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Full Length Article

Effects of Different Food Plants on Reproductive Activities of *Aiolopus* (Oedipodinae: Acrididae: Orthoptera) from District Larkana, Sindh, Pakistan

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Abstract

The genus *Aiolopus* has prevailing position among the band winged grasshopper family *Acrididae*, exhibits definite food preference and some degree of selectivity to certain categories of plants. This selectiveness significantly effects on their reproductive activities. A comparative laboratory study was conducted on two sub-species, namely *Aiolopus thallasinus thalassinus* and *A. thalassimus tumulus*. A rearing was conducted on selected five food plants. The total number of matings was recorded; however, five in *A. thalassinus thalassinus* and four in *A. thalassimus tumulus*. Low preference of plant food significantly affected the number of matings. The prolonged copulation was noted on *Sorghum bicolor* followed by *Triticum aestivum* and mixed diet while, short copulation was noted on *Cynodon dactylon*. Moreover, the number of eggs per pod was also affected by the food preference, *i.e*., *A. thalassinus thalassinus* laid more eggs per pod on *S. bicolor* and *A. thalassinus tumulus* on *T. aestivum*. While both lay less eggs per pod on *C. dactylon*. Mated females were different from unmated female in weight and size. Significant difference in the weight gain was observed on favorite host plant as compared to less favorite host plant. Female shows more weight gain on *Saccharum officinarum*. However, no significant gain in the weight of mated and unmated male was recorded with respect to food plant. This study provides the base line data for pest controlling activities about food preference and their effects on reproductive activities of important pests of cash crops.

Keywords: Food plants; Reproduction; Mating duration; Oviposition; Oviposition duration; Egg per pod

Introduction

Talking about agriculture related areas *Aiolopus* has their own multidimensional rank. It is a major pest that strictly harms food plants and decreases their normal manufacturing. The individuals from genus *Aiolopus* are exceptionally natural pests between the groups of Acrididae. They cause continuous destruction to important harvests *i.e*., maize, millet, wheat, barseem, alfalfa, grasses and vegetables. They are found all over world and in Asia, around 13 species are accepted as major pests (Meena and Singh 2016). *Aiolopus* is found to have a monster regenerative capacity to live in serious climatic conditions. Bughio *et al.* (2014) and Soomro *et al.* (2016) revealed the occurrences of *Aiolopus thalassinus* from different regions of Sindh are thought to be among the fundamental pests of many crops in Sindh.

The species of *Aiolopus* are mostly polyphagous and feed on an extensive variety of food plants (Otte and Joern 1976). Mostly they are feeding on binder crops with extensive diet breadth (Pitafi *et al.* 2016). March and October are observed to be the months where reproduction in species of Oedipodinae takes place. Furthermore, humidity, temperature and mud-covered or sandy soil enhance the degree of reproduction and oviposition. Ananthakrishnan *et al.* (1986) utilized such parameters for dissecting the host; however, the top choice of cotton grasshopper is also the significance of sensillar thickness and variety inside the nourishing assortment. The adult maturation, oocyte formation and egg production of insects can also be determined *via* the nutritional rate of food plant and also determined by the life cycle of hopper (Nzekwu and Akingbohungbe 2002). Fanny *et al.* (1999) observed that the shortest nymphal periods in *Oxya nitidula* when reared on *Panicum maximum*. Furthermore, assessment of meals intake by using an insect is essential knowledge and their effect on natural or agro ecosystems because different host vegetation effect on the development and distribution of grasshoppers (Scriber and Slansky 1981; Slansky 1985). Our main purpose was to study and compare the effects of different food plants on reproductive activities of key pests of the

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genus *Aiolopus* along with their life parameters, reproductive behavior, development, eggs production and growth rate.

Materials and Methods

Study areas

Specimens of genus *Aiolopus* were collected throughout the year 2020 and total 1552 specimens of *A. thalassinus thalassinus* and 1007 specimens of *A. thalassinus tamulus* were collected from different agricultural fields of district Larkana, Sindh, Pakistan, including the villages Mitho Dero, Village Sultan Bughti, Village Hyder Brohi, Village Sher Mohammed Jamali, Village Wada Mahar, Village Panju Dero, Village Aghani, Village Chouharpur, Village Jeewan and Village Mohammed Hayat Brohi. These species were captured at 9:00 am and in the evening one to two h before sunset while in the winter season collection started from 12:00 noon and it was a perfect time for collection.

