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Assortment and comparative abundance of foliage insects on lemon (*Citrus limon* L.) and fruiter (*Citrus reticulata* Blanco cv. Feutrell's Early)

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Abstract
The present research work was conducted to accord assortment and comparative abundance of foliage insects on lemon (*Citrus limon* L.) and fruiter (*Citrus reticulata*) during the flowering season of these orchards. Among both fields, total 4547 specimens were collected during entire sampling and maximum population was recorded from fruiter orchards 68.24% (N = 3103) and least population was recorded from lemon orchards i.e. 31.76%. Wherein in case of lemon orchard, maximum population was recorded during 6th sampling (350 ± 145.38) and least as well as equal values were recorded during 1st, 2nd and 7th sampling (69 ± 53.32). Whereas, species abundance was recorded utmost and equal during 4th and 9th sampling (32 species) at temperature and humidity of 29.2°C and 31.5% and 35°C and 58%, respectively. However, least species abundance was recorded during 1st sampling i.e. 17 species at 29ºC (temperature) and 37% (humidity). In case of fruiter orchards, maximum population was recorded during 5th sampling (537 ± 160.30); while, least value was recorded during 1st sampling (119 ± 135.27). Whereas, species abundance was recorded utmost in 5th and 4th sampling (30 and 27 species, respectively) at temperature and humidity of 33.4 ºC, 38% and 28.6 ºC, 30%, respectively. However, least species abundance was recorded during 1st sampling i.e. 26 species at 32.6ºC temperature and 32% humidity. Diversity (H') was recorded maximum from fruiter orchards (0.7758) and least was recorded from lemon orchards (0.3610). However, richness was a little bit recorded high from fruiter orchards (23.9561) and least for lemon orchards (23.7652). Results of Analysis of Variance (ANOVA) among both orchards showed non-significant results (F = 0.48; P = 0.4997).

Keywords: Lemon (*Citrus limon* L.), fruiter (*Citrus reticulate.* Blanco cv. Feutrell's Early), assortment, abundance, foliage insects

Introduction

The fruits pertaining to various plants are derived from the specific tissues having one or more ovaries and fleshy seeds. Owing to nutritional values, they are vital for daily nutrition as well as food industries e.g. cookies, ice cream and cakes. They are also used to make juice (mango, apples, lemon, orange and grapes) and beverages such as wine, fruit beer and vinegar (James, 2003) [19].

Among these fruits, citrus is an excellent type for nutrition and marketing demand. It belongs to family Rutaceae (Kawaii, 1999) [22] and native to South East Asia (Indonesia and China); while now grown worldwide as a preferred product due to its beneficial fruits e.g. oranges, lemon, grapefruit and limes. All these types are rich source of vitamin C, minerals, sugars, flavonoids (phytonutrients which is used for protection against cancer and cardiovascular diseases) (Kawaii *et al*., 1999) [22].

In Pakistan, citrus is cultivated over an area of 185,400 hectares with 1.75 million ton annual production (Anonymous, 2015) [3] that makes 40% of total fruit production in country. However, of total production 95% is produced in province of Punjab, and major portion (70%) is made in case of Kinnow (Niaz *et al*., 2004) [26] with average yield up to 9-10 tones/ha (Anonymous, 2015) [3]. Lemon (*Citrus limon* L.), member of genus *Citrus* contains phenolic compositions, essential oils, vitamins, fiber, carotenoids and minerals; they support health and provide economy value especially in food industry. Its byproducts contain bioactive compounds which are used for animal feed and health care (González-Molina *et al*., 2010). It has immunomodulatory effects to ease hangover symptoms e.g.

pomelo is used in treatment of circulatory problems; bitter orange and citron have anti-cancerous effect (Arias and Ramón-Laca, 2005). Its leaves are used for treatment of diabetes, blood lipid lowering, brain disorders, cardiovascular diseases, cancer and obesity (Miyake *et al*., 1997).

Fruiter (*Citrus reticulata*) is known as king of citrus community, its peel contains flavonoid, pectin and highest total carotenoid contents (Wang, 2008). Wherein citrus is host of many pests because more than 850 species of insects are recorded in association with citrus; while, insects pests and mites cause damage to leaves, flowers, bark, fruits and branches of citrus. They mostly belong to order Neuroptera, Hemiptera, Coleoptera, Hymenoptera and Acari (Buker *et al*., 2006; Kamel, 2010) [5, 21]. Annual production of citrus decreased by nuisance like "whitefly" *Dialeurodes citri* (Ashmead), "citrus psylla" *Diaphorina citri* (Kuwayama), "leaf miner"*Phyllocnistis citrella* (Stainton), "citrus caterpillar" *Papilio demoleus* (Linnaeus), "citrus red scale" *Aonidiella aurantii* (Maskell) and "fruit piercing moth" *Ophideres* spp. (Hashmi, 1994). Among them, citrus leaf miner (CLM), *Phyllocnistis citrella* (Lepidoptera: Gracillariidae: Phyllocnistinae) is most destructive nuisance (Clausen, 1931) that causes an indirect distortion by lowering yield of mature trees (Garrido, 1994).

