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Three non-toxic insect traps useful in trapping wasps enemies of honey bees

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Abstract

The insects *Vespa orientalis* L. and *Vespula germanica* (F.) are social wasps (Hymenoptera Vespinae) that can cause intense damages in apiaries, places where they can find the best combination of proteins from animal origin (bees and larvae) and carbohydrates (nectar and honey). The purpose of the present study was to compare three improvised types of traps (wood-glue, plastic bottle, double chamber) in combination with two different animal baits (fish and meat), free of insecticides, in order to control the populations of the wasps in apiaries. The experiments were conducted during the summers from 2001 to 2004. The traps were placed in three apiaries located in the Attica region of Greece. Trapped wasps were collected and the bait was replaced three times per week. The three types of traps are considered environmental friendly because they do not include insecticides that might pollute the environment, or result in the total destruction of wasp colonies and/or the death of non-target organisms, especially honey bees.

The results showed that the use of the wood-glue trap in combination with the fish as a bait was a reliable solution for controlling the wasps in apiaries. Special attention should be paid to the time the fresh bait is placed because the performance of the traps is the best early in the day. Also the baits should be changed regularly (every 1-2 days) because the decomposition reduces the total number of wasps captured.

Key words: *Vespa orientalis*, *Vespula germanica*, Greece, trap, fish, meat, glue.

Introduction

Vespa and *Vespula* genera that belong to the *Vespinae* subfamily (Hymenoptera) are commonly called wasps. *Vespa orientalis* L. (oriental hornet) and *Vespula germanica* (F.) (yellowjacket) are social wasps. The *Vespula* spp. can be easily distinguished from the insects of genus *Vespa* by their small size (Bilò *et al*., 2005).

Wasps are predatory–carnivorous insects feeding mainly their brood with animal proteins (insects, pieces from fresh or spoiled meat and fish) while the adults are fed with carbohydrates (nectar, honeydew and ripe fruits). Bee hives constitute places where the wasps can find the best combination of proteins from animal origin (bees or larvae) and carbohydrates (nectar and honey). According to De Jong (1979) some social wasps are quite dynamic enemies of honey bees which in some cases may cause serious damages to bee-colonies. The large wasp *V. orientalis* has been reported as being an insect particularly dangerous to the bee colonies (Edwards, 1980; Shoreit, 1998). Mayer *et al.* (1987) indicates that yellowjackets [*Vespula pensylvanica* (Saussure), *Vespula vulgaris* (L.) and *V. germanica*] eat bee brood, rob honey and sometimes kill the queen or the colony. Stringer (1989) also reported that *V. germanica* and *V. vulgaris* compete with honey bees for honeydews, resulting in a considerable decrease in the annual honey production.

In Greece many species of wasps that live in societies are known. Some of them [*Vespa crabro* L., *V. orientalis*, *V. germanica*, *Vespula rufa* (L.), *V. vulgaris*, *Dolichovespula sylvestris* (Scopoli)] belong to the *Vespinae* subfamily, while others [(*Polistes atrimandibularis* Zimmerman, *Polistes associus* Kohl, *Polistes bischoffi* Weyrauch, *Polistes gallicus* (L.), *Polistes nimphus* (Christ), *Polistes sulcifer* Zimmerman] belong to the *Polistinae* subfamily (Santas, 1991; Kainadas, 1995; Ifantidis, 2003; Bilò *et al*., 2005; Fauna Europaea Web Service, 2005). The dangerous wasp species are almost the same with those of the European fauna (Santas, 1991; Ifantidis, 1995). The social wasps are particularly problematic and cause considerable damage to bee hives in late summer and autumn, when their colony sizes are peaking for the season (Tzanakakis, 1980; Tzanakakis and Katsogiannos, 1998; Ifantidis, 2003; Wegner and Jordan, 2005). At first they attack on the weak bee colonies, which are the most defenseless, and then the damages are extended to the healthier ones. (Ifantidis, 2003). Bee colonies can be weakened by wasp, especially hornet, predation (Adlakha, 1975; Akratanakul, 1986). Apart from the damages in the bee hives, the wasps constitute a particular problem for food industries and bother in habitants of urban areas (Day and Jeanne, 2001; Wood *et al*., 2006).

In order to control wasps, various methods have been used based either on the use of insecticides or on the use of traps free of insecticides and chemical substances. For example, baits with acetic acid, isobutanol, citrus-based sodas or heptyl butyrate have been used. These traps are known to be effective for many species of social wasps (Landolt, 1998; Landolt *et al*., 1999, 2000; Reed and Landolt, 2002; Wegner and Jordan, 2005), but their effects in bee hives have not been investigated. Also baits soaked with stomach insecticides have been used. In this case the adults become victims but before they are killed they transfer the poisoning insecticide to the brood (Tzanakakis and Katsogiannos, 1986; Sackmann *et al*., 2001). In other cases, the nest can be detected and

