Seasonal dynamics of forest spiders (Arachnida: Araneae) in the temperate zone of the Basque Country and Navarra (northern Spain)

A. Castro Gil

ABSTRACT

The aims of this research are to determine the time of year with the highest species richness to avoid whole-year samplings in future studies, and to contribute to the seasonal dynamics and faunistic knowledge of the spider fauna of the study area. Hence, it summarizes temporal changes in species richness and seasonal activities of spiders collected in several temperate forests sampled using different methods. Results show the May-June transition as the period with the peak in species richness. However, this maximum takes place earlier in the epigeal stratum (May), and later on tree trunks (June). Additionally, lower strata show higher representation of species of long mating periods. Three species, *Centromerita bicolor*, *Micrargus apertus* and *Midia midas* are new records for Iberian fauna, while *Peponocranium ludicrum* is a new genus record for Spain. Seasonal activities of *Nemesia simoni* and *Labulla flahaulti* are described for the first time. Data obtained in two of the sampled forests will make it possible to evaluate the efficiency of future short-term collecting protocols for the study area.

KEY WORDS: Araneae, seasonal activity, temperate forests, species richness, Spain.

RESUMEN

Los objetivos del presente trabajo son determinar la época del año que registra el mayor número de especies a fin de evitar muestreos de ciclos anuales completos en estudios futuros y contribuir al conocimiento faunístico y de las dinámicas estacionales de la araneofauna del área de estudio. Para ello, se compendia las variaciones temporales de la riqueza específica y de las actividades estacionales de las arañas capturadas en varios bosques templados muestreados a través de distintos métodos. Los resultados determinan la transición entre Mayo y Junio como el periodo que presenta el máximo de riqueza específica. Sin embargo, este máximo tiene lugar antes en el estrato epigeo (Mayo) y más tarde (Junio) en los troncos de los árboles. Además, los estratos más bajos muestran una mayor representación de especies de periodos de reproducción largos. 3 nuevas especies, *Centromerita bicolor*, *Micrargus apertus* y *Midia midas*, se citan para la Península Ibérica y un nuevo género, *Peponocranium ludicrum*, para España. Las actividades estacionales de

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**Nemesia simoni** y **Labulla flabaulti** se describen por primera vez. Los datos obtenidos en dos de los bosques muestrados permitirán evaluar la eficacia de futuros protocolos de recolección a corto plazo para el área de estudio.

- **PALABRAS CLAVE:** Araneae, actividad estacional, bosques templados, riqueza específica, España.

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**LABURPENA**


- **GAKO-HITZAK:** Araneae, urte-sasoietako jarduera, baso epelak, aberastasun espezifiko, España.

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**INTRODUCTION**

Registering the entire biological diversity at regional scale is an impossible task, whatever economic and time resources are available, since biological diversity is constantly changing. The use of surrogate taxa as biodiversity indicators of a specific area has been proposed as a way of addressing this problem and facilitating biodiversity management and conservation policies (Williams et al., 1997; Vanclay, 2004). Spiders are often used as biodiversity indicators for the following reasons (Marc et al., 1999; Platnick, 1999; Maelfait et al., 2004; Pearce & Venier, 2006): they show high species richness, play an important role in terrestrial ecological webs, are of economic interest, are easy and inexpensive to sample (yielding quantitative analyzable results), their taxonomy is reasonably well known in developed countries, and their communities are sensitive to environmental change.

Knowledge of spider fauna is far from being complete both in the Iberian Peninsula (Morano, 2004; Cardoso, 2008) and in the area covered by this study (Castro, 2004a). To counter this lack of information, maximizing economic and
time resources, intensive short-time sampling protocols have been developed in
other countries (Coddington et al., 1991, 1996; Sorensen et al., 2002; Scharff
et al., 2003; Cardoso et al., 2008). The first step in applying these methods is to
conduct sampling programs encompassing entire year cycles to ascertain at what
time of year the highest spider diversity is found (Cardoso, 2004, Cardoso
et al., 2007).

Potentially, almost the entire surface of the study area would be taken up by
forest ecosystems (Aseginolaza et al., 1996). Forestry covers 61% of the Basque
Country’s temperate area, although more than half of the forest surface is occupied
by plantations of exotic species (Departamento de Agricultura, Pesca y
Alimentación 2007). The situation in the temperate zone of Navarra is similar,
though native species predominate (ICONA, 1994). In any case, most indigenous
forests are exploited for sylvicultural and shepherd activities (Loidi & Bascones,
1995; Aseginolaza et al., 1996). In this regard, knowledge of spider communities
in temperate forests can be applied for designing suitable biodiversity conservation
programs in the study area, as is happening in other European regions (Riecken,
1998; De Bakker et al., 2002).

This study therefore analyses collections of woodland spiders available for the
study area with the following objectives: 1) To determine which period of the year
would be most suitable for intensive short-time sampling programs yielding a repre-
sentative range of regional spider fauna, and 2) to contribute to an understanding
of seasonal dynamics and a faunistic knowledge of spider fauna in the study area.

**STUDY AREA**

The data came from four independent studies whose locations are summarized in
Table I. All them show oceanic temperate climate (Rivas-Martinez, 1994). The
characteristics of the different forest sites sampled are described below:

<table>
<thead>
<tr>
<th>Site</th>
<th>Town/Province</th>
<th>U.T.M. Coordinates</th>
<th>Altitude (m)</th>
<th>Orientation</th>
<th>Termotope/Ombrototope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorbea</td>
<td>Areatza-Villaro/Bizkaia</td>
<td>30TWN1673</td>
<td>400-510</td>
<td>Diverse</td>
<td>C/Hi</td>
</tr>
<tr>
<td>Artikutza</td>
<td>Goizueta/Navarra</td>
<td>30TWN9786</td>
<td>575-650</td>
<td>SW</td>
<td>C/U</td>
</tr>
<tr>
<td>Arrasate/Gipuzkoa</td>
<td>30TWN4070</td>
<td>450</td>
<td>E</td>
<td>C/Hi</td>
<td></td>
</tr>
<tr>
<td>Ataun/Gipuzkoa</td>
<td>30TWN6760</td>
<td>390</td>
<td>W</td>
<td>C/Hi</td>
<td></td>
</tr>
<tr>
<td>Deba-Itziar/Gipuzkoa</td>
<td>30TWN5951</td>
<td>310</td>
<td>E</td>
<td>C/Hi</td>
<td></td>
</tr>
<tr>
<td>Mendaro/Gipuzkoa</td>
<td>30TWN4990</td>
<td>225</td>
<td>SW</td>
<td>C/Hi</td>
<td></td>
</tr>
<tr>
<td>Zumaia/Gipuzkoa</td>
<td>30TWN6194</td>
<td>20</td>
<td>SW</td>
<td>T/H</td>
<td></td>
</tr>
<tr>
<td>Larraun/Navarra</td>
<td>30TWN8464</td>
<td>312</td>
<td>SE</td>
<td>C/Hi</td>
<td></td>
</tr>
<tr>
<td>Igara</td>
<td>San Sebastián/Gipuzkoa</td>
<td>30TWN7894</td>
<td>50-70</td>
<td>E</td>
<td>T/H</td>
</tr>
</tbody>
</table>

Table I.- Location and climate of the studied sites. Abbreviations: C = coline, T = thermocline,
Hi = lower hyperhumid, U = ultrahyperhumid, H = upper humid.
Gorbea: Samples were taken in the area of Upomakatxa, from seven forest stands near to each other: five plantations of *Pinus radiata* D. Don (three 30 year-old plantations, one 18-year-old and one 8-year-old), and two indigenous stands—one small beech forest (*Fagus sylvatica* L.) and one young deciduous broadleaf mixed forest (with predominance of *Quercus robur* L., *Castanea sativa* Miller and *Corylus avellana* L.). The main objective of this study was to analyse the impact of exotic pine forest plantations on soil invertebrate fauna. Livestock was commonly present in all stands. More details on the sampling design and first results obtained are given in BARRAQUETA (1985, 1988, 2001).

Artikutza: Samples were taken from a 5 ha interface between a beech forest and a deciduous broadleaf forest (with predominance of *Quercus robur* L.). This stand was in a regeneration process after a plantation of Scots pine (*Pinus sylvestris* L.) had lain abandoned for 70 years. The forest contained a large amount of dead wood. Livestock was also present at this site. The original purpose of this research was to study the spatial activity patterns of several families of Hymenoptera (Martínez de Murguía, 2002). More details of the study area may be found in Martínez de Murguía et al. (2001, 2002).

Cantabrian evergreen oak forests: This sampling program was carried out in the six most representative Cantabrian evergreen oak forests in the provinces of Gipuzkoa and Navarra. This type of forest is characterized by the dominance of the holm oak *Quercus ilex* L. subsp. *Ilex*. At the time of the research, the stands were in a recovery process due to the abandonment of charcoal extraction and their development on lands of little economic interest. Although the spider community of these forests had already been described (CASTRO, 2004b), the seasonal dynamics of the species had not been analysed, and they were therefore included in this work. A detailed description of the sampled stands may be found in CASTRO (2004b).