Bactrocera invadens, Drew Tsuruta and White, *Bactrocera cucurbitae* (Coquillett), *Ceratitis ditissima* (Munro), *Ceratitis capitata* (Wiedemann) and *Dacus bivittatus* (Bigot) are eminent citrus nuisance (Umeh *et al*., 2004) [34]. But, major fly pest on citrus was medfly (*C. capitata*) (Fappiah *et al*., 2009) [13]. Citrus fly pest in Asia, especially in China is *Bactrocera dorsalis* (Hendel) (Yang *et al*., 2009) [38] and *Bactrocera zonata* Saunders in India (Sanjeev *et al*., 2008) [31].

Planococcus citri has been recorded as a major nuisance of citrus over the world by feeding primarily on leaves and cause reduction in photosynthesis resulting in premature leaf fall, shoot die back and reduced plant vigor. Athough! Condition may be severe in spring, which decreases at the start of summer (Childers, 1994; Jamieson *et al*., 2005; Childers *et al*., 2007; Fadamiro *et al*., 2008) [9, 20, 10, 12].

Phyllocoptruta oleivora feeds on fruits and cause losses toward yield and quality (English and Turnipseed, 1940). Specially, at developmental stage, root weevils (*Diaprepes abbreabbreviatus* L.), "blue green weevil" *Pachnaeus litus* (Germar) and "aphids" (*Aphis spireacola* Patch) and *Toxoptera citricida* (Kirkaldy) act as vector for these diseases to enhance losses (Hall *et al*., 1991; Futch and McCoy, 1994; Browning *et al*., 1995; Halbert and Manjunath, 2004; Hall, 2005; Fadamiro *et al*., 2007).

Citrus mealybugs are common pests of citrus but mostly preferred grapefruit among this family (Griffiths and Thompson, 1957) [17], even cause damages in greenhouses and decorative plants (Anonymous, 2007) [2]. They are mainly expected in spring and at the beginning of summer. This cycle (Spring-Summer) is key distress to citrus growers with maximum infestations in June and July (Griffiths and Thompson, 1957) [17].

Diaprepes abbreviates L. is a subtle nuisance to citrus as its adult causes indentation of the leaf boundary, while, larva annihilates fibrous roots and bark (Quintela *et al.*, 1998) which cause annual loss upto $75 million by tree decline and loss in production to citrus growers (Simpson *et al*., 1996).

"Citrus rust mite" *Phyllocoptruta oleivora* (Ashmead) (Acari: Eriophyidae) and "spider mite" *Tetranychus mexicanus* (McGregor) (Acari: Tetranychidae) cause damage to citrus mainly in north eastern Brazil (Chiaradia, 2001; Pritchard and Baker, 1955; Quiros-Gonzalez, 2000; Vacante, 2010) [8, 27, 30, 36].

Black fly population (52-66%) abridged by spiders in citrus orchards in Florida and *Ceroplastes floridensis* population was reduced by *Cheiracanthium mildei* and *Theridion* spp. in citrus orchards in Israel (Mansour and Whitecomb, 1986).

Seven species of Coccinellidae residing citrus orchard in Florida were evaluated for ability to develop and reproduce on the citrus aphids *Toxoptera citricida* (Kirkaldy) and *Aphis spiraecola* (Patch). *Cycloneda sanguinea* was recorded as best contestant for augmentative biocontrol of *T. citricida*, the primary vector of citrus tristeza virus. *Serangium parcesetosum* successfully restrict *Dialeurodes citri* population and prevented them from causing sooty-mold growth in the citrus orchard (Yigit *et al*., 2003).

Hence, keeping in view the economic importance of lemon and fruiter as well as handicaps induced by insect, pests/nuisance the present study was designed to record assortment and comparative abundance of foliage insects on lemon (*Citrus limon* L.) and fruiter (*Citrus reticulate.* Blanco cv. Feutrell's Early) for the formulation of strategies to manage these handicaps in future.

