Geometrid larvae and their food-plants in the south of Madrid (Central Spain) (Geometridae)

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Abstract. Between January 2004 and May 2006 15 plant species were inspected for geometrid larvae in the gypsym soils of Ciempozuelos (Madrid, 600 m), which resulted in the collection of 1,625 larvae (25 species; four subfamilies). Although Sterrhinae larvae were only represented by seven species, their abundance was important numerically, with 497 individual larvae (35.8%) taken, of which just two species: *Scopula asellaria dentatolineata* (Wehrli, 1926) and *Casilda consecraria* (Staudinger, 1871) provided 486 specimens (29%) of the total. In the Larentiinae, in contrast, a mere of 173 individual larvae were collected (16.5%), whilst in the Ennominae, there were 503 larvae collected (36%), 282 (17%) individuals corresponding to just one species: *Petrophora convergata* (Villers, 1789). The study also looked at whether the species in question were monophagous, oligophagous or polyphagous; it has been difficult to come to a definitive conclusion with some species for example, *Camptogramma bilineata* (Linnaeus, 1758) and *Hospitalia flavolineata* (Staudinger, 1883) did not accept in captivity the plants on which they were found in or under in the wild. Three species: *Idaea incisaria* (Staudinger, 1892), *Idaea longaria* (Herrich-Schäffer, 1852) and *Idaea cervantaria* (Millière, 1869) cannot be placed into any of these categories, as they are detrivores. Of the other 20 species in the sample, 13 species can be regarded as monophagous (65%), 7 species as polyphagous (35%).

Resumen. Entre enero 2004 y mayo 2006 se inspeccionaron 15 especies de plantas para la recolección posterior de larvas en la familia Geometridae en Ciempozuelos (Madrid, 600 m) ubicada en suelos yesosos. Como resultado se recogieron 1.625 larvas (25 especies; cuatro subfamilias). A pesar de su representación faunística relativamente baja en la Sterrhinae, con siete especies recogidas, tenía un peso cuantativamente importante, con 497 larvas (35,8%) recogidas, de las cuales dos especies: *Scopula asellaria dentatolineata* (Wehrli, 1926) y *Casilda consecraria* (Staudinger, 1871) dieron 486 ejemplares (29%) del total. Sin embargo, la subfamilia Larentiinae, se vio representada únicamente por 173 larvas (16.5%), mientras, la subfamilia Ennominae se aportaron 503 larvas (36%), 282 (17%) de las cuales correspondía a una especie *Petrophora convergata* (Villers, 1789). Las estrategias alimenticias se refieren a monofagia, oligofagia o polifagia; es posible que no se haya llegado a una conclusión definitiva, ya que *Camptogramma bilineata* (Linnaeus, 1758) y *Hospitalia flavolineata* (Staudinger, 1883) no aceptaron las plantas por debajo de las cuales se encontraron en el estado silvestre. Tres especies: *Idaea incisaria* (Staudinger, 1892), *Idaea longaria* (Herrich-Schäffer, 1852) e *Idaea cervantaria* (Millière, 1869) no entran en ninguna de estas categorías porque son especies detrivoras. De las veinte especies restantes en la muestra, 13 especies son monófagas (65%) y 7 especies son polífagas (35%).

Introduction

Soria (1987), Gómez de Aizpúrua (1987; 1989), Domínguez & Baixeras (1995), Oltra et al. (1995), Gómez de Aizpúrua et al. (2003, 2005, 2006) and King (2000, 2002, 2004, 2005) have contributed to an understanding of the biology of a limited number of geometrids in the Iberian Peninsula, but if one considers the extraordinary richness of the Iberian fauna, there is something amiss. For example, the subfamily Sterrhinae has an important focus on the Mediterranean basin with 70% of the 196 European species recorded there (Hausmann 2004). Certain genera are well represented in the Iberian Peninsula,

for example, *Idaea* Treitschke, 1825 contains some 125 species in Europe, 115 being recorded from Iberia, with an important endemic component (Hausmann 2004). The genus *Scopula* Schrank, 1802 (with subgenus *Glossotrophia* Prout, 1913) is represented by seven species in the Mediterranean basin, reaching the steppes of central Asia, with two subspecies and one species in the Iberian Peninsula (Hausmann 1993, 2004).

Study area

The two localities which formed the basis for the collection of geometrid larvae were southeast of Madrid in the Tagus Valley: Ciempozuelos (40°09'09.1 N 003° 36'27.1W, 518 m) Cerros de Vallecas (40°21'09.1 N 003°40'42.6 W, 504 m). The Miocenic and Triassic gypsyperous soils are relatively frequent in the Iberian Peninsula in the Tagus and Ebro basins, and the south-east Peninsular (Ferrandis et al. 2005). The climate is Mesomediterranean, with important drought conditions from June to September. The little rain that falls does so in the spring (March–May), and in the autumn (September–November). In the winter, conditions of thermic inversion tend to prevail (Izco 1984). The general lack of precipitation and the corresponding aridity ensures that the influence of the gypsym soils is constant, with a consequential effect on the vegetation which is generally understood to be included in the botanic order Gypsophiletalia. This order includes three syntaxonomical alliances: *Lepidion subulati*, *Thymo-Teucrion verticillati* and *Gypsophilion hispanicae*; the first of these alliances is found in the centre and south of the Iberian Peninsula, occuring in both Madrid and Castilla-La Mancha (Rivas Martínez & Costa 1970). However, Ferrandis, Herranz & Copete (2005) question the validity of the alliance *Lepidion subulati* in the centre of the Iberian Peninsula, and that this supposed alliance coincides entirely with *Thymo-Teucrion verticillati* which includes such plants as: *Gypsophila struthium* L. in Loefl. (Caryophyllaceae), *Helianthemum squamatum* (L.) Dum. (Cistaceae), *Thymus lacaitae* Pau.(Labiatae) and *Lepidium subulatum* L.(Cruciferae).