Igara: This sampling took place in a small eutrophic alder forest (with dominance of *Alnus glutinosa* (L.) Gaertner) located outside the city of San Sebastián. The forest was unexploited, but at a young stage, with no tree measuring more than 35 cm in diameter at breast height. The understorey was very dense, with several trees covered by ivy (*Hedera helix* L.) and the presence of scattered fallen trees. The main aim of this sampling was to compare two different bark trap designs to study trunk-dwelling spiders. The results are currently being analysed and are to be published shortly.

**Materials and methods**

**Sampling methods:** Table II summarizes the different sampling programs conducted at each forest site. Spider catches come from eight different collecting methods:
- **Kempson method:** On each sampling date, 314 cm$^2$ samples of the litter layer, including the first centimetre of mineral soil, were taken at each forest stand. A steel cylinder (20 cm in diameter and 25 cm high), equipped with an opening device, enabled extraction of intact sample units.

Spiders were extracted by creating gradients of light, humidity and temperature using a Kempson apparatus (KEMPSON *et al.*, 1963). Kempson extraction estimates densities of spiders and soil fauna with a high degree of accuracy (EDWARDS & FLETCHER, 1971). A detailed description of the use of this method may be found in BARRAQUETA (1985).

- **Berlese Funnels:** Litter samples of 500 cm$^3$, including the first centimetre of mineral soil, were taken with a shovel. Saxicolous moss samples of the same volume were collected by hand. A plastic recipient was kept in contact with the stone wall and just under the moss sampled to prevent the individuals escaping. Since there were no stones above ground level in the Zumaia stand, 8 samples of litter were taken per sampling date (see Table II).

Each sample was put into a plastic funnel with a 6 mm wire mesh inside and covered by a fibreglass mosquito net. A 60 W bulb was placed 10 cm above each funnel and left on for 8 days. This length of time ensures effective extraction (DUFFEY, 1972; HUHTA, 1972). The specimens were collected in glass bottles filled with a solution of 70% alcohol plus some drops of glycerine inside as a preservative. More details are given in CASTRO (2004b).

This kind of extraction is one of the most effective for catching spiders (EDWARDS & FLETCHER, 1971). Berlese funnels are useful for estimating population densities and for studying microhabitat preferences (HUHTA, 1971; DUFFEY, 1972; CANARD, 1981; HÖVEMEYER & STIPPICH, 2000).

- **Epigeal pitfall traps:** These were made using plastic beakers 6.5 cm in diameter and 8 cm high. Another smaller beaker was placed inside to avoid turning over mud and litter around the trap. The risk of flooding by rain and clogging with litterfall was prevented by making two small holes in the upper third of the beaker, and placing a cork (evergreen oak forests) or plastic (Artikutza) roof, held by wire, 5 cm above the trap. Each trap was filled to one-third full with a solution of 4% formalin as preservative. Some drops of detergent were added to increase capture efficiency (TOPPING & LUFF, 1995). Samples were taken uninterruptedly every two weeks, except in 1996 (Artikutza) on the following dates: 18-II, 28-VII, 8-IX, 3-XI and 29-XII.

Pitfall traps are efficient for collecting a great number of species (UETZ & UNZICKER, 1976; CANARD, 1981; CHURCHILL & ARTHUR, 1999; HÖVEMEYER & STIPPICH, 2000, STANDEN, 2000; BUDDLE & HAMMOND, 2003). They mostly catch mature individuals (TOPPING & SUNDERLAND, 1992), which facilitates identification at species level of most specimens. They are also useful for studying the seasonal dynamics and mating periods of epigeal spiders, favouring the capture of cur-
sorial species (CURTIS, 1980; BARRIENTOS, 1985a; CHURCHILL, 1993; LANG, 2000). Another advantage is that they act continuously, allowing both diurnal and nocturnal species to be caught.

- **Malaise Traps:** The model proposed by TOWNES (1972) was used: black with a white roof and thin mesh. The collecting recipient was placed at a height of 2 m and filled with a solution of 75% ethanol and 5% acetic acid (MARTÍNEZ DE MURGUIÁ, 2002). Samples were taken uninterruptedly every two weeks, except in 1996 on the following dates: 18-II, 28-VII, 8-IX, 3-XI and 29-XII.

  These traps are normally used to capture flying insects (PUJADE, 1996). Because they are complex to install, and collect a considerable quantity of insects, they are usually set up in small numbers or for short time periods, yielding low catches of spiders (see data in BARRIENTOS & PUJADE, 1999 and VECÍN et al., 2002). However, 6 traps placed in Artikutza that were active for two years yielded a large number of spiders. The method biases towards typical dwellers of higher-than-epigeal vegetation strata (HAUGE & MIDTGAARD, 1986). The spider fauna of Malaise traps shows greater similarity with arboreal stratum than epigeal, because the method probably collects herbaceous and bush strata dwellers (JENNINGS & HILBURN, 1988).

- **Bark traps:** These traps were 20 x 30 cm in size. They were tied with wire around tree trunks at a height of 1.5 m. Two kinds of traps were laid: some made of corrugated cardboard (described in DUFFEY, 1969) and some of grooved plastic (see CASTRO, 2004b). In the evergreen oak forests, only plastic traps were used, while in Igara 20 of each type were laid.

  Bark traps have been used to study species composition and seasonal dynamics of spiders on trunks (DUFFEY, 1969; CURTIS & MORTON, 1974; HORVÁTH & SZINETÁR, 1998; HORTON et al., 2001).

- **Trunk pitfall traps:** These consisted of white plastic beakers 5.5 cm in diameter and 6.5 cm high. They were tied with wire around tree trunks at a height of 1.5 m. Two small holes were made in the upper third of each beaker to prevent flooding. A saturate ClNa solution was used as a preservative. Some drops of detergent were added to increase catch effectiveness (TOPPING & LUFF, 1995).

  These traps are used for the same purposes as epigeal pitfall traps (RUZICKA et al., 1991; WEISS, 1995; RUZICKA, 1997).

- **Beating:** This method consisted of beating one sector of vegetation 30 times with a stick. Spiders were collected on a white sheet of 1 m² spread out and placed 50 cm under sampled vegetation. Samples were taken between 0.5-1.5 m for liana stratum (made up *Smilax aspera* L.) and between 1.5-4 m for tree foliage (more details in CASTRO, 2004b).

  Beating allows vegetation parts to be reached that are not accessible using other methods, yielding an abundant catch. However, it is important to bear in mind that
the time of day, meteorological conditions and vegetation height can influence the number of individuals and species composition collected (ABRAHAM, 1983; CODDINGTON et al., 1996; SORENSEN et al., 2002).

- **Chance searching by hand:** While sampling, spiders detected visually by chance were collected by hand or with the help of a paintbrush moistened with alcohol.

This method allows valuable complementary information to be gleaned on the microhabitat and biological aspects of the species (DUFFEY, 1972; FUJII, 1998).

**Identification and preservation of spiders:** Species were identified using the classic European keys of ROBERTS (1985-87, 1995), HEIMER & NENTWIG (1991), NENTWIG et al. (2003) and SIMON (1914-1937). The nomenclature used was as proposed by PLATNICK (2008).


<table>
<thead>
<tr>
<th>Site Method</th>
<th>Number of traps or samples</th>
<th>Periodicity</th>
<th>Number of collections per trap or sample</th>
<th>Whole sampling period</th>
<th>Forest habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorbea K</td>
<td>32-40</td>
<td>1 month</td>
<td>14</td>
<td>V-1982 to VI-1983</td>
<td>Forest litter</td>
</tr>
<tr>
<td>Artikutza P</td>
<td>30</td>
<td>2 weeks</td>
<td>46</td>
<td>V-1995 to V-1997</td>
<td>Epigeic</td>
</tr>
<tr>
<td>Artikutza M</td>
<td>6</td>
<td>2 weeks</td>
<td>46</td>
<td>V-1995 to V-1997</td>
<td>-</td>
</tr>
<tr>
<td><strong>Evergreen oak forests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>30</td>
<td>2 weeks</td>
<td>27</td>
<td>XII-1998 to XII-1999</td>
<td>Epigeic</td>
</tr>
<tr>
<td>Fl</td>
<td>28</td>
<td>8 weeks</td>
<td>6</td>
<td>I-1999 to X-1999</td>
<td>Forest litter</td>
</tr>
<tr>
<td>Fm</td>
<td>20</td>
<td>8 weeks</td>
<td>6</td>
<td>I-1999 to X-1999</td>
<td>Saxycolous moss</td>
</tr>
<tr>
<td>BT</td>
<td>30</td>
<td>4 weeks</td>
<td>12</td>
<td>I-1999 to XII-1999</td>
<td>Tree trunks</td>
</tr>
<tr>
<td>TP</td>
<td>30</td>
<td>2 weeks</td>
<td>23</td>
<td>I-1999 to XII-1999</td>
<td>Tree trunks</td>
</tr>
<tr>
<td>BL</td>
<td>30</td>
<td>8 weeks</td>
<td>7</td>
<td>XII-1998 to XI-1999</td>
<td>Liana layer</td>
</tr>
<tr>
<td>Bf</td>
<td>30</td>
<td>8 weeks</td>
<td>7</td>
<td>XII-1998 to XI-1999</td>
<td>Tree foliage</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>2 weeks</td>
<td>-</td>
<td>XII-1998 to XII-1999</td>
<td>Several</td>
</tr>
<tr>
<td><strong>Igarra</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>40</td>
<td>1 month</td>
<td>12</td>
<td>IX-2002 to VIII-2003</td>
<td>Tree trunks</td>
</tr>
</tbody>
</table>