Materials and Methods

Study Area

Present research was done to find the "Assortment and comparative abundance of foliage insects on lemon (*Citrus limon* L.) and fruiter (*Citrus reticulata*)" orchards under ecological conditions of Faisalabad (Punjab), Pakistan during session 2015-2016. Soil of research fields (district Faisalabad) was consist of rolling flat plains, between longitude 73°74 E, latitude 30°31.5 N, with an elevation of 184 meters (604 ft) above sea level. District Faisalabad is adjoin on the north by Chiniot and Sheikhupura, on the east by Sheikhupura and Sahiwal, on the south by Sahiwal and Toba Tek Singh and on the west by Jhang Districts.

Vegetation

Present study was conducted in Citrus Research Fields, R sq. 09, University of Agriculture Faisalabad (Punjab), Pakistan and citrus fields were consisted of different herbs/ shrubs and tree plantations along their surroundings with: *Mangiffera indica* (Mango), *Vitis vinifera* (Grape), *Punica granatum* (Pomegranate), *Citrus reticulata* Blanco cv. Kinnow mandarin (Kinnow Mandarin), *Citrus limetta* (Mosambi), *Phoenix dactylifera* (Dates), and *Grewia asiatica* (Phalsa).

Collection and Identification

Collection of data

To collect the foliage insect fauna inhabiting these orchards, sampling was made weekly during the flowering season by selecting five fruit plants randomly for two hours from 6:00 am to 8:00 am by following methods:

- Direct hand picking
- By using Sweep Net
- By using Forceps

Moreover, temperature and humidity of area were also recorded and collected specimens were stored temporarily in jars containing 70:30% alcohol and glycerin solution and after that collected specimens were shifted to Biodiversity Laboratory, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad for further systematic studies. Here, the specimens were separated and preserved in separate glass vial, containing 70:30% alcohol and glycerin solution for further identification. The glass vials were labeled as sampling number, plant name, temperature and humidity of

the sampling day.

Identification

The collected specimens were identified and sorted with the aid of:

- Naked eye
- Magnifying glass
- Microscope

All the specimens were identified up to species level according to the taxonomic/ reference material (Borror and DeLong, 2005) and on electronic keys (internet).

Result and Discussion

Among Fruiter orchards, total 93 species were recorded belonging to 06 orders, 49 families and 79 genera; whereas among lemon orchards, total 97 species were counted pertaining to 07 orders, 56 families and 86 genera. Among both fields, total 4547 specimens were collected during entire sampling (10 sampling from each category) and maximum population was recorded from Fruiter orchards 68.24% (N = 3103) and least population was recorded from lemon orchards i.e. 31.76% (N = 1444).

Wherein in case of lemon orchards (Table 01), maximum population was recorded during 6th sampling (350 ± 145.38), followed by 249 ± 73.96 (4th sampling), 224 ± 56.29 (9th sampling) and so on. Whereas, species abundance was recorded utmost and equal during 4th and 9th sampling (32 species) at temperature and humidity of 29.2°C& 31.5% and 35°C & 58%, respectively. However, least species abundance was recorded during 1st sampling i.e. 17 species at 29ºC (temperature) and 37% (humidity). In case of Fruiter orchards, maximum population was recorded during 5th sampling (537 ± 160.30), followed by 527 ± 153.23 (4th sampling), 454 ± 101.61 (6th sampling), 393 ± 58.48 and so on. Whereas species abundance was recorded utmost in 5th and 4th sampling (30 and 27 species, respectively) at temperature and humidity 33.4 ºC, 38% and 28.6 ºC, 30%, respectively. However, least species abundance was recorded during 1st sampling i.e. 26 species at 32.6ºC temperature and 32% humidity. Previously, Kamel, (2010) [21] reported that citrus host of many insect pests over more than 850 species and mites have been recorded more associated with it. These insects usually belong to order Neuroptera, Hemiptera and Coleoptera, Hymenoptera and Acari (Hashmi, 1994; Buker *et al.*, 2006) [5]. Fruit fly assortment and abundance has also been reported from many citrus producing areas and causes huge economic losses in Nigeria (Umeh *et al*., 2008) [35]. The findings of present study was quite analogous with them.

However, comparative abundance was recorded maximum from lemon orchards for order Lepidoptera (63.68%) and least for order Isopoda (0.15%). Wherein Dipterans population densities were recorded in conflicting contribution. However, impacts of climatic changes (temperature and humidity) were not significant over the occurrence of both orders in both orchards.

