Pak. J. Agri. Sci., Vol. 50(3), 359-366; 2013
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

MONITORING HYMENOPTERA AND DIPTERA POLLINATORS IN A SUB-TROPICAL FOREST OF SOUTHERN PUNJAB, PAKISTAN

Muhammad Amjad Bashir[1], Shafqat Saeed[2,*] and Asif Sajjad[2]

[1]College of Agriculture, Dera Ghazi Khan (Sub-campus), University of Agriculture, Faisalabad-38040, Pakistan; [2]Department of Entomology, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University Multan, Pakistan
[*]Corresponding author's e-mail:bumblebeepak@gmail.com

Bees (Hymenoptera) and flies (Diptera) play an essential role in natural and agricultural ecosystems as pollinators of flowering plants while pollinators are declining around the world. Colored pan traps and Malaise traps have widely been used for monitoring pollinators. However, their efficiencies may vary with landscapes and type of fauna in a particular habitat. A yearlong study was carried out during 2009 to investigate the relative efficacy of colored pan traps and Malaise traps towards sampling flies and bees for the first time in a sub-tropical wildlife sanctuary 'Pirowal' of Southern Punjab, Pakistan. Fifteen pan traps (5 each of 3 colors i.e. white, red and blue) were deployed against one Malaise trap for 7 hours (9:00-16:00 hrs) on fortnightly basis. For the comparison and confirmation of an insect as a floral visitor, collection with the hand net was also performed. It was concluded that hand net collection is essential to have a comprehensive list of floral visitors of an area as the maximum number (63) of species and their abundance (5428 individuals) were recorded with it. Malaise trap collected only 671 individuals of 48 species. Although blue, yellow and white pan traps caught 46, 51 and 35 species but the numbers of individuals (1383) were fairly higher than that of Malaise traps. Keeping in view the cost effectiveness and better performance of colored pan traps, we recommend species specific pan trap colors when targeting certain groups or species, nevertheless variety of pan colors should be used when sampling overall biodiversity. We generalize these findings for both bees and flies due to similar collection pattern i.e. the maximum abundance and diversity in hand net method followed by pan traps and Malaise traps.
Keywords: Sampling, bees, flies, pan traps, Malaise traps, forests, Pakistan

INTRODUCTION

Pollination is a critical ecosystem service delivered by pollinators in natural and agricultural ecosystems (Nabhan and Buchmann, 1997). Pollinators are declining on account of land use change and intensification in agriculture and this is an important concern for conservation biologists across the world (Biesmeijer *et al*., 2006, Lonsdorf *et al*., 2009, Potts *et al*., 2010). There is a need for continuous assessment of composition and size of pollinator populations through efficient monitoring programs. This will help in making some future conservation strategy. Such information is rare even in developed countries, where ecologists recently have started log term monitoring programs.

A number of methods (e.g. Malaise traps, colored pan traps, hand netting), spatial scales (e.g. different habitats), time periods (e.g. seasons), taxonomic groups and sample units have been employed to record fluctuation in pollinators. This variability in monitoring methods has made it very difficult to reliably compare the findings among existing studies. Few recent studies have recommended colored pan traps (plastic bowls filled with soapy water) as the most efficient monitoring method in variety of habitats (Wetphal *et al*., 2008; Gollan *et al*., 2011). However color of pan traps, have shown mixed results. Few studies have shown no significant effect of pan colors on bee populations (Wilson *et al*., 2008; Tuell *et al*., 2009) while others have shown high sensitivity of bees towards different pan colors e.g. blue, red, yellow and white (Leong and Thorp, 1999; Campbell and Hanula, 2007). This clearly suggests that preference of bees towards pan colors varies from species to species while species vary across the habitats and geographical regions (Gollan *et al*., 2011). Hence, there is a clear need to develop a standardized set of monitoring methods to allow quick, consistent and repeatable assessments within and across different habitat types.

Greater sampling effort is especially needed in sub-tropical ecosystems of Indian sub-continent where previously no baseline is in hand. Forests of sub-tropical Punjab, Pakistan, are natural or semi-natural habitats which provide sufficient floral resources and suitable nesting sites for the pollinators. In agricultural landscapes, semi-natural landscapes are often small and bees travel to the adjacent flowering crops for the forage (Westrich, 1996). Forests are structurally and biologically diverse, often containing a mixture of herbaceous plants, shrubs, mid story and over story trees. This composition may across geographical gradient e.g. from deserts to tropical rain forests. Therefore, there is a need to develop simple and effective sampling procedures for assessing the relative abundance and species richness of pollinators in forested habitats.

