DEMOGRAPHIC STUDY OF *DROSICHA SPECIES* FED ON DIFFERENT HOSTS UNDER LABORATORY CONDITIONS IN SKARDU, GILGIT BALTISTAN

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Abstract

The life history parameters of mealybug, *Drosicha sp*, fed on willow (*Salix wilhelmsiana)* and apricot (*Prunus armeniaca* L.) hosts were studied under laboratory conditions at 25 ± 2 °C temperature and 60-65 relative humidity in the Integrated Pest Management Laboratory of Agriculture Directorate Skardu during 2019-2020. The data regarding the life table parametrs viz the mean generation time (*T*), finite rate of increase (λ), the intrinsic rate of increase (*r*) and net reproductive rate (*Ro*) of *Drosicha sp* reared on willow and apricot hosts were (60.96 ± 0.357, 62.45 ± 0.422) days, (1.085 ± 0.002, 1.079 ± 0.002) days, (0.081 ± 0.001, 0.076 ± 0.002) days, (147.66 ± 15.97, 120.9 ± 14.47) eggs/female respectively. The results further revealed that significant differences were observed in the developmental times, adult longevity and fecundity of *Drosicha sp* when reared on willow and apricot hosts. Male longevity was recorded longer on willow (64.46 ± 0.924 days) as compared to apricot (63.5 ± 1.27 days). Similarly, female longevity observed shorter on willow (67.80 ± 0.42) as compared to apricot (69.78 ± 0.48 days). *Drosicha sp* reared on apricot resulted in significantly decreased oviposition days (5.060 ± 0.113) and fecundity (219.81 ± 5.487 eggs) as compared to *Drosicha sp* reared on willow. These results revealed that the invasive mealybug, *Drosicha sp* can be considered as serious threats to willow, apricot and other ornamental plants in forests and fruits orchards. Therefore, understanding of the demographic study *Drosicha sp* is important for the success of its management program.

Key Words: *Apricot, Demographic, Mealybug, Willow, life table*

Introduction

Willows are deciduous trees or shrubs which belong to the Genus *Salix* having about 400 species distributed worldwide. *Salix wilhelmsiana* is the native and most common naturally growing willow species of Skardu- Gilgit Baltistan, Pakistan. Willows trees provide fuel, fodder and green cover to the beautiful land of Gilgit Baltistan. But presently, the survival of this species in the area is endangered due to severe insect pests attack and other infectious diseases. Major pests include mealybug, aphids, scales and leaf curl virus. Among these pests, mealybug pose serious threats to the willow forestation in the region (Alford, 2012). Besides willow

trees, *Drosicha sp* has also been observed on apricot, mulberry and other horticultural crops as a secondary pest (Rizvi *et al.,* 2016). Apricot (*Prunus armeniaca* L.) is an important and essential fruit of Gilgit Baltistan. Due to high nutritional value and pleasant aroma, apricots are cultivated and consumed all over the world (Solis-Solis *et al.,* 2007). Apricots contain dietary fibers which play important role in diabetes, malfunctioning of the digestive tract, cancer and prevention of other diseases (Enomoto *et al.,* 2010; Waterhouse, 2009). Unfortunately, due to lack of facilities and other techniques, a major portion of the apricots are lost at the farm level. Further severe losses in apricot fruit occur mostly due to the birds and insects (mealybug) infestation which leads to the dropping of immature fruits, insects and fungal invasion (Kader and Hussein, 2009).

The mealybug, *Drosicha* specie (Homoptera: Margarodidae) is an invasive and polyphagous pest in Gilgit Baltistan, Pakistan. This pest was first recorded in 2005, as primary pest of the willow tree (*Salix*). Since then, it has become more common in Gilgit-Baltistan and is now a serious pest of forest trees and vegetables in Skardu, Pakistan and adjacent areas (Tanwar *et al.,* 2007). The mealybugs are soft-bodied insects that feed on phloem tissue, suck plant sap and causing distortion and yellowing of leaves. The nymphs and adult bugs suck sap from young leaves, shoots, inflorescence and even fruits. As a result, the flowers become shrunken and get dried. In case of severe infestation, the plants may die. These mealybugs also produce honeydew resulting further in sooty mold growth on the infested plant parts and interfere with the plant photosynthesis process (Venkatesha and Dinesh, 2011).

A mealybug secretes a certain type of fluid or wax that covers their body, therefore the name mealy has been given (Tanwar *et al.,* 2007). Female mealybug lays eggs only once in a year. These eggs are laid two to six inches below the tree or within the bark of the trees. These eggs are enclosed inside a cotton sack which protects these eggs from adverse climatic conditions. A female lays on average 300 to 500 eggs. These eggs hatched in the first week of April or May. The adult mealybugs appear in the first week of July to the end of June. Male and females are distinguished by their wings. Females are wingless while males are winged. Females and males of mealybug (*Drosicha sp)* have two and three nymphal instars, respectively. They need one to four-month to complete their life cycle. Male mealybug dies within a week or two weeks after mating with the female. In late August, *Drosicha* species lay eggs in the soil and die in September (Hodgson *et al.,* 2008). Growers use different methods for the management of the *Drosicha sp*. These include cultural or chemicals. Gunny bags wrapping technique was not proved to be useful to stop the crawlers (Karar *et al.,* 2010; Solangi *et al.,* 2012). *Drosicha sp* is polyphagous in nature, different researchers have studied their biology on a different host (Rizvi *et al.,* 2016). Due to this variation in methodologies, efforts in estimating the true-life table parameters become complicated (Kumar *et al.,* 2013).

