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Efficiency of traps in collecting selected Diptera families according to the used bait: comparison of baits and mixtures in a field experiment

Peter Manko, Lenka Demková, Martina Kohútová, Jozef Oboňa

Department of Ecology, Faculty of Humanities and Natural Sciences, University of Prešov, 17. novembra 1, 081 16 Prešov, Slovakia. Corresponding author, E-mail: peter.manko@unipo.sk, lenka.angelovicova@gmail.com, martinakohutova41092@gmail.com, obonaj@centrum.sk

ABSTRACT

Traps made from PET bottles were used to assess the efficiency of four baits in terms of the number of individuals for selected Diptera families collecting in Eastern Slovak gardens in summer and autumn. Bait used in traps significantly affected the taxonomical composition of the samples obtained. Moreover, significant differences in bait efficiencies and temporal shift in bait efficiencies were confirmed for the Diptera order and for selected dipteran families. The most effective bait for baited-trap Diptera sampling was beer, followed by wine, meat, and syrup from the summer sampling season. In the autumn sampling season, the wine was most effective, followed by beer, syrup, and meat. For the family Scatopsidae wine, and for the family Platystomatidae, meat were the most effective baits. Drosophilidae were most attracted to beer in summer and to wine bait in autumn.

KEYWORDS

Trap, efficiency, Diptera, bait, beer, wine, syrup, meat

INTRODUCTION

Information on animal populations is used for various purposes, but the methods used largely determine the actual subject of the study (e.g. Morris 1960). The information thus obtained is often used to assess the distribution, abundance of selected species, or population parameters (Macdonald et al. 1998). Using traps, it is also possible to monitor the occurrence and spread of pests or parasites (e.g. Knight et al. 1992). The captured samples of the pests serve to confirm the presence or lack of presence on the territory in order to determine whether control measures are necessary.

Traps are widely employed as a passive method for sampling arthropods (Southwood & Henderson 2000). Simple DIY (Do It Yourself) traps from plastic bottles are considered inexpensive, easy to use, low selective, and all-day operating traps (Allemand & Aberlenc 1991).

When using a baited trap, insects are attracted to the bait. A liquid bait based on red wine, beer, fermented fruit, meat, and other substances is often used for arthropods (Basset et al. 1997). Catches are obviously biased toward species attracted to the particular baits and, if a trap is used, those liable to enter become caught in the trap (Ausden & Drake 2006). Hence, the agent (bait) selection is crucial in the sampling design relevant to the target insect group. The knowledge on bait preferences is, therefore, a huge advantage especially in the monitoring of the occurrence of pests, ectoparasites, or other economically or epidemiologically relevant flying insects. Till date, a great variety of different traps and baits have been described (e.g. by Bellamy & Reeves 1952, Wilson & Richardson 1970, MacLeod & Donnelly 1956, Gillies 1974, Chararas 1977, Howell et al. 1975, Lewis & Macaulay 1976, Anderbrant et al. (1989) etc.)

The bait or attractant is usually a substance of biological nature (e.g., rotten fruit) used to attract the interest of organisms. The so-called meat baits are used to capture flies, especially for Brachycera suborder (Dodge & Seago 1954). The freshness (the degree of decay) of the bait, location of the traps, and the presence of other flies have a great influence on the amount and species composition of the captured flies (MacLeod & Donnelly 1956, Fukuda 1960, Kawai & Suenaga 1960). The rotting fruit attracts some butterflies (Sevastpulo 1963), and bananas or vinegar with yeasts attract Drosophilidae (Mason 1963). Different chemicals prove to be attractive for insects (Bateman 1972); there are also fully synthetic baits that are as effective as natural ones (Beroza et al. 1961, Fletcher 1974). The frequently used bait is, for example, beer (Oboňa et al. 2017).

The aim of this study is to evaluate the sampling efficiency of bottle traps with different baits on selected insect families in gardens of Eastern Slovakia.

