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Natural hymenopteran parasitoids of pod fly, *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae) on pigeonpea UPAS 120 in relation to weather parameters

Manoj Kumar Singh*,Sunil Kumar Dwivedi, Monali Upadhyay, Ridhima Dhiman, Ananya Sharma, Smriti Kumari, Jadhav Abhishek Ashok

*[1]Research Scholar, Department of Zoology, Lovely Professional University, Phagwara, Punjab-144411, India
[2]Assistant Professor, Department of Entomology, Lovely Professional University, Punjab-144411, India
[3]Department of Horticulture, School of agriculture, Lovely Professional University, Punjab-144411, India
[4]Department of Horticulture,School of agriculture, Lovely Professional University, Punjab-144411, India
[5]Department of Horticulture, School of agriculture, Lovely Professional University, Punjab-144411, India
[6]Department of Horticulture, School of agriculture, Lovely Professional University, Punjab-144411, India
[7]Department of Horticulture, School of agriculture, Lovely Professional University, Punjab-144411, India
*Corresponding author: singhkmanoj11@gmail.com (Mob. No. 8630167719)

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ABSTRACT

The current study shows presence of two major hymenopteran parasitoids viz., Euderus lividus (Ashmead) and Ormyrus orientalis (Walker) on the pigeonpea major pest, Melanagromyza obtusa (Malloch). Pigeon pea pod fly infestation has been prevalent during the Kharif crop seasons of 2022-23 and 23-24, persisting until harvest. First appearance of pod fly larvae and pupa was observed in the 41stand39thstandard meteorological week (SMW). The larval population peak at 52.00 and 41.00 larvae per 100 pods was noticed in the 44th SMW at both years, while pupal population peak at 49.00 and 40.00 pupae per 100 pods showed during the 50th and 45th SMW. The parasitism level of E. lividus declined from 31.82 to 10.53%and 29.72 to 7.14% from 46thupto 52nd and 45th upto 50thSMW. The highest percentages of pupal parasitism O. orientalis recorded 25.64 and 24.32% in 47th and 44th SMW.While low percentage of pupal parasitism was noted 3.22 and 3.84% in 1st and 51st SMW at both years. Simple correlation between weather parameters with pod fly larvae and pupae showed that the larval population exhibited a significant positive relation with maximum temperature (r=0.646*) and (r=0.746**) at both years.The natural enemies of pod fly larvae and pupae by E. lividus and O. orientalis would improve knowledge on biological control of the pest population.

Keywords:Euderus lividus, Melanagromyza obtusa, Natural enemies, Ormyrus orientalis, Weather parameters.

INTRODUCTION

Pigeon pea, *Cajanus cajan* (Millsp.) is the most significant and nutritious pulse. *Cajanus cajan*, sometimes known as pigeon pea (Sarkar *et.al*., 2020). Pigeon pea is India's second-most significant pulse crop after gram and contributes to nearly 90% of the world's pigeon pea production.In India pigeon pea is cultivated in area of 5.05 million hectares with an annual production of 4.34 million tonnes result on average yield is 859 kg per hectare (Anonymous, 2022). While it is covering an area of 1.4 thousand hectares with a production of 1.4 thousand tonnes. The average yield per hectare was 10.14 quintalsper acre in Punjab state at 2023 (Anonymous, 2023). Pigeon peaassociated bacteria benefit the soil through the symbiotic nitrogen fixation.This inclusion of pigeon pea in crop rotation aims to ensure the long-term preservation of soil health and fertility. Pigeon pea is a rich source of protein (21.71%), minerals (3.5%), carbohydrate (57.6%) for vegetarian population (Khamoriya*et. al*., 2017).

