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Comparison of Attractive and Intercept Traps for Sampling Rove Beetles (Coleoptera: Staphylinidae)

Shabab NASIR[1,*] Iram NASIR[2] Faisal HAFEEZ[3] Iqra YOUSAF[1]

[1]Department of Zoology, Government College University, Faisalabad, PAKISTAN
[2]Department of Statistics, Government College Women University, Faisalabad, PAKISTAN
[3]Department of Entomology, Ayub Agriculture Research Institute, Faisalabad, PAKISTAN
e-mails: [1,*]flourenceshabab@yahoo.com, [2]drirumemmo407@yahoo.com,
[3]faisalhafeez143@yahoo.com, [4]iqrayousaf12@gmail.com
ORCID ID: 0000-0003-4735-1062

ABSTRACT

Field experiment was conducted to collect/sample staphylinid beetles with four different traps (flight intercept trap, Berlese funnel trap, light trap and pit fall trap) and net/hand collection from eleven selected locations of Punjab (Pakistan) in 2013 and 2014. Each locality was sampled for 4 days with an interval of two months. Different abiotic factors were noted and Shannon diversity index was calculated for each locality. A total of 4386 specimens (beetles) were collected. Pit-fall traps were found most conducive and effective in sampling beetles followed by Berlese funnel traps and net/hand collection while light traps showed least efficiency. Maximum value of species richness and abundance was observed during Monsoon season (July-August). *Paederus fuscipes* was the most common species. The highest value of α-diversity index was observed from Sargodha during both years while in case of Shannon-Wiener index value, Murid Wala was the highest during 2013 and Gutwala during 2014. Changa Manga was the place with highest evenness value. The results of Generalized Linear Mixed Model (GLMM) also indicated that the abundance/number of beetles sampled with different collection methods had significant effects with locality and crop type while insignificant effects with time (years). We conclude that methods of trapping need refinement by installing traps for large duration in all study location keeping all conditions (biotic & abiotic) in view to enhance the efficiency of collection methods and exploration of staphylinid beetles.

Key words: Collection methods, Staphylinids, comparison, Rove beetles, Punjab, Pakistan.

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INTRODUCTION

Staphylinids are the group of beetles found easily in the natural conditions i.e forest, meadows, decaying animal or plant matter, on flower, under seaweed, under stones or bark, in fungi and leaf litter and in the nests of birds, mammals (Good & Giller, 1991). Majority of the species are free-living, predators of other invertebrates (Coombes & Sotherton, 1986). Some species are medically important causing skin dermatitis in man called spider lick, night burn or dermatitis linearis (Nasir, Akram, Khan, Arshad, & Nasir, 2015a). Along with these factors, their activity also depends upon aboitic factors, i. e., temperature, relative humidity, soil moisture contents, organic matter, altitude, latitude and longitude (Shah, Brooks, Ashby, Perry, & Woiwod, 2003; Nasir et al, 2015b). They are generally restricted to humid conditions like marshes, edges of canals and water channels and agricultural fields. So, their activity (richness & abundance) can be studied by their collection. The collection of rove beetles requires a wide variety of methods for a comprehensive sampling. However, in broader sense, these methods are divided into direct and indirect sampling methods.

Direct sampling methods include physically collection of beetles from the microhabitats (decaying animal or plant matter, on flower, under seaweed, under stones or bark, in fungi and leaf litter etc). These methods involve hand collection, sweep netting and beating vegetation. In case of indirect methods of collection, a variety of traps are used for mass collection of the rove beetles (flight intercept trap and light trap) or from the ground (pitfall traps). The use of Berlese funnels to collect rove beetles from leaf litter and other substrate, with or without sifting is another indirect collection method. The wingless species, especially, belonging to sub-families Oxytelinae, Paederinae and Staphylininae are collected through Berlese funnels by placing the leaf litter, rotten woods and fungi into it (Besuchet, Burckhardt, & Löbl, 1987) and by sifting it. Flight intercept traps (FITS) are used for capturing individuals of flight capable species (Peck & Davies, 1980; Masner & Goulet, 1981). When the traps are installed in prime locations, consisting of falling trees and leaf litter, these methods are more productive. The best method to collect relatively large sized species form vegetation, stems, dung and from fungi is net/hand collection. However, pit fall traps are considered the best method for the said taxa that are active at ground level such as adults of *Paederus* genus and some Tachyporinae members (Prasifka et al, 2006). The light trap is used to attract and sample rove beetles like Oxytelinae, Tachyporinae and some members of Omaliinae, Paederinae, Staphylinea and Aleocharinae are collected by this method (Hollingsworth & Hartstack, 1972; Onsager, 1976).

A study was planned to sample the staphylinid beetles from eleven different localities of Punjab, Pakistan for a comparative evaluation of different collecting methods/traps w.r.t different climatic conditions in prevailing environmental conditions.

MATERIALS AND METHODS

Samples were carried out during 2013-2014 at eleven different localities (eight cropped localities and three forest localities) in the Punjab, Pakistan as shown in

the table 1. Latitude, longitude and elevation above sea level for each locality were recorded with the help of Magellan GPS (Explorist 660). At each locality one field was selected. The selected fields contained seasonal crops (Table 2). Within each field, five different collection methods were used (Roeder, 2003; Derunkov, 2007) to collect the beetles. The choice of time of year was very crucial because of strong seasonality of the climate. So, it was decided to sample whole year to overcome this problem. The pattern of activity of Coleoptera is very seasonal and follows the rainfall pattern (Noguera, 1990) in the arid climate and forests. The time required for sampling each locality was about four days and this estimated two months for sampling all localities (Table 1) with six time sampling each year, hence 66 samples were collected each year with each collection method and mean value was calculated.