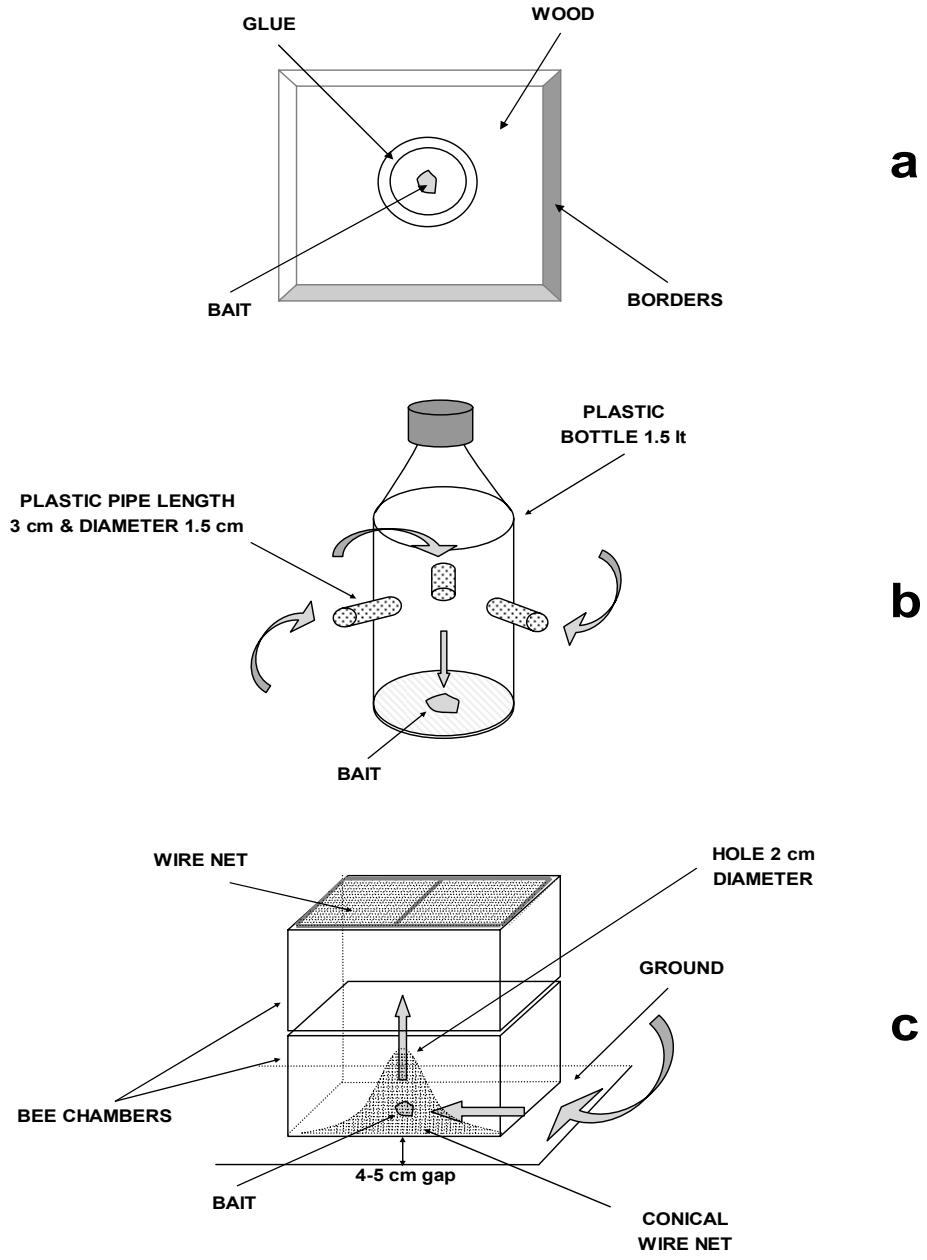

Figure 1. The pattern of each experimental trap: a) Wood-glue trap, b) Plastic bottle trap, c) Double chamber trap.

sprayed during the night with various insecticides or can be burnt (Ifantidis, 1995). Undoubtedly insecticides contaminate the environment and poison other organisms that have access to the bait. For that reason, attempts are made to control wasp populations with non-toxic methods. Carbohydrate-based baits, such as dry icing sugar (Walton and Reid, 1976), artificial honeydews, glucose, sucrose or molasses (Palmer-Jones *et al*., 1949; Thomas, 1960), grenadine syrup, cola, ginger ale or honey (Christie, 1992) have been used as alternative non-toxic baits. However, the great disadvantage of the carbohydrates used as baits for wasp control is the trapping of non-target species, especially of honey bees. Alternatively, protein-rich baits can be used for wasps control. It is known that wasps are attracted to meat (Edwards, 1980; Reid and MacDonald, 1986; Pappas, 1990; Bikos, 1994; Kainadas, 1995; Spurr, 1995; Ifantidis, 1995; Sackman *et al*., 2001; Ifantidis, 2003; Wood *et al*., 2006) and fish (Chang, 1988; Spurr, 1995, 1996).

The purpose of the present study was to compare three improvised types of insecticide free traps in combination with two different types of protein-rich baits in order to control the population of the wasps in bee hives. Additionally efforts have been made to determine the appropriate time that the bait should be placed so as the effectiveness to be increased.