Table II.- Summary of the sampling program carried out in each study site. Abbreviations: K: Kempson method, P: epigeic pitfall traps, M: Malaise traps, Fl: Berlese funnels, litter samples, Fm: Berlese funnels, saxycolous moss samples, BT: bark traps, TP: trunk pitfall traps, Bl: beating of liana layer, Bf: beating of tree-foliage, C: chance hand collecting.
The collaboration of several taxonomists was needed to identify some more difficult specimens: Robert Bosmans from the University of Gent, Belgium (Theridiidae y Salticidae); Miguel Ángel Ferrández from the Society for the Study and Conservation of Spiders, Spain (Segestriidae, Dysderidae and several families); Peter Van Helsdingen (Linyphiidae) of the National Museum of Natural History of Holland, Eduardo Morano of the Iberian Arachnology Group, Spain (Araneidae, Tetragnathidae); Carles Ribera of the University of Barcelona, Spain (Linyphiidae); Michael Saaristo of the Museum of Zoology, Turku, Finland (Linyphiidae) and Carmen Urones of the University of Salamanca, Spain (Miturgidae).

Spiders were preserved in 70% ethanol and stored in the Entomology Department of the Sociedad de Ciencias Aranzadi (San Sebastián, Spain).

**Data analysis:** In order to determine which is the best period of the year to sample, seasonal variations in species richness were displayed in graph form. This determination was based in the highest occurrence of species in adult stage, although species at immature phases were also added to the analysis because there is little literature available on seasonal variations in their richness. For each species, graphical displays were limited to the most abundant species (> 10% of identified sample to the species level per study site and method).

This analysis was limited to sampling methods that were carried out systematically at least 12 times, completing an entire year. Thus data from samples from Berlese funnels, beating, and hand searching from evergreen oak forests were used as complementary data to confirm the occurrence of the species in specific periods of the year and forest strata. Data from the six evergreen oak forests were pooled, and there are therefore two values for the dates displayed, because in two stands (Ataun and Larraun) sampling started one week later than in the other four.

The occurrence periods of each species were determined by reviewing data from this study and from the main studies (101 in total) on biological cycles and seasonal dynamics of European spiders. Among them, several with scattered records were consulted to complete the scarce knowledge that exists on some little-studied spiders of South European distribution.

Most of the literature consulted was based on pitfall traps. It was therefore possible to determine the main activity periods for several species. For each study consulted, all the maximum activity periods of the most abundant species were registered. Since some species were represented in more than one study and activity patterns may vary from year to year, the period finally obtained for each species is probably wider it would be for any one specific year. Data which did not match the literature reviewed is dealt with in the discussion.

Classifications of dynamic cycles based on overwinter stages and season and length of breeding period (TRETZEL, 1954; SCHAEFER, 1977; YSNEL & CANARD, 1990) were avoided for the following reasons: 1) It was impossible to identify all
immature specimens, 2) there is a lack of information in most literature on immature stages, 3) sometimes the same species is classified differently depending on the source, and 4) in the absence of direct observations, it is difficult to determine whether a long period of male activity is due to a eurychronous species with several overlapping generations or to a diplochronous species with a partial concurrence of two different generations.

RESULTS

Global results and faunistic contribution

Breakdown data of samples from Gorbea, Artikutza and Igara are shown in Appendices I, II, III and IV, respectively. Breakdown results from evergreen oak forests have been published in CASTRO (2004b), and for this reason are not given here.

All samples together added up to 6976 specimens collected (immatures included). 5407 spiders (77.51%) could be identified to species level. The various sampling methods accounted for the following percentages of identified individuals: Pitfall traps: 98.44% in Artikutza and 93.74% in evergreen oak forests; Kempson method: 45.51%; Berlese funnels: 82.29%; Trunk pitfall traps: 71.49%; Bark traps: 90.88% in evergreen oak forests and 91.76% in Igara; Beating: 70.61%; Hand searching: 84.38%.

Table III shows how the higher the forest stratum sampled, the smaller the proportion of adult specimens present, both in abundance and activity. Rates of adults and immature specimens matched for different sites and years in methods that register abundances in the same kind of microhabitat (Litter: Kempson and Berlese. Tree trunks: bark traps).

<table>
<thead>
<tr>
<th>Sampling method (Site)</th>
<th>Males</th>
<th>Females</th>
<th>Juveniles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (Artikutza)</td>
<td>73.68</td>
<td>15.38</td>
<td>10.94</td>
</tr>
<tr>
<td>P (Evergreen oak forests)</td>
<td>52.95</td>
<td>22.79</td>
<td>24.25</td>
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<tr>
<td>M (Artikutza)</td>
<td>37.40</td>
<td>14.48</td>
<td>48.12</td>
</tr>
<tr>
<td>TP (Evergreen oak forests)</td>
<td>18.88</td>
<td>15.26</td>
<td>65.86</td>
</tr>
<tr>
<td><strong>Abundance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K (Gorbea)</td>
<td>6.18</td>
<td>15.75</td>
<td>78.07</td>
</tr>
<tr>
<td>Fl (Evergreen oak forests)</td>
<td>7.41</td>
<td>13.33</td>
<td>79.26</td>
</tr>
<tr>
<td>Fm (Evergreen oak forests)</td>
<td>4.06</td>
<td>10.43</td>
<td>85.51</td>
</tr>
<tr>
<td>BT (Evergreen oak forests)</td>
<td>1.66</td>
<td>13.81</td>
<td>84.53</td>
</tr>
<tr>
<td>BT (Igara)</td>
<td>2.69</td>
<td>12.94</td>
<td>84.37</td>
</tr>
<tr>
<td>Bl (Evergreen oak forests)</td>
<td>2.75</td>
<td>6.42</td>
<td>90.83</td>
</tr>
<tr>
<td>Bf (Evergreen oak forests)</td>
<td>2.35</td>
<td>7.40</td>
<td>90.25</td>
</tr>
</tbody>
</table>

Table III.- Percentage of mature and immature specimens caught using each sampling method. Abbreviations: see Table II.
Identified specimens have yielded 148 species distributed in 27 families (Table IV). Three species, Centromerita bicolor, Micrargus apertus and Midia midas were new records for Iberian fauna, while Peponocramium ludicum was a new genus record for Spain. According to PLATNICK (2008), known geographic distributions for these four species are Palaearctic and Canada, Palaearctic, Europe, and Europe and Russia, respectively.

Two species Centromerus sp. and Tenuiphantes cf. jacksoni, are currently being reviewed by specialists. Tenuiphantes cf. jacksoni could be a new species for science (VAN HELSDINGEN, BOSMANS, personal communication).

Following MELIC (2001) – excepting where other authors are indicated – 8 species were endemisms of Ibero-Pyrenean scope or surrounding distributions: Troglohyphantes furcifer is found in the Spanish autonomous regions of the Basque Country, La Rioja and Navarra and in the French department of Basses Pyrénées. Bordea negrei is a Pyrenean endemism. Labulla flabulosa is found in Southern France and the Pyrenees (HORMIGA & SCHARFF, 2005). Tegenaria inermis, Borzocoma subterraneum, Walckenaeria dalmasi, and Malthonica lusitanica are Pyrenean and Northern Iberian Peninsula endemisms, the distribution of the latter extending to almost the entire Atlantic area of the peninsula (BARRIENTOS & CARDOSO, 2007), while Lepthyphantes bacelarae is an Iberian-Atlantic endemism (CASTRO & ALBERDI, 2002).


Seasonal dynamic of species richness: Among most species, activity was concentrated from spring to autumn (Figures 1 and 2). A winter minimum was usually found in January-February. Activity peaked in spring (normally in May-June) and autumn (varying between September and November). Some relative minima and maxima were observed between these two peaks. Autumn maxima showed more species at immature stages than spring peaks. The largest proportion of immature spider species was found from late summer, continuing right through the autumn. Spring peaks were almost exclusively made up of species at adult stage. Peaks in Artikutza obtained in pitfall traps were smaller in the second year than in the first year (Figure 1). This trend was not observed in samples from Malaise traps.

