

Migration patterns and feeding resources of the Painted Lady butterfly, *Cynthia cardui* (L.) (Lepidoptera, Nymphalidae) in the northeast of the Iberian peninsula

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Migration patterns and feeding resources of the Painted Lady butterfly, Cynthia cardui (L.) (Lepidoptera, Nymphalidae) in the northeast of the Iberian peninsula.— The Painted Lady butterfly, *Cynthia cardui* (L.), is a subtropical species that periodically migrates from the edges of the desert bands to northern latitudes. Between 1988-89 and 1991-96 quantitative data on the abundance of the Painted Lady were collected from a number of fixed transect routes throughout Catalonia (northeast of the Iberian peninsula) using the standard methodology of the Butterfly Monitoring Scheme. This area in the western Mediterranean is presumably one important migratory route connecting the African continent with central and northern Europe. *C. cardui* was recorded regularly in all kind of habitats but numbers fluctuated greatly depending on the season. The high synchrony of population changes from site to site was indicative of the level of migration that occurred throughout the whole area in a particular year. Seasonal abundance showed a clear pattern and revealed that overwintering of immature stages and adults is negligible and that populations begin to build up at the end of spring, coinciding with northward mass migrations. On the other hand, population levels remain quite low during the summer and autumn, and the data do not show a southward return flight as noted in other migrant butterflies. During the study data on larval foodplants and nectar sources were also systematically collected. Though *C. cardui* is a polyphagous species, there is a clear hostplant preference rank, and *Malva sylvestris* was the main foodplant at most sites. Likewise, within each site the use of nectar sources was limited to a few species that changed during the season according to their abundance and availability.

Key words: *Cynthia cardui*, Nymphalidae, Lepidoptera, Migration, Feeding Resources, NE Iberian peninsula.

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Introduction

The Painted Lady, *Cynthia cardui* (L.), is one of the most widely distributed butterflies in the world and is only absent from the tropical rain forests and parts of South America. This cosmopolitan distribution is a consequence of its strong migratory behaviour coupled with the polyphagy of the larvae, two ecological traits allowing the species to be present on virtually any kind of habitat.

The migratory behaviour of *C. cardui* has been the subject of numerous studies over widely dispersed areas. Apart from numerous notes published in entomological journals, some authors have tried to establish broad patterns applicable to relatively extensive areas. After the classical work of WILLIAMS (1930) devoted entirely to butterfly migration, ABBOT (1951) and TILDEN (1962) analysed migratory patterns of the Painted Lady in North America and particularly in the state of California. Although migrations in the Palaearctic have also been the subject of a number of general works, the data are irregular in nature and there are still vast areas where little or no information exists. In the Middle East considerable information has been assembled by LARSEN (1976). Much of the data concerning migrations of the Painted Lady across the European continent in the last 15 years have been systematically compiled and published in the journal *Atalanta* (e. g. RENNWALD, 1987; STEINIGER & EITSCHBERGER, 1990), but in most cases these are qualitative and report only occasional migratory events. More detailed information has been gathered for the British Isles, where general patterns of migration have been described by several authors (e. g. WILLIAMS, 1951; BAKER, 1972; BRETHERTON & CHALMERS-HUNT, 1981; POLLARD, 1982; POLLARD & YATES, 1993).

Although the western Mediterranean area is presumably one of the most important migratory routes of the Painted Lady connecting the African continent (the origin of most of the migrants) with central and northern Europe, no general account of its temporal and spatial distribution has yet been published. Likewise, information on larval or adult feeding plants is extremely vague and in most cases relies on inaccurate lists compiled by earlier workers and not from observations made directly in the field.

The aim of this paper is to contribute to filling this gap, providing detailed information on the phenology and feeding resources of *C. cardui* in the northeast Iberian peninsula. Although many questions remain unresolved and deserve future investigations, some consistent migratory patterns can be established and will help to understand the behaviour of the Painted Lady within a broader geographical scale.

Material and methods

Quantitative data on the abundance of *C. cardui* were collected from a number of fixed transect routes throughout Catalonia (northeast Spain) (fig. 1) based on the standard methodology of the British Butterfly Monitoring Scheme (POLLARD, 1977; POLLARD & YATES, 1993). The transects were walked once a week and only those butterflies seen within 5 m in front of the recorder were counted. At the end of the season, an annual index of abundance was calculated for each surveyed site as the sum of the weekly counts, including the estimated figures for missing values (see POLLARD, 1977, for more details). Site data were combined to obtain a collated index of abundance, following prior logarithmic transformation of the site values (MOSS & POLLARD, 1993). The collated index was calculated using the method of ratio-estimates (POLLARD, 1984) and provides information at a national level on changes in abundance between two successive years. An arbitrary value of 100 was chosen for the 1994 index (when most of the transects started to provide data, see below), and this value was then multiplied by successive ratio-estimates.

Sampling began on March 1st and ended on September 26th, thus comprising a total of 30 weeks. Recording was always restricted to the official time between 9.00 a.m. and 2.00 p.m. When the temperature was below 15°C, transects were only walked if sunshine exceeded 75%.

Data from a total of 22 transects have been used, over different time intervals in each case (table 1). In 1988-1989 three transects were established in the Aiguamolls de l'Empordà Natural Park, at the northeast tip of the Catalan coast (fig. 1). Two of these

were recorded for one year only, but the "El Cortalet" transect has provided continuous data for the period 1988-1996. In 1994 a Butterfly Monitoring Scheme (BMS) was set up in Catalonia, and data for most of the transects considered in this paper are available for the three-year period 1994-1996. Six and two new transects were incorporated to the scheme in 1995 and 1996 respectively, thus providing data only for 1995-1996.

All the five major phytogeographical zones in Catalonia (cf. RIBA et al., 1980) are sampled in the BMS, though with an uneven frequency (table 1). At present, the subalpine and continental zones are poorly represented, and therefore most of the phenological data provided in this paper are biased towards mediterranean, coastal and eurosiberian ecosystems. This problem has been minimized to a certain extent due to some additional data available from the Pyrenees and western Catalonia. In 1996 the migration of the Painted Lady was particularly abundant and was noted by a considerable

number of entomologists from many localities in Catalonia. In spite of their irregular nature, these observations covered widely dispersed areas and in some cases quite distant from the nearest transect, and therefore they are reported here (fig. 1, table 2).