Materials and methods

Two trapping experiments were conducted in three apiaries located in the Attica region of Greece during 2001 to 2004. The distances among bee hives were about 10 km. Three different types of traps (Wood-glue, Plastic bottle, Double chamber) and two different types of protein-rich bait (fresh sardine fish, fresh beef meat) were used. The baits were pieces which weighed approximately 20 g each. The highest attractiveness of the bait is lasting about 90 minutes. Once a week the positions of the traps were roundly changed in each hive in order to exclude the effect of trap position.

The first experiment was carried out in the summers during late July and August (weeks 31 to 35). The baits were put during midday hours, remained for 48 hours and then were replaced (3-4 trapping samplings per week).

The second experiment took places during the first two weeks of October (weeks 41-42) of each year. During the first week, baits were put in the morning (08:00 h) of each day while during the second week the baits were put in the early afternoon (14:00 h), in order to determine the effect of the time on the efficacy of the trap. These baits were replaced every 24 hours. At the end of each trapping period, the caught insects were collected, identified and counted.

In order to check whether or not the wasps flying activity is relative to wind speed, data of the average hourly wind speed - provided from the Hellenic Ministry for the Environment, Physical Planning & Public Works, Directorate of Air and Noise Pollution Control - were analysed to reveal the diurnal pattern of wind speed.

Repeated measure ANOVA, using General Linear Model procedure, was applied to the data, after Box-Cox transformation (Box and Cox, 1964), in order to explore the significance of the main effects of the factors trap, bait, week and wasp species, with year and week used as repeated variables. A separate ANOVA was applied to the data of the first two weeks of October in order to examine whether the efficacy of traps is greater in the morning or in the early afternoon hours.

Wood-glue trap

This type of trap consisted of one piece of wood 20x20 cm and 0.5 cm thickness. The piece of wood had borders of 1.5 cm height (figure 1a). The Gardencol (Zapi, Italy) glue is a mixture of polybutane and polyisobutane. According to the manufacturer the glue is not toxic and its composition guarantees a great ability of sticking without being affected by humidity. The glue was placed on the wood in a ring shape (1-1.5 cm in width with 5 cm internal ray). The bait was placed in the centre of the ring. The trap was placed on the top of a bee hive in horizontal and semi shadowed position in order to avoid the uncontrollable flow of the glue and the rapid decomposition of the bait (figure 1a). The function of this trap is based on the ability of the glue to entrap insects which are attracted by the odour of the bait. Insects approach to grab a piece of the bait and are trapped in their attempt to escape when their wings and/or legs touch the glue.

Plastic bottle trap

This type of trap consisted of a 1.5 lt plastic bottle which had in the middle, three holes of 1.5 cm diameter, in equal distance each from the other. In each hole one piece of plastic tube 3 cm in length and 1.5 cm in diameter was placed. The bait was placed in the plastic bottle. The plastic bottle was hung in a tree or a wooden bearing at 0.7 m height (figure 1b). In this trap the insects are attracted by the odour of the bait and entered the plastic bottle from the three tubes. In their attempt to escape, they fly to the upper closed part of the bottle and get trapped.

Double chamber trap

This type of trap consisted of two bee chambers placed one over the other (figure 1c). At the bottom part of the lower chamber a wire net had been adjusted with gaps of 0.2 cm in diameter. The net was placed in a way that created a 33 cm tall cone up. The cone led up to a hole of 2 cm in diameter. On the top of the upper chamber a wooden frame with a wire net similar to the one that had been mentioned was placed horizontally. The base of the trap stood 4-5 cm from the ground with the help of pieces of wood placed at the four corners. The bait was placed on the bottom and in the centre of the lower chamber. The odour of the bait attracted the wasp which entered from the gaps of the lower chamber. After the insect grabbed the bait it flied upwards. In its attempts to escape it passed through the wire cone into the upper chamber where it was trapped.

Results

Over the entire experimental period, individuals of several insect taxa were trapped. The majority of them (14,652 individuals) were *V. orientalis* and *V. germanica*, no other species of the *Vespidae* family were caught. The rest were few and belonged to other taxa (ants, diptera, etc.) and were not considered in the analysis. Very few honey bees were trapped.

The trapped individuals of *V. orientalis* were much more numerous in comparison to those of *V. germanica* (11,122 *vs* 3,530) (table 1). Repeated measure analysis

Table 1. Total values of the trapped wasps (*V. orientalis* and *V. germanica*) during the experimental period 2001 to 2004.

	Vespa orientalis			*Vespula germanica*		
	Fish	Meat	Total	Fish	Meat	Total
Plastic bottle	2521	1465	3986	704	551	1255
Double chamber	732	421	1153	239	175	414
Wood-glue	3938	2045	5983	1021	840	1861
Total	7191	3931	11122	1964	1566	3530

Table 2. Repeated measures ANOVA for the number of trapped wasps (*V. orientalis* and *V. germanica*) in three types of traps with two kinds of baits. The traps operated for 4 year (2001-2004), for five weeks per year during summer months (late July and August). Year and week constituted the repeated variables. The analysis was conducted on Box-Cox transformed data.

