeus*, showed a greater preference for the wooded area (*Quercus* brushwood), probably due to the need of these species for soft soils that allow nesting (HALFFTER & EDMONDS 1982; GALANTE et al. 1991), whereas smaller species (Table I) were dominant in open area (*Sideritis-Teucrium* shrub), confirming observations done in other Mediterranean ecosystems of the Iberian Peninsula (GALANTE et al. 1991; 1993). Only the biggest species *S. sacer* was absent from the wooded habitat, probably due to its biology being linked to sandy soil and open habitat (LUMARET 1977; GALANTE 1993). *O. furcatus* and *O. merdarius* were more abundant in *Sideritis-Teucrium* shrub (96.4% of the total individuals of *O. furcatus* and 97.8 % of *O. merdarius*), whereas *O. emarginatus* and *T. perlatus hispanicus* were mainly collected in *Quercus* brushwood (67.3% of the total individuals of *O. emarginatus* and 82.4% of *T. perlatus hispanicus*), and the Geotrupidae species were exclusively found in *Quercus* brushwood (GALANTE 1993).

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