Sampling and identification of species

The specimen of both genders of *Aiolopus* were mainly gathered from various cultivated areas of Larkana district (27º56'N, 68º41'E) with the help of insect net (10.20 cm in width and 55.12 cm long). The collection of both genders of genus *Aiolopus* was done in the year 2020 beginning in the month of May to November at that time adults were present in the field. Insect pest collected from agricultural areas *i.e*., maize, millet, wheat and common grasses. Adult male and female directly transferred in perforated plastic jars and offer their preferred food plant before moving to laboratory. Then dissimilar species were seprated by utilizing keys. After that couples (both male and female) of dissimilar species of *Aiolopus* were segregated and moved to 4 L plastic container and fed with dissimilar nutrients vegetation to live for extended period.

Stock culture and rearing

Mature couples of the species of genus *Aiolopus* reared on four food plants *i.e*., mixed diet, *Sorghum bicolor* (millet), *Saccharum officinarum* (Sugarcane), *Zea mays* (Maize, Corn) and *Cynodon dactylon* (common grass). Five couples of each species kept in separate plastic container (4 L) couple alongside favorite food plant underneath semi-controlled research center conditions at temperature went between 30 ± 2°C to 41 ± 2°C and humidity between 32 ± 2 to 65 ± 2%. For rearing, the technique was applied as it was designated by Riffat and Wagan (2010) and followed standardized cleaning procedure for insect rearing. Food plants freshly brought from field and put damp soil in beaker (200 mL) or clay pot for oviposition and checked these samples regularly.

Reproduction parameters of adults *Aiolopus*

Single male and female adults *Aiolopus* set up in five plastic containers with base enclosed wheat bran. The insect stock culture is maintained on specific food plants until death, with 15 replicates on each food plant. The following parameters counted for copulation for example time spell prior then afterward copulation and mating period. For oviposition beaker/pot filled with damp, disinfected soil (gravel sand) placed in each jar, soil disinfection was done using an oven model SANFA, DHG-9202 for 48 h likely to sterilize the soil and prevent contamination. The following parameters were measured *i.e*., Pre-oviposition period, oviposition duration, number of pods laid and eggs per pod.

Results

Distribution of genus *Aiolopus* on selected food from various localities of District Larkana

During this study the total of 1552 specimens of *A. thalassinus thalassinus* were collected from various fields of agriculture *i.e*., *S. bicolor*, *Triticum aestivum* (common wheat), *S. officinarum* and *C. dactylon*. Out of 1552 specimens, the maximum numbers were collected from *S. bicolor* field *i.e*., 905 specimens followed by *T. aestivum* (common wheat) *i.e*., 432 specimens and minimum collection was done on *C. dactylon* (common grass) *i.e*., 96 specimens were collected while 1007 specimens of *A. thalassinus tamulus* were collected. Out of 1007 specimens, the highest number of 535 collection was made on *T. aestivum* (common wheat) from this field, furthermore from *S. bicolor* field 278 specimens were collected whereas a smaller number (75 specimens) was from *C. dactylon* field (Table 1, 2).

Monthly collection of genus *Aiolopus*

The collection of species of genus *Aiolopus* in various months was done. In *A. thalassinus thalassinus* the highest number of collections was made in five months May, June, July, August, and September. In May, the percentage of collection was 11.6%, in June 27.1%, in July 35.5%, in August 11.0% and in September 7.1%. The most favorable months for collection were May, June, July, August, September while lowest collections were made in March (1.9%) and October (0%). This is due to the fact that *A. thalassinus thalassinus* is a polyvoltine species and gives more than two generations. Therefore, the population of *A. thalassinus thalassinus* was dominant as compared to *A. thalassinus tamulus* (Fig. 1).

In *A. thalassinus tamulus* maximum collection was done in June, July and August. In June the extent of collection was 34.9%, in July 29.1%, in August14.0%. A minimum collection of specimens was made in the months of March (1.8%) and October (0.8%), as we know that *A. thalassinus tamulus* is a bivoltine species and gives only two generations in a year that's why collection of *A. thalassinus tamulus* as compared to *A. thalassinus thalassinus* was lower (Table 3; Fig. 2).