Table 1. GPS positions of the selected localities and bimonthly schedule for sampling.

Plot #	Locality name	Latitude	Longitude	Elevation (m)	No. of weeks (W) and months (M)
1	Lahore	31 14.287	73 59.513	194	2nd and 3rd W of 1st M
2	Sheikhupura	31 34.723	73 29.117	187	2nd and 3rd W of 1st M
3	Faisalabad	31 26.271	73 04.699	183	1st W of 1st M
4	Multan	30 12.534	71 27.813	104	2nd and 3rd W of 2nd M
5	Rahim Yar Khan	28 26.450	70 19.712	83	4th W of 2nd M
6	Sargodha	32 05.379	72 40.566	183	4th W of 1st M
7	Rawalpindi	33 34.425	73 05.161	496	4th W of 1st M
8	Dera Ghazi Khan	30 18.209	70 43.324	117	2nd and 3rd W of 2nd M
9	Changa Manga	31 04.729	73 59.967	196	2nd and 3rd W of 1st M
10	Gutwala	31 28.254	73 12.291	185	1st W of 1st M
11	Muridwala	30 72 03	72 45 65	150	1st W of 2nd M

Table 2.General sowing and harvesting periods of different crops in the Punjab (Annonymous, 2016).

Crop	General Sowing period	Harvesting period	Duration of crop
Wheat	November to December	April	160 days
Maize	February and July	May and October	100 days
Cotton	End of April to June	November	180 days
Rice	May to June	October	150 days
Berseem	October	March	180 days
Summer vegetables	February to March	June to July	120 days
Winter vegetables	September to October	December to January	120 days

Sampling methods

Different traps were used to collect the insects.

Flight intercept trap (FIT)

One FIT was installed at every selected place i. e. cultivated area or forest area. A piece of black netting (180 cm x 90 cm) was used for this trap. Its mesh size was 1mm x 0.8 mm. On all sides of netting black twill tape was wrapped. Two sticks of bamboo that were longer than netting were used to tie up the netting. A small portion of these sticks were buried in to the soil and then two ropes were tied up to each stick, then the other ends of ropes were tied to the tent nails. Under the netting a trench 60 cm wide, 30 cm deep and 180 cm long was made for preservative solution. A polythene sheet was used for spreading in the trench to avoid the seepage of solution in the trench. A rain cover was also tied over the netting with ropes to avoid rain water in the trench. A mixture of water, table salt and small amount of shampoo was used as preservative in the trench (Nasir, Akram, Ahmed, & Sahi, 2011; Masner & Goulet, 1981). This trap was installed for 4 days at each locality during every visit within 2 months.

Pit-fall traps

Five pit-fall traps were installed within the area of one acre in a transect form, from the corners of field towards the centre of the fields to all places; i. e. cultivated area (with in crops) and non-cultivated area (forest). Four traps were installed in four corners of field within 2nd or 3rd row of crop or within the distance of three meters (in forest) while 5th trap was installed in the centre of field (Shah et al, 2003; Apigian, Dahlsten, & Stephens, 2006).

Each trap consisted of a plastic basket with dimensions of 22.5 cm in diameter and 60 cm in length. These baskets were half filled with brine solution (tap water+table salt) containing small amount of soap or shampoo to reduce the surface tension and to ensure that the insects would sink. Traps were protected from rain fall, leaves or other materials by plastic trays suspended above the basket. Traps were installed for 4 days during each visit. Insects were collected after 2 months interval. Then these were stored in vials and taken to laboratory where these were sorted under magnifying lens and then stored in the vials containing 75% alcohol.

Light trap

One light trap at each collection site was installed for 4 nights during every visit within 2 months. For this purpose a cylindrical plastic container having capacity of 250 cm^3 with a plastic funnel was used (Bohac & Bezdek, 2004). Brine solution containing small quantity of shampoo was used for collection. In the morning, the collected material was sorted out. The rove beetles were stored in the vials containing 75% alcohol for further studies.

Berlese funnel

Forest litter and crop debris was collected and beetles were extracted in two steps;

a) Sifting was done to collect the rove beetles and larger debris was removed.

b) The collected samples were put in the boxes and the poison bottles containing 10% formaline were put below these boxes to collect and store the beetles. Above the boxes ordinary bulbs were lighted to collect the beetles.

Sweep net/hand picking

To further enrich the collection material, arthropods were collected by sweep netting of grass and other crops (Hall & Barney, 2011). Hand picking was also done from flowers and each selected place for about an hour.

Storage and identification

The collected samples were brought to the Biodiversity Laboratory in Department of Zoology, Government College University, Faisalabad. The samples were sorted through visual observation and then identified under microscope (M33OO-D) in the laboratory with the help of available keys (Scheerpeltz, 1960; Abdullah & Qadri, 1970; Coiffait, 1982, 1984; Lobl, 1986; Pace, 1986; Herman, 2001; Smetana, 2004), web sites and entomological articles.