Epigeal pitfall and Malaise traps showed continuous activity of adults all year round, except for some sporadic interruptions in winter in Artikutza. In contrast, activity halted all winter in trunks of trees in evergreen oak forests.
Figure 1.- Seasonal changes in species richness recorded in the beech forest of Artikutza.
Figure 2.- Seasonal changes in species richness recorded in Cantabrian evergreen oak forests.
Figure 3.- Seasonal changes in species richness recorded in the litter layer and in barks.
Nonetheless, adult-stage species were present all year round in the litter and tree bark (Figure 3). In these samples, the largest proportion of species in adult stage also occurred in spring (and in a part of the summer in the evergreen oak forests). The minima occurred in winter in the bark traps and in summer in Kempson samples. Overall species richness in bark traps attained a maximum in autumn, continuing in winter, but interrupted by a relative minimum in January or in February. In litter samples from Gorbea, overall species richness peaked in January, showing another relative maximum in April, after a relative minimum in February-March.

If we continue to focus on adult stages, Table IV shows periods of maximum activity and presence for each species. It has been possible to determine the period of maximum activity of males, females, or both for 119 species. May and June were the months most frequently included in the periods of maximum breeding activity (Figure 4). Together these months encompassed 78.15% of species. If the entire period of adult presence – currently known – is taken in account, besides breeding peaks, 93.92% of the 148 species found were included between May and June.

Sampling data coincided with this trend: May and June usually continue to be the months with the highest number of species (Table V). Kempson samples from Gorbea and bark traps from the evergreen oak forests were the exceptions to this pattern. However, pooled together, May and June ranked as the second richest

![Figure 4. Percentage of mature species that include the specified month in their main reproduction period.](image-url)
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Table IV.- Months of the highest activity and presence (in brackets) of each species.
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<td>V-VII (V-X, XII)</td>
<td>10,16,111,188</td>
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<tr>
<td>(Walckenaer, 1805)</td>
<td>V-VII (IV-VII)</td>
<td>V-VIII (IV-XI)</td>
<td>6,9,16,78,128,164, 188,205,207</td>
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<tr>
<td><em>Ero spisa</em></td>
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<td>V-VIII (I-XII)</td>
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<tr>
<td>(Walckenaer, 1802)</td>
<td>(I, IV-VIII)</td>
<td>(I, II, V-VI, VIII-XI)</td>
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<td><em>Ero scita</em></td>
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<td>Villers, 1838</td>
<td>(V-VII)</td>
<td>(I, II, V-VI, VIII-XI)</td>
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<td><em>Mimetidae</em></td>
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<td><em>Pardosa nigricans</em></td>
<td>IX-XI (IX-II)</td>
<td>(I-XII)</td>
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<tr>
<td>Thorell, 1856</td>
<td>(I, IV-VII)</td>
<td>(I-X)</td>
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<td><em>Pardosa lutea</em></td>
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<td>(Walckenaer, 1802)</td>
<td>(V-VII)</td>
<td>(I, II, V-VI, VIII-XI)</td>
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<td><em>Mimetidae</em></td>
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<td><em>Pardosa pallida</em></td>
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<td>(I-X)</td>
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<td>(Walckenaer, 1802)</td>
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<td>(III, V-VII)</td>
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<td>Simon, 1884</td>
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<td><em>Philodromus dispars</em></td>
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<td>Walckenaer, 1826</td>
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Table IV.- Continue
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<td>V-VII (IV-VI, XI)</td>
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<td>Salticidae</td>
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<tr>
<td>Salticus chalybeus (Walckenaer, 1802)</td>
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<td>V-VII (V-IX)</td>
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<td>Marus erectus (Walckenaer, 1802)</td>
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<td>(V-VII)</td>
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<td>Neos reticulatus (Blackwall, 1853)</td>
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<td>Neos robustus (Lohmander, 1945)</td>
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<td>Satits barbipes (Simon, 1868)</td>
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<td>Salticus zebratus (C. L. Koch, 1837)</td>
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<tr>
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<td>Segestria barbara (C. L. Koch, 1843)</td>
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<td>Segestria nesentula (Linnaeus, 1758)</td>
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<td>V-VII (III-V)</td>
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<tr>
<td>Metellina mongei (Blackwall, 1870)</td>
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<td>IV-VII (I-XII)</td>
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<tr>
<td>Metellina hermaniae (Scopoli, 1763)</td>
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<td>IV-VII (I-XII)</td>
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<tr>
<td>Metellina seminula (Clerck, 1757)</td>
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<td>Tetragenatia montana (Simon, 1874)</td>
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<td>V-VII (III-V)</td>
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<tr>
<td>Theridiidae</td>
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<tr>
<td>Agelastica alniata (Clerck, 1757)</td>
<td>V-VI (V-VII)</td>
<td>V-VI (V-XI)</td>
<td>78,100,139,164,182,184</td>
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<tr>
<td>Araneus aurantius (C. L. Koch, 1836)</td>
<td>V-VI (III-VII)</td>
<td>(IV-VII)</td>
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<tr>
<td>Dipothoe melange (C. L. Koch, 1837)</td>
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<td>(V-VIII)</td>
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<tr>
<td>Enoplognatha orvata (Clerck, 1757)</td>
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<td>VII (III-V)</td>
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<tr>
<td>Enoplognatha theresa (Hahn, 1833)</td>
<td>V-VII (IV-VIII)</td>
<td>VI-VII (II-XI)</td>
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</tr>
<tr>
<td>Epistopus maculipes (Cavanna, 1876)</td>
<td>VII (IV-V, VII-X)</td>
<td>(V-X)</td>
<td>19,111</td>
</tr>
<tr>
<td>Epistopus theridionis (Simon, 1873)</td>
<td>(X)</td>
<td>(III, IV, VII, X)</td>
<td>26</td>
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<tr>
<td>Epistopus truncatus (Latreille, 1809)</td>
<td>VI-VII (IV-VI)</td>
<td>(V-XI)</td>
<td>78,128</td>
</tr>
<tr>
<td>Karijaincta tincta (Walckenaer, 1802)</td>
<td>V-VI (I, III-VI)</td>
<td>V-VII (I, III-VI)</td>
<td>19,78,111,139,164</td>
</tr>
<tr>
<td>Pardosa pulchra (Blackwall, 1834)</td>
<td>IV-VI (III-VIII)</td>
<td>V-VII (III-V)</td>
<td>19,78,164,182</td>
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<tr>
<td>Parasteatoda tepidariorum (C. L. Koch, 1841)</td>
<td>IV-V, VII-X (II-XII)</td>
<td>(I-XII)</td>
<td>22</td>
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<tr>
<td>Pholcus phalangioides (Westring, 1851)</td>
<td>IV, IX-XII (I-XII)</td>
<td>III-V, IX-XII (I-XII)</td>
<td>35,78,128,139,164</td>
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<tr>
<td>Pteronis dida (Lucas, 1846)</td>
<td>(II, VIII)</td>
<td>(VI, VIII)</td>
<td>111,204</td>
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Table IV.- Continue
period in Gorbea (13 species), and June-July in the oak forests (6 species). Besides, the lower the stratum, the sooner the species richness peak occurred: mainly in May in epigeal pitfall traps, June in Malaise and trunk pitfall traps, and the second half of June and beginning of July in trees (trunk pitfall and bark traps pooled).

**Seasonal dynamics of the species:** Seasonal dynamics of the most abundant species are displayed as graphs in Figures 5-9. Species whose seasonal dynamics are poorly known or for which scarce literature data are available, are shown in Figures 5 and 6. Better known species are represented in figures 7-9.