1. MATERIAL AND METHODS

1.1. Trap design

The samplings were done by homemade bait traps. As the most suitable and easiest available model, we chose traps created from transparent PET bottles (Fig. 1). The traps were made as follows: (I) first the same shaped 1.5 L transparent PET bottles were selected, cleaned, and stripped of all labels; (II) circular hole with a diameter of 4 cm was cut in the upper third of the bottle; and (III) a hanging cord was installed on the bottleneck.

1.2. Field sampling design

Traps were divided into four series, each set containing three repeats. Thus, 12 traps were present on each site. Each series was filled with different media, that is, bait. The first series contained 3 dL of beer (hereinafter referred to as beer trap); the second series mix of 3 dL of white semi-sweet wine and 3 tablespoons of sugar (hereinafter referred to as wine trap); the third contained the mix of 2 dL of fruit syrup (mixture of glucose–fructose syrup, min. 10% fruit juice from raspberry, black currant, strawberries, cherry, and blueberries concentrates, citric acid, aroma, carrot and blackcurrant extracts, ammonia sulfite caramel; 1 dL of water, and half the overripe banana (hereinafter referred to as syrup trap); and fourth series (hereinafter referred to as meat trap) contained 3 dL of vinegar and spoiled meat attached to the bottle closure, the meat (pork shoulder) was exposed for 10 days at room temperature, placed in the fabric and not in contact with vinegar.

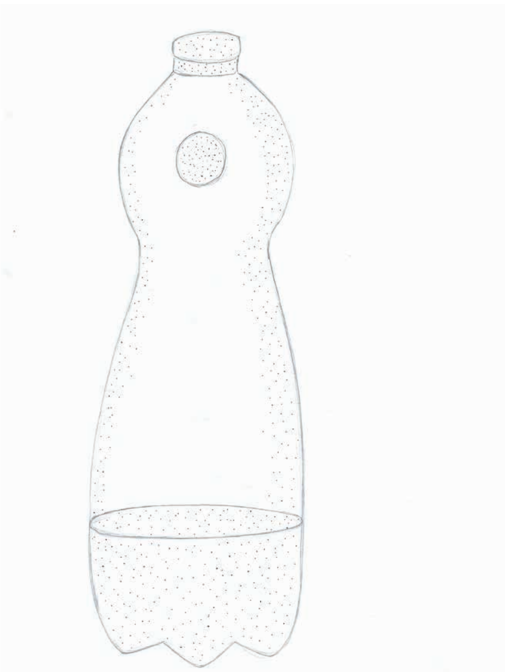

Figure 1. The schema of PET bottle bait trap design.

Individual traps were then labelled and fixed randomly on one tree branches in gardens at three different locations (see Table 1) where they were exposed for 10 days. Sampling was carried out first in early summer (June 2 to 13, 2017) and second in autumn (September 8 to 19, 2017).

1.3. Sample processing

After a 10-day field exposure, the traps were transferred to the laboratory where they were further processed. First, the entire contents of the individual traps were removed, thoroughly washed, and fixed with alcohol. This fixed material was then counted and determined to the level of the orders, and then to the level of the families (in Diptera: Brachycera) by J. Oboňa according to Ooesterbroek (2006).

1.4. Data analysis

Multivariate analyses were carried out to investigate differences and similarities in the structure of assemblages among the baits. Nonmetric multidimensional scaling (NMDS) ordinations were performed on Bray–Curtis similarity matrices using the obtained data.

SIMPER (similarity percentage) analysis was used to assess the contribution of various Diptera families to the differences in the taxonomical composition of samples obtained by traps with different baits.

The differences in the efficiency of baits were evaluated using two-way ANOVA.

In case of a statistically significant difference, Tukey's pair *post hoc* test was used to evaluate differences between pairs of baits.

In box plots, the graphical representation of the median (the horizontal line in the "box"), 25% and 75% of the quartiles (box) 1.5 times the height of the box height (horizontal lines at the end of the whiskers) as well as remote observations (outliers, the ring means that the value is more than 1.5 times the range of values in the box and the asterisk that the value is more than three times larger) are represented.

Differences in the effectiveness of traps were analyzed only by Diptera families, which have a relative abundance of more than 5% in the sample from the sampling period.

All analyses and graphical outputs were performed using the PAST software (ver. 3.19; Hammer et al. 2001).