Malaise traps are famous for capturing high abundance and diversities of flying insects (e.g. Diptera and Hymenoptera) while pan traps have widely been used in many conservation programs as a tool to monitor the diversity of floral visitors (Matthews and Matthews, 1970; Darling and Packer, 1988; Noyes, 1989; Aizen and Feinsinger, 1994). Pan and Malaise trappings are reckoned as a smart alternative to traditional hand net collection method because it is cheaper, requires no man-hours, and most probably reduce collector bias (Wilson *et al*., 2008). However, few studies have opposed using pan traps alone to estimate the relative abundance of bee species (Leong and Thorp, 1999; Cane *et al*., 2000; Toler *et al*., 2005; Roulston *et al*., 2007) as some species are rarely collected in pan traps.

We conducted a yearlong survey of floral visitors in a sub-tropical forest of southern Punjab, Pakistan and compared the abundance and richness of fly (Diptera) and bee (Hymenoptera) floral visitors in pan traps (blue, yellow and white) and Malaise traps. The study aimed to validate for the first time the efficacies of these sampling methods in the sub-tropical forests of Pakistan. The findings of this research will facilitate future monitoring and conservation programs in the region.

MATERIALS AND METHODS

***Study area*:** The study was conducted in Pirowal Wildlife Sanctuary (17823 acres; 30º34´N; 72º03´E; 437±16.5 meter above sea level) situated in District Khanewal of Southern Punjab, Pakistan. We selected a protected fenced area of 1500 acres for our study due to almost no human disturbance. Climate of the area is sub-tropical; the mean monthly temperature ranges between 25°C and 30°C, with mean maxima 35°C to 40°C, and mean minima 10°C to 20°C. The extreme maximum temperature of the region varies between 45°C and 48°C, recorded in May and June, while the lowest minimum temperature is 0°C to -2°C, recorded in January (Khan *et al*., 2010).

***Data collection*:** Fortnightly data was recorded from 1st week of January to 4th week of December in 2009, covering all the four seasons (summer, winter, autumn and spring). Fifteen pan traps (five of each color i.e. blue, yellow and white) were deployed in five sets in a focal plot of 2.5 acres (Campbell and Hanula, 2007). Each set comprised three pan traps (one of each color) and closely spaced in a triangle. The distance between two sets was at least 20 feet. In the same plot, a Malaise trap was also installed. To avail the active flight timings for most bees and flies, sampling was performed from 9:00 to 16:00 hrs. Only diurnal observations were made on fortnightly basis. Hand net collection was also performed by a trained collector for two 60-minute periods on each sampling day i.e. 9:00 to 10:00 hrs and 15:00 to 16:00 hrs.

All the insect specimens were first morphotyped and then identified to the lowest possible taxonomic level. The identification to family level of Diptera was done following Borror *et al*. (1981). The syrphid fly species were identified by the specialist (Acknowledgement). Bee genera were identified following Michener (2000). Voucher specimens were deposited at the Agricultural Museum of the University College of Agriculture, Bahauddin Zakariya University Multan.

***Data Analysis*:** Three traits of insect assemblage were analyzed for each trap, i.e. richness (total number of species), abundance (total number of flower visits) and diversity (Shannon-Wiener index, Hulbert's Probability of Inter-specific Encounter (PIE), Evenness and Dominance). Percentages of insects collected by pan traps, Malaise traps and hand netting are represented as proportions of total sample (N). The maximum abundance of each species was also identified among the three sampling methods (colored pan traps cumulatively, Malaise traps and hand netting) (Table 2 & 3). Dominance was calculated as the relative abundance of the most abundant visitor species while Hurlbert's PIE is an evenness index that combines the two mechanistic factors affecting diversity, i.e. dominance and species abundance (Hurlbert, 1971).

We used hierarchical cluster analysis to estimate the similarity in three sampling methods i.e. hand netting, Malaise trap and pan traps (treating pan traps of three colors separately), on the basis of relative abundance of 66 insect species. We used Bray-Curtis distance instead of Euclidean distance as input since many of the cells in the data matrix were zero (Beals, 1984).

RESULTS

A total of 24 sampling days (168 hours) resulted in 8867 individuals of 66 species. The hand netting resulted in the maximum number of species (63) with maximum individuals (5428). Although Malaise trap caught 48 species but the numbers of individuals were quite less (671). Blue and yellow pan traps also proved efficient in sampling number of species (46 and 51, respectively) while the number of individuals (1383) of all the pan traps were far less than that of hand netting. White and blue pan traps proved taxa more specific as dominance was the maximum in the both pan traps. Hand netting exhibited the minimum dominance, proving it to be more generalized (taxa less specific) method. Shannon-Wiener index was the highest in hand netting while Hulbert was the highest in yellow pan trap i.e. 0.57 (more than 57% probability of two randomly selected insects belong to different species) (Table 1).