Source of variation	SS	df	MS	F	p
wasp species	**7300.00**	**1**	**7300.00**	**54.3786**	**0.000000**
trap	**11919.26**	**2**	**5959.63**	**44.3940**	**0.000000**
bait	**1274.59**	**1**	**1274.59**	**9.4946**	**0.005111**
insect*trap	61.46	2	30.73	0.2289	0.797121
insect*bait	127.93	1	127.93	0.9530	0.338703
trap*bait	3.72	2	1.86	0.0139	0.986240
insect*trap*bait	0.43	2	0.22	0.0016	0.998394
error	3221.86	24	134.24		
year	**14758.31**	**3**	**4919.44**	**66.6200**	**0.000000**
year*insect	**3191.55**	**3**	**1063.85**	**14.4069**	**0.000000**
year*trap	**3517.78**	**6**	**586.30**	**7.9398**	**0.000001**
year*bait	397.64	3	132.55	1.7950	0.155796
year*insect*trap	**1693.67**	**6**	**282.28**	**3.8227**	**0.002306**
year*insect*bait	408.35	3	136.12	1.8433	0.146977
year*trap*bait	188.06	6	31.34	0.4245	0.860383
year*insect*trap*bait	262.40	6	43.73	0.5922	0.735489
error	5316.71	72	73.84		
week	**7875.48**	**4**	**1968.87**	**64.8209**	**0.000000**
week*insect	225.06	4	56.26	1.8524	0.125151
week*trap	317.61	8	39.70	1.3071	0.249239
week*bait	74.09	4	18.52	0.6098	0.656541
week*insect*trap	**980.10**	**8**	**122.51**	**4.0335**	**0.000364**
week*insect*bait	95.45	4	23.86	0.7856	0.537292
week*trap*bait	321.94	8	40.24	1.3249	0.240479
week*insect*trap*bait	232.20	8	29.02	0.9556	0.475331
error	2915.90	96	30.37		
year*week	**4280.18**	**12**	**356.68**	**11.8920**	**0.000000**
year*week*insect	576.46	12	48.04	1.6016	0.090347
year*week*trap	1084.32	24	45.18	1.5063	0.063584
year*week*bait	458.05	12	38.17	1.2727	0.234034
year*week*insect*trap	682.98	24	28.46	0.9488	0.535101
year*week*insect*bait	331.78	12	27.65	0.9218	0.525342
year*week*trap*bait	786.21	24	32.76	1.0922	0.351540
year*week*insect*trap*bait	823.67	24	34.32	1.1442	0.294427
error	8638.09	288	29.99		

showed significant difference between subject (wasp species, trap type and bait kind) main effects (table 2, first panel). The significance of the trap and of the bait indicates that the wood-glue trap was superior over the bottle and chamber trap types and the fish was more attractive than meat (table 1). It is noticeable that the first and second order interactions were not statistically significant indicating that, over all, the order of the effectiveness of the traps was the same for both baits and for both wasp species and that the fish was more attractive in comparison to meat for both species and for all the three trap types tested (table 2).

The within subject analysis (table 2, panels 2, 3, 4) showed significant year and week effect. The number of individuals, of both species, trapped during the experimental period of the year 2003 (9,077) was about three-fold than those trapped during each experimental period of the other years (2001: 1,964; 2002: 2,165 and 2004: 1,447). Besides, the number of the trapped individuals during each of the first three weeks of each experimental period was higher in comparison to that in the following two weeks (figure 2). The significant interaction between year and species is attributed to the relatively higher number of *V. orientalis* trapped during the experimental period 2003 in comparison to the *V. germanica.* The ratio of the total number of trapped individuals of *V. orientalis* to the total number of trapped individuals of *V. germanica* for the year 2003 was the

highest (4.28) in comparison to the other years (2001: 2.22; 2002: 2.40 and 2004: 1.56). This may be due to the annual fluctuations of the densities of the natural populations of these species. The variation of the population sizes during the weeks and over the years may also explain the observed significance of the year*trap, year*insect*trap and week*insect*trap interactions (table 2).

Concerning the time of the bait placement (morning or early afternoon), it had been observed that in all cases of traps and baits the insect entrapment was more effective when the bait was placed in the morning (08.00 h) than in the early afternoon hour (14.00 h) [*V. orientalis*: (df=143, F=29.94, P<0.0001) and *V. germanica*: (df=143, F=12.67, P=0.0005)] (table 3, figures 5 and 6). The better efficacy during the morning may be due to the fact that the insects begin with an intense pace to find food at the beginning of the day. Besides, the analysis of the diurnal pattern of wind speed (figure 7) showed that it was low (~1.5 m/sec) during the morning hours and gradually increased during midday and afternoon hours. Similar diurnal patterns have been observed at several other regions (Patra, Volos, Thessalonica, ect; unpublished data) indicating that it is a classic pattern that should be taken into account in studies of insects activity. The low wind speed during early morning facilitates the wasps flying while the higher wind speeds prevailing during afternoon hours may restrain them from searching for their food. In addition, fresh bait seems to be more attractive to wasps. When meat or fish bait was put in the early afternoon for 24 hours, fewer wasps were in traps next afternoon.