Abbreviations

GEK Gareth Edward King
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Methodology

The study areas were visited at least once every six or seven days from January 2004 until the end of May 2006 (Cerros de Vallecas was incorporated into the study only from February 2006). All visits were made in the day, the intention being to avoid the extreme midday heat from mid-May to the end of August. On arrival an area of about 20 m^2 was chosen in which all plants were examined methodically and the space underneath each plant and the associated leaf litter were also searched in order to be able to locate those species which are regarded as detriphagous, especially those in the genus

Tab. 1. Larvae taken January 2004–May 2006; Ciempozuelos (Madrid). * includes data Cerros de Vallecas (Madrid, 600 m).

Year	2004	2005	2006*	2004–2006
Total per year:	584	672	346	1,625
Larvae not indentified:	2.2% (14 larvae)	1.3% (9 larvae)	0.6% (2 larvae)	1.5% (25 larvae)
Total species:	22	18	14	14

Idaea (Ryrholm, 1989). Larvae found were collected into a vial with details annotated as to the plant on which they were taken, as well as the stadia in which they were found, the latter being assessed according to larval size and morphology, which in some species e. g. *Phaiogramma etruscaria* (Zeller, 1849), is very characteristic. In captivity, larvae were generally kept in plastic boxes in an unheated room with the windows open, and a sprig of the food-plant in water, if this was regarded as necessary, along with dry vegetable matter so that the larvae could perch away from the plant. In some cases, such as the Sterrhinae, rearing was extremely easy. In others, such as the Ennominae, it was necessary to maintain the larvae in open net cages exposed to light and air, but even so, mortality rate was high. Another function of the leaf litter was to provide material for the larvae to pupate without disturbance, as well as structural support for the emerging insect. Inside the rearing containers labels were kept which indicated: date of pupation (when the larva either ceases to feed, begins wandering, evacuates its gut, changes cuticular colour, or begins to spin a cocoon), date of larval-pupal metamorphosis, date of emergence of imagines, pairing records etc. Where possible, all records of larval events were kept in a separate collection, with the material being maintained alongside in capsules and vials, including dead larvae in good condition (preserved in alcohol), pupal excuvia, and all records of hymenopterous or dipterous parasitoides (Diptera: Tachinidae; Hymenoptera: Braconidae, Ichneumonidae) for future studies.

Results

Between 25.i.2004 and 27.v.2006 130 visits were made (Ciempozuelos 121 visits; Cerros de Vallecas seven visits; Valdemoro two visits); 15 species of plants from 11 plant families were inspected. The total of larvae taken was 1,625 of 25 species; Table 1 indicates how many larvae were taken in each of the three years and the proportion of larvae which were not identified at the time of collection (a majority of specimens are preserved in alcohol for later analysis).

Systematic account

Taxonomic order and nomenclature according to Dantart (2000); Hausmann (2001, 2004); Scoble & Krüger (2002); Mironov (2003) and Sihvonen (2005).

Geometrinae Leach, 1815

Phaiogramma etruscaria (Zeller, 1849)

Published records of food-plants: *Quercus ilex* (Fagaceae), *Clematis vitalba* (Ranaculaceae) (Cuní i Martorell 1881); *Quercus* sp. (Fagaceae) (Rebel 1910; Forster & Wohlfahrt 1981); *Paliurus* (Rhamnaceae) (Schwingenschuss & Wagner 1926); *Pimpinella*, *Peucedanum*, *Seseli*, *Eryngium*, *Melilotus*, *Rosa* etc. (Carrara 1926–1928); *Gypsophila struthium* (Caryophyllaceae) (King 2000, 2002); *Ferula communis* (Apiaceae), *Retama sphaerocarpa* (Papilionaceae) (Gómez de Aizpúrua et al. 2003).