Table 1. Among traps difference in pollinators abundance and diversity at Pirowal Wildlife Sanctuary from January to December, 2009

	Blue	Yellow	White	Pan traps Total	Malaise Trap	Hand-net
Richness	46	51	35	58	48	63
Abundance	470	509	406	1383	671	5428
Dominance	0.081	0.056	0.105	0.0741	0.0851	0.0530
Shannon-Wiener	3.107	3.378	2.759	3.238	3.065	3.451
Hulbert (PIE)	0.486	0.574	0.451	0.439	0.447	0.500

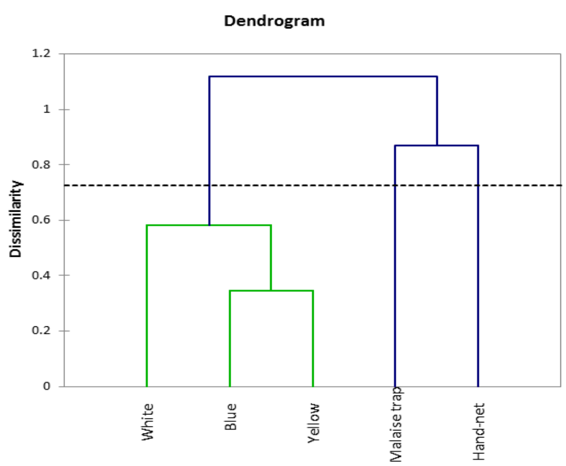

Figure 1. Hierarchical cluster analysis of three sampling methods (treating pan traps of three different colors separately) using Bray-Curtis distance, based on abundance of 66 species at Pirowal Wildlife Sanctuary from January to December, 2009.

Bees**:** A total of 35 bee species were collected in five families (Table 2). The maximum number (13) of species belonged to family Halictidae while the minimum (2) number of species belonged to family Colletidae. Hand-netting resulted in the maximum number (34) of bee species, followed by pan trap (31) and Malaise trap (27). Twenty six bee species were the most abundant in hand-net method followed by pan traps (9 species) and Malaise traps (2 species). Twenty four bee species were alike among the three sampling methods. The entire bee species of pan traps were also captured by hand nets while 26 out of 27 bee species of Malaise trap were also captured by hand nets. *Megachile* sp.2 and *Megachile* sp.3 were solely present in Malaise trap and hand net method, respectively.

In pan traps, 31 bee species were recorded in five families of which four i.e. Andrenidae, Apidae, Megachilidae and Colletidae were the most abundant in yellow pan traps. The maximum number (29) of species were caught in yellow pan trap followed by blue (24 species) and white pan traps (18 species). Seventeen bee species were alike among the three pan traps. Five bee species were common in yellow and blue pan traps. On the other hand one species was common in blue and white pan traps. *Megachile* sp.1, *Megachile* sp.5, *Colletes* sp.1, Halictidae sp.1 ,Halictidae sp.3, *Nomioides* sp. and Ceratina sp.3, were observed only in yellow pan traps. On the other hand, Nomia sp.1 was recorded only in blue pan traps.

Flies**:** A total of 31 fly species were recorded in 9 families (Table 3). Syrphidae was species most rich family i.e. 7 species. Muscidae and Strtiomyidae had the minimum numbers of species (1 in each). Hand net method proved to be the most fruitful, resulting in 29 species, followed by pan traps (27 species) and Malaise trap (21 species). Twenty five species were the most abundant in hand netting, followed by total pan traps (6 species). Malaise trap had not even a single most abundant species.

Seventeen fly species were found common among the three sampling methods. Eight fly species were alike in pan traps and hand net method while only single specie was found common in Malaise trap and hand net method. Moreover in family Syrphidae, *Sphaerophoria bengalensis* and in family Calliphoridae, Calliphoridae sp.3 was sole to pan traps. Six species *viz*., Calliphoridae sp.1, Calliphoridae sp.3, *Eristalinus laetus*, *S. bengalensis*, Asilidae sp.3 and Anthomiidae sp.1 had their maximum abundant in pan traps. All except these six species had their maximum abundance in hand netting.

