

Distribution of vespid species in Europe

Javier Fernández

Purpose of review

Knowledge of the different stinging vespids found in various parts of Europe and their venom cross-reactivity is important in order to improve the venoms available for diagnostic and therapeutic purposes.

Recent findings

In recent years the amino acid sequences of different vespid venom allergens have been determined. Comparison of these sequences has led to an improved taxonomical classification of vespids compared with that based on morphological differences. However, the distribution of vespids in Europe is still based on a very good but somewhat old study carried out in the 1970s. Most recent epidemiological studies focus on the type of reaction produced rather than the insect responsible.

Summary

The genera *Vespula*, *Dolichovespula* and *Vespa* are found all over Europe, but the genus *Polistes*, although present in central Europe, is not found in the UK and only represents a specific clinical problem in areas around the Mediterranean sea. Although there are significant differences in the distribution of stings, the genus *Vespula* predominates over *Polistes* and *Vespa* throughout Europe, except in Mediterranean areas. The different species of *Polistes* in Europe show a great similarity in the sequences of their venom allergens, but the similarity to their American counterparts is less marked. *Vespula* allergens show up to 95% sequence identity and almost complete cross-reactivity. There is also great cross-reactivity among the genera *Vespula*, *Vespa* and *Dolichovespula*. This identity of amino acid sequences confirms the latest morphological taxonomy of Hymenoptera and opens the way for the use of recombinant hybrids of different species in venom immunotherapy.

Keywords

vespids, distribution, cross-reactivity, venom allergen, amino acid sequence

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Introduction

Vespids, together with bees, are the most important pollinators of flowering plants, including fruits and vegetables. Most of them are also parasites of other arthropods, including pest insects. In this respect, they represent a real ecological benefit.

There are antigenic and allergenic differences within the Vespidae family, which includes the subfamilies Vespinae and Polistinae [1,2]. Although there are some common species, there are also different species in Euro-Asia [3] and North America [4]. Fig. 1 shows the relevant species found in Europe according to Sánchez *et al.* [5].

Taxonomy

Within the animal kingdom, vespids belong to the insect order Hymenoptera. The aculeatae or stinging insects (the ovipositor is modified into a sting which is retractable into the body and is not used for laying eggs) are characterized by their 'thin or wasp waist' usually located in the second abdominal segment. Most aculeates are solitary, nonaggressive species. However, 'social Hymenoptera', an indistinct group comprising all the ants, many bees and wasps, and other insects, inflict most stings of concern to man [6].

Characteristic features

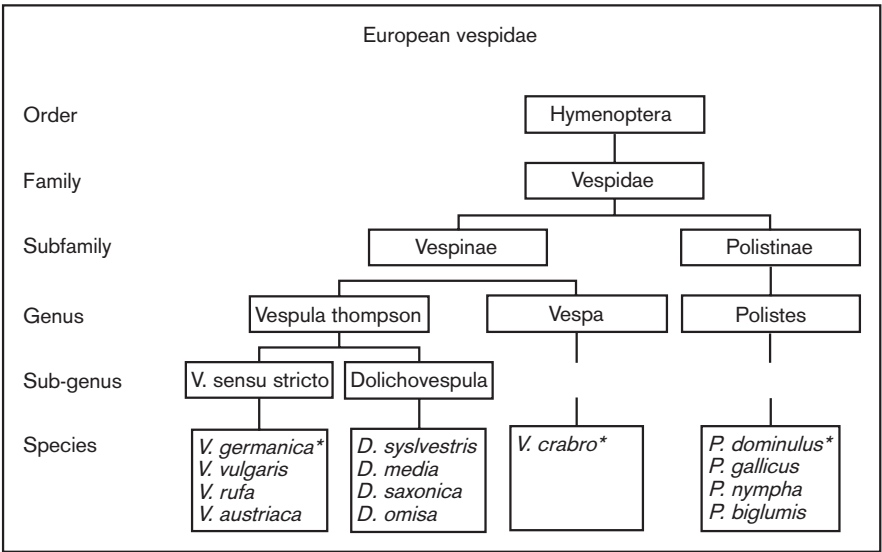
The two main characteristics of vespids are their prognatum and the position of their wings. The prognatum (dorsum of the first thorax segment) extends back to the tegulae (a kind of shoulder strap) covering the base of the front wings. The wings are folded longitudinally at rest.