The pod fly, *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae) is most obnoxious pest, leading to grain losses ranging from 20 to 80% due to its destructive impact. Its infestation leads to significant loss of the pods and seeds of pigeon pea resulting in reduced germination rate and rendering them unsuitable for human consumption or any other purpose (Hadiya *et. al*., 2020). Pod fly oviposition occurs in tender pods and inner surface of the pods. The larvae feed on the seeds and pupate inside the pods (Nair *et. al*., 2017). Pod fly laid fewer eggs in December and January when temperatures are low. Pod fly population increases with temperature rise (Chiranjeevi and Patange, 2018). The female pod fly lays upto 80 eggs into maturing green pods. Such pods don't exhibit any visible signs of damage until the larvae emergence and same causes shot-holes in the pod walls upon maturity.Typically, one maggot requires only a single seed for its development (Yadav *et. al*., 2016). After hatching, the larva burrows into the pods and feeds upon tender seeds, rendering them unfit for both human consumption and further propagation. The pod fly is being an internal feeder inhabits both larval and pupal stages within the pod wall leaving behind a fragile papery membrane. Inside the podthe larvae consume the developing seeds followed by pupal development (Patange*et. al*., 2017). This perforation serves as an exit point for the adult flies as they emerge from the pod as described by Kumar *et. al*. (2015).Egg phase typically ranges from 3 to 5 days followed by larval development duration of 6 to 11 days and further the pupal stage extends from 9 to 23 days. Yadav *et. al*., (2020) also discovered that the adult insects have a lifespan of about 6 days without nourishment, but this extends to 12 days when they provided with food. Such newly

emerged young ones are small and black coloured. *Euderus lividus* is a species of parasitoid belonging to the family of Eulophidae.*E. lividu*s are known for their role in biological control. Particularly, against major pest (*M. obtusa*) that attack pigeonpea.*Euderus lividus* was identified as an ectoparasitoid larva of *M. obtusa*during the study. The eggs are deposited onto the bodies of second and third instar larvae of the host. Females observed laying upto nine eggs per host(Ahmad, 1940). Previous reports indicate that females lay their eggs through the exit hole created by the final instar larva of *M. obtusa*. However, Singh (1991) reported that, *E. lividus* had also parasitized the larvae in their second instar. *E. lividus*, eggs are not always laid exclusively through the exit hole created by the final instar larva of the pest in the pod wall. Instead, the female parasitoid is capable of depositing eggs through the pod wall using its elongated ovipositor (Yadav *et. al*., 2011).*Ormyrus orientalis* is belonging to the family of Ormyridae reported as major bio-control agents. The parasitoid lays its egg inside the puparium, on the body of the pupa (Chiranjeevi and Patange, 2018).*Ormyrus orientalis* is a solitary nature parasitoid, as only a single individual was found developing on each pupa (Yadav et. al., 2011). The female oviposits its eggs on the body of the pod fly's pupa, possibly inside the puparium (Chiranjeevi and Patange, 2018). These two natural parasitoid species *E. lividus* and *O. orientalis* were identified as the main or dominant parasitoids attacking the pigeonpea pod fly.The high levels of parasitism reported 80.00% for *E. lividus* and 46.66% for *O. orientalis*, indicate they can be quite effective in suppressing the pod fly population. These two parasitoid species are important natural biological control agents that can help manage populations of the pest *M. obtusa* based on the information provided (Yadav *et. al*., 2012). Dry pigeon pea pods exhibit one or more perforations on upper surface, indicating infestation. Seeds within infested pods appear desiccated, wrinkled and partially consumed (Sharma and Keval, 2021). Various workers have established that more than 20 Hymenopteran parasitoids have been recorded on this pest (Sharma, 2007; Yadav and Yadav, 2011). The incidence of parasitism of *M. obtusa* was studied by several workers (Yadav *et. al*., 2012). Future scope of this paper utilization of natural parasitoids effective for management of pod fly without any residual effects.

MATERIALS AND METHODS

The experiment was conducted at Experimental Research Farm of Lovely Professional University, Punjab, India during 2022-2023 and 2023-24 in a Randomized Block Design with seven treatments and three replications. To observe population dynamics of pod fly and its

natural hymenopteran parasitoids. In Punjab state UPAS-120 variety of pigeon pea crop was cultivated in the mid of June with recommended agricultural practices by PAU, Ludhiana (Bisen *et. al*., 2023). The variety is early sown high yield variety is not check in Punjab against pod fly. The pigeon pea variety UPAS-120 grown under normal field condition by maintained spacing 20 X 90 cm. No synthetic chemicals were applied to protect crop from natural incidence of pod fly and its parasitoids. The population of pod fly and parasitoids were weekly recorded from pod formation to maturity of crop. The immature stages (larval and pupal) along with its pod damage were counted on randomly collected 100 pods were plucked by selecting 5 plants at weekly interval in each replication (Tiwari *et. al*., 2006; Yadav and Yadav, 2013). The following formula was used to calculate the percentage of pod damage. (Patange*et. al*., 2017).