Whereas, comparative abundance of each species from each orchard was recorded heterogeneously (Table 2-3), because overall comparative abundance of each species was variable from each other and between each orchard; some species were recorded more abundantly in one type while other type was devoid off by them or exist with very lest abundance. A lot of species representing one fruit plantation instead of overall representation. For example, from lemon orchards, maximum comparative abundance 56.23% (N = 812) was recorded for *Tineola bisselliella* and thereafter, *Halictus confusus* was recorded with utmost comparative abundance 4.22% (N= 61), followed by *Solenopsis geminata* 3.05% (N= 44), *Apis dorsata* 2.98% (N= 43). Afterward, gradual decrease was recorded for *Culex pipiens* 2.22% (N= 32), *Cacoxenus indigator* 1.87% (N= 27), *Drosophila funebris* 1.80% (N= 26), *D. transversa* 1.59% (N= 23), *D. immigrans*, *Smicronyx coecus*, *Empoasca fabae* 1.45% (N= 21), *Oxycarenus hyalinipennis* 1.18% (N= 17), *Belenois aurota* 1.11% (N= 16), *Polistis wattii* 1.04% (N= 15), *Gonatocerus morrilli* 0.97% (N= 14), *Prenolepis impairs* 0.90% (N= 13), *Docosa* spp. 0.83% (N= 12), *Disophyrus* spp. 0.76% (N = 11), *Rhapium* spp. 0.69% (N= 10), *Cicurina varians* 0.55% (N= 08), *Lasioglossum zonulum*, *Parasteatoda tepidarioum* 0.48% (N= 07), and *Apis florae*, *Eusphalerum longipenne*, *Anthaxia quercata* 0.42% (N = 06). Whereas, least comparative abundance (n ≤ 05) was recorded for *Emathis makilingensis*, *Cheilomenes sexmaculata*, *Agrotis ipsilon*, *Psammotettix alienus*, *Mycodrosophila* spp., *Zizula hylax*, *Siphanta acuta*, *Leucophenga maculata*, *Chamaepsila* spp., *Dicrotendipes* spp., *Scymnus nubilus*), *Myrmarachne plataleoides*, *Opisthonocus* spp., *Anasaitis canosa*, *Clubiona obesa*, *Thanatus parangvulgaris*, *Oniscus asellus*, *Halictus soladonia*, *Myzinum* spp., *Thyanta custator*, *Aphodius makarovi*, *Chrysomya vomitera*, *Chironomus* spp., *Oscinella* spp., *Musca domestica*, *Byturus tomentosus*, *Tribolium castaneum*, *Hypoblemum albovittatum*, *Thiodina sylvan*, *Acacesia hamata*, *Lasioglossum pilosum*, *Lasioglossum* spp., *Megachile* spp., *Osmia spinulosa*, *Sceliphron caementarium*, *Isodontia elegans*, *Tryphon rutilator*, *Danaus chrysippus*, *Planococcus citri*, *Heterogaster urticae*, *Oxyrachis tarandus*, *Abedus herberti*, *Sepsis punctum*, *Phortica variegata*, *Chrysosoma leucopogon*, *Physiphora alceae*, *Physiphora smaragdina*, *Eristalinus megacephalus*, *Crumomyia nitida*, *Hermetia illucens*, *Dolichopus* spp., *Thevenetimyia funesta*, *Chrysomya megacephala*, *Lucilia cuprina*, *Stomorhina lunata*, *Pollenia vagabunda*, *Trachina fera*, *Bactrocera cucurbitae*, *Otiorhynchus rugosostriatus*, *Liparus glabirostris*, *Henosepilachna vigintioctopunctata*, *Brumoides suturalis*, *Anthicus cervinus*, *Lasioderma serricorne*, *Anthocomus equestris*, *Clubiona* spp., *Philodromus exilis*, *Zygiella x-notata* and *Oxyopes lineatus*, *O. matiensis*. In this context, Nasir *et al.* (2011) [25] reported that living entities show assortment which in turn contributes to ecosystem variance and abundance of class Insecta noted from cultivation sites fluctuate depending on cultivation system, crop thickness, level of pesticides used, and controlling methods along with effects of biotic and abiotic factors. The findings of present study was an acknowldgement with Forster (1991) [15]; Kremen *et al.* (1993) [23]; Nasir *et al.* (2011) [25].

In Fruiter orchards, maximum comparative abundance 75.60% (N= 2346) was recorded for *Tineola bisselliella*, followed by 2.13% (N= 66) *Drosophila funebris*, Thereafter, *D. funebris* was recorded with maximum comparative abundance 2.13% (N= 66), followed by *Solenopsis mandibularis*, *Gonatocerus morrilli* 1.58% (N= 49), *Cacoxenus indigator*, *Emathis makilingensis* 1.55% (N= 48), *Culex pipiens* 1.32% (N= 41), and then gradual decrease was recorded for *D. transversa* 0.77% (N= 24), *D. immigrans* 0.74% (N= 23), *Culiseta annulata* 0.68% (N= 21), *Docosa* spp., *Aphodius fossor* 0.61% (N= 19), *Cheilomenes sexmaculata* 0.58% (N= 18), *Polistis wattii* 0.55% (N= 17), *Physiphora alceae*, *Opisthonocus* spp. 0.52% (N= 16), *Cicurina varians* 0.48% (N= 15), *Solenopsis geminate* 0.45% (N= 14), *D. melanogaster*, *Parasteatoda tepidarioum* 0.42%

