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Standard IPM measures against an invasive pest Mealy bug, *Drosicha Sp*. (Homoptera: Coccoidea) on Willow tree (*Salix Wilhelmsiana*) in Skardu, Pakistan

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Abstract
The *Drosicha* sp (mealy bug) is an invasive and polyphagus pest in Baltistan, Pakistan. This pest was recorded in 2005, as primary pest of willow tree (*Salix wilhelmsiana)*. The secondary hosts of *Drosicha* sp was recorded in Skardu region are apricot, apple, cherry, and mulberry. Our study was designed to find out Integrated Pest Management strategies against the *Drosicha* mealy bug. The Gunny bag wrappings along with mud paste was showed best cultural practice to stop the crawlers as in June only 6.0± 0.92 mealy bug was recorded per plant as compared to control (12.000± 1.03). The dispersal behavior (altitude and water availability) mainly affects the infestation of mealy bug in Skardu region. The mealy bug infestation at Chumik was statistically found maximum as compared to Halqa two and Hassan colony. The *Sumnius renardi* was observed as a predator of mealy bug in the field. The population dynamics of mealy bug was showed positive correlation with temperature. The temperature greatly affects the population and reproduction of mealy bug in Skardu. The maximum percent mortality was caused by Movento® 240SC (Spirotetramat +Imidacloprid) 47.13% after 72 hours of application.

Keywords: Mealy bug, insecticides, *Salix wilhelmsiana*, population dynamics, gunny bag, *Sumnius renardi*

1. Introduction
The mealy bug, *Drosicha sp* (Homoptera: coccidae) are soft bodied insects. About 5000 species of mealy bug recorded from all over the world from 246 families of different plants species [2]. The *Drosicha sp* mealy bug is one of the most devastating pests of agricultural crops. From recent decade the tendency of mealy bug invasiveness is increasing towards agricultural and horticultural crops [16]. The name mealy was given by the unique character of mealy bug female of releasing a waxy material from glandular glands of her body in which they laid her eggs. The male of mealy bug are winged while the female are wing less [5].
The mealy bug feeds on sap of plant [4]. The *Drosicha sp* mealy bug sucks the cell sap from succulent part of plant and produce honey dew that reduce surface area of leaves and cause reduction in photosynthesis [1]. Due to the feeding of *Drosicha sp* branches of Plant become weak, in some cases sever infestation may result in premature dropping of fruits [23], ultimately death of whole plant may occur. The mealy bug secretes honey dew on which fungal growth occurs which reduce surface area for photosynthesis and plant health greatly affect. [20]. For the cultural control of mealy bug sticky bands are widely used to stop the crawlers to across the bands and the clustering mealy bugs below the bands are smashed or burn [24]. Burlap bands reduce the population of mealy bug crawlers up to 78.97% when was applied in month of February before emergence of mealy bug nymphs [9].
Several classes of synthetic insecticides were recommended for control of mealy bug including pyrethroids, carbamates, neonicotinoids, organophosphates, some (IGRs) insect growth regulators [13]. However, main reliance on insecticides results in pest resistance, resurgence, environmental hazards [21]. Because of sucking mouth part of the mealy bug and waxy cover around their body only Systemic Insecticides showed good results as compared to the contact insecticides [21, 22]. However the rapid use of synthetic insecticides results in pest resurgence and resistance [5].

Drosicha mealy bug are attacked by numbers of predators and parsatoids *Sumnius renardi and Sumnius vititus* were identified as the natural enemies of *Drosicha sp* mealy bug [3, 12] Reported that *Sumnius renardi* Weise (Coleoptera: Coccinellidae) as a predator of Mango mealy bug from the tropical region of Pakistan. By considering the importance of *Drosicha sp* mealy bug, the present investigation was aimed to sort out the ecology, behavior and multiple control strategies against the *Drosicha sp* mealy bug in Skardu, Pakistan.