Table 1. List of sampling sites

Site No.	Site name (vicinity)	Tree species	Geographical location	Altitude (m a.s.l.)	Collector name
1	Prešov	cherry	48°59′22″N 21°13′33″E	250	J. Oboňa
2	Abranovce	cherry	48°56′8″N 21°20′9″E	426	L. Demková
3	Abrahámovce	cherry	49°59′22″N 21°20′32″E	267	M. Kohútová

2. RESULTS

Traps performed well and caught a considerable number of taxa and individuals despite the short time that the traps were exposed. Throughout the research, the overall number of insect individuals captured was 27 393 (11 098 individuals in the summer and 16 295 individuals in the autumn sampling period). In both sampling periods, the following orders were present in the traps: Lepidoptera, Diptera, Hymenoptera, Coleoptera, Dermaptera, Neuroptera, Hemiptera, and Mecoptera. From Diptera, Anisopodidae, Scatopsidae, Platistomiidae, Drosophilidae, Ulidiidae, Cecidomyiidae, Dolichopodidae, Sciaridae, Phoridae, Keroplatidae, Limoniidae, and Hybotidae were analyzed.

2.1. Effect of baits on the taxonomic composition of samples

Non-metric multidimensional scaling (NMDS) indicate that bait used affected the taxonomical composition of samples in both sampling periods (Fig. 2 and 3). Sampling site also affected the assemblage composition, but this variable was less important than the bait used. According to the SIMPER analysis, the abundance of Drosophilidae and Scatopsidae explained most of the differences in the taxonomical structure of samples according to used bait (more than 78% in the first and more than 75% in the second sampling period; Tables 2 and 3).

Among the families, Anisopodidae, Scatopsidae, Platystomatidae, and Drosophilidae (in the first sampling period) and Anisopodidae, Scatopsidae, and Drosophilidae (second sampling period) had the relative abundance greater than 5%. These families also contributed most to the dissimilarity between samples with different baits (Tables 2 and 3).

2.2. Sampling efficiency for Diptera

The effectiveness of baits was evaluated based on the presence of the total number of individuals caught. The most effective bait from the first sampling period was beer, followed by wine, meat, and syrup. In the second sampling period, the wine was most effective followed by beer, syrup, and wine. Markable differences were found between baits in both sampling periods (Fig. 4).

These differences caused by the bait factor were significant in both sampling periods according to the two-way ANOVA ($p < 0.01$ in both sampling periods). The differences caused by the site factor and interaction between the bait and site factors were not significant. The *post hoc* tests proved differences between wine and syrup, beer and syrup, beer and

