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Research Article

Field Infestation and Seasonality Range of *Bactrocera dorsalis* (Hendle) in Major Host Mango Cultivars of Sindh, Pakistan

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AA conducted the research work. NM provided guidance in research work and helped in writing. RS helped in field survey. SP helped in field survey and laboratory examination.

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Infestation, Oriental fruit fly, Mango cultivars, Seasnality range, Bactrocera species

Abstract | This research study was defined the infestation of mango by seasonality occurrence range of *Bactrocera dorsalis* in three different mango cultivars in sindh province of Pakistan during 2013-2014. Experiment was conducted on major three varieties of mango Chunsa, Sindhri, Beganpali, Data were noted on calculating in good physical shape and pest-ridden mango fruit; casually collected from major mango growing areas of sindh. Rearing the fruit flies under controlled conditions in Laboratory. Collected the reared fruit flies from different cultivars and calculate the infestation. The highest infestation was found on Beganpali and Sindhri variety 85%, followed by Chunsa 80% during June, July and August, respectively, during peak of functional time of ripening of varieties, while same as both years the least infestation was found on Beganpali variety during the June and July, because it is late variety during early months of season it is in immature form so because of that it is less infested, during whole season of mango the infestation was significantly different (F 54.05, df 52, p<0.5). The highest number of flies emergence were found from Beganpali (60.9%) followed by Sindhri variety (43.2%), while least No.of emergence found 6% from Sindhri variety (6%) during September. Ratio of fruit flies like *B. dorsalis* 54.7%, from Beganpali, followed by Sindhri variety 41.6% (F 53.24; dF 51, 108; p=0.29) during mean functional time of season. While less no. of *B. dorsalis* were 3% in September. The fecundity and fertility results were in significant in all varieties. The occurrence of *B. dorsalis* in whole season 94% which shows the seasonality range of oriental fruit fly and major host mango. The highest survival 89.64% was found on Chunsa followed by Sindhri 87.17 and Beganpali 70.36%, these result clearly indicate the range of *B. dorsalis* in all cultivars of mango which is significantly different (p<0.005).The adult occurrence during whole mango season shows the linear-correlation between interval of time of host and pest occurrence, The overtone between mango fruit and oriental fruit fly was strongly associated [R2 = 79.9%, P = 0.000]. Linking between host mango and *B. dorsalis* showed durable maintenance for the host-pest guess (HPH) with inclusive co-efficient of determination [75.4%, P = 0.000]. It was determined that the incidence of oriental fruit fly or other Bactrocera species was recorded in all the three cultivars throughout their fruity mango season; it was considered as life-threatening for management host fruit.

Novelty Statement | This study makes it abundantly evident how the host fruit (mango), which is alarmingly vulnerable to fruit flies due to its seasonality, is the next fruit variety. However, as mango season comes to a close, some populations of Bactrocera species rapidly decline since there is a lack of host food and they are attempting to oviposit.

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Introduction

Fruit flies are very serious cost-effective pests, offensive fruits overall world (White and Elson–Harris, 1994). Fruit flies belong genus *Bactrocera*, and the major pests of fruits are *Ceratitis Capitata* (Mediterranean or Medfly), *Anastrpha* (Mexican fruit fly), *Dirioxa* (common fruit fly or vinegar fly, *Drosophila melanogaster*), and *Toxotrypana* (papaya fruit fly**)**. The round figure of fruit flies 2000 species under (71 genera, 13 tribes, and 4 subfamilies) are identified. The fruit fly pest belongs to the genus *Bactrocera* and invades the fruits of several hosts in the hot and humid zones of the Asia continent (Pasiecznik *et al*., 2005). The most diverse group of fruit flies belong to this diverse genus mostly hostile to mango fruit. Of the total number of Fruit flies 128 species were recognized, obtainable '98' species originate in India and Pakistan, and out of them '48' species attack mangoes and other fruits (Kapoor, 1970). Fruit flies threshold noteworthy to the production of fruits and vegetables and the unhindered dissemination of new fruits and chubby vegetables all over the world (Allwoood *et al*., 2001). In Pakistan, 144.6 million US dollars were lost per capita due to fruit flies (Stonehouse et. al, 2002). Mango is one of the most delicious and cash fruits all over the world, due to its nutritional value it is energetic fruit (74 Kcalories per) 100% edible portions, and full of vitamin C (Hossain, 1989). In Pakistan mango is 2nd important cultivated fruit (FAO, 2006). Its massive production of superiority was damaged by some pre-harvesting problems like pests and some contagions (Ishaq *et al*., 2004). Fruit fly pests remain active from March to September during the mango season, oriental fruit fly pest does not have hostility on all fruits (Ye and Liu, 2005) but it is an important pest for deciduous fruits (Hely *et al*., 1982). There is a large erraticism among mango varieties to fruit fly plague, comp ability with eminence and harvest (Joel, 1980; Carvalho and White, 1996; Rossetto *et al*., 2006; Iqbal *et al*., 2004). According to FAO, approximately more than 1000 varieties of mango in the world, but in Pakistan 3500 mango cultivars were recorded, most famous varieties of Mango are Sindhri, Dusheri, Chunsa (summer Bahist, Black, sufaid), fajiri, Langra, etc. these cultivars are different in their taste and flavor (Painter, 1951). The major host of *B. dorsals* in Pakistan, like Khirshapat, Langra, and Fazli varieties of mango, earlier thirty to forty days of garnering oriental fly attack on mango when they fully mature, they have informal oviposit (Karim and Ahmed, 1989). As a fruit fly, *Bactrocera dorsalis* infest many varieties of mango from time to time, like Dushairy 3.6%-10% while Beganpali infests 80% of varietal infestation (Panhwar, 2005). Fruit flies always attacked very selected and suitable fruits as their progeny (larvae) feed easily on the flesh of the fruit (Aluja *et al*., 1996). It was seen that every pest performs all activities of an adult, such as sexual interface, latent, and feeding on a particular host (Shelly and Kennelly, 2007). The availability of seasonal host fruit originated to be a significant impact on pest population, this scenario was observed in mango orchards in Mexico, the ecological factors also play an important role directly or indirectly in the biological aspect of fruit flies (Bateman, 1972; Tan and Serit, 1994; Aluja *et al*., 1996; Panhwar, 2005), Adult pest always in search of suitable host or major host for its oviposition purpose, although its host or present in an accessible area or even in whole farm (Papadopoulos *et al*., 2003). Both sexes (male and female) need proteinaceous nutrition to achieve sexual maturity and perform full of possible reproductive activities, adult males gather on the exact part of particular host sampling and discharge pheromones (Prokopy and Hendrichs, 1979). The late cultivars of mango are highly effective (Sheikh and Yesavage, 1986). Due to fruit flies pest in Pakistan an estimated loss 200 million $ yearly (Stonehouse *et al*., 1998). Sindh has a temperate season, which is very suitable for growing and cultivating the host fruit mango, and there are a lot of commercial varieties are grown in this province of Pakistan. In Sindh province, *D. zonata* (saunder fly) and *Dacus Dorsalis* (Hendle) are very commonly hostile to fruits and hardly on vegetables (Panhwar, 2005; Kapoor, 1970; Stonehouse *et al*., 1998). Both species of fruit fly spoil the excellence and amount of mango obstructing the swapping overseas. The same idea was given by (Karim and Ahmed, 1989; Ghafoor, 2010) that regrettably, insect pests (fruit flies) play a dynamic role in the destructive superiority of mango and enormous damage in the quantity of this delightful fruit. According to a report by Leghari and Zaidi (2013), in Sindh province, 2013 mango fruit fly is highly hostile to major varieties such as Chunsa, Sindhri, and Sonara variety. The infestation of fruit fly pests increasing day by day, therefore, the purpose of this publication is to indicate the percentile damage of the mango crop threatened by fruit flies and to give attention towards safety and implications of important economic varieties of mango in Sindh. Moreover, the study also revealed the current status of mango fruit fly pest in Sindh.