Among the colored pan traps, the maximum numbers of the species were recorded in blue and yellow pan traps (18 species in each) followed by white pan trap (12 species). No any member of families Sarcophagidae, Muscidae and Strtiomyidae were recorded in the white pan trap. The blue pan traps caught *Euphumosia* sp., Asilidae sp.3, Anthomiidae sp.1 and Bombyliidae sp.1 in maximum abundance; the yellow pan traps caught *Ischiodon* sp., *Syritta* sp., Anthomiidae sp.2, Anthomiidae sp.3, Muscidae sp.1 and Strtiomyidae sp.1 while the white pan traps caught Calliphoridae sp.1, *Calliphora* sp.1, Calliphoridae sp.3, *E. laetus*, *E. aeneus*, *Eristalis tenax*, *Eristalinus* sp.3, *S. bengalensis*, Asilidae sp.1, Asilidae sp.2 and Anthomiidae sp.4 in highest abundances.

The similarity between the five traps on the basis of species abundance and composition revealed three distinct clusters

Table 2. Percentages of bees (Hymenoptera) collected by hand net, Malaise trap and pan traps are proportions of total sample (N) at Pirowal Wildlife Sanctuary from January to December, 2009

Family	Genus	Pan Traps				Malaise	Hand-net
		Blue	Yellow	White	Total (n)		
Andrenidae	*Andrena* sp.1	2.44	2.44	0.00	4.88	0.00	**95.12**
	Andrena sp.2	12.20	17.07	7.32	36.59	21.95	**41.46**
	Andrena sp.3	2.47	4.94	2.47	9.88	1.23	**88.89**
Andrenidae Total		4.91	7.36	3.07	15.34	6.13	**78.53**
Halictidae	*Halictus* sp.	21.57	15.69	21.57	**58.82**	23.53	17.65
	Nomia sp.1	15.38	0.00	0.00	15.38	38.46	**46.15**
	Nomioides sp.	0.00	6.82	0.00	6.82	0.00	**93.18**
	Nomia sp.2	3.00	8.00	4.00	15.00	11.00	**74.00**
	Lasioglossum sp.1	30.36	17.86	8.93	**57.14**	17.86	25.00
	Nomia sp.3	4.92	0.00	1.64	6.56	9.84	**83.61**
	Lesiglosum sp.2	18.18	14.55	9.09	41.82	9.09	**49.09**
	Halictidae sp.1	0.00	18.60	0.00	18.60	25.58	**55.81**
	Halictidae sp.2	15.00	20.00	20.00	**55.00**	10.00	35.00
	Halictidae sp.3	0.00	12.50	0.00	12.50	4.17	**83.33**
	Halictidae sp.4	25.00	25.00	33.33	**83.33**	0.00	16.67
	Halictidae sp.5	0.00	0.00	0.00	0.00	4.76	**95.24**
	Halictidae sp.6	22.50	7.50	0.00	30.00	**40.00**	30.00
Halictidae Total		10.87	10.34	6.06	27.27	14.44	**58.29**
Apidae	*Amigella* sp.1	2.70	2.70	2.70	8.11	0.00	**91.89**
	Apis dorsata	2.32	1.93	1.16	5.41	15.44	**79.15**
	Apis florea	12.82	17.31	17.31	**47.44**	36.54	16.03
	Ceratina sp.1	32.00	16.00	0.00	**48.00**	4.00	48.00
	Amigella sp.2	1.72	6.90	0.00	8.62	3.45	**87.93**
	Tetralonia sp.	9.09	15.58	3.90	28.57	9.09	**62.34**
	Ceratina sp.2	21.57	11.76	5.88	39.22	15.69	**45.10**
	Ceratina sp.3	0.00	34.62	0.00	34.62	19.23	**46.15**
Apidae Total		7.58	9.50	5.23	22.31	16.53	**61.16**
Megachilidae	*Megachile* sp.1	0.00	75.00	0.00	**75.00**	0.00	25.00
	Megachile sp.2	0.00	0.00	0.00	0.00	**100.00**	0.00
	Megachile sp.3	0.00	0.00	0.00	0.00	0.00	**100.00**
	Megachile sp.4	0.00	0.00	0.00	0.00	12.00	**88.00**
	Megachile sp.5	0.00	16.07	0.00	16.07	7.14	**76.79**
	Megachile sp.6	5.71	4.76	1.90	12.38	16.19	**71.43**
	Megachile sp.7	32.00	16.00	18.00	**66.00**	18.00	16.00
	Icteranthidium sp.	5.56	5.56	0.00	11.11	0.00	**88.89**
	Megachile sp.8	32.00	24.00	4.00	**60.00**	8.00	32.00
Megachilidae Total		10.32	11.61	3.87	25.81	11.94	**62.26**
Colletidae	*Colletes* sp.1	0.00	8.33	0.00	8.33	16.67	**75.00**
	Colletes sp.2	5.71	11.43	8.57	25.71	0.00	**74.29**
Collectidae Total		3.39	10.17	5.08	18.64	6.78	**74.58**
Hymenoptera Total		8.69	9.95	5.06	23.69	13.85	**62.45**

For different pan trap colors, the percentages are also proportions of sub-sample (n). Best collecting method for each species is marked in bold type.

i.e. (i) hand net, (ii) Malaise trap and (iii) three pan traps (white, blue and yellow) (Fig 1). Among the three pan traps, yellow and blue exhibited more similar tendency towards insect abundance and richness than that of white pan.