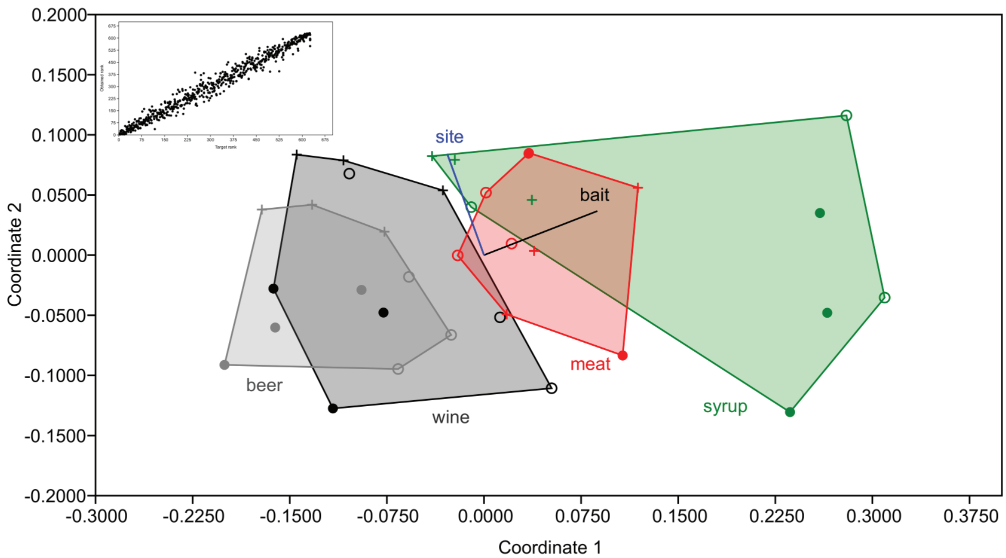

Figure 2. Ordination diagram of the taxonomical structure (family level) of assemblages among the baits from the first sampling period (3D NMDS; 1 + 2 plot axes; baits and sites as explanatory variables; Stress level: 0.08655; Shepard plot in the upper left corner of the diagram; Sampling sites coding: ● - site 1, ○ - site 2, + - site 3).

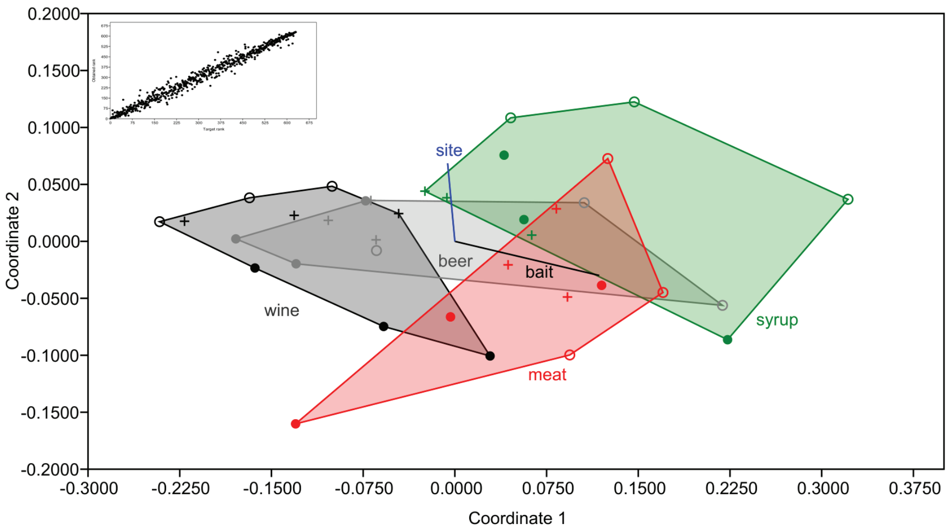

Figure 3. Ordination diagram of the taxonomical structure (family level) of assemblages among the baits from the second sampling period (3D NMDS; 1 + 2 plot axes; baits and sites as explanatory variables; Stress level: 0.0742; Shepard plot in the upper left corner of the diagram; Sampling sites coding: ● - site 1, ○ - site 2, + - site 3).

Table 2. Similarity percentage analysis (SIMPER) of the taxonomical structure (family level) of assemblages among the baits from the first sampling period

Family	Av. dissim.	Contrib. %	Cumul. %	Mean wine	Mean beer	Mean syrup	Mean meat
Drosophilidae	29.82	41.14	41.14	72.7	154	3.22	11.2
Scatopsidae	27.8	37.37	78.51	93.6	85.7	26	17.9
Platistomiidae	7.375	10.18	88.69	7.56	4	2.78	20.8
Anisopodidae	5.142	7.095	95.78	10.8	20.6	2.22	7.56
Cecidomyiidae	0.9466	1.306	97.09	0.889	2	0.111	1.11
Ulidiidae	0.7977	1.101	98.19	0.556	1.89	0.444	1.67
Sciaridae	0.6083	0.8394	99.03	0.333	1.22	0.667	0.889
Phoridae	0.4651	0.6419	99.67	0.222	0.111	0	1.11
Keroplatidae	0.08242	0.1137	99.78	0.222	0	0.111	0
Hybotidae	0.06479	0.08941	99.87	0	0	0.222	0
Limoniidae	0.04916	0.06783	99.94	0	0.111	0.111	0
Dolichopodidae	0.04316	0.05956	100	0	0.222	0	0

meat bait pairs tested in the first, and between wine and syrup, wine and meet in the second sampling season (see Table 4).

2.3. Sampling efficiency for the selected dipteran families

Our results confirmed unequal effectiveness of baits for different families.