Vespidae are almost hairless with black and yellow striped abdomens. Although they are divided into six subfamilies [7], most of the social vespids of primary concern are contained in just two subfamilies, Vespinae and Polistinae. There are differences between these two subfamilies in the junction of the thorax and abdomen. Vespinae have a truncated junction while Polistinae have a more oval shape.

In Vespidae only the queen survives the winter, so the nests reach their full strength in summer and early autumn, which is when there is more probability of being stung. Their stinger rarely remains in place at the site of the sting because barbs are usually absent.

Figure 1. General classification of species of European vespids according to Sánchez et al. [5]

Those marked with an asterisk are the most relevant species found able to induce allergic reactions.



Vespinae subfamily

According to Chinery [8], the three genera of Vespinae are *Vespula*, *Dolichovespula* and *Vespa*.

The genus *Vespula* (yellow jackets) comprises the most important species in Europe to which man is allergic, *V. germanica*, *V. vulgaris*, *V. austriaca* and *V. rufa*. They build their nests preferably underground in the neighbourhood of humans and are found on and around food, especially meat, fallen fruits and sweet things of all kinds in garden waste bins. *Vespula* spp. are distinguished from those of the genus *Vespa* (hornets) by their small size, and from those of the genus *Dolichovespula* by the shorter distance between their eyes and upper jaws. The latter feature gives rise to the name short-headed wasps for *Vespula*.

Dolichovespula, in contrast, are known as long-headed wasps, but for a lay person they are difficult to distinguish from *Vespula*. The most important species in Europe are *D. media*, *D. saxonica* and *D. sylvestris*. They often build their nests hanging freely from tree branches or under the eaves of buildings, but they live farther removed from human beings than *Vespula* spp.

In the genus *Vespa*, *V. crabro* (European hornet) is the main species in Europe and has several subspecies. It builds its nests in hollow tree trunks or in birds' nests. It usually lives at a higher altitude than other vespids [9]. Hornets rarely sting except in the neighbourhood of their nests, where they are very aggressive.

European Vespinae have two different life cycles – long and short. The long cycle, as typified by the genera

Vespula and *Vespa*, starts in early April and lasts until October; whereas the short cycle, as exemplified by the genus *Dolichovespula*, starts in May and ends late in September.

Considerable confusion exists between the local names of the different vespids, but Table 1 shows the common names by which vespids are known in various European languages as well as the terms used in North America.

Polistinae subfamily

Polistinae have a worldwide distribution. In Europe and North America their colonies outnumber those of all other social wasps combined, but there are areas in Europe, such as the UK, where they are not present [10]. In Europe, stings from *P. gallicus*, *P. biglumis*, *P. nympa* and above all *P. dominulus* are especially relevant in Mediterranean areas [5]. Their paper nests containing a few individuals hang from tree branches or eaves. A single queen starts her nest in May, having hibernated until then, and by late July there may be up to 200 workers in the nest. Sexual larvae start appearing in August, and in September adults are ready to leave the nest and mate outside. Mated females then seek a safe place to hibernate. The genus *Polistes* has a relatively simple life cycle, which is well adapted to a warm climate such as that found in Mediterranean areas.

Geographic distribution

Getting to know the geographic distribution of European vespids is not an easy task. Nevertheless, we can try it at least in two different ways. One is by checking the presence of the different species in entomological

fieldworks, and the other is through the reported incidence of vespid stings in epidemiological surveys.

Entomological fieldwork sources

One of the most important and extensive studies in this area was done in 1972 by Delfa Guiglia [10]. In this study no distinction was made between *P. gallicus* and *P. dominulus*. In Spain, however, both species were grouped together as *P. gallicus* [11] up to the 1990s.

Based on this study, the vespid distribution in Europe could be represented as shown in Figs 2 and 3. Obviously these maps produce vague and variable limits as in Akre and Reed [6], and it would be necessary to find many local sources in order to update and define them better, especially as regards the density of colonies; however, this is something that is outside the scope of our review. Since Guiglia’s study there have been many local studies of all kinds of vespids, not just of social Hymenoptera (most of these references are interesting from the entomological point of view; see [12] for a recent example), but the core of her work is still in use.