Observations on the host selection of the Painted Lady were made systematically from three transects ("El Cortalet", "Can Liro" and "El Puig", see table 1) in 1994-1996, searching for eggs and larvae and following ovipositing females. The larvae are easily detected as they form characteristic tents by spinning together the edges of one or more host leaves. These tents are conspicuous long after the larva has departed. Additional data were obtained from other transects and also from a short stay in the Pyrenees (near the village of Caregue, Pallars Sobirà, at 1,300 m) in August 1996. The larval foodplants were subsequently classified in three different categories according to the frequency with which they were used at

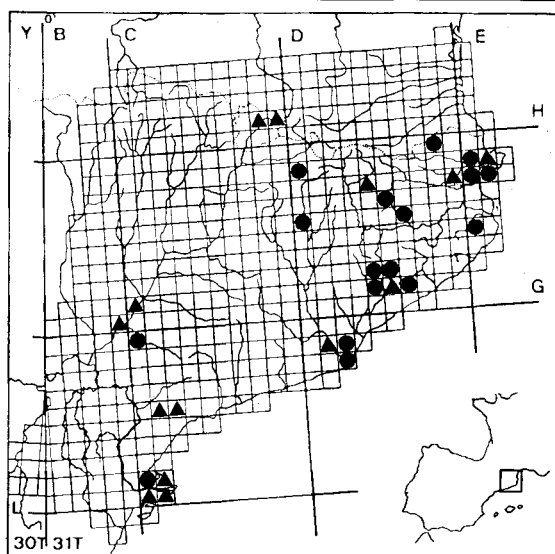


Fig. 1. Location of the BMS sites (●) and other sites where *Cynthia cardui* migration was observed in 1996 (▲). Note that some circles correspond to more than one BMS site (cf. table 1).

Situación de las estaciones del BMS (●) y de otras localidades donde se observó la migración de Cynthia cardui en 1996 (▲). Algunos círculos corresponden a más de una estación del BMS (cf. tabla 1).

Table 1. Station data for the recorded BMS transects: Alt. Altitude (in m); Phy. Phytogeographical zone; UTM, 10x10 km. AEm. Alt Empordà; Be. Berguedà; BEb. Baix Ebre; BEm. Baix Empordà; BLI. Baix Llobregat; Ce. Cerdanya; Ga. Garrotxa; VOc. Vallès Occidental; VOr. Vallès Oriental; Se. Segrià.

Datos relativos a las estaciones del BMS. (Para las abreviaturas ver arriba.)

Site	County	UTM	Alt	Phy	Ecosystem	Years
El Cortalet	AEm	31TEG07	0	coastal	coastal wetland	1988-96
La Rubina	AEm	31TEG17	0	coastal	coastal wetland	1988
Vilaüt	AEm	31TEG08	0	coastal	riparian forest	1989
Closes de l'Ullal	AEm	31TEG08	10	coastal	riparian forest	1996
El Remolar	BLI	31TDF27	0	coastal	coastal wetland	1994-96
Cal Tet	BLI	31TDF27	0	coastal	coastal wetland	1994-96
La Marquesa	BEb	31TCF01	0	coastal	coastal wetland	1995-96
Can Ferriol	BLI	31TDF28	200	mediterranean	evergreen oak forest	1994-96
Turó d'en Fumet	VOc	31TDF28	300	mediterranean	evergreen oak forest	1996
Can Riera	VOr	31TDG61	275	mediterranean	evergreen oak forest	1994-96
Can Liro	VOr	31TDG41	300	mediterranean	evergreen oak forest	1994-96
Santa Susanna	VOr	31TDG42	700	mediterranean	evergreen oak forest	1994-96
Can Prat	VOr	31TDG52	450	mediterranean	evergreen oak forest	1995-96
La Barroca	Ga	31TDG65	445	mediterranean	evergreen oak forest	1995-96
Fitor	BEm	31TEG04	200	mediterranean	evergreen oak forest	1994-96
Darnius	AEm	31TDG89	200	mediterranean	evergreen oak forest	1994-96
El Puig	VOr	31TDG52	1000	eurosiberian	oak and beech forests	1994-96
Can Jordà	Ga	31TDG56	600	eurosiberian	oak and beech forests	1994-96
Olván	Be	31TDG05	550	eurosiberian	oak and pine forests	1995-96
Turó de l'Home	VOr	31TDG52	1,675	subalpine	heath	1995-96
Font Llebrera	Ce	31TDG08	1,300	subalpine	subalpine meadows	1995-96
Timonedà d'Alfés	Se	31TCF09	250	continental	steppe	1995-96

each site: 1. Preferred (> 10 observations); 2. Regular (2-10 observations); 3. Occasional (one observation).

Nectar sources for the adults were studied in 1996 at the three most extensively surveyed sites. While walking the transect route all the butterflies seen nectaring and the feeding plant were recorded. The lack of sexual dimorphism in this species meant it was not possible to distinguish between the two sexes. Once a month (from March to September) the relative abundance of flowers of all species was also determined. Flower-heads of each species were ranked from 0 to 4: 0 (0 flower-heads); 1 (1-10); 2 (11-100); 3 (101-1,000); 4 (> 1,000) subjec-

tively whilst walking along each section of the transect. The relative abundance for the whole transect was then calculated as an arithmetic mean of the section abundances.

Results

Fluctuations of abundance

The Painted Lady was recorded in all the transects included in the BMS in 1994-96 ($n = 12$ in 1994, $n = 18$ in 1995, $n = 20$ in 1996), this being a consequence of its success in colonizing all kind of habitats. Though its presence was regularly recorded at each site, num-

bers fluctuated greatly depending on the season. In "El Cortalet", where data are available since 1988, the annual index ranged from 8 in 1993 to 209 in 1996 (fig. 2), thus showing a variation of more than one order of magnitude. Similar fluctuations have also been observed at the other sites of the BMS, as shown by the values of the collated index ranging from 100 in 1994 to 471 in 1996 (fig. 2).

One of the main characteristics of the fluctuations of the Painted Lady is the synchrony of population changes from site to site throughout the area. This synchrony was particularly noticeable in 1996, when numbers increased at all the sites (proportion of increases vs. decreases different from the equality at $p < 0.001$, binomial test). In 1995 there was also a generalized increase of the

Table 2. Major migrations of *Cynthia cardui* recorded in 1996: A. At BMS sites; B. By casual observers at other sites (County in brackets): Alt. Altitude (m); Flight. Flight direction; UTM, 10x10 km. An. Andorra; Br. Barcelonès; Ma. Mallorca (Balearic Islands); Mn. Montsià; Pr. Priorat; Ri. Ripollès. (For other abbreviations see table 1.)