Understanding the population variations of pests at different stages of their life cycle necessitates the study of life table factors. It's a type of bookkeeping system that entomologists use to keep track of different insect pests' developmental stages and fatality rates. (Kakde *et al.,* 2014). The most essential analytical tool in ecological studies is the life table, which provides extensive information on population dynamics and allows for the generation of basic but more meaningful statistics. It also goes into great depth about survival, development, and life expectancy. Collecting data on insect survival at different temperatures is an important task for pest control in different environmental condition (Arshad and Rizvi, 2009). Life tables studies are important tools for both theoretical and applied population ecology because they provide full information on insect survival, population development, and death (Chi and Yang,

2003). Keeping in view the importance of life table theory, this study was design to study the life-history parameters of *Drosicha sp* fed on willow and apricot hosts.

Materials and Methods

The research regarding the life history parameters of mealybug, *Drosicha sp*, fed on willow and apricot hosts were carried out at 25 ± 2 °C temperature and 60-65 relative humidity in the Integrated Pest Management Laboratory of Agriculture Directorate Skardu during 2019-2020.

2.1. Rearing of the Mealybug Drosicha sp.

For this purpose, the initial culture of mealybug was collected during the first week of May 2020 from infested areas of District Skardu, Baltistan region. Collection of mealybugs was done using soft hand brushes in Petri dishes along with host leaves and cuttings was brought into the laboratory. The mealybug culture was reared in rearing cages (35×33.7cm) on willow and apricot leaves and cuttings for one generation. The cultures were maintained at 25 ± 2 °C temperature and 60-65 (R.H) in the laboratory. Fresh leaves were provided daily. When a sufficient number of mealybugs were reared, various studies were initiated.

2.2. Life table study of Mealybug on willow host

Age-specific life-tables study of *Drosicha sp* on willow tree leaves was studied in the Integrated Pest Management Laboratory (IPM) Skardu. Ten mated pairs of *Drosicha sp* were released in rearing cages on excised willow leaves and shoots cuttings, with the base of the leaves and cuttings dipped in a bottle of water to keep them fresh. Every two days, the leaves and cuttings were replaced. Approximately sixty freshly oviposited eggs of *Drosicha sp* was used for studying the life table parameter, each egg was considered as a replicate. The eggs were separated using a camel hairbrush. Each egg was transferred into a petri dish containing fresh leaves and shoots cuttings of willow tree. These Petri dishes were observed daily for egg hatching. After egg hatching, various nymphal instars duration was recorded daily. Different instars were confirmed by the presence of exuviae. Full-grown nymph along with willow tree cuttings were transferred into new Petri dishes containing soil for pupation. Adults were seen in these Petri dishes on a daily basis. The presence of wings on newly emerging adults was used to sex them (male have wings, female wingless). After sexing mated pairs were then moved to new Petri dishes for egg laying. The leaves and cuttings were change every two days. Eggs laying data per day per female were counted and recorded daily until the death of all females. The data was recorded on percent egg hatching, survival rate, development period of various stages, pre-pupal and pupal period, pre oviposition period, oviposition period and adult's longevity were measured.

2.3. Life table study of Mealybug on Apricot host

Age-specific lifetables of *Drosicha sp* on apricot tree leaves and shoots cuttings were studied in Integrated Pest Management laboratory Skardu. Ten mated pairs of *Drosicha sp* were released on excised apricot leaves and shoots cuttings in rearing cages. The leaves and cutting were kept fresh by dipping their bases in a bottle containing water and were replaced with new leaves and fresh cuttings every two days.

Approximately sixty freshly oviposited eggs of *Drosicha sp* were used for studying the life table parameters. Each egg was deemed as a replicate. The eggs were separated using a camel hairbrush. Each egg was transferred into a petri dish containing fresh leaves of apricot tree. These Petri dishes were observed daily for egg hatching. After egg hatching, various nymphal instars durations were recorded daily. Different instars were confirmed by the presence of exuviae. Full-grown nymph along with apricot tree leaves and fresh cuttings were transferred into new Petri dishes containing soil for pupation. Every day, these Petri dishes were checked

for the appearance of adults. After sexing one male and one female, newly emerged adults were sexed by the presence of wings (males have wings, females wingless). The mated pairs were then put onto new Petri dishes for egg-laying. Every two days, the leaves and cuttings were replaced. Eggs laying data peer day per female was counted and recorded daily until all the females died. Data on eggs hatching, various developmental durations (nymphs and adults) male and female longevity and reproduction period, Oviposition period were calculated.

2.4. Statistical analysis

The data regarding the life history parameters of mealybug, *Drosicha sp* were analyzed by the computer program TWO SEX-MSChart programe (Chi, 2018).

Results

3.1. Life table parameters

The total developmental time of *Drosicha sp* individually reared individually on willow and apricot hosts under laboratory condition are shown in Table 1. The data showed that non-significant difference was observed for egg developmental duration (*P*= 1.000) when reared on willow and apricot hosts. Further non-significant differences were recorded for nymphal stages (N1 and N2) with *P* values of 0.387 and 0.086 respectively. However, the 3rd nymphal stage of the *Drosicha sp* fed on apricot had significantly longer developmental duration (13.12 ± 0.216 days, *P*= 0.015) as compared to *Drosicha* sp reared on willow host (12.45 ± 0.176 days). There was non-significance difference in the doubling time duration of *Drosicha sp* reared on willow and apricot hosts (*P*= 0.065). *Drosicha sp* reared on willow had significantly lower preadult survival rate (54.88 % ± 0.354 days, *P*= 0.043), significantly lower female total longevity (67.80 days ± 0.424, *P*= 0.002) as compared to *Drosicha sp* reared on apricot host.