Statistical analysis

Variation was increased among the samples from fields receiving distinct treatments (plot size, crop type, fertilize or insecticide use; Prasifka et al, 2006). However, to simply summarize arthropod captures by trap type and year, means and standard errors derived from individual traps were calculated for each arthropod group, but not tested for differences among means based on trap type. To test for differences in the frequency with which particular arthropod taxa were collected by the five trap types, 2x5 contingency tables categorized each trap as successful (one or more individuals collected) or unsuccessful (zero individuals collected), and differences were assessed with chi-squared tests (Conover, 1999). Dominance of the each species was determined and Shannon diversity and evenness were calculated using natural logarithm (Shannon-Wiener, 1949; Pielou, 1984). The Generalized Linear Mixed Model (GLMM) was applied with locality (study area), time (years) and crop (crop type) as random effects. The significance of each random effect is tested so that if any of the random effects has insignificant effect, the model will be fitted without that effect. The variable collection methods were taken as fixed effects in the model. The GLMM was fitted using *lme4* package of statistical programming language R-3.0.2 (Team, 2013). The abundance of staphylinid beetles was treated as response variable and for testing it following hypotheses were formulated.

H_0: The random effect time has insignificant effect

H_1: Time is a significant effect in the GLMM

and

H_0': The random effect locality is not significant

H_1': Locality is a significant effect in GLMM

and

H_0: The random effect crop type has insignificant effect

H_1: Crop type is a significant effect in the GLMM

Likelihood ratio test was used to test the significance of random effects. The likelihood ratio test is used to compare the null model and the alternative model. The

log-likelihood ratio (or likelihood ratio) can be used to compute a p-value to decide whether to reject or accept the null hypothesis.

RESULTS AND DISCUSSION

A total of 4386 specimens were collected with different traps during 2013-2014 from 2 families, 6 subfamilies, 16 genera and 27 species (identified up to species level) with numerous unidentified taxa. However, more specimens collected during 1st study year than 2nd study. Results predicted that pit-fall traps are more conducive and effective than Berlese funnel, net/hand collection and flight interception traps (Table 3). Light trap was proved least effective / nominal among all traps. The highest numbers of beetles of the subfamily Paederinae (on average 4.1 individuals) was collected by pit-fall trap followed by other beetles (2.7) whereas subfamily Tachyporinae individuals were sampled in least numbers (0.1) in 2013. Berlese funnel trapping was at 2nd position in terms of mean individuals, having maximum numbers of other beetles followed by Paederinae family. Net/hand collection method of trapping was at intermediate in terms of mean individuals. Flight intercept and light trap proved least effective/nominal. However, Oxytelinae, Aleocharinae and Tachyporinae subfamilies were absent from these two sampling methods. The same trapping trend was recorded during year 2014 with more effective trap was pit fall followed by Berlese funnel, net/hand collection and flight intercept (Table 3).

The data relating abiotic factors (environmental temperature, relative humidity and soil moisture) was collected from meteorological stations close to the sampling localities. There was a temperature variation between and among the sampled localities with respect to months of the years, i. e., The hottest place among the studied sites was Rawalpindi (cultivated non irrigated area) with average temperature (35.1°C) during May-June, 2014 followed by a forest locality Changa Manga (34.3°C). The highest variation of temperature with 22.1°C was recorded at forest site, Changa Manga (12.2°C to 34.3°C) and the site with smallest variation (18.3°C) was again a forest site (15.1°C to 33.4°C). All the other sites showed intermediate conditions between these (Table 4). All selected sites had almost similar trend in case of relative humidity variations. During monsoon season (July to September), the relative humidity was high and during hot and dry season (November to May) its value was low. The site with the lowest relative humidity (26.7%) was Dera Ghazi Khan during May-June while Faisalabad was with the highest R.H (65.7%) during July-August (Table 4). Generally soil moisture contents were high in irrigated lands during rainy season (July to September) and low during dry season (November to May). The soil of Gutwala was dry and contained lowest value of soil moisture (16.8%) during November-December while the highest value (58.4%) was recorded from Lahore during July-August with highest soil moisture variance (13.1%), i.e., from 45.3% to 58.4% (Table 4). A sum of 4386 specimen were collected with the help of five collection methods during the 2 years (2013-2014) belonging to 2 families, 6 subfamilies, 16 genera and 27 species (identified up to species level) with numerous unidentified taxa. Mostly specimens were identified up to species level. During 2013, the most diverse locality was Murid

Comparison of Attractive and Intercept Traps

Table 3. Mean (±SEM) number of rove beetles collected from different traps during 2013-14.