Table 1: Distribution of genus *A. thalassinus tamulus* on selected food from various localities of district Larkana in the year 2020

S. No	Locality	*S. bicolor*		*T. aestivum*		*S. officinarum*		*C. dactylon*	
		Total no. of specimens collected 1007							
		No. of specimen	%	No. of specimen	%	No. of specimen	%	No. of specimen	%
1	Village Mitho Dero	13	1.2%	112	11.1%	23	2.2%	17	1.6%
2	Village Sultan Bughti	63	6.2%	83	8.2%	9	0.8%	9	0.8%
3	Village Sher Mohammed Jamali	73	7.2%	77	7.6%	17	1.6%	11	1.0%
4	Village Hyder Brohi	35	3.4%	63	6.2%	9	0.8%	7	0.6^
5	Village Wada Mahar	19	1.8%	43	4.2%	12	1.1%	6	0.5%
6	Village Mohammed Hayat Brohi	37	3.6%	32	3.1%	13	1.2%	5	0.4%
7	Village Panju Dero	9	0.8%	19	1.8%	7	0.6%	6	0.5%
8	Village Agani	7	0.6%	17	1.6%	5	0.4%	5	0.4%
9	Village Chouharpur	13	1.2%	26	2.5%	9	0.8%	4	0.3%
10	Village Jeewan	9	0.8%	63	6.2%	15	1.4%	5	0.4%
	Total	278		535		119		75	

Table 2: Shows distribution of genus *A. thalassinus thalassinus* on selected food from various localities of district Larkana in the year 2020

S. No	Locality	*S. bicolor*		*T. aestivum*		*S. officinarum*		*C. dactylon*	
		Total no. of specimens collected 1552							
		No. of specimen	%	No. of specimen	%	No. of specimen	%	No. of specimen	%
1	Village Mitho Dero	77	4.6%	119	7.6%	35	2.2%	13	0.8%
2	Village Sultan Bughti	178	11.4%	83	5.3%	13	0.8%	15	0.9%
3	Village Sher Mohammed Jamali	80	5.1%	14	0.9%	12	0.7%	5	0.3%
4	Village Hyder Brohi	218	14.0%	63	4.0%	9	0.5%	9	0.5%
5	Village Mahar Wada	103	6.6%	22	1.4%	7	0.4%	7	0.4%
6	Village Mohammed Hayat Brohi	63	4.0%	17	1.0%	9	0.5%	6	0.3%
7	Village Panju Dero	73	4.7%	13	0.8%	12	0.7%	8	0.5%
8	Village Agani	56	3.6%	21	1.3%	7	0.4%	14	0.9%
9	Village Chouharpur	30	1.9%	27	1.7%	5	0.3%	12	0.7%
10	Village Jeewan	27	1.7%	53	3.4%	10	0.6%	7	0.4%
Total		905		432		119		96	

Table 3: Shows monthly collection of genus *Aiolopus*

Months	*A. thalassinus thalassinus*	%	*A. thalassinus tumulus*	%	Total number of specimens
March	31	1.9	19	1.8	50
April	62	3.9	65	4.1	127
May	181	11.6	85	8.4	266
June	431	27.7	352	34.9	783
July	551	35.5	294	29.1	845
August	171	11.0	141	14.0	312
September	111	7.1	42	4.1	153
October	14	0.0	9	0.8	23
Total	1552		1007		2559

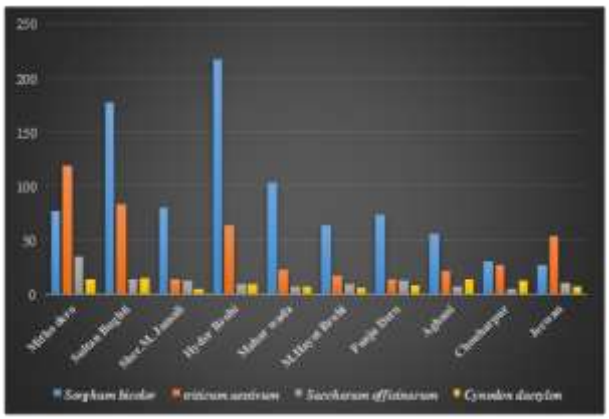

Fig. 1: Collection of *A. thalassinus thalassinus* on different localities of district Larkana