For some species, males were active for a long period (Figure 5): Adults of *Malthonica lusitanica* show oscillations in activity, though this occurred mainly in

<table>
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<th>Presence of females</th>
<th>Reference number</th>
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<tbody>
<tr>
<td>Roberiota lindas (Blackwall, 1836)</td>
<td>V-VII (I-XII)</td>
<td>V-X (I-XII)</td>
<td>4,78,91,99,128,139,164,188</td>
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<tr>
<td>Sinistiram similis (C. L. Koch, 1836)</td>
<td>V-VI (V-VII, X)</td>
<td>V-VI (V-X)</td>
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<tr>
<td>Stenoda triangularis (Walckenaer, 1802)</td>
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<tr>
<td>Theridium mystaceum (K. Koch, 1876)</td>
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<td>V-VI (I-XII)</td>
<td>35,78,142</td>
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<td>Theridion pinastri Koch, 1872</td>
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<td>(V-I)</td>
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<td>Theridion varians Hahn, 1833</td>
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<td>VI-VII (III-XII)</td>
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<td>Theridula gorgaster (Simon, 1873)</td>
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<td>(IX)</td>
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<td>THOMISIDAE</td>
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<td>Cosyphitis blackwalli (Simon, 1875)</td>
<td>VI-VIII (V-IX, XII)</td>
<td>(I-VIII)</td>
<td>19,111</td>
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<td>Dioca dorsata (Fabricius 1777)</td>
<td>III, V-VI (III-VIII)</td>
<td>VI (V-XI)</td>
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<td>Pisirrus iranicus (Pallas, 1772)</td>
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<td>(V-VIII)</td>
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<td>Timaras stello Simon, 1875</td>
<td>V (V-VII, IX)</td>
<td>V-VI (III-X)</td>
<td>78,111</td>
</tr>
<tr>
<td>Oxyscus anidex (Schrinck, 1803)</td>
<td>V-VI (IV-IX, XI)</td>
<td>V-VII (IV-XI)</td>
<td>4,78,129,164,182</td>
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<tr>
<td>Oxyscus cristatus (Clerck, 1757)</td>
<td>V-VI (I-XII)</td>
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<td>(VIII-II)</td>
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<td>Hypsogaster flavipes (Blackwall, 1862)</td>
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<td>ZODARIDAE</td>
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<td>Zodaria iricicum (Canestrini, 1868)</td>
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<td>ZORIDAE</td>
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<td>Zora spinimana (Sundevall, 1833)</td>
<td>IV-X (I-XII)</td>
<td>IV-X (I-XII)</td>
<td>6,9,29,78,129,164</td>
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</table>
spring and autumn, with a peak of males in the autumn. *Palliduphantes cernuus* was active all year, except for late fall and the beginning of the winter, reaching the maximum in spring and early summer. Adults and immature specimens of *Chorizomma subterraneum* were present all year round. Adults were active mainly in autumn and winter, though with several fluctuations. Juveniles are most active from mid-summer to the beginning of the autumn, with three peaks of abundance in late spring, the first half of the autumn and winter (the maximum). Maximum adult abundance of *Gongylidiellum murcidum* occurred in late autumn and the beginning of the winter. Although males could be found for all autumn and winter, this period did not perhaps indicate true mating activity (this issue is dealt with later in the discussion). Other species with long activity periods in males (see Figure 7 and Appendices II and III) were *Tenuiphantes flavipes* (spring to autumn), *Tenuiphantes zimmermanni* (spring and summer) and *Tenuiphantes cf. jacksoni* (spring and summer).

Other species showed male activity periods restricted to a certain time of year (Figure 6): In *Dipoena melanogaster* this was from late spring to the beginning of summer. *Labulla flabaulti* adults were present from the second half of the summer to mid-autumn, while immatures appear in spring and summer. *Nemesia simoni* males reached maximum activity in autumn, mainly between September and November, with a few sporadic adult catches during the rest of the year. Males of better-known species (Figure 7 and Appendices II-IV) were active in the following periods: *Clubiona comta*, *Anyphaena accentuata* and *Pardosa lugubris* in spring, *Malthonica picta* in spring and the beginning of summer, *Textrix denticulata* and *Clubiona terrestris* in late spring and summer, *Coelotes terrestris* from mid-summer to mid-autumn and *Scotina celans* in late autumn and winter.

There were species in which both adult males and females, were present in two different periods of the year: *Episinus maculipes* at the beginning of spring and in summer (Figure 5), and *Micrargus apertus* (Figure 6) in spring and late autumn-winter.

Bark traps showed the seasonal dynamics of immatures of several species, whose captures were concentrated from late summer to winter (Figure 8). Despite the activity overlap among the species, their peaks did not coincide, with the exception of *Clubiona brevisipes* and *Cheiracanthium mildei*. However, both species co-occurred in the forest of Zumaia, where the dates of their peaks also differ (CASTRO, 2004b).
Figure 5.- Seasonal dynamics of species with scarce bibliographical data.
Figure 6.- Seasonal dynamics of species with scarce bibliographical data.
Figure 7.- Seasonal dynamics of species collected in high numbers in Malaise traps and epigeal pitfall traps (Artikutza).
Figure 8.- Seasonal dynamics of immature specimens of species caught in high numbers using bark traps.
Figure 9. Seasonal dynamics of some species during two consecutive sampling years (Artikutza: Malaise traps).
Vertical distribution of the species: Several species were active in more than one forest stratum. This was the case of *Malthonica picta*, *Tenuiphantes cf. jacksongi*, *T. zimmermanni* (Figure 7) and *T. flavipes*. In Artikutza, these species were caught both in pitfall and Malaise traps. But in the evergreen oak forests, they were not collected, or only sporadically collected, in trunk pitfall traps and bark traps, and never reached the tree foliage and liana stratum. In contrast, *Clubiona comta* and *Saitis barbipes* were caught by all kinds of collecting methods. *Dysdera fusciopes*, *Harpactea hombergi*, *Neon robustus* and *Saitis barbipes* were also active in both SEASONAL DYNAMICS OF FOREST SPIDERS (ARACHNIDA: ARANEAE) IN THE TEMPERATE ZONE OF THE BASQUE COUNTRY AND NAVARRA (NORTHERN SPAIN)

<table>
<thead>
<tr>
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<th>The two consecutive dates that showed the highest species richness</th>
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<td>K</td>
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<td>Artikutza</td>
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<tr>
<td>First cycle</td>
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<tr>
<td>P</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>P + M</td>
<td>62</td>
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<td>Second cycle</td>
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<tr>
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<td>16</td>
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<tr>
<td>M</td>
<td>42</td>
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<tr>
<td>P + M</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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</tr>
<tr>
<td>P</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>61</td>
<td></td>
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<tr>
<td>P + M</td>
<td>74</td>
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<tr>
<td>Evergreen oak forests</td>
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<tr>
<td>P</td>
<td>54</td>
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<tr>
<td>TP</td>
<td>30</td>
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<tr>
<td>BT</td>
<td>17</td>
<td>28 VIII/4 XI and 25 IX/2 X</td>
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<tr>
<td>P + TP</td>
<td>73</td>
<td>5/12 VI 22 30.14</td>
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<tr>
<td>P + BT</td>
<td>63</td>
<td>3/10 VII and 8.57</td>
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<td>39</td>
<td>3/10 VII and 5/12 VI</td>
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<td>3/10 VII 5/12 VI</td>
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<td>XI and V 4 33.00</td>
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Table V.- Observed species richness (only in adult phase) with each sampling method (or by combining more than one) in the whole sampling period and during the periods of highest species richness. Abbreviations: see Table II. In Artikutza, the first cycle ran from 15 May 1995 to 28 April 1996, and the second from 12 May 1996 to 20 April 1997.
environments, epigeal and tree trunks and the latter extended its activity to tree foliage. Despite showing vertical displacement, other species such as *Palliduphantes cernuus*, showed greater activity in lower strata, while *Episinus maculipes, Labulla flabaulti* and *Textrix denticulata* were mainly found in upper strata.

All the most abundant species with long mating period (2 seasons or more) were found in the coger vegetation strata. The only exception was *Tenuiphantes zimmermanni*. However, this species was only caught in large numbers in Malaise traps, being sporadically found in bark traps and totally absent in trunk pitfall traps and beating samples.

**Differences between consecutive years:** In Artikutza, there were differences in abundance within species between the first and the second year (Appendices II and III). Higher numbers of individuals were registered by pitfall traps in the first year for almost all the most abundant species: *Malthonica picta, M. lusitanica, Coelotes terrestris, Tenuiphantes cf. jacksoni, T. zimmermanni* and *Pardosa lugubris*. The only exception was *Nemesia simoni*, where the trend was just the opposite (Figure 6). On the contrary, with the exception of *Tenuiphantes zimmermanni*, catches in Malaise traps were more numerous on the second year for the most abundant species: *Malthonica picta, Textrix denticulata, Clubiona comta* and *Clubiona terrestris*.

Within each species, main male activity did not vary more than one month between different years and places. In *Nemesia simoni* (Figure 6), the main activity always took place in October (though it extended to November in 1996). In *Coelotes terrestris* this period occurred in September; in *Malthonica picta* (Figure 7) and *Pardosa lugubris* it varied from April to May; and in *Clubiona terrestris* and *Textrix denticulata* (Figure 9), it took place from July to August (but it is possible that the July peak did not vary, given that in the second year, a July sample was missing in Artikutza). Only *Clubiona comta* showed larger oscillations, with the main male activity between late March and mid-May depending on the year. However, a lack of samples before May in 1995 in Artikutza may have led to an earlier activity peak for this species being missed.

**DISCUSSION**

**Faunistic contribution:** The capture of the following new species for the Iberian Peninsula and Spain was not surprising, since all are widespread in Europe (CANARD, 2005), and have already been recorded from the south of France: *Centromerita bicolor* had been registered from several locations in the French Pyrenees (BOSMANS & DE KEER, 1985; LEDOUX et al., 1996; LE PERU, 2007), *Peponocranium ludicrum* is common in the Atlantic side of France (LE PERU, 2007).
and has been recently recorded in Portugal (CARDOSO et al., 2008). *Micrargus apertus* is a less frequent species, usually recorded in forest ecosystems in Europe (HÄNGGI et al., 1995), but in France it is only known in the Department of Pyrénées Orientales (MILLIDGE, 1975).