Taxon	Pitfall trap	FIT	Berlese funnel trap	Light trap	Net/Hand collection
Staphylinidae					
Oxytelinae	0.55 ± 0.1	0.0 ± 0.0	0.9 ± 0.2	0.0 ± 0.0	0.9 ± 0.2
Oxytelus ferrugineus	0.12± 0.0	0.0 ± 0.0	0.34± 0.1	0.0 ± 0.0	0.12± 0.1
Oxytelus sordidus	0.17± 0.1	0.0 ± 0.0	0.21± 0.1	*	0.17± 0.1
Oxytelus varipennis	0.34± 0.1	*	0.15± 0.1	0.0 ± 0.0	0.24± 0.1
Platystethus cornutus	0.10± 0.0	*	0.09± 0.1	*	0.04± 0.1
Paederinae	4.0 ± 0.3	0.9 ± 0.1	1.65 ± 0.15	1.15 ± 0.2	1.05 ± 0.2
Paederus fuscipes	0.56± 0.1	1.13± 0.2	0.25± 0.1	0.50	0.20± 0.1
Paederus tumulus	0.04± 0.0	0.0 ± 0.0	0.42± 0.1	0.32	0.32± 0.1
Paederus pubescens	0.12± 0.0	0.6± 0.0	0.23± 0.1	0.44	0.06± 0.1
Paederus basalis	0.28± 0.1	0.12± 0.0	0.15± 0.1	0.23	0.11± 0.1
Stilicus ceylanensis	0.13± 0.0	0.1± 0.0		0.00	0.27± 0.1
*Astenus*sp.	0.15± 0.0	0.02± 0.0		0.00	0.13± 0.1
Cryptobium abdominalis	0.32± 0.1	0.03± 0.0	0.50± 0.1	0.00	0.12± 0.1
Staphylininae	0.6 ± 0.1	0.9 ± 0.15	1.25 ± 0.1	0.8 ± 0.2	0.9 ± 0.2
Philonthus delicatulus	0.1± 0.0	0.02± 0.0	0.45± 0.1	0.31	0.32± 0.1
Philonthus cinotulus	0.12± 0.0	0.15± 0.0	0.34± 0.1	0.12	0.18± 0.1
Philonthus gemellus	0.25± 0.1	0.07± 0.0	0.67± 0.1	0.0	0.03± 0.1
Philonthus minutus	0.18± 0.0	*	0.0 ± 0.0	0.0	0.09± 0.1
Leptacinus parumpunctatus	0.11± 0.0	0.10± 0.0	0.00	0.19	0.09± 0.1
*Staphylinus*sp.	*	0.5± 0.2	0.46± 0.1	0.12	0.03± 0.1
Aleocharinae	0.3 ± 0.1	*	0.4 ± 0.1	*	0.6 ± 0.2
Aleochara clavicornis	0.06± 0.0	*	0.14± 0.1	*	0.2± 0.1
Aleochara puberula	0.02± 0.0	*	0.09± 0.1	*	0.1± 0.1
Myrmecopora elegans	*	*	0.21± 0.1	*	0.3± 0.1
Astilbus mixtus	0.02± 0.0	*	0.23± 0.1	*	0.2± 0.1
Aleochara spp.	0.13± 0.0	*	0.32± 0.1	*	0.23± 0.1
Tachyporinae	0.15 ± 0.0	*	0.2 ± 0.0	*	0.2 ± 0.0
Tachyporus himalayicus	0.02± 0.0	*	0.07± 0.1	*	0.19± 0.1
Tachinomorphus ceylonicus	0.12± 0.0	*	0.12± 0.1	*	0.09± 0.1
Carabidae	1.3 ± 0.1	0.0 ± 0.0	2.0 ± 0.2	0.0 ± 0.0	0.65 ± 0.2
Other beetles	2.5 ± 0.2	1.2 ± 0.1	3.0 ± 0.3	1.2 ± 0.1	0.4 ± 0.1
Other arthropods	3.6 ± 0.25	1.3 ± 0.1	2.85 ± 0.2	0.9 ± 0.1	0.35 ± 0.1

FIT = Flight Intercept trap, Mean and standard error values based on 132 samples per trap type. Asterisk (*) indicates trap x taxon combinations where no individuals were collected.

Wala with respect to Shannon diversity index (2.502) while Gutwala had highest diversity index value (2.568) during 2014 with Rawalpindi lowest value (1.899). The remaining sites showed intermediate values. During both years, the more even site was Changa Manga (J´=0.899) while its value was low (0.694) in Lahore with the highest value of dominance (0.306) (Table 5). Generally the value of α-diversity index was higher during 2014 than 2013. The Shannon diversity index was slightly higher during 2014 than 2013 of different studied localities while the dominance was higher in 2013 (Table 5). Shannon diversity (H´) refers to both species richness and abundance. Some species like *Paederus fuscipes*, *Philonthus cinotulus*, *Philonthus gemellus*, *Myrmecopora elegans*, *Tachyporus himalyicus* and *Astilbus mixitus* were found exclusively in cropping areas. No species was found to be the site exclusive but some species were found only in cropped areas and some were found to be confined up to forest areas only. Some species were found to be associated with some crops like *Paederus fuscipes* was found mostly from maize (may be due to more aphids) and berseem or with cropping patterns and some were found to be associated with humus (organic matter) in the soil but all species were found to be dependent on moisture contents in the soil. The highest number of species and their abundances were collected during rainy season (July-August) except site 10 where the highest number of specimens was collected during March-April. Some places have similar temperature and soil moisture but different number of specimens, this was due to different crops and their sowing and harvesting time (Table 2) or other biotic factors like prey availability or less disturbance.

A GLMM fitted with random effects produced log-likelihood value = -2496.178. The log-likelihood values for GLMMs with crop type effect, locality effect and time effect were found to be -2499.765, -2552.19 and -2598.987 respectively. The value of log-likelihood ratio statistic for testing H_0 was $\wedge$ = 2.201 with p-value = 0.1509 suggesting that we may accept H_0 and conclude that time is not a significant effect in the model. To test H_0', value of log-likelihood ratio statistic was $\wedge$ = 89.49 and 92.23 for locality and crop type respectively with p-value < 0. On the basis of p-value, we may reject H_0' and can conclude that locality and crop type had a significant effect. So, a GLMM was finally fitted with two random effects i.e., locality, crop type and fixed effects. The results of fitting of the models are given in Table 6 and 7. The results in Table 6 showed that three collection methods (pitfall trap, flight intercept trap and Berlese funnel trap) out of five collection methods indicated significant effects with locality while table 7 indicated that three collection methods (flight intercept trap, Berlese funnel trap and light trap) out of five collection methods indicated significant effects with crop type.