Principales migraciones de Cynthia cardui registradas en 1996: A. En estaciones del BMS; B. En otras localidades (la comarca entre paréntesis). (Para las abreviaturas ver arriba y tabla 1.)

A			
Sites	Date	Local time	Flight Observations
El Cortalet (AEm)			
	20 V	11.15-13.15	N
	14 VI	11.10-13.50	N High numbers nectaring on <i>Rubus ulmifolius</i>
	20 VIII	10.30-12.50	N, S
	4 IX	11.00-13.30	W
Cal Tet (BLI)			
	8 V	10.00-12.00	N High numbers nectaring on <i>Galactites tomentosa</i>
	17 V	10.00-12.00	N High numbers nectaring on <i>Galactites tomentosa</i>
La Marquesa (BEb)			
	26 V	9.45-11.00	N High numbers nectaring on <i>Scabiosa atropurpurea</i>
	4 VI	9.15-10.45	- Thousands nectaring on <i>Scabiosa atropurpurea</i>
Can Liro (VOr)			
	7 V	11.00-17.00	N Estimated numbers: 2,672 ex. flying over a 80 m E-W line
	19 VIII	11.15-12.15	NWW 26 ex. flying over a 20 m NE-SW line
Can Prat (VOr)			
	28 V	12.30-12.45	N 119 ex. flying over a 30 m E-W line High numbers nectaring on <i>Cistus salviifolius</i>
Darnius (AEm)			
	13 VI	10.30-12.00	N
El Puig (VOr)			
	18 IV	11.45-12.55	N
	25 IV	12.10-13.10	N
	27 V	11.30-13.15	N
	10 VI	11.15-13.15	N Together small numbers of <i>Vanessa atalanta</i>
	18 VIII	10.30-12.30	W

Tabla 2 (cont.)

B						
Sites	UTM	Alt.	Ecosystem	Date	Local time	Flight Observations
4-5 miles off Cap Blanc (Ma)						
		0	marine	30 V-4 VI	10-12 h	N swarms of thousands of indiv. flying at 3-4 m.o.s.
Marina de Lluçmajor (Ma)						
		0	coastal line	30 V-4 VI	-	N
Les Llaunes beach near "El Cortalet" (AEm)						
31TEG07		0	coastal line	27 V 4 IX	11-12 h 15-16 h	- High numbers on flowers Hundreds nectaring on <i>Inula crithmoides</i> and <i>Cakile maritima</i>
Ebro Delta (BEb/Mn)						
31TCF01		0	coastal wetland	23 IV	-	- Thousands seen in the whole Delta
31TCF10						
Les Torroelles-Vilaüt (AEm)						
31TEG18		60	evergreen oak forest	13 VI	19 h	N
Figueres (AEm)						
31TDG97		40	evergreen oak forest	13 VI	10 h	N
Marçà / Torre de Fontaubella / Mola de Collejou (Pr)						
31TCF15/25		315-900	evergreen oak forest	26 VI	9-17 h	N Estimated numbers in a 5 km front: > 500,000
Llinars del Vallès (VOR)						
31TDG51		200	evergreen oak forest	7 V	12 h	N
Barcelona (Br)						
31TDF27		0	urban	7 V	9.30 h	- Nearly 80 ex. and 1 ex. of <i>Vanessa atalanta</i> resting on a bush
Barcelona (Br)						
31TDF28		50	urban	17 V	-	N About 20 ex. in 5 min flying at 4-5 m in Casanovas Street
Cervelló (BLI)						
31TDF18		122	urban	3-5 VI	10.30-16.30 h	N Uninterrupted pass during three days with stronger freq. at 12.30-15.30 h
Coll de Sentigosa (Ri)						
31TDG47		1,060	Scotch pine forest	27 V	12 h	N
Pla de Sorteny (An)						
31TCH81		2,000	alpine meadows	V	-	N
Vall d'Incles (An)						
31TCH91		1,700-1,900	alpine meadows	V	-	N
Lleida-Alcarràs (Se)						
31TCG01		130-220	steppe	23 IV	16 h	N
31TBG90		130-220	steppe	23 IV	16 h	N

populations at most sites, but the proportion of increases vs. decreases (9 vs. 3) was not significantly different from the equality ($p = 0.054$). This synchrony is due to the close relationship between the counts at a particular place during a specific period and the level of migration in general terms occurring throughout the whole area that particular year.

Migratory pattern

The seasonal abundance of the Painted Lady is shown in figure 3a-c. Although some differences exist between the years, a general pattern can be detected. Until April, *C. cardui* is recorded sporadically or not recorded at all. Towards the end of this month however the numbers rise considerably and may reach a distinctive small peak before the following months (e.g. in 1995). In most cases, these individuals are early migrants, as shown by their sudden appearance at a given locality, their poor condition and, occasionally, by their directional flight. The highest counts are invariably reached in May and June, coinciding with the mass arrival of migrants flying northward. Migratory waves of this species at the end of spring are particularly conspicuous and have been well documented at many of the BMS sites in the period 1994-96 (e.g. STEFANESCU et al., 1996, and see below). From July onwards, individuals are regularly seen in most transects but the population levels remain quite low. Nevertheless, high numbers have been recorded at individual sites in some years during August, possibly as a result of local migrations to mountain areas or even in a westward direction.

Although the recording season of the BMS is finished by the end of September, the counts have been extended until October and even November in some transects. These samples have shown that a few individuals are usually on the wing until late in these months, though their presence is always subject to weather conditions. Indeed, the scarcity of records early in the spring indicates overwintering adults are quite exceptional, and may only occur in years with abnormally mild winters or at particularly sheltered areas. This also holds for the immature stages, which are usually killed by the winter cold (pers. obs.).

Although the highest counts at any one site reflect the mass arrival of butterflies, the

migratory process has been reported only infrequently by the recorders. This may partly be due to the fact that the recorders do not pay particular attention to the behaviour of the butterflies they count, but also because the migrants may remain in an area a few days without showing migratory behaviour if there is a good availability of nectar sources or if the weather does not allow further long distance flight. Nevertheless some reports are available both from the transects and from other sources (table 2).