Although several species of vespids may be found in the wild, this does not necessarily mean that stings are due to these kinds of vespids. Other factors should be taken into account, such as the behaviour of the insects and that of human beings, the location of the nests, and other factors [13].

Epidemiological study sources

Another approach to determine which vespid is responsible for the stings is to study the epidemiological references in the literature in English, which would tend to underestimate local and non-English reports of vespid stings.

When cases of death from vespid stings are studied, few reports are found and there are only two old American references with series of cases of death [14,15]. In these studies, wasp (*Polistes*) stings were seen to cause by far the most deaths – three times more than yellow jackets (*V. germanica*) and seven times more than hornets (*Dolichovespula*). There are few similar studies in Europe, but in Switzerland from 1978 to 1987 most of the 29 patients who died following Hymenoptera stings had been stung by honey bees or wasps (*Vespula*) [16].

If we look, for example, at references dealing with stinging insect allergy in Spain, two broad areas of widespread sensitization to *Vespula* and *Polistes* can be identified, the former in the northwest [17] and the latter in the southeast [18]. But even so, there was a certain degree of overlap with patients sensitized to either or both venoms in both areas [19]. Sensitivity to *V. crabro* (European hornet) was less than 3% in the southeast, but reached 11% in the centre of Spain [20]. In the centre of Italy, however, 26.5% of systemic reactions were unequivocally caused by stinging *V. crabro* [21]. There

Table 1. Scientific and common names of vespids in Europe

Scientific	Danish	Dutch	French	German	Italian	Spanish	UK	USA
<i>Apis mellifera</i>	Honningbi	Bij	Abeille	Biene	Ape	Abeja	Honey bee	Honey bee
<i>Bombus</i>	Humlebi	Hommel	Bourdon	Hummel	Bombo	Abejorro	Bumble bee	Bumble bee
<i>Vespula</i>	Hveps/Gedehams	Wesp	Guêpe	Wespe	Giallone	Avispa	Wasp	Yellow jacket
<i>Dolichovespula</i>	Hveps/Gedehams	Wesp	Faux Frelons	Wespe	Callabrone americano	Avispa	Wasp	Hornet or aerial yellow jacket
<i>Vespa</i>	Stor gedehams	Hoornaar	Vrais Frelons	Hornisse	Vespa or Callabrone	Avispón	Hornet	European hornet
<i>Polistes</i>	Papir hveps	Veldwesp ^a	Guepes	Feld-Wesp	Vespa	Avispa Papelera	– ^a	Paper wasp

^aNo *Polistes* in UK and rarely seen in the Netherlands.

Figure 2. Distribution maps of predominant genera of stinging vespids in Europe

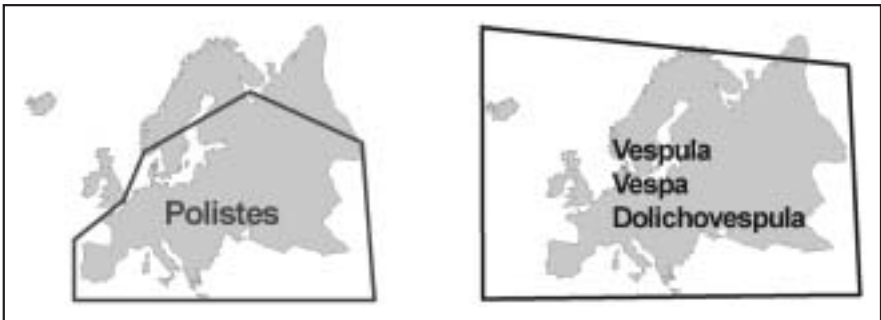
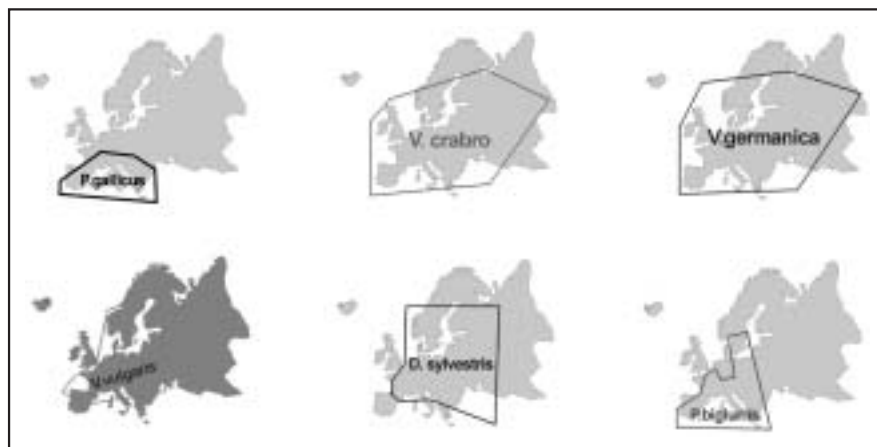