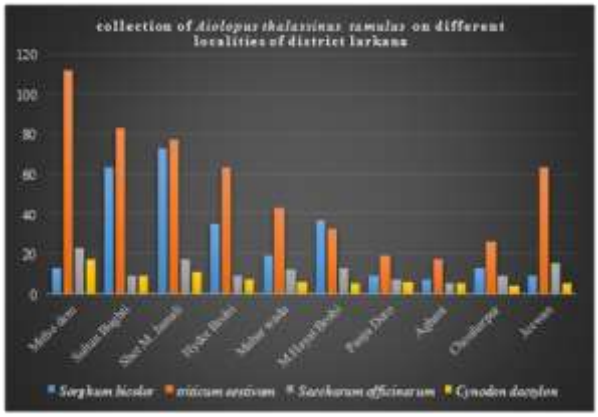

Fig. 2: Collection of *A. thalassinus tamulus* on different localities of district Larkana

Copulation in genus *Aiolopus* on *S. bicolor*

Table 4 shows the length of pre-copulation, copulation and number of matings of *A. thalassinus thalassinus* and *A. thalassinus tamulus* on *S. bicolor*. In *A. thalassinus thalassinus*, a maximum pre-copulation length was recorded as 7 days 2 h and 32 min and minimum recorded as 4 days and 10 min. The maximum copulation length was 2 h and 20 min and minimum was 1 h 15 min and total 5 number of matings was recorded in the lifetime. Contrarily, in *A. thalassinus tamulus* maximum pre-copulation length was 8 days 1 h and 30 min, while the minimum pre-copulation length was 5 days 7 h and 19 min. The longest copulation time was 1 h and 47 min and minimum were 1 h and 15 min. A total of four matings were recorded in the lifetime.

Copulation in genus *Aiolopus* on food *T. aestivum*

Table 5 shows the length of pre-copulation, length of copulation and number of matings of both sub-species *A. thalassinus thalassinus* and *A. thalassinus tamulus* on *T. aestivum*. In *A. thalassinus thalassinus* the maximum pre-copulation length was recorded 9 days 1 h and 12 min minimum pre-copulation length was recorded in 5 days 0 h 5 min and the maximum copulation length was 1 h and 39 min and the minimum copulation length was 57 min. A total of five matings were recorded in the lifetime with one failed attempt. However, in *A. thalassinus tamulus* maximum pre-copulation period was 8 days 14 h 39 min and minimum was 6 days 10 h and 19 min. The highest copulation length was 1 h and 27 min and minimum copulation length was 38 min and a total 4 number of matings were recorded in a lifetime with no failed attempt.

Copulation in genus *Aiolopus* on mixed diet food

Table 6 shows the length of pre-copulation, length of copulation and number of matings of both the species on a mixed diet. In *A. thalassinus thalassinus* the maximum pre-copulation length was noted as 11 days 5 h 19 min and minimum was recorded 5 days 17 h and 55 min. A maximum copulation length was 1 h 25 min and the minimum copulation length was 26 min total 5 number of matings were recorded in lifetime. In *A. thalassinus tamulus* the maximum pre-copulation length was 9 days 7 h 18 min and the minimum was 5 days 22 h and 19 min. The highest copulation length was 1 h and 29 min and the minimum copulation length was 39 min. A total of three matings were recorded in lifetime with no failed attempt.

Copulation in genus *Aiolopus* on food *S. officinarum*

Table 7 shows the length of pre-copulation, length of copulation and number of matings of both sub-species *A. thalassinus thalassinus and A. thalassinus tamulus on Saccharum officinarum* (sugarcane) food plant. In *A. thalassinus thalassinus* the maximum pre-copulation length was recorded 11 days 9 h 23 min and minimum pre-copulation length was recorded 6 days 2 h and 18 min and maximum copulation length was 1 h and 2 min and minimum copulation length was 33 min total 4 number of matings was recorded lifetime and no failure attempt while in *A. thalassinus tamulus*, maximum pre-copulation length was recorded 9 days 4 h 18 min and the minimum pre-copulation length was 6 days 5 h and 17 min. The highest copulation length was 55 min and the minimum copulation length was 25 min and total 4 numbers of matings were recorded in lifetime with no failure attempt.