Sampling of insects (beetles) greatly depends on the trap efficiency (Márquez, 2003; Roeder, 2003). In our case, the efficiency of the traps is very unequal because of attractive traps (light trap, pit fall trap and Burlese funnel trap) and intercept traps (Flight intercept Traps and net/hand collection) were used together as done previously (Roeder, 2003). The efficiency of light trap was very poor in our case as was described by other scientists such as Roeder (2003) and it was totally different from Martínez, Acosta, & Franz (2009) who had captured more beetles with light traps than FIT'S and

pit fall traps due to different light colour and intensity. Mostly specimens were aught with pitfall traps followed by Berlese Funnel and least was caught with flight intercept traps and light traps. As some species were not attracted by traps so sweep nets and hand collection were also used to enrich the collection. Mostly scientists used only pit fall traps and found it a successful method for staphylinids as indicated by our studies. Dagobert, Klimaszewski, Mamadou, Daouda, & Mamadou (2008) also cused a combination of four types of collection methods and concluded that FIT'S was the most successful method and pit fall traps were least effective. These results are in contrast with our findings. In 2009, Martinez and his co-workers noticed the similar results those used two types of collection methods and recorded more individuals with pit fall traps followed by light traps. Conversely, some traps within plots were placed too close to each other to be considered independent (<10 m apart), which reduced variability. Commonly, all the collection methods do not have the same capacity to collect the beetles, so the application of different collection methods would be helpful in tropical habitats (Braet, Aimé, & Fretey, 2000).

Table 4. Record of abiotic factors affecting population of rove beetles.

Months Sites/Elevation	Jan. Feb.13	Mar. Apr.13	May Jun.13	Jul. Aug13	Sep. Oct.13	Nov. Dec13	Jan. Feb.14	Mar. Apr.14	May. Jun.14	Jul. Aug.14	Sep. Oct.14	Nov. Dec.14
LHR/ 196m												
Temperature	12.5	25.2	33.6	32.1	28.7	18.4	15.3	24.3	34.2	30.4	29.0	19.4
R.H (%)	29.4	32.3	31.2	55.1	51.4	32.2	31.4	35.3	32.6	60.2	53.1	31.3
S.M.C (%)	47.1	52.2	51.3	58.4	53.1	48.2	45.3	51.1	49.2	56.4	52.2	49.1
species richness	6	8	7	6	10	5	5	11	14	17	11	10
SHP/ 188m												
Temperature	12.1	24.6	33.4	32.3	27.2	17.4	14.3	23.4	33.3	32.2	28.3	19.3
R.H (%)	34.1	36.2	32.9	52.3	43.5	30.3	32.6	38.2	36.4	53.4	41.6	35.5
S.M.C (%)	45.5	48.2	49.3	56.2	52.3	48.5	46.2	47.7	48.5	55.4	51.3	46.3
species richness	7	9	11	9	11	7	7	7	11	10	9	6
FSD/ 182m												
Temperature	12.8	24.5	31.7	31.6	27.5	17.7	14.5	23.7	33.3	32.2	28.3	18.1
R.H (%)	39.4	42.1	39.3	65.7	58.5	55.5	56.5	47.4	32.2	65.3	59.1	44.2
S.M.C (%)	46.1	48.3	48.5	52.2	51.0	48.3	45.4	49.2	48.4	51.5	49.3	47.4
species richness	9	10	10	12	7	7	8	10	11	11	9	9
MTN/ 108m												
Temperature	14.2	26.0	33.3	33.7	29.0	19.3	16.2	24.6	34.4	34.3	30.2	19.9
R.H (%)	60.2	53.1	43.2	62.6	50.4	51.3	49.3	47.1	45.4	57.2	48.9	39.8
S.M.C (%)	38.5	39.4	39.3	45.5	42.3	40.5	37.4	38.3	39.1	42.5	39.4	36.3
species richness	9	9	9	12	5	6	9	8	9	11	6	5
RYK/ 81m												
Temperature	13.6	24.5	32.5	32.7	28.3	17.6	14.7	24.7	33.2	33.5	28.7	18.5
R.H (%)	46.4	45.3	39.4	53.8	47.4	37.7	43.5	46.4	40.4	56.3	42.2	39.4
S.M.C (%)	35.2	37.4	36.5	42.3	40.3	34.2	34.3	35.4	36.3	43.5	40.7	34.6
species richness	7	9	11	13	7	7	8	8	10	12	5	7
SGD/ 185m												
Temperature	12.4	23.7	31.3	31.2	27.4	17.2	12.6	24.2	32.4	31.6	27.3	17.7
R.H (%)	36.3	42.4	40.2	59.3	42.1	37.5	38.3	43.2	41.4	58.6	49.4	34.7
S.M.C (%)	28.3	32.4	34.6	45.3	40.2	33.5	29.6	34.4	34.5	45.2	38.7	32.6
species richness	8	12	10	10	7	11	9	11	10	10	6	12
RWP/ 501m												
Temperature	16.2	25.5	34.3	30.5	28.4	19.1	18.4	24.3	35.1	34.3	26.7	17.4
R.H (%)	56.3	48.2	35.3	56.3	47.6	38.6	52.4	46.7	45.3	56.3	45.7	37.5
S.M.C (%)	26.2	30.4	30.4	36.6	35.4	30.4	27.5	32.6	30.7	35.8	31.5	29.7
species richness	5	5	6	4	5	5	4	6	6	4	5	7
DGK/ 120m												
Temperature	15.2	24.3	34.1	34.1	30.5	19.32	10.2	24.2	34.3	34.2	30.3	19.2
R.H (%)	35.2	28.1	26.7	49.3	42.1	32.2	35.3	34.3	30.4	50.1	43.2	37.3
S.M.C (%)	27.0	32.5	31.2	34.2	39.2	29.4	25.4	29.4	30.4	34.4	32.5	30.4
species richness	6	7	7	13	7	6	6	8	7	12	5	7

Table 4. Continued.