Table 1. Developmental time (means ± standard error) of different stages of *Drosicha sp* reared on willow and apricot hosts under laboratory condition.

Stage/Parameter	n *	Willow	n*	Apricot	*P*-value
Egg (days)	60	14.3 ± 0.089	60	14.3 ± 0.094	1.000
N1 (days)	60	13.26 ± 0.258	60	13.566 ± 0.222	0.387
N2 (days)	52	14.30 ± 0.270	47	14.87 ± 0.187	0.086
N3 (days)	51	12.45 ± 0.176	47	**13.12 ± 0.21	0.015
Doubling time (days)	60	8.459 ± 0.193	60	9.028 ± 0.244	0.065
Pre adult survival rate (%)	51	54.88 ± 0.354	47	**55.97 ± 0.41	0.043
Female total longevity (days)	36	67.80 ± 0.424	33	**69.78 ± 0.48	0.002
Male total Longevity (days)	15	64.46 ± 0.924	14	63.5 ± 1.278	0.535
Total longevity (days)	60	60.85 ± 1.893	60	59.36 ± 2.166	0.608

n* indicates number of replicates in each treatment, ** Specifies mean significance difference of different stages of *Drosicha sp* be reared individually on Willow and Apricot hosts using bootstrap technique with 100000 resampling.

The data presented in Table 2 showed that non significance difference was observed in the adult pre oviposition (APOP) of *Drosicha sp* when reared on either willow or apricot hosts (*P*= 0.210), while there was significance difference in the total pre oviposition days (TPOP) of *Drosicha sp* when reared on willow and apricot hosts (*P*= 0.003). The mean oviposition days of *Drosicha sp* when reared on willow and apricot hosts were 5.083 and 5.060 days respectively. The data further showed that *Drosicha sp* reared on willow host had resulted in significantly

higher fecundity (246.11 ± 5.646 eggs) as compared to apricot with 219.81 ± 5.487 eggs (*P*= 0.001).

Table 2. Pre-oviposition period (APOP), total pre-oviposition period (TPOP), oviposition period and fecundity of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions.

Stage/Parameter	**n***	**Willow**	**n***	**Apricot**	***P*-value**
APOP (days)	33	4.277 ± 0.122	36	4.515 ± 0.144	0.210
TPOP (days)	36	58.83 ± 0.415	33	**60.60 ± 0.438	0.003
Oviposition day	36	5.083 ± 9.939	33	5.060 ± 0.113	0.887
Fecundity (egg)	36	**246.11 ± 5.64	33	219.81 ± 5.487	0.001

n* indicates number of replicates in each treatment, ** Specifies mean significance difference of different stages of *Drosicha sp* be reared individually on Willow and Apricot hosts using bootstrap technique with 100000 resampling.

3.2. Population Parameters

The population parameters of *Drosicha* sp reared on willow and apricot hosts under laboratory conditions are documented in Table 3. The data showed non-significant difference for the mean values of the intrinsic rate of increase (*r*) per day of *Drosicha* sp when reared on willow and apricot hosts (0.081 ± 0.001 and 0.076 ± 0.002) respectively. The results further demonstrated non significance difference for the mean values of finite rate of increase (λ) per day and net reproductive rate (R_0) of *Drosicha sp* as the values for these parameters in willow host were (1.085 ± 0.002 and 147.66 ± 15.97 offspring) per day and that of apricot host were (1.079 ± 0.002 and 120.9 ± 14.47) per day. The data further showed that significantly higher value of the mean generation time (*T*) in days of *Drosicha sp* was recorded on apricot (62.45 ± 0.422) as compared to willow (60.96 ± 0.357 days) i-e. (*P*= 0.007). The gross reproductive rate (*GRR*) of *Drosicha sp* showed non-significant difference (*P*= 0.325) when reared on apricot (188.16 ± 13.56) and willow hosts (217.84 ± 24.81) respectively.

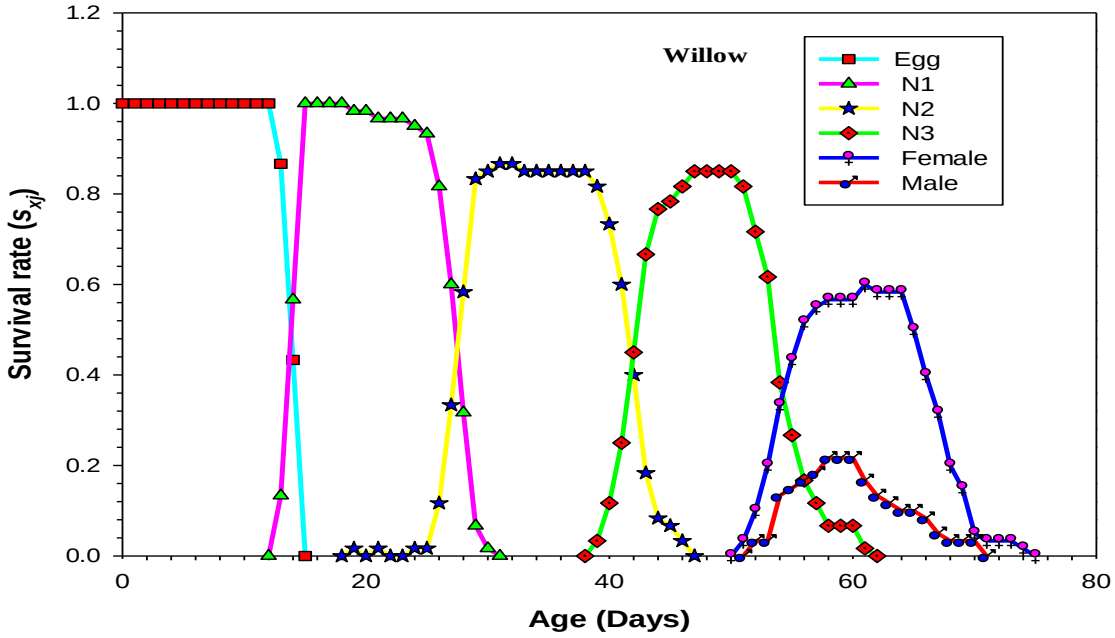
Table 3. Life table parameter (mean ± standard error) of Mealybug (*Drosicha sp*) reared on willow and apricot hosts under laboratory conditions.