Materials and Methods

Study areas

The study areas were mango fields belonging to the Sindh province of Pakistan. The experiment was conducted from 2013-14 years. The infested varieties of mango fruit such as Chunsa, Sindhri, and Beganpali were collected during the fieldwork. Almost 50 mangoes of each variety were collected at weekly intervals from June to September by visiting mango fields (gardens) in different cities of Sindh, i.e., Sukkur, Khairpur, Naushahro Feroze, Hyderabad, Umarkot, Mirpurkhas, Sanghar, Tando Muhammad Khan, and Tando Allahayar. Fruit samples were collected from approximately 10 km^2 per area of each Garden; where more than 10-20 varieties were available.

Sampling and collection of varieties

Sampling was performed at weak intervals from June to September. During each sampling day, the ripened mangoes were harvested from the trees and were also collected from the ground field. Samples were collected as feasible for each cultivator (weight: half-1Kg or 1-200 fruits). Moreover, the mango samples were collected during the ripening period of each variety like Chunsa during July to September and Sindhri during the mid-May to mid-July being very common mango varieties found in upper and lower districts of Sindh. However, the Beganpali mango variety is cultivated only in Hyderabad, Mirpurkhas, Sanghar, Tando Allahayar, and Tando Muhammad Khan, and the samples were collected from July to August. The collected mango samples were first identified and separated with the help of native cultivators, thereafter were also verified by the department of crop protection at Sindh Agriculture University, Tandojam, Sindh. A magnifying glass was used to observe the infested and non-infested mangoes based on ovipositor attempts. Non-infested mangoes were kept separately for feeding flies as a previously reported method (Kakar *et al*., 2014) till further experiment analysis.

Rearing of pests (fruit flies)

Reared flies were taken out from each variety cage containing a sand and kept in five adult rearing cages (size 35 × 30 × 35cm for each variety). The 100g of each given variety of non-infested mangoes were kept in each cage with 200-250 specimens of sexually matured flies, which were considered as 5 replicas of each variety. Infested samples from a particular variety were placed separately in plastic dishes (size 10×10×8cm) containing a ~ 4cm thickened layer of sterilized (100°C) dust and showered (H_2O) with a spray bottle to moisten the dust regularly and kept for 2 to 3 weeks, till the fly maggots port pods and pupated (the third instar maggots always jump, stop feeding, left the fruit and get buried in the sand for pupation). Later the fruits were detached from the cage and shifted, while the remaining sand in the cage was riddled after two to three days after complete pupation. Thus, the pupae were collected and kept in plastic dishes up to the emergence. The number of appeared pupae and flies from each cultivar was noted. Many mature flies evolving per 100g of fruit sample presented the appropriateness of mass for the nurture of oriental fruit flies. This experiment was conducted and reared the flies at (28 °C ±1 °C, 60-65% RH, Photo period 10-12hr) in the insectary Department of Zoology University of Sindh Jamshoro. The methods were performed according to the standard procedure of ICIPE (International programmed at the international center of insect physiology and ecology) (Kalia and Srivastava, 1992; Mir *et al*., 2014).

Recognize the collected fruit flies

Sexually matured adult specimens were observed under dissecting binaural microscope and photographs were examined by microscope [Olympus S2 X 10, Japan linked with camera Olympus E 450 Japan] in adding a computer-grounded key instrument [CD-ROM] mentioned by (Moher *et al*., 2003) through several species of Genus *Bactrocera* and related facts about morphological structures, hosts and topographical conveyance was practice. Emerged fruit flies (*Bactrocera* species) were identified according to morphological characteristics examined with associated standard documented taxonomic keys by literature (Hancock, 1994) and (Moher *et al*., 2003). Illustration of imaginings of every specimen of recognized fruit flies was made through its important distinguishing characteristics by using [Dino lite premier digital Microscope (An Mo electronics crop. Taiwan)].

Host specificity

Fruit flies host specificity was analyzed for three sampled varieties. The Chunsa, Sindhri, and Beganpali were found to be an appropriate hosts of *B. dorsalis*. As the data calculation was thoughtfully analyzed round for the two years (2013 and 2014), during the successful season of mango. Fruit flies were separately documented from each mango variety and host specificity was analyzed by fruit fly species as reared from specific varieties. Fruit flies feed on each variety in a specific way, 100 fruit flies that weigh 1kg. Mature fruit flies were retained and animated for about 1 week or more until to be able for mating and attempt ovipositor then counted, killed, and preserved in 70% alcohol and mango cultivars used as average fruit assessment.