Months Sites/Elevation	Jan. Feb.13	Mar. Apr.13	May Jun.13	Jul. Aug13	Sep. Oct.13	Nov. Dec13	Jan. Feb.14	Mar. Apr.14	May. Jun.14	Jul. Aug.14	Sep. Oct.14	Nov. Dec.14
CNG/ 199m												
Temperature	12.2	25.2	33.3	32.2	28.1	18.1	15.2	24.3	34.3	33.4	29.6	19.2
R.H (%)	30.5	34.5	32.6	51.5	45.3	30.2	32.4	32.4	31.1	51.5	46.3	30.1
S.M.C (%)	25.6	26.1	25.2	32.7	30.4	29.4	25.2	26.1	25.6	32.7	30.1	29.4
species richness	9	7	8	11	8	7	8	7	8	10	6	7
GTW/ 184m												
Temperature	13.1	24.6	32.1	32.2	28.8	17.2	15.6	23.9	33.5	32.4	29.8	18.3
R.H (%)	29.5	41.5	38.5	57.7	27.3	48.1	38.2	42.5	36.8	58.3	51.6	36.6
S.M.C (%)	23.7	25.2	23.8	28.3	19.4	16.8	23.3	24.3	24.5	30.5	28.1	23.2
species richness	6	6	5	11	1	1	4	9	5	13	10	4
MDW/ 149m												
Temperature	15.1	23.4	33.3	32.4	29.7	18.6	15.1	23.7	33.4	33.3	30.4	19.3
R.H (%)	35.4	43.2	38.2	53.2	47.4	38.3	34.3	42.2	36.4	51.4	43.3	36.6
S.M.C (%)	24.2	25.1	24.1	30.5	28.1	23.2	23.7	25.1	24.1	30.5	28.5	23.1
species richness	7	11	8	12	6	7	7	10	9	11	6	7

LHR = Lahore; SHP=Sheikhupur; FSD=Faisalabad; MTN=Multan; RYK=Rahim Yar Khan; SGD=Sargodha; RWP=Rawalpindi; DGK=Dera Ghazi Khan; CNG=Changa Manga; GTW=Gutwala; MDW=Murid Wala; R.H=Relative humidity; S.M.C=Soil moisture contents.

Table 5. Diversity measures of rove beetles from different localities (cropped and forest) of the Punjab, Pakistan.

Localities	2013				2014			
	H´	J´	D	A	H´	J´	D	A
LHR	1.798	0.694	0.306	13.789	2.492	0.829	0.171	19.799
SHP	2.353	0.840	0.160	16.699	2.399	0.849	0.151	16.801
FSD	2.346	0.781	0.219	20.698	2.408	0.789	0.211	20.799
MTN	2.401	0.859	0.141	18.745	2.501	0.859	0.141	17.769
RYK	2.499	0.887	0.113	17.697	2.444	0.840	0.160	18.800
SGD	2.299	0.819	0.181	20.776	2.499	0.829	0.171	20.812
RWP	1.759	0.781	0.219	09.801	1.899	0.789	0.211	11.669
CNG	2.401	0.899	0.101	15.811	2.499	0.899	0.101	15.802
GTW	2.390	0.869	0.131	15.740	2.568	0.869	0.131	18.698
MDW	2.502	0.870	0.130	16.799	2.501	0.889	0.111	15.810

H´=Shannon diversity; J´=Evenness; D=Dominance; α=Diversity index; LHR=Lahore; SHP=Sheikhupur; FSD=Faisalabad; MTN=Multan; RYK=Rahim Yar Khan; SGD=Sargodha; RWP=Rawalpindi; DGK=Dera Ghazi Khan; CNG=Changa Manga; GTW=Gutwala; MDW=Murid Wala.

During our study, we found H'value between 1.9-2.5, while Shah *et al.* (2003) found this value less than 2.0 due to different ecological conditions. Some researchers (Magurran, 1988; Márquez, 2003) reported that these values usually ranged between 1.5 to 3.5 and rarely exceeded 4.5. Our findings were in line with these results during both years (2013-2014). All 26 species were present in cropped areas while only 17 species were found in the forest areas. This difference in species can be referred to biotic factors, e.g. different crops, and abiotic factors, e.g. temperature, relative humidity, and soil moisture. These results were at par with the study of other scientists (Schiegg, 2000; Judas, Dornieden, & Strothmann, 2002; Kehler, Bondrup-Nielson, &

Corkum, 2004). Staphylinid's activity (species richness & abundance) is dependent on the type of season, e.g. rain fall. Maximum activity was present during the months having more rainfall (July-August) with respect to the months with less rain fall, i.e. during May- June and September to January. There was normally a maximum abundance and a maximum diversity during July-August. These results are consistent with the results of other scientists (Koller, Alberto, Sergio, & Julio 2002). It was clear from our results that most species were not strongly associated with a particular season (Elliott et al, 2006).