All migrations reported from April to June were invariably in a northward direction, independent of such factors as distance from the sea (fig. 1), topography, wind direction or time of day. Observations of summer migrations were scarce, but seemed to indicate a change in the flight to a predominantly westerly component (table 2).

Data from table 2 also show that the spring arrivals occur in many independent migratory waves that can last several days and extend over several tens of km. A good example is provided by the strong migration detected in the Alt Empordà county on 13-14 June. Individuals flying northward were first seen in Figueres at 10 a.m. At 10.30 a.m. migrants were observed in Darnius, near the border with France. The same afternoon, at 7.00 p.m., a marked move was recorded in Les Torroelles-Vilaüt, in Aiguamolls de l'Empordà Natural Park. The following morning the counts from "El Cortalet", the highest in the eight year period of available data, showed the migration still to be occurring. On 15 June, the directional flight had finished and only a few examples were seen while walking the same transect. Although no attempts were made to determine the exact extent of this migration front, it can be assured that at least covered 40 km wide in two consecutive days.

Feeding resources of the larvae

The hostplants recorded at several sites are listed in table 3. Eggs or larvae have been found on 21 plant species belonging to five different families but mainly the Compositae. It can be concluded that the Painted Lady is a polyphagous species, which uses a wide range of hostplants from several families.

Notwithstanding this polyphagy, the data show a clear hostplant preference rank.

Thus, in most sites *Malva sylvestris* can be considered as the main hostplant, while *Carduus nigrescens*, *Cirsium arvense*, *Cirsium vulgare*, *Galactites tomentosa* and *Silybum marianum* are also used with a high frequency whenever available. Such species as *Urtica dioica*, *Plantago lanceolata*, *Arctium minus* or *Picris echioides* are only rarely used, and in several occasions a female was seen to refuse to lay eggs after an inspection of these plants.

Nectar sources for the adults

A wide range of flowers were visited by the adults, but there was a clear preference for some of them (table 4). Thus, the Painted Lady was seen nectaring on only between 23.3-31.5% of the plant species available, that is, those plants that were recorded as nectar sources for other butterflies.

Moreover, within each site the use of nectar sources was basically limited to a few species that changed during the season according to their abundance and availability (fig. 5). These preferred plants accumulated as much as 50% or more of the observations made during their flowering period and only

in a few cases (e.g. *Galactites tomentosa* and *Carduus nigrescens*) they coincided in being commonly used larval food plants.

Although data from other areas are very fragmentary, the preference for a few nectar sources seems to be the norm. In the Ebro Delta, for example, large concentrations are recorded on *Scabiosa atropurpurea* coinciding with the mass arrival of migrants (table 2; M. Cebolla, pers. comm.), while in the Llobregat Delta this same species together with *Galactites tomentosa* are highly preferred (table 2; M. Lockwood, pers. comm.).

Discussion

C. cardui is a subtropical continuously-brooded species in which migration is an alternative to a diapause as a means of surviving climatic extremes (WILTSHIRE, 1949; LARSEN, 1976; MAIER & SHREEVE, 1996). In the Palaearctic zone its main permanent centre is on the edges of the desert bands of North Africa, Arabia and central Asia, while its regular permanence within Europe remains doubtful (BRETHERTON & EMMET, 1990)

Although *C. cardui* is a regular breeder

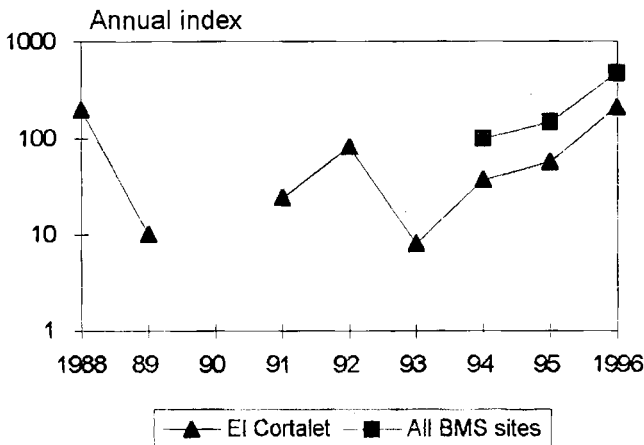


Fig. 2. Fluctuations in index values of *Cynthia cardui* in "El Cortalet" (period 1988-96, except 1990) and all sites (period 1994-96).

Fluctuaciones de los índices anuales de Cynthia cardui en El Cortalet (período 1988-96, excepto 1990) y para todas las estaciones (período 1994-96).