Food-plants recorded from the study area: In the summers of 2004 (73 larvae) until 2005 (163 larvae) 236 larvae of this species were taken in Ciempozuelos. The larvae of *P. etruscaria* utilise four different plants each one of these belonging to a different family, characteristic of a typical polyphage (Hering, 1950; Huemer, 1988). It is also floricolous, this species feeding on the flowers according to their availability over the summer. For example, *Ruta montana* (Rutaceae) has a very short flowering season (end of May to end of June), whilst *Gypsophila struthium* flowers are available from June until well into October, when the first autumn rains destroy the flowers. Even so, in 2004, the total of larvae found on *Ruta montana* was 21 (28. 8%); in 2005, 96 larvae (55. 5%) were found on this plant. The relation that the species maintains with *Gypsophila struthium* seems more stable: in the two-and-a-half years of the study (not including 2006 as the study finished at the end of May); in 2004, 48 larvae (65. 8%) were collected between the months of July and October on this latter plant, whilst in 2005, 42 larvae (24.3%) were collected between June and October. It is important to point out, however, that the availability of flowers is not absolutely necessary: for example considering *P. etruscaria* and its relationship with *Limonium dichotomum* and *Foeniculum vulgare*, flowers of both these species are widely available, and yet the flowers of these plants are not always used by the immature stages of the moth; with 3 larvae (4.1%) of the 73 larvae collected in 2004, and 1 larva (0.6%) of the 163 collected in 2005 on the flowers of *Limonium dichotomum*, but never on the leaves of either of these plants. In 2004, 1 larva (1.36%) and in 2005 21 (12.9%) larvae were taken on *Foeniculum vulgare*. Hausmann (2001) emphasises the fact that *P. etruscaria* is a species to be found in areas with a high concentration of umbelliferous plants (Apiaceae), however, the only umbel used by this species was *Foeniculum vulgare*, and then only marginally, although this could be an artefact of the study. Nevertheless, on 16.vi.2007, after the study finished, eight larvae were collected on the flowers and fruits of a species of *Torilis* (Apiaceae) in Ciempozuelos (King, pers. obs.).

Quercus ilex has been cited as a food-plant for *P. etruscaria* (Rebel 1910; Dantart 1990), but this should be treated as doubtful, if one considers the species being floricolous; with *Q. ilex* flowering at the end of April, this would be too early for the larvae of this species, which appear from the end of May (King, pers. obs.).

The inclusion of *Ruta*, as well as *Limonium* as new food-plants for this species, in two different botanical families (Rutaceae; Plumbaginaceae) increases the spectrum of plants utilised.

It is interesting to note that *P. etruscaria* is capable of feeding on both *Ruta montana* (Rutaceae) and *Foeniculum vulgare* (Apiaceae), a behaviour shared only with the Papilionidae whose larvae are able to deal with those plants which contain the compounds; methyl chavicol and anethole (Dethier, 1952).

Microloxia herbaria (Hübner, 1813)

Published records of food-plants: *Teucrium polium capitatum* (Lamiaceae) (Millière 1874; Staudinger 1879; Gómez de Aizpúrua et al. 2003); *Vernonia centaureoides* (Compositae) (Scoble 1999); *Helichrysum stoechas* (Lamiaceae) (Leipnitz *in* Hausmann 2001); *Gypsophila struthium* (Caryophyllaceae) (King 2002); *Limonium dichotomum* (Plumbaginaceae) (King & Romera 2004).
Food-plants recorded from the study area: 64 larvae were collected between 2004 and 2006; 31 in both 2004 and 2005, with 2 being collected in the spring of 2006, four plants are utilised by the larvae, from three botanical families: Labiatae, Plumbaginaceae and Caryophyllaceae. For this reason, the species is, strictly speaking, polyphagous. However, its relationship with each of its food-plants is distinct: for example, with *Teucrium polium* it is not floricolous, and larvae use *Teucrium* throughout the year (25 larvae = 39.1%) In the winter moths the plant also seems to serve as a refuge, as well as a source of food, with larvae in the first two stadia overwintering underneath the plant, becoming fully-grown in April. Nevertheless, in the summer the larva feeds on the flowers of other plants. In October, larvae of the third generation appear to be restricted to the *Teucrium* plants. Although *M. herbaria* maybe floricolous on other plants (*Thymus lacaitae*, *Gypsophila struthium*, *Limonium dichotomum*), it does not feed upon the flowers of *Teucrium*.

Sterrhinae Meyrick, 1892

Idaea incisaria (Staudinger, 1892)

Published records of food-plants: Data available refer to those larvae reared in captivity with larvae showing a marked preference for dead or dying leaves of *Polygonum aviculare*, *Rumex*, *Atriplex halimus*, *Rubia peregrina* and *Galium* (King & Romera 2004; King & Viejo Montesinos 2007). These observations tie in with those larvae reared ex ♀ 7.x.07 (code genit. prep. GK499MA GEK *leg. et det.*) which fed upon *Rumex* and *Polygonum aviculare* (Polygonaceae).
Food-plants recorded from the study area: A wild-caught larva which was collected on 18.vi.2005 (♀ genit. prep. GK115MA GEK *leg. et det.*) on withered leaves of *Antirrhinum majus* (Scophulariaceae) (King & Viejo Montesinos 2007).

Idaea longaria (Herrich-Schäffer, 1852)

Published records of food-plants: Previous papers referred to larvae bred out on with-

ered leaves in captivity (Zerkowitz 1946; Trusch & Müller 2000; King & Romera 2004), however, King & Viejo Montesinos (2007) refer to the capture of a larva in Tres Cantos (Madrid) 7.iv.07 below *Artemisia campestris glutinosa* which fed on the withered leaves and inflorescences of *Rumex* sp. in captivity.
Food-plants recorded from the study area: In the two-and-a-half years of the study a single larva was taken under *Centaurea hyssopifolia* 6.iii.2004 (♂ genit. prep. GK007MA GEK *leg./det.*) which fed on the withered leaves of this composite in captivity (King & Viejo Montesinos 2007).

***Idaea cervantaria* (Millière, 1869)**

Published records of food-plants: Previous papers referred to larvae bred out in captivity on withered leaves (Trusch & Müller 2000; King & Romera 2004).
Food-plants recorded from the study area: A single larva was taken 6.iii.2004 (♂ genit. prep. GK078MA GEK *leg. et det.*) below and between two plants: *Gypsophila struthium* and *Thymus lacaitae* feeding on the withered leaves of these plants in captivity (King & Viejo Montesinos 2007).