Table 6. Results of GLMM fitted with "abundance/numbers" as response variable, "locality" as random effect and collection methods as fixed effects.

Effect		Variance		std. dev.	
Random	Locality	0.0259		0.1598	
		Estimate	Std. Error	z- value	p-value
Fixed	(Intercept)	0.22	0.17	1.29	0.16
	Pitfall trap	0.04	0.02	2.07	<0.001**
	FIT	-0.07	0.08	-1.03	0.02*
	Berlese funnel trap	-0.29	0.09	-2.98	<0.001**
	Light trap	0.03	0.07	0.22	0.78
	Net/Hand collection	-0.29	0.11	-3.45	0.65

*=significant at 5% level of significance, **=significant at 1% level of significance, FIT=Flight intercept trap.

Table 7. Results of GLMM fitted with "abundance/numbers" as response variable, "crop type" as random effect and collection methods as fixed effects.

Effect		Variance		std. dev.	
Random	Crop type	0.0159		0.1099	
		Estimate	Std. Error	z- value	p-value
Fixed	(Intercept)	0.18	0.13	1.22	0.13
	Pitfall trap	0.06	0.04	2.18	0.56
	FIT	-0.12	0.07	-0.99	0.01*
	Berlese funnel trap	-0.19	0.10	-2.89	<0.001**
	Light trap	0.03	0.07	0.22	0.02*
	Net/Hand collection	0.27	0.19	3.95	0.85

*=significant at 5% level of significance, **=significant at 1% level of significance, FIT=Flight intercept trap.

It is concluded that method of trapping need refinement by installing traps for large duration in all study location keeping all conditions in view to enhance the efficiency of collection methods and exploration of staphylinid beetles. Moreover, it was also concluded that different biotic (soft bodied insects, crop type) and abiotic (temperature, soil moisture contents, rain fall, type of locality) factors significantly affect the activity of rove beetles and efficacy of collection methods.

REFERENCES

Abdullah, M. & Qadri, N.N. (1970). The Staphylindiae [sic], Coleoptera of Pakistan. Part III. A key to the genera and species of the Piestinae, Osoriinae, Pseudopsinae and Oxytelinae, with descriptions of new genera, subgenera and species from Karachi. *Pakistan Journal of Science and Industrial Research,* 13, 114-131.

Apigian, K., Dahlsten, D.L., & Stephens, S.L. (2006). Biodiversity of Coleoptera and the importance of habitat structural features in a Sierra Nevada mixed-conifer forest. *Environmental Entomology,* 35, 964-975.

Annonymous. (2016). *Agriculture department, Government of the Punjab.* URL: http://www.agripunjab.gov.pk/downloads.

Besuchet, D., Burckhardt, D.H. & Löbl, I. (1987). The "Winkler/Moczarski" eclector as an efficient extractor for fungus and litter Coleoptera. *Coleopterists Bulletin,* 41, 392-394.

Bohac, J. & Bazdek, A. (2004). Staphylinid beetles (Coleoptera, Staphylinind) recorded by pitfall and light trapping in Mrtvy Luh peat bog. *Silva Gabreta,* 10, 141-150.

Braet, Y., Aimé, J., & Fretey, J. (2000). Notes sur quelques insectes récoltés au pièges malaise en Guyane française. *Notes Fauniques de Gembloux*, 38, 3-20.

Coiffait, H. (1982). Staphylinides (Col.) de la régionhimalayenne et de l'Inde (I. Xantholininae, Staphylininae et Paederinae). *Entomology Basilien,* 7, 231-302.

Coiffait, H. (1984). Coléoptères staphylinides de la région paléarctique occidentale III. Sous famille Paederinae, Tribu Paederini 2. Sous famille Euaesthetinae. *Nouvelle Revue d'Entomologie,* 8, 1-424.

Conover, W.J. (1999). *Practical Nonparametric Statistics.* (3rd ed.). John Wiley and Sons, New York, 1-217 pp.

Coombes, D.S. & Sotherton, N.W. (1986). The dispersal and distribution of polyphagous predatory Coleoptera in cereals. *Annals of Applied Biology,* 10, 461-474.

Dagobert, K.K., Klimaszewski, J., Mamadou, D., Daouda, A., & Mamadou, D. (2008). Comparing beetle abundance and diversity values along a land use gradient in tropical Africa (oumé, Ivory Coast). *Zoological Studies,* 47, 429-437.

Derunkov, A. (2007). Species diversity of Staphylinidae in the Neman River bason in Belarus. 22nd Int Meeting on Biol Syst Staphylinidae. [Abstracts].

Elliott, N.C., Tao, F.A., Giles, K.L., Royer, T.A., Greenstone, M.H., & Shufran, K.A. (2006). First quantitative study of rove beetles in Oklahoma winter wheat fields. *BioControl*, 51, 79-87.

Good, J.A. & Giller, P.S. (1991). The effect of cereal and grass management on staphylinid (Coleoptera) assemblages in South West Ireland. *Journal of Applied Ecology,* 28, 810-826.

Hall, S.L. & Barney, R.J. (2011). Leaf beetle (Coleoptera: Chrysomelidae) biodiversity within isolated Remnant grasslands in Kentucky state nature preserves. *Journal of Kentucky Academy of Science,* 72, 24-38.