Discussion

The results of this study demonstrate that the wood-glue design was the best trap type and that fish was the best bait for the *V. orientalis* and *V. germanica* (figures 2, 3 and 4). This type of trap was open and the insects had access to the bait directly in contrary to the other traps in which the bait was inside. These results agree with those of Wagner and Reierson (1969), Perrott (1975), Edwards (1980) and Spurr (1996) which reported that fish and generally baits based on fish are more attractive to wasps. In the third year of the study the relative efficacy of the wood-glue trap was reduced (figure 2). This probably happened due to the reduced fluidity of the glue during that period.

Also in the third year of the experiment the numbers of trapped wasps were higher than in the other years The fluctuations of population densities of wasps may occur over one to many years (Fox-Wilson, 1946; Edwards, 1980) and depends on various factors such as developmental strategy, reproductive success, distribution of colonies, dispersal of queens and mortality factors (Archer, 1980). Food availability as well as environmental factors would be considered factors influencing the population densities of wasps.

In all cases, the numbers of the *V. orientalis* trapped were larger than the same ones of the *V. germanica*. The greatest difference was in 2003, when the number of the *V. orientalis* trapped was fourfold the number of *V. germanica* trapped. During the other years, the *V. orientalis* trapped were about double the *V. germanica*. This proportion might reflect the relative population densities of these wasps, during the years of the experiment.

The average numbers of wasps trapped for both species, decreased from the first to the fifth weeks of each summer trapping period (figure 2). This may represent the effect of trapping on populations sizes and suggests that trapping can be used to control the wasps populations. Furthermore, the differences in number of wasps trapped among the traps were more noticeable in the first three weeks of each experimental period than in the last weeks. These differences are probably attributable to the higher population densities of wasps early.

The efficacy of the plastic bottle trap was mediocre. The efficacy of the chamber trap was the lowest of all. A similar type of trap with different kind of bait is reported by Bikos (1994) in Greece and by Shoreit (1998) in Egypt. Bikos used for bait frames without honey and Shoreit had used bait that contained sugar. In both cases the authors report that the efficacy was quite good without comparing them to other types of traps.

The use of the wood-glue trap in combination with the proper bait may be an efficient solution for controlling the wasps that invade bee hives during summer in

Table 3. Total number of trapped wasps during the morning (08.00 h) and in the early afternoon (14.00 h).

Trap type	Bait	*Vespa orientalis*			*Vespula germanica*		
		Morning	Afternoon	Total	Morning	Afternoon	Total
Plastic bottle	Fish	349	123	472	232	142	374
	Meat	292	56	348	238	58	296
	Total	641	179	820	470	200	670
Double chamber	Fish	199	53	252	104	44	148
	Meat	138	21	159	87	22	109
	Total	337	74	411	191	66	257
Wood-glue	Fish	806	191	997	345	191	536
	Meat	546	145	691	267	137	404
	Total	1352	336	1688	612	328	940
Grand Total		2330	589	2919	1273	594	1867