2. Materials and Methods

The field experiment was carried out in Skardu, Pakistan during 2015. Skardu city is located in the north of Pakistan 35° 18' North, 75° 37' East at an altitude of nearly 2,500 meters (8,202 feet).

2.1 Population Dynamics: The number of mealy bug was counted from five selected branches at 2:00pm of three willow trees from three locations. Location was selected on the bases of difference in latitude, altitude, and availability of water. The temperature data was obtained from Agriculture Department Skardu Baltistan.

2.2 Dispersal behavior: The study area was divided into three parts, Chumick (2,350 m (7,709 ft), Hassan Colony (2,500 m (8,200 ft) and Halqa Two (2,150 m (7,053 ft) based on difference in topography and elevation. Overall three surveys were conducted during the month of June, July, and August; during these months mealy bug proliferation is on its peak in Skardu. Data were recorded by counting number of mealy bug on five selected tagged branches of three willow trees from three locations.

2.3 Cultural control: According to [9] gunny bags wrapping technique was not proved to be useful to stop the crawlers. In our case we did a modification by filling the cracks on trunk of willow trees with wet mud paste. The gunny bag (size is not same because of difference in diameter of willow trees) was wrapped above the wet mud paste filled in the cracks of willow trees trunk before it dry. The gunny bag was wrapped in such a way that it upper portion was closed tightly and lower portion was wide so that the mealy bug crawlers cannot across the wrap and form clusters on trunk of trees beneath the gunny bag wrap. The gunny bag wrappings was placed 100cm above the ground and gunny bags were wrapped on trunk of tree in 20th of February before emergence of mealy bug. The soil around the trunk of tree was also ploughed to destroy previous eggs of mealy bug. Six trees were randomly selected from each site and three of them given treatment and three were left untreated to compare the effect of intercultural practices. Data was recorded as number of mealy bug on trunk of willow trees above the gunny bag wrappings.

2.4 Chemical control: Four broad spectrum systemic Insecticides from Bayer Crop sciences and Syngenta Pakistan were selected on the basis of feeding behavior of mealy bug, Curacron® 500 EC (Profenofos), Belt® 480 SC (Flubendiamide), Actara® 25W/G (Thiamethoxam) and Movento® 240SC (Spirotetramat + Imidacloprid) were applied during July. The insecticides were applied in open field at Chumik as population of mealy bug was more at Chumik as compared to other location in Baltistan. First we selected the willow trees where infestation of mealy bug is more. For each insecticide three replications were made. Total 15 willow trees were selected including control where only water with detergent was sprayed. The dose of insecticides was made according to the Company label, Motorized Knack Sack sprayer was used to spray insecticides. Data were recorded on indiscriminately selected from three branches from different sides of the willow tree by recording the numbers of mealy bugs on each selected branches. Each branch was tagged before application. Data were recorded after interval of 24, 48, 72 and 96 hours after insecticides application and control were treated with water and detergent spray. The aim of this trail was to find the most suitable insecticide for the control of mealy bug in Skardu region.

2.5 Natural enemies associated with mealy bug: For finding the predator of mealy bug in Skardu region we did survey during peak population of mealy bug in month of June and July, 2015. Survey consisted of five weeks. We frequently visited the selected locations, Chumick, Hassan Colony, and Halqa Two for finding predator of mealy bug. Data was recorded by counting the numbers of any available predator from the selected willow trees.

2.6 Statistical Analysis

The experimental data was subjected to one way ANOVA and treatments mean was separated, using by using Tukey's HSD test at 5% level of significance using Statistics (Version 6, Stat Soft, Inc., Tulsa, OK, USA). [15]

3. Results

3.1 Population dynamics: Studies on population dynamics of mealy bug revealed that in March, the highest mean population of mealy bug was recorded from Chumik that was 6.3±0.11 followed by Halqa Two 5.3± 0.09 and Hassan colony 4.01±0.07.The population of mealy bug increased with increased in temperature. The mean temperature was recorded from 24.9 °C**.** March to September. The maximum number of mealy bug was recorded from Chumik in June and July followed by Halqa Two and Hassan colony i.e. 15.15±0.97, 12.23±0.82, and 9.11± 0.45 respectively. A positive significant correlation was recorded between temperature and population of mealy bug. The temperature of Skardu region increased from first week of March.