***Scopula imitaria* (Hübner, 1799)**

Published records of food-plants: There are no data on this species' food-plant in the Iberian Peninsula, nevertheless, Chrétien (1928) gives *Chaenorhinum origanifolium* (Scrophulariaceae) in the French Pyrenees This observation is of interest given the plant on which larvae were found in Madrid (see below).
Food-plants recorded from the study area: Only two larvae were collected in Ciempozuelos (14.iii.2004; 3.iv.2005) both of these specimens on the same plant, *Antirrhinum majus* (Scrophulariaceae). It remains to be seen, but it is highly probable, that the species is oligophagous on plants of this family, rather than polyphagous as suggested by Hausmann (2004).

***Scopula* (*Glossotrophia) rufomixtaria* (Graslin, 1863)**

Published records of food-plants: Chrétien (1928) gives *Silene* and *Dianthus* (Caryophyllaceae); whilst King (2000) gives *Gypsophila struthium* (Caryophyllaceae). King & Romera (2004) describe the refusal of newly eclosed larvae of this species to accept leaves of a species of *Silene* sp. common in the area where a female was taken 2.x.03 in Tres Cantos (Madrid) (♀ genit. prep. GK124MA GEK *leg. et det.*).
Food-plants recorded from the study area: There were only four larvae collected in the years 2004–2006 (19.iii.2005, 3.iv.2005, 26.iii.2006) on *Gypsophila struthium,* the recognised food-plant (King 2000).

***Scopula* (*Glossotrophia) asellaria dentatolineata* (Wehrli, 1926)**

Published records of food-plants: *Linaria, Antirrhinum* (Scophulariaceae) (Millière

1869–1874); *Fagonia cretica* (Zygophyllaceae), *Anarrhinum brevifolium* (Scrophulariaceae), *Salvia aegyptiaca* (Lamiaceae) (Chrétien, 1917); leaves of herbaceous plants (Forster & Wohlfahrt, 1981); King & Romera (2004) cite *Scopula* (*Glossotrophia) asellaria dentatolineata* in *Antirrhinum majus*; the use of *Gypsophila struthium* is still to be confirmed, as although a larva was collected from this plant on 23.xi.07, there is no evidence that the larva actually fed on it (King pers. com.).

Food-plants recorded from the study area: A total of 335 larvae were taken in the two-and-a-half years of the study on *Antirrhinum majus* mainly feeding on the shrivelled-up leaves of this plant, especially in the summer months.

Casilda consecraria (Staudinger, 1871)

Published records of food-plants: A monophagous species on plants of the genus *Limonium* (Hausmann 2004); Leipnitz in Hausmann (2004) gives the flowers and leaves of *L. sinuatum* and *L. gmelini/augustifolium* in Cyprus; in Spain, *L. dichotomum* is recorded (King 2002; King & Romera 2004; Gómez de Aizpúrua et al. 2005).

Food-plants recorded from the study area: There were 158 larvae collected over the two-and-a-half years of the study on the recognised food-plant, *L. dichotomum* (Plumbaginaceae). The larva is floricolous, but the finding of specimens in May, before the plant flowers, would indicate that the larva also consume the leaves. In any case, the moth also flies as early as February, well before flowering, and also before the leaves are completely available (King 2002).

Larentiinae Duponchel, 1845

Xanthorhoe fluctuata (Linnaeus, 1758)

Published records of food-plants: Monophagous on the flowers and the leaves, of *Lepidium subulatum* (Cruciferae) King (2005).

Food-plants recorded from the study area: There were 121 larvae taken over the years 2004–2006 on *Lepidium subulatum*.

Camptogramma bilineata (Linnaeus, 1758)

Published records of food-plants: *Rumex* (Polygonaceae) *Urtica*, (Urticaceae), *Digitalis* (Scrophulariceae), *Viola* (Violaceae), *Verbascum* (Scrophulariceae) (Gómez de Aizpúrua 1989); *Rumex thyrsiflorus*, *Ononis repens*, *Helianthemum* sp. (Ebert 2001); *Urtica urens* (Gómez de Aizpúrua et al. 2006).

Larva collected from *Asphodelus ramosus* L (Liliaceae) (La Ponderosa, Chinchón, Madrid, 600 m) 24.iii.2001 (♂ genit. prep. GK159MA GEK *leg. det.*), but this cannot be confirmed as a larval food-plant, as probably the larva was only resting on this plant; larva also collected from *Taraxacum*, but in the vicinity of *Rumex* sp. (Tres Cantos (Madrid) 1.iv.2007), feeding on this latter plant in captivity.

Food-plants recorded from the study area: Only four larvae were taken between 2004–2006 (21.ii.2004, 6.iii.2004, 6.iii.2005, 8.i.2006) under *Thymus lacaitae*, but this cannot be confirmed as the food-plant, as the larvae did not thrive on this plant in captivity. It is probable that the plant serves only as a refuge. The specimen taken in January 2006 was found under moss growing in the vicinity of this thyme species.