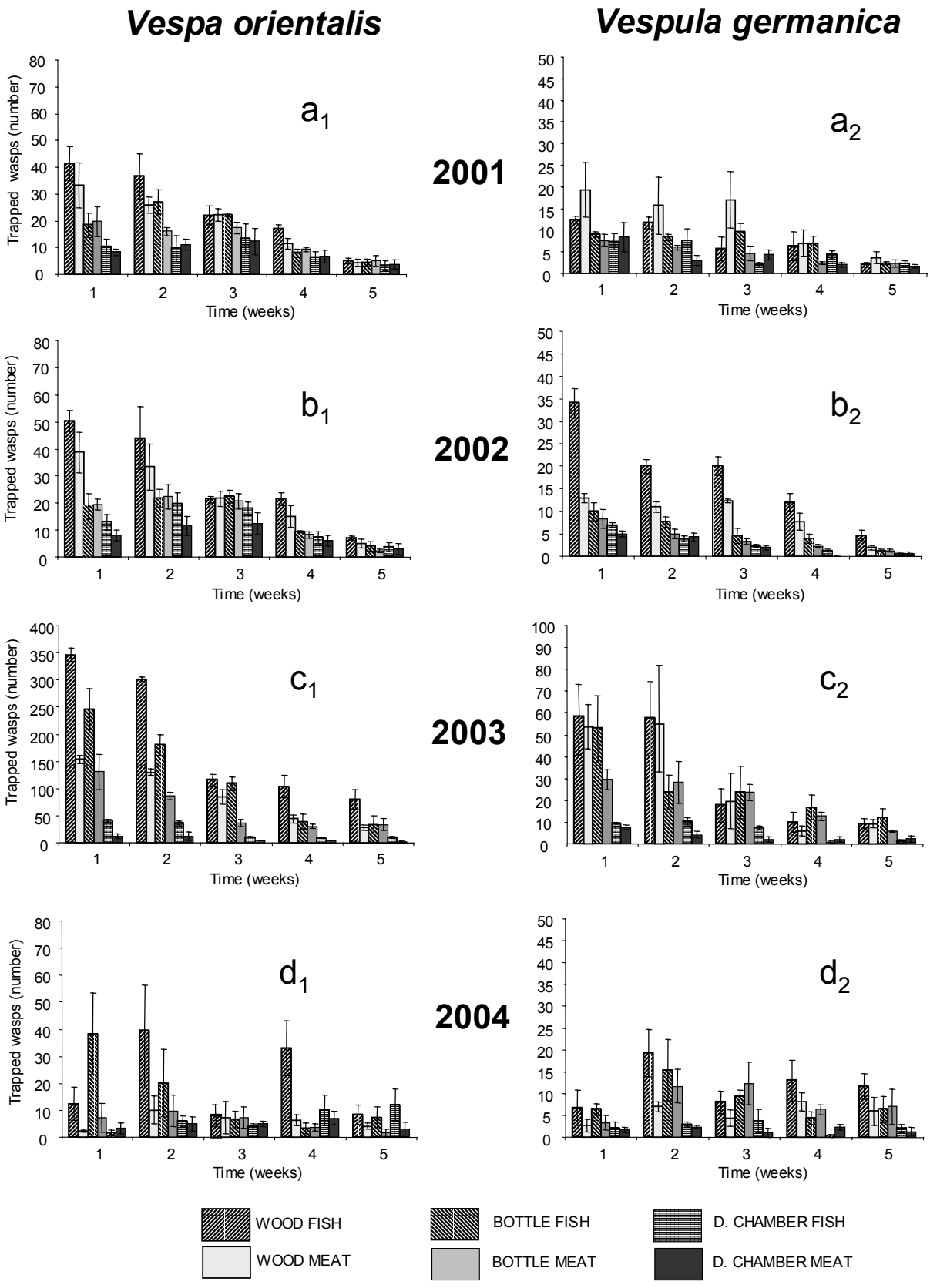

Figure 2. Mean values ± S.E. of the trapped wasps (*V. orientalis* and *V. germanica*) during the five weeks for each experimental year (total of the three apiaries).

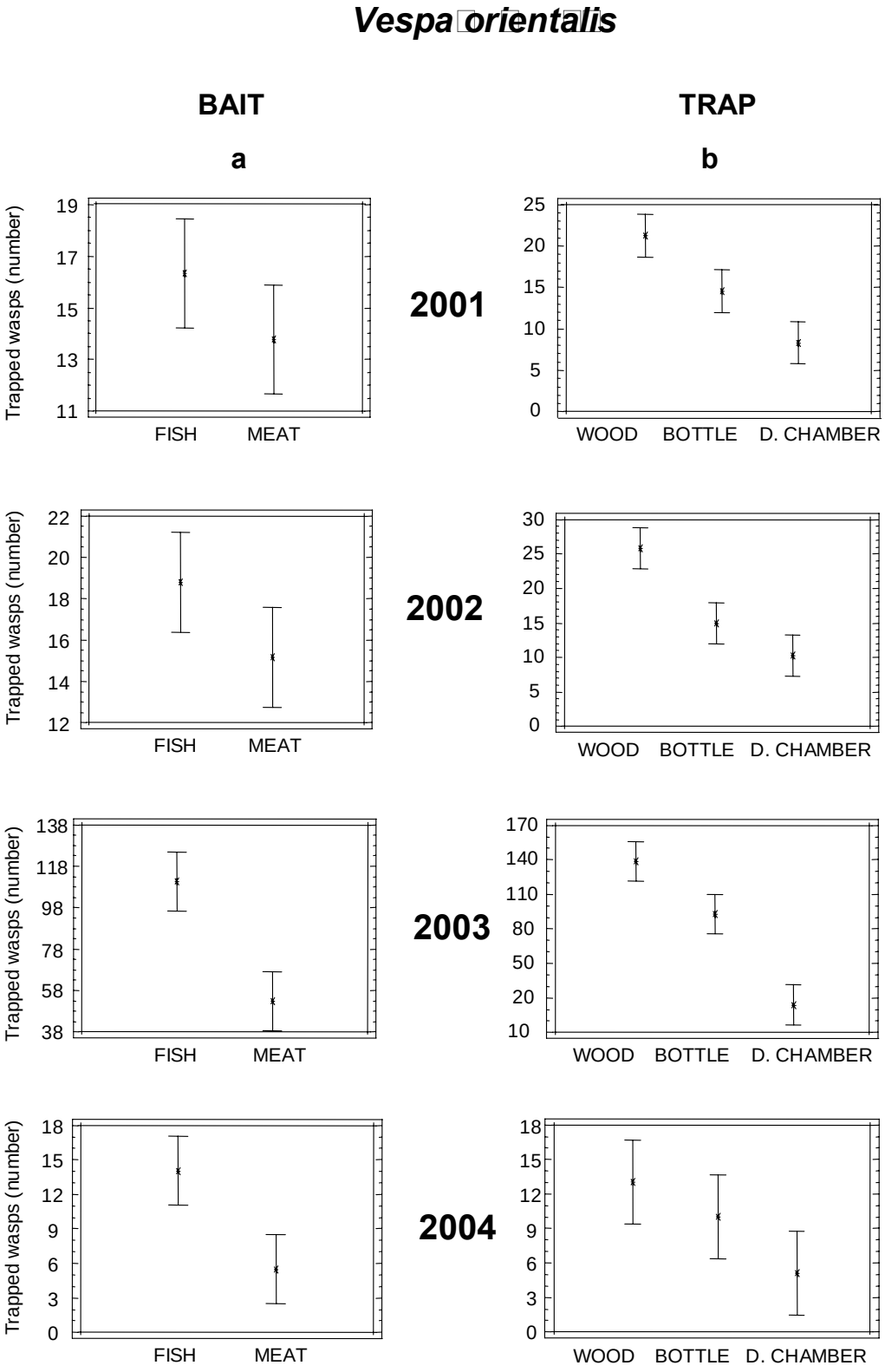

Figure 3. Mean values and 95% Duncan intervals for the *V. orientalis* wasp for the two factors (trap and bait). When the intervals are covered one another the factors are not significant different.