The nearest record for the fourth species, *Midia midas*, is in a forest in the Department of Seine-et-Marne (SIMON, 1884, 1914-1937), in the north of France. There are more scattered citations of *Midia midas* in Central and Atlantic Europe (CANARD, 2005). The species is considered an old growth forest specialist (DUFFEY, 1993; HARVEY et al., 2003). According to these authors, *Midia midas* seems to be confined to senescent trees, living in loose bark, dead wood, litter inside cavities of beeches and oaks, and in the nests of birds and squirrels. Corroborating these data, *Midia midas* was found in the forest of Artikutza, the only one with a large amount of dead wood caused by a lack of forestry work over more than 70 years at the time of sampling (MARTÍNEZ DE MURGUÍA et al., 2002). Only one specimen was found, collected by Malaise traps. More specimens would probably have been found if the oldest trees in the forest had been sampled.

Despite finding 14 endemic species or with South-western European distribution, their presence in the study area was expected, because it is included in their known geographic distribution. In any case, the capture of *Bordea negrei* is remarkable, since hitherto all known citations have been from caves (BOSMANS, 1995). Surprisingly, the only individual caught was found in a pitfall trap in Artikutza, where the soil has no connection to a subterranean cavernicolous environment, because of the substrate of intrusive rocks characteristic of this area (CATALÁN et al., 1989).

**Seasonal dynamics:** In agreement to the literature reviewed the species richness peak of active adult specimens takes place in the temperate part of the central and atlantic Europe between May and June: In Germany in several strata (TRETZEL, 1954), in Denmark for several strata pooled (TOFT, 1976), and in Portugal in epigeal stratum (CARDOSO, 2004; CARDOSO et al., 2007). However, this pattern is broken in mediterranean places as in west-central Spain, where the main epigeal activity takes place in June-August, with the maxima in August (JERARDINO et al., 1988). Likewise, in boreal climates like in Finland, there is also a delay in the peak of species richness, which occurs between June and July (NIEMELĂ, 1994).

The later occurrence of maximum richness in upper strata has also previously been observed: In German forests, epigaedic richness extends from April to June, and trunk-canopy richness from June to July (ALBERT, 1982). LUCZAK (1959), sampling the ground flora with a sweep net in Polish pine forests, found June to be the period of main diversity. HOREGOTT (1960) sampled the arboreal stratum of a German pine forest and concluded that the diversity peaks in July-August. Although they do not provide data on seasonal variations in species richness, other studies report the
same months within the peaks of maximum adult spider abundance: in Germany, May-September in the epigeal stratum and May-July in the trees (ALBERT, 1982) and in Austria May-July in the epigeal stratum (NOFLATSCHER, 1993).

All of these results were expected, since most species breed between the spring and summer in most European countries: Germany (SCHAEFER, 1977), Austria (NOFLATSCHER, 1993), Belgium (BAERT & KEKENBOSCH, 1982; BAERT et al., 1983), Finland (PALMGREN, 1972) and Norway (HAUGE, 2000).

In this work, whereas the May-June peak is due almost exclusively to the activity of adult spiders, the second relative maximum, usually in autumn, is the result of active immatures in period of dispersal, most probably looking for overwintering shelters (SCHAEFER, 1977). These immatures probably come from females that mated in spring and summer (LUCZAK, 1959). At this time, there are also some adults in breeding activity and others looking for sites in which to overwinter (TOFT, 1976; SCHAEFER, 1987). The sum total of the adults’ activity causes the autumn peak observed in Artikutza. This second maximum has also been observed in several localities in Portugal, specifically in October (CARDOSO, 2004; CARDOSO et al., 2007).

Results from litter samples and bark traps reflect other dynamics apart from seasonal reproductive displacements. For example, linyphiids are the most abundant and diverse family in litter samples in Gorbea. Among them, several species breed in the fall or winter (SCHAEFER, 1976; CARDOSO, 2004). In addition, other species overwinter in the litter (SCHAEFER, 1977), explaining the winter maximum observed. The summer minimum coincides with the driest season. This condition reduces the presence of linyphiids (HAUGE, 2000). Summer is also the season when the least amount of litter is available on the forest floor (GABBUT, 1956) and higher amounts of litter are usually positively linked with diversity in of spiders (UETZ, 1979).

The autumn movements of species looking for overwintering sites (DUFFEY, 1969; PEKÁR, 1999b; HORTON et al., 2001; HORVÁTH & SZINETÁR, 2002) are responsible for the maximum species richness observed in this season using bark traps. As the each species’ activity ends, diversity falls during the winter, to a January-February minimum. From then on, there is activity among more species in adult stages, and thus juveniles mature or disperse to other strata or environments. As a result, there was a second peak of adults in spring-summer. During the warm season some species breded or feded in tree trunks: *Textrix denticulata*, *Harpactea hombergi*, *Clubiona comta*, *Labulla flabautli*, *Segestria bavarica* and *Neon robustus*. Some of them were not present in the Igara samples, causing a relative summer minimum. In the autumn, several of these species disappeared and displacements of immatures looking for overwintering sites started again.

**Seasonal dynamics of the species:** Usually, species with long-reproductive periods do not concentrate them in one specific time of the year (SCHAEFER, 1987).
This is the example of the mating period of *Tenuiphantes flavipes*, as observed by several authors (MERRETT, 1969; JOCQUÉ, 1973; RIBERA & HORMIGA, 1985). The species appears to be very flexible in this regard since peaks of males can occur at different times of year, according to different studies: winter (TOFT, 1976), June (SCHAEFER, 1976), and even in two different periods of the year, May-July and October-November (HARVEY et al., 2002). The principal mating period of *Palliduphantes cernuus* extends from late spring to the beginning of summer, according to specimens collected in the Pyrenean foothills, Jaca, Spain (RIBERA & HORMIGA, 1985). But in Jaca, the species shows two differences with regard to this study: a second peak of males between December-February, and an adult minimum extending from August to November. There are also differences between the two Spanish areas in the seasonal dynamics of *Chorizomma subterraneum*. In Jaca, the mating period is between August and December, with a maximum between August and October (BARRIENTOS, 1985b). But in the study area this period extends to May, with three maxima observed: September-October, December-January (peak of male activity), and February-April (secondary peak interrupted by a slight drop in March). In Jaca, *Chorizomma subterraneum* has been collected in damp low-altitude forests, and is more common in floors with thick layers of moss and needles. This, combined with its troglophilous character (RIBERA, 1980), leads one to think that *Chorizomma subterraneum* is a stenotopic species looking for damp habitats with narrow temperature margins throughout the year (BARRIENTOS, 1985b). The colder winter of Jaca would probably prevent activity of the species, at least on the epigaeic layer. In the Basque Country, its life cycle seems to have an overlap of three generations per year, thus each mating peak is followed by an activity of females and a consecutive peak in abundance of immatures, which remain inactive in the litter during the cold season (Figure 5).

Data from the literature shows greater consensus in the case of *Tenuiphantes zimmermanni* and *Malithonica lusitanica*. Both species have a minimum reproductive activity in winter, with two main mating periods between spring-summer and late summer-autumn. However, in *Malithonica lusitanica*, the spring-summer activity of males can be greater—as in Portugal (BARRIENTOS & CARDOSO, 2007) and Artikutza—or smaller than the late summer-autumn peak, as in Jaca, Spain (BARRIENTOS, 1985a,b) and the evergreen oak forests. In addition, BARRIENTOS (1985b) observed differences between habitats sampled at high and low altitudes within the same geographic area: at higher altitudes, males did not show spring-summer activity. Hence, what is always conservative is the late summer-autumn peak. BARRIENTOS (1985b) suggests that winter and spring breeding activity might be confined to deeper layers inside the litter. It has been observed that *Malithonica lusitanica* shows a clear preference for woodland habitats with a relatively deep litter and ground moss (BARRIENTOS & CARDOSO, 2007). In the litter and saxycalous moss of evergreen oak forests, adults are mainly concentrated in spring-sum-
mer (males only in spring), and immatures all year round (CASTRO, 2004b). In this kind of forest, pitfall traps show that each peak in males, even secondary ones, is followed by activity amongst females. These data suggest the presence of consecutive overlapping generations, as previously hypothesized (BARRIENTOS, 1985b).

Among species with short reproductive periods, only *Scotina celans* showed a peak in male activity that did not coincide with the data from the literature. According to the references consulted, the peak occurred between September and November, while in Cantabrian evergreen oak forests it occurs between December and February, with a presence stretching to April. Females were found all year round. The same was true for immatures, which abundantly colonized the saxicolous moss. In Brittany (France), CANARD (1984) found that adults started to be active at the beginning of the autumn, and the greatest population of this species had a biological cycle of two years, it being possible that one small portion completed it in a single year. It is possible that in the more moderate climate of the evergreen oak forests of the study area, the cycle could be mostly resumed in one year, with the first males maturing in the second half of the autumn. Only URONES (1985a) also finds a persistence of males from October to April in the Pyrenean foothills (northern Spain), but her data is made up of a small number of specimens, and they come from different habitats comprising a wide spectra of climatic conditions that may represent a mix of one and two-year cycles.