***Nebula ibericata* (Treitschke, 1871)**

Published records of food-plants: Monophagous on *Galium fructicesens* (Cav.) (Rubiaceae) (King 2005).
Food-plants recorded from the study area: Only two larvae were collected between 2004–2006 (24.iv.2004, 11.iii.2006), both examples were taken beneath other plants, for example, *Thymus lacaitae*, but in the vicinity of *Galium fructicesens*, which only develops in the cooler months, as it dessicates with the arrival of heat in May. With the field study completed, three other examples were found (6.xii.2006, 17.xii.2006, 25.ii.2007) amongst the tiny specimens of this rubiaceaous plant.

***Antilurga alhambrata* (Staudinger, 1859)**

Published records of food-plants: King & Romera (2004) cite the larva on *Helianthemum apenninum*, but the plant was misidentified and is actually *H. hirtum* which belongs to the plant association *Gypsophilo-Centaureetum hypssopifoliae* (Bellot 1952) (Rivas Martínez 1970) a typical gypsophilous plant. In the winter of 2006–2007 (30.xii.2006, 7.i.2007, 14.i.2007) 21 larvae were found underneath *H. hirtum* in an area of gypsym soils in the metropolitan area of Madrid (Cerros de Vallecas, 600 m).
Food-plants recorded from the study area: A total of 16 larvae were taken between the years 2004–2006 on the recognised food-plant, *H. hirtum*, on which it is monophagous.

***Hospitalia flavolineata* (Staudinger, 1883)**

Published records of food-plants: There are no published data on food-plants.
Food-plants recorded from the study area: One larva was taken (8.ii.2004; ♂ genit. prep. GK150MA GEK *leg*/LR *det.*) underneath *Thymus lacaitae*. However, whether this labiate is indeed the host-plant, is still to be confirmed, given that the larva pupated four days later. It should be emphasised that the moth did not emerge successfully and was identified by dissecting the specimen within the pupal exuvium.

***Gymnoscelis rufifasciata* (Haworth, 1809)**

Published records of food-plants: Despite being recognised as a polyphagous species (Mironov 2003) there are few food-plant records for the Iberian Peninsula, except *Salvia lavandulifolia, Lavandula pedunculata* (Lamiaceae) (Gómez de Aizpúrua et al.

2005), and for the Canary Islands in *Adenocarpus viscosus* (Papilionaceae) (Viejo & Cifuentes 1995).
Food-plants recorded from the study area: There was only one larva taken between 2004 and 2006, despite being common as an imago (King per. obs.); on *Gypsophila struthium* 22.vii.2004 (♂ genit. prep.GK182MA). With the field study over, a further larva was taken 13.x.07 on *Limonium dichotomum*. There are no previous records of larvae of this species in plants of either of these botanic families (Caryophyllaceae; Plumbaginaceae).

***Eupithecia gemellata* Herrich-Schäffer, 1861**

Published records of food-plants: Carrara (1928) cites *Tunica saxifraga* (Caryophyllaceae) as the food-plant in Trieste (Italy); King & Romera (2004) include *Gypsophila struthium* and *Limonium dichotomum* from larvae collected in Madrid.
Food-plants recorded from the study area: Of the 12 larvae collected (2004–2005) most were noted on the flowers of one plant only: *Gypsophila struthium* (10 = 83.3%), however, with the two specimens taken in 2005 (17.ix.2005, 1.x.2005) these were found on two different plants of two distinct plant families: *Limonium dichotomum* (Plumbaginaceae) and *Reseda stricta* (Resedaceae) this would suggest that the species is not monophagous as indicated by Mironov (2003).
The following specimens were identified by examination of the genitalia: ♂ ex larva 18.ix.2004 GK181MA; ♀ ex larva 1.x.2004 GK180MA; ♂ ex larva 1.x.2004 GK185MA; ♀ ex larva 9.x.2004 GK184MA; ♂ ex larva 24.x.2004 GK176MA; ♀ ex larva 6.xi.2004 GK179MA; ♂ ex larva 1.x.2005 GK379MA; all specimens GEK/leg. et det. Of the 12 larvae, eight survived to produce moths, of which seven were dissected, one ♀ ex larva 17.ix.2005 emerged eleven months later: 23.viii.2006.

***Eupithecia centaureata* (Denis & Schiffermüller, 1775)**

Published records of food-plants: Polyphagous on the leaves, flowers and seeds of various herbaceous plants (Mironov 2003; Ratzel 2003).
Food-plants recorded from the study area: Although the species is regarded as being polyphagous, the data recorded here are the first host-plant records for the Iberian Peninsula. In Ciempozuelos larvae are floricolous on two plants: *Gypsophila struthium* and *Foeniculum vulgare* (Apiaceae); with 18 larvae from *Gypsophila* (81.8%) and four from *Foeniculum* (18.2%). This species is not known from these plants, although it is recorded from other caryophyllaceous plants e.g. *Silene vulgaris* (Mironov 2003); however, records from other umbelliferous (Apiaceae) plants are quite numerous e.g. *Angelica sylvestris*, *Peucedanum oreoselinum*, *P. palustre*, *Selinum carvifolia*, *Daucus carota*, *Pastinaca sativa*, *Heracleum sphondylium*, *Seseli annuum*, *Bunium bulbocastanum*, *Torilis japonica*, *Cicuta virosa*, *Eryngium* sp., *Ferulago* sp. (Mironov 2003). The importance that the umbells play in the early stages of *E. centaureata*, can be emphasised by the finding of two larvae once the study had finished (16.vi.2007) in a species of *Torilis*. This attraction for the Apiaceae has been also commented on by Ratzel

(2003). In this way, the species can be regarded as oligophagous rather than polyphagous, as it tends to utilise plants in the same botanical family.