(N= 13), *Leucophenga maculata*, *Brumoides suturalis* 0.39% (N= 12), *Aphodius makarovi* 0.35% (N= 11), *Apis dorsata* 0.29% (N= 09), *Oxycarenus hyalinipennis*, *Eusphalerum longipenne*, *Byturus ochraceus* 0.26% (N=08), *Scymnus nubilus* 0.23% (N = 07) and *Halictus confusus*, *Exallonyx trifoveatus*, *Scaptodrosophila fumida*, *Mycodrosophila* spp., *Chamaepsila* spp. 0.19% (N = 06). While, least comparative abundance (N≤ 05) was recorded for *Empoasca fabae*, *Hypoblemum albovittatum*, *Apis florae*, *Homoeocerus* spp., *Chrysosoma leucopogon*, *Lucilia Caesar*, *Otiorhynchus rugosostriatus*, *Prenolepis impairs*, *Lasioglossum zonulum*, *Aoraia senex*, *Thyanta custator*, *Dicrotendipes* spp., *Tribolium castaneum*, *Myrmarachne plataleoides*, *Icius makilingensis*, *Disophyrus* spp., *Hockeria tamaricis*, *Tetraponera mocquerysi*, *Zizula hylax*, *Psammotettix alienus*, *D. virilis*, *Crumomyia nitida*, *Lucilia sericata*, *L. cuprina*, *Anthaxia quercata*, *Clubiona* spp., *C. obesa*, *Ciurina* spp., *Ceratina sequoia*, *Sphex pensylvanicus*, *Sepsis punctum*, *Auplopus mellipes*, *Tryphon rutilator*, *Myzinum* spp., *Heterogaster urticae*, *Exitianus indicus*, *Siphanta acuta*, *Oxyrachis tarandus*, *Rhagovelia obese*, *Hermetia illucens*, *Odontomyia angulata*, *Dolichopus atratus*, *Lucilia coeruleiviridis*, *Pollenia pediculate*, *Melinda* spp., *Bactrocera cucurbitae*, *Polypedium* spp., *Musca domestica*, *Anthocomus equestris*, *Clubiona terrestris*, *C. victoriaensi*, *Thanatus parangvulgaris*, *Acacesia hamata*, *Araneus sturna*, *Zygiella x-notata*, *Hypsosinga pygmaea*, *Oxyopes latreille* and *O. matiensis* and remaining all (36) species were not recorded from these orchards. These findings were again an acknowledgement with Nasir *et al.* (2011) [25]; Forster, (1991) [15]; Kremen *et al.* (1993) [23]; Umeh *et al.* (2004) [34]; Fappiah *et al.* (2009) [13]; Yang *et al.* (2009) [38]; Sanjeev *et al.* (2008) [31].

Genera level grouping was made to weigh up the overhead protocol and from lemon orchards, genus *Tineola* was recorded with maximum 56.2% (N = 812), followed by (4.85%; N= 70) for *Drosophila.* However, least comparative abundance (N ≤ 05) was recorded for *Cheilomenes*, *Agrotis*, *Psammotettix*, *Mycodrosophila*, *Clubiona*, *Zizula*, *Siphanta*, *Leucophenga*, *Chamaepsila*, *Chrysomya*, *Dicrotendipes*, *Scymnus*, *Myrmarachne*, *Opisthonocus*, *Anasaitis*, *Thanatus*, *Onisus*, *Myzinum*, *Thyanta*, *Aphodius*, *Physiphora*, *Chironomus*, *Oscinella*, *Musca*, *Byturus*, *Tribolium*, *Hypoblemum*, *Thiodina*, *Acacesia*, *Oxyopes*, *Tryphon*, *Megachile*, *Osmia*, *Sceliphron*, *Isodontia*, *Danaus*, *Pianococcus*, *Heterogaster*, *Oxyrachis*, *Abedus*, *Sepsis*, *Phortica*, *Chrysosoma*, *Eristalinus*, *Crumomyia*, *Hermetia*, *Dolichopus*, *Thevenetimyia*, *Lucilia*, *Stomorhina*, *Pollenia*, *Trachina*, *Bactrocera*, *Otiorhynchus*, *Liparus*, *Henosepilachna*, *Brumoides*, *Anthicus*, *Lasioderma*, *Anthocomus*, and *Philodromus*, *Zygiella*. While, form Fruiter orchards, genus *Tineola* was recorded with maximum75.60% (N = 2346), followed by 4.13% (N=128) for *Drosophila*. However, least comparative abundance (N ≤ 05) was recorded for *Empoasca*, *Hypoblemum*, *Homoeocerus*, *Chrysosoma*, *Otiorhynchus*, *Prenolepis*, *Lasioglossum*, *Aoraia*, *Thyanta*, *Dicrotendipes*, *Tribolium*, *Myrmarachne*, *Icius*, *Neoscona*, *Disophyrus*, *Hockeria*, *Tetraponera*, *Zizula*, *Psammotettix*, *Crumomyia*, *Anthaxia*, *Oxyopes*, *Ceratina*, *Tryphon*, *Sphex*, *Sepsis*, *Auplopus*, *Myzinum*, *Heterogaster*, *Exitianus*, *Siphanta*, *Oxyrachis*, *Rhagovelia*, *Hermetia*, *Odontomyia*, *Dolichopus*, *Pollenia*, *Melinda*, *Bactrocera*, *Polypedium*, *Musca*, *Anthocomus*, *Thanatus*, *Acacesia*, *Araneus*, *Zygiella* and *Hypsosinga*. Similar findings were reported by (Chiaradia, 2001; Pritchard and Baker, 1955; Quiros-Gonzalez, 2000; Vacante, 2010) [8, 27, 30, 36].