Artificial medium for egg laying of Bactrocera *species*

The 10 pairs of newly hatched sexually matured fruit flies were kept in distinct cages and provided artificial food (water in glass bottles with cotton swabs, yeast hydrolysate, and sugar crystals). Adult fruit flies were kept to assess the pre-oviposition period and fertility. The experiment was repeated thrice for each variety of mango. The thin slice (weight 2-g) of the host variety was kept inside each cage for oviposition attempts and regularly checked the cage for eggs laying process, hence, the piece of fruit was removed from the medium, and the number of eggs was noted on daily basses up to one weak, and examined the properties of trial host variety on the fertility of flies (McQUATE *et al*., 2000).

Statically analysis

The total number of fruits and infested fruits and flies was counted by percentile calculation. The following formulas were used for % of reared flies, survival, and infestation as reported by (Kakar *et al*., 2014)

$$\text{Fruit infestation (\%)} = \frac{\text{No. of infested fruits}}{\text{Total number of fruit}} \times 100 \quad \ldots (1)$$

$$\text{Survival (\%)} = \frac{\text{No. of adult}}{\text{Total number of Pupae}} \times 100 \quad \ldots(2)$$

$$B.dorsalis\ (\%) = \frac{\text{No. of } B.dorsalis}{\text{No. of total flies}} \times 100 \quad \ldots(3)$$

The statistical analysis of modification was conducted for diverse biological factors by mean significant values followed by least significant difference (LSD) with a 5% probability status. Satisfactory (p values > or = to 5%) was applicable for statically significant (Lee *et al.*, 2009). The regression analysis and correlation representation were described by SPSS version 21.0.

Results

Infestation of field

An overview according to the infestation of fruit flies in mango orchards of the Sindh province of Pakistan is given in Table 1. The observation during different intervals of mango season in three different cultivars discovered the significant influence of fruit flies *Bactrocera* species during both seasons (2013-14). Two-year average data of infestation in three different cultivars of mango shows that it gradually increases from the last week of May, the peak of mango season occurs during June and July, and it started gradually declining during the mid of August in Sindh province. The higher infested average No. of mangoes were collected in Sindhri and Beganpali varieties during June-July, and August (Av. No. 208, 208.5, and 229.5 with 85% of infestation, respectively). Although the least infested fruits were collected during June and July in the Beganpali variety (Av. No 85, 82 with 45% of infested mangoes). Fruit flies plague were overlapping during 4 months of mango season with significant difference [F 54.05, df 52, p<0.00], (Table 1).

Pupal recovery and adult emergence

The collected fruits of different cultivars during two years are most significant in number, but somewhere is insignificant No. of infested fruits and for that purpose data of puparia and sexual matures were pertaining based on per-kg during 2013-2014. Findings in (Table 2) revealed that the highest pupal recovery was found from the Beganpali variety during August (49.5%), followed by the Sindhri variety (42.3%), respectively, while the lowest 6.5% puparia were found from the Sindhri variety during September. The emergence of adult scrutiny figures specified that 60.9% of adults were found in Beganpali during its seasonal month of August, followed by the Sindhri variety with 43.2% in June. While lowest emergence of 6% was noted from the Sindhri variety during September (Table 2). After the sexual maturity of *Bactrocera* species in both species, the results indicated that 54.7% of *Bactrocera dorsalis* were found from Beganpali followed by 41% from Sindhri variety with (F 53.24; df 51, 108; p=0.29) as shown in Table 2. Additionally, a least No. (3%) of *Bactrocera dorsalis* was found in the Sindhi variety during September. Though other *Bactrocera* species were 1% overall round the season and it was non-significant in number.

Survival of oriental fruit fly with the interval of time during mango season

Table 3 indicates the month-wise survival % of *Bactrocera dorsalis*. That was found highest in the Sindhri variety (93.4%, 91.2, respectively) during July-June, followed by Chunsa and Beganpali (91.4%, and 92.7%, respectively) during July and August. Whereas the lowest survival was found during June and July with 5% respectively in the Beganpali variety. Statistically, the findings were noted significantly (p<0.001) differed.

Table 1: Showing the % of field infestation on three varieties of mango during 2013-2014.

Variety name	Month	Year (Month) 2013-2014 No. of infested mangoes		Pupal recovery (per-kg)		Adult emergence (per-kg)		*Bactrocera* dorsalis (%)	Other *Bactrocera* species (%)
		Season-2013	Season-2014	(%)	Mean±Sd	(%)	Mean±Sd		
Chunsa	June	204	220	29.6^{ab}	44.7±6.34	29.3	35.7±15.56	27.92	1.4
	July	158	159	29.8^{ab}	44±12.3	29	35.7±12.01	28.64	0.3
	August	132	134	21.02	31.75±6.55	21	35.7±9.2	20.9	0.7
	September	87**	50**	19.5	29.5±8.22	20	35.7±6.75	18.1	1.8
Sindhri	June	225	225	42.3	55±2.1	43.2	43.5±1.41	41	2.2^{ab}
	July	130	135	39.6	51.5±3.87	40.4	43.48±2.64	39.2	1.08
	August	85	70	11.5	15±8.98	10.4	43.82±8.2	9.6	0.8
	September	29	26	6.5	8.5±3.1	6	43.4±3.69	3.8	2.2^{ab}
Beganpali	June	94**	104**	14.3^{ab}	21±2.16	9.1	10±4.19	8.8	0.2
	July	74**	92**	15.04^{ab}	22±4.8	8.8	10±2.8	8.4	0.4
	August	198	195	49.05**	71.75±5.37	60.9	68.75±6.1	54.7	7.09
	September	79**	109**	21.5	31.5±6.55	21.2	24±3.16	19.95	1.33

**Values with (%, Mean ±Sd) of infestation indicating with same letters in columns are not significant (p≥0.05) with each other.

Table 2: Shows the pupal-recovery and adult emergence (*Bactrocera* Species) from infested mangoes of two years of successive season during 2013-2014.