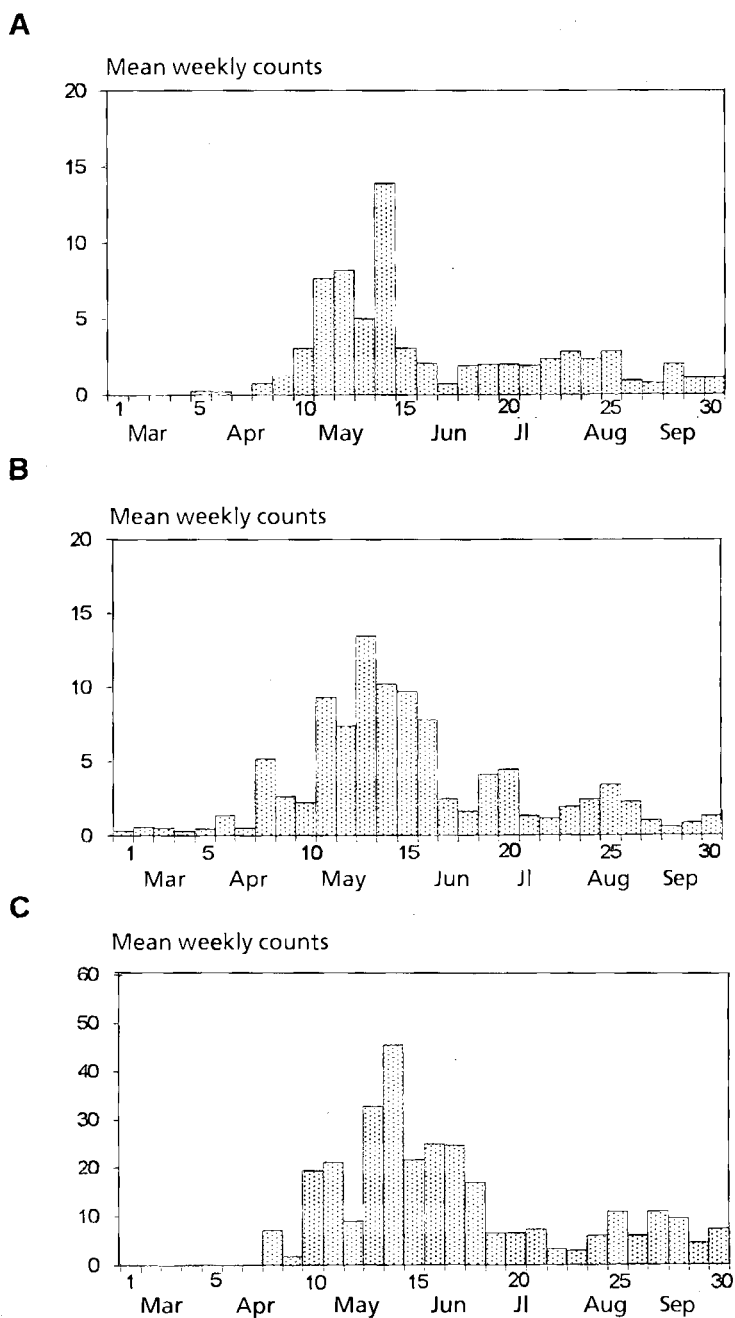


Fig. 3. Mean weekly counts per site of *Cynthia cardui* in (A) 1994 (n = 12 sites), (B) 1995 (n = 18 sites), and (C) 1996 (n = 20 sites).

Medias de los recuentos semanales de Cynthia cardui por estación de muestreo en (A) 1994 (n = 12 estaciones), (B) 1995 (n = 18 estaciones), y (C) 1996 (n = 20 estaciones).

Table 3. Host plants used by *Cynthia cardui* at different studied sites: 1. El Cortalet; 2. Can Liro; 3. El Puig; 4. Closes de l'Ullal; 5. Can Prat; 6. Cal Tet. 7. Caregue. Observations on the host selection were made systematically at "El Cortalet", "Can Liro" and "El Puig" from 1994-1996, searching for eggs and larvae and following ovipositing females. The larval foodplants were subsequently classified in three different categories according to the frequency with which they were used at each site: 1. Preferred (> 10 observations); 2. Regular (two to 10 observations); 3. Occasional (one observation). The symbol "-" means that the plant is present at the site but no eggs or larvae have been recorded from it, "+" indicates additional observations made at other sites. The nomenclature used for plants follows Bolòs et al. (1990).

Plantas nutricias utilizadas por Cynthia cardui en diferentes localidades estudiadas: 1. El Cortalet; 2. Can Liro; 3. El Puig; 4. Closes de l'Ullal; 5. Can Prat; 6. Cal Tet. 7. Caregue. Las observaciones respecto la selección de plantas nutricias se llevaron a cabo sistemáticamente en las estaciones El Cortalet, Can Liro y El Puig entre 1994-1996, buscando huevos y larvas y siguiendo hembras en ovoposición. Las plantas nutricias se clasificaron posteriormente en tres categorías distintas de acuerdo con la frecuencia con que fueron utilizadas en cada localidad: 1. Preferida (> 10 observaciones); 2. Regular (dos a 10 observaciones); 3. Ocasional (una observación). El símbolo "-" indica que no se encontraron huevos o larvas en una planta que estaba presente en una determinada estación de muestreo, "+" indica observaciones adicionales realizadas en otras localidades. La nomenclatura utilizada para las plantas está basada en Bolòs et al. (1990).

Host plant	1	2	3	4	5	6	7
Malvaceae							
<i>Malva neglecta</i>			2				+
<i>Malva sylvestris</i>	1	1	1	+	+	+	
<i>Althaea officinalis</i>	-			+			
Urticaceae							
<i>Urtica dioica</i>	-	-	3				
Boraginaceae							
<i>Echium vulgare</i>		-	2				
Plantaginaceae							
<i>Plantago lanceolata</i>	-	-	3				
Compositae							
<i>Filago minima</i>			3				
<i>Gnaphalium luteo-album</i>					+		
<i>Carlina acaulis</i>							+
<i>Arctium minus</i>	3	-	3				
<i>Carduus tenuiflorus</i>		2					
<i>Carduus nigrescens</i>			1				
<i>Cirsium vulgare</i>	1	1				+	
<i>Cirsium eriophorum</i>							+
<i>Cirsium monspessulanum</i>						+	
<i>Cirsium arvense</i>	1						
<i>Galactites tomentosa</i>	1	1				+	
<i>Onopordum acaulon</i>							+
<i>Cynara scolymus</i>		2					
<i>Silybum marianum</i>	1						
<i>Picris echioides</i>	-	3					

and one of the commonest butterflies in Catalonia, its presence in this area is highly dependent on the arrival of migrants from the south each spring. The monitored areas show that overwintering adults are negligible, and that populations begin to build up at the end of April or, more frequently, in May and June coinciding with the major migrations (fig. 3). This pattern highly contrasts with that belonging to other related species (e.g. *Nymphalis antiopa*, *N. polychloros*, *Inachis io*, *Aglais urticae* and *Polygonia c-album*) that overwinter as adults and regularly appear during the first BMS counts taking place in March and early April.

Moreover, the counts for the Painted Lady show abrupt changes in magnitude which can only be explained by the mass arrival of migrants. This is particularly evident when a week with no records is followed by another with one of the highest counts for the whole season.

In figure 4 weekly counts of the Painted Lady and the Peacock, *Inachis io*, in one BMS site have been plotted to show their contrasting patterns. As usual for every season, in 1997 overwintering individuals of the Peacock were recorded in March and early April, at the time that mating and egg-laying take place. This species usually has two generations in southern Europe (PULLIN, 1986), the first brood emerging in late May and June and the second one during July and August (fig. 4b). Although the Peacock is a highly mobile species, its presence at this site does not depend on the arrival of migrants from other areas. Therefore both broods were easily recognized as a steady rise to a peak during the brood's emergence, followed by a decline as individuals died or entered hibernation.

The phenological pattern of the Painted Lady is very different from that of the Peacock (fig. 4a). No overwintering butterflies were detected early in the season, and the first individuals recorded by the end of April were migrating in a northward direction (table 2). Strong migrations were also detected in weeks 13 at 15, but only a few butterflies were recorded in week 14. Later in the summer, highly counts were made by the end of July. It is doubtful, however, whether this peak of abundance was the progeny of early immigrants in late May and early June or was

the result of local migration from other nearby lowland sites, or both. The last individuals recorded in week 25 were migrating in a westward direction.