To launch the IPM strategies in a best fitted manner, use of community representative for population suppression or to motivate the beneficial organisms is considered a cornerstone factor. For this purpose, the highlighting assortment and density of various existing families under reference fields can provide a realistic approach (Tillman *et al*., 2002) [33]. Hence, the fundamental issue, comparative abundance was again accessed at family level to overcome these aspects. From total of 61 recorded families, 56 were recorded from lemon orchards and among them, extra ordinary comparative abundance (56.23%; N = 812) was recorded for Tinidae family, followed by Drosophilidae (8.17%: N= 118), Formacidae (5.96%; N = 86), Halictidae (4.99%; N= 72), Apidae (3.39%; N= 49), Culicidae (2.22%; N= 32), Cicadellidae (1.87%; N=27), Salticidae (1.45; N= 21), Curculionidae (1.59%; N= 23), Pieridae (1.11%; N= 16), Lygaeidae (1.18%; N= 17), Vespidae (1.04%; N= 15), Mymaridae(0.97%; N= 14), Braconidae (0.83%; N= 12) and Coccinellidae (0.69%; N= 10). However, all the remaining families representing to lemon orchard were recorded with least population (N ≤ 10). Wherein, from total of the 61 recorded families, 05 families were not recorded from lemon orchards. However from total of 61 recorded families, 48 were recorded from Fruiter orchards and among them, comparatively higher abundance (75.60%; N = 2346) was recorded for Tinidae family. Thereafter, comparative abundance was recorded utmost for Drosophilidae (7.19%; N= 223), Salticidae (2.42%; N= 75), Formicidae (2.19%; N = 68), Culicidae (2.00%; N = 66), Mymaridae (1.58%; N = 49), Coccinellidae (1.19%; N = 37), Cicadellidae, Scarabaeidae (0.61%; N = 19), Vespidae, Dictynidae (0.55%; N = 17), Ulidiidae (0.52%; N = 16), Apidae (0.45%; N = 14), Theridiidae (0.42%; N = 13) and Calliphoridae (0.35%; N = 11). However, all the remaining families representing to both orchards were recorded with least population (N ≤ 10). Whilst, from total of the 61 recorded families; 12 families were not recorded from Fruiter orchards. Fadamiro *et al*. (2009) sampled leaves of nine Satsuma citrus orchards (seven conventionally sprayed and two unsprayed) in southern Alabama from March 2005 to February 2006 for predacious mites and recorded population pertaining to following families: Anystidae, Ascidae, Bdellidae, Cheyletidae, Cunaxidae, Erythraeidae, Eupalopsellidae, Phytoseiidae, and Stigmaeidae; whereas 29 species of predacious mites were identified. Most abundant families were Phytoseiidae (18 species) and Stigmaeidae (one species) While, dominant species were *Typhlodromalus peregrines*, *Proprioseiopsis mexicanus* and *Agistemus floridanus*. Abundance of Phytoseiid mites was high in spring while decline in population occur in summer which continues till fall and winter. Analysis of samples collected in fall showed that phytoseiid mite's population was greater on ground cover plants than on fruits and leaves because they serve as winter reservoirs. Predacious mites were more abundant in the conventionally sprayed orchards than unsprayed orchards. Whereas, Yoldas *et al.* (2011) [40] studied the innate pest of four Satsuma mandarin orchards in Izmir, Turkey over one year and observed following aphid species: *Aphis craccivora*, *Aphis gossypii*, *Aphis spiraecola*, *Myzus (Nectarosiphon) persicae* and *Toxoptera aurantii*; and recorded predators belonging to following families: Coccinellidae (Coleoptera), Chrysopidae (Neuroptera), Syrphidae, Cecidomyiidae, and Chamaemyiidae (Diptera). Aphid population varies near the beginning of April, and startsto increase in July and was

maximum in late April to early June. Our findings supported their views.