***Lithostege castiliaria* Staudinger, 1877**

Published records of food-plants: *Lepidium subulatum* (King 2002, 2005).
Food-plants recorded from the study area: 24 larvae collected in May in the years 2004–2006 (30.v.2004, 5.vi.2004, 14.v.2005, 13.v.2006) were found in the flowers of *Lepidium subulatum* (King 2005), affirming its status as a monophagous species, which synchronises larval development with the flowering period of *Lepidium*.

Ennominae Duponchel, 1845

***Petrophora convergata* (Villers, 1789)**

Published records of food-plants: *Ephedra nebrodensis* (Ephedraceae), *Rosmarinus officinalis, Teucrium polium capitatum* (Labiatae) (Gómez de Aizpúrua et al. 2003).
Data from the field in Madrid (localities situated 710–730 m) confirms the following food-plants *Thymus lacaitae* (6.v.2000; Ciempozuelos); *Lavendula stoechas* (14. iv.2006; Tres Cantos), 5.v.2007 El Goloso, 13.v.2007 Tres Cantos; *Thymus* sp. (29. iv.2007 El Goloso).
Food-plants recorded from the study area: This species would appear to be restricted to *Thymus lacaitae* with 282 larvae collected only from this labiate.

***Petrophora narbonea* (Linnaeus, 1758)**

Published records of food-plants: *Teucrium chamaedrys, T. scorodonia* (Lamiaceae) (Chapaleon 1992). Data from the field in Madrid (all from Ciempozuelos) indicate the following food-plant: *Teucrium polium* (larvae collected: 18.iii.2001, 9.ii.2002, 9.iii.2002).
Food-plants recorded from the study area: The only plant that the larvae were collected from was *Teucrium polium* with 85 larvae being found.

***Dasypteroma thaumasia* (Staudinger, 1892)**

Published records of food-plants: *Lepidium subulatum* (Gómez de Aizpúrua et al. 2003; King & Romera 2004).
In the winter and spring of 2007 the following food-plant observations in Madrid were made: *Helianthemum hirtum* (Cerros de Vallecas; 7.i.2007); *Artemisia campestris glutinosa* (Compositae) (El Goloso; 4.iii.2007, 22.iv.2007; Tres Cantos; 18.iii.2007; 1.iv.07, 7.iv.2007); *Thymus lacaitae* (3.iv.2007, Barrancos de la Fuente de la Jonquera, Zaragoza, 200 m).

Food-plants recorded from the study area: 46 larvae were collected over the period 2004–2006 from a total of seven plants of five plant families. These were: *Thymus lacaitae, Teucrium polium* (Labiatae), *Centaurea hyssopifolia* (Asteraceae), *Antirrhinum majus* (Scrophulariaceae), *Helianthemum squamatum*, *H. hirtum* (Cistaceae) and *Lepidium subulatum* (Cruciferae). However, there were differences in the preferences shown for these plants: for example, 29 larvae (63%) were collected from just one plant species, *Thymus lacaitae*, which suggests that the larvae browses on different low plants as it develops; in captivity the larvae were not always reared on the plant on which they were found, but on the plants which last better in captive conditions e.g. *Teucrium polium*.

***Calamodes occitanaria* (Duponchel, 1829)**

Published records of food-plants: *Dorycnium pentaphyllum* (Fabaceae (Leguminosae)) (Gómez de Aizpúrua, *at al* 2006). The following observations were made of larvae collected in the field in Madrid and Guadalajara: *Thymus lacaitae* (18.ii.2001, 25.ii.2001; La Ponderosa, Chinchón), (27.i.2002; Barajas), (30.xii.2006; Cerros de Vallecas), *Thymus* sp. (29.iii.2002; Iriépal (prov. Guadalajara)]; *Santolina rosmarinifolia* (El Goloso; 4.ii.2007, 11.ii.2007, 4.iii.2007; Tres Cantos 18.iii.2007), *Artemisia campestris glutinosa* (4.iii.2007; El Goloso, Tres Cantos; 18.iii.2007).
Food-plants recorded from the study area: The species is monophagous on *Thymus lacaitae*, with all 73 larvae collected from this plant. It is interesting to note that the larvae are to be found in the winter months, probably when the leaves of its sclerophyllous food-plant are in a suitable condition to be consumed.

***Aspitates ochrearia* (Rossi, 1794)**

Published records of food-plants: *Artemisia campestris glutinosa* (Gómez de Aizpúrua et al. 2003). The following observations were made of larvae collected in the field in Madrid, Valladolid and Zaragoza: *Artemisia campestris glutinosa* (3.ii.2002 Madrid; Barajas), (4.iii.2007, 11.iii.2007, 18.iii.2007, 7.iv.2007; Tres Cantos); *Centaurea hyssopifolia* (9.iii.2002; Ciempozuelos), *Carlina corymbosa* (1.ix.2002; Tres Cantos) although it is likely that the larva was only resting on this plant. *Thymus* sp. (1.ix.2002; Tres Cantos), *Dorycnium* sp. (21.iii.2004; Valladolid), *Bupleurum* sp (3.iv.2007; Montes de Torrero, Zaragoza) . It is likely that the larva was only resting on this plant, as in captivity it fed on *Rumex* sp.
Food-plants recorded from the study area: Although only 6 larvae were collected over the years 2004–2006 (25.i.2004, 22.ii.2004, 6.iii.2004, 5.xii.2004, 1.iv.2006) the larva was polyphagous on five plant species each in a different family: *Centaurea hyssopifolia* (Compositae) (2 larvae), *Lepidium subulatum* (Cruciferae) (1 larva), *Thymus lacaitae* (Labiatae) (1 larva), *Helianthemum hirtum* (Cistaceae) (1 larva) and *Gypsophila struthium* (Caprifoliaceae) (1 larva).