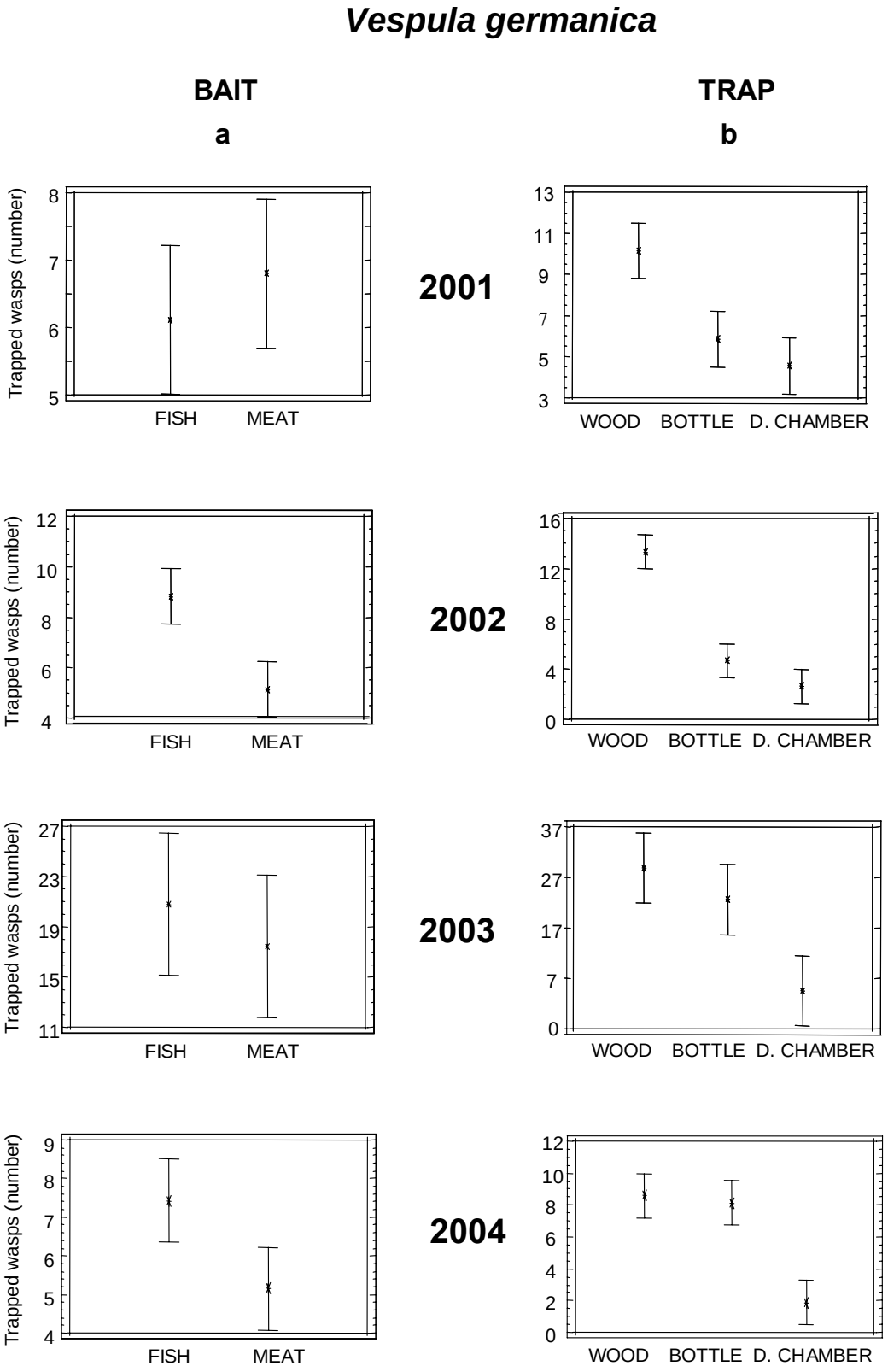

Figure 4. Mean values and 95% Duncan intervals for the *V. germanica* wasp for the two factors (trap and bait). When the intervals are covered one another the factors are not significant different.