Parameter	**n***	**Willow**	**n***	**Apricot**	***P*-value**
The intrinsic rate of increase (*r*) per day	60	0.081 ± 0.001	60	0.076 ± 0.002	0.060
The finite rate of increase (λ) per day	60	1.085 ± 0.002	60	1.079 ± 0.002	0.060
The net reproductive rate (R_0)	60	147.66 ± 15.97	60	120.9 ± 14.47	0.215
The mean generation time (*T*) in days	60	60.96 ± 0.357	60	**62.45 ± 0.422	0.007
Gross reproductive rate(*GRR*)	60	217.84 ± 24.81	60	188.16 ± 13.56	0.325

n* indicates number of replicates in each treatment, ** Specifies mean significance difference of different stages of *Drosicha sp* be reared individually on Willow and Apricot hosts using bootstrap technique with 100000 resampling.

3.3. Age stage specific survival rates (s_{xj})

Age stage specific survival rates (s_{xj}) of *Drosicha sp* mealybug fed on willow and apricot hosts are shown in Fig. 1. The different curves showed that due to changed in the developmental time of the different stages, significant overlapping between the curves were observed. The age stage specific survival rate of *Drosicha sp* for egg reared on willow and apricot hosts were 14 and 15 days respectively. The curves regarding the different nymphal stages of *Drosicha sp* reared on willow were 19, 28, and 23 days for N1, N2 and N3 respectively while the age stage specific survival rate of nymphal stages (N1, N2, and N3) of *Drosicha sp* reared on apricot were 17, 23 and 23 days respectively. Similarly, the age stage specific survival rate curves for the male adult reared on willow and apricot were 25 and 23 days respectively while the age stage specific survival rate for the female adult reared on willow and apricot hosts were 21 and 23 days respectively.



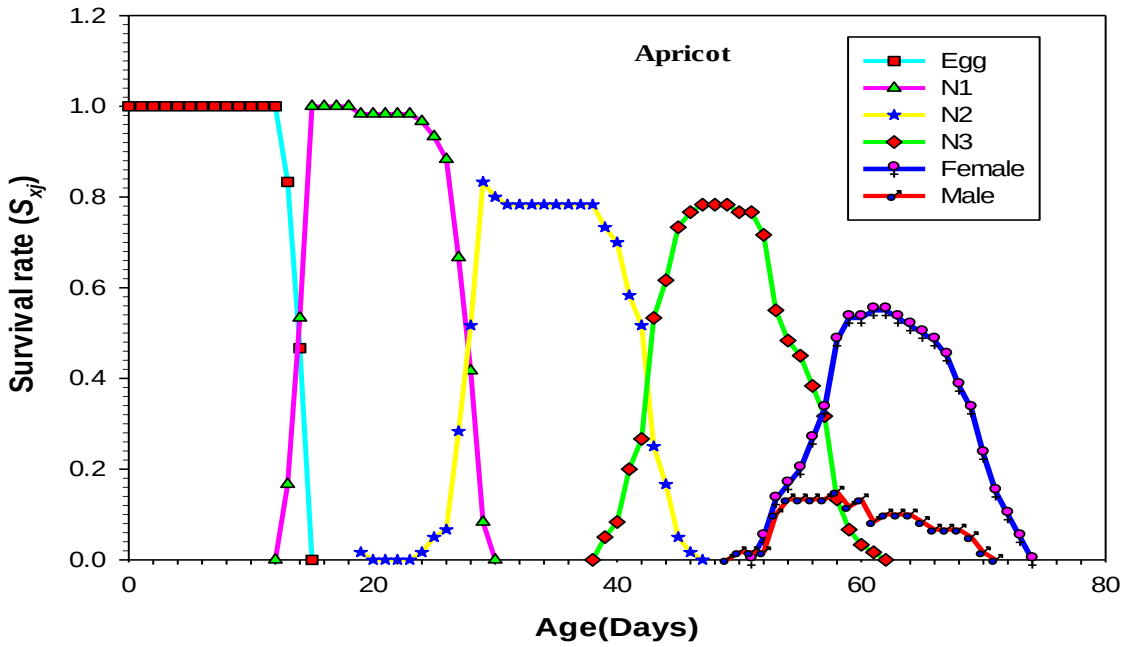


Fig. 1. Age stage specific survival rate of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions

The different curves of the age specific survival rate (*lx*) in Fig. 2 showed that the age specific survival rate (l_x) in *Drosicha sp* gradually dropped early when reared on apricot as compared to willow host. The age stage specific fecundity (f_x) value (41.029 offspring per day) was recorded on day 60 in willow which was higher than on apricot (35.909 offspring per day) on day 62. The curve for the age specific fecundity (m_x) showed greater value (5.361 offspring) reared on apricot at the time of emergence as compared to reared on willow (1.686 offspring). Similarly, the age specific maternity (l_xm_x) of *Drosicha sp* reared on willow host was (23.25 offspring) on day 60 which was greater than the age specific maternity (l_xm_x) (19.75 offspring) on day 62 of *Drosicha sp* reared on apricot host.

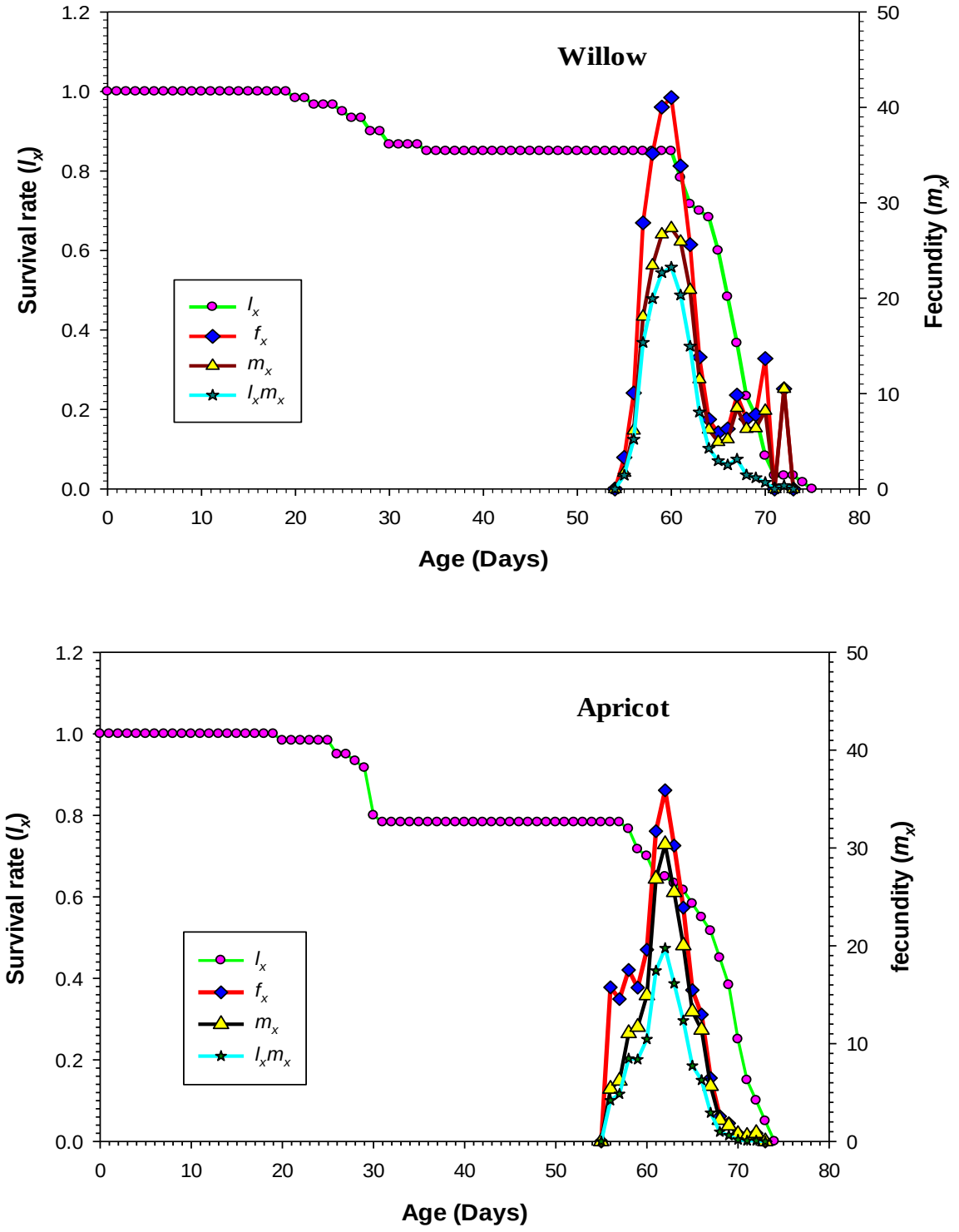


Fig. 2. Reproductive parameters of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions

3.4. The age stage specific life expectancy (e_{xj})

The curves of the age stage specific life expectancy (e_{xj}) of *Drosicha sp* reared on willow and apricot hosts are shown in Fig. 3. The curve of age stage specific life expectancy of newly hatched eggs of *Drosicha sp* reared on willow was 60.85 days while (e_{xj}) of newly hatched eggs

of *Drosicha sp* reared on apricot was 59.36 days respectively. The curves regarding the male and female life expectancy showed that the life expectancy of male (12.17 days) and female was (16.80 days) recorded minimum on willow at the time of emergence. While the life expectancy of male (12.30 days) and female (17.78 days) were recorded maximum on apricot at the time of emergence.