Mealy bug started appearing after 2nd week of March but the population was very low as increased in temperature their population also increases from mid of June when minimum temperature of Skardu region ranges 20-30 °C maximum number of mealy were seen feeding on willow trees. Statistical analysis of the data showed that temperature has positive and significant correlation with the population of mealy bug. In the month of June and July highest population of mealy bug was recorded per plants. Data showed that temperature was optimum in July which ranged from 20-30 °C in Skardu region. During August and September temperature starts declined in Skardu region and after 25th of August mealy bug wrapped themselves in waxes and drastic decreased in their population was occurred. Statistical analysis of the data revealed that a positive significant correlation is present between population and temperature after 1st week of September only waxes are seen on willow trees (Figure1).

3.2 Dispersal behavior: Dispersal behavior of mealy bug observed in Skardu region during our research is quite peculiar. Infestation of mealy bug was more at higher altitudes. Infestation at Chumick is more as compared to

Halqa two and Hassan colony. During our study it was observed that maximum number of mealy bug infestation was on the willow trees which are nearer to water channels as compared to those willow trees which are far from water channels. The reason may be due to more sap content in trees near to water channel as mealy bugs are sap feeder they lived plant with more sap. Humans and domesticated cattle's may help in dispersal of mealy bug as infestation was observed more along road sides and those sites where humans and cattle's frequently visit.

3.3 Cultural control: The Gunny bag wrappings along with mud paste revealed that in March mean number of mealy bug crossed or trapped in the gunny bag wrapping were 2.286± 0.37 per plant while on control plant the mean number of mealy bugs recorded were 4.571± 0.58 per plant while highest number of mealy bug across the gunny bags wrapping were recorded in the month of June was 6.0± 0.92 per plant while on control 16.000± 1.03 per plant (Figure 2).

3.4 Chemical control: Percentage mortality of Mealy bug after application of insecticides data after 24 hours of application data showed that Movento® 240SC (Spirotetramat + Imidacloprid) caused 7.21% mortality and Belt® 480 SC (Flubendiamide) caused 4.32% mortality (Johnson, 2009) while Actara® (Thiamethoxam) caused 1.45%, Curacron® 500 EC (Profenophos) caused 1.22% mortality respectively as compared to control treatment where mortality was 0.32%. After 48th hours of insecticides application showed that maximum mortality was caused by Movento® 240SC (Spirotetramat + Imidacloprid) 12.19% followed by Actara® 25W/G (Thiamethoxam), Belt® 480 SC (Flubendiamide) and Curacron® 500 EC (Profenophos) where the percent mortalities were 7.77, 6.79 and 5.80% respectively while on control plot mortality was 0.89%. Maximum mortalities were observed after 72 hours of application by Movento® 240SC (Spirotetramat + Imidacloprid) which caused mortality of 47.13% while Actara® 25W/G (Thiamethoxam) 11.16, Curacron® 500 EC (Profenophos) and Belt® 480 SC (Flubendiamide) caused mortalities of 6.76 and 4.43% respectively while on control treatment mortality were noted 0.91% (Karar *et al.,* 2010). After 96 hours of insecticide application maximum mortality was observed on Movento® 240SC (Spirotetramat + Imidacloprid) 9.21% followed by Curacron® 500 EC (Profenophos) where mortality recorded was 2.23%, Belt® 480 SC (Flubendiamide) and Actara® 25W/G (Thiamethoxam) caused mortalities 1.45 and 1.35% respectively. Overall data revealed that Movento® 240SC (Spirotetramat + Imidacloprid) caused maximum mortalitiese of mealy bugs that was recorded 18.93% fallowed by Actara® 25W/G (Thiamethoxam) was 5.44%, where Curacron® 500 EC (Profenophos) and Belt® 480 SC (Flubendiamide) caused mortalities 4.00 and 4.22% respectively (MAITLO *et al.,* 2014) (Table 1). Overall Statistical analysis showed that Movento® 240SC (Spirotetramat + Imidacloprid) statistically significant as compared to other three insecticides however all the insecticides were founded statistically significant from the control where only water with detergent was sprayed.