***Dyscia distinctaria* (Bang-Haas, 1910)**

Published records of food-plants: *Helianthemum guttatum* (Cistaceae), *Cistus ledon* (Fabaceae), *C. albus* (Zerkowitz 1946).

Food-plants recorded from the study area: The only larva found was a fully-grown specimen under *Helianthemum hirtum* (Cistaceae) (5.xii.2004) which produced a female in February 2005 (genit. prep. GK165MA GEK *leg et det.*)

***Compsoptera jourdanaria* (Serres, 1826)**

Published records of food-plants: *Santolina rosmarinifolia* (Gómez de Aizpúrua 1987); *Salsola vermiculata*, *Artemisia herba-alba* (Redondo et al. 2001); *Artemisia campestris glutinosa, Artemisia herba-alba* (Compositae) (Gómez de Aizpúrua et al. 2003).

The following food-plant records are from Madrid and Zaragoza: *Thymus lacaitae* (30.xii.2006; Cerros de Vallecas), *Helianthemum hirtum* (30.xii.2006; 7.i.2007 Cerros de Vallecas), *Artemisia campestris glutinosa* (Tres Cantos 4.i.2007, 6.i.2007, 20.i.2007, 11.iii.2007, 22.iv.2007; El Goloso 4.ii.2007, 4.iii.2007), *Artemisia herba-alba* (Ciempozuelos 25.ii.2007; Montes de Torrero, Zaragoza 3.iv.2007), *Santolina rosmarinifolia* (El Goloso 4.ii.2007, 11.ii.2007, 4.iii.2007, 11.iii.2007).

Food-plants recorded from the study area: The species seems to be monophagous on *Artemisia herba-alba*, with 10 larvae collected from this plant in March 2005 (19 and 22.iii.2005). Although, there are two records from *Helianthemum hirtum*, a characteristic gypsophite, in the area of Vallecas, this plant was not used in Ciempozuelos. The host-plant is a new record for this species; an interesting observation was that the parenchyma was scraped away by the young larvae, rather than the leaf being consumed at the margins, as is usually the case with geometrid larvae. In localities in north-central Madrid, the larva feeds on three species of plant (*Thymus lacaitae*, *Artemisia campestris glutinosa*, *Santolina rosmarinifolia*) in two botanic families (Labiadae and Compositae).

Discussion

Hering (1950) and Huemer (1988) describe three strategies related to larval feeding: monophagy (which can be divided into three groups according to whether the species uses only one species of plant, or all plants in a single genus); Oligophagy (when the plants utilised belong to genera in the same family, or related families; disjunctive Oligophagy includes those species who utilise plants that are not related, or whose relationship with the plant varies according to generation. Lastly, polyphagy, involves those species feeding on plants families across a wide botanic spectrum (more than two plant families). Another strategy within the range of feeding possibilities is that of detriphagy, characteristic of the genus *Idaea* (Ryrholm, 1989). This enables the larvae to cope with the hydrological deficit in the Mediterranean basin, especially, but not only, in the summer months.

Tab. 2 categorises the 25 species found as larvae in terms of their apparent feeding strategies, with the majority of species (13 = 55%) being monophagous, whilst 10 species are polyphagous (45%) (this would include the detrivores, as technically, they utilise plants from more than two plant families, although the mechanisms they employ to deal with the plant are distinctive, feeding on dead, decaying or dessicated leaves; the larvae in this way are perhaps in a better position to circumvent ostensible plant defence mechanisms). These detrivores would be: *I. incisaria*, *I. longaria*, and *I. cervantaria*, a strategy recognised as being common in the genus; *Idaea* (Covell 1983; Hausmann 2004, King & Romera 2004; King & Viejo Montesinos 2007). *Scopula* (*Glossotrophia*) *asellaria dentatolineata* is an interesting case, as although it is a monophagous species (at least in the area under study), it has been observed as being a detrivore, both in the wild state and in captivity, feeding on the dried-up leaves of its food-plant *Anthirrhinum majus* on which it monophagous. The *Idaea* feed on the withered leaves of various low plants offered to them in captivity, and probably in the wild state too: In April/May 2008, thirty-four larvae of *Idaea ochrata albida* Zerny, 1936 were found in Madrid (El Goloso, Tres Cantos) from amongst the leaf litter to be found at the base of *Artemisia campestre* plants, as well as from amongst other low plants, including grasses.

It was not clear which food-plant was being used by two species: *C bilineata* and *H. flavolineata*, because the larvae did not feed in captivity on the plant upon which they were found in the wild.