$$\text{Percent pod/grain damage} = \frac{\text{Number of infected pod/grain}}{\text{Total number of pod/grain}} \times 100$$

The healthy and damaged pods in pigeon pea crops were regularly monitored by dissecting each pod in the laboratory and placing them in glass vials (capacity of 30 ml) covered with muslin cloth. Larvae and pupae collected were kept at room temperature until the emergence of *M. obtusa* and various parasitoids. Number of pod fly larvae and pupae within each pod was recorded. To determine the correlation between the population of pod flies (larvae and pupae), parasitoids (*E. lividus* and *O. orientalis* with various abiotic factors such as maximum temperature, minimum temperature, relative humidity and rainfall (Shankar *et. al*., 2021). The percentage of pod fly infestation was calculated during maturity stage. Observational techniques were employed to examine abiotic factors affecting the population dynamics of the pigeon pea pod flies and its parasitoids. Correlation analysis was conducted to understand the association between weather parameters with pod flies and parasitization, investigating their potential influence on each other. Correlation analysis by OPSTAT software. As a result, the information on parasitoids emerging from the host fly stages (larvae and pupae of *M. obtusa*) was appropriately processed to determine the percentage of parasitism and interpret the results. The following formula were used to find the percentage of parasitism (Patange*et. al*., 2017).

$$\text{Percent larval/pupal parasitization} = \frac{\text{Number of infected larvae /pupae}}{\text{Total number of larvae/pupae}} \times 100$$

RESULT AND DISCUSSION

During the kharif crop 2022-23 and 2023-24 the incidence of pest started with the development of pod and continue upto maturity throughout the reproductive stage of crop. Initially, the larval

population was started at 16.00 and 14.00 larvae per 100 pods during the 41st and 39th SMW of both years which increased at peak level 52.00 and 41.00 larvae per 100 pods by the 44th SMW at that time maximum temperature of 34.00 and 31.32^0 C, while minimum temperature of 19.00 and 13.30^0 C, maximum relative humidity of 56.00 and 94.01% and minimum relative humidity of 42.00 and 45.82%. Eventually, the larval population decreased to 5.00 and 9.00 larvae in the 2nd and 52nd SMW. The pupal population of *M. obtusa* (10.00 and 7.00 pupae/ 100 pods) was observed from the 41st and 40th SMW. Which also showed increasing trend, progressively, peaked at 49.00 and 40.00 pupae per 100 pods on the 50th and 45th SMW at maximum temperature of 25.00 and 29.00^0 C, minimum temperature of 10.00 and 13.57^0 C, maximum relative humidity of 97.00 and 93.23%, minimum relative humidity of 65.00 and 47.22% and rainfall of 0.60 mm (in 2023-24). While the temperature was very low then population decreased to 8.00 and 14.00 pupae in the 2nd and 1st SMW. Pod damage symptoms appeared on the 41st and 39th SMW in 29 and 25%. Increased gradually pod damage percentage peaked at 79 and 73% on the 46th and 44th SMW with maximum temperature of 28.00 and 34.30^0 C, minimum temperature of 23.00 and 19.96^0 C, maximum relative humidity of 59 and 92.65% and minimum relative humidity of 43.00 and 65.50% then population declining to 17 and 19% on the 2nd and 1st SMW of both years (Table-1 and 3). The findings from our current study regarding the population dynamics of the pod fly, *M. obtusa* and its impact on pigeon pea align closely with the research conducted by Pillai and Agnihotri (2013). They observed that the highest activity of the pod fly occurred around the 46th SMW, whereas the lowest population of *M. obtusa* (31 per 100 pods) was recorded during the 49th standard week. Similarly, Patange*et. al*., (2017) reported that the pod fly was first time noticed in the 48th SMW, while pods (26.00%) infestation with larvae and pupae were observed during thar period.

The larval parasitism level of pod fly was shown from 43rd and 41st SMW on the 11.76% and 4.17%. Which larval parasitism increased to peak at 46th and 45th SMW with 31.82 and 29.72 % with maximum temperature of 28.00 and 29.05^0 C, minimum temperature of 13.00 and 13.57^0 C, maximum relative humidity of 52.00 and 93.23%, minimum relative humidity of 47.00 and 47.22% and rainfall of 0.60 mm (in 2023-24).Subsequently, the larval parasitization decreased to zero during the 1st SMW of 2022-23 and 51st SMW of 2023-24.