Copulation in genus *Aiolopus* on food *C. dactyolon* (common grass)

Table 8 the length of pre-copulation, length of copulation and number of matings of both sub-species *A. thalassinus thalassinus* and *A. thalassinus tamulus* on *C. dactylon* (common grass) food plant. In *A. thalassinus thalassinus* the maximum pre-copulation length was recorded 14 days 9 h and 17 min the minimum pre-copulation length was recorded 8 days 23 h and 35 min and the maximum copulation length was 54 min and the minimum copulation length was 29 min total 4 number of matings was recorded lifetime with one failure attempt while in *A. thalassinus tamulus* maximum pre-copulation length was recorded 13 days 2 h 21 min and minimum pre-copulation length was 11days 7 h and 13 min only one copulation was successful which length was 35 min and 3 number of matings were recorded in lifetime while two were failure attempts.

Duration of oviposition, no. of oviposition and no. of eggs per pod in *A. thalassinus* on different foods

Data on the number of eggs per pod, duration of oviposition and number of oviposition on different food plants are shown in Table 9. Highest results were observed on the *S. bicolour* food plant with the range of 42 to 18 eggs per pod and lowest results were observed on *C. dactylon* (common grass) was 17 to 15 eggs per pod, while on *S. bicolor* food the maximum duration of oviposition was 40 min and minimum 10 min and highest number of eggs per pod were 42 and lowest were 22. Total 5 oviposition were found in lifetime.

In *T. aestivum* field, maximum duration of oviposition was 37 min and the minimum 17 min and maximum number of egg per pod was 40 and the minimum was 26 and a total 4 oviposition found in the lifetime. In mix diet, the highest duration of oviposition was 35 min the lowest 10 min the maximum number of eggs per pod was 40 and minimum was 17 and a total five oviposition found in the lifetime. In *S. officinarum*, the highest duration of oviposition was 34 min and the lowest 26 min and maximum number of eggs per pod was 28 and minimum was 24 and a total 4 oviposition was found in the lifetime. In *C. dactylon*, the longest duration of oviposition was 28 min and lowest 10 min. A maximum

Table 4: Shows the length of copulation in genus *Aiolopus* on *S. bicolor*

Name of species	Length of pre copulation days: hours: minutes	Length of copulation in hours: Minutes	No. of mattings
A. thalassinus thalassinus	05:0:20	2.20	1st
	06:0:32	1.39	2nd
	4:0:10	1.15	3rd
	7:2:32	1:44	4th
	5:9:25	1.28	5th
A. thalassinus tumulus	08:1: 30	1.47	1st
	5:7:19	1.35	2nd
	6:3:19	1.15	3rd
	6:10:39	Failure attempt	4th

Table 5: Shows the length of copulation in genus *Aiolopus* on *T. aestivum*

Name of specimen	Length of pre copulation days hours: minutes	Length of copulation in hours: minutes	No. of mattings
A. thalassinus thalassinus	09:1:12	1:30	1st
	05:0:5	1. 25	2nd
	07:3:16	Failure attempt	3rd
	06:11:19	1.39	4th
	07:14:23	0.57	5th
Aiolopus thalassinus tumulus	06:10: 19	1:18	1st
	08: 14:39	0:52	2nd
	07:17: 19	0:38	3rd
	06::19: 23	1.27	4th

Table 6: Shows the length of copulation in genus *Aiolopus* on mix diet food plants

Name of specimen	Length of pre copulation days hours: minutes	Length of copulation in hours: minutes	No. of matings
A. thalassinus thalassinus	11:05:19	1:10	1st
	09: 17:23	0.57	2nd
	8:23:29	1.12	3rd
	6:22:07	1:25	4th
	05:17:55	0.26	5th
A. thalassinus tumulus	09:7:18	0.54	1st
	07:15:25	0.39	2nd
	05:22:19	1.29	3rd