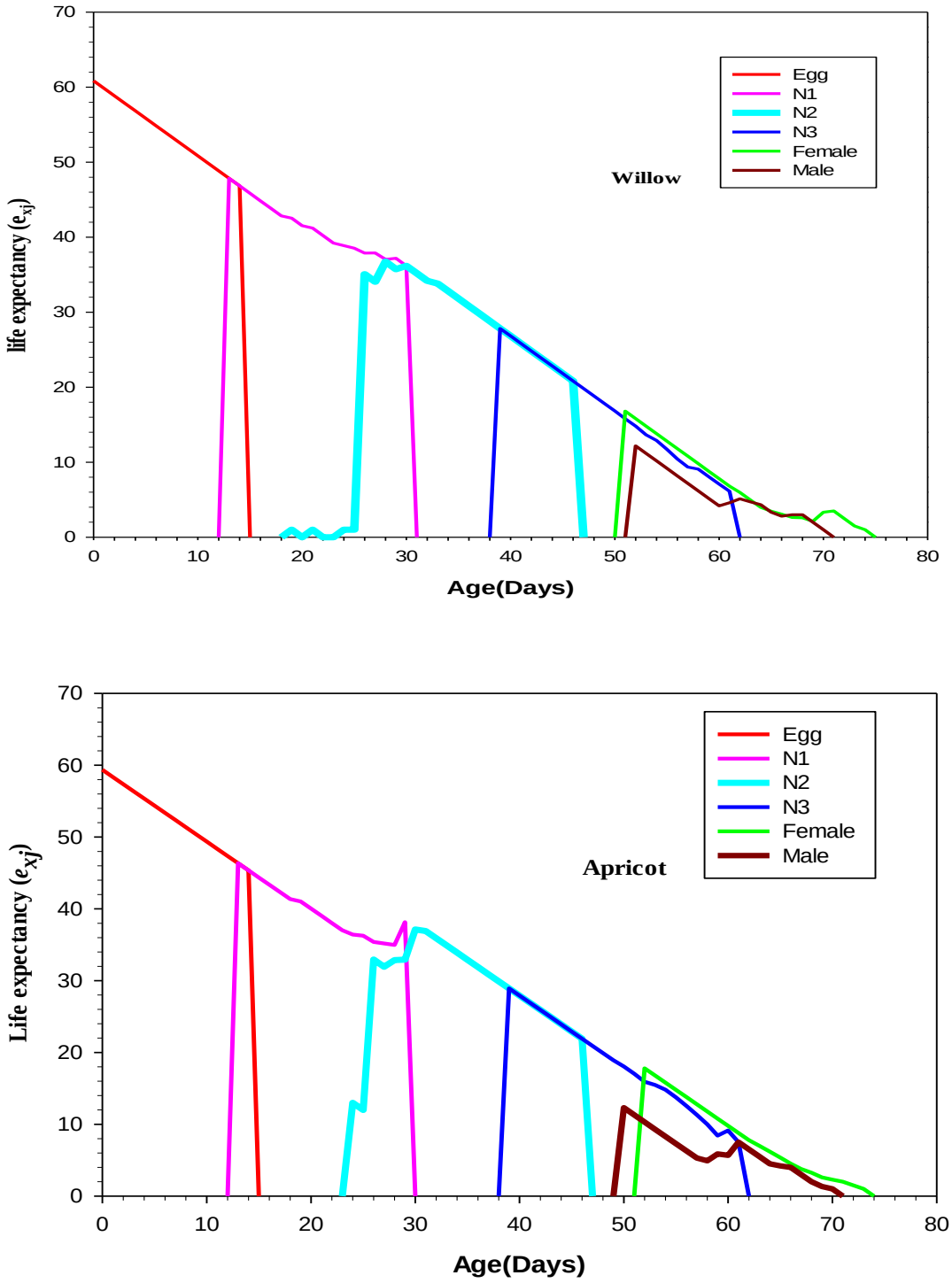
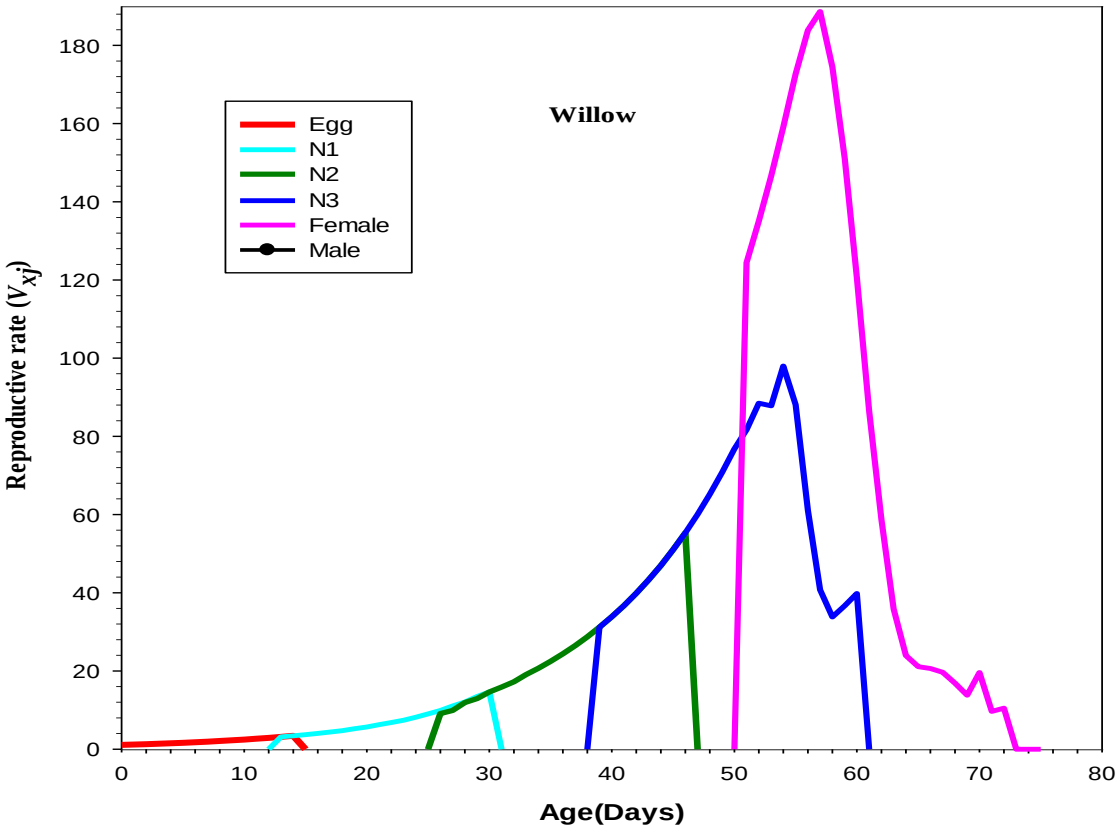