Analysis of Variance is used to compare the random impacts of different treatments with regard to governing factors in a particular area or habitat. The present study was conducted to record the assortment among two Fruiter orchards under ecological conditions of district Faisalabad. But, among Fruiter orchards order Isopoda was not recorded. Hence, to compare the overall occurrence, density and assortment of insects in lemon and Fruiter fields, Analysis of Variance (ANOVA) was made. After completing the analysis, it was observed that population mean of recorded taxa among both orchards (Fruiter and lemon) showed non-significant results (F = 0.48; P = 0.4997). Helal *et al*. (2000) [18] conducted a survey to record pests and mites occurring on (*Citrussinensis* Qsheck var. Washington and *Citrus aurantium* L.) at Alexandria and Damanhour, Egypt and recorded seven insect pests. Among them citrus white fly (*Aleurotrachelus citri*) and predator aphid lion (*Chrysopa vulgaris*) were attacking on the citrus mealy bug (*Planococcus citri*). As well as, they recorded eleven phytophagous, predaceous and saprophagous mite species prevailing orange and sour orange. They endorsed that *Aleurotrachelus citri* as major pest and correlations between temperature and comparative humidity and the abundance of insects and mites for both fields was non-significant.

Table 1: Record of Mean ± SD, Species Abundance, Temperature and Humidity among Lemon and Fruiter orchards.

Sampling No.	Lemon				Fruiter			
	Population Mean ± SD	Species	Temperature (°C)	Humidity (%)	Population Mean ± SD	Species	Temperature (°C)	Humidity (%)
1	69±53.32	17	29	37	119±135.27	26	32.6	32
2	69±53.32	20	33.2	21	120±134.56	27	34.2	20
3	78±46.95	24	32	28	236±52.54	25	32.2	27
4	249±73.96	32	29.2	35	527±153.23	27	28.6	30
5	140±3.11	28	42	40	537±160.30	30	33.4	38
6	350±145.38	27	30.7	46	454±101.61	32	32.7	37
7	69±53.32	19	32.2	44	164±103.45	27	33.5	42
8	118±18.67	20	32.2	57	393±58.48	23	28.6	65
9	224±56.29	32	31.5	58	310±0.21	28	33.32	56
10	78±46.95	20	31.4	55	243±47.59	29	26.2	60

Table 2: Comparative abundance of foliage insect fauna (≥ 05) recorded from Lemon and Fruiter orchards.