Varieties name	Locality Name	Month	Average (per-season) of collected mangoes from field	Percentage (%) / Mean of infested mangoes (During season 1-2)	
			During season (2013-2014)	(%)	Mean±Sd
Chunsa	Sukkur, Khairpur, Hyderabad, Mirpur khas, Matiari	June	256.5	82.6	42.4±3.56
		July	210	75.5	39.6±5.23
		August	193	65.8^{ab}	33.4±1.98
		September	76.5	65^{ab}	18.7±8.43
Sindhri	Sukkur, Khairpur, Hyderabad, Mirpur khas, Matiari	June	208	85.2^{cd}	45.1±2.62
		July	208.5	85^{cd}	44.3±2.55
		August	158.5	62.5	24.75±5.33
		September	67.5	55.5	9.37±6.36
Beganpali	Hyderabad, Mirpur khas, Sanghar	June	185	45.3^{gh}	19.5±3.8^{gh}
		July	182	45.6^{gh}	20.7±3.4^{gh}
		August	229.5	85.6^{cd}	49.12±6.5
		September	131	71.3	23.3±7.1

**Values with (%, Mean ±Sd) indicating with (**) in columns are significant ($p<0.05$), while same letters are in-significant ($p>0.05$) by Tukey's (HSD) test.

Table 3: Shows the reared *Bactrocera dorsalis* and survival (%).

Variety name	Month (2013-2014)	No. of *B. dorsalis* flies	Survival (%)
Chunsa	June	155	89.5
	July	159	91.4
	August	116	88
	September	101	87
Sindhri	June	205	91.2
	July	196	93.4
	August	48	62
	September	19	36
Beganpali	June	40	5
	July	38	5
	August	247	92.7
	September	90	65

Table 4: shows the fecundity and fertility of *Bactrocera dorsalis*.

Parameters	Variety name (Host mango fruit)		
	Chunsa	Sindhri	Beganpali
Pre-oviposition period (days±SE)	19.33±2.07	19.31±2.08	19.31±2.07
Oviposition */♀/day (No.±SE)	16.1±1.24	16.00±1.23	16±1.23

Fecundity and fertility of Bactrocera dorsalis

The findings in Table 4 show the pre-oviposition period of sexually mature flies of oriental fruit fly on three different varieties (host fruits were not significant ($p > 0.005$, different). Results were found after three replications of flies during the alternative time duration of mango varieties. The pre-oviposition period of *Bactrocera dorsalis* was 19.33 days. The fertility frequency findings were almost 15-16 eggs/day/female in different host varieties. All the host varieties were fully buttressed by the growth of oriental fruit flies from egg to sexually matured appearance.

Seasonality range and hostility of oriental fruit fly as compared to other Bactrocera *species*

Figure 1 revealed the host specificity of *Bactrocera* species in the mango variety during two seasons of mango. It was observed that 94% of mango per year was attacked by *Bactrocera dorsalis,* while 6% of other species belonging to *Bactrocera* attacked mango per year, which is defined as a strongly significant number ($p<0.05$). Additionally, the graph indicates that all three varieties originate maximum favorable mass fruits started on their convenience during alternative time host for the whole season.

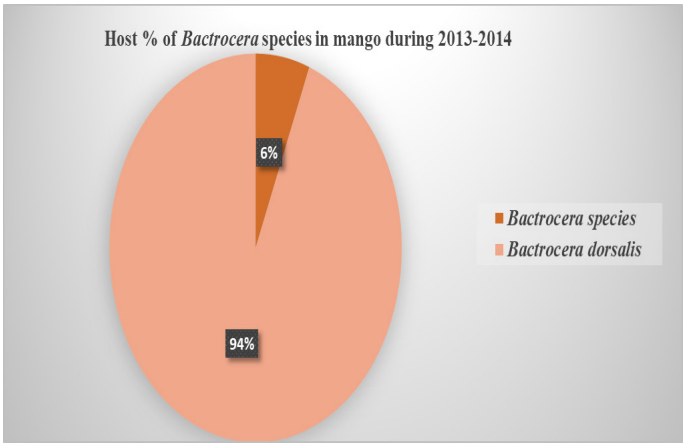

Figure 1: shows the seasonal % of *Bactrocera* species on mango host.

Survival % of Bactrocera dorsalis *on different varieties of mango*

Figure 2 revealed that during the mango season, the highest survival rate of *Bactrocera* occurs in the Chunsa variety at 89.64%, followed by the Sindhri variety at 87.36%, while on Beganpali there is the least survival of adult fruit flies with 70.36%. These findings defined the significantly ($p<0.05$) differed results during the season of mango.

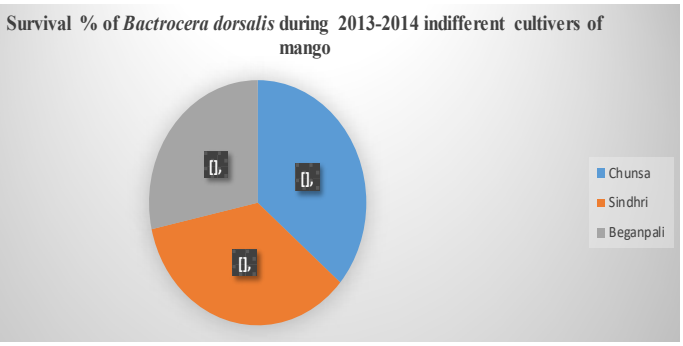

Figure 2: Shows the s survival % of *Bactrocera* species on mango varieties.

Occurrence of Bactrocera dorsalis *with the host during whole months of the season*

The number of emerged flies was collected from infested mangoes during the peak time of mango fruit season and studied the appearance of the adult population correlated with the main host plant. Figure 3 clearly shows the level of pest (fruit fly) occurrence from collected host varieties of mango, which varies in the meantime as a function of the growing time of the latent host varieties. Moreover, during to 4th month of the mango season, the dominant hostility of *Bactrocera dorsalis* depicted a significant linear relationship with the host varieties, while the other species of *Bactrocera* were also available but not in immense numbers. The association among host mango and pest *Bactrocera dorsalis* was strongly linked R2 = 79.9%, P = 0.000. Linking between host mango and *Bactrocera dorsalis* showed durable sustenance for the host-pest deduction (HPH) with a general co-efficient of self-control (75.4%, P = 0.000).