Figure 3. Distribution maps of individual species of vespids in Europe



are no data available on other countries in current databases.

In some local European studies of Hymenoptera stings, the term wasp was mentioned but no specific details were given about the species involved, such as whether it was *V. germanica*, *P. gallicus*, *P. dominulus* or any other vespid found in the areas under study [22], and this adds greatly to the confusion about the role of different vespids in sting events. In other studies, such as a report from Turkey, *V. vulgaris* was the only vespid studied [23], although others are present [10].

In Florence [24] and in Marseille [25], 30% of the patients studied had positive skin tests to *Polistes* and 40% were positive to *Vespula*. However, in Greece [26], using the same methods, the percentage of individuals with positive skin tests to *Vespula* (23.9%) was double that of those positive to *Polistes* (12.5%). Using a radioallergosorbent test instead of skin tests, the proportion was rather low in the south of Spain [27], 12% due to *V. germanica* and 8% to *P. dominulus*. But in Sweden [28], where *Polistes* is rarely seen, specific serum IgE to *Vespula* venom was higher than that to bee venom, as opposed to Bavaria, Germany [29], where the percentage was inverted, 8.5% *Vespula* and 24.8% bee venom. These regional differences may be due to many factors related to the insect, its distribution, interaction with human activities (such as bee keeping) and also to methods used to detect sensitization.

Cross-reactivity between vespid venoms

Combinations of sensitization to Hymenoptera venoms vary with the geographical distribution of Hymenoptera, as Hoffman *et al.* [30] pointed out in the USA and as we have seen above in Europe. Sensitization to more than one type of vespid is frequently found in these studies [24–29] and the distinction between cross-reactivity and

true double sensitization may be important when deciding on the venom of choice for immunotherapy [31]. In the central, northern and eastern parts of Europe, vespid (mainly *Vespula* and *Vespa*) and bee stings are more prevalent, whereas in the Mediterranean areas, *Polistes* and *Vespula* stings are more frequent, as mentioned above.

Vespid venoms have similar components, mainly phospholipase A1, hyaluronidase and antigen 5, and the single allergens have similarities in their primary structure [32–34]. Others, such as serine-protease, are important allergens in European *Polistes* wasp venom [35]. Also venom glycoproteins seem to be the major cause of in-vitro cross-reactivity between honey bee and vespid venoms in up to 50% of patients with dual sensitization [36].

The allergens from different *Vespula* spp. have a primary structure that is up to 95% identical [32,33]. Therefore, the pattern of cross-reactivity is related to these sequence similarities, and cross-reactive antibodies are produced against the highly conserved regions [37]. There is also great cross-reactivity among *Vespula*, *Vespa* and *Dolichovespula* venoms [20,25,38,39].

Polistes is more distantly related to *Vespula* and *Vespa*, and its cross-reactivity is generally lower than within Vespinae [20,37,40]. Furthermore, the amino acid sequence similarities between *Polistes* and other vespid allergens are less marked [41]. Specific sensitization to *Polistes* seems to play a major role in Mediterranean countries [20,42] and in some parts of North America [4,43]. The cross-reactivity between European and American *Polistes* is only partial [5,42], but it is very strong between the two dominant species in Europe, *P. dominulus* and *P. gallicus* [44•]. This study also suggests that, apart from phospholipase, antigen 5 is the major

cause of the different immunological responses between American and European venoms. There is a 98% sequence identity between antigen 5 derived from *P. dominulus* and *P. gallicus*; whereas the identity between the antigen 5 of *P. gallicus* and that derived from American paper wasps decreases to 85% [44•].