Herman, L.H. (2001). Catalog of the Staphylinidae (Insecta: Coleoptera) 1758 to the end of the second millennium. *Bulletin of American Museum of Natural History,* 264, 1-83.

Hollingsworth, J.P. & Hartstack, Jr. A.W. (1972). Effect of components on insect light trap performance. *Transitions of American Society of Agricultural Engineering,* 15, 924-927.

Judas, M., Dornieden, K., & Strothmann, U. (2002). Distribution of carabid beetle species at the landscape level. *Journal of Biogeography,* 29, 491-508.

Kehler, D., Bondrup-Nielson, S., & Corkum, C. (2004). Beetle diversity associated with forest structure including deadwood in softwood and hardwood stands in Nova Scotia. *Proceedings of Nova Scotian Institute of Science,* 42, 227-239.

Koller, W.W., Alberto, G., Sergio, R.R., & Julio, M. (2002). Staphylinidae (Coleoptera) associated to cattle dung in Campo Grande, MS, Brazil. *Neotropical Entomology,* 31(4), 641-645.

Lobl, I. (1986). Contribution à la connaissance des Scaphidiidae (Coleoptera) du nord-ouest de l'Inde et du Pakistan. *Revue Suisse Zoology,* 93, 341-367.

Magurran, A.E. (1988). *Ecological diversity and its measurement*. Croom Helm, London, Great Britain, 179 p.

Márquez, L.J. (2003). Ecological patterns in necrophilous Staphylinidae (Insecta: Coleóptera) from Tlayacapan, Morelos, México. *Acta Zoologica Mexicana,* 89, 69-83.

Martínez, N.J., Acosta, J.A., & Franz, N.M. (2009). Structure of the beetle fauna (Insecta: Coleoptera) in forest remnants of western Puerto Rico. *Journal of Agriculture University of Puerto Rico,* 93, 83-100.

Masner, L. & Goulet, H. (1981). A new model of flight interception trap for some Hymenopterous insects. *Entomological News,* 92, 199-202.

Nasir, S., Akram, W., Ahmed, F., & Sahi, S.T. (2011). Biodiversity of Staphylinids in cropped area of the Punjab (Pakistan). *Pakistan Journal of Agricultural Sciences,* 48, 125-128.

Nasir, S., Akram, W., Khan, R.R., Arshad, M., & Nasir, I. (2015a). Paederus beetles: the agent of human dermititis. *Journal of Venomous Animals and Toxins Including Tropical Diseases,* 21, 5.

Nasir, S., Akram, W., Zahid, F.M., Ahmed, F., Hussain, S.M., & Nasir, I. (2015b). Effect of crop type and production systems (conventional and organic agriculture) on the diversity of rove beetles (Staphylinidae: Coleoptera) in the Punjab, Pakistan. *Journal of the Kansas Entomological Society,* 88, 1-9.

Noguera, (1990). The activity pattern of the Coleoptera in the dry tropical forest in Chamela, Jalisco State in Mexico. *Conservation Biology,* 10, 99-109.

Onsager, J.A. (1976). Influence of weather on capture of adult southern potato wireworm in blacklight traps. *US Department of Agricultural Technology Bulletin,* 1527, 27.

Pace, R. (1986). Aleocharinae Riportatedall'Himalaya dal Prof. Franz. Parte II. (Coleoptera, Staphylinidae). *Nouvelle Revue d'Entomologie,* 3, 81-97.

Peck, S.B. & Davies, A.E. (1980). Collecting small beetles with large-area "window" traps. *Coleopterists Bulletin,* 34, 237-239.

Pielou, E.C. (1984). *The interpretation of ecological data*. Willey, New York, USA, 288 p.

Prasifka, J.R., Schmidt, N.P., Kohler, K.A., Hellmich, R.L., O'Neal, M.E., & Singer, J.W. (2006). Effects of living muscles on predator abundance and sentinel prey in a corn-soyabean forage rotation. *Environmental Entomology,* 35, 1423-1431.

Roeder, G. (2003). *Coleopteran biodiversity of shipstern nature reserve in Belize, with a comparison of the fauna of two tropical forest types*. Diploma project, Institute of Zoology, University of Neuchâtel, 1-47.

Scheerpeltz, O. (1960). Die von Dr. Chr. Lindemann gelegentlich ihrer Reise 1955/56 in West Pakistana ufgesammelten Staphyliniden (Col.). *Opuscula Zoologica,* 51, 1-7.

Schiegg, K. (2000). Effects of dead wood volume and connectivity on saproxylic insect species diversity. *Ecosciences,* 7, 290-298.

Shah, P.A., Brooks, D.R., Ashby, J.E., Perry, J.N., & Woiwod, I.P. (2003). Diversity and abundance of the coleopteran fauna from organic and conventional management systems in Southern England. *Agricultural and Forest Entomology,* 5, 51-60.

Shannon, C.E., & Wiener, W. (1949). *The mathematical theory of communication*. University of Illinois Press, Urbana, 3 p.

Smetana, A. (2004). Family Staphylinidae Latreille, 1802 [except Pselaphinae and Scaphidiinae]. In I. Löbl & A. Smetana (Eds.). *Catalogue of Palaearctic Coleoptera, Hydrophiloidea-Histeroidea-Staphylinoidea* (pp. 237-272, 329-495, 505-698*)*. Apollo Books, Stenstrup, 2.

Team, R.C. (2013). *R: A language and environment for statistical computing. R Foundation for Statistical Computing,* Vienna, Austria. URL http://www.R-project.org/.

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