Table 7: Shows the length of copulation in genus *Aiolopus* on *S. officinarum*

Name of specimen	Length of pre copulation days hours: minutes	Length of copulation hours: minutes	No. of matings
A. thalassinus thalassinus	09:5:18	1.02	1st
	11:09:23	0.44	2nd
	06:2:18	0.35	3rd
	08:02:30	0.33	4th
A. thalassinus tamulus	06:05:17	0.55	1st
	9:4:18	0.41	2nd
	07:09:22	0.31	3rd
	8:9: 33	0.25	4th

Table 8: Shows the length of copulation in genus *Aiolopus* on *C. dactylon*

Name of specimen	Length of pre copulation days hours: minutes	Length of copulation in hours: minutes	No. of matings
A. thalassinus thalassinus	12:0:22	0:54	1st
	8:23:35	Failure attempt	2nd
	9:15:63	0.48	3rd
	14:09:17	0.29	4th
A. thalassinus tamulus	13:02:21	Failure attempt	1st
	11:07:13	Failure attempt	2nd
	13:0:19	0.35	3rd

number of eggs per pod was 17 and minimum was 12 and a total 4 oviposition was found in lifetime (Table 9).

Duration of oviposition, no. of oviposition and no. of eggs per pod in *A. thalassinus tamulus* on different foods

Data in Table 10 indicated that in *T. aestivum* field, the highest duration of oviposition was 38 min and lowest 25 min and highest number of eggs per pod were 35 and lowest was 15 and total 4 oviposition was found in lifetime. In *S. bicolor* field, the highest duration of oviposition was 35 min and the lowest 14 min, and maximum number of eggs per pod was 30 and minimum was 15. A total four oviposition was found in a lifetime. In mixed diet the highest duration of oviposition was 33 min and lowest 27 min and highest number of eggs per pod were 28 and minimum was 18 and

Table 9: Shows duration, no. of oviposition and no. of eggs per pod of *A. thalassinus*

Name of plants	Duration of oviposition	No. of ovipositions	No. of eggs per pod
S. bicolor	35 minutes	1	42
	40 minutes	2	30
	10 minutes	3	38
	30 minutes	4	28
	25 minutes	5	22
T. aestivum	30 minutes	1	37
	37 minutes	2	40
	17 minutes	3	No egg pods foamy mass only
			26
	23 minutes	4	
Mix diet	31	1	25
	35	2	23
	30	3	35
	10	4	40
	20	5	17
S. officinarum	30	1	24
	34	2	27
	32	3	28
	26	4	25
C. dactylon	10	1	17
	16	2	No egg pods foamy mass only
			15
	28	3	12
	25	4	

Table 10: Shows duration, no. of oviposition and no. of eggs per pod of *A. thalassinus tamulus*

Name of plants	Duration of oviposition	No of oviposition	No. of eggs per pod
	30 minutes	1	35
T. aestivum	38 minutes	2	31
	27 minutes	3	17
	25 minutes	4	15
	29 minutes	1	30
S. bicolor	35 minutes	2	25
	26 minutes	3	15
	14 minutes	4	No egg pods foamy mass only
S. officinarum	28 minutes	1	30
	34 minutes	2	28
	30 minutes	3	31
	20 minutes	4	14
mix diet	27 minutes	1	28
	33 minutes	2	18
	28 minutes	3	22
C. dactylon	15 minutes	1	No egg pods foamy mass only
			No egg pods foamy mass only
	10 minutes	2	15
	23 minutes	3	

total 3 oviposition were found in a lifetime.

In *S. officinarum*, the longest duration of oviposition was 34 min and lowest 20 min and highest number of eggs per pod was 30 and lowest 14. A total 4 oviposition were found in a lifetime. In *C. dactylon* field, the shortest duration of oviposition was 15 min and minimum 10 min only, while one egg pod was found in a lifetime, with 15 eggs were found in the pod while two were foamy mass (Table 10).

Weight of mated and non-mated male and female of *A. thalassinus thalassinus* and *A. thalassinus tamulus* on different foods plants

The weight of both male and female of *A. thalasssinus thalassinus* and *A. thalassinus tamulus* before mating and after mating on different food plants are given in Tables 11 and 12. In *A. thalassinus thalassinus* maximum weight gain was recorded on *S. officinarum i.e*., 929.8 ± 70.83 in non-mated females to 1088 ± 176.56 in mated female. However, in case of males, the increase in weight was little slower as compared to females on the same food plant *i.e*., 638.6 ± 93 in non-mated males to 675.8 ± 100.22 in mated males. It was followed by *S. bicolor i.e*., 906.2 ± 67.85 in non-mated females to 1055.2 ± 133.98 in the mated females. However, it was 634 ± 86.08 in non-mated male to 651 ± 99.29 in mated male.