The phylogenetic tree designed by Pantera *et al.* [44•] using the known amino acid sequences of antigen 5 derived from various vespid species is shown in Fig. 4. This tree shows that *Polistes* wasps are distantly related to yellow jackets and that European and North American paper wasps are on different branches. These facts also confirm the position they have on the cladogram (a tree-like diagram showing evolutionary relationships) of the subgenus *Polistes* based on morphological differences, proposed more recently by Carpenter [45].

Recombinant technology has been very helpful in clarifying cross-reactivities between venom allergens from different species, genera or even families of Hymenoptera [46]. Finally, the use of recombinant hybrids as immunotherapeutic reagents may be useful in man [47].

Conclusion

Vespid species characterized by a 'thin or wasp waist' are usually solitary, except for those that inflict most stings and are thus of concern to humans. These are called 'social Hymenoptera' because they have a social behaviour and live in nests with queens and workers.

The genera *Vespula*, *Dolichovespula* and *Vespa* are found all over Europe, but the genus *Polistes*, although it can be seen in central Europe, is not found in the UK, and is rare in northern Europe, only representing a specific clinical problem in areas around the Mediterranean sea. Most epidemiological studies focus on the type of reaction produced after being stung, whereas there are few references to the insect responsible and sometimes few venom species are used for diagnostic purposes. Although there are important differences in the distribution of culprit insects responsible for stings, the genus *Vespula* predominates over *Polistes* or *Vespa* throughout Europe, except in Mediterranean areas.

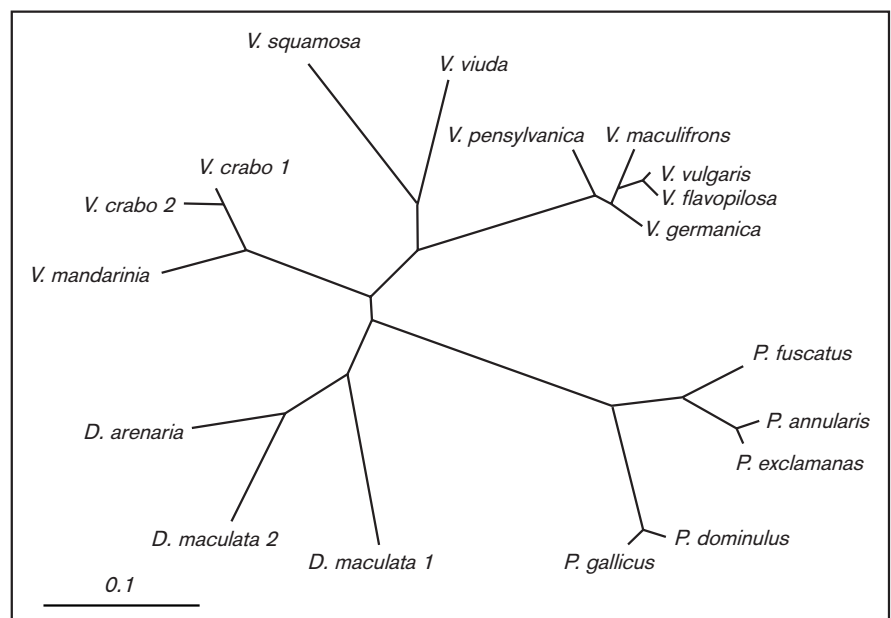
P. dominulus and *P. gallicus* are the predominant species of *Polistes* in Europe, and there is a great similarity in the sequences of their venom allergens, but there is less similarity when compared with their American counterparts. *Vespula* allergens have up to 95% identity, and their cross-reactivity is almost complete. There is also great cross-reactivity among the genera *Vespula*, *Vespa* and *Dolichovespula*. This identity of amino acid sequences confirms the latest morphological taxonomy of Hymenoptera and opens the way for the use of recombinant hybrids of different species in venom immunotherapy.

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Figure 4. Phylogenetic tree of Vespidae according to Pantera *et al.* [44•]

The tree was obtained by alignment of antigen 5 sequences from various Vespidae. It was obtained with the TreeView plot program using the data from the Clustal W alignment employing the neighbour joining method. The sequences were taken from the Swiss-Prot Database. The scale bar (its length corresponds to 0.1 substitution per site) below the tree indicates the evolutionary distance.



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