DISCUSSION

The results of current study also suggest that both Malaise and colored pan traps caught considerable number of species (58 and 48 each, respectively) but their abundance was better predicted by pan traps than that of Malaise traps.

Pollinating insects are attracted towards color, fragrances, rewards (pollen/nectar) and shapes of the flowers (Niesenbaum *et al*., 1998) with color being the most attractive trait (Kevan, 1972). Following this idea, Campbell and Hanula (2007) found significant increase in Malaise trap capture by adding colors to Malaise traps. Most of the recent monitoring studies have omitted the option of Malaise trap due to its poor efficiency as compared to colored pan traps in terms of species abundance (Westphal *et al*., 2008; Gollan *et al*., 2011). However, the results of our study suggest that if the focus is simply the species richness, any of the two methods can be applied, however if the focus is abundance in addition, then pan traps should be used.

As different insect species have unlike tendency towards pan trap colors and insect fauna varies across geographical area, the performance of different pan trap colors may vary across geographical area. For example studies conducted in North America have shown mixed results. Some indicated no significance in color preference among bees (e.g. Toler *et al*., 2005; Wilson *et al*., 2008; Tuell *et al*., 2009), while others showed high sensitivity towards trap colors (Leong and Thorp, 1999; Campbell and Hanula, 2007).

In this study, blue and yellow pan traps proved more efficient in sampling pollinating insect than that of white pan traps. Similar tendency towards yellow color have also been reported in Australian bees (Gollan *et al*., 2011). Contrary to this, in Oregon, United States, blue color traps caught more bees than that of yellow traps (Stephen and Rao, 2005). On the other hand, white and blue pan traps proved to be species more specific as both had the maximum dominance as compare to yellow traps. This finding was in contrary to that of Gollan *et al*. (2005) who found that eight of thirteen most common bees were significantly caught by yellow pan traps. We recommend species specific pan trap colors when targeting certain groups or species, nevertheless variety of pan colors should be used when sampling overall bee biodiversity.

A long-term and large-scale sampling technique should be simple, effective, labor less intensive and with minimum human bias (Westphal *et al*., 2008). Although hand netting in this study caught the maximum number (29) of bee species in maximum abundance (1136 individuals) but it cannot be applied for long-term and large-scale sampling. However, hand netting is sometime required to know the plant-pollinator interactions and complete list of bee species in any area because there could be some species which are rarely caught in pan traps (Krug and Alves-Dos-Santos, 2008) e.g. 8 of such bee species were observed this study.

The maximum number (29) of bee species and their abundance (181 individuals) were recorded in yellow pan traps. Moreover, white pan traps collected far less number (18) of bee species that that of yellow pan traps and no bee species was alike in both the pan trap colors. The response of bees towards yellow color could be family specific as Monsevieius (2004) warned that the use of Soderman yellow traps can give biased results due to abnormal attraction of particular species to yellow color especially the members of family Apidae. Contrary to this, Gollan *et al*. (2011) found *Apis mellifera* significantly higher in white pan traps. Blue pan traps in this study closely followed yellow pan traps in terms of abundance and richness of bee species.

Blue pan traps has also shown to be more attractive for bees than the yellow pan traps in terms of abundance and richness in some studies (e.g. Stephen and Rao, 2005; Grundel *et al*., 2011). Therefore it would be a best practice to use variety of colors for a comprehensive assessment of relative attractiveness of each taxonomic group and then use that information for future monitoring purposes accordingly. For example in this study, *Megachile* sp.1, *Megachile* sp.5, *Colletes* sp.1, Halictidae sp.1, Halictidae sp.3, *Nomioides* sp. and *Ceratina* sp.3, were observed only in yellow pan traps while *Nomia* sp.1 was recorded only in blue pan traps.

Flies are the second most important order of insects after bees that pollinate flowers (Larson *et al*., 2001).The collection pattern of flies was also the similar to that of bees i.e. the maximum abundance and diversity in hand net method followed by pan traps and Malaise traps. A Malaise trap collects flying insects which by chance come under its enclosure. Adding some color to Malaise traps can increase the population of specific group of flying insects (Campbell and Hanula, 2007) however we did not add any color to Malaise traps in this study. This might be the reason that there was not even a single most abundant fly species in Malaise traps yet it caught 21out of 31fly species. Eleven fly species *viz*., Calliphoridae sp.1, Calliphora sp.1, Calliphoridae sp.3, *E. laetus*, *E. aeneus*, *E. tenax*, *Eristalinus* sp.3, *S. bengalensis*, Asilidae sp.1, Asilidae sp.2 and Anthomiidae sp.4 had their maximum abundance with pan traps. All the eleven species have been reported visiting flowers in the region (Sajjad *et al*., 2008; Ali *et al*., 2011).