A lowest gain in weight was recorded on *C. dactylon* fields in both sexes *i.e*., 822.6 ± 23.12 in non-mated females

Table 11: Showing weight (mg) of mated and non-mated male and female of *A. thalassinus thalassinus*

Name of the host plant	Mated female (n = 5) (Mean ± SD)	Not mated female (n = 5) (Mean ± SD)	Mated male (n = 5) (Mean ± SD)	Not mated male (n = 5) (Mean ± SD)
S. bicolor	1055.2 ± 133.98	906.2 ± 67.85	651 ± 99.29	634 ± 86.08
T. aestivum	929.6 ± 112.29	852.6 ± 37.87	582.8 ± 72.74	571.2 ± 76.27
Mix diet	886.6 ± 84.28	823.6 ± 30.85	545.8 ± 24.63	538 ± 23.93
S. officinarum	1088 ± 176.56	929.8 ± 70.83	675.8 ± 100.22	638.6 ± 93.31
C. dactylon	859.6 ± 39.13	822.6 ± 23.2	533.2 ± 15.18	525 ± 15.24

Table 12: Showing weight (mg) of mated and non-mated male and female of *A. thalassinus tamulus*

Name of the host plant	Mated female (n = 5) (Mean ± SD)	Not mated female (n = 5) (Mean ± SD)	Mated male (n = 5) (Mean ± SD)	Not mated male (n = 5) (Mean ± SD)
S. bicolor	968.4 ± 113.20	858 ± 55.26	564.2 ± 21.56	548.2 ± 29.49
T. aestivum	910.6 ± 98.48	842.6 ± 22.5	551.4 ± 20.18	541.6 ± 26.66
Mix diet	886.2 ± 67.90	829.8 ± 9.85	541.4 ± 19.56	532.6 ± 18.51
S. officinarum	1009.2 ± 154.76	865.8 ± 59.23	633.6 ± 42.51	600.2 ± 34.95
C. dactylon	857.4 ± 38.18	825 ± 8.12	535.8 ± 15.33	530.2 ± 17.42

to 859.6 ± 39.13 in mated females followed by 525 ± 15.24 in non-mated male to 533.2 ± 15.18 in mated males. In *A. thalassinus tamulus* indicated maximum gain in the weight in *S. officinarum* field *i.e*., 865.8 ± 59.23 in non-mated females to 1009.2 ± 154.76 in mated females. However, in case of males the increase in weight was little lesser as compared to females on same food plant *i.e*., 600.2 ± 34.95 in non-mated male to 633.6 ± 42.51 in mated male. It was followed by *S. bicolor i.e*., 858 ± 55.26 in non-mated females to 968.4 ± 113.20 in the mated females while it was 548.2 ± 29.49 in non-mated males to 564.2 ± 21.56 in mated males. However, lowest gain in the weight was also recorded on *C. dactylon* in both sexes *i.e*., 825 ± 8.12 in non-mated females to 859.6 ± 39.13 in mated females followed by 530.2 ± 17.42 in non-mated males to 535.8 ± 15.33 in mated males (Table 11, 12).

Discussion

The present study was aimed at examining the effects of selective host plants on the reproductive life of Genus *Aiolopus.* This group represents the most destructive pest of short horned grasshoppers and these are chiefly polyphagous in nature and infesting on important agricultural crops. Host plants significantly modify the uplifting, survival and reproductive potential of insects (Finke 2013). Many studies suggested that diet has a direct effect on the life cycle and survival of hoppers (Behmer and Joern 1993). Nutritive contents of high energy molecules such as carbohydrates, protein, essential ions and water for the reproduction of insects (Ghosh *et al.* 2014). This study was focused on two closely related species of the genus Aiolopus i.e., A. thalassinus thalassinus and A. thallassinus tamulus and occupied the same ecological niche and highly similar morphology. It was observed that *A. thalassinus thalassinus* population was greater in field while *A. thalassinus tumulus* shows its predominance.