The pupal parasitization level of *M. obtusa* was identified during 44th SMW (9.37%) and 42nd SMW (11.53%). Which increased gradually until reach a peak stage i.e. 25.64 and 24.32% with 47th and 44th SMW during both years with maximum temperature of 28.00 and 31.32^0 C, minimum temperature of 19.00 and 13.30^0 C, maximum relative humidity of 81.00 and 94.01%,

minimum relative humidity of 76.00 and 45.82%. Along with decrease in temperature, the percentage of pupal population also decreases in 1st SMW with 3.22%. Similarly next year 2023-24, the percentage of pupal population also decreased in 51st SMW with 3.84% with decreased in temperature. The pupal parasitization level was observed nil during the 2nd and 52nd SMW of 2022-23 and 2023-24 (Table1 and 3). According to Chakravarty *et. al*., (2016), who also noted the presence of *Ormyrus orientalis* on pod flies. The highest natural parasitization percentage (17.39%) of *M. obtusa* by these parasitoids occurred during the 51st SMW at maturity stage of crop. These results are in accordance with Chiranjeevi and Patange (2018) documented the initial observation of larval and pupal parasitization during the 46th (SMW) by *Euderus lividus* (Ashmead) (41.18%) and *Ormyrus orientalis* (Walker) (18.75%) with observed during the 48th SW. Yadav *et. al*., (2020) reported that parasitization in the pod fly ranged between from 14.28 to 25.71%. There was an increase in parasitization during the first fortnight of March reaching its peak at 25.71%. The simple correlation between weather parameters and the proportion of pod damage, as well as the ratios of larval and pupal population of pigeon pea podfly were also examined. The findings from the data indicate the simple correlation between these parameters. A simplecorrelation was worked out between the population of *M. obtusa* with weather parameters presented of both years in Table 2 and 4. The damaged pods showed a positive correlation (r = 0.550*) with the maximum temperature in 2022-2023. While, in 2023-24 its showed non-significant correlation (r= 0.482) with maximum temperature. Conversely, the minimum relative humidity showed non-significant negative correlation (r= -0.360) and a significant negative correlation (r = -0.744**) in both years. The findings were larval population of pod fly in both years showed a significant positive correlation (r=0.646*) and (r=0.746**) with the maximum temperature.Similar type of results was also reported by Chakravarty *et. al*., (2016) it revealed that there was a significant positive correlation with maximum temperature (r = 0.746*). While according to Yadav *et. al*. (2011) observed that the larval population began to increase when the maximum temperature fell below 32°C, reaching its highest point before subsequently decreasing. In the both years, the pupal population of pod flies showed non-significant positive correlation (r = 0.217) and (r = 0.127)with the maximum relative humidity.Patange and Chiranjeevi (2017) reported that the data analysis revealed non-significant positive correlation (r = 0.0490) between the pupal population of pod flywith maximum relative humidity. Whenever temperature rises, there is a decrease in the pupal population of pod fly.Larval parasitization (*E. lividus*) of pod fly showed non-significant positive correlation (r = 0.313) and (r= 0.360) with maximum temperature in both years. However, in both years larval

parasitization showed non-significant negative correlation (r = -0.160) and negative correlation (r = -0.612*) with the minimum relative humidity.The pupal parasitization (*O. orientalis*) of pod flies exhibited a non-significant correlation (r = 0.194) and (r=0.287) with maximum temperature in both years. While, in both years pupal parasitization demonstrated a non-significant positive correlation (r = 0.003) and significant negative correlation (r = -0.564) with the minimum relative humidity.Our present study is according to previous research workers like Yadav *et. al.*, (2012), which identified a parasitoid community consisting of four species of hymenopteran parasitoids. These include the larval parasitoid *Euderus lividus* (Ashmead) from the Eulophidae family as well as three pupal parasitoids: *Ormyrus orientalis* (Walker) from the Ormyridae family Eurytoma sp. from the Eurytomidae family and Pseudotorymus sp. from the Torymidae family. This research previously aligns that our current findings as two out of the six families studied corroborate with our results (Table-5). Makinson *et. al*., (2005) conducted the initial rearing of two parasitoids, namely *Callitula* sp. (Hymenoptera: Pteromalidae) and *Ormyrus* sp. (Hymenoptera: Ormyridae) from *M. obtusa* found on *Cajanus latisepalus* pods in Australia. The current results align that those reported by Dar *et. al*., (2005) indicating that *Ormyrus orientalis*, a parasitoid species was identified as the primary parasitoid of the pod fly. The current results partially coincide with the research conducted by Chakravarty *et. al*., (2016), where it was shown that *Euderus lividus* and *Ormyrus orientalis* was detected in association with pod fly. The highest natural parasitization rate (31.82% and 25.64%) of *M. obtusa* by these parasitoids occurred during the 46^{th} and47^{th} SMW period.