The most efficient bait was wine for Scatopsidae, meat for Platystomatidae, beer (first sampling period) and wine (second sampling period) for Drosophilidae (Fig. 5). However, no significant difference was found between baits for Anisopodidae. For Scatopsidae, we found significant differences in baits in both sampling periods ($p < 0.01$) and between bait pairs (Tab. 5). However, site factor was also important ($p < 0.01$) for Scatopsidae in the first sampling period and interaction between site and bait factors was significant in both periods ($p < 0.01$ in the first, $p < 0.05$ in the second sampling period). The bait efficiency also significantly differs for Platystomatidae (Fig. 5) in the first sampling campaign ($p < 0.01$). Differences between two bait pairs were also significant (Tab. 5). Site factor and interaction were not significant for this family. In the second sampling period, only six specimens were caught (three in wine traps at site No. 1, two in meat traps at site 2, and one in wine trap at site 3). Therefore, we did not analyze this family in the second sampling period. The site factor in both sampling periods ($p < 0.01$ and $p < 0.05$ respectively) and the bait factor in the first period ($p < 0.01$), were significant when testing the differences in the Drosophilidae, but the interaction between these factors was not significant. The efficiency significantly

Table 3. Similarity percentage analysis (SIMPER) of the taxonomical structure (family level) of assemblages among the baits from the second sampling period

Family	Av. dissim.	Contrib. %	Cumul. %	Mean wine	Mean beer	Mean syrup	Mean meat
Scatopsidae	30.98	50.41	50.41	184	100	32	21.2
Drosophilidae	15.15	24.65	75.06	53.1	36.2	6.89	33.3
Anisopodidae	8.015	13.4	88.1	32.8	17.6	8.44	5.33
Sciaridae	3.272	5.325	93.43	12	6.11	3.89	4.56
Ulidiidae	1.996	3.248	96.67	5	3.44	4.22	0.556
Phoridae	1.117	1.817	98.49	1	0.333	0.444	4.11
Cecidomyiidae	0.4039	0.6572	99.15	0.333	0.111	0.889	0.444
Limoniidae	0.2828	0.4602	99.61	0.778	0	0.333	0.444
Platistomiidae	0.1645	0.2676	99.88	0.444	0	0	0.222
Dolichopodidae	0.07616	0.1239	100	0	0	0	0.222
Hybotidae	0	0	100	0	0	0	0
Keroplatidae	0	0	100	0	0	0	0

*Table 4. Differences in the bait efficiencies, Tukey´s post hoc test (significant differences are marked with asterisks, p < 0.05 for * and 0.01 for ** respectively; Tukey´s Q below the diagonal)*

Sampling period		1				2		
Bait	Wine	Beer	Syrup	Meat	Wine	Beer	Syrup	Meat
Wine		-	*	-		-	**	**
Beer	2.453		**	**	3.19		-	-
Syrup	4.212	6.665		-	5.207	2.017		-
Meat	3.389	5.842	0.823		5.849	2.659	0.642	