Within a given species, peaks of activity and density are often not coincident (HUHTA, 1965; 1971). This is the reason for the differences usually observed in the results obtained by pitfall traps and extraction of litter samples (HOVEMEYER & STIPPICH, 2000). For instance, *Gongylidiellum murcidum* shows a spring-summer breeding period, the male peak occurs in summer, and the presence of adults extends till the autumn (PALMGREN, 1972, 1976; PLATEN *et al*., 1996). The data in PLATEN *et al*. are based on pitfall traps, and PALGREM's on litter sifting in the field throughout the year with the exception of the winter. According to the data collected in litter samples in Gorbea (Appendix I), males occurred in autumn and winter, and females all year round, with a peak of adults in January. This peak is in concordance with that obtained by WOZNY (1992) in the litter and moss of Polish pine forests. But this author does not break down the data into males and females. A possible interpretation of all these results may therefore be summarized as follows: there is activity of adults from the spring; the females that mate earlier could lay eggs from which spiders would hatch that become mature in the autumn. These individuals would overwinter—mainly inactively—in the litter, and be active again in spring and summer. This would explain the drop in density observed in Kempson litter samples, because litter extraction methods bias, above all, spiders that are inactive or show static hunting strategies (KOPONEN, 1976). The seasonal dynamics of *Micrargus apertus* were similar (Figure 6). According to HARVEY *et al*. (2002), in England the main breeding period of *M. apertus* is in spring and early summer, with
sporadic presence of adults all year round. Even though they do not specify the sampling methods used to collect this species, it is likely that they reflect its activity. This winter activity, on mild, sunny days, is common in Central Europe (KIRCHNER, 1987). In accordance with the data obtained by BARRIENTOS et al. (1994), Harpactea hombergi is another species whose adults are mainly inactive in winter, but it overwinters in the evergreen oak forests, especially in the saxicolous moss.

Bark traps show displacements of spiders searching for overwintering sites (DUF-FEY, 1969). As this researcher found, I observed that Clubiona comta also used bark traps for egg-laying (females with eggs observed in June and July samples), and C. brevipes as an overwintering site. In addition, Malaise traps shows that immatures of C. comta have more winter activity, being found in the litter, tree foliage, and mainly in tree trunks and arbustive stratum. Corroborating the data showed by KOOMEN (1998), immatures of Anyphaena accentuata were also active in winter, but more restricted to the arboricolous environment. As the findings of HORTON et al. (2001) and HORVÁRTH & SZINETÁR (2002) show, juveniles of C. pallidula and Cheiracanthium mildei also rested in the traps, being sporadically active in winter. Although most individuals from all these species overwinter as immatures, a few do so as adults. Presence of C. terrestris adults has been found in November, C. comta and C. brevipes till December, and A. accentuata in January. However, winter activity of adults has not been observed. The mere presence of adults in winter for some of these species is documented in the literature: C. comta (SCHAEFER, 1976; BARRIENTOS et al., 1996; HARVEY et al., 2002), C. pallidula (SCHAEFER, 1976), C. terrestris (SCHAEFER, 1976; TOFT, 1976, 1978a; HARVEY et al., 2002), and A. accentuata (URONES et al., 1995a; HARVEY et al., 2002). On the other hand, Clubionidae, Miturgidae and Anyphaenidae spiders are all cursorial spiders. The lack of coincidence among activity peaks of spiders belonging to the same guild has been observed previously, and it supports the hypothesis of temporal stratification as a possible factor that explains their co-existence (TRETZEL, 1954; BUDDLE & DRANEY, 2004). However, at least within Clubionidae there is no evidence of intraguild predation on tree trunks (PEKÁR, 1999b). Hence, future research will be needed to test this hypothesis in the study area.

Because their life cycles are not well-known, a further discussion of the data obtained for the species Nemesia simoni, Labulla flahaulti, Dipoena melanogaster and Episinus maculipes is presented below:

Hitherto, sporadic records have given clues about the mating period of Nemesia simoni. The anecdotic observations of THOMAS (1999), who found 46 males (and any females) drowned in a swimming pool in the Department of Gironde (France) in a period of less than five days (12-16 September 1994), tallies with the data obtained in this work, where males of Nemesia simoni concentrate their activity from September to November, with a low number of additional captures till January in the evergreen oak forests.
The cycle of *Labulla flahaulti* fits with that of autumn stenochronous (SCHAEFER, 1977). Immatures were collected from late March, showing activity till August (Figure 6), when more individuals became sub-adults or adults. Throughout that time, they build their webs between large epigeal stones, barks and foliage of trees and bushes (CASTRO, 2004b). Adults are mainly found in tree trunks. Mating took place between the middle of summer and early autumn, when it was common to observe webs of both, males and females, in the same bark trap (personal observation). An egg-sac, found in Igara samples in October, suggests that autumn is the egg-laying period. No specimens were collected in winter, which indicates an annual cycle, overwintering in the egg phase.

*Dipoena melanogaster* shows a life cycle that falls into the spring and summer stenochronous category (SCHAEFER, 1977), which matches the findings of PLATEN et al. (1996). The mating period took place between May and July, with a peak in June. BARRIENTOS et al. (1996) indicate that mating occurs in summer, but without specifying which months. This species - only found in the Cantabrian evergreen oak forests in the present work – overwinters as immature stage in the foliage and branches of trees and shrubs, after showing a remarkable period of activity in the fall.

In the Cantabrian evergreen oak forests, *Episinus maculipes* males occurred in two different seasons: spring (from April to May) and summer (July-September). Adult females have also been registered at the same times. But in the Mediterranean evergreen oak forests of North-Eastern Spain, the mating period only takes place in summer (BARRIENTOS et al., 1996). The species may show diplochrony depending on environmental conditions. The immatures were active in spring and summer on tree trunks, and in the autumn on forest litter where they probably overwinter. However, no individuals have been collected in litter samples, but several have been observed in branches near the forest floor in the cold season of the year.

**Vertical distribution of the species:** The greater proportion of juvenile specimens found in higher strata is explained by the scarcity of species with long breeding periods and by the low winter activity of adult individuals compared with the epigeal stratum. The higher proportion of species active in the adult stage at the lowest strata has previously been observed by several researchers (TRETZEL, 1954; PALMGREN, 1972; TOFT, 1976; ALBERT, 1982; CASTRO, 2004b). PALMGREN (1972) hypothesised that this pattern is due to the greater thermal stability of lower strata. HUHTA (1965) and BARRAQUTA (1985) show that air temperature oscillates more than that of the humus. Likewise, BRAUN (1992) found that higher parts of the trees are colder and drier, showing less diversity of spiders. MERRETT (1968) and TOFT (1976) argue that breeding periods are synchronized within each stratum with the period of maximum activity of prey. According to this, it has been observed that prey abundance is correlated with species richness of litter spiders, above all in spring and early summer (UETZ, 1975, 1979). Precisely, the prey capture by litter
spiders is the greatest in spring months, a period of rapid growth and maturity for many species (MOULDER & REICHLE, 1972).

We can distinguish between the preferences of several spiders for specific strata. Like *Tenuiphantes flavipes* and *T. zimmermanni* (JOCQUÉ, 1973; TOFT, 1976), *Tenuiphantes cf. jacksoni* seems to colonize the plant strata just above the forest floor surface, as Malaise traps indicate. But none of these species seems to show an affinity for tree trunks, since they have rarely been collected in bark and trunk pitfall traps. Data from the literature (ALBERT, 1976; WUNDERLICH, 1982; MARC, 1990; BRAUN, 1992; HORVÁTH & SZINETÁR, 1998, 2002) corroborates this hypothesis for *T. flavipes* and *T. zimmermanni*. Although *T. flavipes* can spread to tree trunks, it prefers the epigeal stratum (SIMON, 1991). Taking pitfall traps as well, it is observed that *Malibonica picta* is active in both strata, and that *Coelotes terestris* makes some vertical displacements, even to tree trunks (ALBERT, 1976). Even though *Clubiona terrestris* was only well represented in Malaise traps, TOFT (1978a) finds that it distributes in all strata in a Danish beech forest, as it was the case with *C. comta* in this study. Among the most abundant species found, the following are considered to be at least facultative trunk dwellers, according to the aforementioned literature: *Harpactea hombergi*, present in the forest floor too, *Textrix denticulata*, which also occurs in lower strata, and *Segestria bavarica*, *Dipoena melanogaster*, *Episinus maculipes*, *Paidiscura pallens*, *Keijia tincta*, *Labulla flabaulti*, *Anyphaena accentuata*, *Clubiona brevipes*, *C. pallidula*, *Philodromus rufus*, *P. aureolus*, *P. dispar* and *Diaea dorsata*, which are equally found in tree trunks, tree foliage and arbustive strata.