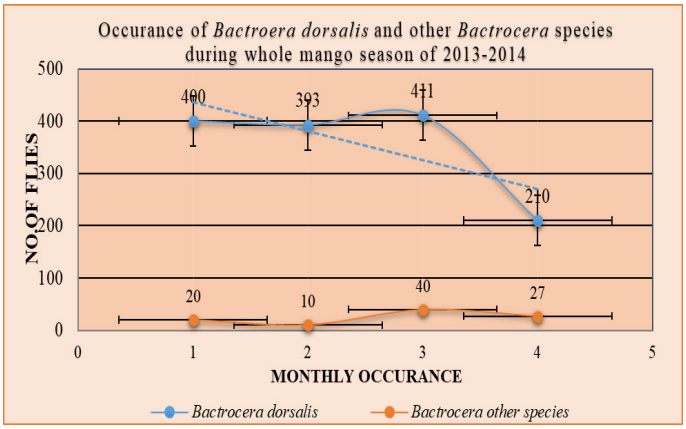

Figure 3: Shows the occurrence of *Bactrocera dorsalis* on mango varieties.

Discussion

The present study revealed that fruit fly injury is a danger to the mango fruit, during both years. The result showed an 87% infestation of fruit flies in mango, consequently, it shows the strong affinity of fruit flies with mango. The outbreak of *Bactrocera* species has strongly threatened the mango cash verities. The field infestation was noted according to the average of collected infested mangoes as shown in table.1. Moreover, all three varieties have a different mean functional time of ripening and growing. The highest regular number (Av. No. 208, 208.5) of Sindhri and Beganpali mangoes were collected at different intervals of time, for example, the peak time of Sindhri is June and July. Herein the infestation rate is 85%, which was found to be a no-significant difference ($p=0.000$). Likewise, the Beganpali mango variety has been occurring in the peak time of mid-August and the number of collected fruits was 229.5 with 85% infestation. However, a minimum infestation was noted in the Beganpali variety during the June and July months. The Chunsa variety is moderate and is less infested as compared to other studied varieties of mango during the entire mango season in Sindh i.e., June-September. Additionally, the Chunsa variety of Sindh also shares different types like Sufaid Chunsa, Black Chunsa, and summer Bahist Chunsa, etc. In the present study, the reason behind the selection of these cultivars for infestation was their mean time of peak functioning and their localities distribution (Table 1). As it is well known that the peak mango season in Sindh starts in June and ends in September. Therefore, the monthly overlapping variation of selected mango varieties exhibits a prominent space for pests to be developed throughout the season. The Chunsa variety occurs during the whole season and acts like an interconnecting bridge for the pest. For example, the Sindhri variety occurs for a short time such as one month and a half month during June. Henceforth, the Sindhri variety is considered to be a good host of *Bactrocera dorsalis*, but it suddenly declines due to harvesting. So, a question may arise how do the pest flies survive and are shifted? The answer would be the Chunsa variety, which further support the pest for one and half month, in the meantime, another late-ripening variety like the Beganpali support the further infestation of fruit flies. The Beganpali is found only in one or two districts of Sindh, it is small in size, low weighted, and remains unripe during the June-July months. The collected data revealed that the host mango varieties own a strong affinity with fruit flies and are very helpful for the development and reproduction of *Bactrocera* species during the entire mango season in Sindh. Other scientists have also concluded that the mango fruit is a major host of *Bactrocera dorsalis* while its secondary host is guava, and its losses about 5-100% mango and 80% guava (Ali *et al.*, 1999; Kafi, 1986). The Beganpali and Sindhri mango varieties were hosting about 80% *Bactrocera dorsalis* in