3.5 Natural enemies associated with mealy bug: So far the population of *S. renardi* observed was low as compared to the population of mealy bug. However statistically there was no significant difference (P<0.5657) between the populations of *S. renardi* from three locations. From chumik the population of *S. renardi* recorded was highest as compared to Hassan colony and Halqa Two. Overall mean population of *S. renardi* recorded (8.8000±0.66) from Chumik was highest and from Halqa Two and Hassan colony where mean population 4.4000±0.51 and3.8000±0.66 was recorded (Figure.3).

Table 1: Mean Percent mortalities of mealy bug after application of insecticide

Treatment	Dose per Tree	24th Hours	48th Hours	72 hours	96 hours	Overall mean
Curacron®	15ml/5L of water	1.22c	5.80b	6.76b	2.23b	4.00b
Actara®	15g/5L of water	1.45c	7.77b	11.16b	1.35b	5.54b
Belt®	20g/5L of water	4.32b	6.70b	4.43b	1.45b	4.22c
Movento ®	15ml/5L of water	7.21a	12.19a	47.13a	9.21a	18.93a
Control		0.31c	0.65c	0.89b	0.91b	0.69c
LSD		2.38	3.74	20.03	2.14	1.70

Mean ± standard deviation. Means in the same column having same letter(s) are not significantly different according to Tukey's HSD test at *P=0.05.*

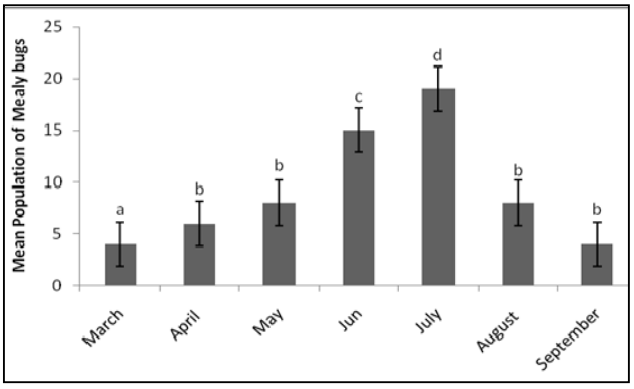

Fig 1: Monthly mean population of mealy bug in Skardu during 2015. Means in the same column having same letter(s) are not significantly different according to Tukey's HSD test at *P=0.05.*

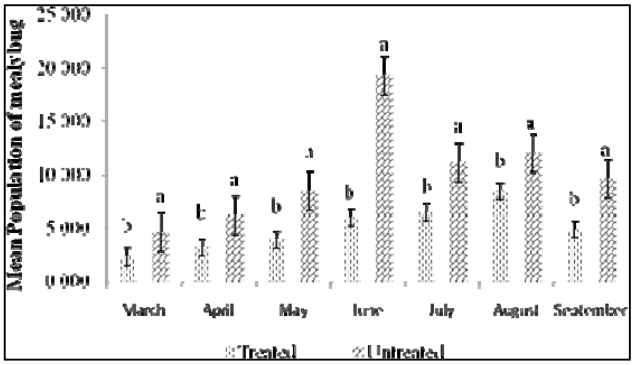

Fig 2: Effect of gunny bags wrapping on crawling of mealy bug on willow trees. Means in the same column having same letter(s) are not significantly different according to Tukey's HSD test at *P=0.05.*