Although further research on this subject has to be conducted, the available data seem to indicate that the Painted Lady cannot overwinter successfully in the northeast of the Iberian peninsula. In fact, captive adults are reported to die at temperatures of 5°C or less, unlike those belonging to other related species (HEATH et al., 1984). Larvae and pupae cannot either survive at low temperatures (e.g. BRETHERTON & CHALMERS-HUNT, 1989; THOMAS & LEWINGTON, 1991; TYSON, 1997) and therefore winter survival of the immature stages is probably a very rare event and may take place only during abnormally mild seasons or at particular sheltered sites.

Interestingly, the earliest records in the year for the Painted Lady in "El Cortalet" were obtained in 1995 (21 and 24 March). The previous November was exceptionally hot (mean of the maximal temperatures 19.41°C, mean of the minima temperatures 9.09°C, in contrast to mean values of 13.77°C and 7.36°C for the period 1989-96), probably allowing an additional autumn brood to take place. The winter was also abnormally mild (mean of the maximal temperatures 15.17°C, mean of the minima temperatures 4.3°C, in contrast to mean values of 13.77°C and 3.35°C for the period 1989-96) almost certainly allowing moderate numbers to survive the unfavourable season and be detected before the first migrations occurred. This situation was reproduced throughout the whole area, and the Painted Lady was recorded, in low numbers, in March and at the beginning of April from many of the BMS sites (fig. 3b).

The migrations of the Painted Lady in the northeast of the Iberian peninsula occur principally during the months of April and especially in May and June (fig. 3, table 2). At this time, the migrants invariably fly in a northward direction, their flying behaviour being fully coincident with that reported by other authors (ABBOT, 1951; TILDEN, 1962). The precise origin of the migrants remains unknown, but the majority almost certainly originate from the edges of the deserts of North Africa. This area provides a similar habitat to that found in the Arabian peninsula and, to a lesser extent, in the Baja California

Table 4. Flower feeding of *Cynthia cardui* at three studied sites in 1996. Observations were made while walking the transects once a week between March and September. The plants available are defined as those used by the whole butterfly community in those months when *C. cardui* was recorded at each site (May-September in "El Cortalet"; April-September in "Can Liro" and "El Puig").

Flores visitadas por Cynthia cardui en tres localidades en 1996. Las observaciones se hicieron mientras se recorrían los transectos una vez a la semana entre marzo y septiembre. Las plantas disponibles son aquellas utilizadas por alguna especie de la comunidad de ropalóceros durante los meses en que se detectó C. cardui en cada localidad (mayo-septiembre en El Cortalet; abril-septiembre en Can Liro y El Puig).

Nectar source	El Cortalet	Can Liro	El Puig
<i>Clematis vitalba</i>			2
<i>Sedum spectabile</i>		3	
<i>Rubus ulmifolius</i>	33		
<i>Rubus</i> sp.		1	24
<i>Medicago sativa</i>		10	
<i>Trifolium fragiferum</i>	13		
<i>Trifolium pratense</i>	4		1
<i>Erysimum grandiflorum</i>			6
<i>Malva sylvestris</i>		1	
<i>Daucus carota</i>	1		
<i>Erica arborea</i>			2
<i>Buddleja davidii</i>	14	26	
<i>Origanum vulgare</i>			2
<i>Thymus vulgaris</i>		3	
<i>Thymus serpyllum</i>			5
<i>Sambucus racemosa</i>			1
<i>Dipsacus fullonum</i>	1		
<i>Scabiosa columbaria</i>			14
<i>Jasione montana</i>			16
<i>Bellis perennis</i>		1	
<i>Inula crithmoides</i>	7		
<i>Inula viscosa</i>	4		
<i>Anthemis</i> sp.			3
<i>Carduus tenuiflorus</i>		1	
<i>Carduus nigrescens</i>			16
<i>Cirsium vulgare</i>		1	
<i>Cirsium arvense</i>	1		
<i>Galactites tomentosa</i>	19	9	
<i>Centaurea pectinata</i>			2
<i>Mantisalca salmantica</i>			45
<i>Hypochoeris radicata</i>			1
<i>Leontodon taraxacoides</i>		1	
<i>Reichardia picroides</i>		2	
<i>Taraxacum officinale</i>			2
<i>Ornithogalum umbellatum</i>			1
Number of observations	97	59	143
Plant species used/available	10/43 (23.3%)	12/46 (26.1%)	17/54 (31.5%)

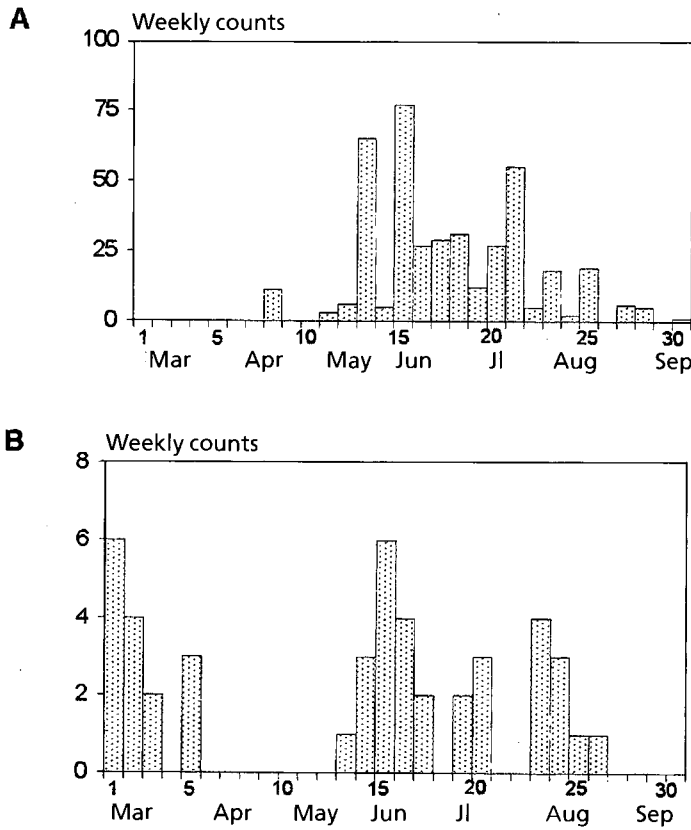


Fig. 4. Seasonal occurrence of (A) *Cynthia cardui*, 1996, and (B) *Inachis io*, 1997, in "El Puig" to show their contrasting phenological patterns.
Distribución temporal de (A) Cynthia cardui, 1996, y de (B) Inachis io, 1997, en El Puig que evidencia unas marcadas diferencias fenológicas entre ambas especies.

deserts, from where mass concentrations of larvae and mass eclosions have been described in April prior to presumably northward migrations (ABBOT, 1951; LARSEN, 1982; LARSEN & NAKAMURA, 1983). Large-scale winter breeding has been reported from the Canary Islands and Crete by OWEN (1987, 1989), and this author suggested that these islands could also be a primary source of migrants.