Order	Family	Species	Comparative Abundance (%)		Significance/ Probablity	P-value
			Lemon	Fruiter		
Hymenoptera	Apidae	*Apis dorsata*	2.98(43)	0.29(9)	***	≤ 0.001
		Apis florae	0.42(6)	0.13(4)	NS	≥ 0.005
	Braconidae	*Disophyrus* spp.	0.76(11)	0.06(2)	**	≤ 0.001
	Formacidae	*Solenopsis mandibularis*	2.01(29)	1.58(49)	*	≤ 0.005
		Solenopsis geminata	3.05(44)	0.45(14)	***	≤ 0.001
		Prenolepis impairs	0.90(13)	0.10(3)	**	≤ 0.001
	Halictidae	*Lasioglossum zonulum*	0.48(7)	0.10(3)	*	≤ 0.005
		Halictus confuses	4.22(61)	0.19(6)	***	≤ 0.001
	Mymaridae	*Gonatocerus morrilli*	0.97(14)	1.58(49)	***	≤ 0.001
	Pompilidae	*Exallonyx trifoveatus*	0.00(0)	0.19(6)	***	≤ 0.001
	Vespidae	*Polistis wattii*	1.04(15)	0.55(17)	NS	
Lepidoptera	Tinidae	*Tineola bisselliella*	56.23(812)	75.60(2346)	***	≤ 0.001
	Pieridae	*Belenois aurota*	1.11(16)	0.32(10)	NS	≥ 0.005
Hemiptera	Lygaeidae	*Oxycarenus hyalinipennis*	1.18(17)	0.26(8)	*	≤ 0.005
	Cicadellidae	*Aphodius makarovi*	0.14(2)	0.35(11)	**	≤ 0.001
		Empoasca fabae	1.45(21)	0.16(5)	**	≤ 0.001
Diptera	Drosophilidae	*Cacoxenus indigator*	1.87(27)	1.55(48)	**	≤ 0.001
		Leucophenga maculata	0.21(3)	0.39(12)	**	≤ 0.001
		Docosa spp.	0.83(12)	0.61(19)	NS	≥ 0.005
		Scaptodrosophila fumida	0.00(0)	0.19(6)	***	≤ 0.001
		Drosophila melanogaster	0.00(0)	0.42(13)	***	≤ 0.001
		Drosophila immigrans	1.45(21)	0.74(23)	NS	≥ 0.005
		Drosophila funebris	1.80(26)	2.13(66)	**	≤ 0.001
		Drosophila transversa	1.59(23)	0.77(24)	NS	≥ 0.005
		Mycodrosophila spp.	0.28(4)	0.19(6)	NS	≥ 0.005
	Ulidiidae	*Physiphora alceae*	0.07(1)	0.52(16)	***	≤ 0.001
	Pysllidae	*Chamaepsila* spp.	0.21(3)	0.19(6)	*	≤ 0.005
	Dolichopodidae	*Rhapium* spp.	0.69(10)	0.00(0)	***	≤ 0.001
	Culicidae	*Culex pipiens*	2.22(320)	1.32(41)	***	≤ 0.001
		Culiseta annulata	0.00(0)	0.68(21)	***	≤ 0.001
	Sepsidae	*Sepsis punctum*	0.00(0)	0.03(1)	**	≤ 0.001
Coleoptera	Curculionidae	*Smicronyx coecus*	1.45(21)	0.00(0)	***	≤ 0.001
	Coccinellidae	*Scymnus nubilus*	0.21(3)	0.23(7)	*	≤ 0.005
		Cheilomenes sexmaculata	0.35(5)	0.58(18)	**	≤ 0.001
		Brumoides suturalis	0.07(1)	0.39(12)	**	≤ 0.001
	Scarabaeidae	*Aphodius fossor*	0.69(10)	0.61(19)	*	≤ 0.005
	Staphylinidae	*Eusphalerum longipenne*	0.42(6)	0.26(8)	NS	≥ 0.005

	Byturidae	*Byturus ochraceus*	0.00(0)	0.26(8)	***	≤ 0.001
	Buprestidae	*Anthaxia quercata*	0.42(6)	0.06(2)	**	≤ 0.001
Araneae	Salticidae	*Emathis makilingensis*	0.55(8)	1.55(48)	***	≤ 0.001
		Hypoblemum albovittatum	0.14(2)	0.16(5)	*	≤ 0.005
		Opisthonocus spp.	0.21(3)	0.52(16)	**	≤ 0.001
	Theridiidae	*Parasteatoda tepidarioum*	0.48(7)	0.42(13)	*	≤ 0.005
	Dictynidae	*Cicurina varians*	0.55(8)	0.48(15)	**	≤ 0.001

Table 3: Comparative Abundance of Foliage Insect Fauna recorded upto order level from Lemon and Fruiter orchards**.**

Order	Comparative Abundance (%)		Significance/ Probablity	P-value
	Lemon	Fruiter		
Isopoda	0.15(2)	0.00(0)	***	≤ 0.001
Hymenoptera	19.35(254)	6.06(171)	*	≤ 0.005
Lepidoptera	63.68(836)	83.70(2361)	***	≤ 0.001
Hemiptera	4.04(53)	1.35(38)	NS	≥ 0.005
Diptera	14.32(188)	11.70(330)	*	≤ 0.005
Coleoptera	4.72(62)	2.91(82)	NS	≥ 0.005
Araneae	3.73(49)	4.29(121)	**	≤ 0.001
Total	1444	3103	---	---

Conclusions

It was concluded from the above all discussion that comparative abundance was recorded maximum from lemon orchards for order Lepidoptera (63.68%) and least for order Isopoda (0.15%). Moreover, from the entire observations, population of order Lepidoptera was high among both orchards. Wherein, Dipterans population densities were recorded in conflicting contribution and a lot of species representing one fruit instead of overall representation.

Recommendations

As per finding of previous researchers and present study, it is quite obvious that insects inhabit the flowering plant variably. So, introductory seminars, symposium and workshops should also be arranged periodically to share and upgrade the knowledge of farmers keeping in view the daily wages research outcomes. While, media campaign should also be started in about the precautionary measures to save their integrity for coming generations as well as environmental sustainability.

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