Mating strategies of this genus in respect to effects of food plant is studied for the first time. Pre-copulation period of *A. thalassinus thalassinus* was minimum on *S. bicolor i.e*., 4 to 7 days and maximum on *C. dactylon i.e*., 8–14 days. However, in case of *A. thalassinus tumulus* minimum duration was noted on *S. bicolor i.e*., 5 to 8 days and maximum on *C. dactylon i.e*., 11–13 days. Prolonged copulation period in both species was noted on *S. bicolor* followed by *T. aestivum* and mixed diet and was shortest in *C. dactylon.* Riffat and Wagan (2008) reported that energetic feeding and preferred food plant significantly affected duration of pre-copulation, copulation and numbers of matings in *Hieroglyphus* species. At present the total mating number was five in *A. thalassinus thalassinus* and four in *A. thalassinus tumulus*. However, low preference of food plants significantly affected the mating numbers.

There was no significant difference in the oviposition behavior of two species. A minimum duration of oviposition was noted in *A. thalassinus thalassinus* and *A. thalassinus tumulus* on *C. dactylon i.e.*, 10 to 28 and 10 to 15 min, while a maximum duration was recorded on *S. bicolor* i.e., 35 to 40 in *A. thalassinus thalassinus* and in *A. thalassinus tumulus* was on *T. aestivum* 25 to 38 min. *A. thalassinus thalassinus* was more selective and dug more number of holes in soil for oviposition, which may enhance hatching of eggs. Numbers of eggs per pod were laid by *A. thalassinus thalassinus* with range between 22–42 eggs per pod and 15–35 in *A. thalassinus tumulus. Aiolopus* species indicated a greater number of oviposition as well as the maximum number of eggs per pod on *S. bicolor* and *T. aestivum* while lowest on *C. dactylon.* In contrast to this, Nozomo (2017) reported that by adults of *Schistocerca gregaria,* maximum duration and greater number of eggs were recorded on *Phaseolus vulgaris* and *T. aestivum* and lowest on *S. bicolor*. This showed a significant difference in host preference among locust and grasshoppers and their effect on oviposition and number of eggs per pods.

Fecundity to produce the number of eggs per pod was also affected by the food preference and nutritive value of

host plant. Failure of mating or resulting release of foamy mass without egg pod or even female on the disturbance occurred when they did not find suitable soil for ovulation to lay their eggs with foamy mass not properly enclosed in egg pod on surface. Mated females were different from unmated females in weight and size as compared to males. In *A. thalassinus thalassinus* and *A. thalassinus tumulus* female gain weight and it was observed the highest on *S. officinarum i.e.,* 1088 ± 176.56 and 1009.2 ± 154.76 and lowest on *C. dactylon i.e.,* 859.6 ± 39.13 and 857.4 ± 38.18. Shah and Sultana (2018) also reported that significant weight gain by mated females as compared to unmated females in 03 acrid species. Furthermore, the male slightly gain weight after mating because they started eating after mating. However, soon after mating few of them lost their weight but regain by feeding again.

Conclusion

Both species of the genus *Aiolopus* had intermingled habitat, morphological aspects and similar host preference. On the other hand, they differed considerably for emergence time and reproductive potential. *A. thalassinus thalassinus* was a more competent invader, which showed dominance in the field and higher reproductive potential. It was noted that both sub-species of *Aiolopus* pre-copulation, copulation and number of matings was longer on *S. bicolor*. However, duration of oviposition, number of oviposition and egg per pod were preferred on *S. bicolor* and *T. aestivum* as compared to *C. dactylon*. In addition, all above-mentioned aspects of reproductive strategies *A. thalassinus thalassinus* had more potential as compared to *A. thalassinus tumulus* on reared host plants. This confirmed the status of *A. thalassinus thalassinus* as a major pest of crops.

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Author Contributions

Imran Khan Brohi carried out research, collected data, analyzed data; Imran Khan Brohi, Shahar Bano and Nasir Hajano wrote and corrected the manuscript; Fakhra Soomro supervised and reviewed all the work.

Conflicts of Interest

The authors do not have any conflict of interest.

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable in this paper.

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