The maximum numbers of fly species were captured in blue and yellow pan traps (18 species in each) followed by white pan trap (12 species). Different fly species exhibited different tendency towards different pan trap colors. For example, syrphid flies (Syrphidae) were captured in higher number with yellow and white pan traps while blow flies (Calliphoridae) were captured in higher number with white and blue pan traps. Like bees, flies also exhibit a strong color preference which even varies within a specific family. For example, the members of family Syrphidae have shown variable attraction towards yellow, blue or white traps (Haslett, 1989; MacLeod, 1999). Campbell and Hanula (2007) suggested blue pan traps to be more successful for monitoring fly populations in Piedmont, Coastal Plain, and Blue Ridge of United states. In this study, we cannot strongly suggest a specific pan trap color for monitoring Diptera populations, however we recommend species specific pan trap colors when targeting certain groups or species, nevertheless variety of pan colors should be used when sampling overall fly biodiversity.

The similarity between the five traps on the basis of species abundance and composition revealed that yellow and blue pan traps exhibited more similar tendency towards insect (cumulatively for both, bees and flies) abundance and richness than that of white pan trap. There were 14 species (5 bees and 9 flies) which were collected with both yellow and blue pan traps but were not collected with white pan traps while only one species (*S. bengalensis*) which was collected with white pan traps but was not collected with yellow and blue pan traps. Therefore performance of white pan traps in collecting overall biodiversity was poor.

Table 3. Percentages of flies (Diptera) collected by hand net, Malaise trap and pan traps are proportions of total sample (N) at Pirowal Wildlife Sanctuary from January to December, 2009

Family	**Genus**	**Pan Traps**				**Malaise**	**Hand-net**
		Blue	**Yellow**	**White**	**Total (n)**		
Calliphoridae	Calliphoridae sp.1	21.32	14.42	25.53	**61.27**	3.00	35.73
	Calliphora sp. 1	6.66	9.79	10.83	27.28	2.71	**70.01**
	Calliphoridae sp.2	2.83	3.30	0.00	6.12	0.00	**93.88**
	Euphumosia sp.	25.35	7.04	7.04	39.44	0.00	**60.56**
	Calliphora sp.2	1.76	1.76	0.00	3.52	0.00	**96.48**
	Calliphoridae sp.3	33.33	0.00	66.67	**100.00**	0.00	0.00
Calliphoridae Total		11.21	9.32	12.59	33.12	1.98	**64.89**
	Eristalinus laetus	15.50	15.50	24.62	**55.62**	0.00	44.38
Syrphidae	*Eristalinus aeneus*	0.53	0.71	1.24	2.48	21.8	**75.69**
	Ischiodon sp.	1.35	2.18	0.83	4.35	12.33	**83.32**
	Eristalis tenax	1.27	5.09	7.63	14.00	7.63	**78.37**
	Syritta pipiens	1.31	9.17	0.00	10.48	5.24	**84.29**
	Eristalinus sp.3	0.00	6.09	7.61	12.18	3.04	**84.78**
	Sphaerophoria bengalensis	0.00	0.00	100.00	**100.00**	0.00	0.00
Syrphidae Total		1.86	3.15	3.04	8.05	13.41	**78.54**
Asilidae	Asilidae sp.1	0.00	0.00	5.12	5.12	9.22	**85.65**
	Asilidae sp.2	23.68	20.03	27.32	9.11	3.64	**87.25**
	Asilidae sp.3	6.65	0.00	2.66	**51.87**	0.00	48.13
	Asilidae sp.4	0.00	0.00	0.00	0.00	5.97	**94.03**
	Asilidae sp.5	0.00	0.00	0.00	0.00	2.20	**97.80**
Asilidae Total		3.67	2.24	4.49	10.40	3.67	**85.93**
Anthomiidae	Anthomiidae sp.1	33.43	28.45	25.25	**87.12**	0.00	12.88
	Anthomiidae sp.2	5.27	15.80	0.00	21.07	7.90	**71.02**
	Anthomiidae sp.3	0.00	4.86	0.00	4.86	3.24	**91.90**
	Anthomiidae sp.4	2.89	2.89	3.86	9.64	0.00	**90.36**
	Anthomiidae sp.5	0.00	0.00	0.00	0.00	5.06	**94.94**
Anthomiidae Total		10.77	10.88	7.84	29.49	3.24	**67.26**
Bombyliidae	Bombyliidae sp.1	1.80	0.60	0.00	2.39	17.95	**79.66**
	Bombyliidae sp.2	0.00	5.79	5.79	11.59	7.72	**80.69**
	Bombyliidae sp.3	0.00	0.00	0.00	0.00	11.09	**88.91**
Bombyliidae Total		0.85	1.99	1.71	4.55	13.36	**82.09**
Tephritidae	Tephritidae sp.1	1.10	0.22	0.44	1.76	3.95	**94.29**
Sarcophagidae	Sarcophagidae sp.1	10.21	22.69	0.00	32.90	1.13	**65.96**
	Sarcophagidae sp.2	1.55	0.00	0.00	1.55	7.73	**90.73**
Sarcophagidae Total		1.67	3.33	0.00	5.00	4.00	**91.01**
Muscidae	Muscidae sp.1	1.63	7.34	0.00	8.97	13.05	**77.97**
Strtiomyidae	Strtiomyidae sp.1	15.96	22.34	0.00	38.30	0.00	**61.70**
Diptera Total		5.43	5.79	5.45	16.67	7.42	**75.91**