The assumption that migrants arriving to the northeast of the Iberian peninsula come from the African continent across the Mediterranean sea, is supported by several observations made from boats off the coast and also by the big hordes that regularly con-

centrate at the Catalan seashore and the Balearic Islands (table 2). Small number of migrants have been previously reported 10-30 miles off Tarragona and 10 miles off Eivissa at the end of May 1992, coinciding with the highest BMS counts recorded at "El Cortalet" (a Catalan coastal site) that year (STEFANESCU, 1992). Between 30 May and 4 June 1996 thousands of individuals were observed by a fisherman flying northward 4-5 miles off the south coast of Mallorca; the same days swarms of hundreds of thousands or even millions were reported from several seashore sites of the island (J. Mayol & M. Munar, pers. com.).

When coming off the sea, the butterflies

may remain a few days near the coastline if the weather does not permit further migratory flight or simply to recover from the long distance travelled. Plants such as *Galactites tomentosa* and *Scabiosa atropurpurea* provide an important nectar resource for the butterflies at this time, before their northward migration is resumed. The observations made in 1996 (table 2) are indicative that subsequent migration takes place throughout the Catalan territory independent of factors such as distance from the sea and topography (fig. 1). Migrations have been reported, for example, from the Pre-Pyrenees and the Pyrenees at heights of 1,000-2,000 m (table 2).

The importance of the spring migrations is, however, highly dependent on the particular year. The evolution of the annual index in "El Cortalet" between 1988-96 is characterized by strong oscillations that can be related to the greater or lesser extent of the migrations in the rest of Catalonia and also on an European scale (fig. 2). Thus, the high count of 1988 coincided with spectacular migrations detected at many European countries and reported in short notes in several entomological journals (e.g. CAMPBELL, 1988; GOATER, 1988; LARSEN, 1988, 1989; BIGOT, 1989; BOUDINOT, 1989; BRETHERTON & CHALMERS-HUNT, 1989; RUNGS, 1989; TOLMAN, 1989; MÉRIT, 1990; STEINIGER & EITSCHBERGER, 1990; HUCHET, 1991). In 1996 very strong migrations were observed again throughout Europe (ALBOUY, 1996; ROPER, 1996; POLLARD et al., submitted), the annual index in "El Cortalet" was the highest recorded up till now and the Painted Lady was also recorded in high numbers at the other BMS sites (fig. 2).

In Catalonia, breeding regularly occurs as soon as the migrants arrive. Egg-laying has been observed while the migration is actually taking place (pers. obs.) or shortly after, at any place where the foodplants are available. As shown in this paper a wide range of foodplants are used (table 3), although some of them are clearly preferred (e.g. *Malva sylvestris*, *Galactites tomentosa*, *Carduus* spp. and *Cirsium* spp.). *Malva sylvestris*, in particular, seems to be the most widely used foodplant in Catalonia, and this is hardly surprising considering *C. cardui* has been recorded as a serious pest of *Malva parviflora*, a closely related species cultivated for food in the Nile delta (LARSEN, 1990).

There is no doubt that many other species could be added to table 3 if additional surveys were conducted in a wider diversity of natural habitats or if the same sites were more intensively studied. Thus, for example, lists comprising an impressive number of plants have been provided in the reviews of ACKERY (1988) and WHITEBREAD (1988). Most of these plants are typically found at the early seral stages and are characteristic of the ruderal and nitrophyllous plant associations. As stated by WARREN (1986), the plants selected are usually growing in fairly exposed conditions such as open over-grazed fields, field margins and improved pasture.

In our area is not possible to identify a definite number of generations (fig. 3a-c), because of the successive arrival of migrants during the spring months, the additional local produced offspring and the variability of the weather conditions both in mid-summer (as a severe drought means a low availability of foodplants and a subsequent emigration of the examples from a particular site) and in autumn allowing the completion of further generations. Under laboratory conditions eight annual broods have been obtained in Egypt (HAMMAD & RAAFAT, 1972), but according to LARSEN (1976) this number is never achieved in the field because of the difficulty of the larvae to survive the hot summer and possibly also the winter. In the study area, breeding experiments outdoors have shown that completion of the whole cycle takes between six to eight weeks, depending on the temperature (unpubl. data). Therefore, at the coastal sites and in many Mediterranean habitats three to four generations (from April to October in an average year) may be a usual number.

An aspect of the migration pattern of the Painted Lady that remains obscure is the existence of a return flight in late summer or in autumn. In their classification of migrant Lepidoptera, EITSCHBERGER et al. (1991) considered *C. cardui* as an emigrant or seasonal migrant of first order, that is, a species that migrates northward during the spring and southward later in the season back to the original breeding grounds. Although this southward migration has not been clearly detected in the synthesis works carried out by many authors in areas as distant as North America, Europe and the Middle East (ABBOT,