CONCLUSION

It is concluded that the emergence of two parasitoids of *M. obtusa* (Malloch) viz., *Euderus lividus* (Ashmead) 31.82% and *Ormyrus orientalis* (Walker) 25.64% are effective to reduce pod fly population. Through eco-friendly management by the natural hymenopteran parasitoids occurrence on pod fly.

Table 1. Natural enemies of *Melanagromyza obtusa* (Malloch) in relation with weather parameters 2022-23.

SMW	Pod damage/ 100 pods	Larvae	Pupae	% of Emergence		Temperature (°C)		RH (%)		Rainfall (mm)
				E. lividus	*O. orientalis*	Max.	Min.	Max.	Min.	
41	29	16	10	0.00	0.00	32.00	23.00	59.00	43.00	0.00
42	42	27	28	0.00	0.00	31.00	20.00	56.00	46.00	0.00
43	56	34	30	11.76	0.00	29.00	18.00	53.00	43.00	0.00
44	78	52	32	17.31	9.37	34.00	19.00	56.00	42.00	0.00
45	69	47	28	25.53	17.86	24.00	18.00	59.00	49.00	0.20
46	79	44	41	31.82	21.95	28.00	13.00	52.00	47.00	0.00
47	72	48	39	22.91	25.64	28.00	19.00	81.00	76.00	0.00
48	65	36	42	25.00	21.43	25.00	11.00	89.00	77.00	0.00

49	70	41	45	12.19	13.33	26.00	9.00	89.00	61.00	0.00
50	68	32	49	18.75	8.16	25.00	10.00	97.00	65.00	0.00
51	57	22	46	13.64	4.35	24.00	9.00	90.00	79.00	0.00
52	43	19	27	10.53	3.70	21.00	9.00	98.00	88.00	2.00
1	31	11	31	0.00	3.22	12.00	6.00	98.00	86.00	0.00
2	17	5	8	0.00	0.00	12.00	10.00	94.00	86.00	0.00

Table 2. Correlation between the population of pod fly with weather parameters 2022-23.

Correlation factor	**Temperature (°C)**		**RH (%)**		**Rainfall (mm)**
	Max.	**Min.**	**Max.**	**Min.**	
Damage Pods	0.550^{*}	0.116^{NS}	-0.276^{NS}	-0.360^{NS}	-0.161^{NS}
Larvae	0.646^{*}	0.380^{NS}	-0.472^{NS}	-0.515^{NS}	-0.203^{NS}
Pupae	0.198^{NS}	-0.370^{NS}	0.217^{NS}	0.075^{NS}	-0.140^{NS}
E. lividus	0.313^{NS}	0.018^{NS}	-0.186^{NS}	-0.160^{NS}	-0.049^{NS}
O. orientalis	0.194^{NS}	0.021^{NS}	-0.051^{NS}	0.003^{NS}	-0.146^{NS}

* = significant at 5% level, ns = non-significant

Table-3. Natural enemies of *Melanagromyza obtusa* (Malloch) inrelation with weather parameters 2023-24.

SMW	**Pod damage/ 100 pods**	**Larvae**	**Pupae**	**% of Emergence**		**Temperature (°C)**		**RH (%)**		**Rainfall (mm)**
				E. lividus	***O. orientalis***	**Max.**	**Min.**	**Max.**	**Min.**	
39	25	14	0	0.00	0.00	34.30	19.96	92.65	65.50	0.00
40	32	26	7	0.00	0.00	34.03	17.42	92.38	51.33	0.20
41	41	27	13	4.17	0.00	32.51	16.32	92.81	45.53	0.00
42	43	29	26	13.79	11.53	28.31	13.12	92.79	51.68	0.80
43	52	35	30	22.85	23.33	31.16	12.36	92.95	35.87	0.00
44	73	41	37	24.39	24.32	31.32	13.30	94.01	45.82	0.00
45	65	37	40	29.72	22.50	29.05	13.57	93.23	47.22	0.60
46	61	30	32	23.33	18.75	27.06	10.20	93.84	49.26	0.00
47	53	22	37	9.09	10.81	26.70	7.38	92.48	40.96	0.20
48	40	21	28	0.00	17.85	22.70	10.10	91.20	59.70	0.20
49	44	17	34	11.76	8.82	23.33	9.44	94.00	47.00	0.00
50	33	14	25	7.14	4.00	20.55	7.77	94.00	52.00	0.00