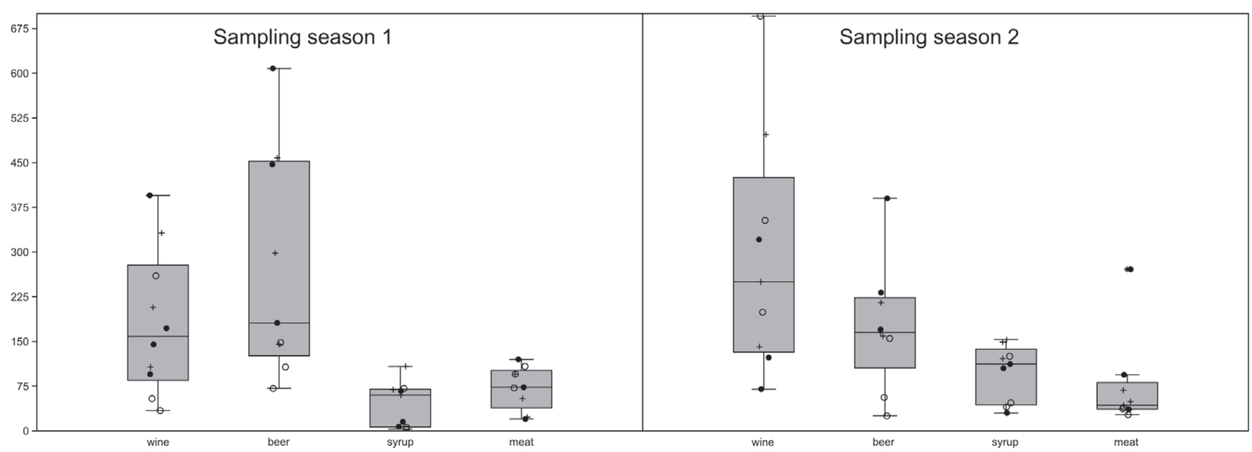

Figure 4. Baits efficiencies for Diptera order in different sampling seasons (Sampling sites coding: ● - site 1, ○ - site 2, + - site 3)

differs between three bait pairs (Tab. 5) in the first sampling period for this family.

3. DISCUSSION

The most effective bait, in general, was beer in June and wine in September. The smell of beer may resemble insect smell of decaying organic substrates and therefore this insect bait was more interesting than other baits at the beginning of the season. Beer traps are often used in many studies to capture a large spectrum of insect taxa. Such bait traps have been used, for example, in Dvořák (2007), Dvořák & Dvořáková (2012), Dvořák et al. (2008). Beer is often used for sampling focused on the families Anisopodidae (Dvořák 2014a, b, 2016a, b) and