Sindh province as previously stated by others (Panhwar, 2005; Leghari and Zaidi, 2013). The mango fruit fly (oriental fruit fly) is highly influenced by Sindhri, Chunsa, and Sonaro varieties and it caused a loss of about 80% of mangoes in 2013. Somewhere else the comparative findings were observed internationally (Nankinga *et al*., 2014). In brief, *Bactrocera invadence* is the most unique species which may have 89% influence on mango orchards. On the other hand, the cultivators also reported that fruit flies had a 100% influence on mango orchards and 1-31% of mango were found infested by oriental fruit flies in India (Verghese *et al*., 2002). Kapoor (1993) stated that the mango economy is most highly infested (5-80%) by *Bactrocera dorsalis.* According to (Kafi, 1986) *Bactrocera* species drop 50% of guava orchards. Similar findings were described by another study (Khalid and Mishkatullah, 2007) that a maximum pest infestation (80%) was found at the ripening stage of guava (Khan *et al*., 2003a; b) also stated the outbreak of fruit flies in the mango crop. In this study, the collection of puparia and adults of *Bactrocera dorsalis,* was performed. So, the findings revealed that the highest pupal recovery (Kg^{-1}) was found at 49.5% during August, followed by June 42.3%, respectively, while the lowest puparia recovery was noted during September with a 6% rate (Table 2). Certain findings indicated the strong affinity between pest and host. Moreover, throughout the season such as from the end of May to the end of September, the fruit flies remained active and consistent. The same findings were discussed by (Nankinga *et al*., 2014; Panhwar, 2005) that all mango varieties (exotic and local) were highly receptive to fruit flies, and the infestation average rate was 5 to 175 $pupae^{Kg-1}$ and 33 to 399 $pupae^{Kg-1}$. This study revealed that the Beganpali mango variety yielded the highest number of pupae during August and the lowest number of pupae in June and July. On the other hand, the Sindhri mango variety has shown the lowest recovery during September (Table 2). Comparable finding was stated by (Nankinga *et al*., 2014) in respect of different mango varieties. Moreover, the authors found a maximum infestation between mango varieties, which were collected from trees or arenas, during their functional meantime. For example, the kagwogwa mango is a local variety that has been highly infested by fruit flies, its outbreak recorded with the catalog was 80-129 pupae Kg^{-1} of fruit. Table 2 showed the highest emergence 60.9% of adults from Beganpali during August, followed by Sindhri variety which showed 43.2% emergence in June. Likewise comparable findings were discussed in previous literature (Ekesi *et al*., 2009) such as *B. invadens* was noted as the major fruit fly. Of them 88% were sexually matured fruit flies in mango gardens of Uganda and 98% were entombed fruit flies. In another study, (Kalia and Srivastava, 1992), stated that about 200 sexually matured adult flies were emerged from 100 gms of mango fruit. Here in this study a less number of sexually matured adult flies were recorded in Sindhri and Beganpali variety amid the peak season, while Chunsa variety depicted a maximum emergence. The results witnessed that the Beganpali, Sindhri and Chunsa varieties are prominent host for *B. dorsalis.* In another study (Akol *et al*., 2013) the survival rate of *Bactrocera invadence* in different host varieties of mango was found significantly differed. The highest survival was seen in common varieties like Biire 36.347±2.00d, following Glen 34.095±1.85d, Kate 33.976±1.70 d, and the least on Tommy 23.580±2.18d and Apple 23.609±2.07d. (Rwomushana *et al*., 2008b) have shown a high infestation 39.2 to 103.3 $flies^{Kg-1}$ in lower altitude areas as compared to low at higher altitude areas (0-29.4 $flies^{kg-1}$). It is also reported that fruit flies epidemic are varied according to the agro-ecological areas or the region of host category and accessibility (Van Melle *et al*., 2008). Table 3 represented that there is non-significant difference among pre-oviposition time of mature flies of *Bactrocera dorsalis* emerging from different host varieties of mango. Moreover, normal pre-oviposition time is eighteen-twenty-two days (Kalia, 2015), although the oriental fruit flies has a wide-range of nine to ten cohort per-year (Meats, 1981; Qureshi *et al*., 1993). Table 3 also described the fecundity of *Bactrocera dorsalis* per fly 15-16 eggs/day. Similar results concerned with *Bactrocera dorsalis* were described by (Kalia, 2015) for different host fruit such as, Banana, papaya, guava and mango. Though certain fruits are the best host source of *Bactrocera dorsalis* to maintain their proper developmental stages starting from egg laying to emergence of adult. Figure 1 described that *Bactrocera dorsalis* has high a kindship with mango varieties i.e., 94% as compared to other species of *Bactrocera* (6%). Some pervious studies (Ekesi *et al*., 2006; De Meyer *et al*., 2007; Rwomushana *et al*., 2008a) have shown 58.3% infestation in Kenya and 61.8% infestation in Tanzania mango orchards. In contrast present study recorded 94% infestation of *Bactrocera dorsalis,* being the major pest of mango in Sindh province of Pakistan (Figure 1). Additionally, 6% other *Bactrocera* species were also found during June-July, so it might be considered a shift of flies from other host fruits such as guava, Jamo and cheekho during the August to September. A highest 89.64% survival rate of flies was found in Chunsa variety, due to its frequent availability throughout the season of this variety. Moreover, Chunsa mango is available from June to August as in ripening stage. Similarly (Kalia and Srivastava, 1992) found that Amarpali was less infested to oriental fruit fly when compared to Mallika in the field. But the highest infestation on Mallika 56% was noted during harvesting stage followed by Totapari 37.8% (Singh *et al*., 2008). Verghese *et al*. (2002) results also supported present study that highly infested variety the Beganpali is significantly differed than other varieties. The occurrence of *Bactrocera dorsalis* and other *Bactrocera* species, during the whole mango season mango reached to its peak harvesting in June and July (Figure 3).

While late coming varieties i.e., at the end of August, encounters a great glassy of adult flies emergence much earlier as well as till the end of season. However, at the end of mango season, such prominent number *Bactrocera dorsalis* population suddenly declines, due to lack of host (food source) and fecundity sites. The Research views of (Joel, 1980) supported present study, that oriental fruit flies occurrence started from May-November, with a peak number in June and July, though it occurs in hot months of year. The adult emergence curve data from peak to end of season showed strong significant linear relationship among seasonal months, cumulative emergence, mango varieties and cumulative flies emergence from infested mangoes was observed as a function of time and the population dynamics linked to the main host (mango) during ripping time (Figure 3). According to (Ndiaye *et al.*, 2008) that the emergence of *Bactrocera invadence* and *C. cosyr* in different type of orchards occurs in different time intervals. In traditional orchards the emergence time is April to mid-July for *Bactrocera* species, while in modern-type orchards the peak time of emergence is the end of June. These observations also supported the present study results. Meanwhile, the uniformity of host availability give space to fruit flies emergence to the next fruit variety. Moreover, as the mango season ends, certain populations of *Bactrocera* species suddenly declines due to scarcity of host food and oviposition attempting.

Conclusions

The present study showed that *Bactrocera* species and *Bactrocera dorsalis* are economic important pest of mango fruit in Sindh Pakistan. The emergence dynamics of oriental fruit flies in mango orchards increased with peak functioning time of harvesting. Study reported a high number of mango fruits infested by *Bactrocera dorsalis* with interval of time during four months of mango season in Sindh Pakistan. The Chunsa, Sindhri, and Beganpali were recorded as promising host of *Bactrocera dorsalis*. Present work, showed periodic plague of fruit flies that was examined at weakly intervals during 2013 to 2014 throughout the harvesting succession in all studied sites from particular orchards of Sindh. The findings revealed the brutality of fruit fly infestation in the life phase of fruitage, so the study provides useful support to minimize the harm and to design strategies for controlling the mango pest to acquire better yield. As the major intention of this research work was to identify the plague of the mango pest, henceforth a long-lasting plague was noted from the end-May and it continued gradually to the June, July and August. Later on, a huge number of fruit fly emergence was decreased to the smallest number in the month of September. The peak plague of *Bactrocera dorsalis* occurred in May to September. This research work concluded that there is a significant increase in the population of *Bactrocera* species, and *Bactrocera dorsalis* is the today's major pest of mango crop, which may also decline the economy of mango in Sindh.

Conflict of interest

The authors have declared no conflict of interest.

References

Akol, A., Masembe, C., Isabirye, B., Kukiriza, C. and Rwomushana, I., 2013. Oviposition preference and offspring performance in phytophagous fruit flies (Diptera: Tephritidae): The African invader, Bactrocera invadens. *Int. Res. J. Hortic.,* **1:** 1-14. https://doi.org/10.12966/irjh.05.01.2013

Ali, I., Ullah, F. and Khan, S.A., 1999. Efficacy of various insecticides and trap heights in methyl eugenol baited traps against fruitflies (*Bacterocera* spp.). *Sarhad J. Agric. (Pakistan)*, **15:** 589-594.

Allwoood, A., Leblanc, L., Vueti, E. and Bull, R., 2001. *Fruit fly control methods for pacific countries and territories*. Plant protection services, Secretariat of the pacific community, pest advisory leaflet No, 40.