51	34	8	26	0.00	3.84	21.11	6.66	97.00	57.00	0.00
52	21	9	21	0.00	0.00	16.66	10.55	95.00	74.00	0.00
1	19	0	14	0.00	0.00	10.00	7.22	94.00	87.00	0.00

Table 4. Correlation between the population of pod fly with weather parameters 2023-24.

Correlation factor	**Temperature (°C)**		**RH (%)**		Rainfall (mm)
	Max.	Min.	Max.	Min.	
Damage Pods	0.482^{NS}	0.027^{NS}	-0.149^{NS}	-0.744^{**}	0.246^{NS}
Larvae	0.746^{**}	0.420^{NS}	-0.403^{NS}	-0.776^{**}	0.376^{NS}
Pupae	-0.091^{NS}	-0.541^{*}	0.127^{NS}	-0.513^{NS}	0.245^{NS}
E. lividus	0.360^{NS}	0.035^{NS}	-0.055^{NS}	-0.612^{*}	0.303^{NS}
O. orientalis	0.287^{NS}	-0.084^{NS}	-0.219^{NS}	-0.564^{*}	0.276^{NS}

* = significant at 5% level, ns = non-significant

Table 5. Two Parasitoids on pod fly, *Melanagromyza obtusa* in pigeon pea.

S. no.	**Species**	**Family**	**Order**	**Stage attacked**
1.	*Euderus lividus* (Ashmead)	Eulophidae	Hymenoptera	Larval stage
2.	*Ormyrus orientalis* (Walker)	Ormyridae	Hymenoptera	Pupal stage