For different pan trap colors, the percentages are also proportions of sub-sample (n). Best collecting method for each species is marked in bold type.

***Conclusions*:** In order to know the complete list of biodiversity of any area and confirm the identity of an insect as floral visitor, hand netting is recommended on flowers as there could be some species which are rarely caught in the traps. Moreover, if the focus of monitoring is simply the species richness, then both Malaise traps and colored pan traps can be applied, while if the focus is abundance in addition, then colored pan traps is the best option. However, we also recommend species specific pan trap colors when targeting certain groups or species, nevertheless variety of pan colors should be used when sampling overall biodiversity. We generalize these findings to both the bees and the flies since both had a similar collection pattern i.e. the maximum abundance and diversity in hand net method followed by pan traps and Malaise traps.

***Acknowledgement*:** We are grateful to Dr. Claus Claussen (Twedter Holz 12 D-24944 Flensburg, Germany) and Dr. Andrew Whittington (Flyevidence, Scotland) for their help in identification of many of the Diptera species.

REFERENCES

Aizen M. A. and P. Feinsinger. 1994. Habitat fragmentation, native insect pollinators, and feral honey bees in Argentine ‘Chaco Serrano’. Ecol. Appl. 4:378–392.

Ali M., S. Saeed, A. Sajjad and A. Whittington. 2011. In search of the best pollinators for canola (*Brassica napus* L.) production in Pakistan. Appl. Entomol. Zool. 46:353-361.

Beals E.W. 1984. Bray-Curtis ordination: an effective strategy for analysis of multivariate ecological data. Adv. Ecol. Res. 14: 1-55.

Biesmeijer, J.C., S.P.M. Roberts, M. Reemer, R. Ohlemuller, M. Edwards, T. Peeters, A.P. Schaffers, S.G. Potts, R. Kleukers, C.D. Thomas, J. Settele, and W.E. Kunin. 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. Science. 313:351–354.

Borror D.J., D.M. Long and C.A. Triplehorn. 1981. An introduction to the study of insects. Saunders College Publishing, Philadelphia.

Campbell J.W. and J. L. Hanula. 2007. Efficiency of Malaise traps and colored pan traps for collecting flower visiting insects from three forested ecosystems. J. Ins. Cons. 11: 399-408.

Cane J.H., R.L. Minckley and L. J. Kervin. 2000. Sampling Bees (Hymenoptera: Apiformes) for pollinator community studies; pitfalls of pan-trapping. J. Kansas Entomol. Soc. 73:225–231.

Darling D.C. and L. Packer. 1988. Effectiveness of Malaise traps in collecting Hymenoptera: the influence of trap design, mesh size, and location. Can. Entomol. 120:787–796.

Gollan J.R., M.B. Ashcroft and M. Batley. 2011. Comparison of yellow and white pan traps in surveys of bee fauna in New South Wales, Australia (Hymenoptera: Apoidea: Anthophila). Aust. J. Entomol. 50: 174–178.

Grundel R., K.J. Frohnapple, R.P. Jean and N.B. Pavlovic. 2011. Effectiveness of bowl trapping and netting for inventory of a bee community. Environ. Entomol. 40: 374-380.

Haslett J.R. 1989. Interpreting patterns of resource utilization: randomness and selectivity in pollen feeding by adult hoverflies. Oecologia. 81: 433- 442.