Aluja, M., Celedonio-Hurtado, H., Liedo, P., Cabrera, M., Castillo, F., Guillén, J. and Rios, E., 1996. Seasonal population fluctuations and ecological implications for management of Anastrepha fruit flies (Diptera: Tephritidae) in commercial mango orchards in Southern Mexico. *J. Econ. Entomol.,* **89:** 654-667. https://doi.org/10.1093/jee/89.3.654

Bateman, M., 1972. The ecology of fruit flies. *Ann. Rev. Entomol.,* **17:** 493-518. https://doi.org/10.1146/annurev.en.17.010172.002425

Carvalho, S. and White, H., 1996. *Implementing projects for the poor: What has been learned?* The World Bank. https://doi.org/10.1596/0-8213-3531-6

De-Meyer, M., Mohamed, S. and White, I.M., 2007. *Invasive fruit fly pests in Africa*. Website: http://www. africamuseum.be/fruitfly/AfroAsia.htm.

Ekesi, S., Billah, M.K., Nderitu, P.W., Lux, S.A. and Rwomushana IV, I., 2009. Evidence for competitive displacement of *Ceratitis cosyra* by the invasive fruit fly Bactrocera invadens (Diptera: Tephritidae) on mango and mechanisms contributing to the displacement. *J. Econ. Entomol.,* **102:** 981-991. https://doi.org/10.1603/029.102.0317

Ekesi, S., Nderitu, P. and Rwomushana, I., 2006. Field infestation, life history and demographic parameters of Bactrocera invadens Drew, Tsuruta and White, a new invasive fruit fly species in Africa. *Bull. Entomol. Res.,* **96:** 379-386.

FAO, 2006. The state of food insecurity in the world. http://www.fao.org/docrep/009/a0750e/a0750e00.htm. Accessed at 08-01-2014

Ghafoor, A., 2010. *Determinants of mangoexport from*

Pakistan. University of Agriculture, Faisalabad.

Hancock, D.S., 1994. *Main circuit breaker or other circuit protective device connector installation kit for panelboards*. Google Patents.

Hely, P.C., Pasfield, G. and Gellatley, J.G., 1982. *Insect pests of fruit and vegetables in New South Wales*. Department of Agriculture, New South Wales.

Hossain, A.K.M.A., 1989. Manual on mango cultivation in Bangladesh. Division of Horticulture, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 39 & 58.

Iqbal, Z., Saleem, A. and Dasti, A., 2004. Assessment of mango malformation in eight districts of Punjab (Pakistan). *Int. J. Agric. Biol.,* **6:** 620-623.

Ishaq, M., Usman, M., Asif, M. and Khan, I., 2004. Integrated pest management of mango against mealy bug and fruit fly. *Int. J. Agric. Biol.,* **6:** 452-454.

Joel, D., 1980. Resin ducts in the mango fruit: A defence system. *J. Exp. Bot.,* **31:** 1707-1718. https://doi.org/10.1093/jxb/31.6.1707

Kafi, A., 1986. *Progress and problems in controlling fruit flies infestation*. FAO, RAPA, Bangkock, pp. 16-19.

Kakar, M.Q., Ullah, F., Saljoqi, A.U.R., Ahmad, S. and Ali, I., 2014. Determination of fruit flies (Diptera: Tephritidae) infestation in guava, peach and bitter gourd orchards in Khyber Pakhtunkhwa. *Sarhad J. Agric.,* **30:** 241-246.

Kalia, M., 2015. Biomarkers for personalized oncology: recent advances and future challenges. *Metabolism*, **64:** S16-S21. https://doi.org/10.1016/j.metabol.2014.10.027

Kalia, V. and Srivastava, M., 1992. Ovipositional behaviour and development of the oriental fruit fly Dacus (Strumeta) dorsalis Hendel on development stages of mango fruit. *Bull. Entomol. New Delhi,* **33:** 88-93.

Kapoor, V., 1970. Indian tephritidae with their recorded hosts. *Orient. Insects,* **4:** 207-251. https://doi.org/10.1080/00305316.1970.10433957

Kapoor, V.C., 1993. *Indian fruit flies:(Insecta: Diptera: Tephritidae)*, International Science Publisher.

Karim, M. and Ahmed, H., 1989. *A field guide on insect pests and diseases of mango in Bangladesh and their control*. HRC, BARI and FAO/UNDP Mango Improvement and Development (BGD/81/022).

Khalid, M. and Mishkatullah, S., 2007. Population dynamics of three species of genus Bactrocera (Diptera: Tephritidae: Dacinae) in BARI, Chakwal. *Punjab Pak. J. Zool.,* **39:** 123-126.

Khan, M., Ashfaq, M. and Khaliq, A., 2003a. Population of fruit fly species trapped by methyl euginol and cue lure versus infestation in guava orchards. *Pak. Entomol.,* **25:** 63-67.

Khan, M., Muhammad, A., Abdul, K. and Amjad, A., 2003b. Population of fruit fly species trapped by methyl eugenol and cue lure versus infestation in apple orchards of Murree Hills. *Pak. Entomol.,* **25:** 191-194.

Lee, H.H., Jan, L.Y. and Jan, Y.N., 2009. Drosophila IKK-related kinase Ik2 and Katanin p60-like 1 regulate dendrite pruning of sensory neuron during metamorphosis. *Proc. Natl. Acad. Sci.,* **106:** 6363-6368. https://doi.org/10.1073/pnas.0902051106

Leghari, S.K. and Zaidi, M., 2013. Effect of air pollution on the leaf morphology of common plant species of Quetta city. *Pak. J. Bot.,* **45:** 447-454.

Mcquate, G.T., Follett, P.A. and Yoshimoto, J.M., 2000. Field infestation of rambutan fruits by internal-feeding pests in Hawaii. *J. Econ. Entomol.,* **93:** 846-851. https://doi.org/10.1603/0022-0493-93.3.846

Meats, A., 1981. The bioclimatic potential of the Queensland fruit fly, *Dacus tryoni*. *Aust. Proc. Ecol. Soc. Aust.,* **11:** 1-61.