Fig. 3. Age stage specific life expectancy (e_{xj}) of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions.

3.5. Age stage specific reproductive values (v_{xj})

The various curves regarding the age stage specific reproductive values (v_{xj}) of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions are shown in Fig. 4. The various curves showed that the age stage specific reproductive rates (v_{xj}) of a new hatched eggs of *Drosicha sp* were recorded high (1.085 progeny) on willow as compared to the *Drosicha sp* reared on apricot host (1.079 progeny). Curve regarding the female reproductive value showed highest rates of (188.654 progeny) per day on day 58 when reared on willow which was higher than the reproductive rate of *Drosicha sp* when reared on apricot (160.64 progeny) on the day 56.



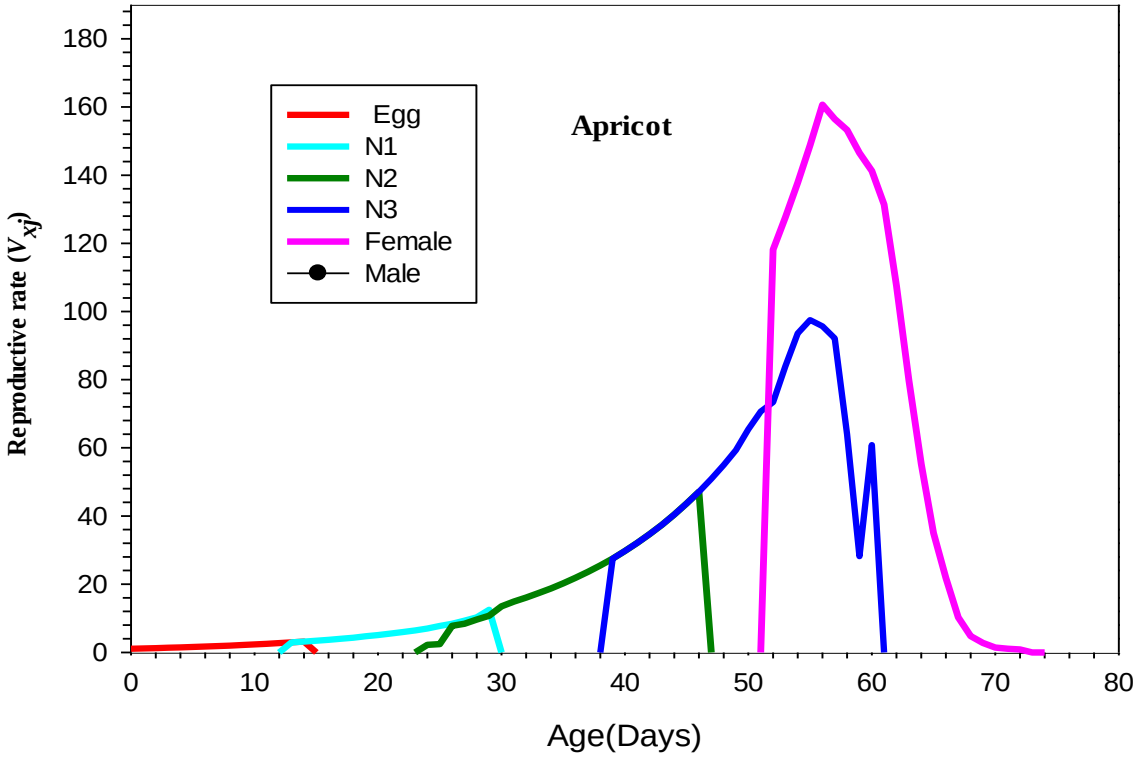


Fig. 4. Age stage specific reproductive values (v_{xj}) of *Drosicha sp* reared on willow and apricot hosts under laboratory conditions.