Hurlbert S.H. 1971. The nonconcept of species diversity: a critique and alternative parameters. Ecology. 52: 577-586.

Kevan P.G. 1972. Floral colors in the high arctic with reference to insect-flower relations and pollination. Can. J. Bot. 50:2289–2316.

Khan S.U., M. Hassan, F.K. Khan and A. Bari. 2010. Climate classification of Pakistan. Balwois 2010 Conference, Ohrid, Republic of Macedonia, http://www.balwois.com/balwois/administration/full_paper/ffp-1295.pdf: 1-47 (Date of access: 20 February, 2011).

Krug C. and I. Alves-Dos-Santos. 2008. The use of different methods to sample the bee fauna (Hymenoptera: Apoidea), a study in the mixed temperate rainforest in Santa Catarina state. Neotrop. Entomol. 37:265-278.

Larson B.M.H., P.G. Kevan and D.W. Inouye. 2001. Flies and flowers: taxonomic diversity of anthophiles and pollinators. Can. Entomol. 133:439–465.

Leong J.M. and R.W. Thorp. 1999. Color-coded sampling: the pan trap color preferences of oligolectic and nonoligolectic bees associated with a vernal pool plant. Ecol. Entomol. 24:329–335.

Lonsdorf, E., K C. remen, R T. icketts, R. Winfree, N. Williams and S. Greenleaf. 2009. Modelling pollination services across agricultural landscapes. Ann. Bot-London. 103: 1589-1600.

Matthews R.W. and J.R. Matthews. 1970. Malaise trap studies of flying insects in a New York Mesic forest. I. Ordinal composition and seasonal abundance. J.N.Y. Entomol. Soc. 78:52–59.

Michener C.D. 2000. The Bees of the World. John Hopkins University Press, Baltimore.

Monsevieius V. 2004. Comparison of three methods of sampling wild bees (Hymenoptera, Apoidea) in Èepkeliai Nature Reserve (South Lithuania). Ekologija. 4: 32–39.

Nabhan G.P. and S. Buchmann. 1997. Services provided by pollinators. p. 133-150. In: G. C. Daily (ed.). Nature’s Services: Societal Dependence on Natural Ecosystems. Island Press, Washington DC.

Nisenbaum R.A., M.G. Patselas and S.D. Weiner. 1998. Does flower color change in *Aster vimineus* cue pollinators? Am. Midl. Nat. 141:59–68.

Noyes J.S. 1989. The diversity of hymenoptera in the tropics with special reference to parasitica in Sulawesi. Ecol. Entomol. 14: 197–207.

Potts S.G., S.P.M. Roberts, R. Dean, G. Marris, M. Brown, R. Jones and J. Settele. 2010. Declines of managed honeybees and beekeepers in Europe. J. Apicult. Res. 49: 15-22.

Roulston T.H., S.A. Smith and A.L. Brewster. 2007. A comparison of pan trap and intensive net sampling techniques for documenting a bee (Hymenoptera: Apiformes) fauna. J. Kansas Entomol. Soc. 80:179–181.

Sajjad A., S. Saeed and A. Masood. 2008. Pollinator community of onion (*Allium cepa* L.) and its role in crop reproductive success. Pak. J. of Zool. 40:451-456.

Stephen W.P. and Rao S. 2005. Unscented Color Traps for Non-Apis Bees (Hymenoptera: Apiformes). J. Kansas Entomol. Soc. 78: 373-380.

Toler T.R., E.W. Evans and V.J. Tepedino. 2005. Pan-trapping for bees (Hymenoptera: Apiformes) in Utah's West Desert: the importance of color diversity. Pan-Pac. Entomol. 81:103–113.

Tuell J.K. and R. Isaacs. 2009. Elevated pan traps to monitor bees in flowering crop canopies. Entomol. Exp. Appl. 131: 93-98.

Westphal C., R. Bommarco, G. Carre, E. Lamborn, N. Morison, T. Petanidou, S. Potts, S. Roberts, H. Szentgyorgyi, T. Tscheulin, *et al*. 2008. Measuring bee diversity in different European habitats and biogeographical regions. Ecol. Monogr. 78: 653-671.

Westrich P. 1996. Habitat requirements of central European bees and the problems of partial habitats. p. 1–16. In: A. Matheson, S.L. Buchmann, C. O'Toole, P. Westrich and I.H. Williams (ed.). The Conservation of Bees. Academic Press, London.

Wilson J.S., T. Griswold and O.J. Messinger. 2008. Sampling Bee Communities (Hymenoptera: Apiformes) in a Desert Landscape: Are Pan Traps Sufficient? J. Kansas Entomol. Soc. 81: 288-300.