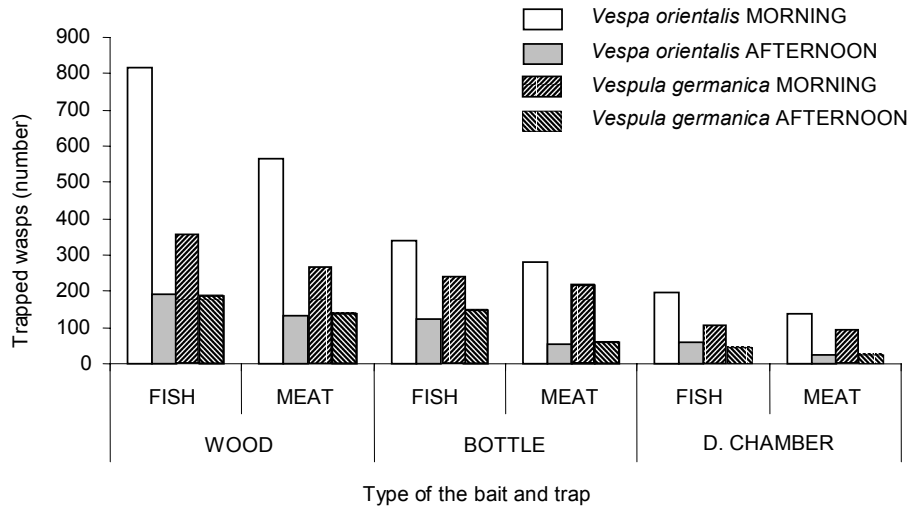

Figure 5. Total number of trapped wasp (*V. orientalis* and *V. germanica*) individuals concerning the time of the bait placement.

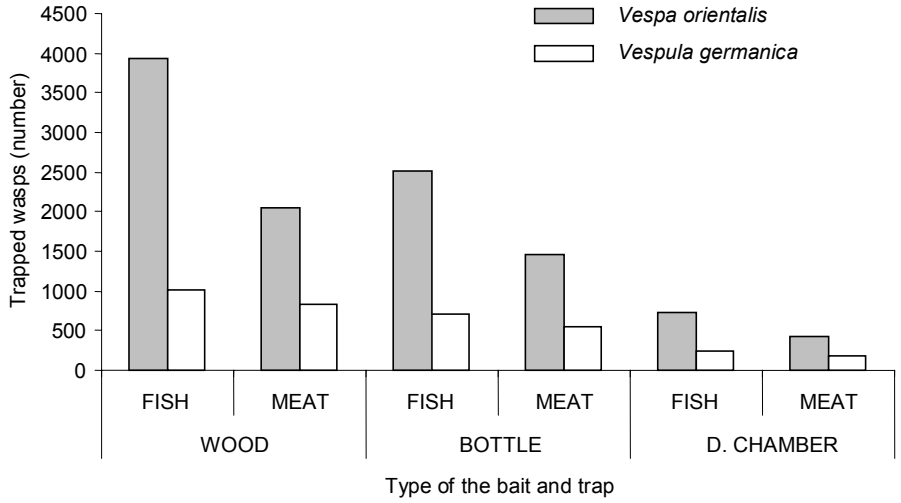

Figure 6. Total number of trapped wasp (*V. orientalis* and *V. germanica*) individuals during the period 2001 to 2004 in the tree apiaries.

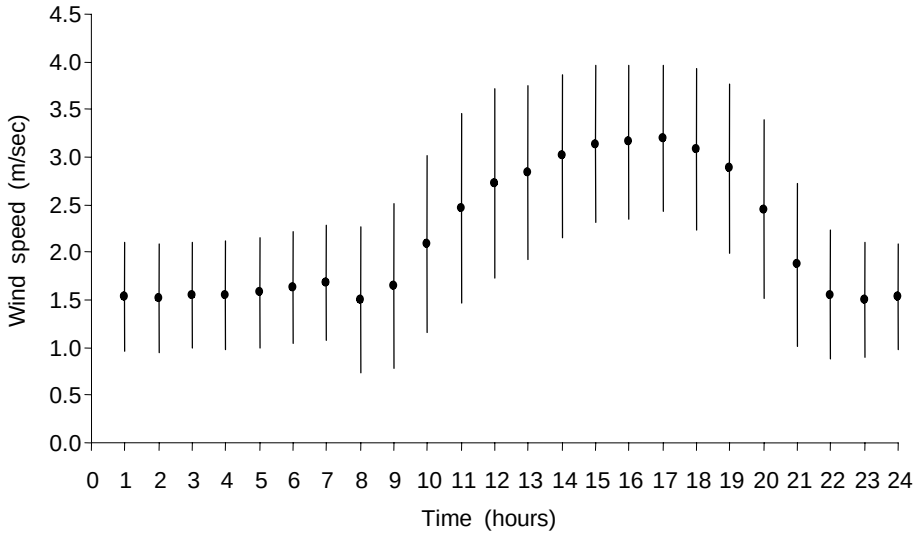

Figure 7. The diurnal pattern of the wind speed (mean ± S.D.) during the months June, July and August over the years 2001-2004.

Greece, especially if fish is used as bait. The three types of traps that have been studied are not based on the action of some insecticide that might lead to the contamination of the environment, to the total destruction of wasp nests and/or to the death of other living organisms. The baits used attract only wasps and not bees. Special attention should be paid to the time the fresh bait is placed because the performance of the traps is fairly high in the morning when wasps are hungrier and the low wind speed facilitates them to fly, seek and pounce to fresh bait. Also the baits should be changed regularly (every 1-2 days) because drying and decomposition repulses the insects.

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