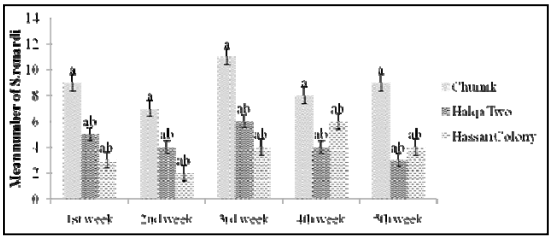

Fig 3: Mean number of *S. renardi* recorded from three locations from Skardu during 2015. Means in the same column having same letter(s) are not significantly different according to Tukey's HSD test at *P=0.05*.

4. Discussions

From our recent investigation it was proved that gunny bag wrappings along with mud paste proved best cultural practice under the agro climatic condition of Skardu. Results revealed that only few mealy bugs can cross the wrapping as compared to the control. Temperature greatly affected the population of mealy bug in Skardu region a positive significant correlation ($P<0.005$) was founded every increase and decrease in temperature showed fluctuations in the population of mealy bug in Skardu region every increase or decrease in temperature greatly affect the population. Our findings are with accordance of [17, 10] in which they stated that 20-30 °C is suitable for mealy bug proliferation, their population, reproduction are increased as increased in temperature a positive significant correlation were also observed. [19] Investigations on *Bactrocera invadens* found that with the increase of temperature from the end of April till end of June population was at its highest level. As the temperature was optimum in July and During August and September temperature starts declining in Skardu region. Similar studies on fruit fly by [6] concluded that shortest hatching period of eggs and no egg hatching in temperature range of 12.5-15 ºC. [13] Also found strong positive correlation between temperature and population during attraction study on *Ideo scopus clypealis* towards sticky color traps.

Dispersal behaviour of mealy bug in Skardu region was mainly based on altitude and water availability. Skardu region topography is inclined we found mealy bug population is more in those areas where altitude low and water availability is more while in upper areas altitude is more and quite less water is available for plant. But it was observed that in few years that mealy bug also starts spreading slowly in upper areas adopting higher altitude. During survey it was found that transportation of infesting burning wood and graft helps in dispersal of mealy bug in non-infested areas of Skardu. While human and animals are also found a source of dispersal. [7] Reported "cost" that is the consumption of herbivores and if we have to determine the effect of predator on population dynamics we have the knowledge about the number of prey killed.

From our recent study we able to say that gunny bag wrappings along with mud paste proved best cultural practice under the agro climatic condition of Skardu. Results revealed that only few mealy bugs can cross the wrapping as compared to the control. Overall results of gunny bags showed that it stops the crawlers to across the bags and mealy bug make cluster inside the wrappings and easily smash them manually. Our findings are not in agreement with the findings of [9] they stated that gunny bags are not fruitful to stop the mealy bug crawlers while in our case gunny bag wrapping proved best cultural control of mealy bug due to modification in wrapping method and filling mud paste. [14] In another study on *Drosicha sp.* found gunny bag wrappings have strong capability to stop the crawlers of mealy bug to across.

The present study revealed that from four pesticides used (Spirotetramat + Imidacloprid) showed maximum mortality against mealy bug these results confirm the finding of [18] that insecticide mixture with dual mode of action is more efficacious against insect pests. (Dhawan *et al.,* 2009; [8] investigates the insecticides mixtures against cotton mealy bug *P. Solenopsis* and found (Spirotetramat + Imidacloprid) most effective.

According to our study *S. renardi* was found to be predating *Drosicha sp* mealy bug, but population was minimum as compared to mealy bug. Prey population can be directly affected if consumed by predator and play important part in food web [11].

5. Future Perspective

We recommend field trials and mass rearing of *S. renardi* and further study for better result upon augmentative release.

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