The diversity of geometrid species hosted by an individual plant species can vary considerably. For example, *Teucrium polium* was examined on 95 of the 130 visits (73.7%), nevertheless, it supports a mere three species namely; *M. herbaria, P. narbonae* and *D. thaumasia*. Another plant which was examined frequently, on 56 visits (43.8%), was *Limonium dichotomum*, but it supports only four species (*P. etruscaria*, *M. herbaria*, *C. consecraria*, *E. gemellata*) all of these species being floricolous, although *C. consecraria* would use the leaves as well, as the larvae are to be found before flowering. *Lepidium subulatum* was examined on 64 occasions (49. 2%) but does not support more than four species (*X. fluctuata*, *L. castiliaria D. thaumasia*, *A. ochrearia*). In contrast, *Gypsophila struthum* (especially the flowers) and *Thymus lacaitae* (only the leaves) support at least twelve species each (including species not identified); *P. etruscaria*, *M. herbaria*, *I. cervantaria*, *G. rufomixtaria*, *G. rufifasciata*, *E. centaureata*, *E. gemellata* and *A. ochrearia* (3 species unidentified). On *Gypsophila struthum*, all species except *S. Rufomixtaria* are generalists, whilst *Thymus lacaitae* provides food for *M. herbaria*, *C. bilineata*, *H. flavolineata*, *P. convergata*, *D. thaumasia*, *C. occitanaria* and *A. ochrearia* (5 species unidentified). *Thymus lacaitae* is interesting in that the plant is used in the winter and spring, but not in the summer, as the leaves are presumably too tough for larvae to eat. In fact, in this latter plant, only two species are specialists on it (*P. convergata*, *C. occitanaria*), at least in Ciempozuelos. With regard to *C. bilineata* and *H. flavolineata*, it was not possible to establish the relationship that they maintain with this plant: was it nutritional or merely structural? The case of *M. herbaria* was interesting as it was the only species which was found on its flowers (1 larva 12.vi.2004) despite it being an established floricolous species in the summer months (see species results), as well as the fact that this thyme species was examined on 73 times out of the 130 visits to the field study site.

Tab. 2. The 25 species taken as larvae in Ciempozuelos 2004–2006 and their feeding strategies. N = number.

Species	N plant species utilised	N plant families utilised	mono-phagous	oligo-phagous	poly-phagous	detrivore
Phaiogramma etruscaria	4	4			+	
Microloxia herbaria	4	3			+	
Idaea incisaria						+
Idaea longaria						+
Idaea cervantaria						+
Scopula imitaria	1	1	+			
Scopula rufomixtaria	1	1	+			
Scopula asellaria dentatolineata	1	1	+			+
Casilda consecraria	1	1	+			
Xanthorhoe fluctuata	1	1	+			
Camptogramma bilineata			?	?	?	
Nebula ibericata	1	1	+			
Antilurga alhambrata	1	1	+			
Hospitalia flavolineata			?	?	?	
Gymnoscelis rufifasciata	2	2			+	
Eupithecia gemellata	3	3			+	
Eupithecia centaureata	2	2			+	
Lithostege castiliaria	1	1	+			
Petrophora convergata	1	1	+			
Petrophora narbonea	1	1	+			
Dasypteroma thaumasia	7	5			+	
Calamodes occitanaria	1	1	+			
Aspitates ochrearia	5	5			+	
Dyscia distinctaria	1	1	+			
Compsoptera jourdanaria	1	1	+			

There are two species of *Helianthemum* in the study area: *H. hirtum* and *H. squamatum*, but they have a very restricted geometrid association; *H. hirtum* harbours two monophagous species in the winter months (*A. alhambrata, D. distinctaria*) and two other generalist species (*D. thaumasia*, *A. ochrearia*). In contrast, *H. squamatum* appears to have no geometrid species associated with it, except two records of *D. thaumasia* (27.ii.2005, 13.iii.2005), where the larvae were just found underneath the plant and not on the leaves or flowers (see species' results). In terms of the attraction of this cistaceous plant for other Lepidoptera, there are two species in Ciempozuelos: *Dipluriella loti* (Ochsenheimer, 1810) (Lasiocampidae) which utilises both the leaves and the flowers of this plant and *Anacampsis scintillella* (Fischer von Röslerstamm, 1841) (Gelechiidae) seems to be a specialist on the leaves (M. F. C. Corley pers. com.).

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Appendix 1:

Plants cited in the study which formed part of the transect, or otherwise cited (not literature references). (Not all of these plants belong to the *Thymo-Teucrion verticillati* botanic alliance).

Cistaceae
Helianthemum hirtum (L.) Mill.
H. squamatum (L.) Dum

Rutaceae
Ruta montana (L.) L.

Brassicaceae (Cruciferae)
Lepidium subulatum L.

Resedaceae
Reseda stricta Pers.

Plumbaginaceae
Limonium dichotomum (Cav.) Kuntze

Scrophulariaceae
Antirrhinum majus L.

Rubiaceae
Galium fructicesens Cav.

Lamiaceae (Labiatae):
Teucrium polium L. *subesp. capitatum* Briq.
Thymus lacaitae Pau.

Caryophyllaceae
Gypsophila struthium L. in Loefl.

Apiaceae
Foeniculum vulgare Mill. subsp. *vulgare*

Asteraceae
Centaurea hyssopifolia Vahl.
Artemisia herba-alba Asso. subsp. *herba-alba*
Artemisia campestris glutinosa
(J. Gay ex Besser).