Mir, S., Dar, S., Mir, G. and Ahmad, S., 2014. Biology of *Bactrocera cucurbitae* (Diptera: Tephritidae) on cucumber. *Fla. Entomol.,* **97:** 753-758. https://doi.org/10.1653/024.097.0257

Moher, D., Pham, B., Lawson, M.L., Klassen, T.P., 2003. The inclusion of reports of randomised trials published in languages other than English in systematic reviews. *Hlth. Technol. Assess.,* **7**: 1-90.

Nankinga, C., Isabirye, B., Muyinza, H., Rwomushana, I., Stevenson, P., Mayamba, A., Aool, W. and Akol, A., 2014. Fruit fly infestation in mango: A threat to the horticultural sector in Uganda. *Uganda J. Agric. Sci.,* **15:** 1-14.

Ndiaye, M., Dieng, E.O. and Delhove, G., 2008. Population dynamics and on-farm fruit fly integrated pest management in mango orchards in the natural area of Niayes in Senegal. *Pest Manage. Hortic. Ecosyst.,* **14:** 1-8.

Painter, R.H., 1951. *Insect resistance in crop plants*, LWW. https://doi.org/10.1097/00010694-195112000-00015

Panhwar, F., 2005. Mediterranean fruit fly (*Ceratitis capitata*) attack on fruits and its control in Sindh, Pakistan. Publisher. Digital Verlag GmbH, Germany, www.chemlin.de.

Papadopoulos, N.T., Katsoyannos, B.I. and Nestle, D., 2003. Spatial autocorrelation analysis of a Ceratitis capitata (Diptera: Tephritidae) adult population in a mixed deciduous fruit orchard in northern Greece. *Environ. Entomol.,* **32:** 319-326. https://doi.org/10.1603/0046-225X-32.2.319

Pasiecznik, N., Smith, I., Watson, G., Brunt, A., Ritchie, B. and Charles, L., 2005. CABI/EPPO distribution maps of plant pests and plant diseases and their important role in plant quarantine. *Eppo Bull.,* **35:** 1-7. https://doi.org/10.1111/j.1365-

2338.2005.00815.x

Prokopy, R.J. and Hendrichs, J., 1979. Mating behavior of Ceratitis capitata on a field-caged host tree. *Annls Entomol. Soc. Am.,* **72:** 642-648. https://doi.org/10.1093/aesa/72.5.642

Qureshi, Z., Hussain, T., Carey, J. and Dowell, R., 1993. Effects of temperature on development of *Bactrocera zonata* (Saunders) (Diptera: Tephritidae). *Pan-Pac. Entomol.,* **69:** 71-76.

Rossetto, C., Bortoletto, N., Carvalho, C., De Castro, J., Walder, J., Nogueira, N., Arthur, V. and Lopes, L., 2006. Mango resistance to fruit flies. I Varietal selection and mechanisms of resistance. VIII Int. Mango Symp., **820**: 575-580. https://doi.org/10.17660/ActaHortic.2009.820.73

Rwomushana, I., Ekesi, S., Gordon, I. and Ogol, C.K., 2008a. Host plants and host plant preference studies for *Bactrocera invadens* (Diptera: Tephritidae) in Kenya, a new invasive fruit fly species in Africa. *Annls Entomol. Soc. Am.,* **101:** 331-340. https://doi.org/10.1603/0013-8746(2008)101[331:HPAHPP]2.0.CO;2

Rwomushana, I., Ekesi, S., Ogol, C. and Gordon, I., 2008b. Effect of temperature on development and survival of immature stages of *Bactrocera invadens* (Diptera: Tephritidae). *J. Appl. Entomol.,* **132:** 832-839. https://doi.org/10.1111/j.1439-0418.2008.01318.x

Sheikh, J.I. and Yesavage, J.A., 1986. Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. *Clin. Gerontol. J. Aging Ment. Hlth.*, 5: 165-173. https://doi.org/10.1300/J018v05n01_09

Singh, H., Verghese, A., Stonehouse, J., Mumford, J., George, S., Naik, G. and Pandey, V., 2008. Developing bait and lure-based integrated pest management module for mango fruit fly (*Bactrocera dorsalis*) management in Orissa. *Indian J. Agric. Sci.,* **78:** 609-613.

Shelly, T.E. and Kennelly, S.S., 2007. Settlement patterns of Mediterranean fruit flies in the tree canopy: An experimental analysis. *J. Insect Behav.,* **20**: 453–472.

Stonehouse, J.M., Mumford, J.D. and Mustafa, G., 1998. Economic losses to tephritid fruit flies (Diptera: Tephritidae) in Pakistan. *Crop Prot.,* **17:** 159-164. https://doi.org/10.1016/S0261-2194(97)00091-4

Stonehouse, J.M., Mahmood, R., Poswal, A., Mumford, J.D., Baloch, K.N., Chaudhary, Z.M., Makhdum, A.H., Mustafa, G. and Huggett, D., 2002. Farm field assessment of fruit flies (Diptera: Tephritidae) in Pakistan: Distribution, damage and control. *Crop Protect.,* **21**: 661–669.

Tan, K.H. and Serit, M., 1994. Adult population dynamics of Bactrocera dorsalis (Diptera: Tephritidae) in relation to host phenology and weather in two villages of Penang Island, Malaysia. *Environ. Entomol.,* **23:** 267-275. https://doi.org/10.1093/ee/23.2.267

Van Melle, C., Arinloye, D., Coulibaly, O., Vayssières, J.F. and Hell, K., 2008. Contribution to mango value chain development in Benin-A producer perception survey. *IV Int. Symp. Trop. Subtrop. Fruits*, **975**: 607-613. https://doi.org/10.17660/ActaHortic.2013.975.77

Verghese, A., Madhura, H., Kamala Jayanthi, P. and Stonehouse, J.M., 2002. Fruit flies of economic significance in India, with special reference to *Bactrocera dorsalis* (Hendel). *Proc. 6th Int. Symp. Fruit Flies Econ. Importance. Stellenbosch, South Africa*, pp. 510.

White, I. and Elson–Harris, M., 1994. *Fruit flies of economic significance*. Their identification and bionomics. CAB. International, UK.

Ye, H. and Liu, J.H., 2005. Population dynamics of the oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae) in the Kunming area, southwestern China. *Insect Sci.,* **12:** 387-392. https://doi.org/10.1111/j.1005-295X.2005.00048.x