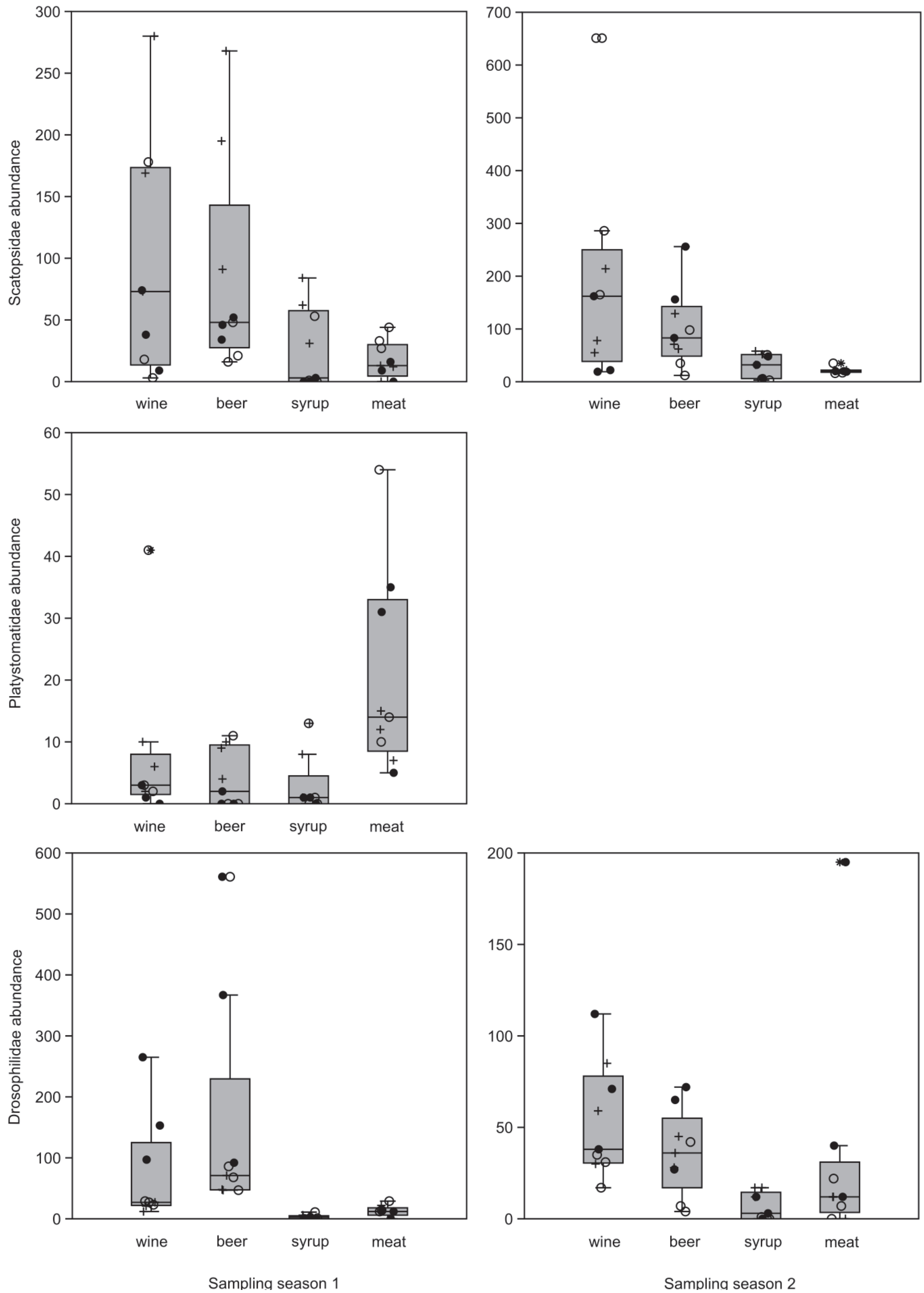

Figure 5. The efficiency of traps in collecting selected Diptera families according to the used bait.

*Table 5. Differences in efficiency of traps in collecting selected Diptera families according to the used bait, Tukey´s post hoc test (significant differences are marked with asterisks, p < 0.05 for * and 0.01 for ** respectively).*

Family	Sampling period	Wine-syrup	Beer-syrup	Beer-meat	Wine-meat	Syrup-meat
Scatopsidae	1	*	*		**	
Scatopsidae	2	**	*	**	**	
Platystomatidae	1			*		**
Drosophilidae	1	*	**	*		

Ulidiidae (Korneyev et al. 2014). In September, the insects preferred wine. It can also be caused by the fact that autumn is characterized by fruit maturation and therefore the substances contained in the wine can attract an insect that feeds or reproduces on fruit. Therefore, wine or apple vinegar is often used in various traps or monitoring traps of fruit pests (e.g. Calabria et al. 2012, Březíková et al. 2014, Asplen et al. 2015). For the Anisopodidae family, beer was the most effective bait. Larvae of this family live in dying plant materials, rotting potatoes, but also in cow manure. Adult individuals go to human dwellings for the winter (Obenberger 1964). Beer appears to be the most suitable bait for this family, which was confirmed by also by Dvořák (2014a, b, 2016a, b). For the Scatopsidae family, wine was the most effective bait in our study. Our finding is interesting because it is known that larvae of this family can develop in an extremely wide range of substances: any decomposing plant material, fungi, manure, or animal material (Haenni 2002). The most effective bait for the family Platystomatidae was meat (in June). In the second sampling date, only a few specimens were captured. This fact may be caused by the dominant species trapped in traps was *Platystoma seminationis* (Fabricius, 1775), which occurs especially at the beginning of the season in large numbers and autumn is relatively rare (Korneev et al. 2014). The most effective bait for the Drosophilidae family in June was beer, and in September was wine. Adult flies of this family are everywhere where they squeeze fruit and tree juices. They can be also found in a nonclosed bottle with the rest of wine, vinegar or beer (Obenberger 1964). Similarly, also in other papers wine, beer, and vinegar (or their various modifications and mixtures) are often used for sampling members of this family (e.g. Calabria et al. 2012, Březíková et al. 2014, Asplen et al. 2015).

In general, we can say that beer at the beginning of the season and wine at the end of the season (or a suitable ratio of the two bait) appear to be suitable as a medium for collecting various groups of Diptera taxa, mainly its families Scatopsidae, Drosophilidae, and Anisopodidae. The exception was mainly first season, representatives of the Platystomatidae family, who preferred the meat bait. However, the site effect was also important in several families. This fact along with identification on lower taxonomical level could bring more light in the bait traps efficiency topic in future research.

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