For the reasons explained in the section on material and methods, of all sampling methods applied, only Malaise traps are not of widespread use among arachnologists. It therefore seems appropriate to discuss some of the properties of the method. According to the results observed, Malaise traps yield a high number of species, requiring active displacements of spiders to allow their capture. The faunistic composition recorded seems to correspond to that of the herb and bush forest strata surrounding the traps, as also observed by JENNINGS & HILBURN (1988); it is not possible to relate the species collected with any particular microhabitat. All these properties suggest that pitfall and Malaise traps perform similarly and therefore the same remarks on the interpretation of the results obtained apply to both. It is also important to point out that spiders account for only 0.11-0.12% of all arthropods captured in Malaise traps (PUJADE, 1996; SCHNEIDER & DUELLI, 1997), and therefore this method is not recommended if the main focus of the study is the spider fauna. Nonetheless, when available, data from Malaise traps should not be neglected, since in some forests the highest species richness of spiders has been observed in low understorey strata (TURNBULL, 1960). Of the 77 species collected in the beech forest of Artikutza, 34 (44.16%) were registered by pitfall traps and 64 (83.12%) by Malaise traps. These percentages tally quite closely with those found in
a German beech forest (ALBERT, 1976): 42.35% by pitfall traps and 78.82% by arboreal photoeclectors (85 species collected). In the Cantabrian evergreen oak forest 100 species have been found, 66 of which are present in the epigeal strata and 55 above this level (CASTRO, 2004b). The data obtained therefore highlights the need to sample above epigeal stratum to get a complete inventory of spider fauna. Regarding future research, it would be advisable to compare Malaise traps with other sampling methods well recognised as being effective in registering spiders active in low forest strata, such as emergency traps (ASCASO & BARRIENTOS, 1986; HÖVEMEYER & STIPPICH, 2000) and arboreal photoeclectors (ALBERT, 1976).

**Differences between consecutive years:** The differences found in pitfall trap samples in Artikutza between two consecutive years, both in terms of the number of specimens and the species observed, may be explained by several factors: one could be the weather conditions, since the second year was rainier and colder than the first (MARTÍNEZ DE MURGUÍA *et al.*, 2001). In Finland, KOPONEN *et al.* (1974) found a positive correlation between temperature and spider activity, though NIEMELÄ *et al.* (1994) do not, even though the latter observe a negative correlation with rainfall. MERRETT (1968) also observed a decrease in the activity of lycosid spiders during rainy periods. Data from field experiments in a temperate forest in the eastern USA also show a reduction in activity for gnaphosids in certain litter layers (LENSING *et al.*, 2005). Although in Portugal, CARDOSO *et al.* (2007) obtained a negative correlation between species richness and rainfall, they did not find temperature to have a significant influence. Although temperature and rainfall might explain the lower activity observed in pitfall traps in the second year, they do not explain why these differences are not so evident in Malaise traps. Several species were caught even more abundantly in the second year by Malaise traps. This effect might be due to the attraction this kind of trap holds for spiders as a sheltering microclimate, a focus of concentration of potential prey and their complex architecture (JENNINGS & HILBURN, 1988). Pitfall-trap sampling intensity is another factor that might depress the populations of the most active species (CANARD, 1981).

Within short-mating period species, slight differences in the occurrence of peak activities of males in consecutive years have also been observed by several authors. In Germany, TRETZEL (1954) found oscillations of one or two months, arguing that it is due to variations in temperature. AITCHINSON (1984) observed differences of two weeks in lycosid spiders in Canada, while BUDDLE & DRANEY (2004) recorded even fewer differences for dominant linyphiids in the same country. RUSSELL-SMITH & SWANN (1972) compared seasonal peaks from England and Germany, obtaining differences that did not exceed of one month. As explained previously, short-mating period species comprised the majority found in the samples, and also in temperate latitudes, and the life cycle of most of them (spring and summer ste-nochronous and diplochronous) is controlled by photoperiod, besides temperature (SCHAEFER, 1977; KISS & SAMU, 2002). This would explain why the activity peaks
are so conservative, and why the main predictive factor of species richness over time is the length of the day, as found by CARDOSO et al. (2007).

Activity minima took place in winter, coinciding with the coldest months of the year in the study area: January and February (MARTÍNEZ DE MURGUÍA et al., 2001; CASTRO, 2004b). These months are usually rainy, but the winter of 1997 was warmer and drier than the previous year in Artikutza (MARTÍNEZ DE MURGUÍA et al., 2001). This would explain the relative maximum observed in the winter of 1997. The presence of relative maxima in winter in the study area is not surprising, given the activity of spiders observed in boreal regions on mild days at this time of the year (HUHTA & VIRAMO, 1979; AITCHINSON, 1984). Species whose activity is more dependent on temperature, or on complex interactions between temperature and photoperiod, might interrupt their simple dormancy in warmer-than-usual days in winter (SCHAEFER, 1977).

Conclusions and further research: With the aim of applying the indicative value of spider diversity in environmental management and conservation, a thorough knowledge is needed of the representative fauna of the forests in the study area. To save resources, budget and time, samples should be concentrated in the periods of the year that yield the most productive results. Most European literature on the topic suggests that peaks of species-richness at adult stage, and consequently the highest proportion of identifiable specimens, occur in May-June. In the study area, in the transition between these months (4 weeks), it is possible to collect around half of the species recorded in a systematic sampling comprising an entire year (similar to the percentages found by SCHARFF et al. (2003) and CARDOSO et al. (2007)), though according to the literature revised, it would theoretically be possible to collect a proportion closer to 94%.

However, as SCHARFF et al. (2003) show, for a specific month, even short intensive three-day sampling protocols can yield results that are as good as two months of systematic collection carried out at two-week intervals. Thus, for future studies, the available data from the Cantabrian evergreen oak forests and Artikutza will make it possible to estimate the performance of short-intensive sampling protocols proposed by several researchers (CODDINGTON et al., 1991, 1996; SORENSEN et al., 2002; SCHARFF et al., 2003; CARDOSO et al., 2008). If these protocols prove effective, considerable material and economic resources could be saved in future research.

It should also be borne in mind that as observed in Artikutza, both the number of individuals and the species richness registered may vary between consecutive years in the same study site. For this reason, this study can be used as a starting reference work that can be used to check whether the yield for a specific year in future short intensive sampling protocols is significantly lower than expected.

Finally, another factor to be taken into account is the forest stratum. Results indicate May (the middle half as the most favourable period) as being the best month
to capture the highest species richness in the epigeal stratum (pitfall traps), the May-June transition for the low understory vegetation (Malaise traps), and June for tree trunks (trunk pitfall and bark traps). When limited resources lead to a focus on a specific stratum, sampling the epigaeic community seems the advisable option in Mediterranean-type forests in the Iberian Peninsula, since it contains the highest diversity and rate of endemics (CASTRO, 2004b, CARDOSO et al., 2007). Nevertheless, this may not be generalized to temperate woodlands since more species richness has been observed in upper strata in Artikutza and other beech forests (ALBERT, 1976). Further research combining several sampling methods in different kinds of forests in the study area is needed to determine whether most diversity and endemic species are generally concentrated in the epigeal stratum.

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A. CASTRO GIL
### Appendix I.- Breakdown of the catches made in the litter layer in Gorbea using the Kempson method. Abbreviations: m = males, f = females. Numbers without letter = immatures.

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Appendix I.- Breakdown of the catches made in the litter layer in Gorbea using the Kempson method. Abbreviations: m = males, f = females. Numbers without letter = immatures.
### Appendix II. Breakdown of the catches made using epigaeic pitfall traps in the forest of Artikutza

**Abbreviations:** m = males, f = females. Numbers without letter = immatures.

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Appendix II.- Breakdown of the catches made using epigaeic pitfall traps in the forest of Artikutza. Abbreviations: m = males, f = females. Numbers without letter = immatures.
### Seasonal Dynamics of Forest Spiders (Arachnida: Araneae) in the Temperate Zone of the Basque Country and Navarra (Northern Spain)

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Appendix II. Continuation.
### Seasonal Dynamics of Forest Spiders (Arachnida: Araneae) in the Temperate Zone of the Basque Country and Navarra (Northern Spain)

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Appendix III.- Breakdown of the catches made using Malaise traps in the forest of Artikutza. Abbreviations: m = males, f = females. Numbers without letter = immatures.
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**Seasonal dynamics of forest spiders (Arachnida: Araneae) in the temperate zone of the Basque Country and Navarra (northern Spain)**

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Appendix III. Continuation.
## Appendix IV. Breakdown of the catches made using bark traps in the alder forest of Igara.

Abbreviations: m = males, f = females. Numbers without letter = immatures.

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