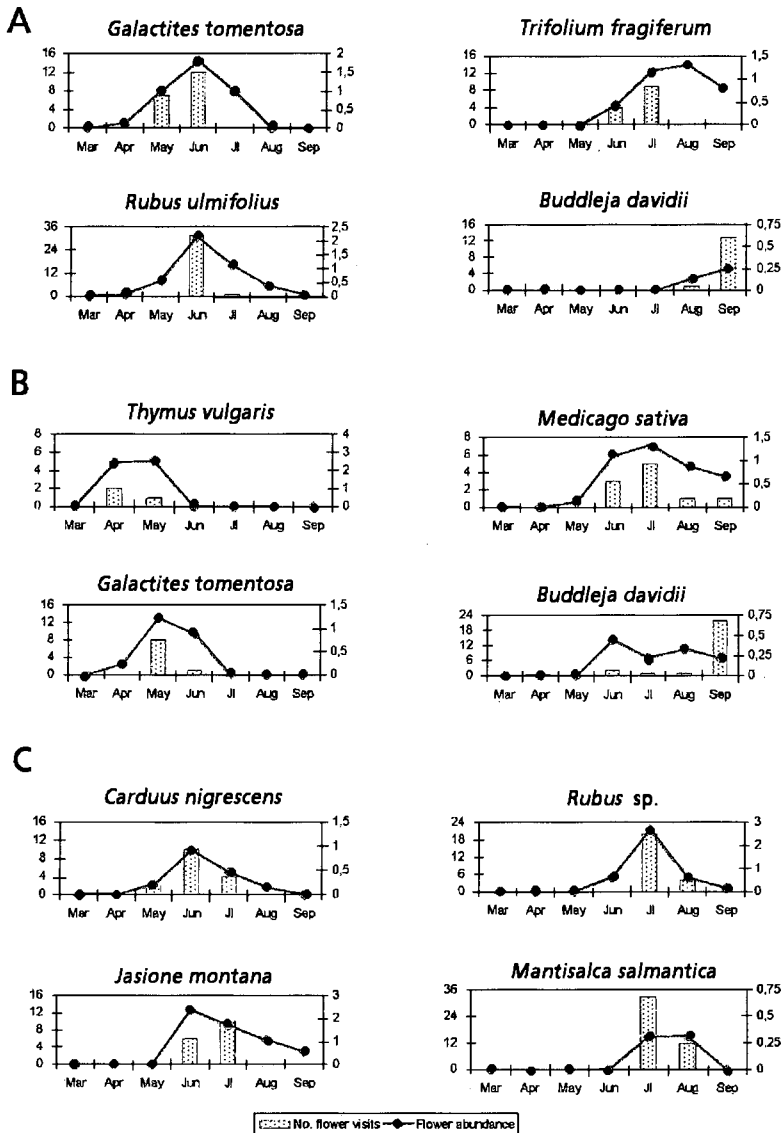


Fig. 5. Seasonal distribution of flower visits and flower abundance for the main nectar resources of *Cynthia cardui* at three studied sites: (A) "El Cortalet", (B) "Can Liro", (C) "El Puig". Flower abundance (expressed in a scale from 1-4) was assessed once a month in each section, and subsequently a mean for the whole transect was calculated (see the text for more details).

Distribución temporal de las visitas a las fuentes de néctar y abundancia de las especies más utilizadas por Cynthia cardui en tres estaciones seleccionadas: (A) El Cortalet, (B) Can Liro, (C) El Puig. La abundancia de las flores (expresada en una escala de 1-4) se obtuvo una vez al mes en cada sección, calculándose posteriormente una media para todo el transecto (ver el texto para más detalles).

1951; WILLIAMS, 1951; TILDEN, 1962; LARSEN, 1976; POLLARD et al., submitted), some contradictory reports indicate the existence of such a movement (e. g. BAKER, 1969, 1972; SHAPIRO, 1980; MYRES, 1985; RENNWALD, 1987).

The data obtained in Catalonia do not show a southward return flight, although some changes in direction have been noted at the end of summer (table 2). Thus, an increased frequency of westerly flights was recorded in August and September, coinciding with the tendency reported for the British Isles by WILLIAMS (1951). The meaning of these directional flight is not clear, but they do not seem to represent a true return migration as noted in other species such as *Pieris brassicae*, *Colias croceus* or *Vanessa atalanta* (LACK & LACK, 1951; WILLIAMS, 1951; TEMPLADO, 1977; BENVENUTI et al., 1994; STEFANESCU et al., 1996).

Although further research will help to clarify this point and will provide additional information on other aspects related to the ecology of the Painted Lady, its general migration pattern and its feeding resources are now quite well established in the northeast of the Iberian peninsula. Nevertheless, as the movements of this species are on a very broad geographical scale, it is clear that co-operation between entomologists from different countries will be necessary before a full understanding of the process is attained. In this respect butterfly monitoring will undoubtedly play a predominant role, especially considering that the existence of the standard Butterfly Monitoring Scheme methodology provides comparable data from several European countries. In this respect, a first quantitative analysis of the migration of the Painted Lady in an European scale is at present in preparation combining data from England, Holland, Finland and Catalonia (POLLARD et al., submitted).

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Resumen

Modelo migratorio y recursos tróficos de Cynthia cardui (L.) (Lepidoptera: Nymphalidae) en el noreste de la península ibérica

Cynthia cardui (L.) es un lepidóptero subtropical que periódicamente efectúa migraciones a gran escala desde los extremos de las zonas desérticas hacia latitudes más septentrionales. Durante 1988-89 y 1991-96 se obtuvieron datos cuantitativos de su abundancia en Catalunya (noreste de la península ibérica), utilizando la metodología estandarizada del Butterfly Monitoring Scheme (fig. 1, tabla 1). Este área del Mediterráneo occidental es presumiblemente una ruta migratoria importante para la especie, ya que conecta el continente africano con Europa central y septentrional. *C. cardui* apareció regularmente en todo tipo de hábitats, si bien su abundancia fluctuó enormemente según la temporada considerada (fig. 2). Se observó una fuerte sincronía en los cambios poblacionales en las distintas estaciones de muestreo, fiel reflejo de la intensidad de las migraciones que tienen lugar en todo el área en un determinado año. Los datos ponen de manifiesto un patrón fenológico muy claro (figs. 3-4). La hibernación de los adultos y de los estadios inmaduros es prácticamente insignificante, y el aumento de las poblaciones coincide con la llegada de las migraciones masivas con dirección norte que tiene lugar al final de la primavera (tabla 2). Durante el verano y el otoño los niveles poblacionales se mantienen bajos y, al con-

trario de lo que ocurre con otros lepidópteros, no se observa un vuelo migratorio de retorno con dirección sur. Durante este estudio también se obtuvieron datos sobre los recursos tróficos de las larvas y de los adultos. Aunque *C. cardui* es una especie altamente polífaga, las larvas muestran una clara preferencia por determinadas especies, siendo *Malva sylvestris* el principal alimento en muchas localidades (tabla 3). Del mismo modo, en cada localidad las fuentes de néctar preferidas se reducen a unas pocas especies, que se suceden a lo largo de la temporada de acuerdo con su abundancia y disponibilidad (fig. 5, tabla 4).

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