Discussion

Understanding the population parameters of insect pests is important in designing integrated pest management programe. This knowlege provides a clue about the population growth rate of the current and next generation of insect pests (Frel et al., 2003). The present research was conducted on the life-tables parameters of *Drosicha sp* reared on willow and apricot tree leaves and shoots cuttings in the Integrated Pest Management Laboratory (IPM) Skardu Gilgit Baltistan. Ten mated pairs of *Drosicha sp* were released on excised willow and apricot leaves in rearing cages. After oviposition sixty eggs were separated using a camel hairbrush. Each egg was transferred into a petri dish containing fresh leaves of willow and apricot trees. These Petri dishes were observed daily for egg hatching. After egg hatching, various nymphal instars duration was recorded daily. Different instars were confirmed by the presence of exuviae. There was significant difference occurred in different stages of *Drosicha sp* due to the availability and different function of their hosts. The mealy bug *Drosicha sp* preferred willow host for feeding as compared to apricot. Host plant cues plays an important role in controlling and deterring different pests population (Golizadeh et al., 2009; Tazerouni et al., 2016; Salim et al., 2021). Plants with antibiotic properties affect the biology and adult performance of the pests (Goldasteh *et al*., 2012; Reddy and Chi, 2015). Bellows *et al*. (1992) and Shahout *et al*. (2011) also reported different developmental time and reproduction rate of mealy bug when reared on different host plants. Musa and Ren (2005) studied the life history parameters of *Bemisia tabaci* on three different bean species and reported that insect select host that meets specific nutritional requirement not offered by others host. Similarly, Syed and Abro

(2003) obtained variable growth pattern of diamond back moth when reared on different hosts and concluded that the difference in growth and development of the diamond back moth may be due to differences in nutrition levels of the host plants.

The current study found that *Drosicha sp* has a shorter life cycle and higher fecundity on willow than on another host. Although a variety of factors influence insect populations, there is a useful relationship between the appropriateness of host plants and their intrinsic growth rate (Soufbaf et al., 2012). The intrinsic growth rate (*r*) is an important indicator of population dynamics. External and internal factors such as plant volatiles, wax, leaf shape, and host plant nutritional quality, or a combination of these elements, have been found to have a significant impact on intrinsic growth rate (Soufbaf et al., 2012; Ahmad et al., 2016).

Our results indicate that the host plant can affect the intrinsic growth rate, finite rate and net reproduction rate of *Drasicha sp*. Goundoudaki et al. (2003) also studied the life history parameters of *Myzus persicae* on Oriental and Virginia tobacco varieties. The conclusion of their study revealed that insect grwoth population can easily be detected by calculating both the life table parameters viz intrinsic rate of increase and net reproduction rate. They further concluded that both of these parameters are significantly affected by nutrients and changing ecological conditions on the hosts.

The age-specific survival rate (l_x) is the simplified version of the survival rate by age stages. Although the differentiation and overlap of stages could not be observed in the (l_x) curve, it was however constructed using the life table of two sex by age stages and could accurately explain the change in survival rate with age. Chi and Huang (2012) demonstrated that incorrect (l_x) curve would be obtained if the usual age-specific female were used. According to our findings, the mean generation time and the net reproduction rate of *Drosicha sp* were much higher on willow than apricot, owing to the fact that willow cuttings are fresh and do not dry as quickly as apricot, allowing the *Drosicha sp* to feed on different days. However, no significance difference was observed between (λ), (*GRR*) and *(r*) per day of the *Drosicha sp* reared onwillow and apricot hosts.

Rearing of the *Drosicha sp* on willow resulted in significantly lower total pre oviposition period (58.83 days) as compared to *Drosicha sp* reared on apricot (60.60 days). Conversely no difference was observed in the oviposition days of *Drosicha sp* when reared on apricot (5.06 days) and willow (5.0833 days). The statistical data also revealed that significantly maximum number of fecundity (eggs/female) of *Drosicha sp* was observed when reared on willow (246.11) as compared to apricot (219.81). Çalışkan et al. (2016) also studied the demographic parameters and biological features of *Phenacoccus solenopsis* on *Hibiscus rosa-sinensis*, *H. syriacus*, *Brugmansia aurea* and *Cestrum nocturnum* under laboratory conditions and reported that total pre-oviposition, oviposition, post-oviposition time, fecundity and longevity are affected by host plant species. Similarly different researchers have documented different estimates of female fecundity of mealy bugs ranging from 90.4 nymphs/female to 424.3 nymphs/female (Abbas et al., 2010; Rashid et al., 2012).

The population growth factors of *Drosicha sp* were much higher on willow than apricot, according to the findings. As a result, willow was a superior host for *Drosicha sp* growth and development than apricot. The difference in some of the findings of the present study with the other researchers may be due to the variation of plant hosts. It is evidence that modification in the developmental time of insect on the base of nutritional needs that reproduce alterations in food intake and feeding behavior (Browne, 1995).

The main purpose of this research work was to examine the overall suitability of *Drosicha sp* life cycle fed on different host. The results revealed that the invasive mealybug, *Drosicha sp* can be considered as serious threats to willow and other ornamental plants in forests and fruits orchards. If the ecological conditions are suitable, the mealybug population will increase rapidly in a short time and will result in significant damage to the forests and fruit

orchards. Further, this study provides a pathway to the farmers for selecting the most suitable biocontrol agents of *Drosicha sp*, to achieve efficient biological control. Therefore, understanding of the demographic study *Drosicha sp* is important for the success of its management program.

Conclusion

The current study concluded that the mealy bug (*Drosicha sp*) effectively feeds on both willow and apricot hosts and hence can be used for mass rearing of *Drosicha sp* and its associated natural enemies under laboratory conditions.

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