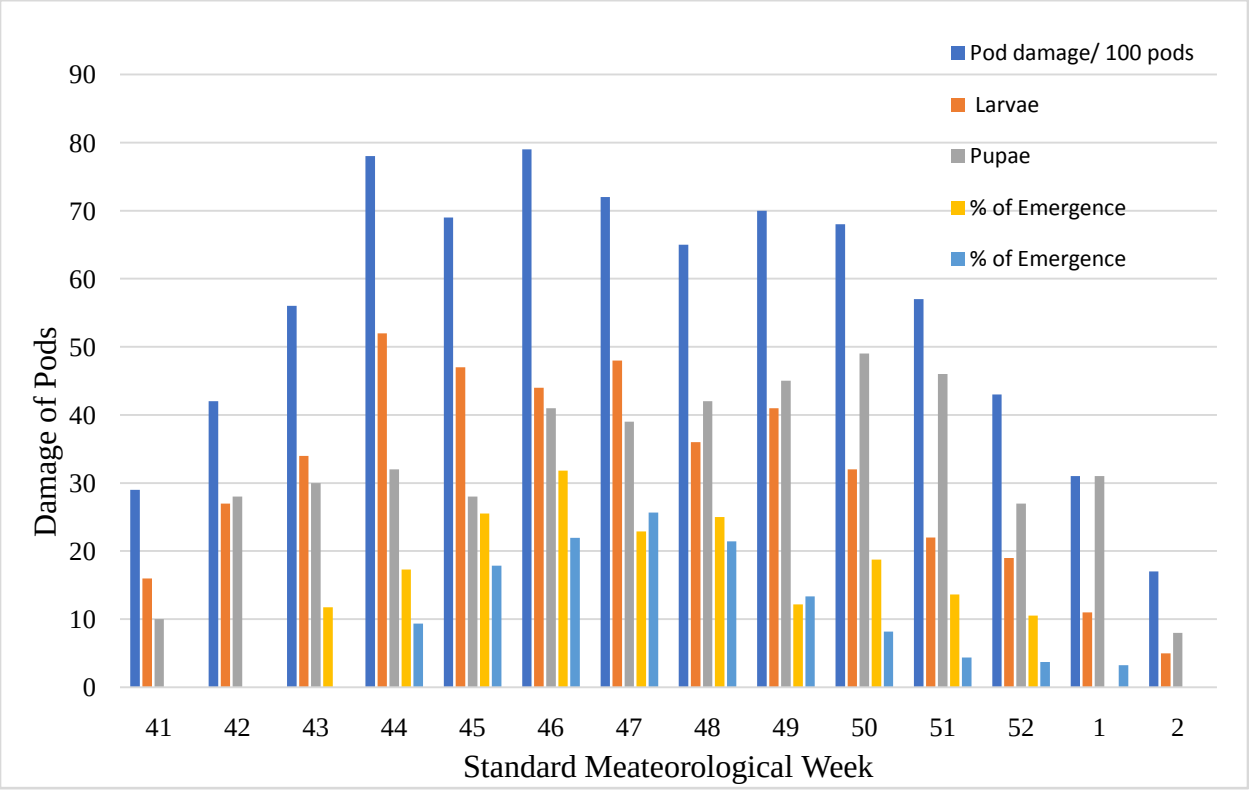

Figure 1. Chart of percentage of natural parasitization on pod fly 2022-23.

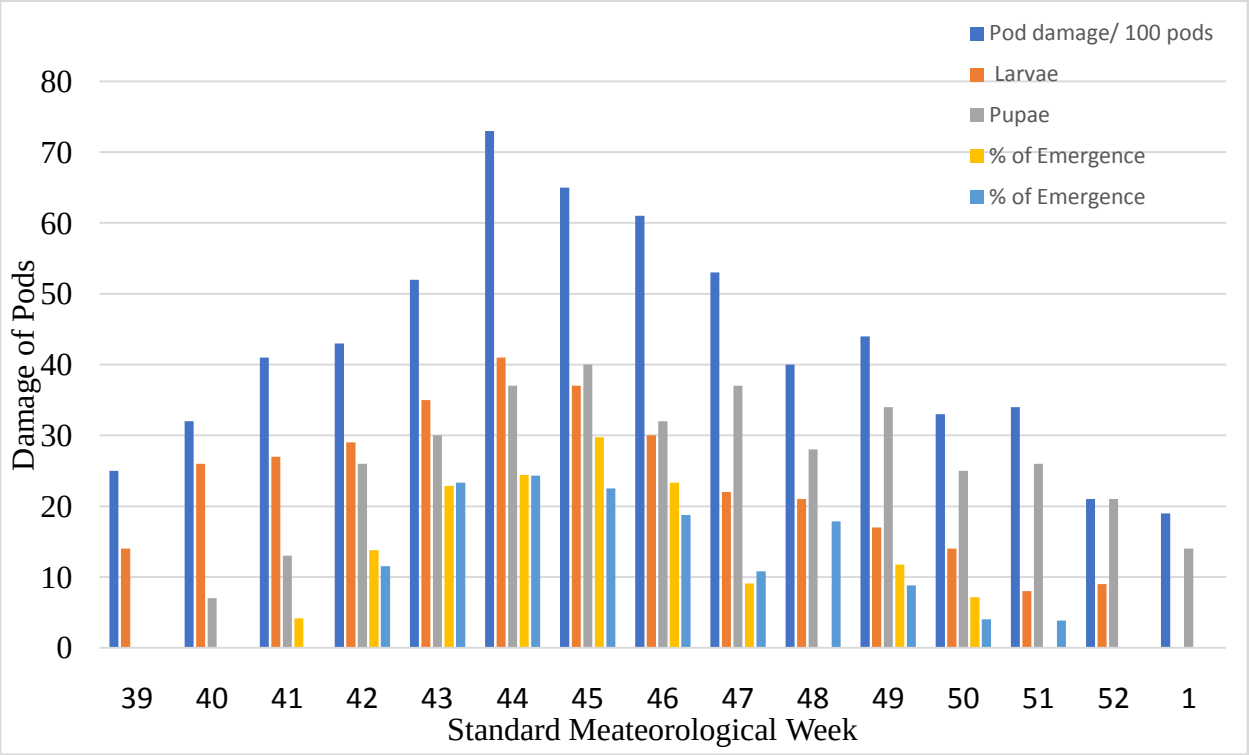

Figure 2.Chart of percentage of natural parasitization on pod fly 2023-24.

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